July 2021

What Drives Bond Yields?

Executive Summary

This paper provides an overview of the various factors that influence government bond yields. The current short-term interest rate, expected future short-term interest rates, and term premia determine the level of (risk-free) bond yields in the economy. While the current short-term interest rate and its near-term expected path are largely controlled by central banks, longer-horizon expectations of future short-term interest rates, as well as term premia, are largely driven by non-policy factors. Different forms of monetary policy – e.g., traditional interest rate policy, forward guidance, and quantitative easing – are unified, reacting to the same set of economic variables and influencing broad economic conditions through their impact on longer-maturity yields. Both in theory and in the data, non-monetary policy factors drive significant variation in yields, particularly at longer maturities. Indeed, ten-year bond yields move nearly one-for-one with changes in long-term growth and inflation expectations, which explains the secular decline in bond yields over the past several decades. Despite "noise" to the contrary, and despite the exceptionally low yield environments we have witnessed, fundamentals continue to drive bond markets.

These findings have implications for investors. From a strategic allocation standpoint, assuming government bond risk is highly one-sided, with low interest rates implying there is no room for bonds to rally, is misguided. From a tactical perspective, despite low yields and innovations in the conduct of monetary policy since the Global Financial Crisis, a fundamentally driven approach to bond market investing should retain its efficacy into the future.

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I thank Cliff Asness, Paolo Bertolotti, Mohsan Bilal, Michael Doros, Tony Gould, Peter Hecht, Bradley Jones, Antti Ilmanen, William Latimer, Zachary Mees, Michael Mendelson, Scott Richardson, Nick Steinbach, and Zhikai Xu for their valuable comments and suggestions.

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1. Introduction

The aim of this paper is to provide a comprehensive, but non-technical, overview of the factors that influence long-maturity government bond yields.[1] What determines the level of bond yields in the economy and what drives their variation over time?

With yield levels recently testing unchartered waters, it is hardly surprising there are many questions, and a lot of "noise," as to why yields are low and where they may venture from here. I outline a framework for identifying and understanding the important drivers of bond yields. In this way, I hope to arm the reader with a structure to thoughtfully produce their own answers to topical questions.

A simple and mechanical decomposition of bond yields proves to be extremely useful. This is where I begin in section 2. The yield on a long-maturity bond is equal to the average expected short-term interest rate over the life of the bond and a "term premium" – the incremental compensation investors require to hold a long-maturity bond versus a series of short-maturity bonds. Yield levels, therefore, depend on 1) the current short-term interest rate, 2) expected future short-term interest rates, and 3) term premia. Variations in one or more of these factors are what causes yields to change.

I analyze the drivers of current and expected future short-term interest rates in section 3. Central banks effectively control the short-term interest rate and their behavior is well described by the "Taylor rule," which relates the level of the short-term interest rate to the near-term outlook for employment and inflation. Expected future short-term interest rates are also influenced by monetary policy. "Forward guidance" refers to the central bank policy of communicating information about the anticipated path of future short-term interest rates with the aim of influencing long-maturity bond yields. Long-horizon expectations of short-term interest rates, however, are anchored by macroeconomic fundamentals: long-term inflation expectations and the "natural rate of interest," itself closely linked to the trend growth rate of output ("trend growth").

The determinants of term premia are the focus of section 4. The level of inflation uncertainty and economy-wide counter-cyclical risk-aversion are two key factors. But term premia are also influenced by exogenous supply and demand conditions, both secular – e.g., the demand for government debt by central bank reserve managers, and shorter-term – e.g., safe-haven demand during times of financial market stress. Monetary policy aims to influence term premia as well. By purchasing bonds and other long-maturity assets, central banks reduce their net supply, suppressing term premia, and, correspondingly, lowering bond yields. This policy, which originated in response to the Global Financial Crisis (GFC) and the ensuing Great Recession, is popularly called "Quantitative Easing" (QE).

Section 5 focuses on monetary policy drivers of bond yields. I discuss how the seemingly disparate policy tools of adjusting short-term interest rates, forward guidance, and QE, are all extremely similar, each aiming to influence the economy by manipulating

1 My focus is on "risk-free" government bonds – i.e., I ignore sovereign credit risk.

yields on long-maturity bonds. Likewise, other tools, some proposed and some adopted – e.g., “average inflation targeting,” “nominal GDP targeting,” “operation twist,” “yield curve control,” to name a few – can all be understood as various implementations of forward guidance and QE.

While monetary policy certainly influences bond yields, it is *far* from the sole determinant. Fundamental macroeconomic forces – long-term inflation expectations and trend growth, uncertainty and risk aversion, exogenous demand factors and regulatory considerations – influence expected future short-term interest rates and term premia, and, therefore, exert considerable influence on bond yields, especially at longer maturities. I discuss non-monetary policy drivers of yields in section 6.

I attempt to shed light on what I think are a (select) few of the current relevant questions regarding bond yields in section 7. With yields having recently tested new lows, there is the temptation to proclaim, “this time is different,” and “the rules of the game have changed.”

But it really isn’t, and they really haven’t. Fundamental forces provide the backdrop for exceptionally low bond yields: despite the recent uptick in inflation, long-term expectations remain near generational lows, and estimates for the natural rate of interest are near zero. Even abstracting from the actions of central banks, long-maturity yields would likely be quite low at present.[2] In terms of how yields may evolve, expected future short-term interest rates and term premia are key determinants of long-maturity yields. Both policy and non-policy factors can drive these components lower (or higher), even if short-term interest rates remain fixed. Central banks can provide additional stimulus through forward guidance and QE. Continued declines in long-term inflation expectations or trend growth could put further downward pressure on yields by suppressing expected future short-term interest rates. This is not a forecast. There are upside risks to yields as well, a potential increase in inflation expectations foremost among them. But in the face of the “noise,” sometimes the obvious needs to be reiterated: bond market risks are two-sided.

2. Decomposing bond yields

My starting point is an identity: the yield on a bond is equal to the average expected interest rate over the life of the bond plus a term premium. (Throughout this paper I will use “yield” to mean the yield on a long-maturity bond – i.e., greater than three-month – and “interest rate” to mean the three-month T-bill rate.) Bond yields, therefore, depend on three factors: the current interest rate, expected future interest rates, and the term premium.

Bond yields and interest rates are familiar concepts, and “expected future interest rates” is intuitive to grasp. The “term premium,” however, may be less familiar. Definitionally, the term premium is the difference between

$$\textit{Bond Yield}^{3} \sim \textit{Current Interest Rate}\ (+),\ \textit{Expected Future Interest Rates}\ (+),\ \textit{Term Premium}\ (+)$$

2 This statement should *not* be interpreted as, "bonds are fairly priced." It should be interpreted as, "even in the absence of accommodative monetary policy, macroeconomic fundamentals imply yield levels would likely be low relative to their history." Providing a tactical outlook for government bonds is not the intention of this paper.

3 Read: “A bond yield depends positively on the current interest rate, expected future interest rates, and the term premium.”

the yield on a bond and the market's expectation of future interest rates over the life of the bond. Hence, it embeds everything impacting the yield other than current and expected future interest rates. Another interpretation, however, is often more useful: the term premium measures the expected excess return investors require to hold to maturity a long-maturity bond versus rolling over a series of short-maturity bonds.[4]

Although the yield decomposition is purely an atheoretical identity, it is nevertheless powerful. For example, Inker (2020) suggests bond yields in G10 markets cannot decline because central banks have set interest rates at their lower bound. The simple yield decomposition is sufficient to dispel this myth. Even with interest rates fixed, yields can move lower (or higher) due to either changes in expected future interest rates from the level bond markets are currently pricing in, or changes in the term premium, which may be the result of either deliberate monetary policy actions or fundamental macroeconomic forces.

