IBKR WHITE PAPER

PortfolioAnalyst

Performance Attribution

Introduction

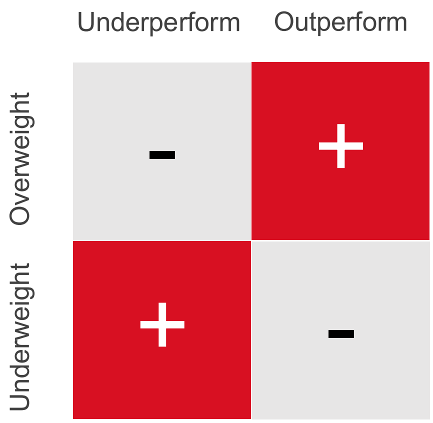
Performance attribution is a quantitative approach to analyzing the result of investment choices. Performance attribution is a tool used to evaluate portfolio managers that decomposes the account's return vs. an appropriate benchmark. The analysis illustrates the decisions made by the portfolio manager.

Performance attribution determines how the portfolio manager's asset allocation and selection of securities affects the portfolio's performance when compared to a benchmark.

Allocation and Selection Effect

Total attribution is the difference between the portfolio's return and the benchmark's return. The two main components of performance attribution are allocation and selection.

Allocation measures the ability to effectively allocate assets to various sectors. It determines whether the overweighting or underweighting of sectors relative to a benchmark contributes negatively or positively to the account's overall return. The allocation effect is illustrated by the chart below.



Positive allocation occurs when the portfolio manager is overweight in a particular sector that has outperformed the benchmark and/or underweight in a sector that has underperformed the benchmark. On the other hand, negative allocation occurs when the portfolio manager is overweight in a sector that has done poorly and/or underweight in a sector that has done well.

Selection measures the ability to select securities within a sector relative to a benchmark. It determines the portion of performance attributable to the portfolio manager's skill in selecting securities. When a portfolio manager is bullish on a security, he or she will be overweight in the security compared to the benchmark's weight. Conversely, if a portfolio manager is bearish on a security, he or she will be underweight in the security compared to the benchmark's weight. Positive selection occurs when the portfolio manager puts more weight than a benchmark in a security that performed well. On the contrary, negative selection occurs when the portfolio manager puts less weight than a benchmark in a security that performed well.

Calculate Allocation Effect

[(Portfolio sector beginning weight plus purchases) – (Benchmark sector beginning weight)]
×
(Benchmark sector return)

Example of Allocation Effect

	Sector	Beginning Weight	Sector Return	Total Return
Portfolio	Basic Materials	10.00%	5.00%	7.50%
S&P 500	Basic Materials	4.00%	2.25%	3.50%

[(10.00%) – (4.00%)] × [2.25%]
(6.00%) × (2.25%) = 0.00135

In this example, the allocation effect is positive since the portfolio manager over weighted the basic materials sector, which performed better than the total benchmark return.

Calculate Selection Effect

(Benchmark sector beginning weight) × [(Portfolio sector return) – (Benchmark sector return)]
+
[(Portfolio sector beginning weight plus purchases) – (Benchmark sector beginning weight)] × [(Portfolio sector return) – (Benchmark sector return)]

Example of Selection Effect

	Sector	Beginning Weight	Sector Return	Total Return
Portfolio	Basic Materials	10.00%	5.00%	7.50%
S&P 500	Basic Materials	4.00%	2.25%	3.50%

[(4.00%) × (5.00%) – (2.25%)] + [[(10.00%) – (4.00%)] × [(5.00%) – (2.25%)]]
(0.0011 + 0.00165) = 0.00275

In this example, the selection effect is positive since the portfolio manager selected securities that performed better than the securities held in the benchmark for that particular sector.

Contribution to Return

Contribution to return measures the contribution of certain portfolio constituents (symbols, sectors) to the portfolio's overall return. For example, contribution to return can decompose a portfolio's return to illustrate which sectors did or did not contribute positively to the portfolio's return.

Calculate Contribution to Return

$$\text{(Portfolio sector beginning weight plus purchases)} \times \text{(Portfolio sector return)}$$

Example of Contribution to Return

	Sector	Beginning Weight	Sector Return
Portfolio	Basic Materials	10.00%	5.00%

[(10.00%)] × [(5.00%)] = 0.5%

In the illustration above, 0.5% is the contribution to return for the basic materials sector.

Frongello Method

	Portfolio	S&P 500	Difference (Portfolio - S&P 500)	Allocation	Selection	Attribution
Quarter 1	4.50%	3.75%	0.75%	0.50%	0.25%	0.75%
Quarter 2	2.25%	3.25%	-1.0%	-0.25%	-0.75%	-1.00%
Cumulative Return	**6.85125%**	**7.12188%**	**-0.27063%**			

As illustrated in the table above, the sum of allocation and selection for quarter 1 and 2 does not equal the cumulative difference in return. Therefore, mathematical smoothing is used to make the total attribution effect equal the cumulative return. The method used is the Frongello.[1]

[1] Andrew Scott Bay Frongello, CFA. Linking of Attribution Results. November 2005.

