PIMCO

The Discreet Charm of Fixed Income

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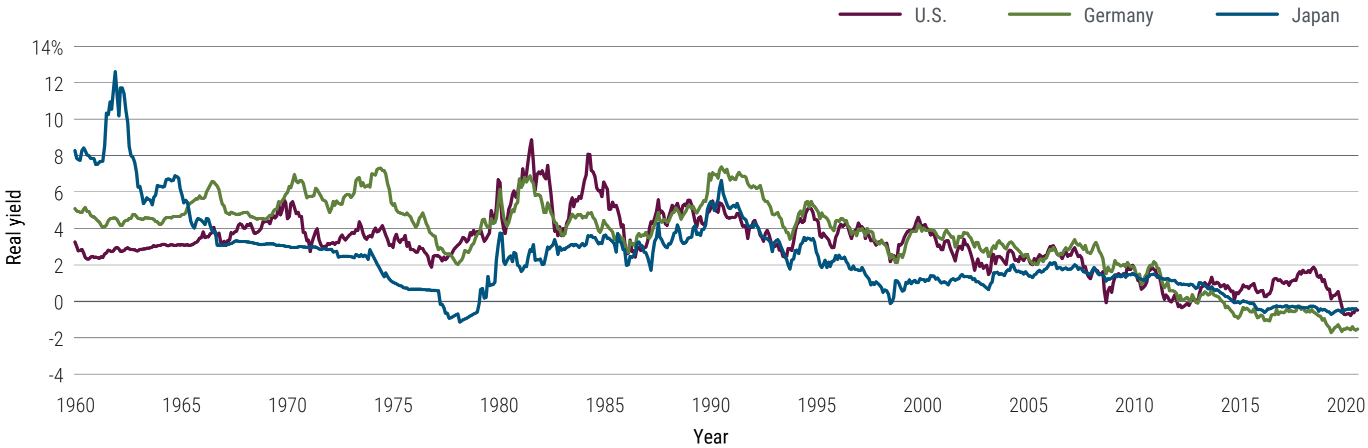
Executive Summary

- It sometimes pays to state the obvious: Some might say that fixed income is in a pickle. After all, real bond yields have trended down for the past 60 years. 10-year real yields are now negative in many major markets.
- Yet what seems obvious isn't necessarily true. Viewed discretely or in the context of a diversified portfolio, bonds continue to offer numerous benefits and potential for appreciation:
  - Interest rate fundamentals remain broadly supportive, and rates have the potential to fall further.
  - Fixed income, particularly credit, remains attractively priced relative to equity, which is valued near historical highs. Furthermore, private credit continues to outperform public high yield, a trend likely to be supported by continued bank regulation.
  - The probability of stocks outperforming Treasuries over the next 10 years may only be 65%, based on our simple model and historical data. If we assume mean reversion in the CAPE ratio, this probability could be substantially lower.
  - Bonds may continue to serve as a potent hedge in broad portfolios. Investors targeting a low portfolio equity beta may well consider increasing their fixed income allocation.
  - The bond market has historically provided much better sources of alpha than the equity market in general, for reasons explained in Baz et al. (2017).

INTRODUCTION: IS FIXED INCOME IN A PICKLE?

It sometimes pays to state the obvious: Some might say that fixed income is in a pickle. The downward trend in real bond yields over the past 60 years speaks for itself. The 10-year real yield is now negative in many major markets (see Exhibit 1).

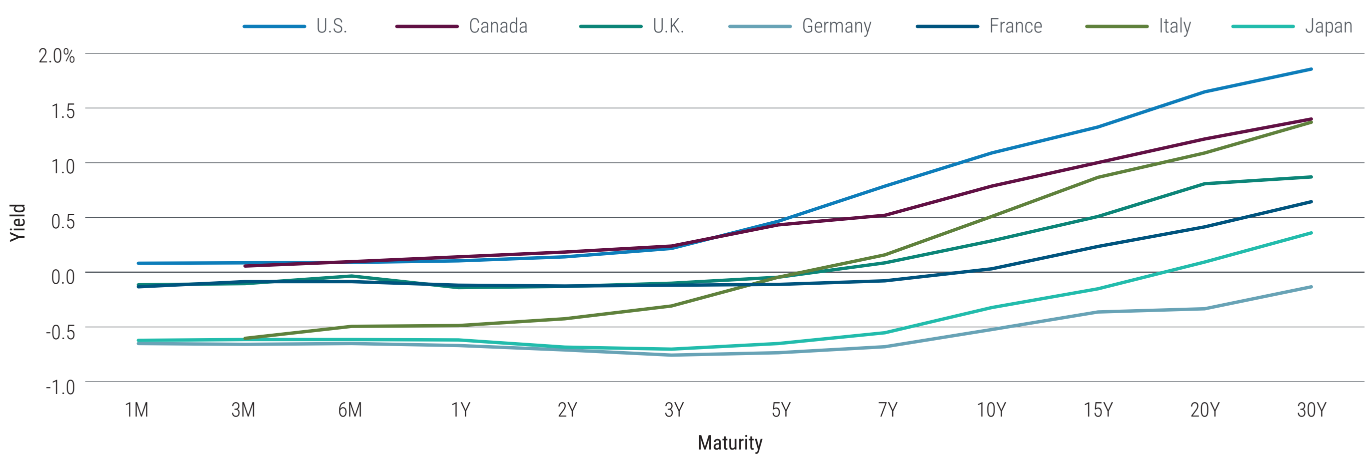
Exhibit 1: 10-year real government bond yields (1960-2020)



Source: PIMCO and Global Financial Data as of 30 November 2020. Real yield is measured by nominal yield of a 10-year government bond minus local expected inflation. Expected inflation is proxied by the 10-year exponentially weighted moving average of realized inflation.

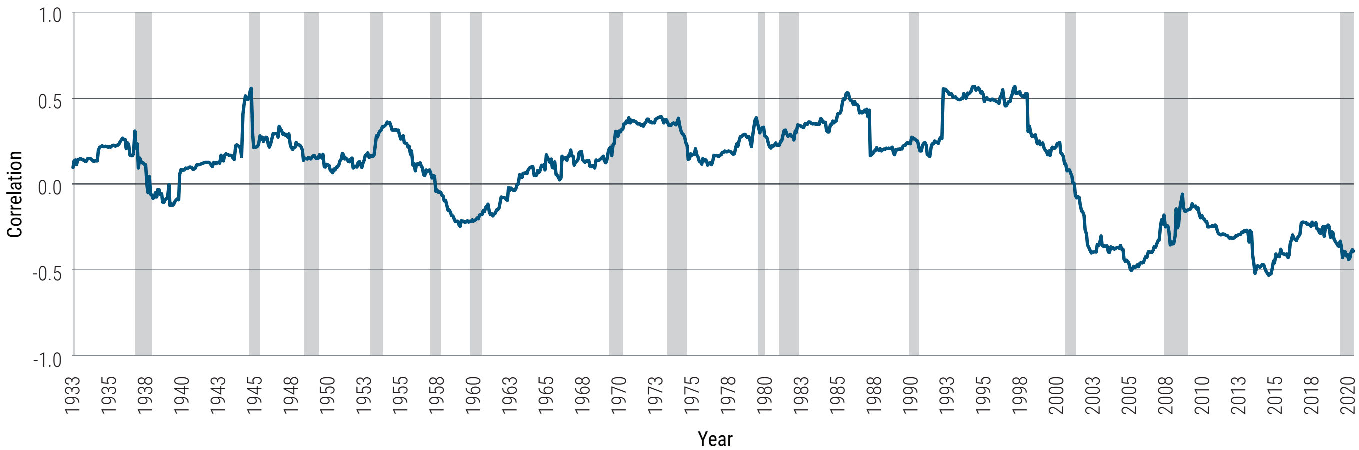
As to nominal returns, the most you can make from holding a bond to maturity is, well, the yield to maturity (YTM) – slim pickings, that is when yields are not negative, as shown in Exhibit 2. How about the downside? It is said that the only way to escape the abyss is to look at it. In this case, investors can look at a host of event risks – including high inflation, sovereign defaults and fiscal dominance – all stemming from fiscal and monetary incontinence.

