Advanced Public Funds Investing: Concepts for Public Investment Analytics

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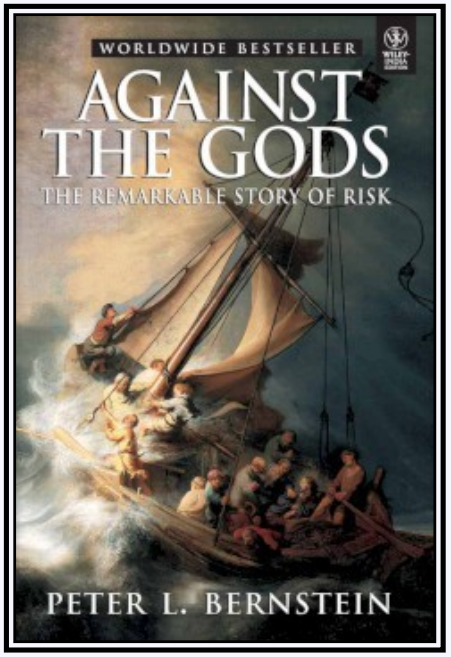
CDIAC

CALIFORNIA DEBT AND INVESTMENT ADVISORY COMMISSION

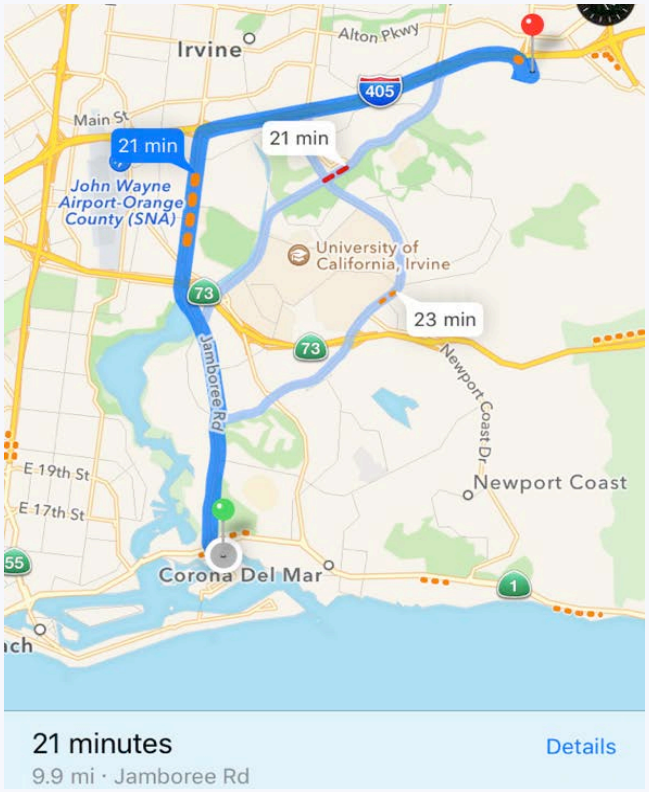


> “Uncertainty is scary. Hard as we try to behave rationally, our emotions often push us to seek shelter from unpleasant surprises. We resort to all sorts of tricks and dodges that lead us to violate the rational prescriptions.”

Bernstein, Peter L. (2008-04-21). Against the Gods: The Remarkable Story of Risk.

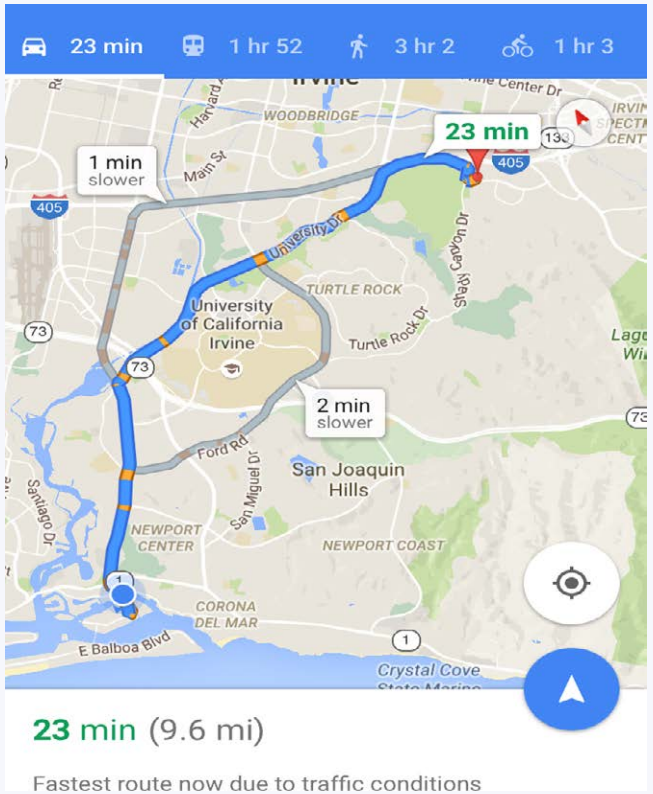
APPLE VS GOOGLE MAPS

Apple



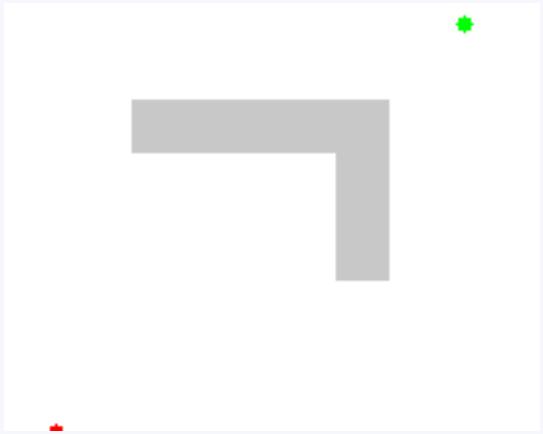
- Both maps agree on 3 potential routes to optimize travel
- Both maps have traffic data based on mobile device data and third-party application tracking
- Both maps disagree on timing and distance of optimal route

Google



Dijkstra's Algorithm

Shortest Path Between Nodes



- Variant first used to explain capabilities of a new computer called ARMAC. Needed a problem and a solution that non-computing people could understand. Dijkstra used an example of simplifying transportation between 64 cities in the Netherlands. Algorithm published after being tasked with minimizing the amount of wire needed to connect pins on the back panel of a new computer.
- Each node tested uniformly in all directions and color fades to green as distance increases and becomes less optimal. Single path finally identified.

Apple and Google, like all navigational products, use this algorithm at its core. However, solutions differ due to human interjection into optimization.

-Google uses separate, proprietary algorithm to exclude anomalies such as a postman that stops more frequently than the average driver. They make minimum assumptions on data collection needs to post traffic warnings and are crowd-sourced driven through apps and direct Android mobile data. They also use their own satellite images through Skybox and Street Map data.

-Apple uses partners like TomTom to archive location data and uses multiple application partners for crowd-sourced map and traffic data like Locationary, Saturn, HopStop, Embark and Mapsense. Apple applies its own proprietary algorithm to ultimately display the optimal route using the information sources available.

> **“Las Vegas is busy every day, so we know that not everyone is rational”**
> **-Charles Ellis**

- Constraints and biases can fuel a fear of being wrong. Fear can drive us to make bad decisions even with good information.

  - Loss-Aversion Bias: Manager sits in cash because they do not understand opportunity cost or are afraid of making the “wrong” decision.

  - Regret Bias / Error of Commission: Manager buys a security and when rates go up, they regret the decision.

  - Overconfidence Bias: Manager focuses on predicting the futures and bases investment decisions on inherent uncertainty.

  - Mental Accounting Bias: Manager buys a security to satisfy relationship and/or political needs acting differently then they would if acting solely for themselves (Prudent Person Rule).

Rationality of Individuals
3 Limitations:

Informational Constraints

- Lack of appropriate information that is easily accessible
  - *Portfolio/Benchmark analytics, efficient offerings, strategy guidelines*
- Too much information clouding the decision process
  - *Research reports, broker spam, conflicting sources*
- Biased information perceived as objective
  - *Solicited bonds, proprietary products, DCM Primary offerings*
- Inappropriate and/or irrelevant information
  - *Economic forecasts, scenario-based analysis, generalized articles (ex// WSJ)*

Rationality of Individuals
3 Limitations:

Informational Constraints

- Creating a concise and unambiguous strategy will limit amount of information to be consumed.
  - *Strategy begins at the Investment Policy level. The Policy establishes legal boundaries which limit the universe of potential security and asset allocation decisions.*
  - *CDIAC Public Fund Investment Primer (#09-02) & Investment Policy Reporting Practices: an Informational Guide (#04-5) provide comprehensive guidelines to implementing and understanding Investment Policies.*

Rationality of Individuals
3 Limitations:

Informational Constraints

- Creating a concise and unambiguous strategy will limit amount of information to be consumed.
  - *Strategy progresses from Policy to Playbook utilizing various methods (broad market, style indices, factor-models, etc..).*
  - *Best practice involves the creation of a Fiduciary benchmark that outlines and encompasses all of the Investment Policy objectives and constraints while maintaining the criteria of a valid benchmark.*
  - *Benchmark should be investable, measurable, specified in advance, unambiguous and appropriate for the fund's purpose.*

Rationality of Individuals
3 Limitations:

Informational Constraints

- Creating a concise and unambiguous strategy will limit amount of information to be consumed.
  - *Your external resources are likely your greatest asset. If internal resources are insufficient to complete the task, then employ your brokers and advisors to get the job done!*
  - *IFB Example*

Rationality of Individuals
3 Limitations:

Finite Time Constraints

- Lack of time to fully understand decisions being made.
- Limited time to focus on portfolio (90% risk, 10% time).
  - *By default, limiting informational constraints creates timing efficiency.*
- Access to resources and leveraging relationships can make the difference between making good decisions and making bad decisions (or no decision at all!).
  - *Portfolio/BM Example*

Rationality of Individuals
3 Limitations:

Cognitive Constraints

- Inability to process data into information
  - *Confusing spreadsheets, complicated financial math, lack skillset to confidently assess situation*
- Lack of understanding fundamental or important concepts
  - *Yield, OAS, Duration, Convexity*
- Irrational expectations
  - *Forecasts will be correct, future can be predicted*
- Framing Effect (Prospect Theory)
  - *Particular decisions made depending on how they are presented: Gains vs Losses*

Rationality of Individuals
3 Limitations:

Cognitive Constraints

- Understand the tools in your toolkit.
  - *Focus on the Risk and Reward parameters that meet your needs and "satisfice" your decision*
  - *Make the process work for you and never stop learning!*
  - *Offerings Manager example*

"It's frightening to think that you might not know something, but more frightening to think that, by and large, the world is run by people who have faith that they know exactly what's going on."

-Amos Tversky

YIELD (Internal Rate of Return)

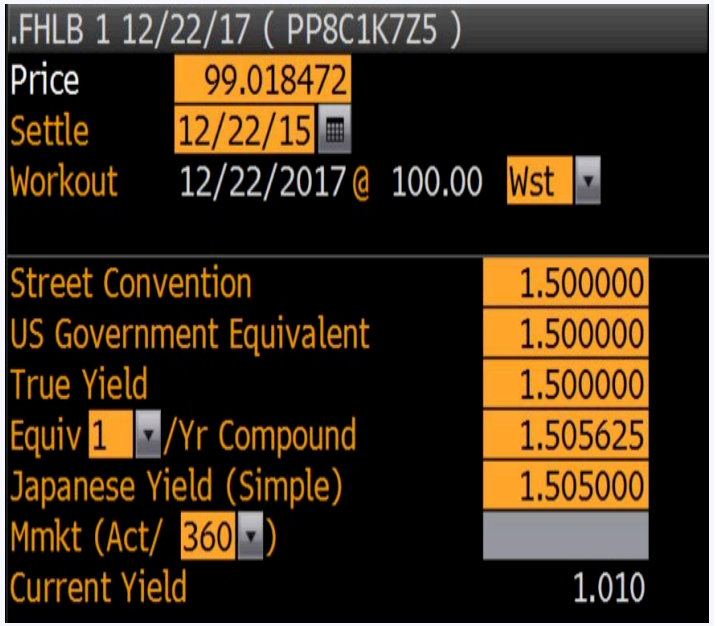
- Yield is the interest rate that will make the present value of the cash flows equal to the price of the bond.
- Yield accounts for both the income received and capital gain or loss that occurs until the point of redemption (YTC/YTM/YTW)
- Assumes that the coupon is reinvested at the stated yield (time value of money concept of compounding).
- Since yield uses a discounted cash flow calculation, the timing of the cash flows are also considered.

**2.00Yr Semi-Annual Pay using YA Function*

Maturity (Yrs)	CPN	YTM	PAR
2	1.00%	1.50%	$1,000,000

Period	Cash Flow	PV Factor 1/(1+y)^n	PV Cash Flow (CF * PV Factor)
1	$5,000.00	0.992555831	$4,962.78
2	$5,000.00	0.985167078	$4,925.84
3	$5,000.00	0.977833328	$4,889.17
4	$1,005,000.00	0.970554172	$975,406.94

Bond Value (Sum PV Cash Flow)	Bond Price (Bond Value / Par Value)
$990,184.72	99.018



YIELD (Internal Rate of Return)

- Yield has an implicit reinvestment assumption that makes the yield achievable only if the coupons are reinvested at that yield.