One way to read the yield decomposition is "current and expected future interest rates, as well as term premia, determine bond yields." But another reading is "the yield curve – the collection of yields on bonds of different maturities – embeds information about expected future interest rates and term premia." An upward sloping yield curve must imply investors expect interest rates to rise, term premia are positive (and increasing with maturity), or some combination of the two. While in absence of a model we can't decompose the yield curve at a point in time into interest rate expectations and term premia, we can in fact learn something purely from the data about *average* term premia. Over a long enough period, expected changes in interest rates should average to zero. If I told you "over the last hundred years investors expected interest rates to rise by an average of two percent per year" that would strain credulity. The fact the yield curve has been upward sloping on average, therefore, implies term premia have been on average positive and increasing with maturity.[5]

Expectations Hypothesis

To understand the drivers of bond yields at a deeper level, and to identify their policy and non-policy drivers, we need to introduce theory. In the remainder of this section, I focus on a simple theory of the yield curve: the expectations hypothesis (EH). In its modern incarnation, the EH stipulates term premia are constant over time, although they may differ by maturity. Under the EH, variation in bond yields are driven by just two factors: the current interest rate and expected future interest rates.

The EH can accommodate a wide range of yield curve shapes and dynamics. It easily captures yield curves are upward sloping on average by postulating term premia are positive and increasing with maturity. It also explains the tendency for the yield curve to be steeper when the interest rate is low and flatter when the interest rate is high. According to the EH, the yield curve is steeper than average when interest rates are expected to rise and flatter than average when interest rates are expected to decline. When the interest rate is low, markets typically expect it to increase over time, hence the yield curve is steeper than

4 The term premium is the expected excess return of holding a bond to maturity, rolling over financing. It is *not* the expected return from a "constant maturity" or "rolled" position.

5 Simple empirical facts support this conclusion. Since 1960 across G6 markets (Australia, Canada, Germany, Japan, UK, US) both the average yield curve slope and average constant-maturity ten-year excess bond returns have been positive, and excess returns have been higher in markets where the curve has been steeper. Data is from Bloomberg.

average. An inverted yield curve is thought to be the harbinger of a recession. Again, the EH provides strong guidance as to why: an inverted curve means investors anticipate the interest rate will fall meaningfully in the future, which typically occurs in a recession.

The EH also provides a lens through which to understand yield curve dynamics. When central banks increase the interest rate, long-maturity bond yields tend to rise as well, but generally by less – i.e., the curve tends to flatten. Why? When the interest rate rises, expected future interest rates out a few years usually rise as well. But long-horizon expectations of interest rates tend to be well-anchored and change by less. As the yield on a bond is the average of expected interest rates over its lifetime, long-maturity bond yields will rise, but they will rise by less than shorter term yields, causing the curve to flatten. The EH seamlessly and intuitively embeds the fact changes in interest rates tend to have an impact on both the level and the slope of the yield curve.

Of course, the EH is not the final word: term premia do vary over time and more elaborate models will allow for this. But they all retain, to a large degree, the spirit of the EH – current interest rates and expected future interest rates are major drivers of bond yields. Now that we understand how changes in current and expected future interest rates transmit to the rest of the yield curve, let's turn to understanding the drivers of the interest rate.

3. Understanding interest rates

To understand the variables that impact bond yields we need to understand the drivers of the interest rate. In developed market economies, the interest rate is, to a large extent, controlled by the central bank and is their primary monetary policy lever.[6] To understand the behavior of the interest rate, therefore, we need a basic understanding of how central banks conduct monetary policy.

All central banks, *de facto* if not *de jure*, strive to maintain 1) low and stable inflation, and 2) full employment. But how do they attempt to achieve these objectives – how do central banks influence economic outcomes? To answer this question, I sketch a simple, yet powerful, model of the business cycle and monetary policy. The model contains four elements:

1. An "aggregate demand" (AD) relationship linking spending and output in the economy to the real yield on long-maturity bonds

2. An "aggregate supply" (AS) relationship linking inflation to inflation expectations and economic activity

3. A monetary policy equation, known as the "Taylor rule" (TR), describing how the central bank sets the interest rate

6 Some central banks do explicitly target the three-month rate, while others, such as the Federal Reserve, target a shorter-term rates (e.g., overnight). At the very front end of the curve, however, the EH is an excellent approximation, so I will (safely) assume throughout this paper central banks explicitly control the three-month interest rate.

4. The expectations hypothesis (EH), which links longer-maturity bond yields to current and expected future interest rates

Although this model is simple and parsimonious, the AD-AS-TR-EH framework is at the core of almost all models used by central banks and practicing macroeconomists to understand the impact of economic events on output and inflation, and to analyze the prospective impact of monetary policy actions.

Aggregate Demand

The aggregate demand relationship links the "output gap" – the difference between the current level of output and the level consistent with full employment ("potential output") – to the *real* yield on long-maturity bonds. The real yield is a new concept. All references above to yields (and interest rates) were implicitly referring to *nominal* yields. The real yield is simply the nominal yield minus maturity-matched inflation expectations. It is the real yield, not the nominal yield, which enters the AD relationship. The output gap is the key measure of economic activity central banks target, as they can hope to influence it over the short-run. Potential output, on the other hand, is not something monetary policymakers are able to influence; it is determined by purely real factors, such as longer-term productivity growth.[7]

The AD equation posits a negative relationship between the output gap and the real yield. The real yield on government bonds influences, directly and indirectly, a variety of borrowing and savings rates across the economy. When the real yield is high, borrowing is more expensive, and savings earns a higher reward. Demand for goods and services falls, reducing aggregate expenditure, and the output gap declines.[8] We can concisely summarize the AD relationship:

Output Gap ~ Real Yield (–)

Aggregate Supply

The aggregate supply relationship links the level of inflation to expected inflation and the output gap.

Inflation depends positively on expected inflation. Firms often cannot continually adjust their prices and wages and must set them based on expectations of the future. If firms anticipate low inflation, they may raise prices at a slower rate. If workers expect higher inflation, they may negotiate larger wage increases. Expected future inflation, therefore, influences the inflation rate today. Inflation also depends positively on the output gap. When the economy is booming and the output gap is positive, firms experience increasing marginal costs and raise their prices. On the contrary, when the economy is in a recession and the output gap is negative, marginal costs fall, and firms lower their prices. We can concisely summarize the AS relationship:

Inflation ~ Expected Inflation (+), Output Gap (+)

Monetary policy

Despite its simplicity, the AD-AS-TR-EH model accommodates a variety of traditional and non-traditional monetary policies. For now, however, I focus on the most traditional monetary policy tool: the interest rate.

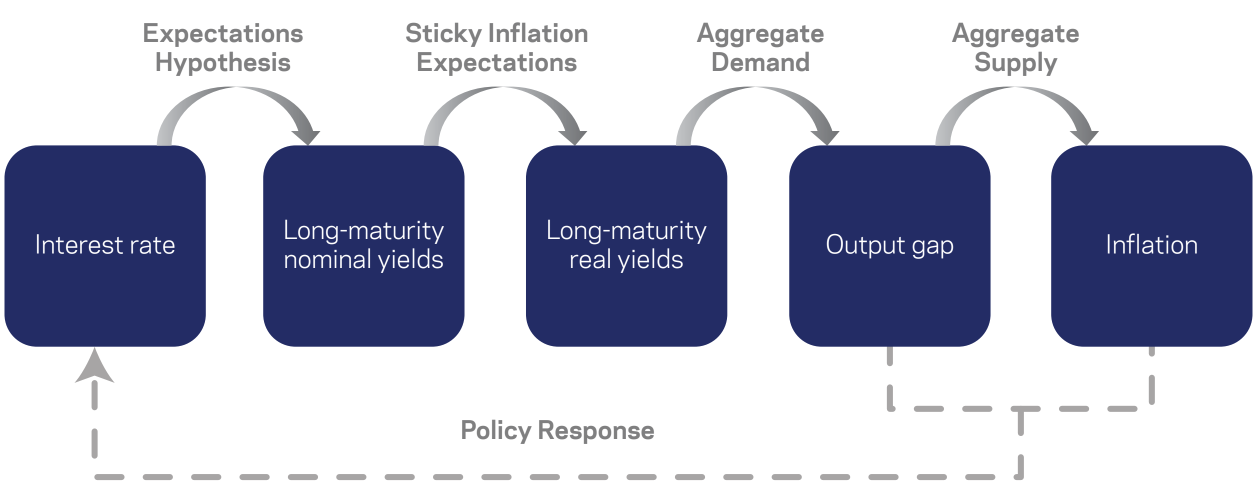
7 In terms of labor markets, the output gap is synonymous to the difference between the unemployment rate and the "natural rate of unemployment," or "NAIRU." I will use "output" and "employment" interchangeably.
8 Real yields can also influence asset valuations, like stock prices or home values, which impacts private sector wealth and, potentially, aggregate spending. This mechanism is sometimes known as the "wealth effect".

