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Mentoring at Scale

Bond Ladder Workbook Methodology

The predictable-income, no-manager-fee fixed-income workbench — with the math, the Excel formulas, and the discipline that turns a bond portfolio into a liability-matching machine.

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Companion to Bond_Ladder_Workbook.xlsx

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QUICK START

Read this page before you touch the workbook.

The Bond Ladder Workbook builds a portfolio of individual bonds with evenly-spaced maturity dates, then reinvests each rung at maturity into a new long-end rung. The result is a fixed-income book that pays predictable income, holds its weighted-average duration constant over time, has no manager fee, and spreads reinvestment risk across N years instead of concentrating it at one date. It is the default advisor tool for retirees, family offices holding operating reserves, and any investor who needs an income stream more than they need alpha.

Tab	What it does	When to open it
1. Single Ladder	One ladder, per-rung schedule	Setting up an income stream
2. Portfolio	Three ladders side-by-side	Multi-account or barbell construction
3. Cash Flow	Year-by-year reinvestment schedule	Modeling the income steady state
4. Reference	Term glossary + Excel functions	Anyone new to laddering

Blue cells are inputs. Gold cells are outputs. Bond-type dropdown and frequency dropdown are validated. Iterative calc is enabled (200 iterations, 0.0001 tolerance) though ladder math doesn't require it — it's on for consistency with the other bond workbooks.

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What's in this PDF

SECTION 1

Why bond ladders exist

A bond ladder solves a specific problem: how does an investor generate a predictable income stream from fixed income while limiting exposure to any single interest-rate regime? The naive alternatives fail in specific, well-understood ways.

The single long bond. Buying a single 10-year Treasury locks in a specific yield for 10 years but concentrates two risks: reinvestment risk at year 10 (when you have to redeploy the principal at whatever rate is prevailing) and mark-to-market volatility along the way. Yields move; a 10-year Treasury with modified duration of ~8.5 years loses roughly 8.5% of its price for a 100bp rise. If the investor needs to sell early, that hurts.

A bond mutual fund or ETF. A fund provides diversification and professional management but comes with three costs. First, an expense ratio (10-50 bps for most bond funds, higher for actively managed muni funds). Second, perpetual duration — the fund's average maturity is roughly constant over time, so there is no maturity date at which the investor is guaranteed to receive full principal. Third, NAV volatility from continuous mark-to-market; even a held-to-maturity ladder book would have zero paper loss at any given moment, whereas a fund reports unrealized losses whenever rates rise.

A ladder. A ladder is N individual bonds with maturity dates spread 1 year apart. Each year one rung matures; principal is reinvested at the long end (year N). Weighted-average duration stays constant at roughly $(N+1)/2$. Income smooths through rate cycles because only 1/N of the book reprices each year. There is no expense ratio. Book value is knowable at every rung (the face value at maturity). For investors who can hold to maturity, the ladder is structurally superior to a fund on cost, transparency, and risk-concentration grounds.

What this workbook covers

The workbook handles vanilla bullet bonds — Treasury, general obligation muni, and investment-grade corporate. Equal-weight rungs from year 1 to year N. Mid-curve yield input with a linear slope in bps per rung. Tax logic for the three product types. Cash-flow projection assuming steady-state reinvestment. It does not handle callable bonds, MBS, floating-rate notes, or inflation-linked bonds — those require option-adjusted duration analysis that is outside this workbook's scope.

SECTION 2

Ladder construction — the mechanic

Given a total investment amount *C*, ladder length *N* years, and a mid-curve yield *y*, the workbook builds an equal-weight ladder by setting per-rung face value to:

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F = C / N
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For $500,000 across 10 rungs, each rung holds $50,000 face. Yield on rung *r* is:

$$y_r = y + (\text{slope\_bps} / 10000) \times (r - (N+1)/2)$$

The slope term shifts each rung's yield above or below the mid-curve based on its position. Rung 1 (short) gets a discount; rung *N* (long) gets a premium. The average across all rungs equals the mid-curve yield *y* by construction — the slope redistributes yield across rungs but does not change the ladder average.