Future Value of 2Yr Bond

FV Annuity Formula for calculating FV of Coupon Payments @ 1.50%/2

Par Value received at Maturity

Future Value of Compounded Cash Flows

Actual Cash Flows

Reinvestment Income at 1.50%

$$5{,}000\left[\frac{(1.00750)^4 - 1}{.00750}\right] = \$20{,}226.127 + \$1{,}000{,}000.00 = \$1{,}020{,}226.127 - \$1{,}020{,}000.00 = \$226.127$$

Present Value of 2Yr Bond

$5,113.346 + $5,075.281 + $5,037.50 + $1,005,000 = $1,020,226.127

1) Pay $4,962.78 to receive $5,000 in 6 Months. That $5,000 reinvested for 3 periods:
$5000(1.0075)^3= **$5,113.346**

2) Pay $4,925.84 to receive $5,000 in 12 Months. That $5,000 reinvested for 2 periods:
$5000(1.0075)2= **$5,075.281**

3) Pay $4,889.17 to receive $5,000 in 18 Months. That $5,000 reinvested for 1 period:
$5000(1.0075) = **$5,037.50**

4) Pay $975,406.94 to receive **$1,005,000** in 24 Months (at maturity)

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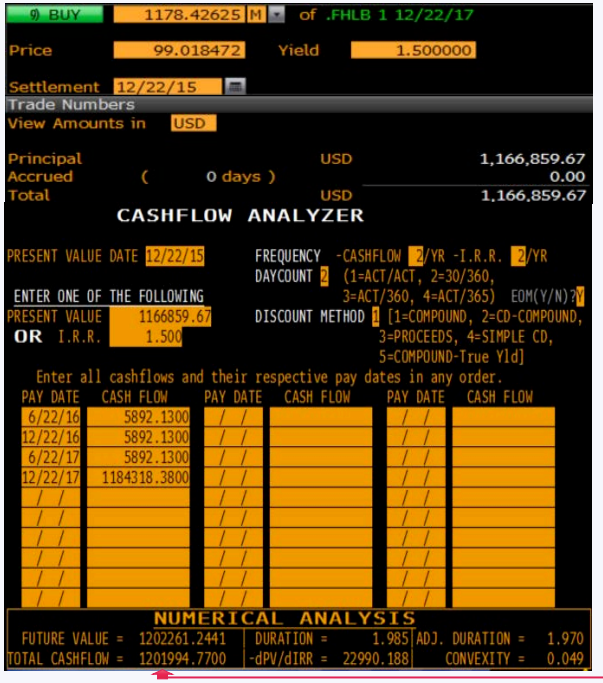
YIELD (Internal Rate of Return)

- Reinvestment Effect Scenario Setup: $1,166,859.69 to spend and can choose between 2 bonds (PF function in Bloomberg)

Buy 1,178.42M in a 2Yr, 1.00% Bullet @ 99.0184; YTM=1.50%



*Same total dollars invested on 12/22/15 at 1.50% YTM

*Total Future Value is the same $1,202,261

*However, the Total Cash Flow is greater with the 1.00% Bullet ($1,201,994.77 vs $1,200,000.00)

Source of Dollar Return

Cpn Interest	= $23,568.52
Int-on-Int	= $266.47
Capital Gain	= $11,566.58
Total	= $35,401.57

Future Value - Initial Investment

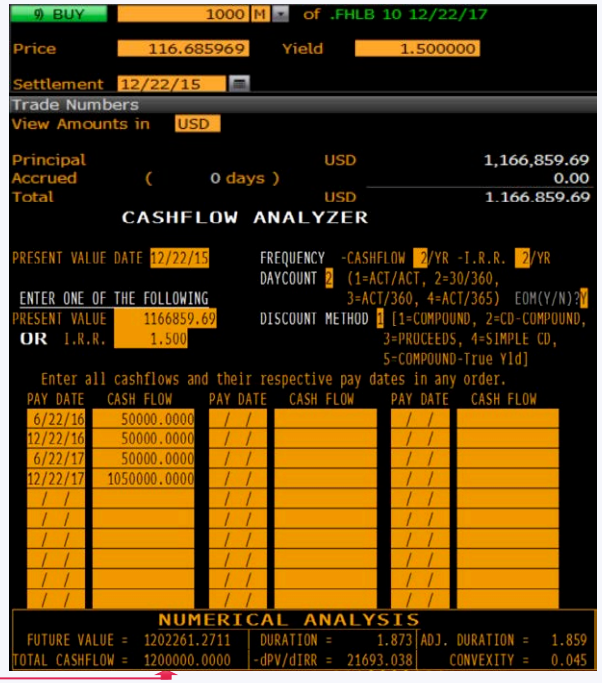
Cpn Interest	= $200,000.00
Int-on-Int	= $2,261.27
Capital Loss	= $166,859.69
Total	= $35,401.58

Future Value - Initial Investment

Interest-on-Interest Variance = Actual Cash Flow Variance

$2,261.27 – 266.47 = $1,994.77

Buy 1,000M in a 2Yr, 10.00% Bullet @ 116.6859; YTM=1.50%



YIELD (Internal Rate of Return)

- Dollar Return is sensitive to the structure of the bond!
  - Holding yield and coupon rate constant, the longer the maturity, the more the Int-on-Int component matters.
  - Holding yield and maturity constant, the higher the coupon, the more the Int-on-Int component matters (thus premiums have higher dependence on the Int-on-Int component than par or discount bonds.

- Yield does not tell the whole story
  - Actual Cash Flows may differ depending on interest-on-interest component.
  - When coupon reinvestment not likely (Public Funds!), understand the tradeoffs between structures.
    - In the real world, higher yields may be present to compensate for the premium being paid and Int-on-Int offset in a similar structure.

YIELD (Internal Rate of Return)

Street Convention: The yield calculated according to conventions used in the market the bond was issued in. Assumes payments are made on scheduled days regardless of weekends or holidays. Street Convention uses compounding based on number of times the bond pays per year (Annual = 1, Semi-Annual = 2, Quarterly = 4, Monthly = 12) and the day count convention specified for that market.

US Government Equivalent: The yield calculated on a Semi-Annual basis using Actual/Actual day count convention.

True Yield: Uses the Street Convention method but adjusts for weekends and holidays. True Yield is always equal to or slightly lower then Street Convention yield as weekends and holidays delay payment.

**1.98Yr Semi-Annual Pay*

YIELD (Internal Rate of Return)

***Equiv#/Yr Compound**:* For comparison, we can use periodicity conversions to convert different compounding bonds to a standardized yield. This is useful when trying to compare multiple offerings with different frequency of payments.

1) For bonds with compounding other than semi-annual, we can use the "Equiv#/Yr" compounding with "2" selected to convert our annual, quarterly, bi-monthly or monthly pay bond yields to the more common semi-annual pay bond yield. This is known as converting to a Bond-Equivalent Yield.
2) For bonds with semi-annual compounding, we can use the "Equiv#/Yr" compounding with 1,4,6 or 12 to convert our Bond-Equivalent Yield to annual, quarterly, bi-monthly or monthly pay bond yields.

**1.98Yr Semi-Annual Pay converted to Quarterly*

Same equivalent yields still create price differentials. CF timing matters!!

**1.98Yr Quarterly Pay converted to Semi-Annual (BEY)*

YIELD (Internal Rate of Return)

Japanese Yield (Simple): Using the simple interest basis, the effects of compound interest are ignored. Simple yield is the annualized cash flow as a percent of the original flat price. It is the sum of the coupon payments plus the straight-line amortized share of the gain or loss, divided by the flat price. Simple yields are used mostly to quote Japanese government bonds, known as "JGBs."

Annual Coupon

Par Price – Clean Price

Time to Maturity (Act/365)
= 725/365

$$\frac{1.00 + \left[\frac{(100 - 99.123282)}{1.98630137}\right]}{99.123282} = 0.0145413$$

Clean Price

**1.98Yr Semi-Annual Pay*

*Slight difference due to rounding

YIELD (Internal Rate of Return)

Mmkt Yield not calculated for bonds with time to redemption beyond two years (To Worst).

Mmkt (Act/#): The money market equivalent yield that equates a periodic coupon-paying security to a security that pays interest at maturity. Each cash flow is compounded from its coupon payment date to the next payment date, and so on until the last payment date. The total is present valued back to the present date via simple interest. An ACT/360 day type is typically used.

FV Annuity Formula for calculating FV of Coupon Payments @ 1.45%/2

Par Value received at Maturity

$$5{,}000\left[\frac{(1.00725)^4 - 1}{.00725}\right] = \$20{,}218.553 + \$1{,}000{,}000.00 = \$1{,}020{,}218.553$$

Calculate Holding Period Yield

$$\left[\frac{\$1{,}020{,}218.553}{\$991{,}399.49}\right] - 1 = .029069$$

Actual days between settlement and maturity / 360 day year

$$\frac{.029069}{(725/360)}$$

*1.98Yr Semi-Annual Pay

*Slight difference due to numerator rounding

Total paid to purchase including accrued interest (Dirty Price)

YIELD (Internal Rate of Return)

Current Yield: The current yield is the sum of the coupon payments received over the year divided by the clean price. The current yield is a crude measure of the rate of return to an investor because it neglects the frequency of coupon payments in the numerator and any accrued interest in the denominator. It focuses only on interest income. (similar to Dividend Yield in equities).

Annual Coupon

$$\left[\frac{1.00}{99.123282}\right] = 0.0100884$$

Clean Price

**1.98Yr Semi-Annual Pay*

*Slight difference due to rounding

YIELD (Internal Rate of Return)

Conventions:

-Yield to Maturity (YTM)

*Assumes cash flows exist through the maturity date.

-Yield to Call (YTC)

*Assumes cash flows exist through the next call date.

-Yield to Worst (YTW)

*Assumes cash flows exist to the point where the lowest obtainable yield is achieved.

Structure Type	Pricing to Par	Yield to Worst
Fixed Rate Clb	Par	YTM/YTC
Fixed Rate Clb	Discount	YTM
Fixed Rate Clb	Premium	YTC
Step Up/Down Clb	Par	YTC (Step Up), YTM (Step Down)
Step Up/Down Clb	Discount	Varies (Step Up), YTM (Step Down)
Step Up/Down Clb	Premium	YTC(Step Up), Varies (Step Down)

*2.00Yr 1.00% Fixed Callable @ Par

*2.00Yr 1.00% Fixed Callable @ Discount

*2.00Yr 1.00% Fixed Callable @ Premium

YIELD (Internal Rate of Return)

Step-Up Yield Analysis

Yield to Call
Yield to Maturity
Yield to Worst

Settlment Date	12/29/15
Maturity Date	12/29/17
Structure	2NC3Mo-DqSU
Frequency	Semi-Annual
Callable Lockout	3 Month
Par Amount	$1,000,000.00
Bond Price	99.9
Coupon Schedule	0.75 to 06/29/16 1.00 to 12/29/16 1.25 to 06/29/17 1.50 to 12/29/17

Date	CallDt1	CallDt2	CallDt3	CallDt4	CallDt5	CallDt6	CallDt7	Maturity
12/29/15	-$999,000.00	-$999,000.00	-$999,000.00	-$999,000.00	-$999,000.00	-$999,000.00	-$999,000.00	-$999,000.00
3/29/16	$1,001,875.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
6/29/16		$1,003,750.00	$3,750.00	$3,750.00	$3,750.00	$3,750.00	$3,750.00	$3,750.00
9/29/16			$1,002,500.00	$0.00	$0.00	$0.00	$0.00	$0.00
12/29/16				$1,005,000.00	$5,000.00	$5,000.00	$5,000.00	$5,000.00
3/29/17					$1,003,125.00	$0.00	$0.00	$0.00
6/29/17						$1,006,250.00	$6,250.00	$6,250.00
9/29/17							$1,003,750.00	$0.00
12/29/17								$1,007,500.00

	Date	Cpn Date	Cpn Accrual	Call Accrual	Cash Flow	Cumulative CF	XIRR
CallDt1	3/29/16	No	0.75%	0.1875%	$1,875.00	Cash Flow 1=$1,001,875.00	1.151%
CallDt2	6/29/16	Yes	0.75%	0.3750%	**$3,750.00**	**Cash Flow 1=$1,003,750.00**	**0.950%**
CallDt3	9/29/16	No	1.00%	0.2500%	$2,500.00	Cash Flow 1=$3,750.00 Cash Flow 2=$1,002,500.00	0.967%
CallDt4	12/29/16	Yes	1.00%	0.5000%	**$5,000.00**	**Cash Flow 1=$3,750.00** **Cash Flow 2=$1,005,000.00**	**0.974%**
CallDt5	3/29/17	No	1.25%	0.3125%	$3,125.00	Cash Flow 1=$3,750.00 Cash Flow 2=$5,000.00 Cash Flow 3=$1,003,125.00	1.029%
CallDt6	6/29/17	Yes	1.25%	0.6250%	**$6,250.00**	**Cash Flow 1=$3,750.00** **Cash Flow 2=$5,000.00** **Cash Flow 3=$1,006,250.00**	**1.065%**
CallDt7	9/29/17	No	1.50%	0.3750%	$3,750.00	Cash Flow 1=$3,750.00 Cash Flow 2=$5,000.00 Cash Flow 3=$6,250.00 Cash Flow 4=$1,003,750.00	1.127%
Maturity	12/29/17	Yes	1.50%	0.7500%	**$7,500.00**	**Cash Flow 1=$3,750.00** **Cash Flow 2=$5,000.00** **Cash Flow 3=$6,250.00** **Cash Flow 4=$1,007,500.00**	**1.172%**

Settlement Date 12/29/15 Price 99.9 Blend Fu

YTC (3134G8EW5)	Date	Price	Yield
Yield to Maturity	12/29/2017	100.00	1.173907
Yield to Custom	06/29/2016	100.00	0.950951
Yield to Next Call	03/29/2016	100.00	1.151151
Yield to Worst Call	06/29/2016	100.00	0.950951

May be called quarterly starting 03/29/2016

Date	Price	Yield
03/29/16	100.0000	1.1512
*06/29/16	100.0000	0.9510
09/29/16	100.0000	0.9677
*12/29/16	100.0000	0.9754
03/29/17	100.0000	1.0304
*06/29/17	100.0000	1.0665
09/29/17	100.0000	1.1282
*12/29/17	100.0000	1.1739

YIELD (Internal Rate of Return)

Bond Return Sources:

1) Periodic interest payments made via coupon payments (non-zero bonds)
2) Capital gain/loss at redemption (matured, called or sold)
3) Interest-on-interest from coupon reinvestment (at yield rate)

Yield drawbacks:

- Yield accounts for all three sources of return, however it assumes that coupons can be reinvested at quoted yield ("promised yield"). Higher coupon and longer maturity bonds derive more dollar return from Int-on-Int component.
- Yield does not depend on par amount, thus can be manipulated (e.g. using weighted average portfolio yield and separating cash from the equation).
- Yield encompasses all the risk inherent in the bond (interest rate, credit, liquidity, reinvestment risk).
- From a portfolio perspective, Yield is dependent on duration of assets and stability over budget cycle.