Central banks seek to exert some near-term control over inflation and the output gap. But how do they influence these variables – how does changing the very front end of the yield curve impact macroeconomic conditions? The sequence of steps delineating how central bank actions influence economic variables like inflation and the output gap is called the "monetary transmission mechanism." The monetary transmission mechanism in the AD-AS-TR-EH framework works as follows.

The central bank sets the (nominal) interest rate. The interest rate itself does not impact any macroeconomic variables in the model. But, via the EH, the interest rate impacts (nominal) yields on long-maturity bonds. Because long-term inflation expectations tend to be "sticky," changes in nominal yields on long-maturity bonds translate to changes in real yields. Through the AD relationship, changes in real yields influence the output gap. And through the AS relationship, changes in the output gap influence inflation. So, by changing the nominal interest rate, central banks can exert influence over the variables they ultimately care about: inflation and the output gap.

How do central banks set the interest rate? Prudent monetary policy suggests central banks *lean against the wind*.[9] When inflation is above the central bank's target level, the central bank should raise the interest rate to contract output and bring inflation down. When inflation is below its target level, the central bank should lower the interest rate to stimulate output and increase inflation. Likewise, for the output gap. When the output gap is positive, the central bank should raise the interest rate, lest it risk higher-than-desired inflation. And when the economy is in a recession and the output gap is negative, the central bank should lower the interest rate to stoke output.

Exhibit 1: The Monetary Transmission Mechanism



Source: AQR. For illustrative purposes only. Not illustrative of any AQR product. Please see the Disclosures for important information.

9 An exceptional reference for those comfortable with some math is Clarida, Gali, and Gertler (1999).

The Taylor Rule

In a seminal paper, Taylor (1993) codified this intuition into a simple and practical equation for the interest rate. It has both normative and positive value, capturing the features of prudent monetary policy, while also fitting the data quite well. The Taylor rule, in one of its many forms, relates the interest rate i to inflation and the output gap:

$$i = r^* + \pi + b_\pi(\pi - \pi^*) + b_Y(Y - Y^*)$$

$\pi - \pi^*$ is the "inflation gap," the difference between the current inflation rate π, and the central bank's inflation target π^*. b_π is a positive number, so the TR captures the intuition the central bank should set a higher interest rate when inflation exceeds its target, and a lower interest rate when inflation is below its target. $Y - Y^*$ is the output gap, the difference between output Y, and the full employment level of output Y^*. b_Y is also greater than zero, so the TR says the interest rate should be higher when the output gap is positive (an expansion) and lower when the output gap is negative (a contraction).

How about the first two terms in the equation, $r^*+\pi$? To understand these terms, it is helpful to recast the TR as a rule for the real interest rate by subtracting inflation from both sides:[10]

$$\textit{Real Interest Rate} = i - \pi = r^* + b_\pi(\pi - \pi^*) + b_Y(Y - Y^*)$$

The TR prescribes a real interest rate above r^* when the inflation gap or output gap is positive, and a real interest rate below r^* when the inflation gap or output gap is negative. When both are zero the TR prescribes a real interest rate equal to r^*. Hence, r^* – typically referred to as either "r-star" or "the natural rate of interest" – defines neutral monetary policy and is the real interest rate consistent with output equal to potential output (i.e., full employment) and stable inflation.

The real interest rate depends on the output gap and inflation gap via the TR. Likewise, near-term expected future real interest rates depend on forecasts of the output gap and inflation gap. What about long-horizon expectations of the real interest rate? At long horizons, cyclical forces eventually wear off and monetary policy is neutral. The expected future real interest rate, therefore, eventually converges to r^*. Hence, long-horizon expectations of the real interest rate are anchored by r^* and long-horizon expectations of the nominal interest rate are anchored by $r^* + \pi^{LT}$, where π^{LT} denotes long-term inflation expectations. Since long-maturity bond yields are largely determined by expected future interest rates, they should be extremely sensitive to $r^* + \pi^{LT}$. Indeed, I will show in section 6 *long-maturity yields tend to move virtually one-for-one with changes in the natural rate of interest and long-term inflation expectations.*

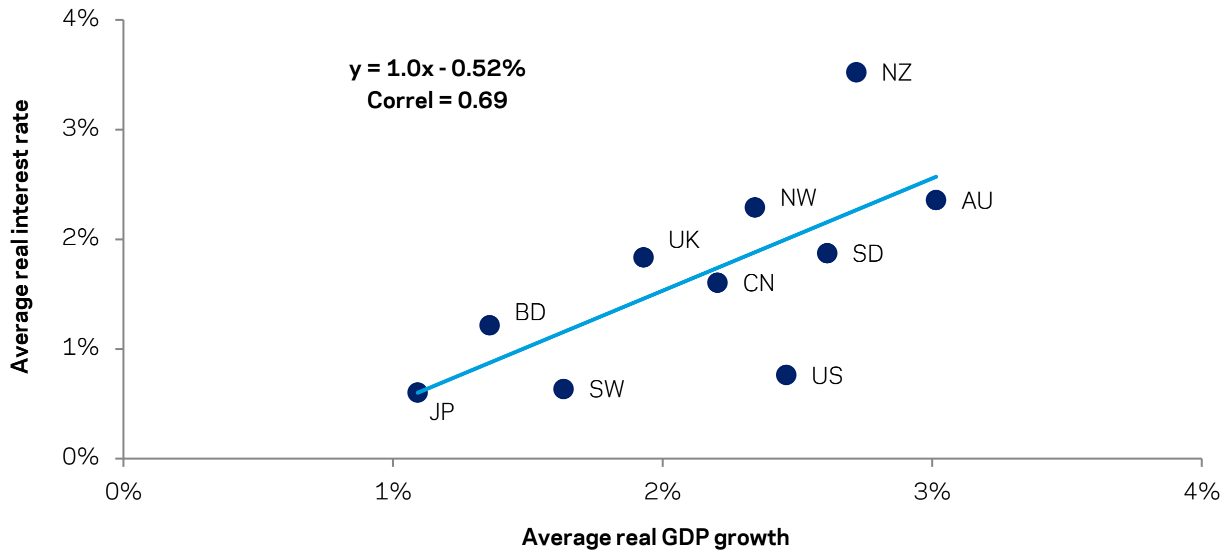
Estimating the natural rate of interest has been a topic of considerable interest post GFC.[11] It is a critically important variable, both for the conduct of monetary policy and for understanding long-maturity bond yields, yet it is not observable (even ex post). The best policymakers and market participants can do is try to estimate it, which is challenging in a real-time setting. Fortunately, we are not completely in the dark. Economic theory provides guidance, linking the natural rate of interest to trend growth in output (itself closely related to expected productivity and labor force growth). Exhibit 2 plots average real GDP growth against average real interest rates from

10 Technically we should subtract a three-month inflation forecast (i.e., the first π in the TR should be expected inflation over the next three months). Realized inflation is a reasonable proxy and makes the notation cleaner.

11 Hamilton et al (2015) is a comprehensive survey.

1990-2020. Over a 30-year sample, average real GDP growth should provide a reasonable estimate of trend growth and the average real interest rate should provide a reasonable estimate of r^* (i.e., the output gap and inflation gap should average out to close to zero). It is clear there is a very strong relationship – countries with higher real growth experienced higher real interest rates and vice versa.

Exhibit 2: Average Real Interest Rates vs. Average Real GDP Growth



Source: Bloomberg. Sample is January 1990 through December 2020. Average three month T bill rate net of realized inflation vs. average real GDP growth. Please see the Disclosures for important information.

