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Abstract

Under some unrealistic assumptions, a bond's yield to maturity is equal to the bond's mean return through maturity. In fact, under those assumptions, because the former is observable, then the latter is certain. Obviously, in practice bond returns are not certain and need to be forecasted. To do so, investors often use a bond's yield to maturity as a proxy for the bond's expected return over a holding period of ten or so years. This paper explores the rationale behind this approach, the conditions under which it may be more or less accurate, and some evidence that strongly supports it.

Introduction

The yield to maturity of a bond (or bond index) at a given point in time often is used as a proxy for the expected return of the bond (or the index) over the subsequent ten or so years. However, neither the rationale behind this approach nor the conditions under which it is more or less accurate are entirely clear. This paper attempts to fill that gap.

Unlike stocks, bonds have fixed cash flows and a fixed maturity date.[1] These two features make bond returns more predictable than stock returns. In fact, if interest rates remain constant during a bond's life, and the cash flows paid by the bond are reinvested at the yield to maturity, then this yield is exactly equal to the bond's mean return if it is held until maturity. The problem, obviously, is that interest rates never remain constant; therefore, the rates at which a bond's cash flows will be reinvested are unknown, and so is the bond's expected return.

In a dynamic world of fluctuating interest rates, then, at least two interesting questions arise. First, is the yield to maturity a good *approximation* to the expected return of a bond or bond index? And second, over what holding period does the yield to maturity provide the best forecast of the return of a bond or bond index? Both questions are addressed in this paper, first with an example and then with evidence. The latter reveals that, in the case of U.S. 10-year Treasury notes and six Bloomberg bond indexes, the yield to maturity and expected bond returns are strongly related, particularly over holding periods between ten and fifteen years.

Importantly, this paper is not about the latest, or the most sophisticated, or the best way to forecast bond returns. Rather, it is about the relationship between a specific variable, the yield to maturity, and expected bond returns. More precisely, the focus is on understanding the reasons why this yield should provide a reasonable forecast of bond returns; discussing the conditions under which those forecasts are expected to be more or less accurate; and ultimately evaluating empirically the forecasting ability of the yield to maturity.

The paper first discusses an example of individual bonds with different scenarios for the evolution of interest rates during the life of those bonds. Next, it discusses the evidence on the relationship between the yield to maturity and expected bond returns, first based on U.S. 10-year Treasury notes and then based on six Bloomberg indexes of investment-grade bonds. The paper concludes with an assessment.

The Issue

Example—Base Case

Consider a 20-year bond with a face value of $1,000 and an interest rate of 5 percent; the bond pays semiannual coupons and its current price is $950. Table 1 shows semesters in the first column and the cash flows to be paid by the bond (C) in the second column, with some intermediate periods omitted for brevity. Given the bond's current price and the cash flows it will pay, it is straightforward to calculate a semiannual yield to maturity of 2.7 percent, and therefore an annual yield to maturity of 5.4 percent.[2] This yield, which will be referred to as the initial yield to maturity, is by definition also the bond's mean annual (compound or geometric) return.

TABLE 1 Base Case

SEMESTER	C	FVC	P	CG	CY	R	G	Diff
0			950.0					
1	25.0	70.8	950.7	0.1	2.6	2.7	5.4	0.0
2	25.0	69.0	951.4	0.1	2.6	2.7	5.4	0.0
3	25.0	67.1	952.2	0.1	2.6	2.7	5.4	0.0
4	25.0	65.4	953.0	0.1	2.6	2.7	5.4	0.0
5	25.0	63.7	953.7	0.1	2.6	2.7	5.4	0.0
...	...	...	...	...	...	...	...	...
36	25.0	27.8	992.3	0.2	2.5	2.7	5.4	0.0
37	25.0	27.1	994.1	0.2	2.5	2.7	5.4	0.0
38	25.0	26.4	996.0	0.2	2.5	2.7	5.4	0.0
39	25.0	25.7	998.0	0.2	2.5	2.7	5.4	0.0
40	1,025.0	1,025.0	1,025.0	0.2	2.5	2.7	5.4	0.0

For a 20-year bond with a face value of $1,000, an interest rate of 5 percent, semiannual coupon payments, and a current price of $950, table 1 shows semesters in the first column, the cash flows to be paid by the bond (C), the future value of each cash flow (FVC), the bond's price (P), capital gain (CG), coupon yield (CY), return (R), geometric mean annual return (G), and the absolute value of the difference between G and the initial yield to maturity (Diff). C, FVC, and P in dollars; CG, CY, R (=CG+CY), G, and Diff in %.

Table 1, column 3, shows the future value of the cash flows to be paid by the bond (FVC), which results from the reinvestment of those cash flows at the calculated (semiannual) yield to maturity; therefore \$70.8 = \$25.0 × (1 + 2.7%)^{39}, \$69.0 = \$25.0 × (1 + 2.7%)^{38}, and so forth. The sum of all these FVCs is \$2,764.3, which leads to another way of calculating the bond's mean (semiannual) return; that is, (\$2,764.3/\$950)$^{1/40}$ – 1 = 2.7%. The fourth column shows the price (P) the bond should have at each point in time, calculated as the present value of all the cash flows to be paid by the bond discounted at the calculated (semiannual) yield to maturity.[3] The bond's price at maturity is equal to its face value plus the last coupon it pays.

Table 1, column 5, shows the periodic capital gains (CG), which for the first and second period are \$950.7/\$950 – 1 = 0.1% and \$951.4/\$950.7 – 1 = 0.1%. The sixth column shows the periodic coupon yields (CY), which for the first and second period are \$25/\$950 = 2.6% and \$25/\$950.7 = 2.6%. The seventh column shows the bond's periodic return (R), which is the sum of the previous two columns; therefore for both the first and the second period R = 0.1% + 2.6% = 2.7%. The whole sequence of returns in this column leads to yet another way of calculating the bond's mean (semiannual) return as the geometric mean of all the figures in this column; that is, {(1 + 2.7%) × (1 + 2.7%) × … × (1 + 2.7%)}$^{1/40}$ – 1 = 2.7%.