Premiums vs Discounts
There are tradeoffs!
-Premiums increase coupon cash flow but create higher up front costs, amortization requirements, and possibly higher int-on-int which can lower actual total cash flow.
-Discounts decrease coupon cash flow but require less capital up front and still require accretion. Current income is lower!

**For income oriented investors, discounts can hurt! When current cash flow is key, par or slight premiums may make more sense.*

Total Return

- Total Return is the actual rate of return of an investment over a given evaluation period. Total Return includes interest, capital gains and losses and distributions realized over a given period of time.
- Total Return is a widely adopted measure of yield that overcomes the shortfalls of reinvestment assumptions at the stated YTW,YTC or YTM.
- Total Return simply calculates the total of actual dollars received via coupon payments, int-on-int and capital gains/losses and divides it by the price paid.
- To account for not reinvesting the coupon payments, we can simply remove the int-on-int component from the equation.

Holding Period Return (HPR)

$$\left[\frac{\text{Ending Mkt Value + Cpn Int + Int-on-Int}}{\text{Beg Mkt Value}}\right] - 1$$

Annualized Total Return: (n = # of compounding units)

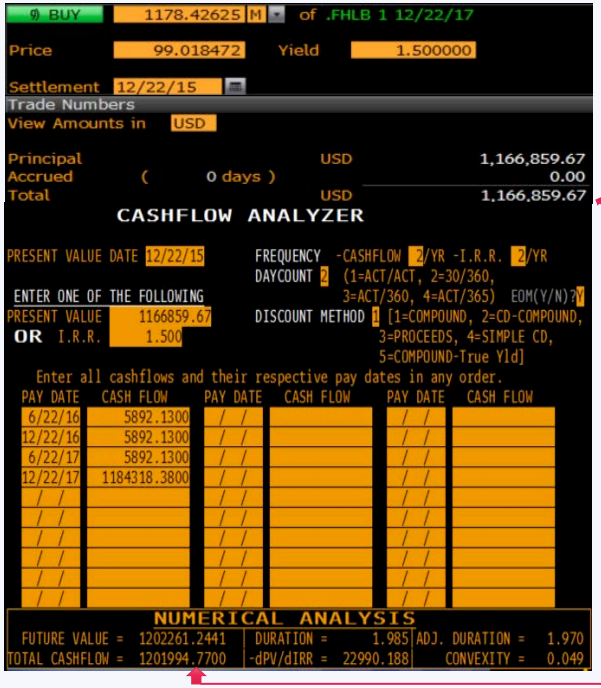
$$(1+\text{HPR})^{1/n} - 1$$

- Like Periodicity conversions we saw in Yield calculations, we can also apply Periodicity conversions to Total Return to keep the output on the same compounding units as the Yield (e.g. For a 2 year, semi-annual pay bond, we use n=4 to make the total return on a Bond Equivalent basis.

Total Return

Total Return Scenario: Using the previous 2 year bonds, we now calculate Total Return without assuming reinvestment of coupons.

Buy 1,178.42M in a 2Yr, 1.00% Bullet @ 99.0184; YTM=1.50%



Holding Period Return (HPR)

Annualized Total Return: (n = # of compounding units)

$$\left[\frac{\text{Ending Mkt Value + Cpn Int + Int-on-Int}}{\text{Beg Mkt Value}}\right] - 1 \quad \Rightarrow \quad (1+\text{HPR})^{1/n} - 1$$

Annual Compounding (Bloomberg Default on HZ2)

$$\left[\frac{1{,}201{,}994.77}{1{,}166{,}859.67}\right] - 1 = .03011 \quad \Rightarrow \quad (1+.03011)^{1/2} - 1 = 1.494\%$$

Semi-Annual Compounding (Bond Equivalent Total Return)

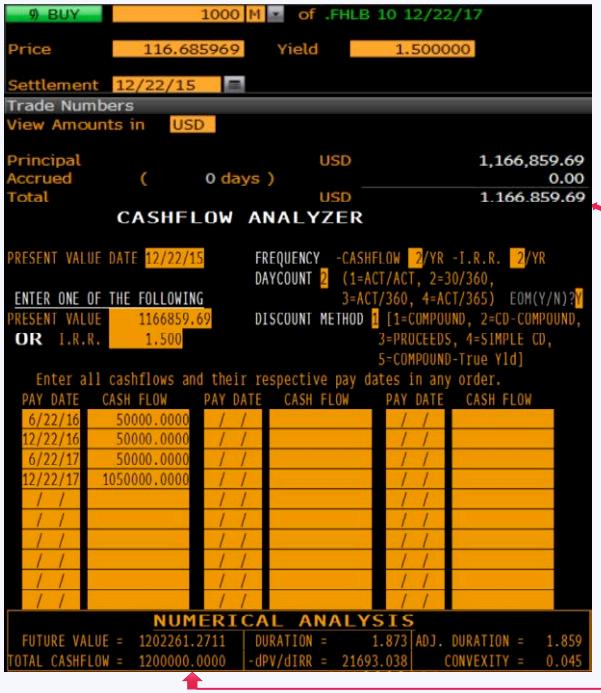
$$\left[\frac{1{,}201{,}994.77}{1{,}166{,}859.67}\right] - 1 = .03011 \quad \Rightarrow \quad (1+.03011)^{1/4} - 1 = 0.744\% \times 2 = 1.489\%$$

Yield Type	Return	Variance to YTM
Yield to Maturity	1.500%	0.00%
Annualized Total Return (Compounded Per Year)	1.494%	0.006% (0.6 Bp)
Annualized Total Return (Compounded Twice Per Year)	1.489%	0.011% (1.1 Bp)

Total Return

Total Return Scenario: Using the previous 2 year bonds, we now calculate Total Return without assuming reinvestment of coupons.

Buy 1,000M in a 2Yr, 10.00% Bullet @ 116.6859; YTM=1.50%



Holding Period Return (HPR)

Annualized Total Return: (n = # of compounding units)

$$\left[\frac{\text{Ending Mkt Value + Cpn Int + Int-on-Int}}{\text{Beg Mkt Value}}\right] - 1 \quad \Rightarrow \quad (1+\text{HPR})^{1/n} - 1$$

Annual Compounding (Bloomberg Default on HZ2)

$$\left[\frac{1{,}200{,}000.00}{1{,}166{,}859.69}\right] - 1 = .02840 \quad \Rightarrow \quad (1+.02840)^{1/2} - 1 = 1.410\%$$

Semi-Annual Compounding (Bond Equivalent Total Return)

$$\left[\frac{1{,}200{,}000.00}{1{,}166{,}859.69}\right] - 1 = .02840 \quad \Rightarrow \quad (1+.02840)^{1/4} - 1 = 0.7025\% \times 2 = 1.405\%$$

Yield Type	Return	Variance to YTM
Yield to Maturity	1.500%	0.00%
Annualized Total Return (Compounded Per Year)	1.410%	0.09% (9.0 Bp)
Annualized Total Return (Compounded Twice Per Year)	1.405%	0.095% (9.5 Bp)

Total Return

- Total Return can be useful when evaluating actual rates of return at different reinvestment rates and redemption periods prospectively (forward-looking).
- Total Return can also be useful when analyzing historical volatility of returns and as a component of Risk/Reward output.

HOWEVER!!

- The use of Total Return for Public Funds for performance measurement should be limited, if used at all!
  - Total Return is not necessarily reflective of good stewardship. By definition, Total Return can be negative and may not reflect the objectives of income oriented investors.
  - Public Funds do not budget gains and losses, thus measuring performance with equal weighting on capital changes does not make sense. Total Return implies investors are equally happy with a dollar gained in principal as they are a dollar earned through income (coupon payment).
  - Total Return calculations can be logistically and quantitatively difficult to implement without resources (portfolio valuations required consistently, possibly even daily).
  - Total Return is not required under GASB guidelines.
  - Fiduciary Benchmarks that focus on all objectives and hold return secondary to safety and liquidity are most appropriate when evaluating performance.

Spread Measures: Yield Spread

- Yield Spread is simply the difference in basis points between the selected benchmark (e.g. maturity/duration matched Treasury) and non-benchmark security.
- It is the potential compensation for accepting the risks of a security relative to that of the selected benchmark.
- These risks can include:
  - Interest Rate Risk
  - Credit Risk
  - Liquidity Risk
  - Reinvestment Risk
- Example:
  - 3 Year Agy Callable: Yield = 1.50%
  - 3 Year Agy Bullet: Yield = 1.35%
  - 3 Year US Treasury: Yield = 1.28%
    - Callable Yield Spread = 22 Basis Points
    - Bullet Yield Spread = 7 Basis Points

Drawbacks:

1) For both bonds, yield spread fails to consider yield curve or spot rate curve (only considers single point).

2) For callables, expected interest rate volatility may alter expected cash flows.

Spread Measures: Zero-Volatility Spread (Z-Spread)

- Z-Spread is the spread that makes the present value of cash flows discounted at the Treasury spot rate plus the spread equal to the bond's price (iterative process).
- Z-Spread is a measure of the spread the investor realizes over the entire Treasury spot rate curve if the bond is held to maturity.
- It is not a spread off of a single point on the Treasury curve like Nominal Spread.
- This measure overcomes the first drawback of traditional Nominal Spread measurement (failure to recognize entire yield/spot curve).

Coupon Payment

Par Received + Coupon

$$PV=\left[\frac{.675}{(1+(.00443/2)+.000669)^{1}}\right]\cdots\left[\frac{100+.675}{(1+(.01285/2)+.000669)^{6}}\right]$$

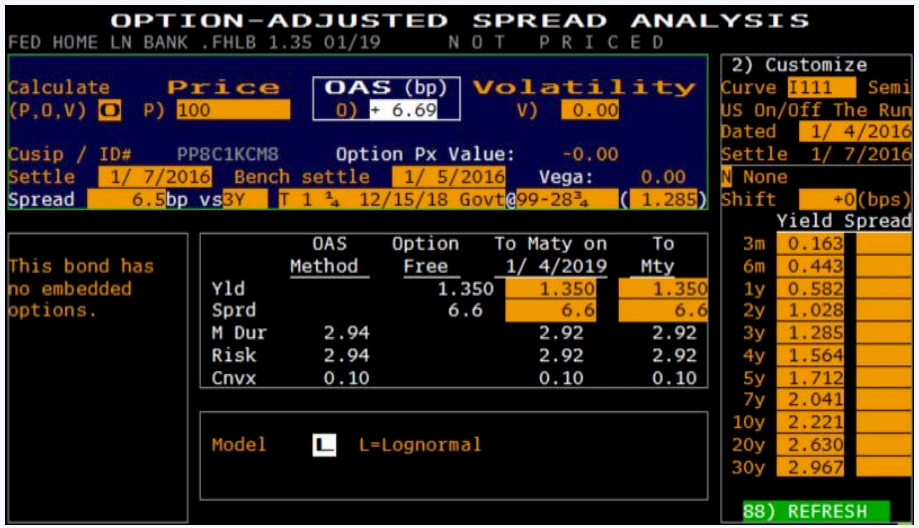
Treasury Spot Rate / 2

Z-Spread (Solved iteratively)

**Z-Spread for an option-free bond is simply its OAS at zero Volatility.*

**Slight differences occur due to actual spot rates used and curve interpolation used by Bloomberg.*

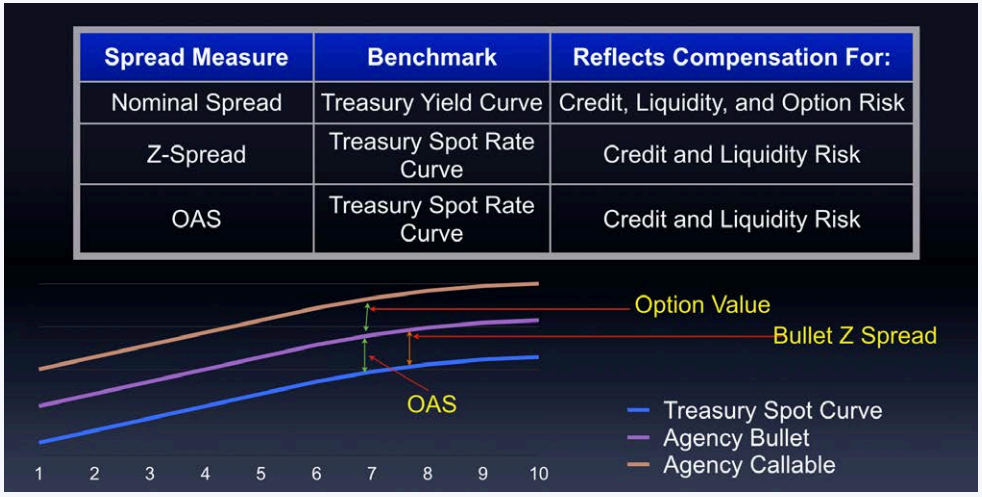
**3.00Yr 1.35% Fixed Bullet @ Par*



Spread Measures: Option Adjusted Spread (OAS)

- OAS is the constant spread that, when added to the spot rates on the binomial interest rate tree, will cause the market price of a bond to equal the present value of its cash flows.
- OAS takes Z-Spread one step further by realizing callable bonds have cash flows with uncertainty. In other words, we aren't guaranteed callable bonds won't be called away at some point in the future.
- By utilizing option models to evaluate characteristics of the embedded options, we create a spread measure that allows us to evaluate the option value (model specific), subtract it from the equation, and compare the spread to other callable and non-callable bonds (this is why it is also sometimes referred to as the "Option Removed Spread").

Spread Measure	Benchmark	Reflects Compensation For:
Nominal Spread	Treasury Yield Curve	Credit, Liquidity, and Option Risk
Z-Spread	Treasury Spot Rate Curve	Credit and Liquidity Risk
OAS	Treasury Spot Rate Curve	Credit and Liquidity Risk



Spread Measures: Option Adjusted Spread (OAS)

Measuring Option Value

- Total option value is derived from two sources:
  - **Intrinsic Value** = Value of the option if we were to exercise it today (if it could be exercised).
    - *Ex// Suppose an issuer can buy back a bond today at a market price of 100.10, or they can exercise an option and buy the bond back for 100.00. This means the option has "intrinsic value" of $1.00 to the issuer holding the call option (remember as the investor, you have essentially sold a call option(s) to the issuer).*
  - **Time Value** = Value of the option derived from expected profitability of exercising the option on a future date. Time Value is measured using complex option models with various inputs to derive the dollar value associated with holding it.

