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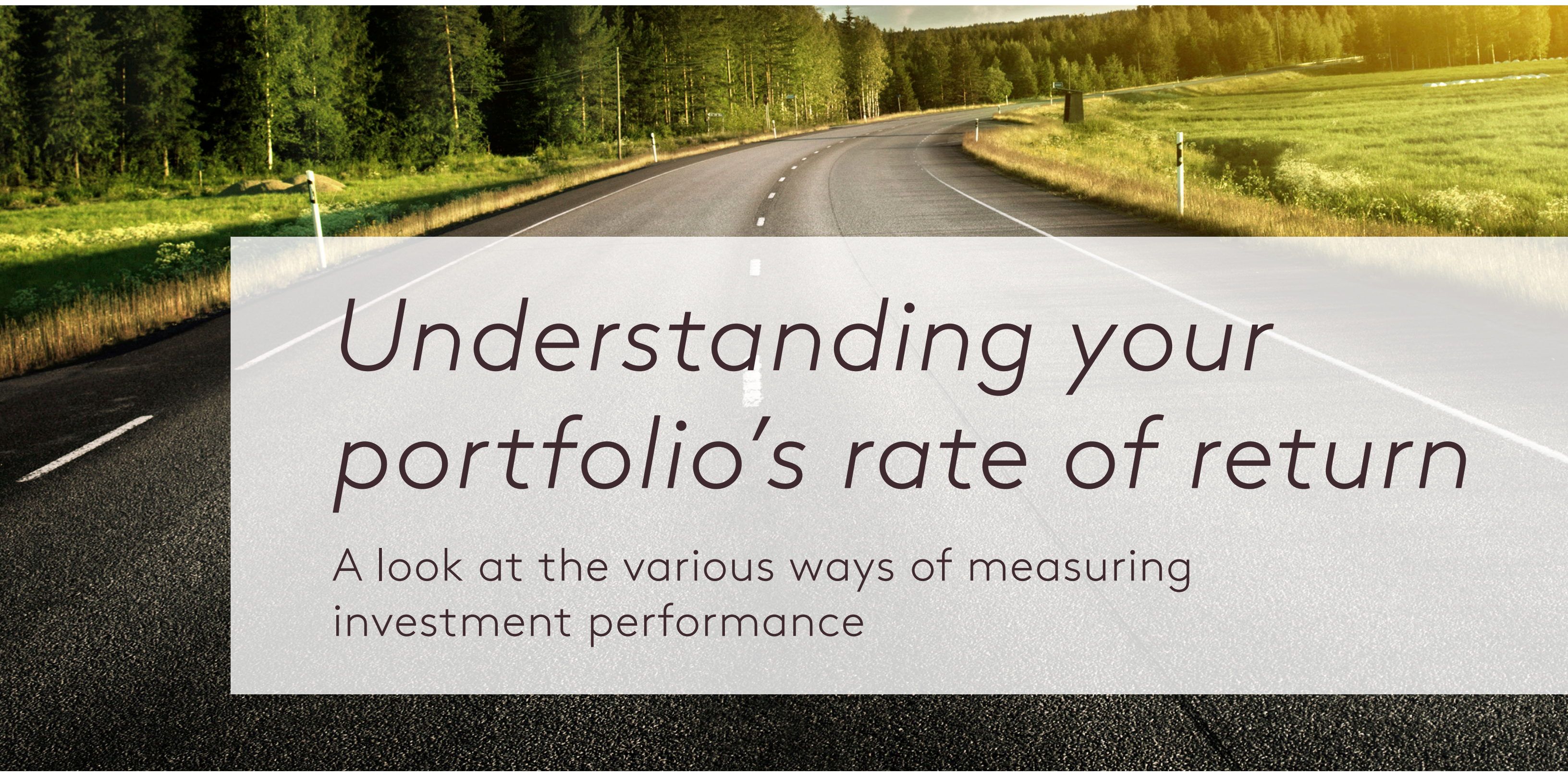

Understanding your portfolio's rate of return

A look at the various ways of measuring investment performance

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July 2015

This report was written by Justin Bender, PWL Capital Inc. and Dan Bortolotti, PWL Capital Inc. The ideas, opinions, and recommendations contained in this document are those of the authors and do not necessarily represent the views of PWL Capital Inc.