Table 1, column 8, shows the mean annual returns (G), calculated as the geometric mean of all the semiannual returns *up to each point in time*, then multiplied by two to express them in annual terms; therefore for the first and second period, G = 2 × {(1 + 2.7%)$^{1/1}$ – 1} = 5.4% and G = 2 × {[(1 + 2.7%) × (1 + 2.7%)]$^{1/2}$ – 1} = 5.4%.[4] Finally, the last column (Diff) shows the absolute value of the difference between the figures in the previous column and the initial yield to maturity; therefore for the first and the second periods, Diff = 5.4% – 5.4% = 0.0%.

Importantly, given the assumptions in table 1, the bond's initial yield to maturity (5.4 percent) is an *exact* forecast of the bond's mean annual return calculated as two times the geometric mean of *all* the returns in the seventh column. However, this equality is based on the strong and unrealistic assumption that all cash flows paid by the bond can be reinvested, period after period, at the initial (semiannual) yield to maturity. Needless to say, in practice that will never be the case, which begs the question at the heart of this paper: In a realistic setting in which the rate at which a bond's cash flows are reinvested is different from the initial yield to maturity, does the latter remain a good *approximation* to the bond's mean return?

Example—Changes in Interest Rates

Table 2 addresses that question. Panel A (B) considers a one-percentage-point increase (decrease) in the general level of annual interest rates with respect to the base case, assumed to have an equal impact on our bond's discount rate. Therefore, the semiannual discount rate goes from 2.7 percent to 3.2 percent in panel A, and to 2.2 percent in panel B. Importantly, the rest of the analysis assumes that an investor bought the bond at \$950, *just before* the change in interest rates, therefore expecting a 5.4-percent mean annual return through maturity (as in the base case).

Consider panel A first. Note that the increase in interest rates has a negative impact on the whole path of bond prices, relative to the path in the base case; this is because although the bond still pays the same cash

TABLE 2 Changes in Interest Rates

SEMESTER	FVC	P	CG	CY	R	G	Diff
A: Increase							
0		950.0 / 842.1					
1	85.6	844.1	−11.1	2.6	−8.5	−17.0	22.4
2	82.9	846.1	0.2	3.0	3.2	−5.7	11.1
3	80.4	848.3	0.3	3.0	3.2	−1.7	7.1
…	…	…	…	…	…	…	…
20	47.0	896.9	0.4	2.8	3.2	5.2	0.2
21	45.5	900.7	0.4	2.8	3.2	5.2	0.2
22	44.1	904.5	0.4	2.8	3.2	5.3	0.1
23	42.7	908.6	0.4	2.8	3.2	5.3	0.1
24	41.4	912.7	0.5	2.8	3.2	5.4	0.03
25	40.1	916.9	0.5	2.7	3.2	5.4	0.01
26	38.9	921.3	0.5	2.7	3.2	5.5	0.04
…	…	…	…	…	…	…	…
38	26.6	986.5	0.7	2.6	3.2	5.8	0.3
39	25.8	993.2	0.7	2.5	3.2	5.8	0.4
40	1,025.0	1,025.0	0.7	2.5	3.2	5.8	0.4
B: Decrease							
0		950.0 / 1,077.6					
1	58.6	1,076.3	13.3	2.6	15.9	31.9	26.4
2	57.3	1,075.1	−0.1	2.3	2.2	17.7	12.3
3	56.1	1,073.8	−0.1	2.3	2.2	13.2	7.8
…	…	…	…	…	…	…	…
20	38.7	1,047.1	−0.2	2.4	2.2	5.7	0.3
21	37.8	1,045.2	−0.2	2.4	2.2	5.6	0.2
22	37.0	1,043.3	−0.2	2.4	2.2	5.6	0.2
23	36.2	1,041.3	−0.2	2.4	2.2	5.5	0.1
24	35.4	1,039.3	−0.2	2.4	2.2	5.5	0.1
25	34.7	1,037.2	−0.2	2.4	2.2	5.4	0.03
26	33.9	1,035.1	−0.2	2.4	2.2	5.4	0.01
27	33.2	1,032.9	−0.2	2.4	2.2	5.4	0.04
…	…	…	…	…	…	…	…
38	26.1	1,005.7	−0.3	2.5	2.2	5.1	0.3
39	25.6	1,002.9	−0.3	2.5	2.2	5.1	0.3
40	1,025.0	1,025.0	−0.3	2.5	2.2	5.1	0.4

For a 20-year bond with a face value of \$1,000, an interest rate of 5 percent, semiannual coupon payments, and a current price of \$950, table 2 shows semesters in the first column, the future value of each cash flow to be paid by the bond (FVC), the bond's price (P), capital gain (CG), coupon yield (CY), return (R), geometric mean annual return (G), and the absolute value of the difference between G and the initial yield to maturity (Diff). Panel A (B) considers a one-percentage-point increase (decrease) in the general level of annual interest rates with respect to the base case. C, FVC, and P in dollars; CG, CY, R (=CG+CY), G, and Diff in %.

flows, they are now discounted at a higher rate. In fact, at time 0, immediately after the increase in interest rates, the bond's price should fall from the $950 paid by our investor to $842.1. By the end of the first semester the bond should trade at $844.1, thus delivering an 11.1-percent (= $844.1/$950 – 1) capital loss and an 8.5-percent (= –11.1% + 2.6%) negative return during that period. If the discount rate remains steady at its new level, after this initial setback our investor expects to make a 3.2-percent return semester after semester through the bond's maturity.