**Almost all callable bonds investors analyze obtain their value from Time Value. This is because investors do not typically buy callable bonds that are already in the money and exercisable. Investors typically own callable bonds that are either still between call dates or "at-the-money" / "out-of-the-money."*

Spread Measures: Option Adjusted Spread (OAS)

Time Value – Basic Process (Binomial model)

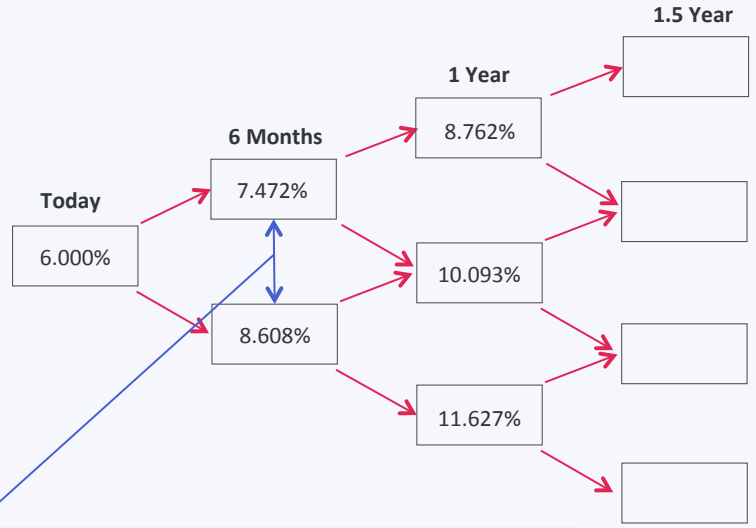
- The Binomial Model evaluates return of a bond by measuring the extent to which its return exceeds the returns described by the risk-free short rates in the tree.
- The difference between these returns is expressed as a spread and is viewed as the incremental return of a bond at a given price. The determination of the spread involved four steps:
    1. Binomial model used to generate a model predicted price for the bond.
    2. Model predicted price is compared to bond's observed price.
    3. If the prices are different, the rates in the binomial tree are tweaked by some uniform amount.
    4. Prices are now compared again (steps 3 and 4 repeated until prices match).

Spread Measures: Option Adjusted Spread (OAS)

Basic Process – Binomial Model

Years to Maturity	Observed Benchmark Yield	Implied Spot Rate	Implied 6-Month Forward Spot Rate
0.5 Yr	6.000%	6.000%	6.000%
1.0 Yr	7.000%	7.018%	8.04%
1.5 Yr	8.000%	8.054%	10.144%
2.0 Yr	9.000%	9.117%	12.338%

Implied Forward Spot Rates @ 10% Volatility on 1.5Yr Bond



Percent volatility of short rate calculation creates a range based off of the implied 6-month forward spot rate. The higher the volatility, the bigger the range.

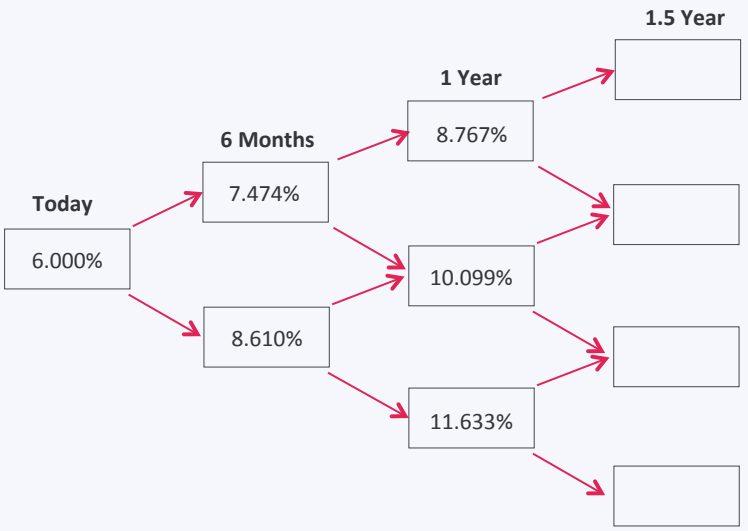
- In this example, a 10% volatility factor creates a high range outcome that is approximately 1.15x greater than the short range outcome.

Spread Measures: Option Adjusted Spread (OAS)

Basic Process – Binomial Model

Implied Forward Spot Rates @ 10% Volatility on 1.5Yr Treasury

"Calibrated" Implied Forward Spot Rates @ 10% Volatility on 1.5Yr Treasury



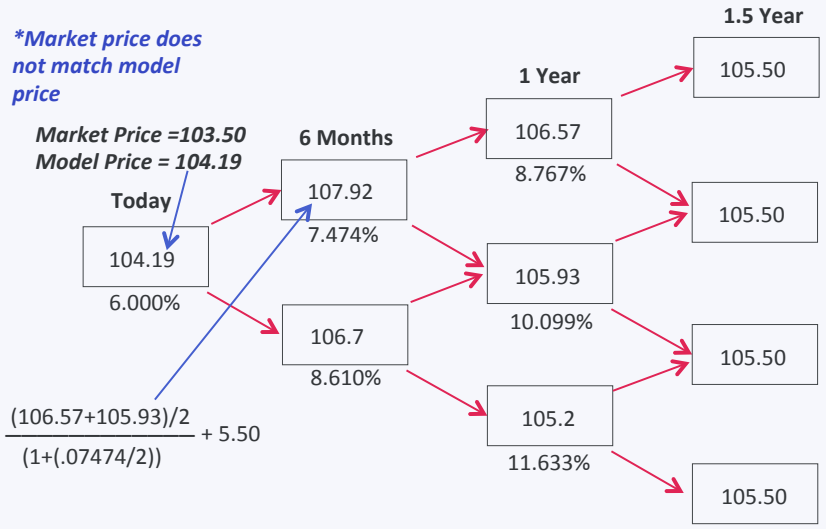
- When Yield Volatility increases, interest rate tree becomes more dispersed.
- Greater probability exists that values at future nodes will be higher than the call price.
- The higher probability of option being exercised makes these options more valuable (decreases value of callable bond).

Calibration tweaks the range of short rate outcomes to ensure the rates make the model-predicted price equal to the observed market price of a benchmark (Treasury) bond.

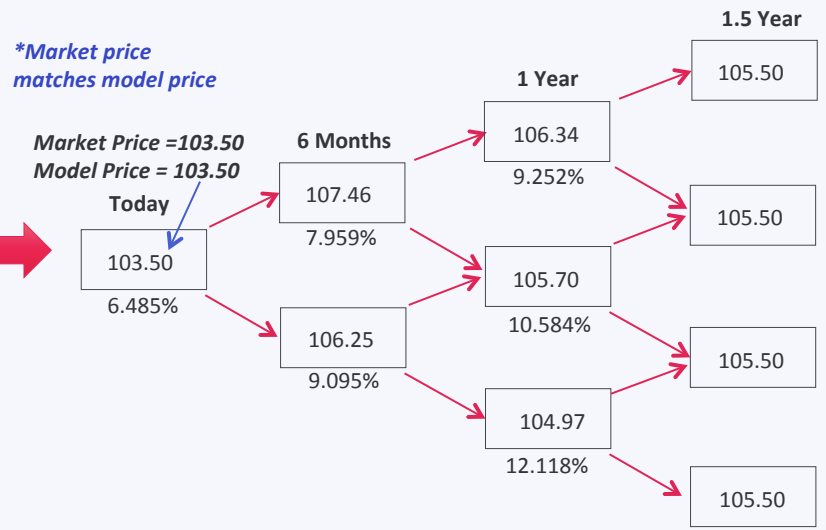
Spread Measures: Option Adjusted Spread (OAS)

Basic Process – Binomial Model

1.5Yr bullet bond paying 11% coupon semi-annually using calibrated rates @ 10% volatility



1.5Yr bullet bond paying 11% coupon semi-annually using calibrated rates AND *48.5bp spread @ 10% volatility



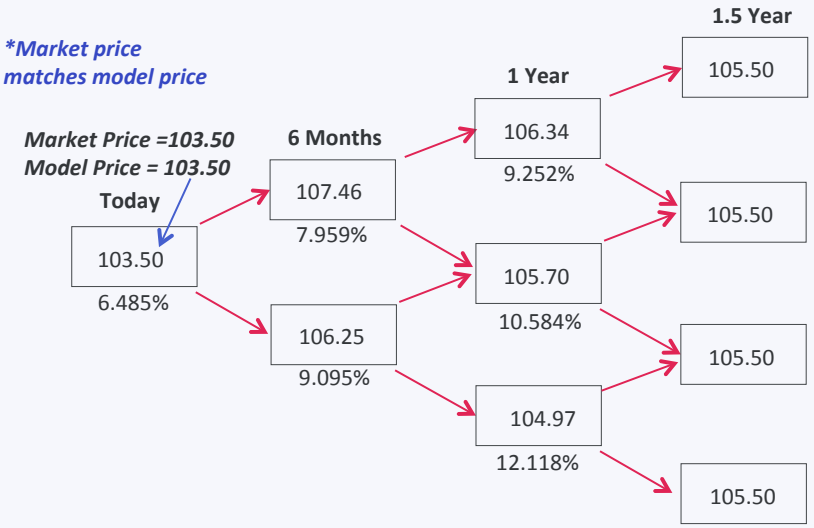
*48.5Bp spread was found using an iterative process and added as a constant spread to every node in the tree. This spread is what makes the model-predicted price equal to the observed market price.

*Each node is calculated as the present value of remaining cash flow to be received + current cash flow received at node + present value of receiving par and the final coupon payment.

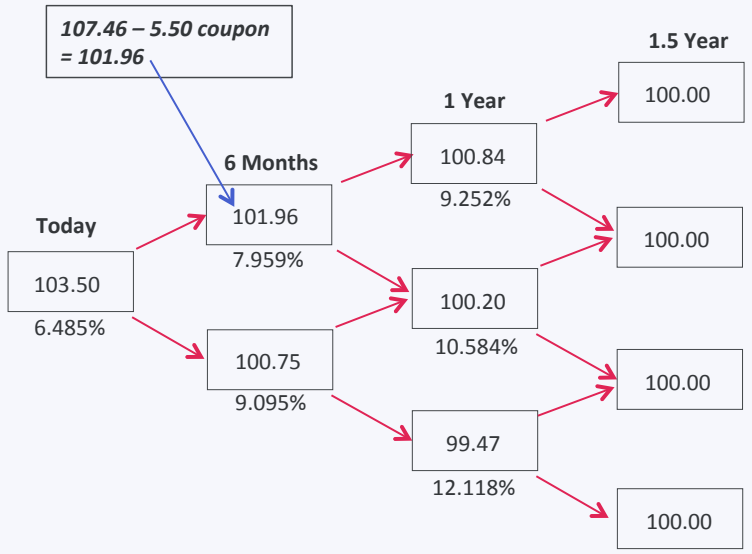
Spread Measures: Option Adjusted Spread (OAS)

Basic Process – Binomial Model

1.5Yr bullet bond paying 11% coupon semi-annually using calibrated rates AND 48.5bp spread @ 10% volatility



1.5Yr bullet bond paying 11% coupon semi-annually using calibrated rates AND 48.5bp spread @ 10% volatility CONVERTED to CLEAN PRICE

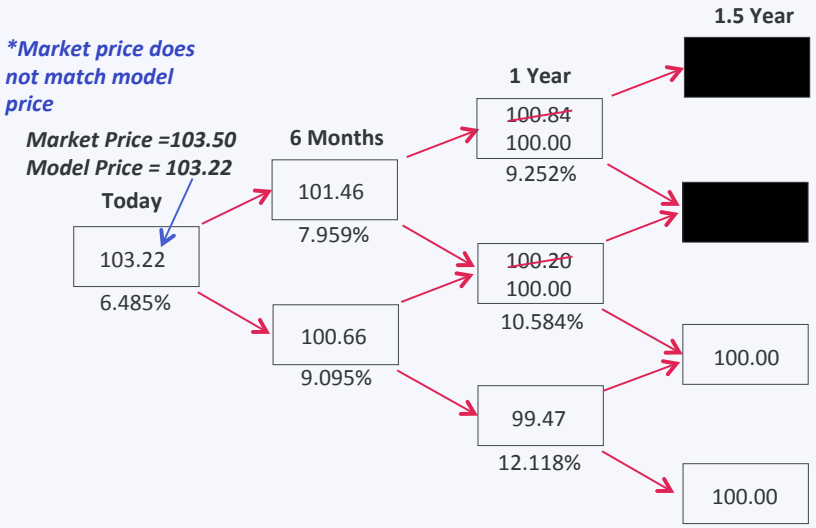


Because each node contains the value of the dollars received in that period (except for today's), we have to subtract those dollars from each node after today to quote the clean price of the bond. As we build a tree for the callable bond, this will tell us if a call is exercised using the market convention of clean price.