Frongello Calculation

$$F_{tb} = G_{tb} \prod_{j=1}^{t-1} (1 + R_j) + \bar{R}_t \sum_{j=1}^{t-1} F_{jb}$$

Example of Frongello

Adjusted Allocation

[(Current quarter allocation)] × [(Previous quarter portfolio return)]
+
[(Previous quarter allocation)] × [(Current quarter benchmark return)]

[(-0.25% × 1.045)] + [(0.50% × 3.25%)]

(-0.26%) + (1.63%) = -0.2450%

Adjusted Selection

[(Current quarter selection)] × [(Previous quarter portfolio return)]
+
[(Previous quarter selection)] × [(Current quarter benchmark return)]

[(-0.75% × 1.045)] + [(0.25% × 3.25%)]

(-0.78%) + (0.0081%) = -0.775625%

	Allocation	Selection	Adjusted Allocation	Adjusted Selection	Total
Quarter 1	0.50%	0.25%	0.50%	0.25%	
Quarter 2	-0.25%	-0.75%	-0.245%	-0.775625%	
Total			**0.255000%**	**-0.525625%**	**-0.27063%**

Using the Frongello method, the total adjusted attribution equals the difference of returns between the portfolio and the benchmark.

Conclusion

In summary, attribution is the difference between the portfolio's return and the benchmark's return. The two main components of performance attribution are allocation and selection. You can use this analysis to determine the performance of the portfolio manager. If the attribution effect is positive, then the portfolio manager has contributed positively to the portfolio's overall return. In contrast, if the attribution effect is negative, then the portfolio manager has contributed negatively to the portfolio's overall return.

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* Calculations assume that purchases take place at the beginning of the day while sales, dividends and corporate actions take place at the end of the day.

Money Weighted Return and Time Weighted Return

Introduction

Why do we measure performance? We use the information derived from performance to analyze the progress of a portfolio, evaluate the portfolio manager and provide analysis of asset allocation and the selection of securities. There is a great debate on how to best calculate a portfolio return. There are a few ways to quantify a return performance when cash flows are present. The money weighted return (MWR) and time weighted return (TWR) can be used to calculate returns.

Money Weighted Return

Money weighted return is used when you are trying to measure the performance experienced by an investor. It is a way to measure the return of a portfolio over a specified time period. The return is influenced by the time of decisions to deposit or withdraw funds from the portfolio, as well as the decisions made by the portfolio manager. MWR takes into consideration not only the amount of the cash flow but also the timing of the cash flow.

Modified Dietz is a calculation that is used to determine a return on a portfolio based upon money weighted cash flows. Modified Dietz provides a computational advantage over Internal Rate of Return (IRR). Unlike IRR, it does not require iterative trial and error to solve for the return.[1]

Modified Dietz Formula

$$\frac{EMV - BMV - CF}{BMV + \sum_{i=1}^{n} Wi \times CF_i}$$

Where:	
EMV	Ending Market Value
BMV	Beginning Market Value
CF	Cash Flow
W*i*	Weight to be applied to the Cash Flow on day *i*
CF*i*	Cash Flow on day *i*

Notes:

- Account: Cash flows are end of the day. (Deposits/Withdrawals/Position Transfers)
- Symbol and Asset Level: Opening proceeds are beginning of the day. Closing proceeds are end of day.

1 Peter Dietz. Pension Funds: Measuring Investment Performance. 1966.

Example of Modified Dietz

Date	Market Value	Cash Flow	Days in Period	Weight	Weighted Cash Flow
10/1/2011	4,549,863.44	-	1.00	1.00	0.00
10/4/2011		(225,000.00)	4.00	0.87	(195,967.74)
10/7/2011		81,500.00	7.00	0.77	63096.77
10/12/2011		(75,000.00)	12.00	0.61	(45,967.74)
10/14/2011		125,000.00	14.00	0.55	68,548.39
10/20/2011		7,500.00	20.00	0.35	2,661.29
10/31/2011	4,256,598.99	-	31.00	0.00	0.00
Total		**(86,000.00)**			**(107,629.03)**

[(4,256,598.99) – (4,549,863.44) – (-86,000.00)] / [(4,549,863.44) + (–107,629.03)] = –207,264.45 / 4,442,234.41 = –4.67%

For the month of October, the MWR was –4.67%.

Time Weighted Return

Time weighted return provides a way to calculate the performance solely attributed to the portfolio manager's actions. TWR eliminates the impact of the timing of cash flows and leaves only the effects of the market and the portfolio manager's actions.
To calculate TWR, the performance period is broken into sub-periods. The returns of the sub-periods are calculated and then geometrically linked to derive the TWR for the performance period.

Time Weighted Formula

$$RN = \frac{EMV}{BMV + CF} - 1 \qquad TWR = [(1 + RN) \times (1 + RN) \times \ldots - 1] \times 100$$

Where:	
EMV	Ending Market Value
BMV	Beginning Market Value
CF	Cash Flow
RN	Sub Period Return

Notes:

- Account: Cash flows are end of the day. (Deposits/Withdrawals/Position Transfers)
- Symbol and Asset Level: Opening proceeds are beginning of the day. Closing proceeds are end of day.

Example of Time Weighted Return

Sub Period Return

Date	Beginning Market Value	Ending Market Value	Cash Flow	Sub Period Return
10/3/2011	4,549,863.44	4,629,129.14	-	1.74%
10/4/2011	4,629,129.14	4,197,829.64	(225,000.00)	-4.68%
10/5/2011	4,197,829.64	4,278,627.55		1.92%
10/6/2011	4,278,627.55	4,249,124.71		-0.69%
10/7/2011	4,249,124.71	4,417,916.19	81,500.00	2.02%

To compute the total return over a time period, we do not simply add the sub period returns. Instead, we use the following geometrically linking calculation to arrive at the total return:

Geometrically Link
[(1 +1.74%) X (1 + –4.68%) X (1 + 1.92%) X (1 + –0.69%) X (1 + 2.02%) –1] X 100
The TWR for the period of 10/3 to 10/7 was 0.14%.