Exhibit 2: Yield curves in G7 countries



Source: PIMCO and Bloomberg as of 7 January 2021

Exhibit 3: Stock-bond correlation in the U.S.



Source: PIMCO, Global Financial Data and Bloomberg as of 31 December 2020. Note: Shaded periods show U.S. recessions designated by NBER. Stocks are represented by the S&P 500 Total Return Index and bonds by the GFD USA 10-year Government Bond Total Return Index. We report rolling 60-month correlations at monthly frequency.

Furthermore, it is not immediately clear that fixed income still acts as a hedge at current yield levels, especially given that the stock-bond correlation historically has not been consistently negative (see Exhibit 3).

Does all this spell the end of fixed income as an asset class – or are the reports of its death greatly exaggerated?

We argue the latter. There are several key reasons:

- Interest rate fundamentals remain broadly supportive.
- Credit remains attractively priced relative to equities.
- Bonds can serve as a potent hedge in a broad portfolio.
- The bond market has historically provided much better sources of alpha than the equity market.

In the pages that follow, we present a deep historical and quantitative analysis that supports our conviction that fixed income is alive and well.

1. THE WEIGHT OF FUNDAMENTALS

A host of factors affect interest rates, and we present a handful of toy models in Appendix 1. They offer a coherent departure point for understanding interest rates. The reality of fixed income is, of course, messier than models (see Exhibit 4). A realistic laundry list of fundamentals would include:

Demographic trends: Lower population growth and aging have three main effects on real interest rates, and they don't all work in the same direction.

- The ratio of elderly individuals (who dissave) to working people (who save) has increased; the result is lower savings and a reduced supply of capital, which exerts upward pressure on rates.
- As life expectancy has risen, workers have increased savings to smooth lifetime consumption; stepped-up savings push rates lower.
- The capital-output ratio has increased with declining demographics, depressing the return on capital and real interest rates.

All in all, looking at a cross section of countries, it appears that the net impact of aging is lower real rates. The Solow–Swan and Long–Plosser models (Equations A.4 and A.28) in Appendix 1 align with this conclusion.

Productivity: Productivity growth is declining, leading households to increase savings and accumulate capital to keep future consumption in line with current consumption (see Exhibit 5). More capital means lower marginal productivity of capital and lower real rates. This is all the more true as households want to smooth consumption.[1] As is often the case, causality might run both ways: Low productivity growth leads to lower rates, but lower interest rates, by allowing zombie companies to survive, result in lower productivity growth.

Inequality: To the extent that the marginal propensity to save is higher with wealth, greater inequality causes higher savings and therefore lower rates.

Preferences: Investor and consumer preferences can, of course, affect interest rates. Two examples come to mind: It is argued that publicly traded companies are guilty of short-termism and invest less as a result, or that in response to "economic scarring" due to crises and pandemics we're living in an age of increasing anxiety, which can lead to higher precautionary savings.[2] In both instances, this dampens interest rates.

Risk premia: As accommodative monetary and fiscal policies have driven more investors into risk assets and compressed risk premia, bonds look more and more attractive on a relative basis.

Inflation: In theory, money is neutral and inflation does not affect real yields in the long run. In practice, however, one can't forget about the role played by central banks. To the extent that central banks are behind the curve when inflation rises above target, their knee-jerk reaction is to tighten monetary policy and induce higher real rates to quell inflationary expectations, as was the case in the Volcker era. But when inflation is missing in action, lower rates, both real and nominal, ensue.

Monetary policy: Evidently, real yields are not indifferent to monetary policy. Official short-term rates propagate across both the nominal and the real yield curves. "Postmodern" monetary policy is more concerned with maximizing employment and easing financial conditions than it is about inflation. It is no wonder why. Consider a world where the equilibrium real rate of interest is -5% and nominal interest rates are at their lower bound of around zero (not a completely ridiculous scenario considering real rates today). In this hypothetical world, the only way to achieve a -5% real rate is to run considerably higher levels of inflation.

Ricardian equivalence is likely to hold, to some degree, which partially neutralizes fiscal policy, and, to that extent, nervousness about fiscal deficits may be overdone.

Bond market net supply: Increased demand for bonds from capital exporters in emerging markets, an underhedged pension sector and quantitative easing (QE) by central banks have all put downward pressure on real rates. Against this background, fiscal incontinence means a higher bond supply and, all else equal, higher real yields. But the counterpoint is the famous Ricardian

1 In the case of the Ramsey–Cass–Koopmans model (Appendix A.1.2) and the consumption model (Appendix A.1.3) with constant relative risk-aversion utility, preference for consumption smoothing corresponds to a $\theta > 1$.

2 Economic scarring resulting from the COVID-19 pandemic is a key concern and something that took center stage at the most recent Federal Reserve conference at Jackson Hole. See Kozlowski, Veldkamp and Venkateswaran (2020) for more details.

Exhibit 4: Fundamentals of fixed income

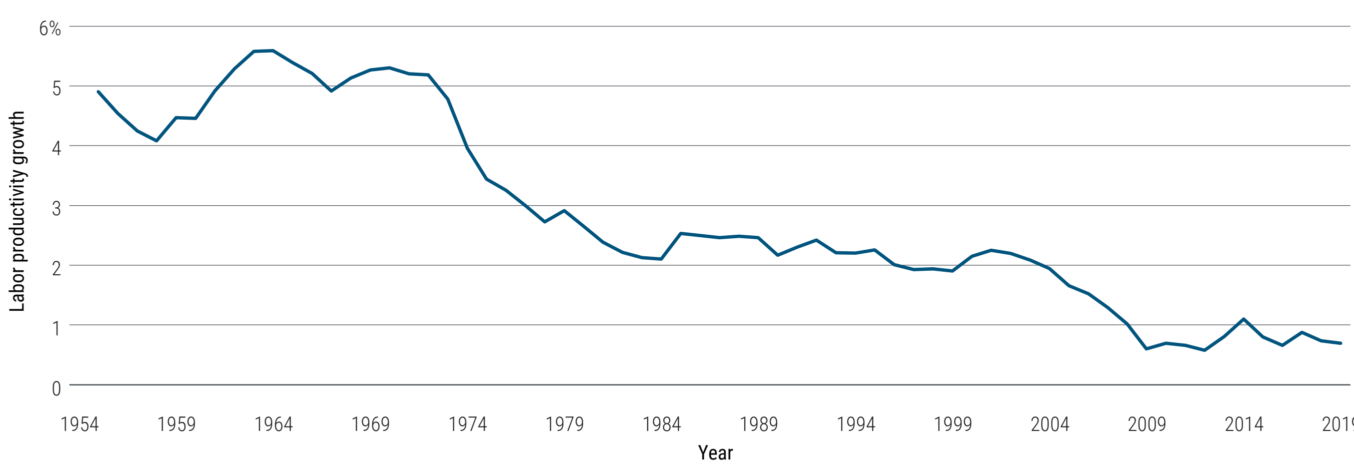
Macro fundamental	Trends and impact	Net impact on rates
Demographics	• Higher proportion of elderly people who dissave (+) • Increased savings from workers (–) • Higher capital-output ratio (–)	lower
Productivity	• Lower productivity growth (–)	lower
Inequality	• More savings for the wealthier (–)	lower
Preferences	• Underinvestment due to short-termism (–) • Higher precautionary savings due to economic scarring (–)	lower
Inflation	• Inflation upward surprise (+)	higher
Monetary policy	• Further central bank cuts (–)	lower
Bond market net supply	• Higher demand from emerging markets, pension plans and QE (–) • Higher supply due to fiscal incontinence (+) • Ricardian equivalence (–)	lower