The (geometric) mean return of the whole sequence of semiannual returns is 2.9 percent, therefore 5.8 percent in annual terms, higher than the 5.4-percent mean annual return in the base case.[5] This is because, as the second column shows, the bond's cash flows can now be reinvested at a higher rate (3.2 percent) than was possible in the base case (2.7 percent). This leads to a larger sum of FVCs, from the $2,764.3 in the base case to $2,975.6, which in turn leads to a higher mean annual return; that is, $2 \times \{(\$2,975.6/\$950)^{1/40} - 1\} = 2 \times (2.9\%) = 5.8\%$.

Alternatively, this higher mean return can be thought of as stemming from the initial drop in price (to $842.1, immediately after the increase in interest rates) and the fact that the bond's price still needs to converge to $1,025 at maturity. This implies that bond prices must increase at a faster rate than they do in the base case, thus delivering larger periodic capital gains. In addition, the lower bond prices (relative to those in the base case) raise the coupon yields. These two effects combined imply semiannual returns of 3.2 percent, higher than the 2.7-percent returns in the base case (except in the first semester, when our investor suffers the 8.5-percent loss already mentioned).

Now for the critical question: Given the change in interest rates that happened just after our investor bought the bond at $950, is the initial yield to maturity of 5.4 percent a good approximation to the bond's mean annual return? Clearly, yes. By now we know that if the bond is held until maturity, our investor will obtain a mean annual return of 5.8 percent, fairly close to the 5.4 percent predicted by the initial yield to maturity. If only stock return forecasters missed by that little!

Moreover, panel A shows two other important results. First, note that for ten years (the holding period most often associated with the initial yield to maturity as a tool to forecast bond returns), the investor would realize a 5.2-percent mean annual return (shown in the seventh column), again very close to the initial yield of 5.4 percent. Second, note that the last column shows that the smallest difference between the bond's mean annual return and the initial yield to maturity is for period 25 (0.01 percent), which happens to be very close to the bond's duration of 12.7 years (25.3 semesters).[6] In short, panel A shows that a bond's initial yield to maturity is a good predictor of its mean annual return if the bond is held until maturity, as well as a good predictor if the bond is held for ten years or for roughly as many years as indicated by the bond's maturity.

Panel B shows that with respect to the base case, when interest rates fall, all bond prices rise (the bond's cash flows are now discounted at a lower rate) and all FVCs fall (the bond's cash flows are now reinvested at a lower rate). It also shows that an investor that buys the bond at $950 just before the decrease in interest rates will get a windfall capital gain in the first semester (13.3 percent), which added to the coupon yield (2.6 percent) implies a return of 15.9 percent during that period; from that point on, semester after semester the investor will obtain a 2.2-percent return, lower than in the base case. The (geometric) mean return of the whole sequence of semiannual returns is 2.5 percent, therefore 5.1 percent in annual terms, lower than the 5.4-percent annual return in the base case.[7]

The reason for this lower mean return can be explained in two different ways, both along the lines of the previous discussion for panel A. First, all the bond's cash flows are now reinvested at a lower rate, resulting in a lower sum of FVCs, and therefore in a lower mean return. And second, the immediate reaction of the bond price to the decrease in interest rates is to rise to $1,077.6, and given that the price still needs to converge to $1,025 at maturity, it will have to *decrease* periodically, thus delivering periodic capital losses (which combined with the coupon yields will amount to 2.2-percent returns semester after semester, except in the first, when the investor will obtain the 15.9-percent return already mentioned).

Importantly, note that by holding the bond until maturity our investor will realize a 5.1-percent mean annual return, fairly close to the initial yield to maturity of 5.4 percent. Furthermore, by selling the bond after ten years our investor will realize a mean annual return of 5.7 percent, again fairly close to the initial yield to maturity. And the smallest difference between the bond's mean annual return and the initial yield to maturity is for period 26 (0.01 percent), which is again very close to the bond's duration of 12.7 years (25.3 semesters).

Finally, the last two columns of table 2 provide some insight on the relationship between a bond's initial yield to maturity and the holding period for which it is able to forecast bond returns accurately. Consider panel A first. Recall that our investor buys the bond at $950, just before the increase in interest rates, and the initial yield to maturity consistent with that price is 5.4 percent. Note from the next-to-last column that over short holding periods, the investor's mean annual return will be negative, well below 5.4 percent. This is because, although the investor will obtain 3.2 percent every semester after the first (instead of the 2.7 percent initially expected), when the holding period is short the 8.5-percent loss in the first period outweighs the subsequent higher returns. On the flip side, over long holding periods, the opposite happens; as the last three rows of the panel show, the higher return over many periods outweighs the impact of the initial capital loss, pulling the mean return above 5.4 percent.

Panel B confirms these results albeit from the opposite perspective. Over short holding periods the initial capital gain (that follows from the decrease in interest rates) outweighs the subsequent lower periodic returns, and over long holding periods the initial capital gain is outweighed by the subsequent lower periodic returns. In short, from the example in table 2 the following conclusions can be drawn about the relationship between the initial yield to maturity and expected bond returns:

- Over "short" holding periods, when interest rates increase (decrease) the initial yield to maturity tends to overestimate (underestimate) mean returns.
- Over "long" holding periods, when interest rates increase (decrease) the initial yield to maturity tends to underestimate (overestimate) mean returns.
- The initial yield to maturity is a good predictor of a bond's mean return through maturity, over ten years, and over as many years as indicated by the bond's duration.