The return for multiple components (i.e. sectors or accounts) over a time period is calculated as follows: Add market values and cash flows across all components for each day, calculate a daily combined return, and then geometrically link the daily returns to get the combined return for the time period. Note that the sum of the component returns over the time period does not equal the combined return over the time period.

Conclusion

As stated earlier, the MWR performance measure factors in deposits and withdrawals. This method places a greater weight on the performance in periods in which the portfolio is the largest. For example, suppose the portfolio manager performs well when the portfolio is minuscule. In all likelihood, the portfolio owner will want to deposit additional funds. After the deposit is received, the market falls out of favor with the portfolio. Unfortunately, the return will be greatly impacted by the deposit. TWR is the preferred method of calculating returns by industry standards. A chief advantage of using TWR is that it enables the portfolio owner to determine the rate of return independent of when funds are added and or removed from the portfolio. Typically, portfolio managers have very little control on when they will receive funds or when they will be withdrawn by the portfolio owner.

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Risk Measures and Exposure

Introduction

The risk measures report shows the current risk of a portfolio using several industry standard valuation measures.
Risk measures are only applicable to the Time-Weighted Return (TWR) performance measure.

Alpha Ratio

A ratio that measures excess return compared to a benchmark.

Calculate Alpha Ratio

(Annualized Portfolio Return - Risk-Free Rate of Return) - (Beta (Annualized Benchmark Return - Risk-Free Rate of Return))

Alpha Ratio Example

Date	Portfolio Return	Risk-Free Rate of Return	Benchmark Return
June 2021	3.74%	0.03%	2.74%
June 2020	2.71%	0.17%	1.37%
June 2019	2.29%	2.28%	1.19%
Average	**2.91%**	**0.8267%**	**1.77%**
Annualized	**2.85%**		**1.65%**

Beta = 0.577361349
(2.85% - 0.8267%) – (0.577361349 (1.65% - 0.8267%))
Alpha = 1.55%

Beta Ratio
A ratio that measures the volatility or systematic risk of the portfolio in comparison to a benchmark.

Calculate Beta Ratio
Covariance (Portfolio Returns, Benchmark Returns) / Variance (Benchmark Returns)

Beta Ratio Example

Date	Portfolio Return	Benchmark Return
6/11/2021	0.48%	0.44%
6/10/2021	-1.54%	-1.37%
6/9/2021	1.99%	1.19%
6/8/2021	1.12%	0.89%

Covariance(Portfolio Returns, Benchmark Returns) = 0.000127
Variance(Benchmark Returns) = 0.000132
Beta = 0.000127 / 0.000132
Beta = 0.968214

Calmar Ratio
A ratio used to determine return versus drawdown risk.

Calculate Calmar Ratio
Average Compound Annual Growth Rate / Maximum Drawdown

Calmar Ratio Example

Date	Compound Annual Growth Rate	Max Drawdown
June 2021	1.52%	0.72%
June 2020	-0.39%	-1.09%
June 2019	1.01%	1.11%
June 2018	2.12%	-0.94%
Average	**1.07%**	
Max Drawdown		**1.09%**

1.07 / 1.09 = 0.98

Correlation

A statistical figure that measures the interdependence between the range of returns for a specified benchmark(s) and your portfolio. A positive correlation exemplifies a strong relationship whereas a negative correlation exemplifies a weak relationship.

Calculate Correlation

Covariance / Product of Standard Deviations

Where:	
A	List of deviations from the mean for each account return per day
B	List of deviations from the mean for each given benchmark return per day
Covariance	(SUMMATION (A~X~+ B~X~)) / (Number of Account Returns – 1)
Product of Standard Deviations	Account Standard Deviation X Given Benchmark Standard Deviation

Correlation Example

Date	Account Return	Benchmark Return	Account Deviation from Mean	Benchmark Deviation from Mean	Account Deviation from Mean Squared	Benchmark Deviation from Mean Squared
9/25/2017	-.008800	-0.002200	-0.009700	-0.003620	.000094	0.000013
9/26/2017	.000100	0.000100	-0.000800	-0.001320	0.000001	0.000002
9/27/2017	.008100	0.004100	-0.007200	0.002680	0.000052	0.000007
9/28/2017	.001100	0.001400	0.000200	-0.000020	0.000000	0.000000
9/29/2017	.004000	0.003700	0.003100	0.002280	0.000010	0.000005
Mean Return	**0.000900**	**0.001420**				
Sum of the Deviation from Mean Squared	**0.000156**	**0.000027**				
Variance	**0.000039**	**0.000007**				
Standard Deviation	**0.006249**	**0.002609**				

0.00001563 / 0.00001630 = 0.96

Distribution of Returns

The range of return percentage of each day, month, or quarter in the specified time period and the number of times the return performance fell within that range for the entire period.

Downside Deviation

The standard deviation for all negative returns in your portfolio in the specific time period.

Information Ratio

A ratio that calculates the risk-adjusted returns of a portfolio relative to a benchmark.

Calculate Information Ratio

(Portfolio Return - Benchmark Return) / Tracking Error

Information Ratio Example

Date	Portfolio Return	Benchmark Return	Difference
June 2021	2.14%	1.74%	0.40%
June 2020	1.98%	1.27%	0.71%
June 2019	0.74%	1.12%	-0.38%
Average	**1.62%**	**1.38%**	**0.24%**

Standard Deviation (Tracking Error) = 0.005616345
Information Ratio = (1.62% - 1.38%) / 0.005616345
Information Ratio = 0.433259219

Max Drawdown

The largest negative cumulative return from a peak to a trough before a new peak is attained, expressed as a percentage. Maximum drawdown is an indicator of downside risk over a specified period.