Source: PIMCO as of 31 December 2020. **For illustrative purposes only.**

equivalence argument: If taxpayers know that fiscal incontinence raises the net present value of taxes by an equivalent amount, then they boost precautionary savings. In reality, Ricardian equivalence is likely to hold, to some degree, which partially neutralizes fiscal policy, and, to that extent, nervousness about fiscal deficits may be overdone. Because quantitative easing and the frustrated pension demand appear overwhelming, consensus has it that, on balance, the net supply of "safe-haven" assets is negative, with real rates lower as a result.

So where does all this leave us? Throughout the past three decades, most of the fundamentals – weak demographic and productivity growth (see Exhibit 5), lower risk premia, rising inequality, market anxiety, easy money, benign inflation and robust central bank and hedging demand for fixed income – drove real yields one way: down. And although the world is one of considerable entropy, none of the factors listed above appears to be reaching an obvious inflection point in the immediate future.

Exhibit 5: Average labor productivity growth in G7 countries (5-year moving average)



Source: PIMCO and the Conference Board as of 31 December 2019

2. LOW, LOWER RATES AND FEEDBACK LOOPS

Rising rates are a common concern for fixed income investors; under this scenario, bonds are more likely to underperform stocks. However, the probability of this should be very low. Baz et al. (2020) show that for an expensive asset to sustain its valuation, the probability of further price increases must be high. In fact, this asymmetry in probability is a general feature of assets with highly skewed returns.

Why is the payoff skewed? With physical currency, nominal short rates can't drop much below -50 basis points (bps) – at which point it may be better to simply stash money beneath a bed. But there is no similar upper bound if rates were to rise.

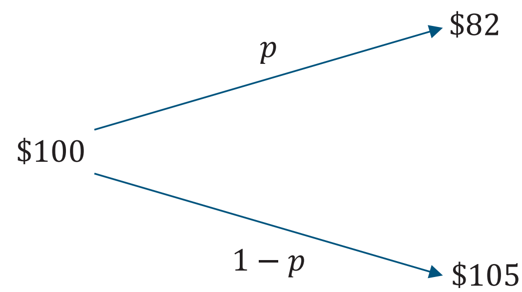
Think of a binomial model with skewed payoffs (see Exhibit 6). An 11-year zero-coupon bond is trading at $100. Assume for simplicity a flat term structure at zero percent, a zero bond risk premium and two possible outcomes: After a year, with probability p, the 10-year yield drops from zero to -50 bps and the price increases to $105, and with probability 1 - p, the yield increases to 200 bps and the price drops to $82. Then

$$100 = 82p + 105(1 - p) \tag{1}$$

and p is 22%. The probability of low rates going lower is 1 - p, which is 78%. This skewed distribution with moderate price appreciation and severe price depreciation implies the probability of rates declining further is high.

Note that the floor on nominal interest rates is caused by the physical nature of currencies. After all, if nominal interest rates are negative, a natural arbitrage is to withdraw money from the bank and store it at home. This would force nominal interest rates to a zero level. However, central banks could decide to go all-in on negative rates, and perhaps further down the line they could enforce negative rates by developing their own digital currencies. As it would not be possible to withdraw physical money in a digital world, the mechanism that prevented negative rates would no longer exist and there would be no formal limits to the upside in fixed income prices.

Exhibit 6: Illustration of a two-period binomial



Source: PIMCO. **Hypothetical example for illustrative purposes only.**

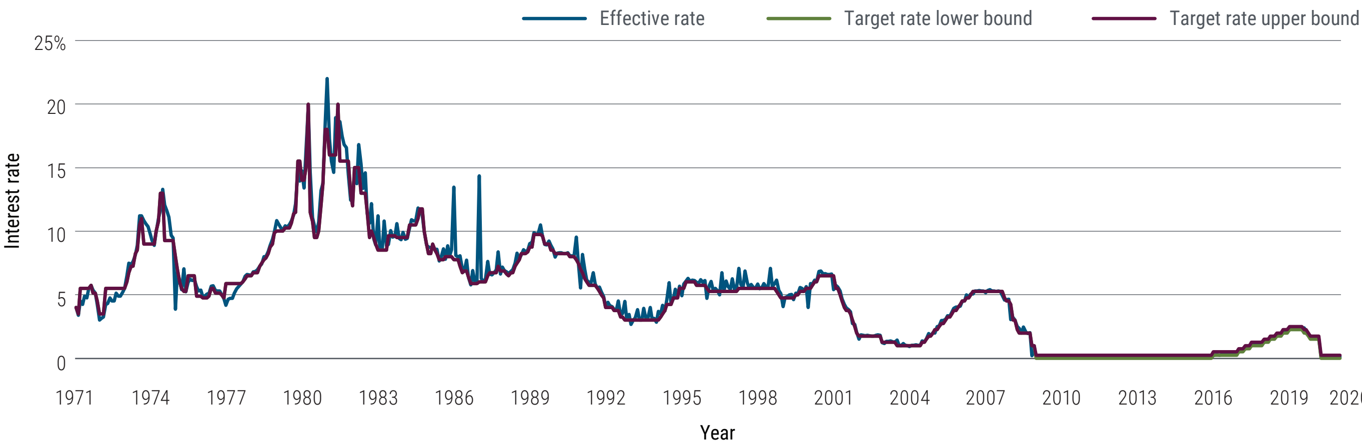
Most central banks seem trapped in a zero interest rate world, with little hope of reaching escape velocity.

Apart from the simple math of skewness, why would low rates imply a high probability of even lower rates? We discuss a few reasons below.

Most central banks seem trapped in a zero interest rate world, with little hope of reaching escape velocity. Looking at the U.S., the federal funds rate was mostly above 5% from the 1970s until 2001, although it spiked to 20% in 1981 (see Exhibit 7). Since 2008, zero rates have been the norm. Despite an attempt to restore positive rates, the Federal Reserve (Fed), like a number of central banks, had to revert to zero rates.

What is keeping central banks from restoring rates to "normal" levels?