A Broader Scope

Table 3 broadens the scope of the previous example and sheds some additional light on the relationship between a bond's initial yield to maturity and its mean return over different holding periods. Table 3 considers four bonds with maturities between five and thirty years, all with a face value of $1,000, a current price of $950, an interest rate of 5 percent, and paying semiannual coupons. It also considers *one-time* changes in annual interest rates between one and five percentage points above and below each bond's initial yield to maturity.[8] The figures in table 3 show mean annual returns over three holding periods: ten years, roughly each bond's duration, and each bond's maturity.[9]

Table 3 highlights at least two important results. First, the smaller (larger) the change in interest rates, the better (worse) the initial yield to maturity forecasts mean returns; this is rather obvious and true for all four bonds and all three holding periods. Second, the initial yield to maturity best forecasts mean returns not necessarily over the widely used ten-year holding period, or over each bond's maturity, but over a holding period similar to the bond's duration.

In fact, for the 20-year bond discussed in the previous section, panel C shows that when interest rates increase (decrease) by one percentage point, the initial yield to maturity of 5.4 percent misses the forecast of the bond's mean annual return through maturity by only 40 (30) basis points; as already mentioned, that is a fairly small error. However, the initial yield's forecast for the bond's mean annual return is right on the mark (5.4 percent) when the holding period is similar to the bond's duration. For the rest of the bonds and interest-rate changes considered, the figures in table 3 show that it remains the case that the yield to maturity makes better forecasts of mean returns when the holding period is similar to a bond's duration than it does when the holding period is ten years or the bond's maturity.

Table 4 again broadens the scope of the inquiry by considering *trending* changes in interest rates; that is, scenarios in which interest rates increase or decrease throughout a bond's life.[10] For the 5-year and 10-year bonds, the initial yield to maturity provides a very accurate forecast of mean returns for all the holding periods considered; the largest forecasting error in panels A and B is less than 60 basis points per year, and in most cases it is substantially lower than that.

TABLE 3 A Broader Scope: One-Time Changes in Interest Rates

	−5	−4	−3	−2	−1	YTM	+1	+2	+3	+4	+5
A: 5-year bond						6.2					
@ 10 years	N/A	N/A	N/A	N/A	N/A		N/A	N/A	N/A	N/A	N/A
@ Duration	6.2	6.2	6.2	6.2	6.2		6.2	6.2	6.2	6.2	6.3
@ Maturity	5.7	5.8	5.9	6.0	6.1		6.3	6.4	6.5	6.6	6.7
B: 10-year bond						5.7					
@ 10 years	4.7	4.9	5.1	5.3	5.5		5.9	6.1	6.3	6.6	6.8
@ Duration	5.8	5.7	5.7	5.7	5.7		5.7	5.7	5.7	5.8	5.9
@ Maturity	4.7	4.9	5.1	5.3	5.5		5.9	6.1	6.3	6.6	6.8
C: 20-year bond						5.4					
@ 10 years	7.4	6.9	6.4	6.0	5.7		5.2	5.0	4.8	4.8	4.7
@ Duration	6.0	5.8	5.6	5.5	5.4		5.4	5.5	5.6	5.7	5.8
@ Maturity	3.9	4.1	4.4	4.7	5.1		5.8	6.2	6.6	7.1	7.5
D: 30-year bond						5.3					
@ 10 years	9.5	8.5	7.5	6.7	5.9		4.8	4.5	4.2	4.0	3.9
@ Duration	6.2	5.9	5.7	5.5	5.4		5.4	5.5	5.6	5.9	6.1
@ Maturity	3.4	3.7	4.0	4.4	4.9		5.8	6.4	6.9	7.5	8.2

Table 3 shows (geometric) mean annual returns for bonds with five-year (panel A), ten-year (panel B), twenty-year (panel C), and thirty-year (panel D) maturities, given one-time changes in interest rates between one and five percentage points with respect to each bond's initial yield to maturity (YTM). All four bonds have a face value of $1,000, an interest rate of 5 percent, pay semiannual coupons, and have a current price of $950. All figures in %.

TABLE 4 A Broader Scope: Trending Changes in Interest Rates

	−5	−4	−3	−2	−1	YTM	+1	+2	+3	+4	+5
A: 5-year bond						6.2					
@ 10 years	N/A	N/A	N/A	N/A	N/A		N/A	N/A	N/A	N/A	N/A
@ Duration	6.5	6.4	6.3	6.3	6.2		6.1	6.1	6.0	6.0	5.9
@ Maturity	5.9	6.0	6.0	6.1	6.1		6.2	6.3	6.3	6.4	6.4
B: 10-year bond						5.7					
@ 10 years	5.3	5.3	5.4	5.5	5.6		5.7	5.8	5.9	6.0	6.1
@ Duration	6.2	6.1	6.0	5.9	5.8		5.6	5.5	5.4	5.3	5.2
@ Maturity	5.3	5.3	5.4	5.5	5.6		5.7	5.8	5.9	6.0	6.1
C: 20-year bond						5.4					
@ 10 years	6.9	6.6	6.3	6.0	5.7		5.1	4.9	4.6	4.4	4.1
@ Duration	6.4	6.2	6.0	5.8	5.6		5.2	5.1	4.9	4.8	4.6
@ Maturity	4.7	4.9	5.0	5.1	5.3		5.6	5.7	5.9	6.0	6.2
D: 30-year bond						5.3					
@ 10 years	7.0	6.7	6.3	6.0	5.7		5.0	4.7	4.4	4.2	3.9
@ Duration	6.4	6.1	5.9	5.7	5.5		5.2	5.0	4.8	4.7	4.6
@ Maturity	4.5	4.6	4.8	5.0	5.1		5.5	5.7	5.9	6.1	6.4

Table 4 shows (geometric) mean annual returns for bonds with five-year (panel A), ten-year (panel B), twenty-year (panel C), and thirty-year (panel D) maturities, given trending changes in interest rates between one and five percentage points with respect to each bond's initial yield to maturity (YTM). All four bonds have a face value of $1,000, an interest rate of 5 percent, pay semiannual coupons, and have a current price of $950. All figures in %.