Calculate Max Drawdown

The largest negative cumulative return from a peak to a trough before a new peak is attained is calculated using VAMI (1000 X (1 + Return).

[(Largest VAMI During Specified Period – Ending VAMI During Specified Period) / (Largest VAMI During Specified Period)]

Notes:

- The Max Drawdown is reflected as a positive percentage.

Max Drawdown Example

Sub Period	TWR	VAMI	Peak VAMI	Max VAMI Drawdown	Max Drawdown %
		1,000.00			
Jan 2023	8.29%	1,082.94	1,082.94	0.00	0.00%
Feb 2023	9.05%	1,180.89	1,180.89	0.00	0.00%
Mar 2023	-0.84%	1,170.92	1,180.89	9.97	0.84%
Apr 2023	10.99%	1,299.61	1,299.61	0.00	0.00%
May 2023	3.17%	1,340.83	1,340.83	0.00	0.00%
Jun 2023	-2.35%	1,309.39	1,340.83	31.45	2.35%
Jul 2023	-0.11%	1,307.91	1,340.83	32.92	2.46%
Aug 2023	0.59%	1,315.69	1,340.83	25.15	1.88%
Sep 2023	-4.77%	1,252.90	1,340.83	87.93	6.56%
Oct 2023	-4.56%	1,195.82	1,340.83	145.01	10.81%
Nov 2023	-6.01%	1,123.95	1,340.83	216.88	16.18%
Dec 2023	0.07%	1,124.69	1,340.83	216.14	16.12%

Mean Return
The average time weighted return of your portfolio for a specified time period.

Negative Periods
The number of occurrences of negative performance returns. For example, if you select a monthly report with 12 months, each month with a negative return would be a negative occurrence.

Peak-to-Valley
The period during which the max drawdown occurred. For example, if the start of the largest negative cumulative return was April 1st and the end was April 5th, the Peak-to-Valley would be 4/1 – 4/5.

Positive Periods
The number of occurrences of positive performance returns. For example, if you select a monthly report with 12 months, each month with a positive return would be a positive occurrence.

Recovery

The time it took for the NAV of your account to recover from the valley (lowest NAV) back to peak (highest NAV).
For example, if the valley was on April 5th and your account NAV returned to peak on April 6th, the recovery would be 1 day.

Notes:

- If the account NAV has yet to recover back to peak, recovery will show ongoing in the Risk Analysis.

Sharpe Ratio

A ratio that measures the excess return per unit of risk. The ratio is used to characterize how well the return compensated the account holder for the risk taken.

Calculate Sharpe Ratio

[(Annualized Account Return – Annualized Risk-Free Rate) / Annualized Standard Deviation]

Where:	
Annualized Account Return	(Average Return) $\times n$
Annualized Standard Deviation	(Standard Deviation) $\times \sqrt{n}$
n	The period, ie. Daily = 360

Notes:

- The Risk-Free Rate is the US 3 Month Treasury Bill.

Sharpe Ratio Example

Using n = 360 and Annualized Risk-Free Rate = 1.37:
If the average account return is .017677, the annualized account return is .017677 $\times$ 360 or 6.363723.
If the standard deviation is .162357, the annualized standard deviation is .162357 $\times \sqrt{360}$ or 3.080508.

Therefore, the Sharpe Ratio is: [(6.363723-1.37) / 3.080508] = **1.62**

Sortino Ratio

The ratio measures the risk adjusted return of the account. The ratio penalizes only those returns that fall below the required rate of return.

Calculate Sortino Ratio

[(Annualized Excess Return / Annualized Downside Deviation)]

Notes:

- The historical annual return including dividends since inception of the S&P 500 is used to calculate the downside deviation and the Sortino Ratio.

Sortino Ratio Example

Date	Account Return	Risk-Free Rate	Excess Return
January 2018	6.50%	0.60%	5.90%
February 2018	1.56%	0.60%	0.96%
March 2018	-15.49%	0.60%	-16.09%
April 2018	31.57%	0.60%	30.97%
Average	**6.04%**	**0.60%**	**5.44%**
Annualized			**6.52%**

[(6.52% / (10.00% × ($\sqrt{12}$)] = 0.19

Notes:

- Downside deviation is the standard deviation of all negative returns within the specified time period. In the above example, the only negative account return was for March 2018.
- The number of values used in the given time period is less than the monthly period used to annualize excess return and downside deviation.

Standard Deviation

A statistical measurement of variability. It shows how much variation or dispersion there is from the average.

Calculate Standard Deviation

$$\sigma = \sqrt{\frac{\Sigma(x - \bar{x})^2}{n}}$$

Where:

σ	Standard deviation of a sample
Σ	Sum of
x	Each value in the data set
x	Mean of all values in the data set
n	Number of values in the data set

Tracking Error

A statistical figure that represents the deviations from the difference between returns of the portfolio and returns of the benchmark.

Calculate Tracking Error

Standard Deviation × [(Portfolio Return Day 1 – Benchmark Return Day 1, (Portfolio Return Day 2 – Benchmark Return Day 2), etc.]

Turnover
Percentage of holdings that have been replaced in a given year.

Calculate Turnover
The total value of new securities purchased, or the value of new securities sold (whichever is less) / monthly average of the market value of the portfolio securities during the report period.

Turnover Example

Date	Portfolio Return	Benchmark Return
June 2021	$1,540.43	$150
July 2021	$2,100.19	-$200
August 2021	$1,903.97	$100
Average	**$1,848.20**	**-**

Value of Securities Purchases = $200
Turnover = 200 / 1,848.20
Turnover = 10.82%

VAMI (Value-Added Monthly Index)
A statistical figure that tracks the daily, monthly, or quarterly performance of a hypothetical $1000 investment.