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Justin Bender, *Portfolio Manager*, PWL Capital Inc. and Dan Bortolotti, *Investment Advisor*, PWL Capital Inc. *"Understanding your portfolio's rate of return: A look at the various ways of measuring investment performance"*

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CIPF Canadian Investor Protection Fund MEMBER

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Perhaps no number is more important to investors than the rate of return on their portfolio. After all, what better way is there to measure your skill as an investor or the performance of your advisor?

Trouble is, if you've made contributions or withdrawals during the year, calculating your rate of return is not straightforward. What's more, there are several ways to perform the calculations: the results can differ significantly, and each method has strengths and weaknesses.

This issue is bound to receive attention in the coming years, thanks to recent changes in the investment industry. Starting in January 2017 (for calendar year 2016), dealers and advisors will be required to provide personal rates of return to their clients. This disclosure is a step in the right direction: hard as it is to believe, many advisors currently provide no performance reports at all. However, reporting personal rates of return can lead to confusion and frustration for both clients and advisors if the results are not properly understood.

In this paper, we introduce the various methods used to calculate a portfolio's rate of return, explain how and why they can produce different results, and help you determine which method is most appropriate to your circumstances. We have kept the math as simple as possible: for those who want to dig deeper, more advanced calculations can be found in the Appendix.

For investors who want to measure their personal rates of return without doing manual calculations, we also provide links to easy-to-use downloadable calculators available at www.pwlcapital.com under *Toronto Team*.

Going with the flow

If a portfolio has no cash flows during the year (that is, the investor makes no contributions and no withdrawals), calculating the rate of return is simple. Moreover, all of the methods we describe in this paper would produce identical figures. The key point to understand, therefore, is that any differences in reported returns come about as a result of cash inflows and outflows.

To illustrate this idea, we will consider each rate-of-return methodology as it would apply to two hypothetical investors. We assume both invest $250,000 on December 31, 2013, into an index fund tracking the MSCI Canada IMI Index, a benchmark for the broad Canadian stock market. We ignore fees and assume the fund tracks the index perfectly.

We have used actual index values in our examples to make the results more relevant. Recall that in 2014 the Canadian equity markets enjoyed strong returns during the first eight months of the year, but then experienced a significant downturn in September and October. With that in mind, we assume that **Investor 1** contributes an additional $25,000 to his portfolio on September 15, 2014, after several months of good performance. **Investor 2**, by contrast, takes some profits off the table by withdrawing $25,000 from her portfolio on the same date.

Note that in both cases our investors held the same fund for the entire year. The only difference in their activity was a single cash flow on a single day.

The charts on the next page display the month-end market values for both investors. We have also indicated the date and amount of the contribution or withdrawal, as well as the new market values after these cash flows occur. We'll continually refer back to these charts, so keep them handy as you work through each of the examples in this paper.

CHART 1: INVESTOR 1 – $25,000 CONTRIBUTION

DATE	PORTFOLIO VALUE (V)	CASH FLOW (CF)	V AFTER CASH FLOW
December 31, 2013	250,000		
January 31, 2014	251,938		
February 28, 2014	262,212		
March 31, 2014	265,256		
April 30, 2014	271,900		
May 31, 2014	270,962		
June 30, 2014	282,868		
July 31, 2014	287,098		
August 31, 2014	293,108		
September 15, 2014	**290,621**	**+25,000**	**315,621**
September 30, 2014	304,818		
October 31, 2014	297,125		
November 30, 2014	299,406		
December 31, 2014	298,082		

CHART 2: INVESTOR 2 - $25,000 WITHDRAWAL

DATE	PORTFOLIO VALUE (V)	CASH FLOW (CF)	V AFTER CASH FLOW
December 31, 2013	250,000		
January 31, 2014	251,938		
February 28, 2014	262,212		
March 31, 2014	265,256		
April 30, 2014	271,900		
May 31, 2014	270,962		
June 30, 2014	282,868		
July 31, 2014	287,098		
August 31, 2014	293,108		
September 15, 2014	**290,621**	**–25,000**	**265,621**
September 30, 2014	256,530		
October 31, 2014	250,055		
November 30, 2014	251,975		
December 31, 2014	250,860		

Time-Weighted Rate of Return

Let's begin our examination by considering the Holy Grail of portfolio performance benchmarking: the time-weighted rate of return (TWRR).

