AGGREGATE CASH FLOW METHOD FOR YIELD and DURATON CALCULATION FOR FIXED INCOME ETFs

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> INTRODUCTION

Fixed income securities have always been an important part of the investment landscape for institutional and individual investors alike. However, structural developments after the 2008 financial crisis have made it more challenging to execute secondary trades and manage fixed income allocations due to a lack of liquidity in the bond market. At the same time, the fixed income ETF market (FI ETF) has grown very rapidly. By the end of 2014, the total Assets Under Management (AUM) of fixed income ETFs was 442 billion dollars, and accounted for about 36% of the total ETF market. As the liquidity gap between secondary cash bonds and FI ETFs widens, more and more institutional investors are considering the inclusion of ETFs in their strategies. Based on a 2015 Greenwich Associate study, one-quarter of the institutions in the study - and 40% of the investment managers - plan to increase their use of FI ETFs in the next 12 months. ETFs are being used by investors as a liquidity enhancement tool, and are being used alongside individual bond holdings, or in place of futures and other derivatives.

Traditional analytics such as yield, spread and modified duration are widely used for fixed income trading and portfolio management due to their simplicity. These measures are also commonly computed and reported for a group of bonds, which can be a portfolio or an index, and they are often computed as the weighted average of security level measures. Since ETFs are baskets of assets, evaluating an ETF has typically meant looking at it from a portfolio perspective. Therefore, most ETFs currently report their yield and duration using the traditional weighted average approach. Although these measures can be obtained from a number of analytics platforms over the last few years, some challenges remain in using FI ETFs.

First, most ETF providers publish daily holdings and portfolio metrics using the weighted average approach on their websites, but the calculation and publication timing of these metrics may differ among ETF providers, making it challenging to perform fair comparisons across different funds. In addition, most ETFs have a large number of individual bond holdings and it is computationally intensive to aggregate all the analytics. Therefore, even though some analytics platforms can aggregate risk analytics for funds from different providers in a consistent manner, it is rarely done in real time throughout the course of a trading day. At the same time, ETFs trades on the exchange and their prices are updated intra-day. Real time analytics on FI ETFs would add great value to the quoting and trading of these instruments.

Secondly, the methodological difference in calculating these metrics at the portfolio level and bond level prevents direct comparison of an ETF's yield to that of an individual bond. Since a coupon bond can be viewed as a portfolio of zero coupon bonds, the current practice of different calculation methods for individual bonds and a fund seems arbitrary at best. To be more specific, the two methods differ in the order: traditional bond yield calculation for a coupon bond first aggregates the cash flows of all the constituents (zero coupon bonds) and then computes a yield for the aggregate (the bond). The portfolio approach, on the other hand, first computes a yield for each bond, then aggregates the individual yields by market value. For simplicity, we refer to the first method as the “aggregate cash flow” method (or ACF hereafter) and the second one as the “weighted average” method (or WA hereafter). Individual bonds yields are computed using ACF method and ETF yields (as a portfolio) are reported using WA method at the portfolio level with bond level yields computed with ACF method.

To address these issues and to facilitate the trading and management of FI ETFs among institutional investors, an Advisory Group consisting of Bloomberg, BlackRock, and State Street Global Advisors has developed a new standard Fixed Income ETF market convention for calculation yield, spread and other risk metrics using the ACF method. This standardization can help market participates ~~to~~ communicate with one language and facilitate evaluation, trading and usage of fixed income ETFs. In this article, we document the details on how to compute risk metrics such as yield, spread and modified duration using an ACF method for an ETF. We then compare the two methods and point out the different results for both.

> YIELD AND MODIFIED DURATION CALCULATIONS FOR A BOND

In this section, we briefly review the basic definition and math for yield and modified duration calculation for a simple bullet bond. As mentioned before, if we regard a bullet bond as a "fund" that consists of a set of zero coupon bonds with different maturities, the traditional yield definition can be viewed as an ACF method.