Calculate VAMI
$1000 \times [(1 + \text{Return})]$ OR Previous VAMI $\times$ [(1 + Current Return)]

Exposure

Exposure is key when considering long and short strategies to evaluate risk and leverage.

Long and Short Exposure

Long/short exposure only includes positions held and long/short parsed exposure includes components of funds held in the portfolio.

Type	Exposure	$	%
Long	Exposure	Total Long Value	Total Long Value / (Total Long Value + Total Short Value)
Long	Parsed Exposure	Total Parsed Long Value	Total Parsed Long Value / (Total Parsed Long Value + Total Parsed Short Value)
Short	Exposure	Abs(Total Short Value)	Abs(Total Short Value / (Total Long Value + Total Short Value))
Short	Parsed Exposure	Abs(Total Parsed Short Value)	Abs(Total Parsed Short Value / (Total Parsed Long Value + Total Parsed Short Value)

Gross and Net Exposure

Gross/net exposure only includes positions held and gross/net parsed exposure includes components of funds held in the portfolio. Key points to keep in mind: The lower the net exposure the lower the risk. If 100% long and 100% short, net exposure is 0%. If net exposure is negative, short exceeds longs positions and portfolio is net short.

Exposure	$	%
Gross Exposure	Total Long Value + Abs(Total Short Value)	Long Exposure % + Total Short Exposure %
Parsed Gross Exposure	Total Parsed Long Value + Abs(Total Parsed Short Value)	Parsed Long Exposure % + Total Parsed Short Exposure %
Net Exposure	Total Long Value + Total Short Value	Long Exposure % - Total Short Exposure %
Parsed Net Exposure	Total Parsed Long Value + Total Parsed Short Value	Parsed Long Exposure % - Parsed Short Exposure %

Conclusion

Risk Measures and exposure are historical predictors of investment risk, volatility, leverage, and overall portfolio analysis. Risk measures assess the performance of a portfolio which can be compared to a specific benchmark.

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End Notes

1. The Risk Measures Benchmark Comparison Report shows the risk of your portfolio compared to the risk of up to three benchmarks. The standard risk measures calculations are the same as the Risk Measures Report.
2. Correlation and Tracking Error will only appear on the Risk Measures Benchmark Comparison Report.
3. Lipper is the fund data source used for parsed exposures. Parsed data is available for most but not all funds.

Retirement Planner Overview

The Retirement Planner may help improve your understanding of your retirement outlook. The tool supports retirement planning for up to two individuals. The tool considers each individual's personal retirement preferences, current and future employment expectations, any potential additional monthly retirement income sources, and current combined monthly expenses. Using the information provided and the accounts included, the Retirement Planner will generate a retirement outlook to help you plan for your future.

User Details

The Retirement Planner utilizes user data when generating a retirement outlook. User data may be prefilled from existing user/account information or manually entered by the user. Some prefilled user data may be changed and, in doing so, may affect the retirement outlook.

Retirement Plan Information

Field	Definition
Name	Name is the individual's name. The name will be prefilled for the user that is currently logged in from existing user/account data and is not an editable field. However, when including an additional individual in the retirement plan, the name field is not prefilled and is editable.
Date of Birth	Date of birth is the individual's date of birth. The DOB will be prefilled for the user who is currently logged in from existing user/account data and is not an editable field. When including an additional individual in the retirement plan, the DOB field is not prefilled and is editable.
Base Currency	The currency used throughout the Retirement Planner is prefilled from existing user/account data and is not an editable field. Accounts included with a currency other than the base currency will have their figures converted to the base currency.
Retirement Status	For each individual, use this field to define whether they are retired or not. The field is defaulted to "Not Retired" but may be changed at any time.
Desired Retirement Age	For each individual, use this field to define the age at which they would like to retire. This field is not prefilled, is required, and can be changed by the user at any time.
Retirement Plan End Year	The retirement plan end is the year in which you would like the retirement plan to end. This field is not prefilled, is required, and can be changed by the user at any time.
Annual Inflation Rate %	The average inflation rate you expect before and during retirement. The default value for the field is 3% and may be changed by the user at any time.
Total Annual Compensation	Each individual's total annual compensation (salary, bonus, commissions, etc.). This field will be prefilled for the user that is currently logged in from existing user/account data and is an editable field. When including an additional individual in the retirement plan, this field is not prefilled, is required, and is editable at any time.
Annual Compensation Growth Rate %	For each individual, this is the average annual rate at which their total compensation will grow. The field defaults to 3% and may be changed by the user at any time.
Effective Tax Rate %	The effective tax rate each individual expects to pay on taxable distributions during retirement. The field defaults to 20% and may be changed by the user at any time.

Monthly Retirement Income

Field	Definition
Income Label	The label given to the additional monthly retirement income. This field is required and can be changed at any time.
Amount	The amount of the additional monthly retirement income. This field is required and can be changed at any time.
Taxable	A toggle to select if an additional monthly retirement income is taxable or not. This field is defaulted to “Yes” and can be changed at any time.
Start Date	A start date for the additional monthly retirement income. This field is not required and may be changed at any time. If no start date is provided, the income will start when the individual retires.
End Date	An end date for the additional monthly retirement income. This field is not required and may be changed at any time. If no end date is provided, the income will continue until the end of the retirement plan.