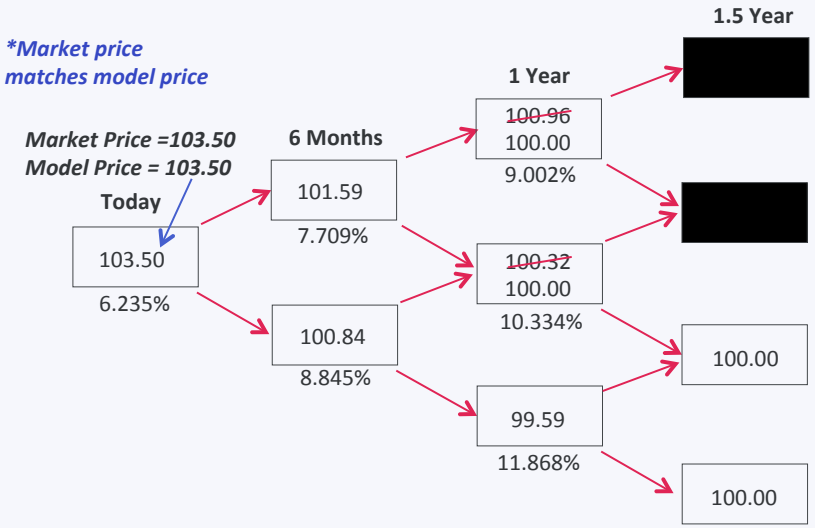
Spread Measures: Option Adjusted Spread (OAS)

Basic Process – Binomial Model

Callable 1.5Yr bond paying 11% coupon semi-annually using calibrated rates AND 48.5bp spread @ 10% volatility (callable one time in one year)



*Callable 1.5Yr bond paying 11% coupon semi-annually using calibrated rates AND *23.5bp spread @ 10% volatility (callable one time in one year)*

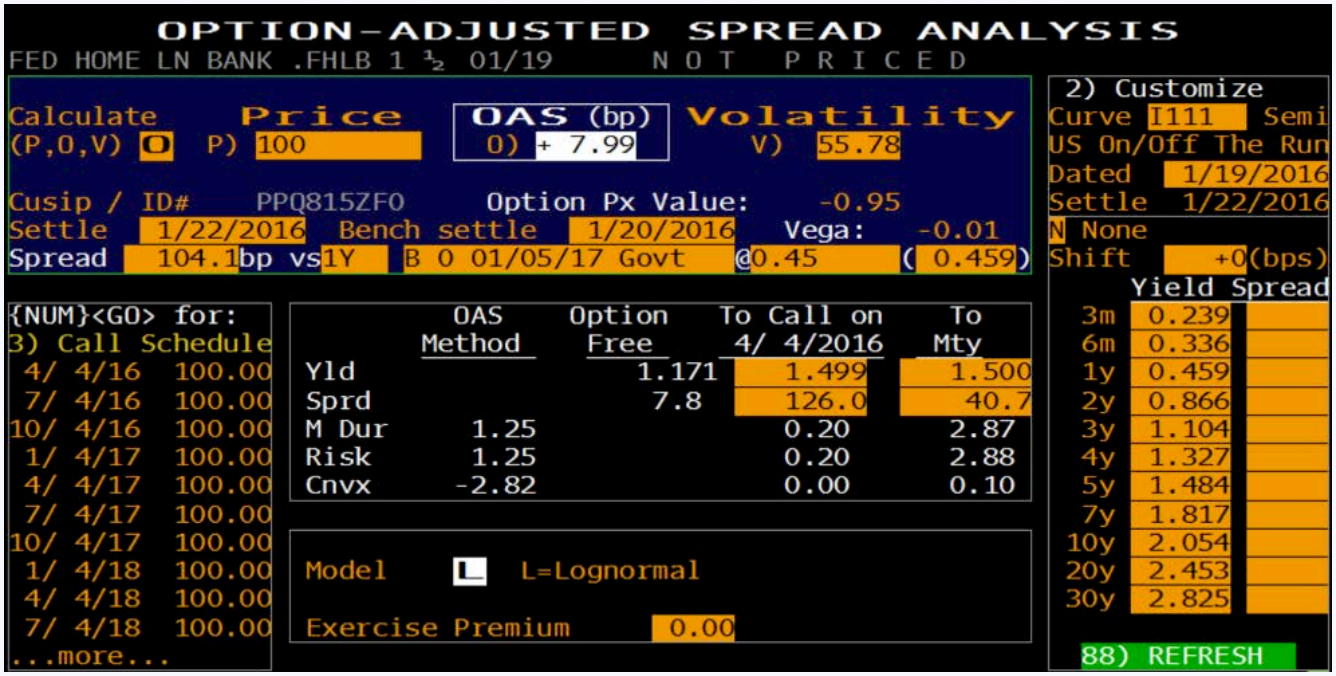


*Remember each node still includes the present value of the coupons to be received, For example, the 6 month lower node would be calculated [(105.5 + 105.5)/2 / (1+(.07959/2))] = 101.46.

*By changing the spread from 48.5bp to 23.5bp (iterative process), we get the model price to match the observed market price. **23.5bp is the OAS.**

Spread Measures: Option Adjusted Spread (OAS)

**3.00Yr 1.50% Fixed Callable, Callable Quarterly After 3 Month Lockout. Priced @ Par*



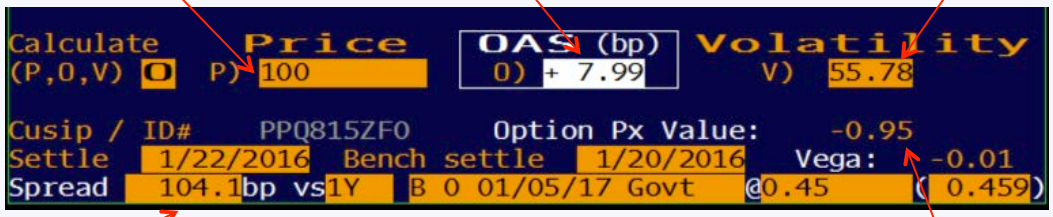
Spread Measures: Option Adjusted Spread (OAS)

Option Adjusted Spread for the bond. This is the constant spread added to every node in the binomial model to make the model predicted price of the bond equal to the market price of 100.00.

The Lognormal model uses the Tullett-Prebon interest rate swaption volatility data set that maps the structure of a bond to an offsetting swaption structure.

- *Ex// 3NC1 uses the one year option on a 2-year swap volatility.*

Bond's market price.



Nominal YTW spread to selected benchmark.

Option value is derived as the dollar difference between the option-free price of the bond (assuming it had the same volatility, short rates, maturity and coupon in the binomial model) and the observed market price of the callable bond. It is expressed in percentage terms.

At -0.95, the compensation for the option to the bond buyer (seller of the option) is $9.50 per bond when the market price is 100.00. This also means the option-free price of the bond is 100.95.

Spread Measures: Option Adjusted Spread (OAS)

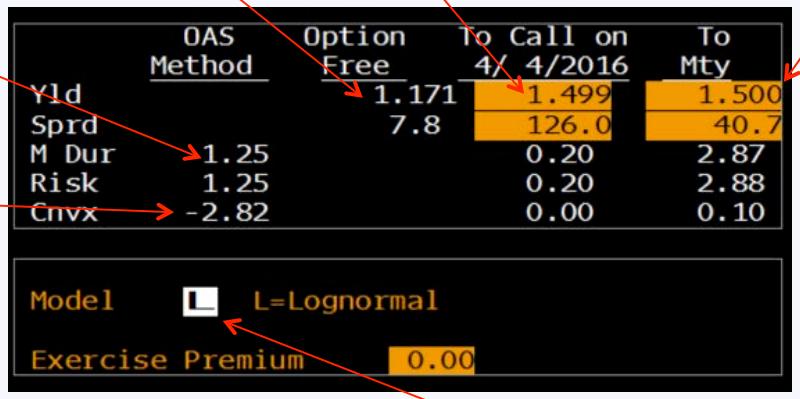
Yield To Maturity if you paid the option free price of the bond (100.95 in this example).

Yield to Call

Yield to Maturity

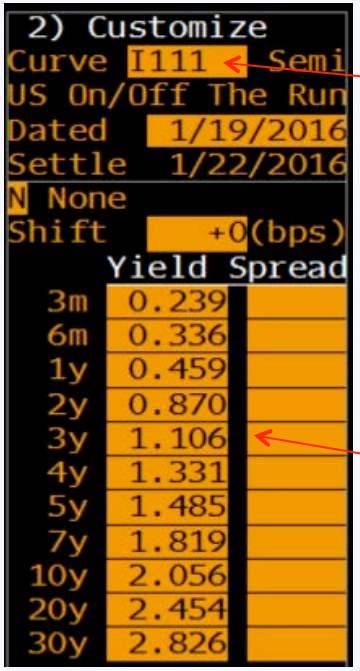
Effective Duration

Effective Convexity



The Lognormal model is the default model on Bloomberg. It also underlies the Bloomberg Fair Value calculations for matrix pricing. The drawback to using the lognormal model is that it uses a single volatility parameter that assumes short rate distribution will grow linearly over time. Each available model description and calculation is available in Bloomberg Help.

Spread Measures: Option Adjusted Spread (OAS)



Curve Selection (i252 and i267 are the default Fannie and Freddie benchmarks for AOAS).

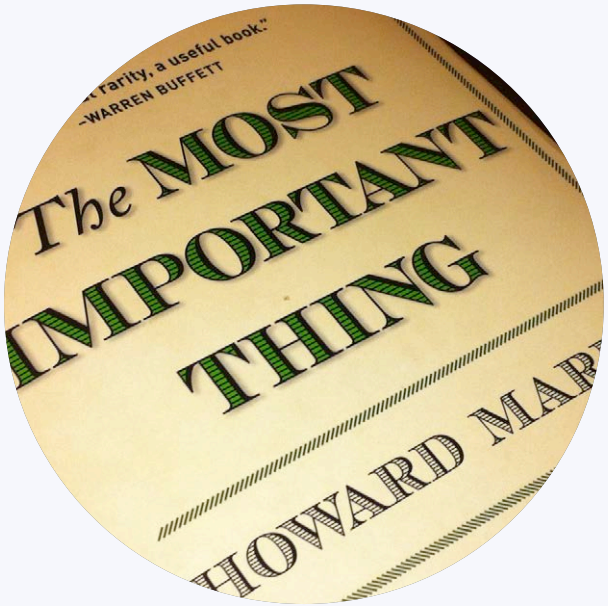
Benchmark yield curve based on curve selection. i111 is the default OTR Treasury curve used in the market. The Benchmark yield curve is converted to the spot rate curve as seen here.

Spread Measures: Discount Margin

- Floating-rate securities adjust periodically, and thus it is not useful to calculate the Yield (adjusted levels are unknown).
- Instead, margin measures are used to estimate value for a floater.
- There are four margin measures that can be applied to floating-rate analysis.
  - Spread for Life
  - Adjusted Simple Margin
  - Adjusted Total Margin
  - Discount Margin

For more information on these 3 measures you can refer to:
Frank J. Fabozzi, Steven V. Mann, *Floating-Rate Securities. (Hoboken,NJ:John Wiley & Sons 2000)*

- The most common is Discount Margin as it estimates the average spread over the reference rate that the investor can expect to earn over the life of the security.
  1) Calculate cash flows assuming reference rates does not change.
  2) Select assumed margin.
  3) Discount the cash flows from first step by reference rate plus assumed margin selected in second step.
  3) Compare present value of cash flows calculated in third step to price. If the present value of the cash flows equals the bond price, the discount margin is equal to the assumed margin selected in step 2.



> "Investing consists of exactly one thing: dealing with the future. And because none of us can know the future with certainty, risk is inescapable. Thus, dealing with risk is an essential—I think the essential—element in investing."

Marks, Howard (2011-04-19). The Most Important Thing: Uncommon Sense for the Thoughtful Investor

RISK: Beyond the Measurements

- Risk means more things can happen then will happen. Much of the risk we take is not directly observable or measureable through statistical or mathematical means:

  Underperforming Expectations
  - Falling short of budgetary estimates of income
    1. Minimal haircut or aggressive projections of income estimates during budgeting process.
    2. Ineffective asset allocation to meet income goals.
    3. Failure to deploy and stay invested appropriately.

  Career Risks
  - Selling at a loss to meet operational liquidity needs
    1. Selling at a loss in the portfolio may cause accusations of liquidity mismanagement and violating the SLI mandate (Safety, Liquidity and Income).
    2. Mark-to-Market (GASB 31) can create impressions of undue risk taking and recognized losses becoming realized headaches. Effective communication is necessary to keep constituents informed and understanding of why losses are an important and necessary part of the investing process (remember…bonds mature!).

RISK: Beyond the Measurements

Career Risks (continued)

- Constituents access to information / confidence in your abilities.
    1. If you are afraid of your own abilities, chances are those around you see it too.
    2. Confidence is much easier to ascertain when the information flow is symmetric.
        - Have a plan, run consistent reports, understand your market, ask questions, leverage your resources!
    3. Arrogance and ignorance are the deadliest combination in investing.

Idiosyncratic / Event Risk

- Specific events can affect individual credits and sectors with little or no ability to measure impact beforehand.
- Example: EMC / DELL Acquisition
    - Solid fundamentals, A1/A Credit and IG 6 Banding.
    - Dell (BB Credit) announces acquisition attempt.
    - EMC volatility spikes, trades through BB credit in anticipation (4+% Yield).
    - Negative watch initiated, Dell on upgrade watch.
    - Fundamentals unchanged.
    - Diversification only tool to mitigate this risk.

RISK: Beyond the Measurements

Systematic Risks

- This risk inherent to the entire market. It is your non-diversifiable, market risk (volatility).
  - Interest rate changes, economic pressures, recessions and expansions, geo-political situations, globalization, integrated markets, etc..
  - Volatility measurements are possible, but are historical in nature.

Credit: Paresh Nath, UAE

RISK: Price / Yield Relationship

Understanding interest rate sensitivity is core to both single security analysis and managing your portfolio as a whole.

- At this point, you should understand the basic price/yield relationship.
  - As interest rates decrease, bond prices increase (holding all else constant).
  - As interest rates increase, bond prices decrease (holding all else constant).