A worked example

$500,000 total, 10 rungs, 4.50% mid-curve, 6bps slope per rung:

Rung	Face ($)	Yield %	Annual coupon
1	$50,000	4.23%	$2,115
2	$50,000	4.29%	$2,145
3	$50,000	4.35%	$2,175
4	$50,000	4.41%	$2,205
5	$50,000	4.47%	$2,235
6	$50,000	4.53%	$2,265
7	$50,000	4.59%	$2,295
8	$50,000	4.65%	$2,325
9	$50,000	4.71%	$2,355
10	$50,000	4.77%	$2,385
Total	$500,000	4.500% (avg)	$22,500

Total annual income is $22,500 = 4.500% × $500,000. Notice the yield curve slope creates dispersion — rung 1 pays $2,115 and rung 10 pays $2,385 — but the total collapses to what a single-bond investor would earn at the mid-curve yield. The value of the ladder is not higher yield but *risk redistribution*.

SECTION 3

Weighted-average duration — the (N+1)/2 result

For an equal-weight bullet ladder with rungs at 1, 2, ..., *N* years and equal face value in each rung, the weighted-average duration is approximately:

$$D_{ladder} \approx (N + 1) / 2$$

This is the arithmetic mean of the integers from 1 to *N*. For a 10-year ladder, average duration is 5.5 years. For a 20-year ladder, 10.5. This approximation is exact if every rung is a zero-coupon bond; for coupon-paying bonds, the actual weighted-average modified duration is slightly less than (N+1)/2 because coupons pull each rung's individual duration below its stated maturity.

Why this matters

A ladder of maturities 1 through 10 has duration of ~5.5. A single 10-year bond has duration of ~8.5. Same mid-point yield, roughly half the rate sensitivity. That is the ladder's core structural advantage: you get the yield-curve premium of a 10-year without the parallel-shift risk exposure of a single 10-year bond.

Practically: if rates rise 100bp, a single 10-year Treasury loses ~8.5% of its market value. An equivalent-yield 10-year ladder loses ~5.5%. For an investor who wants steady book income but is willing to accept some duration risk to get it, the ladder produces a better risk-adjusted result.

The barbell alternative

A 'barbell' portfolio buys equal amounts of very short and very long bonds — say, half in 2-year Treasuries and half in 30-year Treasuries. Weighted-average duration works out to roughly 16 years but with much higher convexity than a pure 16-year bullet. Barbells reward large-magnitude rate moves in either direction. Ladders do neither — they minimize dispersion. Which is right depends on the investor's objective. A retiree wanting steady income should ladder. A pension immunizing a spike in liabilities in year 20 should barbell.

SECTION 4

Yield curve slope — how it distributes across rungs

The workbook's slope input controls how much yield differential exists between adjacent rungs. Slope is specified in basis points per rung. The typical Treasury yield curve is upward-sloping with a spread of roughly 100-200bps between the 2-year and the 10-year — so slope per rung is roughly 10-25bps at the intermediate part of the curve.

Curve shapes

Normal (positive slope). Long bonds yield more than short bonds. The workbook default. The long-end rung gets the premium; over time, as rungs mature and are rolled to the long end, the ladder captures the term premium.

Flat (zero slope). All rungs yield the same. Set slope to 0 in the workbook to model this scenario. The ladder still smooths reinvestment risk over time but does not earn a term premium.

Inverted (negative slope). Short bonds yield more than long bonds — the historical signal of a recession approaching. Set slope to a negative number to model this. Ladders in an inverted-curve regime reinvest matured principal at a lower yield than the maturing rung — income declines over time. This is exactly the rate-decline scenario that ladders are designed to smooth.

The workbook's assumption

The workbook assumes a linear slope — every rung shifts by the same constant basis-point amount above or below the mid-curve. Real yield curves are non-linear (kinked at the 2y or 5y, flatter at the long end). For a first-cut ladder design, linear is close enough. For a final ladder built on live quotes, use the actual quoted yield of each rung on the day of purchase rather than the linearly-extrapolated value.

SECTION 5

Reinvestment discipline — the steady state

The discipline is what makes a ladder work. Each year one rung matures. Principal is *immediately* reinvested in a new bond at the long end of the ladder (year *N*). This preserves the ladder's average duration and keeps the reinvestment schedule systematic.

Year-by-year mechanic

Year 1: the 1-year rung matures. Roll proceeds into a new *N*-year bond. Year 2: the 2-year rung (now the shortest rung after year 1's rollover) matures. Roll into another new *N*-year bond. Years 3 through *N*-1: the same pattern — one rung matures, one new rung added at the long end.

In steady state, the ladder configuration is identical every year: N rungs, maturities 1 through *N*, each holding *C/N* in face. The only thing that changes is the yield of the newly-purchased long-end rung, which reflects prevailing market rates at rollover.