Yield to maturity of a bond or other fixed-interest security, is the internal rate of return (IRR, overall interest rate) earned by an investor who buys the bond today at the market price, assuming that the bond will be held until maturity, and that all coupon and principal payments will be made on schedule[1]. Under the assumption that all the coupons are reinvested at an interest rate equal to the yield-to-maturity, the final value at the maturity can be easily computed as the compounded return of the initial investment at the rate of the YTM. Mathematically, the yield-to-maturity y for a zero-coupon bond with 100 par-amount and a maturity in t years can be easily computed from the following:

$$P = \frac{100}{(1+y)^t}$$

Where P is the market price (dirty price) of the bond. The yield y can be solved explicitly as

$$y = \left(\frac{100}{p}\right)^{\frac{1}{t}} - 1$$

Any coupon bond can be viewed as a portfolio of such zero coupon bonds with different maturity dates and par amounts. For instance, assume such a coupon bond trades at a price P with a maturity of T years. The bond pays C_t at time t. The yield of the bond is the constant y that solves the following equation.

$$P = \sum_{t=1}^{T} \frac{C_t}{(1+y)^t}$$

The yield defined this way is the geometric average return under the assumption that all intermediate coupon and other payments can be reinvested at the same rate and the bond is held to maturity. The yield to maturity is commonly used to compare bonds with different characteristics due to its simplicity.

The modified duration is another commonly used risk measure for fixed income securities. The modified duration for a coupon bond is defined as the percentage price change for a 100 bps change in its yield. Continue with above example, the modified duration is computed as follows:

$$D = \frac{\partial P}{\partial y}\left(\frac{-1}{P}\right) = \frac{1}{P}\sum_{t=1}^{T} \frac{tC_t}{(1+y)^{t+1}}$$

The modified duration measures the price sensitivity of a bond to a yield movement. For a given yield shift, the return from such movement can be simply computed as the product of the modified duration and the yield shift[2].

> YIELD AND MODIFIED DURATION CALCULATION FOR A PORTFOLIO USING WA METHOD

Traditionally, yield and modified duration are reported for a group of securities such as a portfolio or an index. The aggregate level analytics are simply computed as weighted averages of analytics of all the constituents. For instance, let's

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[1] Wikipedia

2 Since it is customary to express durations as positive numbers, the return needs to be multiplied by -1.

assume there is a portfolio of N securities and each has a calculated yield to maturity y_n and market value weight of w_n, the portfolio level yield to maturity is usually defined as

$$Y^{WA} = \sum_{n=1}^{N} w_n y_n$$

This weighted average yield for the portfolio serves as a good estimate for the portfolio return over a short horizon assuming the composition of the portfolio remains unchanged. Whenever the weights change, which can be a result of holding adjustments or simply price movements, the weighted average yield can change.

The weighted average modified duration is similarly defined:

$$D^{WA} = \sum_{n=1}^{N} w_n D_n$$

The weighted average modified duration provides a convenient estimate for the return of the portfolio when all yields are moved up (or down) by a given amount. Similarly, whenever the portfolio is updated with position adjustments, the portfolio level duration needs to be re-computed.

As pointed out in the introduction, the calculation method is different for a bond and for a fund. For a bond, we first aggregate all the cash flows, and then compute the yield. While for a fund, we first compute yields for all bonds, then aggregate to arrive at the fund's yield. Even though the calculation is straightforward, for funds with a large number of holdings, a lot of information is needed to compute a fund level yield and therefore funds' analytics are often published only for close price daily.

> YIELD AND MODIFIED DURATION CALCULATION FOR A PORTFOLIO USING ACF METHOD

The idea of computing yield and modified duration for a fund in the same way as that for a bond is motivated by the growing popularity of fixed income ETFs. These funds are being considered as alternatives to individual bonds and therefore practitioners often need to compare them on an equal footing. Conceptually, this can be done quite easily: since a fund is simply a basket of bonds, we can treat it as a "big bond" by aggregating all the cash flows from the fund's individual holdings. Equating the price of the fund and the sum of all discounted cash flows will give rise to an ACF yield for the fund.