*2 Yr Bullet, Price = **100.00 @ 1.00%***

CUSIP	PP8C1K7Z5	Price Calc:			
Settlement:	12/22/2015	Total Present Value	$1,000,000.00		
Maturity:	12/22/2017	Accrued Interest	$0.00		
YTW Date	12/22/2017	Total Dollar Value	$1,000,000.00		
Par Amount:	1,000,000.00	Price in Convention	100.000		
Yield to Worst	1.00%				
Time Period	Cash Flow Date	Cash Flow	PV Factor	Present Value	Weight
180 Days / 0.50 Years	6/22/2016	5,000.00	0.99502	4,975.12	0.498%
360 Days / 1.00 Years	12/22/2016	5,000.00	0.99007	4,950.37	0.495%
540 Days / 1.50 Years	6/22/2017	5,000.00	0.98515	4,925.74	0.493%
720 Days / 2.00 Years	12/22/2017	1,005,000.00	0.98025	985,148.76	98.515%
	Total	1,020,000.00		1,000,000.00	100.00%

Drop Interest Rates by 50Bp
YTW = 0.50%
*Price increases to **100.994***

CUSIP	PP8C1K7Z5	Price Calc:			
Settlement:	12/22/2015	Total Present Value	$1,009,937.81		
Maturity:	12/22/2017	Accrued Interest	$0.00		
YTW Date	12/22/2017	Total Dollar Value	$1,009,937.81		
Par Amount:	1,000,000.00	Price in Convention	100.994		
Yield to Worst	0.50%				
Time Period	Cash Flow Date	Cash Flow	PV Factor	Present Value	Weight
180 Days / 0.50 Years	6/22/2016	5,000.00	0.99751	4,987.53	0.494%
360 Days / 1.00 Years	12/22/2016	5,000.00	0.99502	4,975.09	0.493%
540 Days / 1.50 Years	6/22/2017	5,000.00	0.99254	4,962.69	0.491%
720 Days / 2.00 Years	12/22/2017	1,005,000.00	0.99006	995,012.50	98.522%
	Total	1,020,000.00		1,009,937.81	100.00%

Increase Interest Rates by 50Bp
YTW = 1.50%
*Price decreases to **99.018***

CUSIP	PP8C1K7Z5	Price Calc:			
Settlement:	12/22/2015	Total Present Value	$990,184.72		
Maturity:	12/22/2017	Accrued Interest	$0.00		
YTW Date	12/22/2017	Total Dollar Value	$990,184.72		
Par Amount:	1,000,000.00	Price in Convention	99.018		
Yield to Worst	1.50%				
Time Period	Cash Flow Date	Cash Flow	PV Factor	Present Value	Weight
180 Days / 0.50 Years	6/22/2016	5,000.00	0.99256	4,962.78	0.501%
360 Days / 1.00 Years	12/22/2016	5,000.00	0.98517	4,925.84	0.497%
540 Days / 1.50 Years	6/22/2017	5,000.00	0.97783	4,889.17	0.494%
720 Days / 2.00 Years	12/22/2017	1,005,000.00	0.97055	975,406.94	98.508%
	Total	1,020,000.00		990,184.72	100.00%

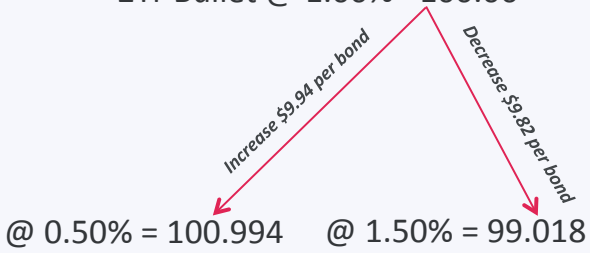
RISK: Price / Yield Relationship

Linkage between bond prices and yields is not linear

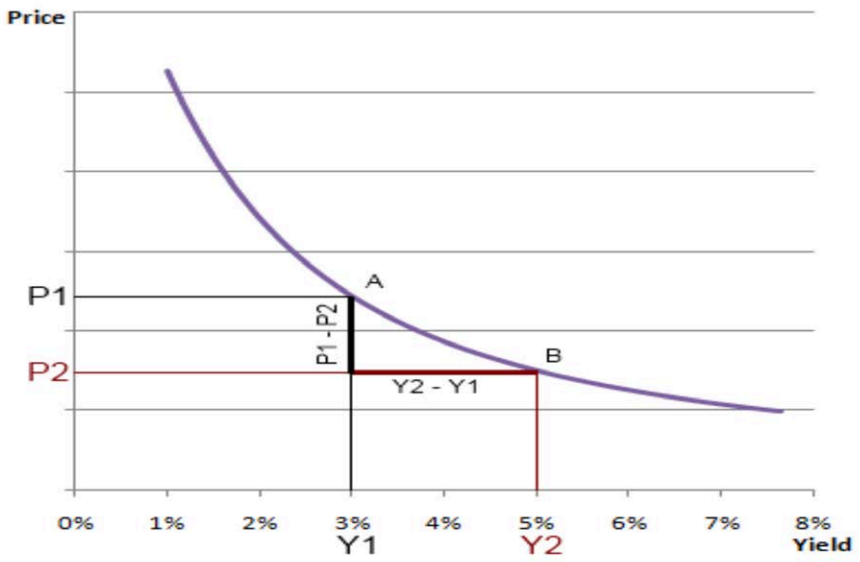
- Because a bond's price is derived from the present value of future cash flows (a percentage in the denominator), we get a curve that is convex in nature.

Using previous example:

2Yr Bullet @ 1.00% =100.00



Basic Price/Yield Relationship



RISK: Macaulay Duration

To interpret and estimate potential price impact, we need measures that help us quickly get an idea of how interest rate changes will affect the security or portfolio as a whole.

To understand Duration, we start from the beginning:

- Macaulay Duration was first introduced in 1938 by Frederick Macaulay, a Canadian economist, in a study he produced analyzing U.S. railroad bond prices.
- Macaulay demonstrated that duration, not maturity, was the more appropriate measure of a bond's "time dimension."
- Macaulay Duration is essentially a measure of the "average maturity" of the present value of the cash flows and is thus quoted in a dimension of time (years).

$$\text{Macaulay Duration} = \sum_{t=1}^{n} \frac{(PV)\,(CF_t) \times t}{\text{Market Price of Bond}}$$

Definitions:

$(PV)(CF_t)$ = present value of coupon at period t

t = time to each cash flow (in years)

n = number of periods to maturity

Maturity (Yrs)	CPN	YTM	PAR
2	1.00%	1.00%	$100,000,000

Bond Price	$1,000.00
Macaulay Duration (Effective Maturity)	
Bond Semi Annual Macaulay Duration	3.970
Bond Annualized Macaulay Duration	1.985

Sum of t*Weight = Semi-Annual Macaulay Duration

Divide Semi-Annual Macaulay Duration by 2

t	CF	PV Factor	PV Cash Flow	PV Cash Flow / Bond Price =Weight	t*Weight	t*(t+1)*Weight*(1/(1+y)^2
1	5	0.995025	$4.98	0.50%	0.0050	0.0099
2	5	0.990075	$4.95	0.50%	0.0099	0.0294
3	5	0.985149	$4.93	0.49%	0.0148	0.0585
4	1005	0.980248	$985.15	98.51%	3.9406	19.5074

Credit: CDIAC Issue Brief: #06-10

RISK: Macaulay Duration

There are four points we learn from the use of Macaulay Duration:

1. The duration of a zero coupon bond is equal to its time to maturity.
2. The duration of a coupon paying bond is less than its time to maturity.
3. Given the same coupon and maturity, the longer the maturity, the greater the duration.
4. Given the same yield and maturity, the lower the coupon, the greater the duration.

Although the basis of Macaulay Duration is fundamentally sound, it did very little to tell investors about the risk inherent with interest rate changes. Because there is a relationship with the Macaulay Duration and the Price/Yield relationship, it was discovered that simply dividing the Macaulay Duration by 1 + (YTM / # of coupons per year), the calculation converts from a time dimension, to a price approximate change based on a 1.00% change in interest rates. The new metric is called Modified Duration.

RISK: Modified Duration

Modified Duration represents the approximate percentage change in a bond's price for a 100 basis points change in yield.

- Modified Duration converts Macaulay Duration into a percentage change measurement.
- Modified Duration assumes that the bond's expected cash flow does not change when the yield changes.
- This metric works for option-free bonds such as Agency Bullets and Treasuries, but not with option-embedded bonds.

$$\left[\frac{1.985}{1+(.0100/2)}\right] = 1.975$$

Macaulay Duration → Modified Duration

$$\text{Modified Duration} = \frac{\text{Macaulay Duration}}{1 + \frac{\text{Yield to maturity}}{\text{Number of coupon periods per year}}}$$

Maturity (Yrs)	CPN	YTM	PAR
2	1.00%	1.00%	$100,000,000

Bond Price	$1,000.00
Macaulay Duration (Effective Maturity)	
Bond Semi Annual Macaulay Duration	3.970
Bond Annualized Macaulay Duration	1.985

Sum of t*Weight = Semi-Annual Macaulay Duration

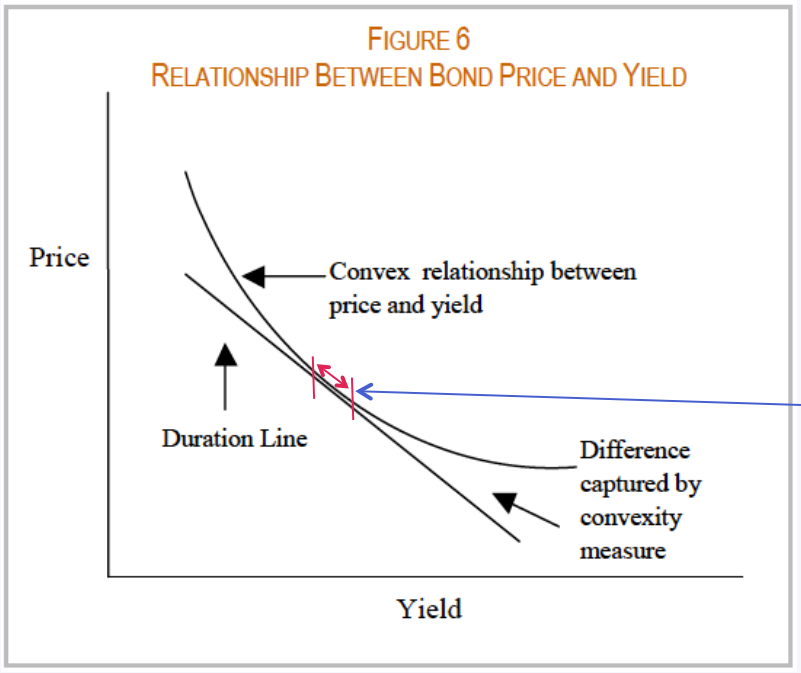
Divide Semi-Annual Macaulay Duration by 2

t	CF	PV Factor	PV Cash Flow	PV Cash Flow / Bond Price =Weight	t*Weight	t*(t+1)*Weight*(1 /(1+y)^2
1	5	0.995025	$4.98	0.50%	0.0050	0.0099
2	5	0.990075	$4.95	0.50%	0.0099	0.0294
3	5	0.985149	$4.93	0.49%	0.0148	0.0585
4	1005	0.980248	$985.15	98.51%	3.9406	19.5074

Credit: CDIAC Issue Brief: #06-10

RISK: Modified Duration

Example: *A Modified Duration of 2.00 means that for a 1.00% change in interest rates, we can expect our price to change* ***approximately*** *2.00% (increasing or decreasing).*



Credit: CDIAC Issue Brief: #06-10

- Modified Duration is represented by the line tangent to the convex price/yield curve.
- Geometrically speaking, the tangent line is linear in nature.
- The slope of the tangent line is the first derivative to the graph of our function.
- This tangent line is the best linear approximation of the Modified Duration function near that input value.
- As you can see, linear approximations have limited usefulness beyond a certain point of our convex curve.
- This is why we say Duration is a good approximation for small price changes.
- For large changes, we have to take Convexity into account.

RISK: Effective Duration

Effective Duration represents the approximate percentage change in a bond's price for a 100 basis points change in yield.

- Effective Duration takes into account that the bond's expected cash flow's can change when the yield changes.
- This metric works for option-free bonds such as Agency Bullets and Treasuries AND Callable Bonds.
- Effective Duration uses the same theory as Modified Duration, however the discounting of cash flows is estimated at different interest rates and the corresponding changes in those cash flows are taken into account.
- This requires a bond option valuation model to calculate and can not be done simply by hand (remember OAS?).

Modified Duration → Effective Duration

$$D_{effective} = -\frac{P_{up} - P_{down}}{2 \times \triangle i \times P}$$

Found by bond option model

P_{up} = Bond's price when yield curve shifted up

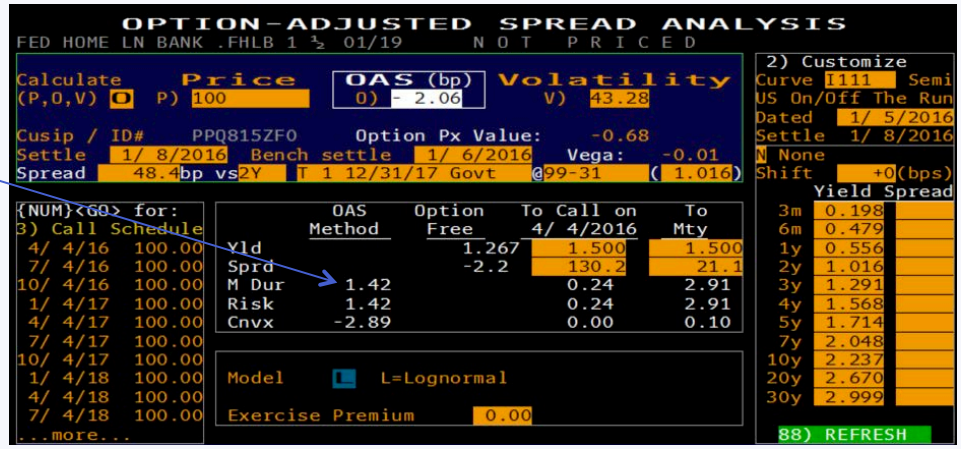
P_{down} = Bond's price when yield curve shifted up

i = Yield curve shift

P = Current price

**3.00Yr 1.50% Fixed Callable, Callable Quarterly After 3 Month Lockout. Priced @ Par*

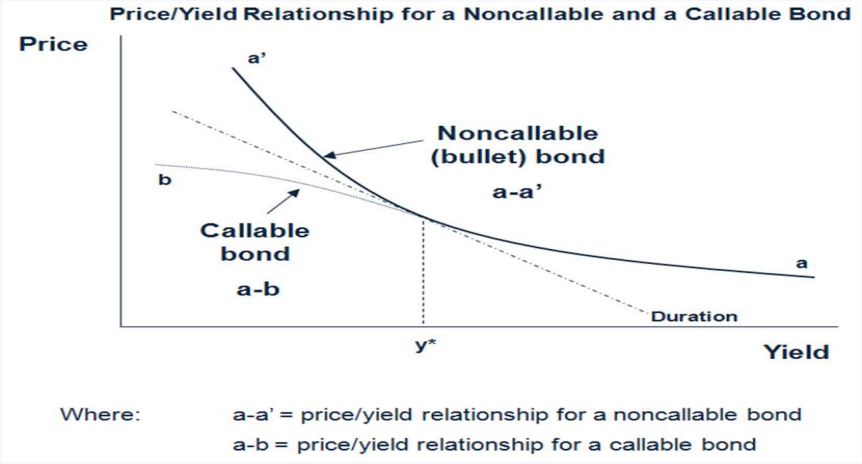
Effective Duration = 1.42



RISK: Convexity

Convexity measures the non-linear relationship between price and yield.