Monthly Expenses

Field	Definition
Expense Label	The label given to the current monthly expense. This field is required and can be changed at any time.
Amount	The amount of the current monthly expense. This field is required and can be changed at any time.
Start Date	A start date for current monthly expense. This field is not required and may be changed at any time. If no start date is provided, the expense will start immediately.
End Date	An end date for the current monthly expense. This field is not required and may be changed at any time. If no end date is provided, the expense will continue until the end of the retirement plan.

Life Events

Field	Definition
Life Event Label	The label given to the life event. This field is required and can be changed at any time.
Amount	The amount of the life event. This field is required and can be changed at any time.
What will be the impact?	Choose between a one-time income or one-time expense as a result of the life event. This field is required and may be changed at any time.
When will this life event take place?	Choose a specific date for the life event or select date ranges for the event to occur randomly during the retirement plan. This field is required and may be changed at any time. If a random date option is selected, a random date during the applicable window will be generated for the life event.

Account Details

The Retirement Planner allows users to include or exclude various accounts within their retirement plan. The tool currently supports brokerage, bank, other asset, and real estate account types. Before an account may be included in the view, the account will need to be configured. The information we will need to collect for an account will be determined by the account type.

Accounts

This panel shows all the possible accounts that may be configured and included in the Retirement Plan.

Account Configuration

Users must configure an account and select to have it included in the plan before the account can be included in the Retirement Plan. Depending on the type of account, you will need to make some simple assumptions to better project the accounts impact throughout the Retirement Plan.

Brokerage Accounts

Question	Additional Information
Taxable	We ask this question to determine if we should deduct taxes from distribution during retirement.
Account Owner	Only applicable to retirement plans which include two individuals. We ask this question to determine if an account is owned by one of the individuals on the plan or if the account is owned jointly.
Contribution Type	We ask this question to determine how the individual(s) will be contributing to the account before retirement. • **No Contribution** • **Amount > Annual Contribution Amount** The amount that will be contributed to the account annually. • **Percent > Percent of Total Compensation** The percentage of total annual compensation that will be contributed to the account annually.

Bank Accounts

Question	Additional Information
Taxable	We ask this question to determine if we should deduct taxes from distribution during retirement.
Account Owner	Only applicable to retirement plans which include two individuals. We ask this question to determine if an account is owned by one of the individuals on the plan or if the account is owned jointly.
Contribution Type	We ask this question to determine how the individual(s) will be contributing to the account before retirement. • **No Contribution** • **Amount > Annual Contribution Amount** The amount that will be contributed to the account annually. • **Percent > Percent of Total Compensation** The percentage of total annual compensation that will be contributed to the account annually.
Interest Rate	We ask this question to determine the interest the checking or savings account receives so that we can project the account growth throughout the retirement plan.

Other Asset and Real Estate Accounts

Question	Additional Information
Account Owner	Only applicable to retirement plans which include two individuals. We ask this question to determine if an account is owned by one of the individuals on the plan or if the account is owned jointly.
Annual Appreciation Rate %	We ask this question to determine the average annual appreciation or depreciation a user would expect to see for the other asset or real estate account.
How will this asset be utilized?	We ask this question to determine how the account will be utilized during retirement: • **Sell** • **Loan > Loan Amount as a Percent of Asset Value** ○ We ask about loan amount as a percentage of the asset value to determine how your expenses are impacted at the time of the sale. ○ Only available for Real Estate account types.
Monthly Expense Adjustment	We ask this question to determine if the monthly expenses should be adjusted up or down based on the sale or loan against the other asset or real estate account.
Liquidate Last	Users can designate only one of their Other Asset or Real Estate accounts to be liquidated last. By designating an account as liquidate last, the Other Asset or Real Estate account would be utilized only after all other accounts have been utilized to cover expenses.

Retirement Outlook

The Retirement Outlook uses an interactive chart and corresponding table to better depict the user's retirement picture. Within the Retirement Outlook, you may choose between an Asset Value view and a Retirement Income view.

The Asset Value view will show the user how the account values grow before retirement, the value of all accounts at retirement, and how withdrawals from the accounts affects the value of all accounts throughout retirement.

The Retirement Income view will show users the yearly Total Income, Expenses, and the Surplus/Deficit when applicable. This view starts from the year of the earliest retirement start date and ends at the retirement end date year.

The Pre-Retirement Return and Post-Retirement Return fields may be adjusted to see how various market conditions impact the Retirement Outlook. Once you have made a change to either field, clicking on the Recalculate button will reload both the chart and table.

Table

Regardless of the view selected, the table will display to users a detailed yearly breakdown of various retirement figures. The table columns are configurable and consist of the following:

- Year
- Age
- Starting NAV
- Contributions
- Distributions
- Weighted Return
- Ending NAV
- Total Retirement Income
- Total Expenses
- Surplus or Deficit
- Total Compensation
- Compensation Growth Rate
- Inflation Rate
- Distribution Income
- Additional Other Income
- Sale & Loan Proceeds Withdrawal

Assumptions and Methodology

Within the Retirement Planner tool, we make various assumptions to assist with projecting the users Retirement Outlook.

General Assumptions

Factor	Assumption
Inflation	The inflation rate will remain constant through the retirement plan.
Monthly Expenses	The shared current monthly expenses are adjusted monthly by the configured inflation rate throughout the retirement plan.
Interest Rate	When including a Bank account type, we assume the provided interest rate remains constant throughout the retirement plan.
Annual Appreciation	The appreciation rate provided for an Other Asset or Real Estate account remains constant throughout the retirement plan.
Market Performance	Both pre-retirement and post-retirement market performance will remain constant throughout their respective time frames and is the return used to calculate brokerage account growth.
Life Events	A life event which results in a one-time income will not be taxed. When creating a life event, if one-time income option is chosen, users should enter the after-tax amount of the life event.