Income under changing rates

If rates are stable, income stays constant. If rates rise, income gradually rises as each maturing rung is replaced with a higher-yield long rung — the ladder captures the rising-rate environment 1/N per year. If rates fall, income gradually falls at the same rate. This is the reinvestment-risk smoothing feature: the ladder does not fully escape reinvestment risk, it distributes the exposure across N years. A single 10-year bond faces the full magnitude of the change at year 10.

Why immediate reinvestment matters

The discipline breaks down if matured principal is not reinvested immediately. Holding cash from a maturing rung defeats the purpose of the ladder — cash yields the short rate (currently near zero, historically near the fed funds rate). If an investor stops reinvesting during a low-rate scare, the ladder gradually collapses into cash and long bonds and loses its structural risk-smoothing property. The Cash Flow tab in the workbook assumes automatic reinvestment; deviate at your own risk.

SECTION 6

Ladder vs. bond fund

The competitive comparison for most retail investors is: hold individual bonds in a ladder, or hold a bond mutual fund or ETF? Both produce fixed-income exposure, but the two structures differ on several dimensions that matter to a long-horizon investor.

Dimension	Ladder	Bond fund / ETF
Duration profile	Anchored (avg = (N+1)/2)	Perpetual (fund never matures)
Book value at maturity	Known (face of each rung)	Never — fund has no maturity
Expense ratio	Zero	10-50 bps (higher for muni funds)
NAV volatility	None if held to maturity	Continuous mark-to-market
Diversification	Investor's own selection	Managed by fund (hundreds of bonds)
Credit selection	Investor picks each rung	Fund manager selects
Reinvestment discipline	Mechanical	Fund manager's discretion
Purchase minimums	$1k-$5k per rung	$1 per share
Bid/ask cost	5-25 bps per rung purchase	Embedded in NAV

The ladder wins on cost, transparency, and duration control. The fund wins on diversification and buy-in flexibility. For high-net-worth families with $500k+ to allocate to fixed income, the ladder's cost advantage compounds into meaningful basis points of return over time. For a $50,000 allocation, the ladder's setup friction may not be worth the savings.

The behavioral case

One under-appreciated ladder advantage is behavioral. Ladder investors hold to maturity, mechanically. Fund investors see quarterly statements with unrealized losses in a rising-rate environment and often sell at the bottom. The ladder's book-value discipline is not just a cost story — it is a way to structurally prevent the largest source of retail fixed-income underperformance.

SECTION 7

Ladder vs. bullet

A bullet portfolio concentrates the entire investment in bonds maturing at a single date — for example, all 10-year Treasuries when the goal is $500k of principal in 10 years. Bullets are the right choice for immunizing a single-date liability. Ladders are the right choice for an income stream.

Immunization theory

Frank Redington's 1952 paper on portfolio immunization established the framework: to hedge a liability due at time T, hold assets with the same modified duration as the liability. A single T-year zero-coupon bond is the exact immunization for a single T-year liability. Any portfolio with equal duration will approximately hedge it, but the bullet is the cleanest.

Ladders solve a different problem: they immunize a *stream* of liabilities — a retiree drawing $50,000/year, a foundation making annual grants, a family office funding an annual distribution. Each rung matures against one year's liability. The ladder's weighted-avg duration matches the liability stream's weighted-avg duration.

When bullets win

A single terminal liability — say, a private-school tuition bill due in year 8 — is best matched with an 8-year bullet position, not an 8-year ladder. The ladder produces intermediate cash flows that must be reinvested, and reinvestment yields are unknown ex ante. The bullet has no reinvestment risk.

When ladders win

Any recurring-liability funding problem. Retirement income. College-tuition streams for multiple children entering different years. Annual charitable distributions from a private foundation. Insurance company liability matching against known annuity payments. The ladder was designed for exactly these use cases.

SECTION 8

Tax mechanics — Treasury vs. Muni vs. Corporate

The workbook handles the three main investment-grade bond types with distinct tax treatments. Getting the tax logic right is the single largest source of after-tax yield differential between otherwise similar bonds.

Bond type	Federal tax	State tax	After-fed rate	After-fed+state rate
Treasury	Yes	No (31 USC §3124)	y × (1 – fed)	y × (1 – fed)
Muni (in-state)	No (§103(a))	No	y	y
Muni (out-of-state)	No (§103(a))	Yes	y	y × (1 – state)
Corporate	Yes	Yes	y × (1 – fed)	y × (1 – fed – state)

The workbook implements the in-state muni case. For out-of-state munis, treat the state tax field as the effective state rate on the coupon portion. Users buying munis from a state they don't reside in should verify their state's specific rules — a small number of states (Illinois, Iowa, Oklahoma, Wisconsin) tax even their own munis at the state level, and one state (Utah) taxes muni interest from states that do not offer reciprocal tax-exemption to Utah bonds.