The TWRR is the method used by mutual funds and ETFs when preparing their published performance reports. The goal of this method is to completely eliminate the effect of cash flows into or out of the portfolio. It does this by dividing the reporting period into several sub-periods: a new sub-period is created every time there is a contribution or withdrawal. The total return is then calculated for each sub-period, and these returns are "geometrically linked" (multiplied) to obtain the time-weighted rate of return over the entire measurement period. (For the mathematically inclined, we have included the formula in the Appendix.)

Let's see how the TWRR works by applying it to our two hypothetical investors. **Investor 1** initially contributed $250,000 on December 31, 2013. On September 15, 2014, his portfolio was worth $290,621. He then added $25,000, bringing the value up to $315,621. By the end of 2014, the portfolio had decreased to $298,082.

To determine his TWRR, **Investor 1** first calculates the sub-period return from December 31, 2013, to September 15, 2014. For the end date he uses the portfolio value *before* the cash flow occurred. During the first sub-period, the portfolio started at $250,000 and ended at $290,621, for a return of 16.25%, calculated as follows:

$$\frac{290{,}621 - 250{,}000}{250{,}000} = 0.1625 = \mathbf{16.25\%}$$

Then he calculates the second sub-period return from September 15, 2014 to December 31, 2014. For the start date he uses the portfolio value *after* the cash flow occurred. During this second sub-period, the portfolio started at $315,621 ($290,621 plus the $25,000 contribution) and fell to $298,082, for a return of –5.56%, calculated as follows:

$$\frac{298{,}082 - 315{,}621}{315{,}621} = -0.0556 = \mathbf{-5.56\%}$$

Finally, he geometrically links the two sub-period returns to obtain a time-weighted rate of return for the year. To do this he adds 1 to each sub-period return, multiplies them, and then subtracts 1:

$$= (1 + 0.1625) \times (1 + (-0.0556)) - 1$$
$$= (1.1625 \times 0.9444) - 1$$
$$= 0.0979$$
$$= \mathbf{9.79\%}$$

Now let's consider the TWRR for **Investor 2**, who also started with $250,000 on December 31, 2013. On September 15, 2014, her portfolio was also worth $290,621, the same as that of **Investor 1**. But on that date, **Investor 2** withdrew $25,000, bringing the portfolio value down to $265,621. By the end of 2014, her portfolio had decreased to $250,860.

To calculate her TWRR, she follows the same steps. During the first sub-period, the portfolio started at $250,000 and ended at $290,621, for a return of 16.25%, calculated as follows:

$$\frac{290{,}621 - 250{,}000}{250{,}000} = 0.1625 = \mathbf{16.25\%}$$

During the second sub-period, the portfolio started at $265,621 ($290,621 minus the $25,000 withdrawal) and fell to $250,860, for a return of –5.56%, calculated as follows:

$$\frac{250{,}860 - 265{,}621}{265{,}621} = -0.0556 = \mathbf{-5.56\%}$$

Then she geometrically links the two sub-period returns to obtain a time-weighted rate of return for the year:

$$= (1 + 0.1625) \times (1 + (-0.0556)) - 1$$
$$= (1.1625 \times 0.9444) - 1$$
$$= 0.0979$$
$$= \mathbf{9.79\%}$$

Note that the sub-period returns are exactly the same for **Investors 1** and **2**, and therefore both end up with the exact same time-weighted rate of return for the year. This is precisely the result that should be expected, because the TWRR is not affected by contributions and withdrawals, making it ideal for benchmarking portfolio managers or active investment strategies. If we compare our two investors' time-weighted rates of return to the return of the MSCI Canada IMI Index (the benchmark their portfolio manager is attempting to track), we also get the same result of 9.79% for the year.

MSCI INDEX PERFORMANCE AS OF DECEMBER 31, 2014

Developed Markets IMI (Gross) as of Dec 31, 2014

MSCI Index	Index Code	Last	Day	MTD	3MTD	YTD	1 Yr	3 Yr
CANADA IMI	664150	1,272.489	-0.02%	-0.44%	-2.21%	9.79%	9.79%	9.65%

Source: MSCI

Unfortunately, while the TWRR is useful for mutual funds and portfolio managers, the calculation is not practical for DIY investors. This is because it requires daily portfolio valuations whenever an external cash flow (a contribution or withdrawal) occurs, and these are not usually available through discount brokerages.