Exhibit 7: Historical fed funds rate



Source: PIMCO and Bloomberg as of 31 December 2020

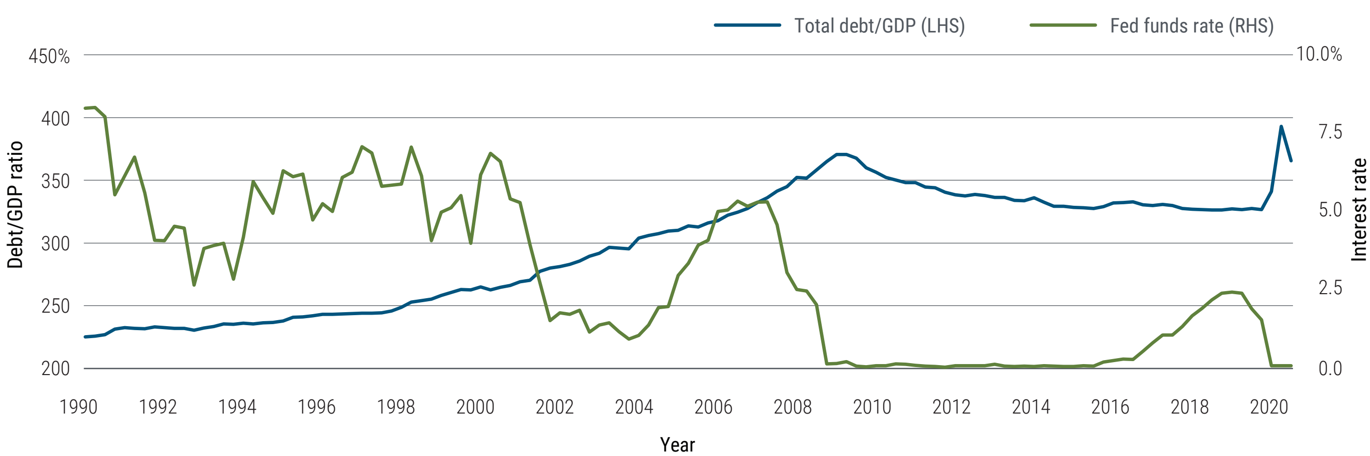
We have provided a long list of factors contributing to lower rates. Most central banks, while pleased with benign inflation, blame lower rates on the factors we listed – including aging, lower productivity growth, lower demand for investment goods, less-capital-intensive technologies, deflationary pressures in the labor and goods markets, the savings glut, and occasional market tremors.

As always, there is what is said and what is meant. In the latter category, one should include everything that feeds a vicious cycle in which low rates get even lower.

Consider a few dynamics:

- As rates decline, there is an incentive for greater leverage in the real economy. To contain capital charges due to debt service payments in highly leveraged economies, central banks are motivated to set rates even lower (see Exhibit 8).

Exhibit 8: Historical total U.S. debt-to-GDP ratio and fed funds rate



Source: PIMCO and Bloomberg as of 30 September 2020

- With lower rates, a stagnating economy and risk assets rallying, the economy becomes more dependent on wealth effects. The sensitivity of equity prices to real yields increases as markets rally and risk premia fall. With lower risk premia and higher equity duration, the market, and hence the economy, become more vulnerable to higher rates. There again, low rates beget lower rates.
- As rates decline, markets rally and expected returns fall, investors increase their portfolio leverage to maintain expected portfolio returns at previous levels. Again, portfolios become ever more sensitive to higher rates and subsequent sell-offs, as sell-offs combined with higher leverage mean a higher risk of ruin in markets – another example of how low rates result in yet lower rates.

This familiar story has various incarnations, from equity markets in the U.S. to real estate in China and southern Europe and industrial metals in Australia. Its implication is simple: The lower the rates, the lower the probability of the economy reaching escape velocity.

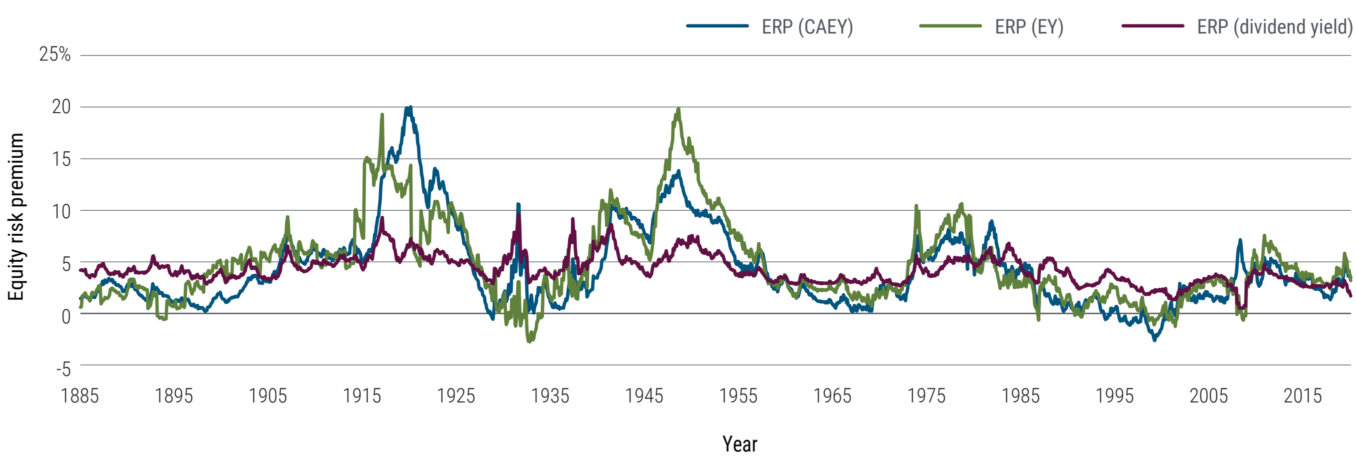
3. EQUITY CERTAINTIES AND THE MIRAGE OF HOPE

Among many consensus views markets hold, a couple may deserve discussion: "Even though it's not cheap, equity is cheap to bonds," and "Equity is certain to outperform bonds over the long run." We will comment on these views in turn.

Let us start with the belief that equity is cheap to bonds. We calculate the value of equity relative to Treasuries. To gauge relative value, we compute the difference between the real equity yield and the real Treasury yield – the so-called equity risk premium – and see how it compares with long-term averages.

We offer three methods to calculate the equity risk premium (see Appendix 2). Under the first method, we use the cyclically adjusted earnings yield (CAEY) as a proxy for the real equity yield, while the 10-year real bond yield is the difference between the nominal yield and expected inflation (using an exponentially weighted average of past inflation). The second method differs from the first in that we use spot earnings instead of the CAEY to calculate the real equity yield. Under the third method, we approximate the equity risk premium by the dividend yield (with a buyback adjustment). Exhibit 9 shows the time series for these three estimates.

Exhibit 9: Historical equity risk premium



Source: PIMCO and Global Financial Data as of 30 November 2020

Using a long time series, Treasuries appear to be fair to cheap to equity despite currently trading at historically low yields.

The short of it is that under all three methods the equity risk premium is currently lower than its long-term average (see Exhibit 10). Using a long time series, Treasuries appear to be fair to cheap to equity despite currently trading at historically low yields.

