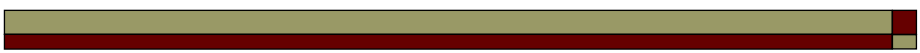


# AIM 10.2 Thematic ETPs

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## Bonds

1



## Bond ETFs

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- Context:
  - “Traditional” long-term investment portfolios include:
    - Stocks
    - Bonds
    - Cash equivalents
  - CAPM says buy-and-hold all assets (not just stocks) with market cap weights.
    - Same principle applies to bonds.
    - Bloomberg US Aggregate Bond Index

2

## Bond ETFs

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- Purpose:
  - Review status of bond ETP markets:
    - Cash equivalents
  - Identify bond risk exposures:
    - Interest rate risk
    - Credit risk
  - Analysis:
    - Determine optimal allocation between stocks and cash.
      - Stock allocation is represented by Vanguard's VTI ETF.
    - Determine optimal allocation between stocks, cash and bonds.
      - Bond allocation will be represented by Vanguard's BND ETF.
    - Consider range of risk tolerance levels.

3

## Cash equivalents

---

- Portfolio managers usually have highly, liquid cash component.
  - Common to use effective Fed funds rate (EFFR).
  - Increasing number of short-term Treasury ETFs.

4

## Cash equivalents

- Examined ETFdb.com database.

Short-term bond ETFs (cash equivalents)								
Symbol	Name	Assets	Inception	ER	Volatility	# of hldgs	Days	Duration
BIL	SPDR Bloomberg 1-3 Month T-Bill ETF	33,353	20070525	0.14%	0.16%	19	35	0.07
USFR	WisdomTree Floating Rate Treasury Fund	17,535	20140204	0.15%	0.12%	5	67	0.02
SGOV	iShares 0-3 Month Treasury Bond ETF	17,488	20200526	0.07%	0.06%	19	50	0.09
SHV	iShares Short Treasury Bond ETF	18,593	20070105	0.15%	0.11%	43	52	0.27
TFLO	iShares Treasury Floating Rate Bond ETF	10,326	20140203	0.15%	0.16%	9	97	0.01

Based on US Treasuries. Used to be short-term corporate debt.

5

## Cash equivalents

- Expense ratios.

Short-term bond ETFs (cash equivalents)								
Symbol	Name	Assets	Inception	ER	Volatility	# of hldgs	Days	Duration
BIL	SPDR Bloomberg 1-3 Month T-Bill ETF	33,353	20070525	0.14%	0.16%	19	35	0.07
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Expense ratios are relatively high considering nature product.

6

## Cash equivalents

- Duration measures interest rate risk.

Short-term bond ETFs (cash equivalents)								
Symbol	Name	Assets	Inception	ER	Volatility	# of hldgs	Days	Duration
BIL	SPDR Bloomberg 1-3 Month T-Bill ETF	33,353	20070525	0.14%	0.16%	19	35	0.07
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Duration of Fed funds is about 0.004.

7

## Cash equivalents

- Duration measures interest rate risk.

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### Floating rate Treasuries

- maturities are two years
- interest rate is reset weekly based on discount rates at 13-week T-bill auction

8

## Cash equivalents

- Summary statistics (Support file: Cash equivalents.xlsx)

Summary						
Description	EFFR	BIL	USFR	SGOV	SHV	TFLO
No. of obs.	936	936	936	936	936	936
Mean (daily)	0.00008	0.00007	0.00008	0.00008	0.00007	0.00008
StDev (daily)	0.00012	0.00016	0.00031	0.00014	0.00018	0.00023
Skewness	2.06053	1.16309	-0.04580	1.44615	0.86777	0.72743
Kurtosis	4.29513	2.15338	0.27626	2.39626	4.07893	3.49401
Autocorrelation	0.49796	0.13306	-0.31589	0.16320	0.11857	-0.18104
Minimum	0.00000	-0.00027	-0.00080	-0.00030	-0.00082	-0.00099
Median	0.00001	0.00000	0.00000	0.00004	0.00000	0.00000
Maximum	0.00059	0.00076	0.00119	0.00072	0.00118	0.00148
Mean (annual)	2.05%	1.82%	2.11%	1.98%	1.72%	2.08%
StDev (annual)	0.19%	0.26%	0.49%	0.23%	0.29%	0.36%
CAGR	2.07%	1.84%	2.13%	2.00%	1.73%	2.10%
HPR	7.91%	7.01%	8.14%	7.63%	6.59%	8.01%
Return risk ratios						
	EFFR	BIL	USFR	SGOV	SHV	TFLO
	11.01	7.09	4.34	8.61	5.94	5.78

Effective Fed funds rate has lowest risk and 3<sup>rd</sup> highest return.