Pre-Retirement Assumptions

Factor	Assumption
Total Compensation	The total compensation provided for each individual will grow annually in January at the provided annual compensation growth rate. Total compensation will be set to zero for the applicable individual during retirement.
Annual Compensation Growth Rate %	The compensation growth rate for each individual will remain constant through the retirement plan.
Contributions	Contributions from an individual will stop once the individual enters retirement.

Post-Retirement Assumptions

Factor	Assumption
Monthly Retirement Income	Additional monthly retirement income grows annually by the expected inflation rate starting when the individual enters retirement. This income is used first to cover any expenses before any distributions or sale/loan proceeds.
Distributions	Distributions occur only during retirement and only up to the amount needed to cover expenses.
Other Asset or Real Estate Sales	A sale of an Other Asset or Real Estate account occurs to cover expenses when all other higher priority accounts have been withdrawn to zero and additional distribution income is needed to cover the total expenses. The sales proceeds will then be used to cover expenses when available. Taxes are not deducted from the sale proceeds.
Real Estate Loans	A loan against a Real Estate account will take place to cover expenses when all other higher-priority accounts have been withdrawn to zero and additional income is needed to cover the total expenses. The loan proceeds will then be used to cover expenses when available.
Taxes	Both Distributions (when configured such that withdrawals are taxable) and retirement income (when configured such that the income is taxable) are taxed at the users specified Expected Effective Tax Rate in Retirement.

Methodology

Factor	Explanation
Compounding	Monthly compounding is used throughout the length of the retirement plan.
Early Withdrawals	This tool does not track or account for early withdrawal penalties in any capacity. Required Minimum Distributions. This tool does not track or account for required minimum distributions (RMDs) in any capacity.
Taxes	If an account is configured such that distributions are taxable, the total net distribution is calculated by [distribution amount – (distribution amount * effective tax rate)].
Weighted Return	The weighted return considers each account's individual expected return and account size to show the combined assumed return for all accounts that are included in the retirement plan.
Starting NAV	The total starting value of all Brokerage, Bank, Other Asset and Real Estate accounts, plus any Other Asset or Real Estate sales or loan proceeds.
Contributions	**Percent Contributions** For each individual, percent contributions are added monthly to the respective account as a percentage of the individual's total monthly compensation (Total Compensation / 12). **Amount Contribution** For each individual, amount contributions are made once annually to an account in January.
Distributions	Distributions occur only during retirement and only up to the amount needed to cover expenses. • **Account Priority** – Distributions are taken first from taxable accounts, then tax- differed accounts, then non-taxable accounts, then Other Asset or Real Estate accounts, and lastly Other Asset or Real Estate accounts marked as the Last Resort. When more than one account of the same type is included, distributions are taken from the largest account first. • **Account Ownership** – Each individual may take distributions from jointly owned accounts, accounts owned by the other individual, as well as their own accounts.
Ending NAV	Total ending value of all Brokerage, Bank and Other Asset accounts, plus any Other Asset sales or loan proceeds. Ending Value = (Starting Value + Contributions – Distributions) + (Starting Value + Contributions – Distributions) * (Market Performance Assumption (for bank/brokerage account types) OR Interest Rate (when selected for bank accounts) OR Annual Appreciation Rate (for Other Asset accounts)).
Sale & Loan Proceeds	**Sale Proceeds** The sale proceeds when a real estate or other asset account is sold is determined by the value of the account at the time of the sale. Note, taxes and fees are not taken out of the sale proceeds. **Loan Proceeds** The loan proceeds when a real estate account is sold is determined by the value of the account at the time of the loan and the loan amount percentage of total account value.
Different Retirement Dates	When a retirement plan includes two individuals, the expenses are combined and shared. In the event of the individuals retiring at separate times within the plan, we will calculate the retirement individual's percentage of expenses that they will need to cover. The retired individuals expense obligation is calculated by (retired profile compensation / total combined compensation). This percentage expense obligation will be used to determine how much distributions must equal for the retired individual.

Interest Rate Sensitivity

Introduction

The interest rate sensitivity widget and report estimate how sensitive a portfolio's fixed income holdings are to changes in interest rates. Interest rate sensitivity is a measure of how much the price of a fixed income holding will fluctuate due to changes in the interest rate environment. Holdings that are more sensitive may have greater price fluctuations than those with less sensitivity.

Bond Example

For each calculation, a hypothetical bond with the below characteristics will be used.

Face Value:	$1,000
Current Market Price:	$973.3569
Coupon Rate:	6% paid semi-annually ($30 per payment)
Current YTM:	7%
Maturity:	3 years (6 semi-annual periods)
Issue Date:	January 15, 2023
Maturity Date:	January 15, 2026

Macaulay Duration

Measures in years the weighted average time until a bond's cash flows are received, reflecting the bond's sensitivity to interest rate changes. Macaulay duration quantifies the time it takes for an investor to be repaid through a combination of interest and principal payments.