Money-Weighted Rate of Return

In the TWRR example above, notice the dramatic difference between the two sub-period returns. During the first sub-period (the beginning of the year until the cash flow date of September 15) the return was a robust 16.25%. But during the second sub-period (the date of the cash flow until the end of the year), the return was a dismal –5.56%.

Both of our hypothetical investors obtained the same TWRR, but chances are they're not feeling equally satisfied. After all, **Investor 1** added money to his portfolio after the sub-period of high returns, so his $25,000 contribution did not benefit from that 16.25% increase. Indeed, his contribution lost 5.56% during the second sub-period. Meanwhile, **Investor 2** removed $25,000 from her portfolio immediately before the second sub-period, thereby avoiding the 5.56% loss on that withdrawn amount.

This scenario illustrates when a money-weighted rate of return (MWRR) can be more relevant to individual investors. Rather than removing the effect of cash flows—as a time-weighted return is designed to do—an MWRR can reward or penalize investors for the timing of their contributions and withdrawals.

Investors will need to understand the strengths and weaknesses of the money-weighted method, because the Canadian Securities Administrators has made the MWRR the industry standard for performance calculations. If you work with an advisor, your personal rate of return will be calculated using this method.

To understand how an MWRR is calculated you first need to understand the concept of *present value*. Say someone offered to give you $100 one year from now. What is the present value of that future $100? If we ignore inflation, the answer depends on the rate of return you expect to receive on your investments during the year. For example, assuming a 5% annual return, $100 paid to you in one year has a present value of $95.24:

$$\$100 \;/\; (1 + 5\%) = 95.23809$$

Calculating a MWRR involves finding the rate of return that makes the net present value of all cash flows equal to zero. To see how this applies to a portfolio, let's return to our hypothetical **Investor 1**. (The complete formula can be found in the Appendix.)

On the left-hand side of our MWRR equation we put the portfolio's value at the end of the year ($298,082). On the right side we include the sum of our two cash flows: the original $250,000 investment and the $25,000 contribution on September 15. Since the $25,000 was added to the portfolio on the 258th day of a 365-day, year we account for it as follows:

$$298{,}082 = \left[250{,}000 \times (1 + r)\right] + \left[25{,}000 \times (1 + r)^{\frac{365-258}{365}}\right]$$

$$298{,}082 = \left[250{,}000 \times (1 + r)\right] + \left[25{,}000 \times (1 + r)^{0.2931506}\right]$$

The money-weighted return for this portfolio is the value for ***r*** that satisfies the equation. Unfortunately, there is no simple way to solve for ***r*** : you can only find this value through trial and error.

Investor 1 would need to make reasonable guesses for the value of ***r*** until he found one that made the right-hand side of the equation equal $298,082 (or as close as possible). The table below shows how he could have arrived at the solution after starting with a guess of 10% and eventually arriving at a value of approximately **8.98%**:

r "guess"	Right-hand side of the equation:
10.00%	300,708
9.00%	298,140
8.99%	298,114
8.98%	**298,088**
8.97%	298,063

Fortunately, you don't need to perform these acrobatics manually: you can download the **Money-Weighted Rate of Return Calculator** from the Calculators section at www.pwlcapital.com under *Toronto Team*.

After downloading this Excel spreadsheet, select the start and end dates for your measurement period and enter the total portfolio value to the right of each date. Next, enter the dates and amounts of any portfolio contributions (+) or withdrawals (-). The computer will then perform the trial and error calculations for you. Here's how it would look for **Investor 1:**

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Money-Weighted Rate of Return Calculator

	Month	Day	Year	Portfolio Valuation
Start date:	December	31	2013	250,000.00
End date:	December	31	2014	298,082.00

	Month	Day	Year	Contributions (+)	Withdrawals (-)
	September	15	2014	25,000.00	

Average Rate of Return* 8.98%

**Annualized if measurement period is longer than a year*

Now let's use the spreadsheet to calculate the MWRR for **Investor 2**. The start and end dates are the same, and so is the initial portfolio value of $250,000. We just need to revise the portfolio value on the end date ($250,860) and change the cash flow from a positive to a negative value (to indicate a withdrawal). When we do so, notice that the money-weighted return jumps to **10.64%**:

Money-Weighted Rate of Return Calculator

	Month	Day	Year	Portfolio Valuation
Start date:	December	31	2013	250,000.00
End date:	December	31	2014	250,860.00

Month	Day	Year	Contributions (+)	Withdrawals (-)
September	15	2014		-25,000.00

Average Rate of Return* **10.64%**

**Annualized if measurement period is longer than a year*

These MWRR results are noticeably different from the TWRR results in our first example. **Investor 1** contributed $25,000 before a period of underperformance (–5.56% versus +16.25%) and ended up with a significantly lower MWRR of 8.98%. On the other hand, **Investor 2** withdrew $25,000 before that period of underperformance and obtained a significantly higher MWRR of 10.64%. This will make intuitive sense to any investor who has added funds right before the markets went down, or those who have withdrawn money before a downturn.

PERFORMANCE RESULTS

METHODOLOGY	INVESTOR 1	INVESTOR 2
Time-weighted rate of return (TWRR)	9.79%	9.79%
Money-weighted rate of return (MWRR)	8.98%	10.64%

Let's review the important lessons here. First, the MWRR assumes all cash flows receive the same rate of return while invested, so it can differ substantially from the time-weighted rate of return when large cash flows occur during volatile periods. Note that the MWRR for **Investor 1** (8.98%) was significantly lower than the time-weighted rate of return (9.79%), while the MWRR for **Investor 2** (10.69%) was significantly higher.

When interpreting money-weighted rates of return, consider the following:

- When a large contribution is made prior to a period of relatively bad performance, the MWRR will understate a portfolio's performance relative to the TWRR. (This was the case for **Investor 1**.)
- Conversely, when a large contribution is made prior to a period of relatively good performance, the MWRR will overstate a portfolio's performance relative to the TWRR.
- When a large withdrawal is made prior to a period of relatively bad performance, the MWRR will overstate a portfolio's performance relative to the TWRR. (This was the case for **Investor 2.**)
- Conversely, when a large withdrawal is made prior to a period of relatively good performance, the MWRR will understate a portfolio's performance relative to the TWRR.

Because it is highly dependent on the timing of cash flows, the MWRR is not ideal for benchmarking portfolio managers or investment strategies.

Consider, for example, an advisor working with our two hypothetical investors. In the first case, **Investor 1** receives a $25,000 windfall and asks the advisor to add it to his portfolio. On the same day, **Investor 2** requests a $25,000 withdrawal to meet an unexpected expense. If their performance is reported using a money-weighted rate of return, both investors may incorrectly conclude that they underperformed or outperformed the benchmark, even though the portfolio manager used the same strategy for both (i.e. tracking the MSCI Canada IMI Index) and played no role in the timing of the cash flows.

If a portfolio manager does control cash flows, however, the MWRR might be more appropriate than a time-weighted rate of return. One example is a hedge fund or private equity manager who actively solicits new cash from clients in order to take advantage of a perceived opportunity: this manager should be held accountable for any outperformance or underperformance that results from this inflow of new capital.

It's important to note that the MWRR is only affected by *external* cash flows: that is, money that is added or removed from the portfolio. Fund managers who use a market-timing strategy—alternating between holding cash and being fully invested—should measure their performance using a TWRR, because their buy and sell decisions are not affected by contributions and withdrawals from the portfolio.

The money-weighted method can also be useful for calculating rates of return when cash flows are small relative to the size of the portfolio. For example, if you have $200,000 in your RRSP and you make monthly contributions of $500, an MWRR would be an appropriate measure, and it would likely be very close to your time-weighted rate of return. However, if you have $40,000 in your TFSA and add $10,000 on a single day, your MWRR will be highly affected by the timing of that contribution and could be misleading.

Despite its shortcomings, the MWRR may be the only option for investors who do not have access to daily or month-end portfolio values (such as those who receive quarterly statements).

Modified Dietz Method

Now that we have compared the two broad types of return calculations, let's look at a methodology that can be used to produce results approximating either a time-weighted or money-weighted return. The Modified Dietz method is particularly useful because it overcomes some of the difficulties inherent in calculating a true TWRR or MWRR.