Return/risk ratio is highest.

9

## Bond valuation

- Value of coupon bond is sum of present values of promised payments.

$$B_c = \sum_{i=1}^n C_i e^{-r_i t_i}$$

- Implies coupon-bearing bond is portfolio of discount bonds.

$$B_c = \sum_{i=1}^n B_{d,i} \quad \text{where } B_{d,i} = C_i e^{-r_i t_i}$$

- Each discount bond valued using zero-coupon rate.

10

## Yield to maturity

- Yield to maturity assumes all zero-coupon rates are same.

$$y = r_i \text{ for } i = 1, \dots, n$$

- Computed by setting observed bond price equal to bond valuation formula.

$$B_c = \sum_{i=1}^n C_i e^{-y t_i}$$

11

## Duration

- Concept developed by Macaulay in 1938.
- Measures *interest rate risk*.
  - Percent change in bond value for change in yield.

- Take derivative of bond valuation formula.

$$\frac{dB_c}{dy} = - \sum_{i=1}^n t_i C_i e^{-y t_i}$$

- Divide through by bond value.

$$\frac{dB_c / B_c}{dy} = - \sum_{i=1}^n t_i \left( \frac{C_i e^{-y t_i}}{B_c} \right) \equiv -D$$

12

## Duration

- Duration of coupon bond is weighted average time to maturity of terms to maturity of its constituent discount bonds.

$$D = \sum_{i=1}^n t_i \left( \frac{C_i e^{-y t_i}}{B_c} \right) = \sum_{i=1}^n t_i \left( \frac{B_{d,i}}{B_c} \right)$$

13

## Duration of bond ETF

- Two measures maturity/interest rate risk are often reported in bond ETF fact sheets.
  - Weighted average term to maturity.

$$T_{ETF} = \sum_{j=1}^{\# \text{ of bonds}} T_j \left( \frac{B_{c,j}}{B_{AUM}} \right)$$

- Weighted average duration.

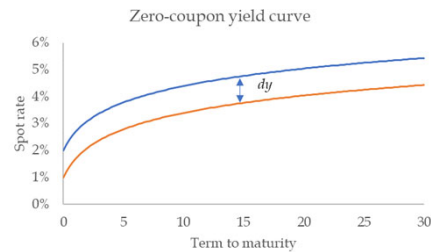
$$D_{ETF} = \sum_{j=1}^{\# \text{ of bonds}} D_j \left( \frac{B_{c,j}}{B_{AUM}} \right)$$

$$\text{where } B_{AUM} = \sum_{j=1}^{\# \text{ of bonds}} B_{c,j}$$

14

## Bond return implications

- Duration assumes small (additive) shift  $dy$  in zero-coupon yield curve.



- Implies bond returns for different maturities are perfectly positively correlated.

15

## Bond return realizations

- Returns for different maturities are positively correlated, but correlation is far from perfect.
- Support file: ICE Treasury bond indexes.xlsx

16



## Treasury return analysis

Summary statistics							
Description	IDCO1STR	IDCO11TR	IDCO13TR	IDCO17TR	IDCO110T	IDCO120T	IDCO1CTR
n	2,636	2,636	2,636	2,636	2,636	2,636	2,636
Mean (daily)	0.0000	0.0000	0.0001	0.0002	0.0002	0.0003	0.0001
StDev (daily)	0.0001	0.0005	0.0020	0.0036	0.0050	0.0083	0.0023
Skewness	0.8170	0.3313	-0.0232	-0.1229	-0.1156	-0.1265	-0.0733
Autocorrelation	0.2250	-0.0548	-0.0382	-0.0303	-0.0437	-0.0383	-0.0467
Minimum	-0.0003	-0.0023	-0.0107	-0.0178	-0.0225	-0.0448	-0.0115
Median	0.0000	0.0000	0.0000	0.0001	0.0001	0.0003	0.0001
Maximum	0.0004	0.0033	0.0084	0.0154	0.0214	0.0439	0.0093
Mean (annual)	0.66%	1.22%	2.93%	4.48%	5.69%	7.42%	3.15%
StDev (annual)	0.09%	0.84%	3.11%	5.67%	7.87%	13.20%	3.72%
CAGR	0.66%	1.22%	2.98%	4.58%	5.85%	7.70%	3.20%
HPR	7.11%	13.57%	35.90%	59.78%	81.24%	117.23%	39.05%

U.S. Treasuries < 1 year.  
Eff. duration is 0.38.