Exhibit 10: Estimated equity risk premium

	30 November 2020 (%)	Average (%)
Method 1 (CAEY minus real bond yield)	3.5	4.3
Method 2 (spot EY minus real bond yield)	3.2	4.8
Method 3 (dividend yield)	1.7	4.2

Source: PIMCO and Global Financial Data as of 30 November 2020

We follow a similar approach to discuss the relative value of equity and credit. Consider the equity and credit of firms in the S&P 500 index. The nominal return of equity is the Treasury yield plus the equity risk premium. The nominal return of credit is the Treasury yield plus BAA spreads (loss-adjusted). The equity-credit risk premium is the difference between the equity risk premium and the loss-adjusted credit spread. Exhibits 11 and 12 show the equity-credit risk premium under all three methods.

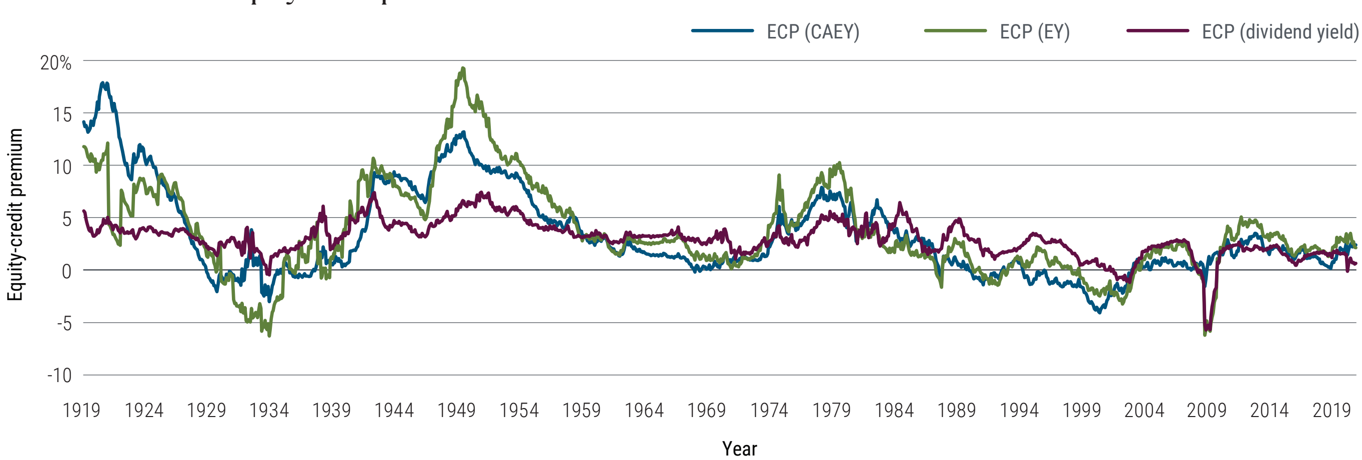
Exhibit 12: Estimated equity-credit premium

	30 November 2020 (%)	Average (%)
Method 1 (ERP 1 – loss-adjusted spread)	2.4	3.3
Method 2 (ERP 2 – loss-adjusted spread)	2.1	3.6
Method 3 (ERP 3 – loss-adjusted spread)	0.6	3.0

Source: PIMCO and Bloomberg as of 30 November 2020

We turn next to the belief that equity is certain to outperform bonds over long horizons. Many investors have heard the factoid that, given enough time, stocks almost always beat bonds. This conventional wisdom explains the popular financial advice that long-term investors should invest most of their portfolios in stocks. Why not, if stocks will eventually come out on top and the investor is patient enough to stomach the short-term volatilities?

Exhibit 11: Historical equity-credit premium



Source: PIMCO and Bloomberg as of 30 November 2020

A curious, evidence-based investor might ask: What does the history of U.S. markets say about this? Recent research by McQuarrie (2019) claims stocks outperformed investment grade bonds in 61.3% of the 10-year holding periods and 65.5% of the 30-year ones since 1793 – pretty decent for bonds, considering the risk difference.

To supplement the (sometimes scant) historical evidence, we present below a simple model to estimate the forward-looking probability of outperformance for stocks versus bonds.

PROBABILITY OF STOCKS OUTPERFORMING TREASURIES

Suppose the expected return for a zero-coupon Treasury bond with maturity T is r. A stock has expected return μ and volatility σ. For simplicity, all returns are expressed on a continuously compounded basis. Then the probability for the stock to outperform the Treasury bond at the end of horizon T is

$$\Phi\left(\left(\frac{\mu-\frac{1}{2}\sigma^2-r}{\sigma}\right)\sqrt{T}\right) \tag{2}$$

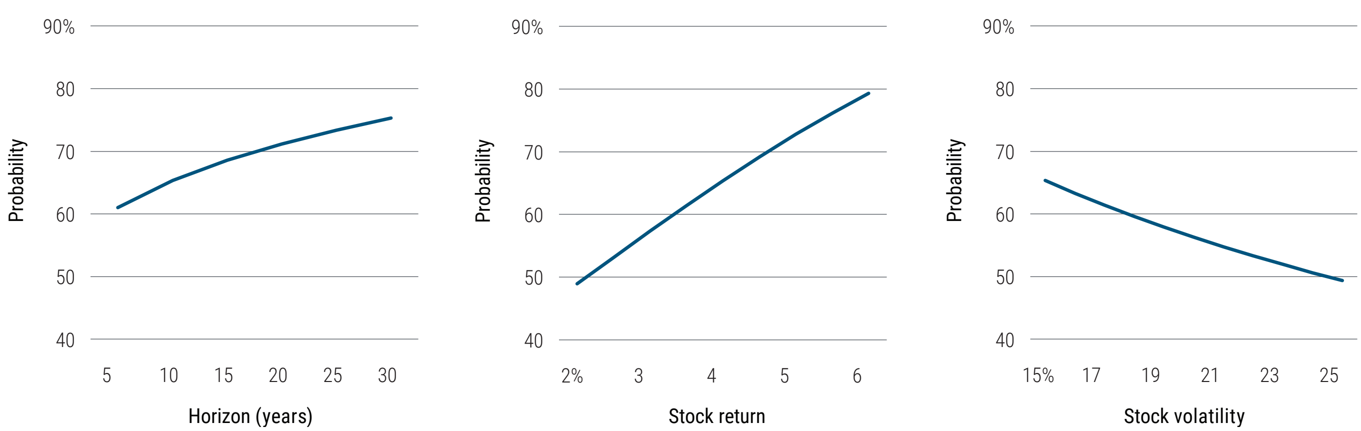
where Φ is the cumulative distribution function for the standard normal distribution (see Appendix 3).

This probability is higher than 50% if and only if the stock's expected geometric growth rate $\mu-\frac{1}{2}\sigma^2$ is higher than the risk-free rate r. Under this condition, the higher the equity risk premium and the longer the horizon, the higher the probability of the stock outperforming. Higher stock volatility can reduce the probability by reducing the stock's expected geometric growth rate as well as increasing noise/dispersion.

When T = 10, r = 1%, μ = 4% and σ = 15%, the probability is 65%. Exhibit 13 shows how the probability changes as we perturb one input while keeping the others fixed.

There is another consideration worth mentioning: In all the calculations of the U.S. equity risk premium and related probabilities of outperformance, we take earnings and dividends as a given. Evidently, the profit-to-GDP ratio, being comfortably higher than the historical average, could easily

Exhibit 13: Probability of stocks outperforming Treasuries



Source: PIMCO. **Hypothetical example for illustrative purposes only.**

revert to lower levels due to declining world trade, higher taxes and pressing labor demands. This is to say that the probability of equity outperformance over Treasuries would be drastically lower than indicated above if taxes, labor power and protectionism were on the rise.