- Convexity is the measure of curvature of our price/yield function.
- Convexity, in a nutshell, corrects the error in the estimation of a bond's price if Duration alone is used to estimate.
- Because Convexity is the second derivative of our function, it essentially measures the rate of change of our first derivative (Modified or Effective Duration).
  - Positive Convexity: Duration rises as yields decline (prices increase at an increasing rate).
  - Negative Convexity: Duration lowers as yields decline (prices increase at an decreasing rate).
- To interpret convexity, think of it as being the approximate percent change in duration for a 1.00% change in yields.

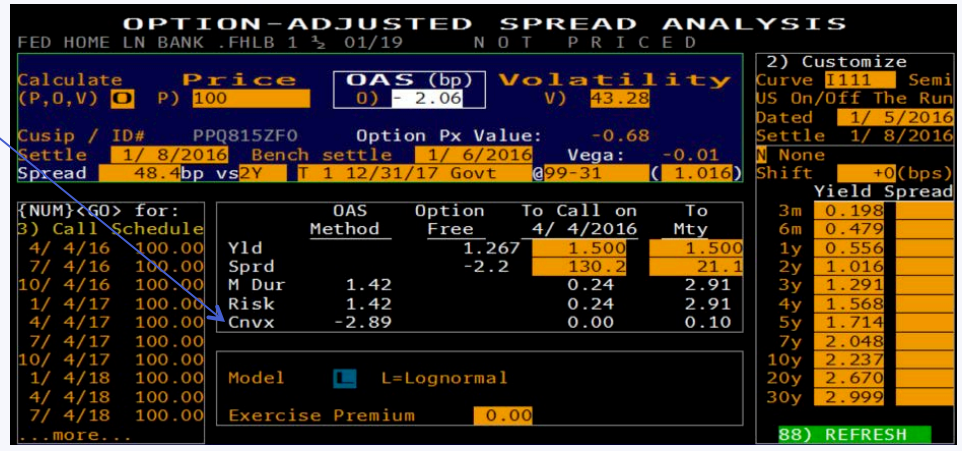


RISK: Convexity

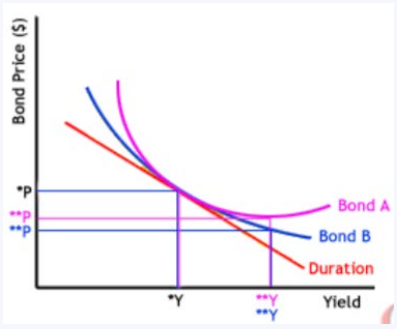
- Effective Convexity uses the same bond option valuation model approach like Effective Duration.
- A Convexity adjustment can be used to evaluate the actual price change of a bond.
- However, Convexity is of less importance for two reasons:
  1. We are usually concerned with smaller changes in interest rates (100bp and smaller) as they are more likely to be the concern investors have over the shorter lifespan of public fund portfolios (5 years and in).
  2. In portfolios with a mix of negatively and positively convex securities, a diversification effect occurs.

**3.00Yr 1.50% Fixed Callable, Callable Quarterly After 3 Month Lockout. Priced @ Par*

Effective Convexity = -2.89



- *We know the more positive the convexity, the less sensitive the bond is to interest rate changes.*
- *Thus, convexity can be used more on a relative value basis by comparing similar structures.*
- *For instance, if we have two like bonds with the same duration, but one has higher convexity (Bond A), we would prefer to own Bond A (assuming all else equal).*



RISK: Duration & Positive Convexity Combined

Maturity (Yrs)	CPN	YTM	PAR
5	2.25%	2.25%	$100,000,000
Bond Price		$1,000.00	
Macaulay Duration (Effective Maturity)			
Bond Semi Annual Macaulay Duration		9.514	
Bond Annualized Macaulay Duration		4.757	
Modified Duration = Macaulary Dur/(1+y)			
Semi Annual Modified Duration		9.408	
Annualized Modified Duration		4.704	
Convexity			
Semi Annual Convexity		100.621	
Annualized Convexity		25.16	

Price decreases at decreasing rate

$$\frac{\Delta P}{P} = -D_m \times \Delta y + \frac{(\Delta y)^2}{2} \times Convexity$$

New YTM	Change in Yield	Predicted Dur % Change	Predicted Dur Price	Actual % Change	Actual Price	Variance Per Bond	Convexity Effect on PAR	Convexity Adjustment
4.25%	2.00%	-9.41%	$905.92	-8.92%	$910.76	$4.84	$483,986.53	-8.91%
4.00%	1.75%	-8.23%	$917.68	-7.86%	$921.40	$3.72	$372,331.66	-7.85%
3.75%	1.50%	-7.06%	$929.44	-6.78%	$932.19	$2.75	$274,867.48	-6.77%
3.50%	1.25%	-5.88%	$941.20	-5.69%	$943.12	$1.92	$191,802.49	-5.68%
3.25%	1.00%	-4.70%	$952.96	-4.58%	$954.19	$1.23	$123,348.55	-4.58%
3.00%	0.75%	-3.53%	$964.72	-3.46%	$965.42	$0.70	$69,720.88	-3.46%
2.75%	0.50%	-2.35%	$976.48	-2.32%	$976.79	$0.31	$31,138.17	-2.32%
2.50%	0.25%	-1.18%	$988.24	-1.17%	$988.32	$0.08	$7,822.62	-1.17%
2.25%	0.00%	0.00%	$1,000.00	0.00%	$1,000.00	$0.00	$0.00	$0.00
2.0000%	-0.25%	1.18%	$1,011.76	1.18%	$1,011.84	$0.08	$7,899.70	1.18%
1.7500%	-0.50%	2.35%	$1,023.52	2.38%	$1,023.84	$0.32	$31,754.83	2.38%
1.5000%	-0.75%	3.53%	$1,035.28	3.60%	$1,036.00	$0.72	$71,802.25	3.60%
1.2500%	-1.00%	4.70%	$1,047.04	4.83%	$1,048.32	$1.28	$128,282.65	4.83%
1.0000%	-1.25%	5.88%	$1,058.80	6.08%	$1,060.82	$2.01	$201,440.60	6.08%
0.7500%	-1.50%	7.06%	$1,070.56	7.35%	$1,073.48	$2.92	$291,524.65	7.34%
0.5000%	-1.75%	8.23%	$1,082.32	8.63%	$1,086.31	$3.99	$398,787.38	8.62%
0.2500%	-2.00%	9.41%	$1,094.08	9.93%	$1,099.32	$5.23	$523,485.46	9.91%

Price increases at increasing rate

RISK: Duration & Negative Convexity Combined

5NC3Mo-Dq	
Annualized Effective Duration	2.010
Convexity	
Annualized Effective Convexity	-3.95

Price decreases at increasing rate

New YTM	Change in Yield	Predicted Dur % Change	Predicted Dur Price	Actual % Change	Actual Price	Duration Change
4.25%	2.00%	-4.02%	$959.80	-7.63%	$923.67	4.49
4.00%	1.75%	-3.52%	$964.83	-6.59%	$934.06	4.45
3.75%	1.50%	-3.02%	$969.85	-5.55%	$944.46	4.39
3.50%	1.25%	-2.51%	$974.88	-4.52%	$954.83	4.31
3.25%	1.00%	-2.01%	$979.90	-3.49%	$965.09	4.17
3.00%	0.75%	-1.51%	$984.93	-2.49%	$975.11	3.96
2.75%	0.50%	-1.01%	$989.95	-1.53%	$984.67	3.55
2.50%	0.25%	-0.50%	$994.98	-0.67%	$993.32	2.84
2.25%	0.00%	0.00%	$1,000.00	0.00%	$1,000.00	2.01
2.0000%	-0.25%	0.50%	$1,005.03	0.30%	$1,003.01	1.31
1.7500%	-0.50%	1.01%	$1,010.05	0.35%	$1,003.48	0.90
1.5000%	-0.75%	1.51%	$1,015.08	0.35%	$1,003.48	0.90
1.2500%	-1.00%	2.01%	$1,020.10	0.35%	$1,003.48	0.90
1.0000%	-1.25%	2.51%	$1,025.13	0.35%	$1,003.48	0.90
0.7500%	-1.50%	3.02%	$1,030.15	0.35%	$1,003.48	0.90
0.5000%	-1.75%	3.52%	$1,035.18	0.35%	$1,003.48	0.90
0.2500%	-2.00%	4.02%	$1,040.20	0.35%	$1,003.48	0.90

Price increases at decreasing rate

RISK: Spread Duration

Spread Duration is a measure of how the market value of a risky bond or portfolio will change with respect to a parallel 100bp change in its spread above the comparable benchmark security or portfolio.

- Because non-treasury bonds have credit risk (e.g. corporate bonds), we have to realize that spreads can change as well as interest rates.
- For non-Treasury securities, Spread Duration is equal to the calculated Modified or Effective Duration.
- For Treasury securities, Spread Duration is equal to zero.
- The Spread Duration of a portfolio is calculated as a market weighted average of the spread durations of the owned securities.
- Thus, if we own a mix of Treasury and non-Treasury securities, the Spread Duration will not be equal to the portfolio duration.

RISK: Duration Drift

- Duration Drift occurs when durations in individual securities (or portfolio) change due to some change in interest rates or some change in time.
- Duration Drift is a byproduct of the convexity that we know exists in the price/yield function.
- Measuring Duration Drift can be an important tool to understanding potential risk at both the individual security and portfolio level.

Duration change under 6mo and 12mo scenario

MISCHLER FINANCIAL GROUP
A Service Disabled Veteran Business Enterprise

Clear Step

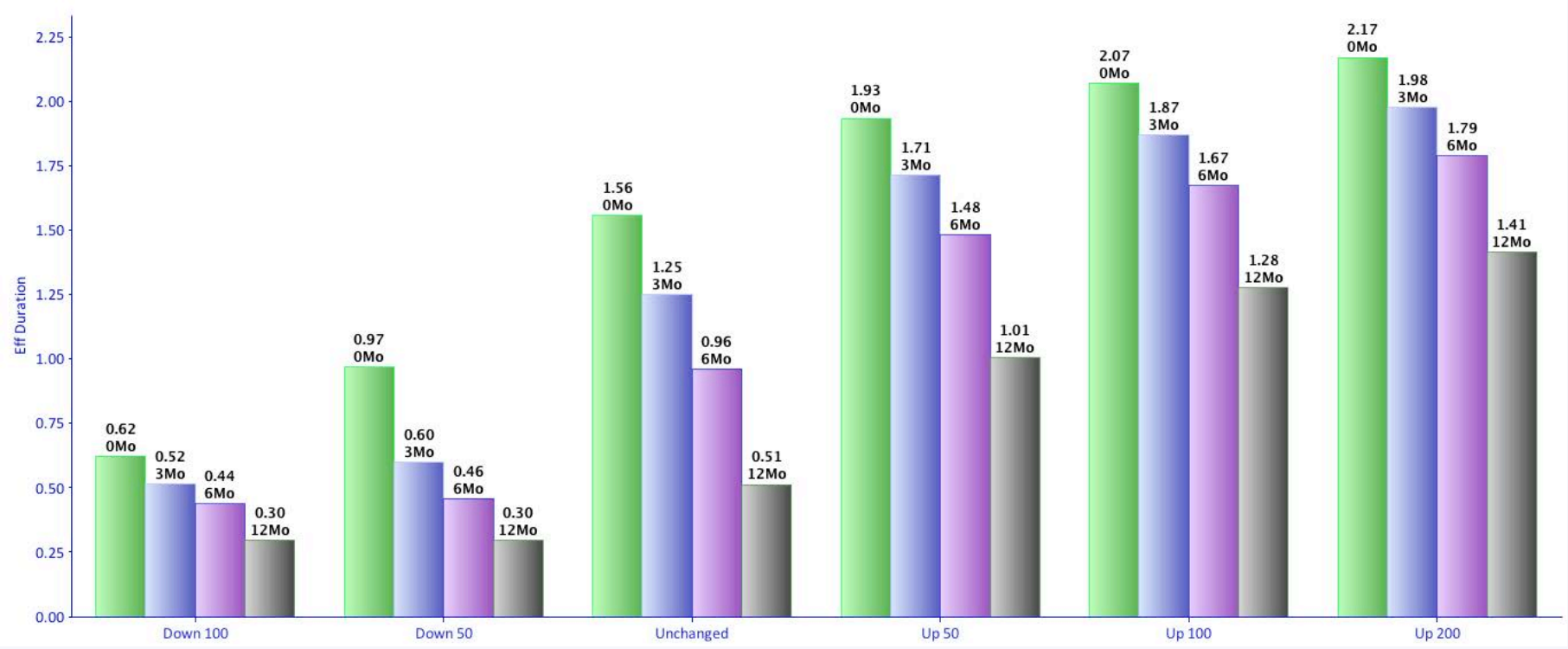
MFG Step Callable Bond Offerings
Offerings Date: Jan 08, 2016
Step Inventory Updated

Years to Maturity Min	5.00	Maximum Days to Settle		Call Type 1	Quarterly
Years to Maturity Max	5.00	Minimum YTW		Call Type 2	
Price Min		Minimum Coupon		Issuer Ticker 1	FHLB
Price Max	100.000	Pay Frequency		Issuer Ticker 2	
Minimum Par Available		Minimum Lockout (Months)		Issuer Ticker 3	
Min Amount Issued (MM)		Maximum Steps	5.00		