Practically, the cash flow production involves the following steps:

1) Generate cash flows for underlying ETF holdings
    a. Underlying holdings from official ETF provider reports valued at official NAV pricing
    b. Cash flows are projected "to worst" and "to maturity"
        i. To Worst: Either to call or to maturity, whichever results in the lowest yield for callable bonds as determined by the official NAV security price
        ii. To Maturity: all bonds are assumed to have cash flows to maturity.
    c. Floaters are valued using next reset coupon held constant to maturity/call date
    d. Mortgages and other complex fixed income securities are not covered in the current release; funds that contain such securities will be covered on a future date.
2) Determine the "implied cash" for the ETF
    a. Implied cash is defined as NAV – Bond MV
    b. Bond MV is the market value of ALL holdings based on official NAV pricing
    c. NAV is the official fund accountant reported Net Asset Vale
3) Aggregate holding level cash flow and "implied cash" into a single cash flow stream for the ETF
    a. "Implied cash" is assumed to mature on Settlement day plus 1 day (SD+1)

   b. SD in US = TD+3 and SD in EMEA = TD+2
   c. Aggregated cash flows are scaled by ETF shares outstanding times 1,000,000. i.e. ((unscaled cash flow/(shares outstanding * 1,000,000))

Once the aggregated cash flow is computed, the analytics can be readily computed following the conventions listed below.

1) Compute intraday/EOD analytics based on ETF market price and cash flows (Yield is computed by equating ETF price multiplied by 1,000,000 to the sum of the discounted aggregate cash flows)
   a. Yield convention for FI ETFs follows following convention
      i. US and GBP = semi-annual 30/360
      ii. EUR = annual 30/360
   b. Spread to benchmark follows corporate bond spread convention
      i. On-the-Run benchmark bond of matching currency to base currency of fund closest to WAL of fund
   c. For EMEA non-base currency listings the market price will need to be converted to the ETF base currency using FX spot
2) Bond Equivalent price is defined as Market Price times 1,000,000 divided by Fund Par times 100 ((Market Price*(1,000,000/Fund Par*100))
   a. Fund Par = implied cash plus holdings current notional
   b. Fund Par is scaled per million shares outstanding

Mathematically, yield to maturity computed using ACF method can be different than yield computed using WA method. Basically, under the ACF method, all cash flows from a fund are consolidated together; ACF yield is the geometric average yield over the “maturity” of the fund with the implicit assumption that earlier cash flows are reinvested at the same yield. The WA yield, on the other hand, computes an arithmetic average of all the bond level yields, with each bond level yield computed separately. If all bonds have the same yield levels, it is easy to validate that these two methods produce the same yields. However, when bonds have different yields, this equality no long holds. We run simulations to study the difference and found some patterns. When yield levels are positively correlated with maturity (upward sloping yield curve), i.e. longer maturity bonds tend to have higher yields, ACF yields are in general higher than WA yields. On the other hand, if yield levels are negatively correlated with maturity (downward sloping yield curve), ACF yields are in general lower than WA yields. In general, the more diverse the cash flows are over time, the steeper is the yield curve, the larger the difference in yields computed using these two methods.

For modified duration, the idea is the same. Once we have per share cash flows, and have computed a fund yield, the modified duration can be computed in the same way as for an individual bond. Similarly, the modified duration computed using aggregated cash flow method is in general different than that computed using weighted average method. Simulation and regression analysis shows that the more dispersed the maturity dates are, the larger the duration difference is.