Exhibit 14 shows the Shiller CAPE ratio since 1881. A mean-reversion scenario from the recent level of 35 halfway to the historical average in 10 years without earnings growth could result in a roughly zero percent equity return. With this expected equity return, the probability for stocks to outperform Treasuries in our example would be only about 33%.

4. CREDIT, RELATIVELY NORMAL

With Treasury bond prices and equity valuation ratios all trading in the tails, a "normal" asset class is a rarity. We claim that credit is relatively normal in that it is not as expensive in a world of compressed risk premia.

To state the obvious, government paper is by no means the dominant bond category within fixed income. In the U.S., for example, Treasuries represent about 35% of total bonds outstanding. While government yields are hovering near all-time lows in all G7 economies, valuations for credit are not in the extreme tails like Treasuries and equities. As shown in Exhibit 15, spreads for many categories of U.S. investment grade and high yield bonds are not as tight against their historical averages. Although in a post-COVID-19 world entire industries – ranging from retail to leisure to healthcare – are at substantially higher risk of default, the default rates implied by market spreads are multiples of historical default frequencies. For example, the implied default rate is 1.6% versus a 0.2% historical default frequency for investment grade corporate bonds, and 4.2% versus 1.6% for corporate bonds rated BB. Similarly, emerging market (EM) USD categories show high implied-to-historical-default multiples.

Credit is relatively normal in that it is not as expensive in a world of compressed risk premia.

Exhibit 14: Historical Shiller CAPE ratio

Source: PIMCO and Robert J. Shiller as of 31 December 2020

Exhibit 15: Implied versus historical realized default rates

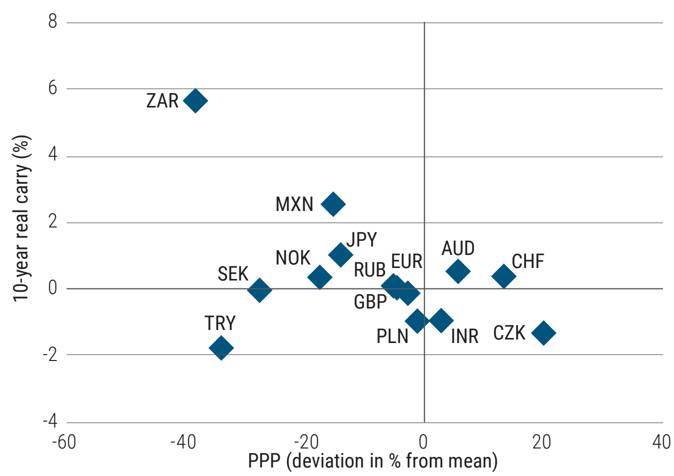
		OAS	Percentile	HY / IG OAS ratio	Percentile	Implied default 40% recovery	Historical probability of default	Implied - realized	Estimated loss	Data start date
Equity	U.S. equity	307*	11.0%							2/27/1970
Investment grade bonds	Nonagency RMBS**	203	27.7%							1/31/2011
	Nonagency CMBS	126	38.3%							1/31/2008
	IG munis	41	71.9%	2.9	46.0%	0.7%	0.0%	0.7%	0.0%	1/31/1980
	IG corp.	94	15.3%	3.7	84.8%	1.6%	0.2%	1.4%	0.1%	9/30/2002
	IG credit: BBB	121	24.7%	2.9	61.7%	2.0%	0.3%	1.7%	0.2%	1/29/1993
	EM IG sov.	155	18.9%	3.8	91.3%	2.6%	0.3%	2.3%	0.2%	12/31/1993
	EM IG corp.	195	22.8%	2.5	63.3%	3.2%	0.3%	3.0%	0.2%	12/31/2001
High yield bonds	HY munis	328	49.6%			5.5%	1.2%	4.2%	0.5%	1/31/1996
	HY corp. BB	254	32.0%			4.2%	1.6%	2.6%	1.0%	9/30/2002
	HY corp. B	373	32.4%			6.2%	4.1%	2.1%	2.5%	9/30/2002
	HY ex-energy	327	15.9%			5.4%	3.2%	2.3%	1.9%	1/31/1994
	EM HY sov.	591	43.5%			9.8%	2.1%	7.7%	1.3%	12/31/1997
	EM HY corp.	496	50.5%			8.3%	3.2%	5.1%	1.9%	2/28/1994

Source: PIMCO and Bloomberg as of 8 January 2021. *The option-adjusted spread (OAS) column for U.S. equity shows its cyclically adjusted earnings yields (CAEY) as of 31 December 2020. ** Nonagency RMBS data is as of 31 December 2020.

How about non-USD sovereigns? Here again, a naive look at Exhibit 16 suggests that a number of bonds live in high value and/or high carry quadrants.[3] If currency value is approximated by the deviation from purchasing power parity (PPP) and carry by the real interest differential in the 10-year maturity bucket, then the expected return in a number of local markets benefits from both a potential appreciation of cheap currencies and a high real yield prevailing in these currencies.

3 We look at carry and PPP for the Australian Dollar (AUD), British pound (GBP), Czech koruna (CZK), Euro (EUR), Indian rupee (INR), Japanese yen (JPY), Mexican peso (MXN), Norwegian krone (NOK), Polish zloty (PLN), Russian ruble (RUB), South African rand (ZAR), Swedish krona (SEK), Swiss franc (CHF) and Turkish lira (TRY).

Exhibit 16: Purchasing power parity versus real carry for non-U.S. sovereign bonds

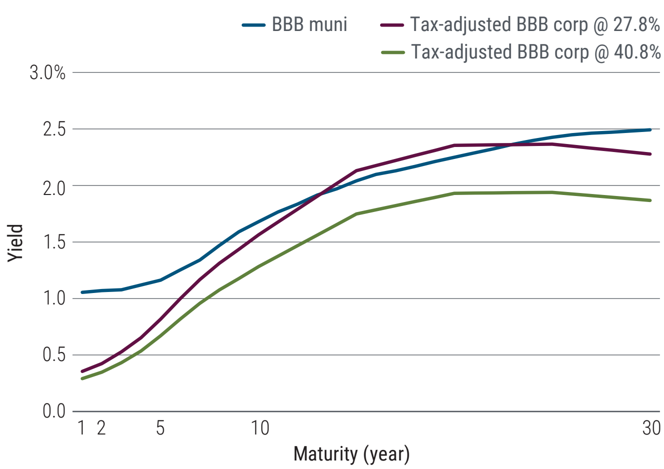


Source: PIMCO and Bloomberg as of 8 January 2021

When you get down to brass tacks, history really offers only two precedents: Japan and Europe.

For retail investors, bond taxation is particularly relevant. When accounting for taxes, municipal bonds provide attractive value on a risk-adjusted basis to U.S.-domiciled investors. Municipal bonds can deliver U.S.-domiciled investors consistent, federal tax-exempt income and, most importantly, serve as a core allocation and ballast for high net worth individuals subject to high tax rates. As Exhibit 17 shows, nontaxable BBB muni yields, to take an example, are mostly higher than after-tax yields on BBB corporates for tax rates above 27%. What is more, munis have experienced lower default rates relative to comparably rated corporate bonds, as well as low correlations to risk assets.[4]

Exhibit 17: Yield curves of BBB muni and corporate bonds



Source: PIMCO and Bloomberg as of 7 January 2021. We consider the top federal tax rate of 40.8% (37% tax bracket + 3.8% Medicare) as well as a lower 27.8% (24% tax bracket +3.8% Medicare).