CUSIP	Offer ID	Par Offered	Settlement Date	Ticker	Coupon	Maturity Date	Short Des	Next Call Date	Amt Issued	Price	Yield To Worst	Yield To Maturity	Yield To Call	Effective Duration	Effective Convexity	OAS	OAS VOL	Step Schedule	Dur 6Mo+50	Px 6Mo+50	Dur 12Mo+100	Px 12Mo+100
3130A6YT8	201	$6,000,000.00	1/29/2016	FHLB	1.000	1/29/2021	5.00NC-3.0Mo-DqSt	4/29/2016	15MM	100.000	1.000	2.376	1.000	1.35	(2.84)	(35.09)	46.74	1.00Yrs 1.000% (Until 01/29/2017) 1.00Yrs 2.000% (Until 01/29/2018) 3.00Yrs 3.000% (Until 01/29/2021)	1.70	99.576	1.77	99.499
3130A72C8	206	$7,500,000.00	1/29/2016	FHLB	1.250	1/29/2021	5.00NC-6.0Mo-DqSt	7/29/2016	15MM	100.000	1.250	2.318	1.250	2.05	(2.36)	(37.29)	45.63	1.00Yrs 1.250% (Until 01/29/2017) 1.00Yrs 1.500% (Until 01/29/2018) 1.00Yrs 2.000% (Until 01/29/2019) 1.00Yrs 3.000% (Until 01/29/2020) 1.00Yrs 4.000% (Until 01/29/2021)	2.34	99.168	2.41	98.614
3130A6ZU4	214	$14,500,000.00	1/29/2016	FHLB	1.250	1/29/2021	5.00NC-6.0Mo-DqSt	7/29/2016	15MM	99.700	1.453	2.252	1.856	2.49	(2.29)	(35.16)	45.63	1.50Yrs 1.250% (Until 07/29/2017) 1.50Yrs 1.500% (Until 01/29/2019) 1.00Yrs 2.000% (Until 01/29/2020) 0.50Yrs 4.000% (Until 07/29/2020) 0.50Yrs 6.000% (Until 01/29/2021)	2.80	98.677	2.76	97.972

RISK: Duration Drift

**Portfolio Level Duration Drift Example*



RISK: Portfolio Characteristics

- Totality of risk is not a clean cut, measurable output. It is important to know your portfolio inside and out. We must focus on the details.
- *We can ask ourselves a series of questions at the portfolio level to help make better decisions and minimize overall risk.*

Is my liquidity in line with expectations?

- *Having money to invest is good, but you never want to sacrifice liquidity to do so.*

	Primary Liquidity
Portfolio	20.07% $43,000,000
Target	13.00% $27,857,236
Variance	7.07% $15,142,764

Is my yield where I want it to be?

- *Staying on a plan will help you from having to make aggressive moves to play catch up.*

	Port	Target	Variance
PYld / MAY(MA)	1.01%	0.64%	0.38%
PYld / IFBY(MA)	1.01%	0.98%	0.03%
Eff Dur	1.56	1.62	0.06

RISK: Portfolio Characteristics

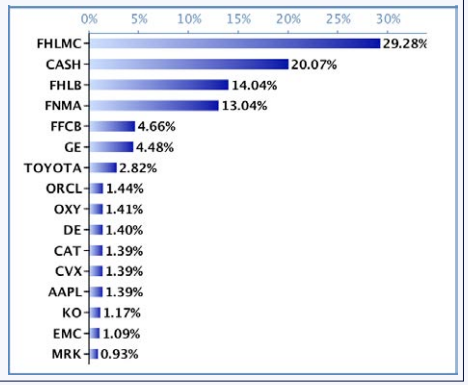
Does my allocation have any gaps that need attention?

- *A good plan involves knowing how you should be invested on average. If large variances occur then you can shift your focus to specific areas.*

	Port	Target	Variance
Bullet 0-1Yr	**2.34%**	0.00%	2.34%
Bullet 1-3Yr	**9.35%**	**10.00%**	(0.65%)
Bullet 3-5Yr	0.00%	0.00%	0.00%
Bullet 5-7Yr	0.00%	0.00%	0.00%
Bullet 7-10Yr	0.00%	0.00%	0.00%
Bullet 10-15Yr	0.00%	0.00%	0.00%
Bullet 15+Yr	0.00%	0.00%	0.00%
Callable 0-1Yr	0.00%	0.00%	0.00%
Callable 1-3Yr	**18.12%**	**25.00%**	(6.88%)
Callable 3-5Yr	**30.28%**	**27.00%**	3.28%
Callable 5-7Yr	**2.32%**	0.00%	2.32%
Callable 7-10Yr	0.00%	0.00%	0.00%
Callable 10-15Yr	0.00%	0.00%	0.00%
Callable 15+Yr	0.00%	0.00%	0.00%

Are my issuers well diversified and within legal limits?

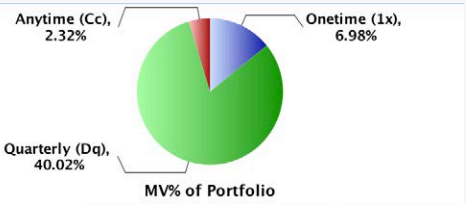
- *Issuer diversification and limiting concentration risk are important to maintaining a well balanced portfolio.*



RISK: Portfolio Characteristics

Does my callable composition make sense?

- *Understanding what callables you own and what option types fit your needs helps mitigate call risk and cash flow uncertainty.*



	MV% of Portfolio	Pyld / WtdCon	EDur / WtdCon
Onetime (1x)	6.98%	1.03% / 0.07%	2.00 / 0.14
Monthly (Dm)			
Quarterly (Dq)	40.02%	1.27% / 0.51%	1.94 / 0.78
Semi-Annual (Ds)			
Annual (Da)			
Anytime (Cc)	2.32%	1.09% / 0.03%	1.59 / 0.04
Other (Oc)			

Do my sector contributions meet my expectations?

- *Breaking down sectors can help see where yield contribution is coming from and where interest rate risk is coming from.*

	% of Portfolio	Pyld / WtdCon	EDur / WtdCon
CASH/MMKT	20.07%	0.22% / 0.04%	0.00 / 0.00
CD/CP			
Treasuries			
Supra-Natl			
Agencies	61.02%	1.17% / 0.71%	1.91 / 1.17
Disco			
Bullet	**11.69%**	**0.92% / 0.11%**	**1.81 / 0.21**
Fixed Clb	**29.28%**	**1.26% / 0.37%**	**1.95 / 0.57**
Structured	**21.44%**	**1.17% / 0.25%**	**1.91 / 0.41**
Corporates	18.92%	1.35% / 0.25%	2.06 / 0.39
Finance	**4.48%**	**1.34% / 0.06%**	**1.68 / 0.08**
Industrial	**14.43%**	**1.35% / 0.19%**	**2.18 / 0.32**
Municipals			
Revenue			
Gen Ob			
Other			

RISK: Portfolio Characteristics

Are my Duration and Maturity buckets allocated appropriately?

- *By bucketing your maturity and duration exposure, you can see where areas of risk may be concentrated.*

	Duration	Maturity
Cash	20.07%	20.07%
0 - 1	2.34%	2.34%
1 - 2	41.34%	14.75%
2 - 3	33.94%	28.81%
3 - 4	2.31%	13.09%
4 - 5	0.00%	18.63%
5 - 6	0.00%	2.32%
6 - 7	0.00%	0.00%
7 - 8	0.00%	0.00%
8 - 9	0.00%	0.00%
9 - 10	0.00%	0.00%
10+	0.00%	0.00%

RISK: Issuer Analysis

Single security analysis outside of the traditional Treasury/GSE framework can require additional time and effort to understand the risks associated with certain issuers and structures. There are a few areas that public fund managers can focus on to help assess risk in a timely and efficient manner (not comprehensive by any means).

- Solvency/Liquidity Ratios:
  - Current Ratio = Current Assets / Current Liabilities
  - Quick Ratio = (Cash + Short Term Marketable Securities + Receivables) / Current Liabilities
  - Cash Ratio = (Cash + Short Term Marketable Securities) / Current Liabilities
  - Interest Burden = EBT/EBIT
  - Interest Coverage Ratio = EBIT / Interest Payments

**Apple Ratios from Bloomberg on DES <go> Ratios tab*

Profitability	
EBITDA	82.5B
EBIT	71.2B
OPM	30.5%
Prtx Mrgn	31.0%
ROA	20.4%
ROE	46.2%
ROC	32.6%
Ast TO	0.9

Structure	
Curr Ratio	1.1
Quick Ratio	0.7
Debt/Assets	22.2%
Debt/Com Eq	54.0%
A/R Trnovr	13.6
Inv Turnover	62.8
GM	40.1%
EBIT/Tot Int Exp	97.2

RISK: Issuer Analysis

- Bid / Ask Spreads
  - The amount by which the ask price exceeds the bid. This is essentially the difference in price between the highest price that a buyer is willing to pay for an asset and the lowest price for which a seller is willing to sell it.
  - Larger Bid/Ask spreads indicate additional cushion needed by dealers to maintain positions (axe) in a specific credit or issue. The larger the spread, the less liquidity is associated with it.

- Issue Size
  - The size of the issue outstanding can impact the liquidity associated with it. Because benchmarks have minimum requirements (usually 250MM), dealers are less inclined to hold non-benchmark eligible securities. This is due to the simple reality that larger funds who are index constrained will not buy issues that do not appear in their designated benchmark universe.
  - This is generally not relevant for the GSE markets as those markets rely heavily on MTN programs (15-50MM issues) for funding.

RISK: Issuer Analysis

- Benchmark Curves
  - Benchmark Curves are published for many credit rating ranges and sector types. These curves can give you a quick idea where the average benchmark issuers are yielding in the same space in which you are comparing. Since these benchmarks make up the biggest and most liquid securities, any yield differentials for a specific security may give insight into the liquidity and credit premium / discount.

* Bloomberg AA Corporate Credit Curve

RISK: Issuer Analysis

- Bloomberg DRSK / IG Banding
  - The DRSK Function is a fairly new tool from Bloomberg that provides a lot of the data scrubbing and adjustments that credit analysts would typically want to make for accounting differentials and advantageous accounting practices that create less transparency.
  - Based on the Merton Distance-to-Default methodology.
  - Financials adjusted for OPEB and Operating Leases to fairly evaluate across issuers (debt levels and interest expense understated otherwise).
  - Creates longer term implied CDS spreads and IG banding for estimation of default over 1 year.

* Bloomberg DRSK for Apple Inc.

RISK: Issuer Analysis

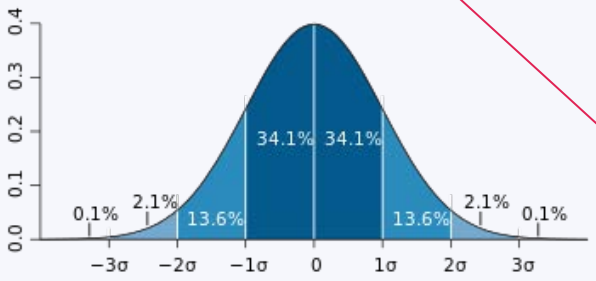
- Standard Deviation
  - Measure of a random variable around its mean or expected value
  - Commonly used as a measure of the **volatility** of prices, yields, or total returns
  - Historical data used to compute Variance and then a standardized output called Standard Deviation

$$\text{Variance} = \sum_{T=1}^{T} \frac{(X_t - \bar{X})^2}{T - 1} \quad \Rightarrow \quad \sqrt{\text{Variance}} = \text{Standard Deviation}$$

T = # of observations in the sample
X_t = Observation t on variable X
X_t = Average sample value for variable X

**Bloomberg stores historical volatilities for prices and yield on the HVT screen*

Standard Deviation = 12.984 Basis Points



GE 5.25 12/6/17

Date	Yield
12/31/2015	1.678
12/30/2015	1.442
12/29/2015	1.672
12/28/2015	1.481
12/24/2015	1.503
12/23/2015	1.637
12/22/2015	1.519
12/21/2015	1.468
12/18/2015	1.611
12/17/2015	1.666
12/16/2015	1.469
12/15/2015	1.381
12/14/2015	1.41
12/11/2015	1.629
12/10/2015	1.483
12/9/2015	1.515
12/8/2015	1.388
12/7/2015	1.727
12/4/2015	1.427
12/3/2015	1.354
12/2/2015	1.387
12/1/2015	1.255
11/30/2015	1.294
Stdev	0.12984
Annl Std Dev	0.48464

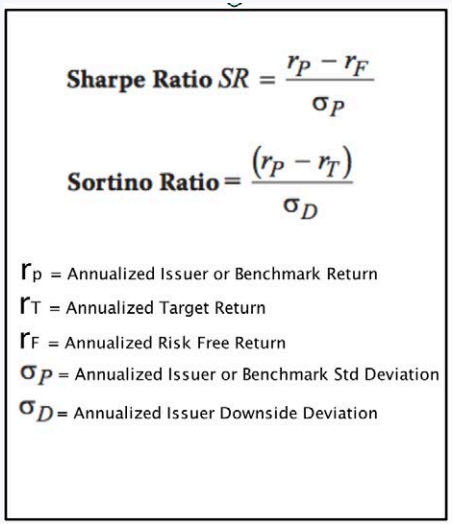
RISK: Issuer Analysis

- Risk/Reward Ratios
  - Ratios used to compare expected returns to the amount of risk undertaken to achieve those returns.
  - Most popular ratios use volatility of total return as the risk parameter.
  - There are varying opinions as to which ratios give the best insight or are the most useful, however there are a few that are well known and widely used measures across portfolio management.

    - ***Sharpe Ratio:*** Uses total volatility (standard deviation) as the denominator and the risk free rate as the base rate .

    - ****Sortino Ratio:*** Uses partial volatility (downside deviation) as the denominator and a specified Target Rate (or minimum return) as the base rate.

*I prefer the "Red Rock" version of Sortino Ratio which uses a manager's Target Rate (r_T) instead of assuming the Risk Free Rate.



Questions?

Wisdom For the Day!

“Never forget the six-foot-tall man who drowned crossing the stream that was five feet deep on average”
– Howard Marks

“The cautious seldom err or write great poetry”
– Best Fortune Cookie

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