4. Understanding term premia

The term premium is the extra return required to hold to maturity a long-maturity bond versus rolling over short-maturity debt (e.g., three-month T-bills). Term premia are on average positive and rising with maturity: investors typically require extra yield to hold long-maturity bonds relative to short-maturity bonds. While the average slope of the yield curve pins down average term premia, term premia at a point in time cannot be directly observed. I make no effort to estimate them. There is a cottage industry of models attempting to pin them down, and all estimates have wide standard errors and are sensitive to specification. My focus is identifying the forces that drive time-variation in term premia.

Mechanically, the determinants of term premia are all factors that influence a bond's yield, other than the current interest rate and expected future interest rates. In practice, two key factors tend to drive term premia: 1) changes in perceived riskiness, and 2) changes in demand and supply.

Perceived Riskiness

On the risk side, term premia are higher when bonds are truly riskier and when investors' tolerance for risk is lower – i.e., when investors are more risk-averse.

The most important risk factor for (fixed-rate) government bonds is inflation. Yields incorporate inflation expectations over the life of the bond, but unexpected increases in inflation erode a bond's real return. Inflation risk is likely the main driver behind the fact term premia are on average positive: the possibility of unexpected inflation makes holding long-maturity bonds riskier than rolling over short-maturity debt.[12] By the same logic, variation in inflation risk should be a key driver of time-variation in term premia. When uncertainty about future inflation is high, say during the 1970s and into the 1980s, a period where inflation rates averaged in the double digits and inflation volatility was extremely elevated, investors require a larger expected return to holding long-maturity bonds relative to their shorter-maturity counterparts. Wright (2012) and Bauer et al (2013) verify this intuition empirically. Using a large international panel data set, both papers find a strong link between estimates of term premia and measures of inflation uncertainty.

In addition to inflation uncertainty, risk aversion – the compensation investors require for bearing risk – also varies materially over time. Theoretical and empirical research supports the view risk aversion varies countercyclically, being higher during recessions than expansions (e.g., see Cochrane (2011)). Indeed, Bauer et al find evidence of a pronounced countercyclical pattern in term premia across international bond markets: term premia estimates on long-maturity bonds are meaningfully higher in recessions than expansions.

Demand and Supply

Variations in net demand can arise from exogenous macroeconomic and geopolitical events, or from the explicit monetary policy actions of central banks.[13] Their relative safety, liquidity, and ability to meet regulatory capital and liability-hedging needs make government bonds appealing to investors. These features are especially attractive during times of financial market stress (e.g., "flight-to-quality" and "flight-to-liquidity" episodes), during which safe-haven demand for government bonds tends to suppress their term premia. Secular trends in net demand, such as increases in the holdings of government bonds by foreign central banks, also influence term premia. Monetary policy may affect term premia as well. Indeed, quantitative easing and all its variants – "yield curve control," "operation twist," etc. – feature the purchases of longer-maturity bonds (among other securities) by central banks, reducing their net supply, with the explicit objective of suppressing their term premia.

The key drivers of term premia can be expressed succinctly:

Term Premium ~ Inflation Uncertainty (+), Risk Aversion (+), Net Demand (–)

How important is time-variation in term premia in explaining the dynamics of bond yields? During the Treasury market "conundrum" of 2004-2006, the Federal Reserve raised interest rates from 1.5 to 5.25 percent, yet long-maturity yields were virtually unchanged. This anomalous behavior is generally attributed to a fall in term premia. What drove the decline? Likely a combination of factors. Inflation uncertainty was quite

12 Indeed, during the gold standard era of 1879-1970 – a period in which inflation fluctuations were quite short-lived – yield curves were on average close to flat according to Wood (1983). No, not Gordon.

13 These factors can also be interrelated to investors' risk tolerance. For example, to accommodate an increase in the supply of bonds, investors, in aggregate, would need to take on more risk. Hence, they require higher expected excess returns to counteract their lower risk tolerance. See, for example, Greenwood and Vayanos (2014).

low, both due to improved inflation-fighting credibility of the Fed and more secular forces (this period – "the great moderation" – featured exceptionally low macroeconomic volatility). Low risk aversion was another likely factor, as the economy enjoyed a prolonged expansion.

Lastly, the "global saving glut," which led to heightened demand for Treasuries by foreign central banks and sovereign wealth funds, fueled an increase in demand for safe and liquid US government debt.[14]

5. Monetary policy drivers of bond yields

In this section I analyze the monetary policy drivers of bond yields. I show a wide array of different central bank tools are, in reality, very similar policies, reacting to the same set of economic variables – the near-term outlook for output and inflation – and relying on the same transmission mechanism to influence the broader economy. In the next section, I shift focus to key drivers of long-maturity yields that are largely uninfluenced by monetary policy.

There are three main monetary policy tools utilized by central banks: the interest rate level, forward guidance, and quantitative easing.

Interest rate level

By adjusting the interest rate, central banks exert influence on long-maturity nominal and real yields. Real yields on long-maturity government debt influence a variety of borrowing rates and asset valuations across the economy – e.g., mortgage rates, corporate bond yields, etc. – which impact aggregate demand, and eventually output and inflation. This is the classical monetary transmission mechanism illustrated in Exhibit 1.

The Taylor rule describes how central banks set interest rates. Central banks set the interest rate low when inflation is less than their inflation target or when output is less than its full employment level. Since monetary policy tends to influence output and inflation with a lag, in practice central banks look at near-term forecasts of output and inflation when setting their interest rate policy.[15] The TR also assumes key variables, like potential output and the natural rate of interest are known with certainty, while they are, at best, noisily estimated. To be clear, the TR is meant to only provide a qualitative description of how central banks set interest rates. The interest rate will often deviate from the exact number prescribed by the TR, but it provides an excellent description as to what monetary policymakers think about in determining the appropriate interest rate setting.

So, what does the TR tell us about yield drivers? Changes in the near-term outlook for the output gap and inflation influence the interest rate, and through this channel, longer-maturity bond yields. Additionally, a monetary policy shock – an unexpected change to the interest rate not explained by the output and inflation outlook, will also influence longer-maturity bond yields. Improving economic

14 See Backus and Wright (2003) for a more complete discussion.
15 Using realized values versus forecasts can make a big difference. See this blog post by Ben Bernanke.

conditions (e.g., falling unemployment), rising inflation, or a positive monetary policy shock will tend to lead to higher bond yields, and the opposite will tend to lead to lower bond yields.

At present many central banks have set their interest rate close to zero or some other perceived "lower bound." Does this mean they can no longer influence bond yields to stimulate the economy? No. Many central banks have broached the zero lower bound and others may follow suit. And, regardless of the willingness to "go negative," central banks have two additional policy tools at their disposal.

Forward guidance

Abstracting from term premia, a bond's yield is equal to the average of current and expected future interest rates over its life. For a long-maturity bond, the current interest rate setting covers only a small fraction of its lifetime, and expectations of future interest rates are the more critical determinant. Central banks are acutely aware expected future interest rates influence bond yields. "Forward guidance" – communications about the anticipated path of interest rates – has been a standard part of the monetary policy playbook for the past 20 years.[16]

The transmission mechanism for forward guidance is virtually identical to the transmission mechanism for interest rate changes. In response to the near-term outlook for the output gap and inflation, central banks provide guidance on future interest rates, which influences long-maturity nominal yields (EH), which influences long-maturity real yields (inflation expectations are sticky), which influences aggregate spending and, eventually, output and inflation.

While forward guidance has been around for two decades, it has gone through multiple iterations. Date-based forward guidance articulates how interest rates are expected to evolve as a function of time. Outcome-based forward guidance articulates how interest rates are expected to evolve as a function of economic conditions. The recent shift by the Fed to "average inflation targeting" is a form of outcome-based forward guidance. By communicating they are targeting two percent inflation *on average*, the Fed is intimating to markets they are willing to tolerate inflation rates temporarily above two percent, and, therefore, will still maintain an accommodative monetary policy stance in that scenario. Nominal GDP and price level targeting are additional variations on this theme.[17]

What does forward guidance tell us about yield drivers? Changes in the near-term outlook for the output gap and inflation will influence communication about future interest rates, and through this channel, influence long-maturity bond yields. Additionally, a "path shock" – an unexpected change to the communicated path of future interest rates – will also influence long-maturity yields. So, improving economic conditions, rising inflation, or a positive path shock will lead to higher yields, and the opposite will lead to lower yields.