Over the secular horizon, federal tax-exempt income should remain in high demand in the U.S., given aging demographics and the potential that personal income tax rates are more likely to increase than decrease. Despite continued robust investor appetite for municipal bonds, the size of the market has remained static. We attribute this to supply-side dynamics. Rising pension costs and other post-employment benefits (OPEB) liabilities continue to crowd out infrastructure investments, and new federal funds for infrastructure may remain scarce. Finally, the market remains ripe for active management due to its retail nature: Valuations remain highly susceptible to fund flows, and, with lower broker-dealer inventory levels, an active approach can lead to outperformance potential.

5. FIXED INCOME, THE CLEANEST DIRTY SHIRT?

A historical perspective affords bond investors few relevant insights about the future. Nominal bond yields below 2% have been exceedingly rare, occurring in approximately 1% of the historical dataset on developed market interest rates spanning 16 countries.[5] And that's the good news. Compounding this lack of relevant data is the fact that monetary policy, a key determinant of interest rates, has changed dramatically over time, making much of the historical low yield scenarios irrelevant for comparison purposes.

When you get down to brass tacks, history really offers only two precedents: Japan and Europe. While the initial conditions facing each were unique, both monetary and fiscal policy responses have followed the same modern playbook endorsed by many of their developed market peers. They serve as leading indicators of sorts for where the rest of us may be headed.

To put things in perspective, 10-year Japanese government bond (JGB) yields have been trading below 2% since 1997 and below 1% since 2010. Furthermore, since 1997 three-month Libor has averaged a whopping 22 bps. It is fair to say that no

4 According to Moody's Investors Services (2020) and data from Bloomberg

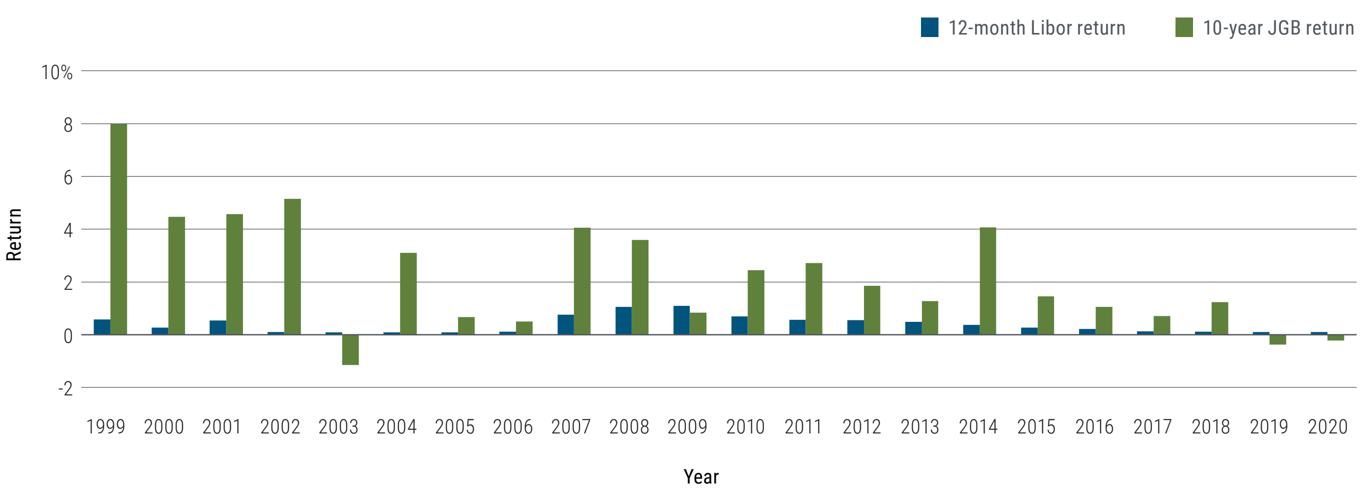
5 Data is from the Jordà–Schularick–Taylor Macrohistory Database (Jordà et al. 2016).

bond market has been less interesting. Monetary policy has put the market on life support. Fiscal policy's role in all of this is to be the defibrillator, shocking the economy back to life when interest rates lie near zero. Since 1997, Japan's ratio of government debt to GDP has ballooned from 101.0% to 266.2%, and yet, despite these extraordinary measures, GDP growth has averaged an anemic 0.7% and inflation a shockingly low 0.2%. Investors have been calling for the demise of JGBs for nearly 25 years, predicting that the immense monetary and fiscal support would result in tears for those brave enough to invest in these troubled waters where upside is minimal and downside arguably unmeasurable.

So how have things played out for the Japanese bond investor? Exhibit 18 shows that less risky cash, here corresponding to the 12-month Libor rate, has persistently underperformed 10-year government bonds over the past 22 years, to the tune of approximately 190 bps per year. The outperformance of Japanese bonds is striking: In only four years did bonds underperform the Japanese cash proxy. The difference between 10-year and one-year JGB yields has averaged 85 bps over this period, yet the outperformance has been more than twice this yield differential. How is this possible? The secret lies in the roll-down. As yields have remained low and the yield curve is upward sloping, Japanese bond investors have collected a risk premium from being invested in longer-dated bonds and "rolling down the curve." The reality is that the fear that monetary and fiscal policy will go too far has been priced into Japanese bonds, and those willing to take the other side of this view have been rewarded rather consistently.

The reality is that the fear that monetary and fiscal policy will go too far has been priced into Japanese bonds, and those willing to take the other side of this view have been rewarded rather consistently.

Exhibit 18: Annual returns of 10-year JGBs and 12-month Libor



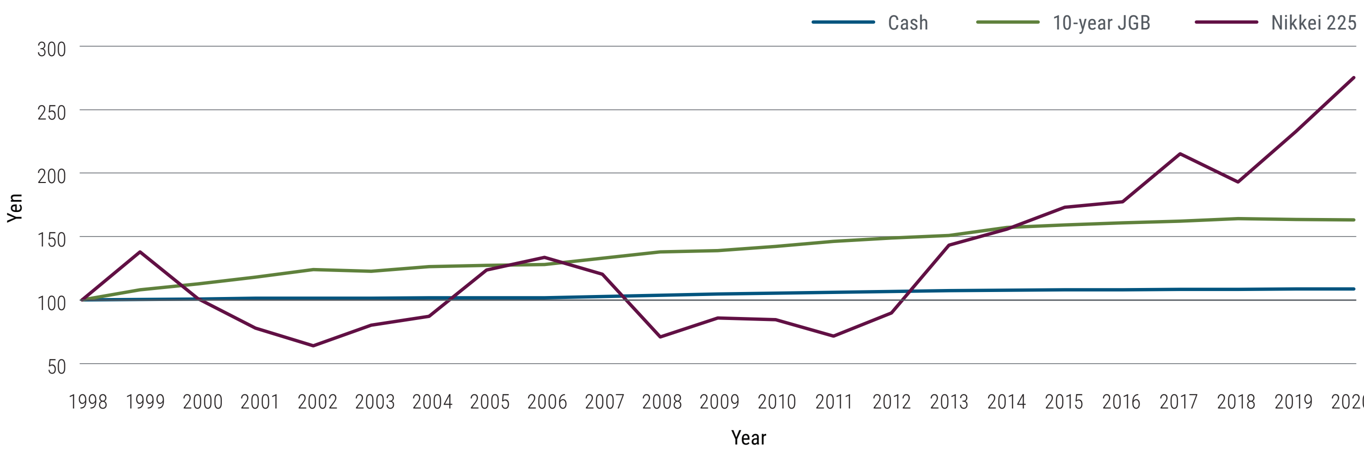
Source: PIMCO and Bloomberg as of 31 December 2020

Instead of accepting lower rates of return from cash and bond investments, investors often shift their portfolios toward riskier equity investments to meet return objectives. "Don't fight the Fed" has become the modern mantra of macro investors, and many argue that the unspoken goal of central banks is to create a bid for risk assets by crowding investors out of "risk-free" assets. So how has the Japanese equity investor fared in the world of low rates? Exhibit 19 shows that although equity investments had outperformed 10-year government bonds by the end of 2020, they possessed much higher volatility and more inconsistency.