1, 3, 7, 10, 20, and  
core (all) total return  
indexes.

Correlation matrix							
	IDCO1STR	IDCO11TR	IDCO13TR	IDCO17TR	IDCO110T	IDCO120T	IDCO1CTR
IDCO1STR	1	0.487	0.346	0.293	0.269	0.231	0.323
IDCO11TR	0.487	1	0.903	0.795	0.720	0.629	0.818
IDCO13TR	0.346	0.903	1	0.963	0.904	0.826	0.955
IDCO17TR	0.293	0.795	0.963	1	0.977	0.929	0.987
IDCO110T	0.269	0.720	0.904	0.977	1	0.977	0.982
IDCO120T	0.231	0.629	0.826	0.929	0.977	1	0.948
IDCO1CTR	0.323	0.818	0.955	0.987	0.982	0.948	1

17

## Treasury return analysis

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Skewness	0.8170	0.3313	-0.0232	-0.1229	-0.1156	-0.1265	-0.0733
Autocorrelation	0.2250	-0.0548	-0.0382	-0.0303	-0.0437	-0.0383	-0.0467
Minimum	-0.0003	-0.0023	-0.0107	-0.0178	-0.0225	-0.0448	-0.0115
Median	0.0000	0.0000	0.0000	0.0001	0.0001	0.0003	0.0001
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Returns and risks are  
monotonically  
increasing.

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18

## Treasury return analysis

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IDCO120T	0.231	0.629	0.826	0.929	0.977	1	0.948
IDCO1CTR	0.323	0.818	0.955	0.987	0.982	0.948	1

As correlations fall, greater is distance between maturities.

19

## Bond products

- Two major risks of longer-term bonds:
  - Interest rate risk – U.S. Treasuries
  - Credit or default risk – Corporates
    - Isolate credit exposure

20

## Morningstar fixed-income box

### Interest-Rate Sensitivity

Limited Moderate Extensive

1	2	3
4	5	6
7	8	9

High

Medium

Low

Interest rate sensitivity: Based on effective duration relative to Morningstar Core Bond Index.

Credit quality: Based on bond rating services.

- High:  $\geq$  AA
- Medium:  $\geq$  BBB and  $<$  AA
- Low:  $<$ BBB

21

## Total bond market ETFs

- Four top total bond market ETFs by \$AUM.

Bond ETFs						
Symbol	Name	Assets	Inception	ER	# of hldgs	Days
BND	Vanguard Total Bond Market ETF	104,870	20070403	0.03%	18,000	188
AGG	iShares Core U.S. Aggregate Bond ETF	101,505	20030922	0.03%	11,500	105
BNDX	Vanguard Total International Bond ETF	54,166	20130604	0.07%	7,500	365
TLT	iShares 20+ Year Treasury Bond ETF	52,163	20020722	0.15%	42	10

- Exposure to entire fixed income market.
  - Various markets and bond types, including municipal bonds, corporate bonds, and other securities.

22

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- BND is benchmarked to Bloomberg US Aggregate Float Adjusted Index. (Bloomberg: LBU**F**TRUU).
- AGG is benchmarked to Bloomberg US Aggregate Float Adjusted Bond Index (Bloomberg: LBU**S**TRUU).

23

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- BNDX is benchmarked to Bloomberg Global Aggregate ex-USD Float Adjusted Index.

24

## Total bond market ETFs

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BNDX	Vanguard Total International Bond ETF	54,166	20130604	0.07%	7,500	365
TLT	iShares 20+ Year Treasury Bond ETF	52,163	20020722	0.15%	42	10

- TLT is benchmarked to ICE US Treasury 20+ Years Bond Index.

25

## Total bond market ETFs

Summary				
Description	BND	AGG	BNDX	TLT
No. of obs.	2794	2794	2794	2794
Mean (daily)	0.000053	0.000052	0.000079	0.000021
StDev (daily)	0.003223	0.003143	0.002435	0.009250
Skewness	-1.274	-1.300	-0.548	-0.020
Kurtosis	46.618	24.613	8.626	4.903
Autocorrelation	-0.01087	0.00927	-0.01258	-0.04107
Minimum	-0.05592	-0.04083	-0.02320	-0.06901
Median	0.00000	0.00009	0.00000	0.00006
Maximum	0.04133	0.02344	0.01326	0.07250
Mean (annual)	1.33%	1.32%	1.99%	0.54%
StDev (annual)	5.12%	4.99%	3.87%	14.68%
CAGR	1.34%	1.33%	2.01%	0.54%
HPR	15.88%	15.76%	24.64%	6.12%

Support file: BND.xlsx

- Volatility highest for TLT.
- BND and AGG has highest correlation.
- BND vs TLT?
- TLT vs BNDX?