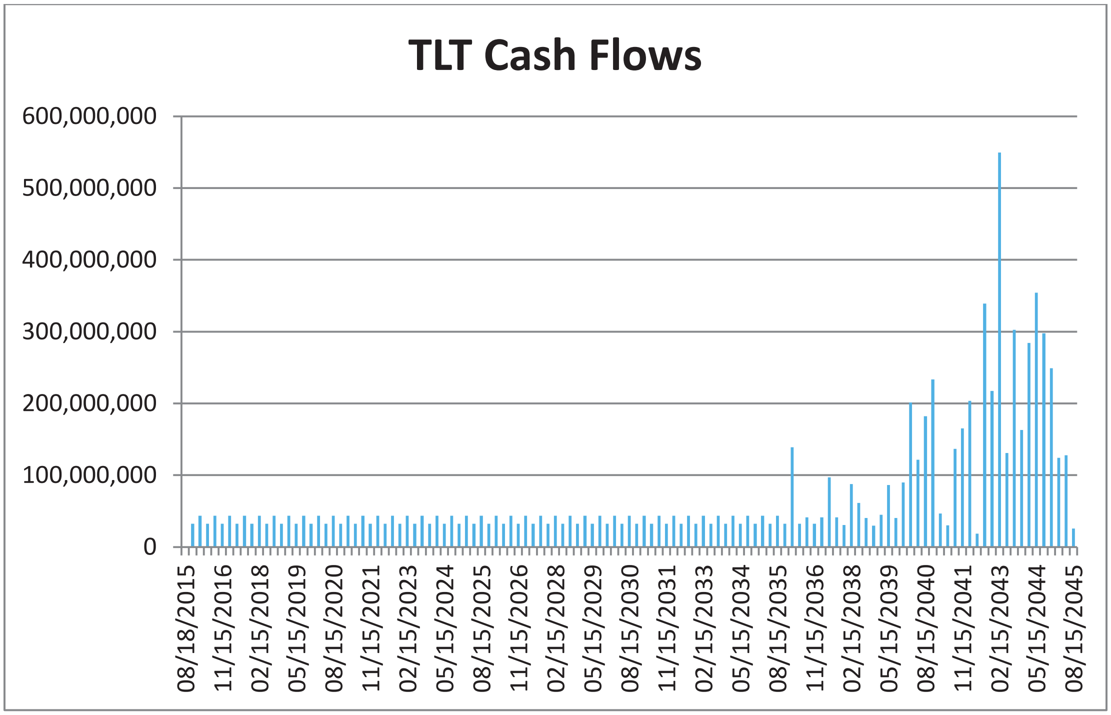
For instance, we compare two funds using these two methods. The first fund is TLT US <equity> - the iShares 20+ year Treasury bond ETF. Looking at the fund as of close 9/17/15 and using the NAV of 118.55, the Yields (Yield to Worst) are 3.027% (YAS function, using the ACF method) and 2.99% (PORT function, using the WA method), and the modified durations are 17.96 years and 17.69 years using the two methods. Both measures are very close to each other. The first screen shot is taken from YAS <Go> and the metrics are computed using aggregated cash flow method (ACF) and the second screen shot is taken from PORT <Go> and the metrics are computed using weighted average method (WA).