Tax-equivalent yield

For comparing muni yields to taxable yields, compute the tax-equivalent yield (TEY) of the muni:

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TEY = Muni Yield / (1 – Combined Marginal Tax Rate)
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For a 3.50% muni yield in a state offering full state tax exemption for an investor at 32% federal + 6% state (combined marginal 38%): TEY = 3.50% / (1 – 0.38) = 5.65%. Compare that to a taxable Treasury of similar duration. If Treasuries yield more than 5.65%, take the Treasury; if less, take the muni. The Bond Yield Workbook has a full TEY calculation tab for this analysis.

SECTION 9

When ladders don't work

Ladders are not a universally good idea. Several specific market or portfolio conditions make them a poor fit relative to alternatives.

Callable bond structures

Callable bonds can be redeemed by the issuer when rates fall enough to make refinancing attractive. This converts what looked like a 10-year rung into a 5-year rung (say, if the bond is callable at year 5). A ladder built with callable rungs faces asymmetric reinvestment risk: when rates fall, calls collapse the long rungs; when rates rise, the calls are not exercised and the ladder holds its full duration. This asymmetry favors the issuer and disadvantages the ladder holder. Municipal bonds especially: most muni issues are callable after 10 years. Read the call schedule before laddering.

Mortgage-backed securities

MBS have prepayment risk — homeowners refinance when rates fall, shortening the effective duration exactly when the investor would prefer longer duration. MBS in a ladder produces the same asymmetric reinvestment problem as callable bonds, only worse. MBS should not be used as ladder rungs.

Small allocations

Building a proper 10-rung ladder requires 10 separate bond purchases. For allocations under about $200,000, the bid-ask cost per purchase (5-25 bps for retail Treasuries, more for munis and corporates) can erode enough yield to make a low-cost bond ETF the better choice. Under $50,000 total allocation, use an ETF.

Highly variable liability streams

If the investor's future cash-flow needs are large and non-uniform (a lumpy business acquisition, an irregular annual expense pattern), the equal-weight ladder does not match the liability stream. A custom-weighted ladder — where face values vary by year — can be constructed, but this workbook does not handle it. For custom weighting, model each rung individually in the Bond Yield Workbook.

SECTION 10

Portfolio-level composition

The Portfolio tab supports up to three ladders side-by-side. This handles two common practitioner use cases: barbell ladder construction and multi-account allocation.

Barbell ladder construction

A barbell ladder mixes a short ladder (e.g., 5 years) with a long ladder (e.g., 20 years) instead of a single intermediate ladder. Same average duration as the intermediate ladder, more convexity. The short ladder handles liquidity; the long ladder captures term premium. For an investor with both near-term and far-future spending needs, this can outperform a single ladder on both dimensions.

Configuration	Total invested	Weighted-avg duration	Blended yield
Single 10-year ladder	$1.0M	5.5 yr	4.50%
Barbell: 5yr + 20yr	$1.0M	6.5 yr	4.60%

Multi-account allocation

Family office ladders often need to sit across multiple accounts with different tax profiles. A common structure: Treasuries in the taxable account (Treasury interest is state-exempt, worth more to a New York or California resident); Corporates in the IRA (income sheltered from tax entirely); Munis in the taxable account for very high-bracket investors where TEY exceeds Treasury yield. The Portfolio tab lets the practitioner model this asset location decision at the ladder level.

Blended metrics

The Portfolio tab computes blended-book duration as a market-value weighted average of individual ladder durations, and blended income as the simple sum. This is correct for parallel-shift risk analysis. For curve-twist scenarios (2y-30y spread widening or compressing), the blend understates risk because it treats short and long ladders as interchangeable when they are not.

APPENDIX A

Excel formula reference

The formulas the workbook uses on the Single Ladder tab, with sample values reflecting the $500,000 / 10-year / 4.50% / 6bps default case.