For the 20-year and 30-year bonds, the forecasting errors are somewhat larger but the initial yield still fairly accurately predicts mean returns, in particular when the changes in interest rate are on the lower end of the range considered. For changes in interest rates three percentage points or less, all forecasting errors are less than 100 basis points in annual terms.[11] Moreover, in these cases, the initial yield provides a better forecast of longer-term (duration and maturity) mean returns than it does of shorter-term (ten years) mean returns.

To summarize, a bond's initial yield to maturity is in general a fairly accurate forecast of the bond's mean annual return, with the forecast being more (less) accurate the smaller (larger) the change in interest rates is during the bond's life. Moreover, when interest rates change and remain rather stable over a bond's life, the forecast seems to be best for a period of time similar to the bond's duration; on the other hand, when interest rates trend upward or downward during a bond's life, the forecast seems to be better for periods longer than the bond's duration.

A Brief Overview of Related Work

The initial yield to maturity has become a tool often used to forecast bond returns, and yet it is not entirely clear who first proposed it. Bogle (1991) refers to the initial yield to maturity as "the single most important factor" when forecasting bond returns and backs his statement with some intuition and data for long-term U.S. Treasury bonds. More precisely, he shows the yield of these bonds at the beginning of six decades, the subsequent ten-year annualized return, and concludes that the former is a "remarkably efficient (if admittedly imperfect) indicator" of the latter.[12] Interestingly, the article does not contain any references to previous work.

Bogle (1995) reaffirms his conviction in the framework he proposed in Bogle (1991), adding that the correlation between the initial yield of long-term U.S. Treasury bonds and subsequent ten-year annualized returns was 0.95 during 1926–1990. Bogle and Nolan (2015) further reaffirm their support for the same framework, which they call the Bogle Sources of Return Model for Bonds, and highlight the very high correlation between the initial yield on 10-year U.S. Treasury notes and subsequent ten-year annualized returns (0.95).

Baker (2011) also supports using the initial yield to forecast bond returns, crediting Bogle (1995) for advancing the idea. He shows that the correlation between the initial yield of 10-year U.S. Treasury notes and subsequent annualized returns is 0.955 during 1881–2008, and rather constant over the three subperiods he considers. Leibowitz et al. (2014) show that the annualized return of a bond tends to converge to the initial yield regardless of whether interest rates increase or decrease during the forecasting period. Brightman (2016) highlights that the strong predictive relationship between the initial yield and subsequent ten-year annualized returns is not limited to the United States. He shows that the correlation between these two variables is 0.53 in the United Kingdon (during 1987–2015), 0.86 in Germany (during 1982–2015), and 0.96 in Japan (during 1987–2015).

The more-academic literature also features many contributions that complement the practitioner-oriented literature just discussed. For example, Cochrane and Piazzesi (2005) find that a single factor (a linear combination of forward rates) successfully predicts excess bond returns with maturity between one and five years; Duffee (2011) finds that "almost half of the variation in bond risk premia cannot be detected using the cross-section of yields," and that fluctuations in this hidden component have strong forecasting power for excess bond returns; Adrian et al. (2013) propose a model that uses the first five principal components of yields to span the cross section of bond returns; and Cepni et al. (2020) introduce an aligned sentiment index that successfully forecasts bonds with maturity between two and five years.

Evidence

In-Sample Correlations

Two samples are used here, one for U.S. 10-year Treasury notes and another for Bloomberg indexes of investment-grade bonds. The former consists of yields to maturity and total returns for the U.S. 10-year Treasury notes based on the data provided by Robert Shiller on his web page.[13] Yields to maturity are year-end values between 1871 and 2023; bond returns are annual, in nominal terms (not adjusted by inflation), and during the 1872–2023 period.

In order to assess the ability of the yield to maturity to forecast bond returns, the first step is to calculate forward annualized returns; that is, annualized returns that followed the observation of a given yield to maturity. This is done over all possible (overlapping) periods of one, three, five, seven, ten, twelve, fifteen, twenty, and thirty years. In all cases, the yield to maturity at the end of each year is paired with the subsequent *t*-year forward annualized return. Figure 1 summarizes the results.

Figure 1, panel A shows the yield to maturity at the end of every year between 1871 and 2013, as well as ten-year forward annualized returns during 1872–1881 and 2014–2023. The very close relationship between these two variables is clear from the picture and further confirmed by a correlation of 0.96 between them.

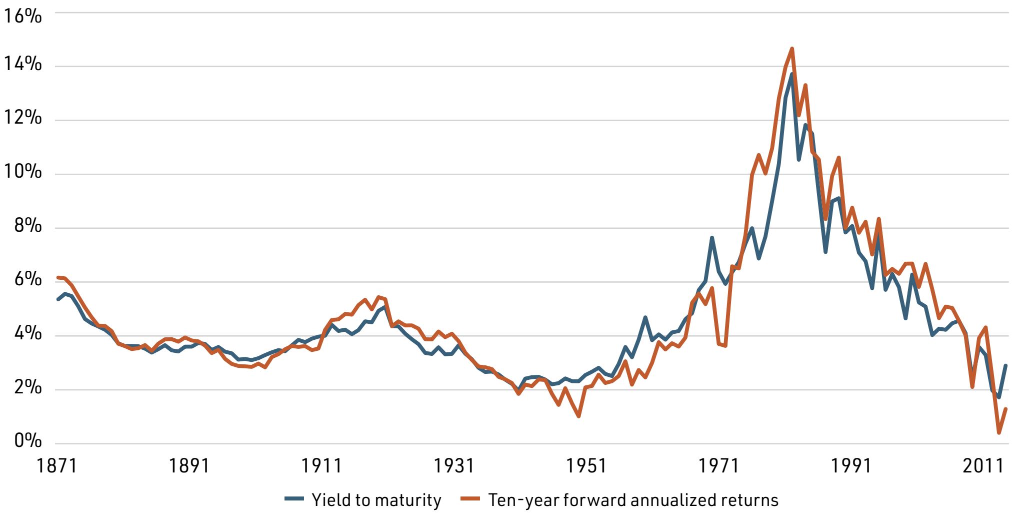
The relationship between the yield to maturity and forward annualized returns, however, is not equally strong across all the forecasting periods considered. As shown in panel B1, the relationship is weaker for returns one year ahead (as revealed by a 0.55 correlation), though it improves for returns three years ahead (0.80 correlation). The strongest correlations between these two variables are for forecasting periods of ten, twelve, and fifteen years (0.96), then correlations decrease slightly (to 0.92) for forecasting periods of twenty years and decrease again for forecasting periods of thirty years (to 0.77).