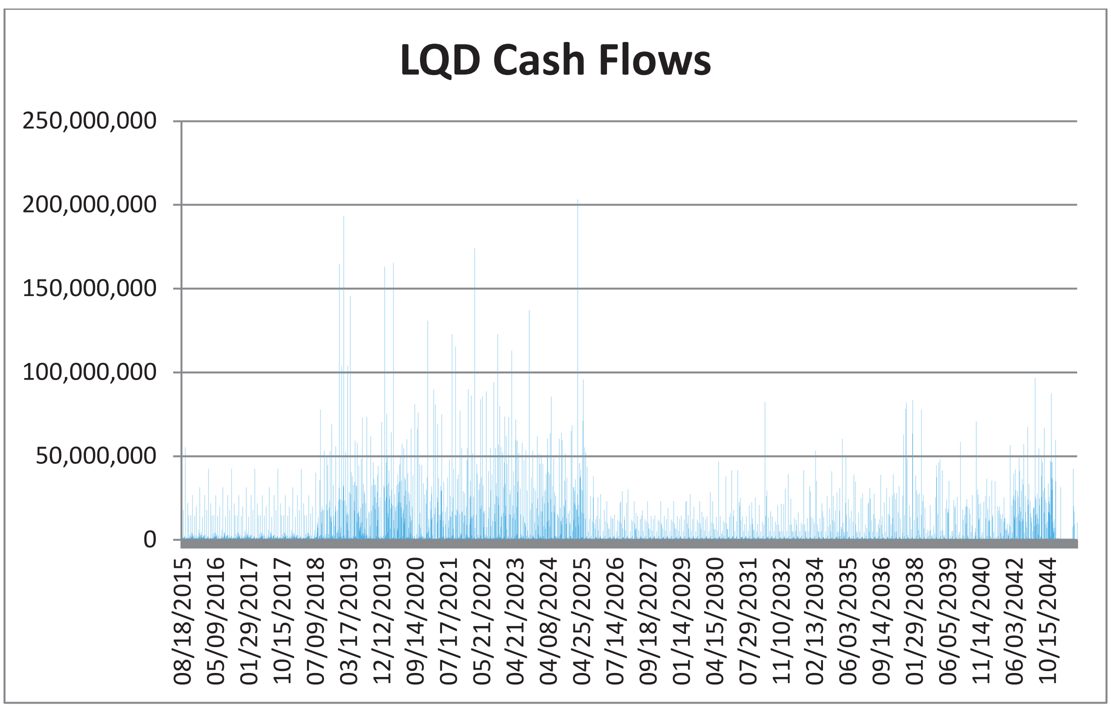
Name	Wgt	Cpn	YTW	Mod Dur	Avg Life	Mkt Val	Pos	Eff Mt
ISHARES BARCLAYS 20+ YEAR TR	100.00	3.416	2.99	17.69	26.81	6,140,801,834	5,683,188,475.70	26.80
Cash	0.06	0.000	0.00	0.00	0.00	3,472,246	3,472,246.00	
US DOLLAR	0.06	0.000	0.00	0.00	0.00	3,472,246	3,472,246.00	
Sovereign	99.94	3.418	2.99	17.70	26.82	6,137,329,588	5,679,716,229.70	26.80
B 0 10/01/15	0.06	0.000	0.00	0.04	0.04	3,693,375	3,693,370.01	0.04
B 0 10/08/15	0.03	0.000	0.01	0.06	0.06	1,921,618	1,921,628.52	0.05
T 0 1/4 10/31/15	0.04	0.250	0.08	0.12	0.12	2,542,817	2,539,893.28	0.12
T 0 1/4 12/31/15	0.03	0.250	0.18	0.28	0.29	1,923,063	1,921,628.52	0.28
T 2 1/2 02/15/45	3.01	2.500	3.06	20.06	29.44	184,727,921	206,748,300.00	29.41
T 2 3/4 08/15/42	6.07	2.750	3.05	18.60	26.93	372,835,124	393,188,100.00	26.91
T 2 3/4 11/15/42	3.91	2.750	3.05	18.57	27.18	240,223,514	251,970,100.00	27.16
T 2 1/8 12/31/15	0.07	2.125	0.24	0.28	0.29	4,347,199	4,304,447.88	0.28
T 2 7/8 05/15/43	3.50	2.875	3.05	18.63	27.68	215,141,268	220,211,500.00	27.66
T 2 7/8 08/15/45	0.58	2.875	3.04	19.73	29.93	35,495,076	36,556,000.00	29.91
T 3 05/15/45	2.61	3.000	3.04	19.31	29.68	160,220,937	159,866,000.00	29.66
T 3 11/15/44	5.03	3.000	3.05	19.09	29.18	308,711,194	308,671,000.00	29.16
T 3 1/2 02/15/39	0.09	3.500	2.93	16.25	23.43	5,807,470	5,283,800.00	23.41
T 3 3/4 08/15/41	2.44	3.750	2.97	17.13	25.93	149,543,406	130,734,300.00	25.91
T 3 3/4 11/15/43	3.55	3.750	3.00	17.89	28.18	218,252,890	189,013,000.00	28.16
T 3 1/8 02/15/42	2.40	3.125	3.01	17.95	26.43	147,726,315	144,238,300.00	26.41