Importantly, even if central banks are reluctant to reduce their interest rate further, forward guidance can still operate with the interest rate at its lower bound. In response to a deteriorating outlook for economic activity

16 Indeed, it is often asserted the two-year yield, which according to the EH embeds information about expected interest rates over the next two years, provides the single best measure of the overall stance of monetary policy.
17 Woodford (2012) has an excellent discussion on the merits of forward guidance and its different variants.

or inflation, central banks can still use communication about future interest rates to influence long-maturity yields.

Quantitative Easing or "Targeted Asset Purchases"

Quantitative easing refers to targeted central bank purchases of financial assets. Of the three monetary policy tools we consider, QE is the newest – adopted in its modern incarnation by central banks in response to the GFC and subsequent global recession – and most often misunderstood.[18]

In the simplest form of QE the central bank purchases long-maturity government bonds and holds them on its balance sheet. By reducing the net supply of long-duration assets, these purchases suppress term premia and reduce yields. By reducing nominal yields, QE influences real yields, which influence borrowing costs across the economy more broadly, eventually impacting aggregate spending, output, and inflation. I hope to impress a critical point: *QE works through the exact same monetary transmission mechanism as traditional interest rate policy and forward guidance*. Each policy aims to influence yields on long-maturity bonds. Interest rate policy and forward guidance do so via current and expected future interest rates, respectively. QE accomplishes the same end by impacting term premia.

In practice, QE may involve the purchase of securities beyond government bonds, including securitized assets (e.g., MBS), corporate bonds, and even equities. And purchases may be financed either by reserve creation or by selling shorter-maturity bonds. These are all different versions, however, of the same fundamental policy.[19] Either by purchasing government bonds and suppressing their term premia, or by purchasing other long-duration assets directly, central banks aim to reduce borrowing costs and increase asset valuations broadly, with the goal of influencing output and inflation. QE1, QE2, "operation twist" – the purchase of longer-maturity government debt financed be the sale of shorter-maturity debt, "yield curve control" – the Bank of Japan announcing a ten-year yield target in the range of zero and the Royal Bank of Australia adopting three-year yield target of 0.25 percent: these are all policies aimed at influencing long-maturity bond yields, conceptually no different than traditional interest rate policy and forward guidance.

QE is *not* "money printing," as pundits and market commentators occasionally refer to it. It is not about the money supply. That's simply not how the monetary policy machine works. QE is about long-maturity bond yields and valuations of long-duration assets, in the same way as traditional interest rate policy and forward guidance. Accordingly, QE does

18 The term "Quantitative Easing" causes unnecessary confusion to this day. It was originally introduced by the Bank of Japan in 2001 to describe a new policy of increasing the supply of bank reserves to target a higher growth rate for the monetary base. Economic theory, corroborated by subsequent empirical evidence, implies increases in reserves should have virtually no impact in a low interest rate environment. (See Krugman, 1998; or Eggertsson and Woodford 2003 for detailed discussions. In summary, with the interest rate near zero – or near the rate paid on excess reserves – the opportunity cost of holding reserves is negligible, and demand for reserves becomes infinitely elastic. Further expansion of the supply of reserves, therefore, has no consequence for interest rates, broader monetary aggregates, aggregate expenditure, or prices.) Largely unsuccessful, the policy was abandoned in 2006. QE, as practiced by central banks since the GFC (including the Bank of Japan, which undertook a new program of "comprehensive monetary easing" in 2010), is importantly different from the original Bank of Japan version. Modern QE emphasizes the purchase of longer-maturity financial assets to reduce bond yields and borrowing costs across the economy, as well as to boost asset valuations. While "targeted asset purchases" is unquestionably a more accurate name, the term QE has stuck.

19 When QE is financed by reserve creation the central bank creates new bank reserves to purchase bonds in the open market from major financial institutions. Relative to QE financed by selling shorter-maturity debt, QE financed by reserve creation has the additional consequence of increasing the amount of reserves held by banks. For reasons discussed in the previous footnote, however, in a low interest rate environment the quantity of reserves has little consequence for bank lending and, therefore, the macroeconomy.

not represent a draconian shift in the conduct of monetary policy. It is simply another tool in the arsenal of central banks to meet their twin objectives of price stability and full employment.

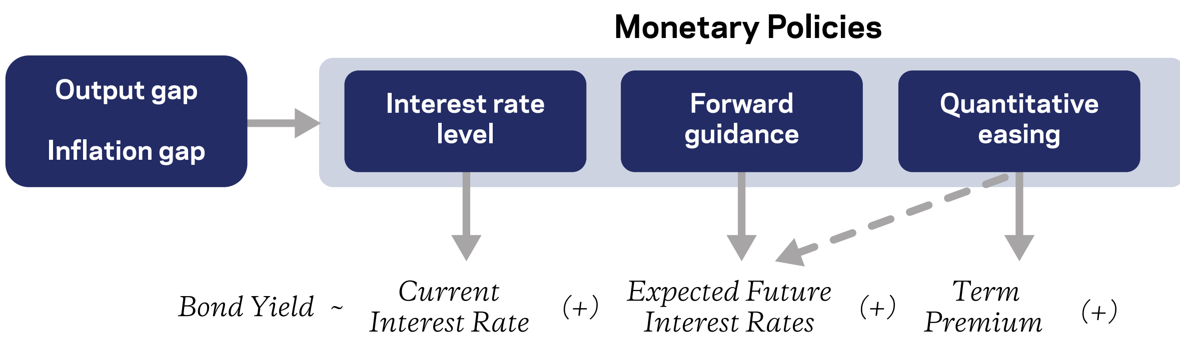
Indeed, the transmission mechanism of QE and other policy tools are so inextricably linked that, according to Bernanke (2020), in addition to reducing term premia, the other channel through which QE principally operates is by reinforcing forward guidance. QE signals policymakers' intention to keep interest rates low for an extended period. Bernanke cites the "taper tantrum" of 2013 as evidence: his own hints the Fed might slow their pace of asset purchases led markets to revise forward expectations for interest rate hikes, causing yields to materially rise. The importance of Bernanke articulating this "signaling channel" of QE is two-fold: 1) if the former Fed Chairman and architect of QE views it as operating through the exact same channels as more traditional monetary policy tools, so should we; 2) Bernanke, and most modern central bankers, view forward guidance as the primary monetary policy tool.

What does QE tell us about yield drivers? Inasmuch as changes in the near-term outlook for output and inflation influences the overall stance of monetary policy, they are likely to influence the size and complexion of QE policies, impacting both expected future interest rates and term premia on long-maturity bonds. Additionally, a "balance sheet shock" – an unexpected change to either the amount, complexion, or timing of asset purchases – will impact yields (e.g., the taper tantrum). So, improving economic conditions, rising inflation, or a negative balance sheet shock will lead to higher bond yields, and the opposite will lead to lower bond yields. Importantly, QE, like forward guidance, remains a viable monetary policy tool to reduce yields and stimulate the economy, even if central banks are averse to additional interest rate cuts.

Summary

By influencing the current interest rate, the expected path of future interest rates, and term premia, traditional interest rate policy, forward guidance, and QE all influence long-maturity bond yields. Given central bank objectives of maintaining low and stable inflation and full employment, policymakers react to changes in the outlook for output and inflation. Improving economic conditions or increasing inflation leads to a more contractionary policy stance and higher yields. Worsening economic conditions or falling inflation leads to a more accommodative stance and lower yields. Any unexpected change to the monetary policy stance of the central bank – be it an interest rate surprise, news about the path of future interest rates, or unexpected changes to size and complexion of the central bank's balance sheet – will also influence longer-maturity yields. Exhibit 3 summarizes these drivers.