The previous correlations are based on overlapping periods, which are well known for potentially inflating the estimated correlations. Panel B2 shows correlations for non-overlapping periods, which reduces substantially the number of observations but deals with the dependency issue. Over non-overlapping periods of five, ten, twelve, and fifteen years the relationship between the yield to maturity and forward annualized returns remains remarkably strong, with a minimum of 0.89 over five years and a maximum of 0.98 over twelve years.

In short, a bond's initial yield to maturity is very closely related to the bond's medium-term expected return, defined as the return over the subsequent ten to fifteen years. The relationship is somewhat weaker over shorter forecasting periods (three to five years) and longer forecasting periods (more than twenty years), but still strong enough to provide useful guidance over those investment horizons as well.

FIGURE 1 In-Sample Correlations: U.S. 10-Year Treasury Notes

A: Yield to Maturity vs. Ten-Year Forward Annualized Returns



B: Correlations

B1: OVERLAPPING	
1 year	0.55
3 years	0.80
5 years	0.89
7 years	0.93
10 years	0.96
12 years	0.96
15 years	0.96
20 years	0.92
30 years	0.77
B2: NON-OVERLAPPING	
5 years	0.89
10 years	0.96
12 years	0.98
15 years	0.92

Panel A depicts, for the U.S. 10-year Treasury notes, the yield to maturity at the end of every year between 1871 and 2013 and ten-year forward annualized returns during 1872–1881 and 2014–2023.

Panel B shows correlations between yield to maturity and forward annualized returns over one, three, five, seven, ten, twelve, fifteen, twenty, and thirty years for overlapping observations (B1), and over five, ten, twelve, and fifteen years for non-overlapping observations (B2).

The second sample consists of three Bloomberg indexes of investment-grade bonds for the U.S. market and three for the global market. In both cases the indexes represent all bonds (U.S. Aggregate and Global Aggregate), only government bonds (U.S. Government and Global Government), and only corporate bonds (U.S. Corporate and Global Corporate). The data consist of monthly yields to maturity, nominal returns, and duration for all six indexes from September 2000 to September 2024.[14] Table 5 summarizes the results.

Table 5 shows in the second column the average duration (D) of each index over the sample period, which ranges between 5.5 and 6.9 years. The next six columns show correlations between the yields to maturity of each index and forward annualized returns over different forecasting periods ranging from one year (1Y) to fifteen years (15Y), including a period roughly equal to the average duration of each index (DY).

As was the case with the U.S. 10-year Treasury notes, the yield to maturity is most highly correlated to forward annualized returns over periods that are neither too short nor too long. For the U.S. indexes the highest correlations correspond to forecasting periods between ten and twelve years; for the global indexes, in turn, the highest correlations are for somewhat shorter periods, roughly equal to the duration of each index (between six and seven years).

In short, this broader evidence (albeit over a shorter sample period) provides additional support to the hypothesis that the initial yield to maturity is very closely related to the medium-term expected return of a bond or bond index. For U.S. indexes, the sweet spot seems to be a forecasting period between ten and twelve years, whereas for global indexes it is for a somewhat shorter period, roughly between six and seven years.

Out-of-Sample Forecasting

The in-sample correlations reported and discussed in the previous section suggest a tight link between the initial yield to maturity and subsequent bond returns. The ultimate test of a model, however, is its ability to forecast out of sample, which is the issue discussed in this section. For each forecasting period considered here between one year and thirty years, the sample is split into two, with the first half used to make a first estimate of α and β in the regression

$$R_{t+n} = \alpha + \beta \times YTM_t + u_t \qquad (1)$$

where R_{t+n} is the expected annualized return n years forward (for n = 1, 3, 5, 7, 10, 12, 15, 20, 30), YTM is the initial yield to maturity, u is an error term, and t indexes periods.

The first estimates of α and β from (1), using the first half of each sample, are used to make a first out-of-sample forecast n years ahead. From that point on stepwise regressions are run adding one period each time, re-estimating α and β in each round, and making new out-of-sample forecasts n years ahead. This process results in series of *expected* annualized returns for each forecasting period considered; the relationship between these series and *observed* annualized returns over those

TABLE 5 In-Sample Correlations: Bloomberg Bond Indexes

INDEX	D	1Y	5Y	DY	10Y	12Y	15Y
U.S. Aggregate	5.6	0.56	0.76	0.79	0.87	0.89	0.48
U.S. Government	5.5	0.54	0.76	0.78	0.86	0.86	0.72
U.S. Corporate	6.9	0.50	0.70	0.70	0.83	0.90	0.18
Global Aggregate	6.2	0.53	0.82	0.84	0.80	0.81	0.19
Global Government	6.9	0.50	0.80	0.82	0.79	0.78	0.31
Global Corporate	6.0	0.49	0.78	0.82	0.69	0.66	−0.17

Table 5 shows, for six Bloomberg bond indexes–three for the U.S. market and three for the global market–the average duration (D, in years), and the correlation between yields to maturity and forward annualized returns over different periods measured in years (Y), including over a period roughly equal to the average duration of each index (DY). The sample period is September 2000 to September 2024.