When using the Modified Dietz method to estimate a money-weighted rate of return over a full year, the investor again needs to know the portfolio value at the start and end of the measurement period, as well as the amount and date of each cash flow. (Unlike with a time-weighted rate of return, the portfolio value on the date of each cash flow is not required.) The advantage of the Modified Dietz method over a traditional MWRR is that the calculation does not require a trial and error process. (For the complete Modified Dietz formula, see the Appendix)

The Modified Dietz method has the same strengths and weaknesses as any MWRR. Specifically, it can differ substantially from the time-weighted rate of return when large cash flows occur during periods of significantly fluctuating portfolio values. This makes it less than ideal for benchmarking portfolio managers or strategies.

To estimate an annual money-weighted rate of return for **Investor 1** using the Modified Dietz method, start by calculating the proportion of the year for which the $25,000 cash flow was present in the portfolio. Because the cash flow occurred on the 258th day of a 365-day year, we calculate the proportion like this:

$$= \frac{(365 - 258)}{365}$$

$$= \frac{107}{365}$$

$$= \mathbf{0.2932}$$

We then use this value to complete the Modified Dietz formula. The numerator takes the portfolio value at the end of the year ($298,082) and subtracts the value at the start of the year ($250,000) and the $25,000 contribution. The denominator adds the starting value and the cash flow multiplied by the proportion of the year it was present in the portfolio (0.2932):

$$= \frac{298{,}082 - 250{,}000 - 25{,}000}{250{,}000 + [25{,}000 \times 0.2932]} = 0.0897 = \mathbf{8.97\%}$$

We can use the same Modified Dietz formula to estimate the money-weighted rate of return for **Investor 2**. In this case, however, the $25,000 cash flow is assigned a negative value because it was a withdrawal rather than a contribution:

$$= \frac{250{,}860 - 250{,}000 - (-25{,}000)}{250{,}000 + [-25{,}000 \times 0.2932]} = 0.1066 = \mathbf{10.66\%}$$

PERFORMANCE RESULTS

METHODOLOGY	INVESTOR 1	INVESTOR 2
Time-weighted rate of return (TWRR)	9.79%	9.79%
Money-weighted rate of return (MWRR)	8.98%	10.64%
Modified Dietz rate of return	8.97%	10.66%

As you can see in the table above, the annual Modified Dietz rate of return is nearly identical to the traditional money-weighted rate of return.

Now we'll take things a step further and describe how the Modified Dietz methodology can also be used to approximate a time-weighted rate of return. Recall that one of the problems with a TWRR is that it requires daily portfolio values, and most DIY investors simply don't have access to these numbers. However, if you receive monthly account statements you can use these values to calculate a Modified Dietz rate of return over monthly periods. Then you can geometrically link these monthly results to produce an approximate time-weighted rate of return for the year. We'll refer to this as the Monthly Modified Dietz method.

To help investors calculate their approximate time-weighted rate of return using this method, we've created a user-friendly calculator that uses the Monthly Modified Dietz method: it is available for free at www.pwlcapital.com under *Toronto Team*

After downloading the spreadsheet, start by inputting the month-end portfolio values for the year in column E. In the columns to the right of E, enter any contributions (+) and withdrawals (-) and the day of the month that each occurred.

The examples below show how **Investors 1** and **2** would use the spreadsheet to calculate their approximate time-weighted rate of return by entering the portfolio's month-end values (found in Chart 1) and the amount and date of the cash flow.

MONTHLY MODIFIED DIETZ RATE OF RETURN: INVESTOR 1

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2014 Rate of Return Calculator *Monthly Modified Dietz*

Month-End	Return (%)	Portfolio Value ($)	Contributions (+) and Withdrawals (-)									
			Cash Flow$_1$	Day$_1$	Cash Flow$_2$	Day$_2$	Cash Flow$_3$	Day$_3$	Cash Flow$_4$	Day$_4$	Cash Flow$_5$	Day$_5$
December 2013		$250,000.00										
January 2014	0.78%	$251,938.00										
February 2014	4.08%	$262,212.00										
March 2014	1.16%	$265,256.00										
April 2014	2.50%	$271,900.00										
May 2014	-0.34%	$270,962.00										
June 2014	4.39%	$282,868.00										
July 2014	1.50%	$287,098.00										
August 2014	2.09%	$293,108.00										
September 2014	-4.35%	$304,818.00	$25,000.00	15								
October 2014	-2.52%	$297,125.00										
November 2014	0.77%	$299,406.00										
December 2014	-0.44%	$298,082.00										
YTD Return %	9.67%											