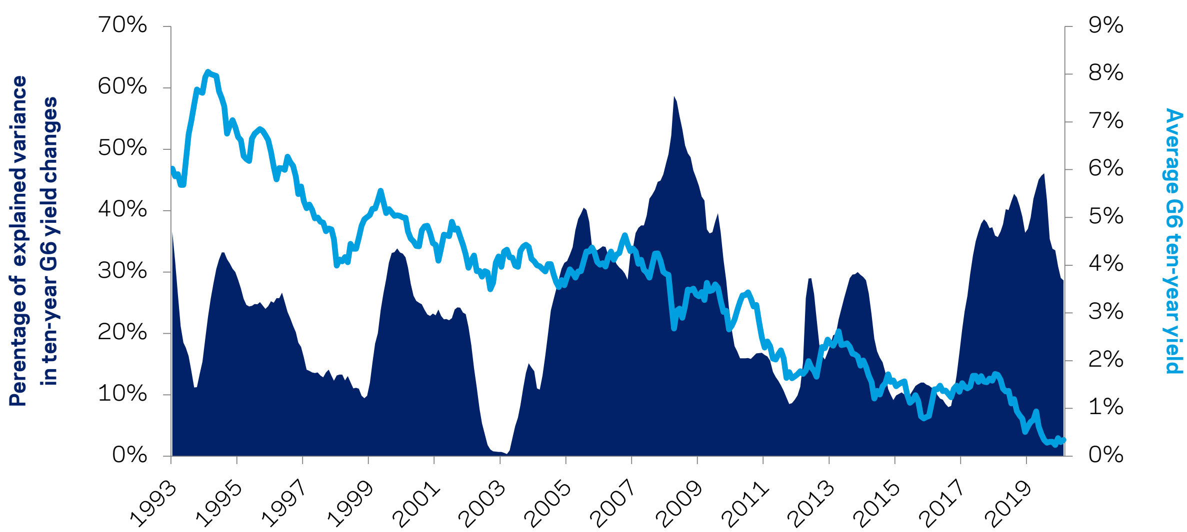
Exhibit 3: Monetary Policy Drivers of Bond Yields



Source: AQR. For illustrative purposes only. Not illustrative of any AQR product. Please see the Disclosures for important information.

Does the fact short-term interest rates are close to zero (or lower) in most major markets impede these dynamics in any fundamental way? No. Several central banks (e.g., the European Central Bank and the Bank of Japan) have showed a willingness to employ negative interest rates. Others, including the Federal Reserve, have been reluctant to embrace negative interest rates. Even if interest rates stay put, forward guidance and QE both remain viable policy tools to further reduce bond yields. Indeed, bond yields continue to react to economic news in a manner consistent with their monetary policy drivers. Exhibit 4 plots the percentage of variation over time in G6 bond yields explained by changes in near-term forecasts of unemployment and inflation. Despite policy rates being at levels close to zero or less, and despite lower bond market volatility, bond yields are still reacting to macroeconomic news in a quantitively similar manner to other periods.

Exhibit 4: News About Employment and Inflation Still Drives Yield Changes



Source: Bloomberg, Consensus Economics. The sample is G6 markets. The sample is G6 markets (Australia, Canada, Germany, Japan, UK, US), January 1990 through December 2020. Chart displays R2s in three-year rolling regressions of changes in ten-year bond yields on revisions to unemployment and inflation forecasts (left), and average ten-year yields (right). Not illustrative of any AQR product. Please see the Disclosures for important information.

6. Non-monetary policy drivers of bond yields

Much recent discussion by fixed income investors has centered around the willingness of central banks to embrace negative interest rates or expand their balance sheets. But monetary policy is far from the only variable influencing long-maturity yields. There are a variety of non-policy-related factors that exert considerable influence over the level and shape of the yield curve. This may sound sacrilegious, but occasionally the role of central banks in markets can be overstated.[20] Changes in trend growth and long-term inflation expectations, variation in inflation uncertainty, as well as shorter-term fluctuations in both the business cycle, and oscillating demand for highly liquid, safe-haven assets, also exert meaningful influence over bond yields.

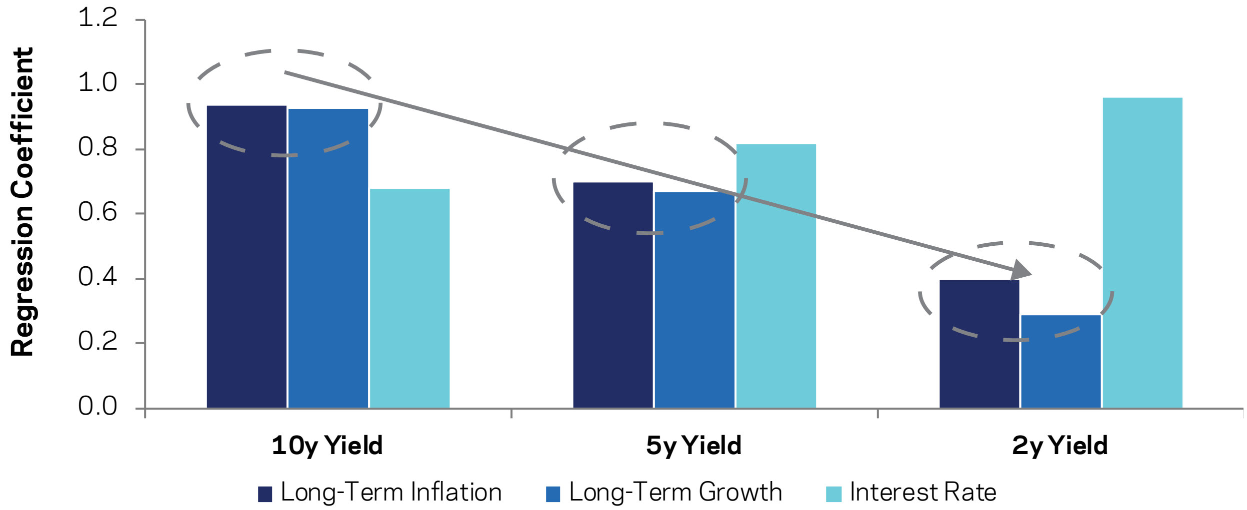
To a good approximation the current interest rate is under the control of the central bank. So, there is limited scope for non-policy related factors to influence yields via that channel. But expectations of future interest rates, particularly at long-horizons, and term premia are largely driven by economic factors beyond the current monetary policy stance.

Central banks exert considerable influence over the expected path of the interest rate in the near-term. Long-maturity bond yields, however, depend on expected interest rates well into the future. According to the AD-AS-TR-EH model, expected future interest rates should eventually converge to $r^{*}+ \pi^{LT}$, the sum of the natural rate of interest and longer-term inflation expectations. As a result, $r^{*}+ \pi^{LT}$ provides an anchor for long-maturity nominal yields, and the long-end of the yield curve should be very sensitive to changes in either the natural rate of interest or long-term inflation expectations.

This is *exactly* what we observe in the data. Exhibit 5 displays the results of regressing ten-year, five-year, and two-year yields on long-term inflation expectations, long-term real growth expectations (a proxy for the unobservable natural rate of interest, in accordance with Exhibit 2), and the current interest rate. *Ten-year yields move virtually one-for-one with long-term inflation and growth expectations*, regardless of the actions of central banks. At shorter maturities, the influence of long-term inflation and growth expectations wanes, although they remain economically and statistically significant, while the influence of the current interest rate is stronger.

20 I equate this statement to my claim *The Shawshank Redemption* is an overrated movie. It is undeniably an awesome film – a classic, and one I'll always stop to watch if it is on TV (take that cord-cutters). But according to IMDB it is the best movie of all-time. Sorry, but Vito Corleone, Rick Blaine, and I – the first and, likely, only time the three of us have appeared in the same sentence – beg to differ.