The second fund is LQD US <equity> - the iShares IBOXX Investment Grade Corporate Bond ETF. Looking at the fund as of close 9/18/15 using the NAV 115.58, the Yield to Worst computed using the two methods produce 4.138% (YAS) and 3.61%(PORT), and the modified durations computed using the two methods are 8.688 years and 8.08 years respectively. The differences are quite large in both yield and duration.

Name	Wgt	Cpn	YTW	Mod Dur	Avg Life	Mkt Val	Pos	Eff
ISHARES GS$ INVESTOP CORPORA	100.00	4.261	3.61	8.08	12.21	22,249,810,124	21,140,945,981.23	12.
Automotive	2.27	4.178	3.56	6.67	9.57	505,553,270	478,527,000.00	9.5
Banking	27.38	4.000	[illegible]	[illegible]	9.25	6,092,270,357	5,748,703,000.00	9.2
Basic Industry	4.28	4.638	4.43	8.18	13.21	951,429,391	954,840,000.00	13.
Bonds	0.87	3.585	3.40	9.32	13.62	194,591,087	191,247,000.00	13.
Capital Goods	4.96	4.479	3.34	9.00	13.69	1,103,763,532	1,006,196,000.00	13.
Consumer Goods	5.59	4.222	3.31	7.68	11.27	1,243,418,826	1,171,390,000.00	11.
Energy	11.82	4.438	4.14	8.25	12.87	2,630,582,636	2,572,928,000.00	12.
Financial Services	1.01	4.543	3.40	5.90	7.43	225,850,867	211,905,000.00	7.4
Healthcare	10.39	3.994	3.59	8.82	13.34	2,311,013,727	2,223,802,000.00	13.
Insurance	1.74	4.800	3.71	10.09	16.37	387,244,480	358,440,000.00	16.
Media	6.35	5.334	4.28	9.13	14.91	1,411,922,590	1,300,218,000.00	14.
Real Estate	0.59	4.110	3.15	5.94	7.58	130,598,608	124,479,000.00	7.5
Retail	4.77	4.134	3.48	9.60	14.87	1,061,875,200	979,901,000.00	14.
Services	0.13	4.177	3.34	7.88	11.68	28,524,876	27,801,000.00	11.
Sovereign	0.51	0.483	0.11	0.10	0.60	112,913,405	112,679,981.23	0.6
Technology & Electronics	7.71	3.534	3.23	8.23	11.91	1,716,305,502	1,681,692,000.00	11.
Telecommunications	7.67	4.961	4.18	9.32	15.47	1,707,176,613	1,600,037,000.00	15.
Transportation	0.83	4.483	3.67	10.34	17.04	184,008,618	173,284,000.00	17.
Utility	1.13	5.447	4.37	12.10	20.77	250,766,539	222,876,000.00	20.

As suggested above, if we compare the aggregated cash flows from these two funds, we find that the first fund's cash flows are more concentrated, while the second one is more dispersed over time.





> CONCLUSION

The proposed ACF method for ETFs is motivated to provide the investment community a standard and simple calculation that is directly comparable to individual bonds. The aggregated cash flows are computed daily based on holdings and then can be easily used to update intra-day analytics based on real time prices. The adoption of this standard calculation by a wide range of investors and market participants will enhance transparency, facilitate quoting and trading, and therefore further increase the usage and liquidity of fixed income ETFs. From methodological point of view, the yields computed using ACF method can differ significantly from that computed using the traditional weighted average method. The yield computed using ACF method provides a good long term average yield measure under the assumption of constant holdings. The weighted average approach, on the other hand, serves as a good expected return estimate for a short horizon.

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