Macaulay Duration Formula

$$Macaulay\ Duration = \frac{\sum_{i=1}^{n} PV(i) \times \frac{t \times CF(i)}{P}}{P}$$

Where:

PV = Present value of each cash flow $= CF/(1+r)^t$

t = Time period of each cash flow (in years)

CF = Cash flow amount (coupon payment or coupon + face value)

P = Current bond price

r = Yield to maturity per period ($YTM/2$ for semi-annual bonds)

n = Total number of periods

Macaulay Duration Example

$$i = 1: [(30/1.035^1) \times (0.5/973.3569)] \times 973.3569 = 14.492$$

$$i = 2: [(30/1.035^2) \times (1.0/973.3569)] \times 973.3569 = 28.0053$$

$$i = 3: [(30/1.035^3) \times (1.5/973.3569)] \times 973.3569 = 40.5874$$

$$i = 4: [(30/1.035^4) \times (2.0/973.3569)] \times 973.3569 = 52.2865$$

$$i = 5: [(30/1.035^5) \times (2.5/973.3569)] \times 973.3569 = 63.1479$$

$$i = 6: [(1030/1.035^6) \times (3.0/973.3569)] \times 973.3569 = 2{,}513.7169$$

$$Macaulay\ Duration = Sum\ of\ all\ terms/P = 2{,}712.2367/973.3569 = 2.7865\ years$$

Modified Duration

Measures the percentage change in a bond's price for a 1% (100 basis point) change in yield. It represents the slope of the price-yield relationship at a given point.

Modified Duration Formula

$$Modified\ Duration = \frac{Macaulay\ Duration}{1 + \left(\frac{YTM}{n}\right)}$$

Where:

YTM = Yield to maturity

n = Total number of coupon periods per year

Modified Duration Example

$$Modified\ Duration = \frac{2.7865}{1 + \left(\frac{0.07}{2}\right)} = \frac{2.7865}{1.035} = 2.6922$$

Convexity

It measures the curvature of the relationship between bond prices and yields. Convexity demonstrates why Modified Duration alone (which assumes a linear relationship) becomes less accurate for larger interest rate changes. Applying Convexity to the calculated Modified Duration makes price estimates more accurate, especially for larger yield changes.

Convexity Formula

$$Convexity \approx \frac{P(+) + P(-) - 2P(0)}{P(0) \times \Delta y^2}$$

Where:

P(+) = Bond market value after yield increase
P(-) = Bond market value after yield decrease
P(0) = Current bond market value
Δy = Change in yield (typically 0.0001 or 1 basis point)

Convexity Example

$P(+)$ calculation using $\Delta y = 0.01\%$ resulting in a current YTM of 3.51% $((7.0\%/2) + 0.01\%)$ per payment period.

$$P(+) = \frac{30}{1.0351^1} + \frac{30}{1.0351^2} + \frac{30}{1.0351^3} + \frac{30}{1.0351^4} + \frac{30}{1.0351^5} + \frac{1030}{1.0351^6}$$

$$P(+) = 28.9827 + 27.9999 + 27.0504 + 26.1331 + 25.2469 + 837.4200$$

$$P(+) = 972.833$$

$P(-)$ calculation using $\Delta y = -0.01\%$ resulting in a current YTM of 3.49% $((7.0\%/2) - 0.01\%)$ per payment period.

$$P(-) = \frac{30}{1.0349^1} + \frac{30}{1.0349^2} + \frac{30}{1.0349^3} + \frac{30}{1.0349^4} + \frac{30}{1.0349^5} + \frac{1030}{1.0349^6}$$

$$P(-) = 28.9883 + 28.0107 + 27.0661 + 26.1533 + 25.2714 + 838.3915$$

$$P(-) = 973.8813$$

Calculating Convexity using the $P(+)$ and $P(-)$ values above.

$$Convexity \approx \frac{972.833 + 973.8813 - 2(973.3569)}{973.3569 \times 0.0001^2}$$

$$Convexity \approx \frac{0.0005}{0.00000973}$$

$$Convexity \approx 51.3874$$

Estimating Bond Value Change

For a given rate change, both the Duration Effect and Convexity Effect can be used to more accurately estimate how the value of a fixed income holding will be impacted.

Bond Value Change Formula

$$Duration\ Effect = P(0) \times (Modified\ Duration \times -\Delta y)$$

$$Convexity\ Effect = P(0) \times \left(\frac{1}{2} \times Convexity \times \Delta y^2\right)$$

$$\Delta P = Duration\ Effect + Convexity\ Effect$$

Where:

P(0) = Current bond market value
Δy = Change in interest rate
ΔP = Total bond value change

Bond Value Change Example

Current bond value $P(0)$ is $973.36. See below ΔP calculation assuming a +2% rate change.

$$Duration\ Effect = 973.3569 \times (2.6922 \times -0.02)$$

$$Duration\ Effect = -52.4094$$

$$Convexity\ Effect = 973.3569 \times \left(\frac{1}{2} \times 51.3874 \times 0.02^2\right)$$

$$Convexity\ Effect = 10.0036$$

$$\Delta P = -52.4094 + 10.0036$$

$$\Delta P = -42.4058 = -\$42.41$$

Rate Change	Duration Effect	Convexity Effect	ΔP	Est. Bond Value	% Value Change
+2%	-$52.41	$10.00	-$42.41	$930.95	-4.36%
0%	$0.00	$0.00	$0.00	$973.36	0.0%
-2%	$52.41	$10.00	$62.41	$1,035.77	6.41%

Conclusion

Within the Interest Rate Sensitivity report and widget, we calculate the Macaulay Duration for each fixed income holding in a portfolio. Using Macaulay Duration, we calculate the Modified Duration which is used to determine the Duration Effect from a given interest rate change. We then estimate each bond position's Convexity by calculating the bond value given a small positive and negative interest rate change. Using a bonds calculated Convexity allows us to determine the Convexity Effect for a given interest rate change. The total estimated bond value change for a given interest rate change is then calculated by combining the Duration Effect and the Convexity Effect demonstrating a position or portfolio's interest rate sensitivity.

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