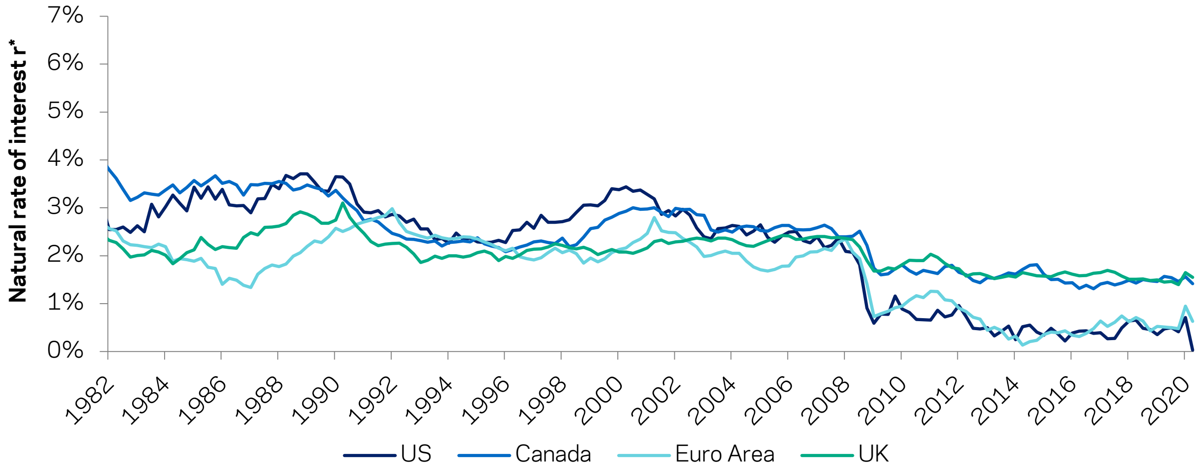
Exhibit 5: Long-Maturity Yields Depend on Inflation and Growth Expectations

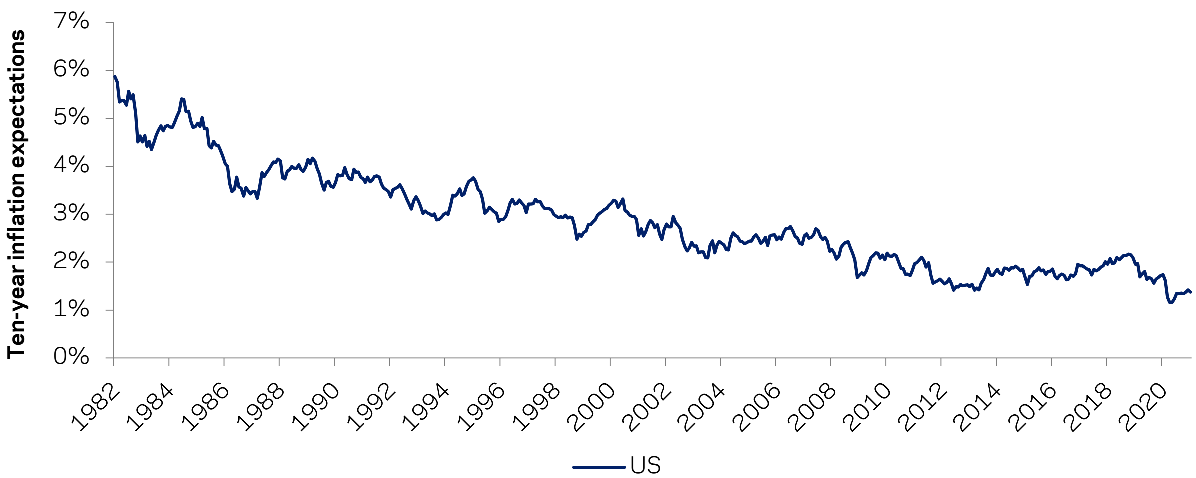


Source: Consensus Economics, Bloomberg. Sample is G6 (Australia, Canada, Germany, Japan, UK, US), quarterly, December 1990 through December 2020. Long-term inflation and growth are median forecasts of average inflation and real GDP growth rates between 6-10 years ahead from Consensus Economics. Yield and interest rate (T-bill) are from Bloomberg. Dynamic OLS regression includes country effects and two leads/lags of changes in the dependent variables. Not illustrative of any AQR product. Please see the Disclosures for important information.

Long-maturity bond yields depend on long-term inflation expectations and the natural rate of interest and both vary meaningfully over time. According to the model of Holston, Laubach, and Williams (2017) maintained by the Federal Reserve Bank of New York, estimates of the natural rate of interest for the US and Euro area have declined from levels of three to four percent in the late 1990s to between zero and one percent, in large part driven by estimated declines in trend growth due to slowing labor force growth and a slowdown in trend productivity growth. According to the model of Haubrich, Pennacchi, and Ritchken (2012) maintained by the Federal Reserve Bank of Cleveland, the current expected average inflation rate over the next 10 years (as of June 30, 2021) in the US is 1.6 percent, having declined from just north of two percent in 2018, and spending the majority of 2000-2010 decade hovering at around 2.5 percent. Picking 2000 as a reasonable reference date, the natural rate of interest in the US has declined from 3.4 percent to zero percent, and long-term inflation expectations from 3.2 percent to 1.6 percent. That's a decline in $r^{*}+\pi^{LT}$ from 6.6 percent 1.6 percent. For reference, over the same period, ten-year US Treasury yields declined from 6.5 percent to 1.5 percent. The natural rate of interest, itself linked to trend growth, and long-term inflation expectations fluctuate meaningfully and drive variation in long-maturity bond yields. Together they can account for the entirety of the secular decline in US Treasury yields over the last two decades.

Exhibit 6: The Natural Rate of Interest and Long-Term Inflation Expectations



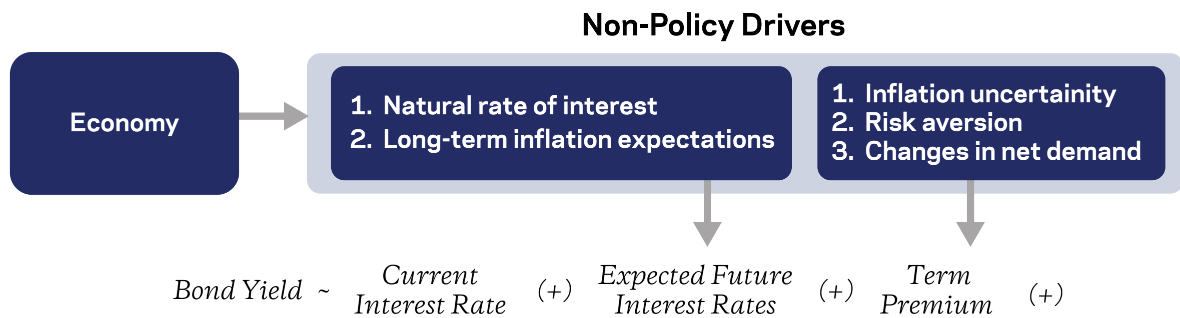


Source: Federal Reserve Bank of New York, Federal Reserve Bank of Cleveland. Sample is January 1982 through April 2020 for the natural rate of interest and January 1982 through December 2020 for inflation expectations. Natural rate of interest estimates follow Holston, Laubach, and Williams (2017) and are maintained by the Federal Reserve Bank of New York (https://www.newyorkfed.org/research/policy/rstar). Long-term inflation estimates follow Haubrich, Pennacchi, and Ritchken (2012), and are maintained by the Federal Reserve Bank of Cleveland (https://www.clevelandfed.org/our-research/indicators-and-data/inflation-expectations.aspx). Not illustrative of any AQR product. Please see the Disclosures for important information.

While QE influences term premia on nominal bonds, there are a host of other factors, not under the direct control of central banks, which also drive term premia. As discussed in section 4, these include inflation uncertainty, risk aversion, and changes in net demand for government bonds. The latter may be due to exogenous variation in safe-haven demand for government bonds; as well as more secular trends, such as foreign demand for safe government debt emanating from China and other Asian economies, oil producers, and emerging markets. At varying times over the last half century, each of these factors have been important drivers of term premia. And each are likely to play important roles in the future. Inflation uncertainty has subsided from the levels it attained in the 1970s, but the current unprecedented amount of monetary and fiscal stimulus calls into question whether central banks will be as successful in managing inflation expectations – and therefore inflation itself – over the next decade. And while term premia are generally counter-cyclical – both inflation uncertainty and investor risk aversion tend to be higher in recessions than in booms – a flare-up in safe-haven demand can further suppress term premia and bond yields over the near-term.

Summarizing, non-policy factors play at least as important a role as monetary policy in driving bond yields. Trend growth (via the natural rate of interest) and inflation expectations anchor expectations of future interest rates and are the key determinants of long-maturity bond yields. Inflation uncertainty and investor risk aversion drive counter-cyclical variation in term premia. And fluctuations in the net demand for government bonds – either driven by safe-haven flows or more secular changes in global demand for liquid, low risk assets – influence yields on government debt. Fluctuations in any of these factors – in the near-term and beyond – can drive bond yields higher or lower.