MONTHLY MODIFIED DIETZ RATE OF RETURN: INVESTOR 2

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2014 Rate of Return Calculator *Monthly Modified Dietz*

Month-End	Return (%)	Portfolio Value ($)	Contributions (+) and Withdrawals (-)									
			Cash Flow$_1$	Day$_1$	Cash Flow$_2$	Day$_2$	Cash Flow$_3$	Day$_3$	Cash Flow$_4$	Day$_4$	Cash Flow$_5$	Day$_5$
December 2013		$250,000.00										
January 2014	0.78%	$251,938.00										
February 2014	4.08%	$262,212.00										
March 2014	1.16%	$265,256.00										
April 2014	2.50%	$271,900.00										
May 2014	-0.34%	$270,962.00										
June 2014	4.39%	$282,868.00										
July 2014	1.50%	$287,098.00										
August 2014	2.09%	$293,108.00										
September 2014	-4.13%	$256,530.00	-$25,000.00	15								
October 2014	-2.52%	$250,055.00										
November 2014	0.77%	$251,975.00										
December 2014	-0.44%	$250,860.00										
YTD Return %	9.92%											

PERFORMANCE RESULTS

METHODOLOGY	INVESTOR 1	INVESTOR 2
Time-weighted rate of return (TWRR)	9.79%	9.79%
Money-weighted rate of return (MWRR)	8.98%	10.64%
Modified Dietz rate of return	8.97%	10.66%
Monthly Modified Dietz rate of return	9.67%	9.92%

You'll notice that both **Investor 1** and **2** had the same TWRR of 9.79%. However, when we use the Monthly Modified Dietz method, **Investor 1** underperforms the true TWRR and **Investor 2** outperforms.

To understand the reason for this difference, we must first calculate the sub-period returns during the month the cash flows occurred. In our examples, the only cash flow occurred on September 15. The TWRR for the entire month of September was –4.24%, but we can also calculate the sub-period returns before and after the cash flow. From the beginning of the month to September 15, the TWRR was –0.85%. After the cash flow (September 15 to the end of the month), the sub-period return was –3.42%, a relatively worse result compared with the first half of the month. (These calculations can be found in the Appendix.)

Because **Investor 1** made his contribution immediately before the poor sub-period, he had a relatively worse return in September: –4.35% using the Modified Dietz method compared to the TWRR of –4.24%. He also had a lower Monthly Modified Dietz return of 9.67% during the calendar year, compared to the TWRR of 9.79%.

Investor 2 had the opposite result. She made a withdrawal before the poor sub-period and therefore enjoyed a relatively better Modified Dietz return in September of –4.13%. She also had a higher Monthly Modified Dietz return of 9.92% during the calendar year.

To summarize, the approximate time-weighted rate of return using the Monthly Modified Dietz method can differ substantially from a true TWRR when large cash flows occur during months when portfolio values fluctuate significantly:

- When a large contribution is made before a sub-period (that is, part of a month) of relatively bad performance, the Monthly Modified Dietz method will understate performance relative to the TWRR. (This was the case for **Investor 1**.)
- When a large contribution is made before a sub-period of relatively good performance, the Monthly Modified Dietz method will overstate performance relative to the TWRR.
- When a large withdrawal is made before a sub-period of relatively bad performance, the Monthly Modified Dietz method will overstate performance, relative to the TWRR. (This was the case for **Investor 2.**)
- When a large withdrawal is made before a sub-period of relatively good performance, the Monthly Modified Dietz method will understate performance relative to the TWRR.

Despite these potential shortcomings, the approximate time-weighted rate of return using the Monthly Modified Dietz method is a good choice for investors looking to calculate their personal rate of return and compare it to an index benchmark. It will also be a useful comparison for those who work with advisors providing only money-weighted rates of return.