Metric	Excel formula	Sample
Per-rung face	`=C6/C7`	$50,000
Rung r yield	`=$C$9 + ($C$10/10000)*(B_r − ($C$7+1)/2)`	4.23% (r=1)
Rung r income	`=D_r*E_r`	$2,115 (r=1)
Total pre-tax income	`=SUMPRODUCT(D18:D27,E18:E27)`	$22,500
Weighted-avg yield	`=F7/C6`	4.500%
Weighted-avg duration	`=SUMPRODUCT(C18:C27,D18:D27)/SUM(D18:D27)`	5.5 yr
After-fed income (Muni-aware)	`=IF(C8="Muni", F7, F7*(1-C11))`	$15,300
After-fed+state (all types)	`=IF(C8="Treasury", F7*(1-C11), IF(C8="Muni", F7, F7*(1-C11-C12)))`	$15,300
Portfolio-blended duration	`=IFERROR((C6*C16+D6*D16+E6*E16)/F22, 0)`	varies

Note on the yield curve slope formula. The slope term *(B_r − (N+1)/2)* is the rung's distance from the ladder center. For rung 1 in a 10-year ladder, that distance is 1 − 5.5 = −4.5. Multiplied by the slope (6 bps = 0.0006 in decimal), rung 1's yield is discounted by 27bps below mid-curve. For rung 10, the distance is 10 − 5.5 = 4.5, so rung 10 is +27bps above mid-curve. The dispersion is symmetric around the mid-curve.

Note on the bond-type conditional formulas. The two after-tax output formulas use nested IF statements to route between Treasury, Muni, and Corporate treatment. Treasury coupons are federally taxable but state-exempt, so after-fed+state equals after-fed. Muni coupons are federally exempt, so after-fed equals gross income (in-state assumption). Corporate coupons are taxable at both federal and state.

APPENDIX B

Sources and further reading

Canonical references

Fabozzi, Frank J. *Fixed Income Analysis* (5th ed., 2021). Chapters on portfolio construction cover laddering and bullet strategies at the CFA level of depth. Fabozzi's treatment of bullet-versus-ladder trade-offs is more theoretical than this workbook's, but reads well alongside it.

Fabozzi, Frank J. *The Handbook of Fixed Income Securities* (9th ed., 2021). Practitioner reference. Chapters on individual bond purchase mechanics, callable bond analysis, and dealer market microstructure explain the ladder implementation details this workbook glosses over.

Tuckman, Bruce, and Angel Serrat. *Fixed Income Securities: Tools for Today's Markets* (3rd ed., 2011). The most rigorous immunization coverage in the standard fixed-income library. Chapter 4 derives the duration-matching conditions that underpin ladder theory.

Historical

Redington, F. M. *Review of the Principles of Life-Office Valuations* (Journal of the Institute of Actuaries, 1952). The founding paper on portfolio immunization. Redington's original insight — that asset and liability durations must match to hedge parallel yield-curve shifts — is the theoretical basis for both bullets and ladders.

Practitioner

Fidelity Fixed Income Team. Public research notes on ladder construction for retail clients. Concise, practical, and freely available at fidelity.com/fixed-income-bonds/individual-bonds/ladders. The retail-broker perspective is worth reading in parallel with the academic treatments above.

Schwab Center for Financial Research. Bond ladder research notes at schwab.com/learn/topic/bonds. Similar to Fidelity's material; useful as a cross-check.

Regulatory and statutory

26 U.S.C. §103(a). Federal exemption for state and local bond interest. The statutory basis for the muni tax treatment in this workbook.

31 U.S.C. §3124. State and local tax exemption for federal debt. The statutory basis for the Treasury state-tax treatment in this workbook.

MSRB (Municipal Securities Rulemaking Board). emma.msrb.org — official disclosure repository for all publicly-issued municipal bonds. Any muni ladder rung should be verified against its EMMA-posted call schedule before purchase.

APPENDIX C

Disclaimers and licensing

Educational reference only

This workbook and its methodology PDF are educational reference materials. They are not investment advice, tax advice, or a recommendation to buy, sell, or hold any security. The Baratelli Institute publishes under the publisher exception recognized by the Supreme Court in Lowe v. SEC, 472 U.S. 181 (1985). The Institute does not provide personalized investment advice and is not registered as an investment adviser.

Accuracy

The formulas in this workbook produce arithmetically correct outputs given the input assumptions. Real-world ladder implementation involves bid-ask spreads, settlement-date conventions, credit-quality differentials across rungs, callable provisions, and state-specific tax rules that the workbook simplifies. Users must verify any specific bond purchase decision independently and consult a fixed-income specialist and CPA before implementing a ladder strategy.

Scope limitations

The workbook handles bullet (non-callable) bonds only. It does not model callable structures, mortgage-backed securities, floating-rate notes, TIPS, convertible bonds, or any structured product. It assumes a linear yield curve slope. It does not compute credit spread duration or key-rate duration. It does not model AMT exposure on private-activity muni bonds. It does not model the Net Investment Income Tax (§1411 3.8% surtax).

Licensing

— End of methodology PDF —
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