Correlations				
	BND	AGG	BNDX	TLT
BND	1	0.954	0.723	0.785
AGG	0.954	1	0.729	0.823
BNDX	0.723	0.729	1	0.641
TLT	0.785	0.823	0.641	1

26

## Bond ETFs by issuer

Bond ETPs by issuer (20211231) Source: ETFdb.com

Issuer	No. of funds	\$AUM(M)	% of total
Blackrock Financial Management	99	519,038	42.5%
Vanguard	20	369,632	30.3%
State Street	32	106,651	8.7%
Charles Schwab	7	43,863	3.6%
Invesco	51	34,001	2.8%
First Trust	17	26,428	2.2%
Allianz Investment Management LLC	12	26,266	2.2%
JPMorgan Chase	12	24,570	2.0%
VanEck	14	17,992	1.5%
Deutsche Bank	8	7,943	0.7%

27

## Bond ETFs by category

Bond ETPs by category (20211231) Source: ETFdb.com

Category	No. of funds	\$AUM(M)	% of total
Total Bond Market	91	393,621	32.2%
Corporate Bonds	83	247,702	20.3%
Government Bonds	41	174,355	14.3%
High Yield Bonds	61	102,537	8.4%
Inflation-Protected Bonds	17	101,223	8.3%
National Munis	48	78,271	6.4%
Mortgage Backed Securities	13	54,687	4.5%
Emerging Markets Bonds	21	32,192	2.6%

28

## Government bond ETFs

- Exposure to government and agency bonds.
  - Include fixed and floating rate Treasuries and TIPS.

Government bond ETFs						
Symbol	Name	Assets	Inception	ER	# of hldgs	Days
TLT	iShares 20+ Year Treasury Bond ETF	52,163	20020722	0.15%	42	10
BIL	SPDR Bloomberg 1-3 Month T-Bill ETF	33,353	20070525	0.14%	19	35
IEF	iShares 7-10 Year Treasury Bond ETF	27,345	20020722	0.15%	14	22
SHY	iShares 1-3 Year Treasury Bond ETF	25,656	20020722	0.15%	86	56
VGSH	Vanguard Short-Term Treasury ETF	23,062	20091119	0.04%	97	111
GOVT	iShares U.S. Treasury Bond ETF	22,724	20120214	0.05%	175	80
VGIT	Vanguard Intermediate-Term Treasury ETF	21,837	20091119	0.04%	106	109

29

## Corporate bond ETFs

- Exposure to investment-grade corporate bonds.

Corporate bond ETFs						
Symbol	Name	Assets	Inception	ER	# of hldgs	Days
VCIT	Vanguard Intermediate-Term Corporate Bond ETF	45,062	20091119	0.04%	2,500	71
VCSH	Vanguard Short-Term Corporate Bond ETF	35,411	20091119	0.04%	2,500	99
LQD	iShares iBoxx \$ Investment Grade Corporate Bond ETF	32,035	20020722	0.14%	3,000	12
IGSB	iShares 1-5 Year Investment Grade Corporate Bond ETF	21,321	20070105	0.04%	4,000	92
IGIB	iShares 5-10 Year Investment Grade Corporate Bond ETF	12,307	20070105	0.04%	3,000	121
USIG	iShares Broad USD Investment Grade Corporate Bond ETF	10,171	20070105	0.04%	10,000	171

30

## High yield bond ETFs

- Exposure to “junk” (below investment grade) bonds.

High yield bond ETFs						
Symbol	Name	Assets	Inception	ER	# of hldgs	Days
HYG	iShares iBoxx \$ High Yield Corporate Bond ETF	19,109	20070404	0.49%	1,500	5
USHY	iShares Broad USD High Yield Corporate Bond ETF	12,067	20171025	0.08%	2,000	55
JNK	SPDR Bloomberg High Yield Bond ETF	8,530	20071128	0.40%	1,500	10

31

## Bond market allocation

- Support file: Bond ETP.xlsx
  - Data for 10-year period ending 20220401
  - SHV: Cash equivalents
  - VOO: Stock portfolio
  - AGG: Total bond market
  - TLT: Long-term Treasury bond (thematic)
  - HYG: High-yield bond (thematic)