TABLE 6 Out-of-Sample Forecasting

A: 10Y T-NOTE	1Y	3Y	5Y	7Y	10Y	12Y	15Y	20Y	30Y	
A1: REGRESSIONS										
Rho	0.50	0.79	0.88	0.92	0.95	0.95	0.95	0.92	0.80	
MD	−0.16	−0.03	−0.02	0.02	0.04	0.10	0.19	0.16	−0.37	
MAD	5.82	2.41	1.51	1.12	0.79	0.75	0.73	0.96	1.42	
A2: YTM										
Rho	0.54	0.79	0.89	0.93	0.95	0.96	0.95	0.90	0.76	
MD	−0.29	−0.16	−0.18	−0.18	−0.19	−0.19	−0.21	−0.27	−0.55	
MAD	5.78	2.40	1.58	1.24	0.93	0.79	0.70	0.96	1.72	
B: BLOOMBERG INDEXES	**1Y**	**5Y**	**10Y**	**12Y**	**15Y**	**1Y**	**5Y**	**10Y**	**12Y**	**15Y**
	B1: REGRESSIONS					**B2: YTM**				
Rho										
U.S. Aggregate	0.53	0.01	0.89	0.94	0.70	0.42	−0.28	0.76	0.93	0.46
U.S. Government	0.46	−0.18	0.77	0.94	0.84	0.37	−0.36	0.67	0.85	0.80
U.S. Corporate	0.49	−0.04	0.92	0.95	0.17	0.47	0.05	0.80	0.94	−0.14
Global Aggregate	0.26	−0.09	0.90	0.92	0.58	0.25	−0.09	0.82	0.89	−0.05
Global Government	0.12	−0.15	0.90	0.91	0.71	0.14	−0.09	0.80	0.83	0.31
Global Corporate	0.46	0.20	0.88	0.88	0.03	0.45	0.20	0.82	0.92	−0.36
MD										
U.S. Aggregate	1.56	0.76	0.72	0.54	0.79	1.00	0.15	0.26	0.68	1.54
U.S. Government	1.88	0.85	0.67	0.68	0.75	0.84	−0.19	−0.32	0.10	1.09
U.S. Corporate	0.46	0.14	0.75	0.46	0.58	0.59	−0.23	0.00	0.42	1.17
Global Aggregate	1.36	0.38	1.19	1.22	1.51	1.60	0.90	1.15	1.33	1.48
Global Government	1.61	0.32	1.33	1.49	1.77	1.92	1.04	1.14	1.20	1.14
Global Corporate	0.61	0.32	1.34	1.37	0.99	0.88	0.45	0.94	1.31	1.64
MAD										
U.S. Aggregate	3.77	1.15	0.76	0.56	0.84	3.71	1.16	0.73	0.70	1.54
U.S. Government	4.10	1.21	0.79	0.68	0.78	3.94	1.30	0.69	0.56	1.10
U.S. Corporate	4.45	1.38	0.79	0.58	0.72	4.60	1.44	0.85	0.56	1.31
Global Aggregate	4.91	1.77	1.20	1.27	1.51	4.80	1.71	1.19	1.34	1.58
Global Government	5.82	2.13	1.34	1.50	1.77	5.61	1.97	1.20	1.29	1.41
Global Corporate	4.70	1.43	1.34	1.37	1.04	4.68	1.38	1.09	1.31	1.79

Table 6 shows, for the U.S. 10-year Treasury notes (panel A), the correlation between the forecasts of annualized returns from stepwise regressions and observed annualized returns over different periods measured in years (Y), the mean deviation (MD), and the mean absolute deviation (MAD), as well as the same information for forecasts of annualized returns directly from the yield to maturity (YTM). It also shows the same information for the Bloomberg Bond indexes of investment-grade bonds (panel B) for the U.S. market and for the global market. MD and MAD in %.

periods is assessed by the correlation (Rho), mean deviation (MD), and mean absolute deviation (MAD) between them.[15] Panel A1 of table 6 shows the results for the U.S. 10-year Treasury notes.

The out-of-sample correlations between expected and observed returns are consistent with the in-sample results discussed in the previous section; that is, except for the rather weak correlation for returns expected one year ahead, for the rest of the forecasting periods considered all the correlations between expected and observed returns are higher than 0.75. In addition, and also consistent with the results in the previous section, the highest correlations are for forecasting periods of ten, twelve, and fifteen years (0.95); for these three periods, the mean deviation (that is, the average forecasting error) is less than 20 basis points a year, and the mean absolute deviation (the average forecasting error in absolute value) is less than 80 basis points a year.

The success of this very simple regression model, however, should be compared with an even simpler alternative, namely, forecasting annualized returns only with the yield to maturity; that is, setting $\alpha = 0$ and $\beta = 1$ so that $R_{t+n} = YTM_t$. The results of forecasting with this even simpler model are reported in table 6, panel A2 and are similar to those in panel A1. The highest correlations between expected and observed returns are again for forecasting periods between ten and fifteen years (0.95–0.96), with somewhat lower correlations for the rest of the periods, and the lowest correlation is again for the one-year period. Across all the forecasting periods considered here, the MDs in panel A2 are slightly higher than, and the MADs are very similar to, those in panel A1.

All things considered, then, there does not seem to be a significant gain from estimating regression models; the yield to maturity by itself produces forecasts that are similarly accurate. In any case, the analysis does clearly support the more general hypothesis that the initial yield to maturity, by itself or as an explanatory variable in a simple regression model, produces reliable estimates of expected bond returns some ten to fifteen years ahead.

IN THE CASE OF BOND INDEXES THE REGRESSION MODELS SEEM TO HAVE A VERY SLIGHT ADVANTAGE OVER THE YIELD TO MATURITY BY ITSELF IN TERMS OF FORECASTING ABILITY, MOSTLY IN TERMS OF SLIGHTLY HIGHER CORRELATIONS.