Appendix

Time-weighted rate of return (TWRR)

The following formula can be used for calculating a portfolio's time-weighted rate of return:

$$r_{TWRR} = \left[(1 + r_{t,1}) \times (1 + r_{t,2}) \times \cdots \times (1 + r_{t,n})\right] - 1$$

where:

$r_{t,n} = \dfrac{V_1 - V_0}{V_0}$ = the total return for sub-period t,n

V_1 = the full fair value of the portfolio, including cash and accrued income, at the end of the period

V_0 = the full fair value of the portfolio, including cash and accrued income, at the beginning of the period

Source: CFA Institute

Calculations of sub-period returns for the time-weighted rate of return

Example for the Month of September – Investor 1

To calculate the sub-period returns before and after the cash flow on September 15, use the TWRR formula. This requires you to know the market value of the portfolio on the last day of August ($293,108), on day of the cash flow ($290,621 before the cash flow and $265,621 after the withdrawal) and on ther last day of September ($256,530). These values are found in Chart 1.

$$r_{t,1} = \frac{V_1 - V_0}{V_0} = \frac{(290{,}621 - 293{,}108)}{293{,}108} = -0.0085 = -0.85\%$$

$$r_{t,2} = \frac{V_1 - V_0}{V_0} = \frac{(304{,}818 - 315{,}621)}{315{,}621} = -0.0342 = -3.42\%$$

$$r_{TWRR} = (1 + r_{t,1}) \times (1 + r_{t,2}) - 1 = (\ 1 + (-0.0085)) \times [1 + (-0.0342)] - 1$$

$$= 0.9576 - 1 = -0.0424 = \mathbf{-4.24\%}$$

Example for the Month of September – Investor 2

$$r_{t,1} = \frac{V_1 - V_0}{V_0} = \frac{(290{,}621 - 293{,}108)}{293{,}108} = -0.0085 = -0.85\%$$

$$r_{t,2} = \frac{V_1 - V_0}{V_0} = \frac{(256{,}530 - 265{,}621)}{265{,}621} = -0.0342 = -3.42\%$$

$$r_{TWRR} = (1 + r_{t,1}) \times (1 + r_{t,2}) - 1 = (\ 1 + (-0.0085)) \times [1 + (-0.0342)] - 1$$

$$= 0.9576 - 1 = -0.0424 = \mathbf{-4.24\%}$$

Money-weighted rate of return (MWRR)

The money-weighted rate of return can be thought of as the rate of return, ***r*,** which equates the right-hand side of the following equation to the ending portfolio value, V_1 .

$$V_1 = \sum_{i=1}^{n} \left[CF_i \times (1 + r)^{w_i} \right] + V_0 (1 + r)$$

where:

V_1 = the full fair value of the portfolio, including accrued income, at the end of the period

V_0 = the full fair value of the portfolio, including accrued income, at the beginning of the period

$w_i = \frac{(CD - D_i)}{CD}$

CD = the total number of calendar days in the measurement period

D_i = the number of calendar days from the beginning of the measurement period that cash flow CF_i occurs

CF_i = the i^{th} cash flow

Source: CFA Institute

Modified Dietz rate of return

The Modified Dietz methodology approximates a money-weighted rate of return, but unlike a traditional MWRR it can be calculated without trial an error:

$$r_{ModDietz} = \frac{V_1 - V_0 - CF}{V_0 + \sum_{i=1}^{n} (CF_i \times w_i)}$$

where:

V_1 = the full fair value of the portfolio, including cash and accrued income, at the end of the period

V_0 = the full fair value of the portfolio, including cash and accrued income, at the beginning of the period

$\sum_{i=1}^{n} (CF_i \times w_i)$ = the sum of each cash flow multiplied by its weight

$CF = \sum CF_i$ = the sum of each cash flow

$w_i = \frac{(CD - D_i)}{CD}$ = the proportion of the measurement period, in days, that each cash flow has been in the portfolio

CD = the total number of calendar days in the measurement period

D_i = the number of calendar days from the beginning of the measurement period that cash flow CF_i occurs

Source: CFA Institute

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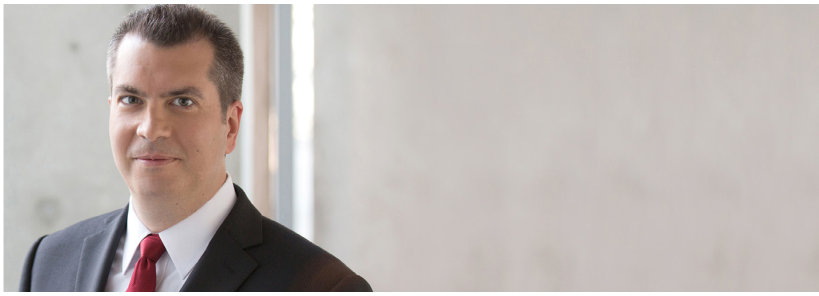

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