Exhibit 7: Non-Policy Drivers of Bond Yields



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7. Discussion

Bond yields recently touched all-time lows in several developed markets and remain extremely low relative to history. Many investors are pondering how much lower they can go, while others wonder whether aggressive fiscal policy might lead to the end of the era of record low yields. I make no predictions. Even in chartered waters, forecasting the near-term direction of markets – bonds, stocks, bitcoins, or beanie babies – is a fool's errand, and, therefore, any "market timing" tilts within an asset allocation should be modest. While I make no forecast, I do hope to try to at least guide the discussion to the relevant questions.

Why are yields so low?

In a paper devoid of predictions, I will assert one (albeit unverifiable) counterfactual. Regardless of the actions of central banks in response to COVID-19 and the subsequent global economic slowdown, long-maturity bond yields would be low relative to historical levels at present. With slowing labor force growth (due to demographics) and a slowdown in trend productivity growth causing estimates of the natural rate of interest to be sub-one percent across the developed world, low long-term inflation expectations, relatively low uncertainty about future inflationary outcomes, generally low levels of risk aversion, and persistent demand for government debt

– there are a variety of cyclical and secular factors all exerting downward pressure on bond yields. Add the actions of central banks – zero (or negative) interest rates, forward guidance pledging to maintain an accommodative interest rate setting for the foreseeable future, and targeted asset purchases reducing the overall net supply of long-maturity debt and exerting downward pressure on term premia – and current yield levels, to a reasonable approximation, appear to be justifiable. Yields *should* be in the range of their historical lows.

What can make yields go lower (or higher)?

Monetary policy influences long-maturity bond yields through setting the current interest rate, influencing the expected path of future interest rates via forward guidance, and manipulating term premia (and reinforcing forward guidance) via quantitative easing. Several central banks have set their policy interest rate negative. Others, the Federal Reserve foremost among them, have not yet embraced negative interest rates. Should the Fed "go negative," it would provide some downward pressure on yields, both because the current interest is lower and because it would likely cause markets to revise down the expected path of future interest rates. But even if the Fed and other central banks keep their respective interest rates at bay, forward guidance and QE remain potent tools. Given the aggressiveness with which central banks have responded to deteriorating economic conditions since the GFC, I think the baseline case must be they would continue to add monetary stimulus should economic or financial market conditions materially worsen. The fact inflation expectations remain well within most central banks' target range allows them to be aggressive in their policy responses. They face no tradeoff between their dual objectives at present.

In terms of non-policy drivers of yields, the most important determinants are the natural rate of interest and long-term inflation expectations. The secular decline in these variables has been a primal force spurring the decline in yields over the past two decades, as they anchor long-horizon expectations of interest rates. Should either decline materially, long-maturity yields would follow. Inflation uncertainty and risk aversion appear quite low, so it is hard to imagine cyclical variation in the term premia presents much of a downside risk to yields at present. But should the pandemic worsen, or should the geopolitical situation weigh further on the global economy, we could see a material pickup in safe-haven demand for government bonds, which would likely drive yields to even lower levels.

The same framework is useful for identifying upside risks. From a monetary policy perspective, withdrawing some of the extraordinary stimulus would put upward pressure on yields. In what state of the world might central banks do this? The good state: economic activity sees a strong rebound as the pandemic fades, growth and employment pick up meaningfully, and within a year or so global economies have returned to full employment. The "risk management" approach of central banking might still argue to withdraw stimulus only tepidly, but it is certainly plausible the pace of asset purchases (QE) slows and forward guidance moves more neutral. This would, of course, put upward pressure on yields. The bad state: inflation expectations meaningfully increase. Most central banks undoubtably would accommodate – let me be even more clear: they'd *welcome* – a pickup in inflation. But should we see a de-anchoring of inflation expectations, perhaps driven by fears over the extraordinary levels of fiscal and monetary stimulus, central banks may indeed take their foot off the accelerator. From a non-policy perspective, an increase in either the natural rate of interest or long-term inflation expectations would put upward pressure on long-maturity bond yields regardless of the policy responses of central banks. A rise in inflation uncertainty or declining demand for government debt, among other factors, can drive term premia higher, and with them long-maturity yields.

Is there a floor on government bond yields?

Presumably yes, at some level. But the floor is likely materially lower than zero. The logic of a zero-lower bond on the interest rate is cash-currency earns a zero yield: savers can put money in their mattresses and earn a higher return. But this idea doesn't hold up to scrutiny or reality (the current ECB policy rate is -50 basis points). And yields can go materially lower than the interest rate, as there are plenty of factors that can drive term premia temporarily well into negative territory: bonds provide a highly liquid and relatively low-risk store of value; bonds have provided diversification to risky assets (e.g., equities); and bonds serve regulatory and transaction functions. Moreover, expected returns across the board are quite subdued at present, and bond yields look far less abnormal when compared to other assets. Finally, even at negative yields bonds may be attractive from a portfolio perspective – their real returns can be meaningfully positive in a deflationary scenario. It is beyond this paper to estimate the lower-bound on bond yields, but it certainly isn't zero or -50 basis points, and it is likely quite a bit lower. While many believe, explicitly or tacitly, in the zero lower bond, and thus think bond risk is highly asymmetric, theory and evidence do not bear this out.

Have the rules of the game changed?

This is my way of summarizing the multitude of questions that have continued to arise for the last decade. The implication is usually two-fold: QE represents a whole new playbook in terms of monetary policy, and bond markets are no longer reacting to fundamentals as they have in the past.

I hope I have impressed QE is *not* a fundamentally different monetary policy tool. It impacts the economy by influencing long-maturity bond yields, just as traditional interest rate policy and forward guidance. Whereas the latter two policies influence yields through manipulating the current interest rate and expected path of future interest rates, QE influences bond yields by manipulating term premia.

Fundamentals continue to drive government bond markets. The current low level of yields globally is consistent with broader macroeconomic developments: slowing productivity growth, depressed long-term inflation expectations, low inflation uncertainty and generally low levels of risk aversion, as well as central banks providing stimulus – via interest rate policy, forward guidance, and QE – in an attempt to support economic activity and inflation. There's no unchartered policy or unexplained influences at work: yields are reacting in the manner we'd expect, and central banks are utilizing essentially familiar policy tools.

The reaction of bond markets to changes in economic conditions continues to be broadly in line with what we expect. Good news about economic growth, either over the short-term or long-term (i.e., influencing the natural rate of interest) moves yields higher, while bad news moves them lower. Ditto for inflation. Yields appear to have been responsive to interest rate, forward guidance, and QE policies. And during the dark days of March and April 2020, when credit and liquidity conditions tightened meaningfully, yields declined sharply, reflecting a rapid decline in term premia, precipitated in part by the actions of the Federal Reserve and other central banks.

To be sure, the economy and markets face extraordinary challenges. But it is during these times one needs to remember the playbook, not throw it out the window. We have a reasonable sense of the factors that influence bond yields to help navigate the times ahead.

8. Conclusion

By decomposing longer-maturity bond yields into the current interest rate, expected future interest rates and term premia, and analyzing the drivers of each component, I've presented a framework for understanding the determinants of bond yields, and identified several of their fundamental drivers. Through the systematic response of monetary policy, the near-term outlook for economic activity and inflation influence bond yields. Unexpected monetary policy changes – to the current interest rate, the expected path of future interest rates (i.e., changes in forward guidance), and the size and complexion of the central bank's balance sheet (i.e., change in QE policies) – influence yields as well. Non-monetary policy drivers are also critical, particularly at longer maturities. Indeed, declining estimates of the natural rate of interest, in part driven by a pessimistic outlook for trend growth, and falling long-term inflation expectations are important factors behind the secular decline in bond yields over the past few decades, and provide the backdrop for the extremely low yield levels we observe today.

Looking towards the future, investors would be prudent to conclude government bond risk remains two-sided even at low levels of bond yields, and a fundamentally driven approach to bond market investing remains viable.

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