Are these results for the U.S. 10-year Treasury notes also valid for bond indexes, and more precisely for the Bloomberg indexes of investment-grade bonds? This is explored in table 6, panel B; panel B1 shows the results for the regression model in (1) and panel B2 for the yield to maturity by itself.[16] Overall, the correlations between expected and observed returns are slightly higher for the regression models than for the yield to maturity by itself. In both cases, across forecasting periods, the highest correlations are for forecasts twelve years ahead, largely consistent with the results for the U.S. 10-year Treasury notes.

For both models forecasting errors are lowest for predictions five to twelve years ahead when measured by MD, and more tightly concentrated for predictions ten to twelve years ahead when measured by MAD (with the sole exception of the Global Corporate index, which has a minimum MAD at fifteen years for the regression models). Furthermore, regardless of whether forecasting errors are assessed with MD or with MAD, the results do not show any clear outperformance of one model over the other.

All things considered, then, in the case of bond indexes the regression models seem to have a very slight advantage over the yield to maturity by itself in terms of forecasting ability, mostly in terms of slightly higher correlations. At any rate, as was the case with the U.S. 10-year Treasury notes, the analysis based on bond indexes does support the more general hypothesis that the initial yield to maturity, by itself or as an explanatory variable in a simple regression model, produces reliable estimates of expected bond returns some ten to fifteen years ahead.

Assessment

Forecasting the return of financial assets is, in general, a mix of art and science; forecasting the return of bonds, however, relies much more on the latter than on the former. This is the case because bonds have two characteristics that most other assets do not have, namely, fixed cash flows and a fixed maturity date. These two features, combined with some specific assumptions, render bond returns certain.

Needless to say, bond returns are not certain. The underlying assumption that the cash flows paid by a bond always can be reinvested at the calculated initial yield to maturity is clearly unrealistic. In fact, because the rates at which those cash flows will be reinvested are unknown, a bond's initial yield to maturity is in general not equal to its mean return even if the bond is held until maturity. Still, investors often use this initial yield as a proxy for the expected return of bonds, in particular over holding periods of ten or so years.

The example discussed in this paper highlights that changes in interest rates affect bond prices (hence capital gains and coupon yields) and the reinvestment rate of coupon payments (hence the future value of those cash flows). When the changes in interest rates are small, these effects also are small and therefore the bond's yield remains very close to the bond's mean return through maturity. When the changes in interest rates are large, however, the bond's yield tends to diverge from the bond's mean return, in particular over very short and very long periods.

The evidence discussed, based on U.S. 10-year Treasury notes and Bloomberg bond indexes, generally supports the approach of forecasting the return of a bond or bond index using the yield to maturity of the bond or the index. For holding periods of around ten to fifteen years, yields and forward returns are strongly related, both in sample and out of sample. In fact, the evidence suggests that it may not even be necessary to link these two variables through a simple regression model; the yield by itself delivers correlations and forecasting errors very similar to those of regression models.

All in all, then, conventional wisdom seems to have it approximately right. The yield to maturity does provide very sensible forecasts of medium-term bond returns. And as Warren Buffett is fond of saying, it is better to be approximately right than precisely wrong.

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ENDNOTES

1. This article considers coupon (not floating-rate) bonds, which are by far the most common.
2. As usual when discussing bond yields, the impact of compounding (that stems from the fact that the bond pays semiannual coupons) is ignored; therefore 5.4 percent is the annual yield to maturity calculated as 2 × (2.7%), not the *effective annual* yield to maturity calculated as $(1+2.7\%)^2 - 1 = 5.5\%$.

3. Note that what is referred to as the bond's *price* actually is the bond's *intrinsic value*. In other words, throughout the discussion the implicit assumption is that the market values the bond correctly, and therefore the bond's price is equal to its intrinsic value.
4. To clarify, G adds one observation to its calculation as each period goes by; it uses one return at the end of the first semester, two returns at the end of the second semester, and all the returns at maturity.
5. This 5.8-percent mean annual return also can be seen at the bottom (period 40) of the seventh column.
6. This figure is the bond's Macaulay duration, which approximately measures interest-rate risk; that is, the change in the bond's price given a 1-percent change in interest rates.
7. The 5.1-percent mean annual return also can be seen at the bottom (period 40) of the seventh column.
8. To clarify, the figures in table 3 are based on interest rates changing by x percentage points right after a bond is bought (for $950) and then remaining at the new level through each bond's maturity.
9. The durations of the 5-year, 10-year, 20-year, and 30-year bonds considered are 4.5, 7.9, 12.7, and 15.5, respectively.
10. To clarify, the figures in table 4 are based on interest rates changing by x percentage points between the time right after a bond is bought (for $950) and each bond's maturity, trending upward or downward in between. Therefore, if a five-percentage-point increase is considered for a 20-year bond, discount rates would trend upward at the rate of 0.125 percent per semester, thus accumulating a five-percentage-point increase by the end of the bond's life.
11. A reviewer rightly points out that what may seem like small differences in mean annual returns may compound to large differences in terminal wealth over long periods.
12. Table 3 in Bogle (1991) implies average forecasting errors between 0.8 percent (for the 1940s) and 2.9 percent (for the 1960s), and on average 1.9 percent, in all cases in annual terms.
13. See "Online Data Robert Shiller," http://www.econ.yale.edu/~shiller/data.htm.
14. In the case of bond indexes, which do not have a maturity date, the yield to maturity is a weighted average of the yields to maturity of all the bonds in the index.
15. MD is the average difference between the periodic expected and observed returns; MAD, in turn is the average difference, in absolute value, between the periodic expected and observed returns.
16. The regressions in (1) are run as already discussed. The only difference is that in this case *t* indexes months instead of years (as was the case for the U.S. 10-year Treasury notes).

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