32



## Bond market allocation

Summary statistics					
Description	SHV	VOO	AGG	TLT	HYG
n	2,502	2,502	2,502	2,502	2,502
Mean (daily)	0.0000	0.0005	0.0001	0.0002	0.0002
StDev (daily)	0.0001	0.0105	0.0026	0.0087	0.0049
Skewness	0.6291	-0.9251	-2.8164	-0.0888	-0.1191
Autocorrelation	-0.2062	-0.1515	0.0291	-0.0164	0.0346
Minimum	-0.0006	-0.1249	-0.0408	-0.0690	-0.0565
Median	0.0000	0.0008	0.0002	0.0006	0.0003
Maximum	0.0011	0.0911	0.0235	0.0725	0.0634
Mean (annual)	0.57%	13.76%	2.13%	4.08%	4.39%
StDev (annual)	0.21%	16.71%	4.12%	13.85%	7.85%
CAGR	0.58%	14.75%	2.16%	4.17%	4.49%
HPR	5.86%	292.07%	23.58%	49.95%	54.64%

Correlation matrix					
	SHV	VOO	AGG	TLT	HYG
SHV	1	-0.145	0.096	0.164	-0.085
VOO	-0.145	1	-0.029	-0.377	0.763
AGG	0.096	-0.029	1	0.782	0.157
TLT	0.164	-0.377	0.782	1	-0.203
HYG	-0.085	0.763	0.157	-0.203	1

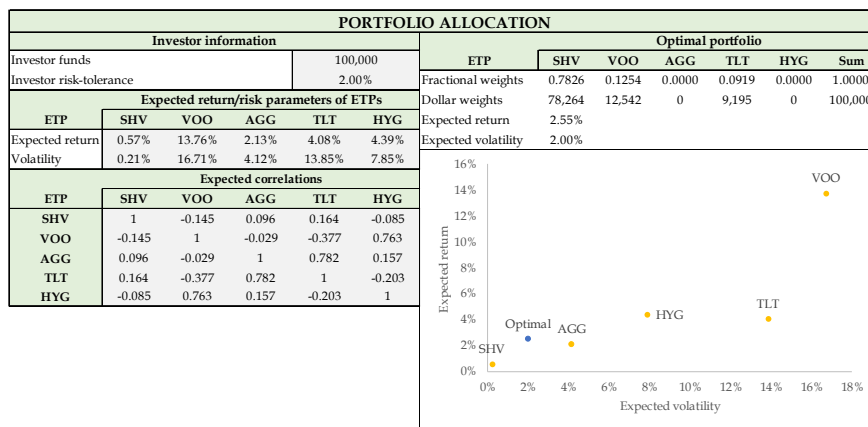
33

## Bond market allocation

- Assume \$100,000 to invest.
  - Cannot short any ETF except SHV (cash equivalents).
  - Cannot borrow more than 100%.
  - Consider range of risk tolerances from 2% to max%.

34

## Bond market allocation



35

## Bond market allocation

Portfolio allocations at different risk tolerances						
Expected return	Expected volatility	Optimal portfolio weights				
		SHV	VOO	AGG	TLT	HYG
2.55%	2.00%	0.7826	0.1254	0.0000	0.0919	0.0000
4.53%	4.00%	0.5639	0.2505	0.0000	0.1856	0.0000
6.50%	6.00%	0.3460	0.3755	0.0000	0.2784	0.0000
8.48%	8.00%	0.1260	0.4997	0.0000	0.3743	0.0000
10.45%	10.00%	-0.0929	0.6243	0.0000	0.4687	0.0000
12.42%	12.00%	-0.3117	0.7488	0.0000	0.5629	0.0000
14.40%	14.00%	-0.5305	0.8734	0.0000	0.6570	0.0000
16.37%	16.00%	-0.7497	0.9978	0.0000	0.7519	0.0000
18.34%	18.00%	-0.9683	1.1224	0.0000	0.8459	0.0000
20.03%	20.00%	-1.0000	1.2854	0.0000	0.7146	0.0000
22.44%	24.00%	-1.0000	1.5345	0.0000	0.4655	0.0000
24.45%	28.00%	-1.0000	1.7423	0.0000	0.2577	0.0000
26.30%	32.00%	-1.0000	1.9330	0.0000	0.0670	0.0000
26.95%	33.46%	-1.0000	2.0000	0.0000	0.0000	0.0000

36

## Lesson summary

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- Choosing among thematic bond ETFs considers:
  - Interest rate risk
    - Behaviors are different at different maturities.
  - Credit risk
- Same analysis techniques apply.

37