When adjusting equity and bond returns for their respective levels of risk, the relative performance becomes even more apparent. Using annual data from 1999 to 2020, corresponding again to the period of low interest rates in Japan, the Sharpe ratio on 10-year JGBs was 0.90, whereas that of Japanese equities was only 0.29. Although equities eventually outperformed bonds as of 2020, the Japanese equity investor faced much more risk along the way and at times suffered substantial underperformance relative to both bonds and cash. Bonds, while unloved due to the extremely low level of yields, were a consistent source of return as monetary policy remained accommodative for more than two decades. Instead of reducing their exposure to fixed income when yields fell, investors should have increased their exposure, as both the risk-adjusted returns and diversification properties of JGBs made them far more valuable in a portfolio. The irony of hedging is something we discuss in more detail in Section 9.

Although European bonds have been trading at low yields for a much shorter time than Japanese bonds, they nonetheless serve as an important reminder that Japan's situation may not be an outlier. For many reasons discussed in this piece, the bond investor may find that interest rates near zero are a black hole that no economy can escape. Since 2014, 10-year German Bunds have traded below a 1% yield; the European Central Bank (ECB) was one of the first central banks to embrace the concept of negative interest rates, lowering its deposit rate to -0.1% in June 2014. To put it bluntly, one euro invested in cash since 31 December 2014 would be worth less than one euro today, courtesy of the ECB. Investing in "risk-free" assets in Europe are currently guaranteed to lose money, and saving now incurs a storage cost.

Exhibit 19: Growth of 100 yen invested in cash, bonds and equities



Source: PIMCO and Bloomberg as of 31 December 2020. Dividends were reinvested in stock investment. The 10-year JGB is proxied by the S&P 10-year JGB Futures Total Return Index. Equity is proxied by the Nikkei 225 Index, and cash is proxied by 12-month Japanese yen Libor.

Much like the situation in Japan, the yield curve in Europe is upward sloping, and investors have been consistently collecting a risk premium for bearing the risk embedded in longer-dated bonds.

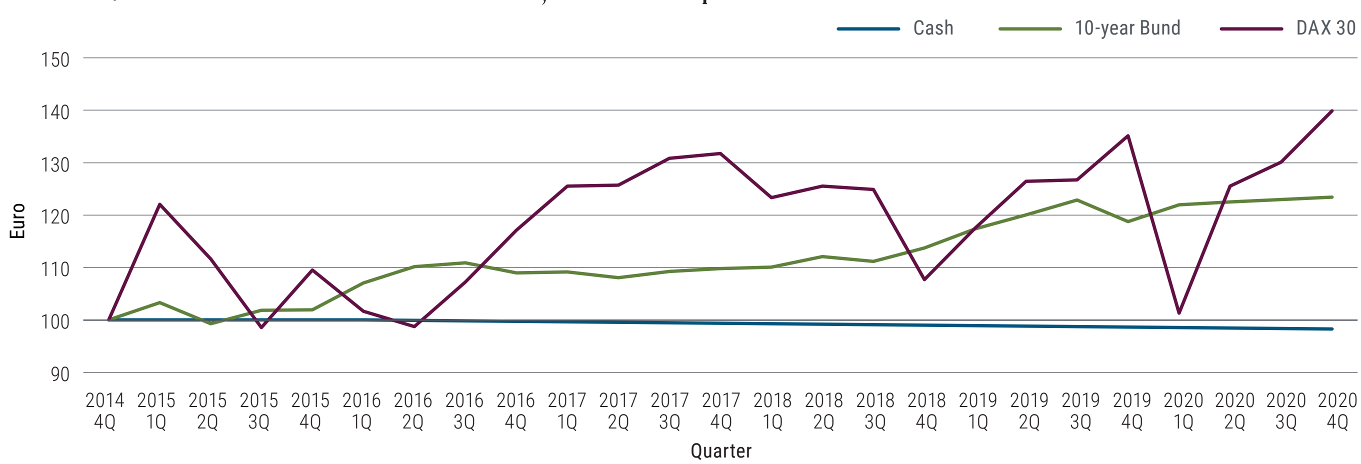
Like their Japanese counterparts, European bond investors have seen better times. It doesn't take an astute investor to realize that it is time to move on to markets that offer greener pastures. It would seem that the only saving grace for European bonds is that investors may lose less money than if they invested in cash at negative interest rates. However, digging a little deeper, something interesting emerges. Much like the situation in Japan, the yield curve in Europe is upward sloping, and investors have been consistently collecting a risk premium for bearing the risk embedded in longer-dated bonds. Furthermore, much like Japan, despite bonds offering little upside due to extremely low yields and policy spurring investors to move toward riskier equity investments, equity and bonds have delivered mostly similar overall performance. Though we have only six years of data – too short a window to draw definitive conclusions – it is nonetheless striking that 10-year government bonds with yields averaging only 14 bps have been a more consistent source of return than both cash and equities.

Again, adjusting equity and bond returns for their respective levels of risk reveals the consistency of bond returns in a low yield environment relative to those of equities (see Exhibit 20). Using quarterly data from 2015 to 2020, a period when 10-year Bund yields were less than 1%, the Sharpe ratio on Bunds was a mind-boggling 1.60, which is more than two times the 0.66 Sharpe ratio delivered by DAX equities. Much like the situation in Japan, German investors who reduced their bond holdings due to the low yields not only reduced their portfolio diversification but also faced a very rough ride, only to arrive at a similar destination.

6. PRIVATE CREDIT AND THE PRICE OF LIQUIDITY

Although public credit can be characterized as relatively normal, private markets are anything but normal. As regulation continues its relentless march forward, banks are increasingly incentivized to lend prudently amid a tide of rising leverage and uncertainty. The regulatory effort that is meant to foster greater financial sector stability has, ironically, left many would-be borrowers without access to traditional bank lines of credit. Meanwhile, equity and bond valuations live in their tails and many investors are in search of greater returns to satisfy their

Exhibit 20: Growth of 100 euro invested in cash, bonds and equities



Source: PIMCO and Bloomberg as of 31 December 2020. Dividends were reinvested in stock investment. The 10-year Bund is proxied by the Credit Suisse Euro-Bund Futures Total Return Index. Equity is proxied by the DAX 30 Index, and cash is proxied by the three-month euro Libor.

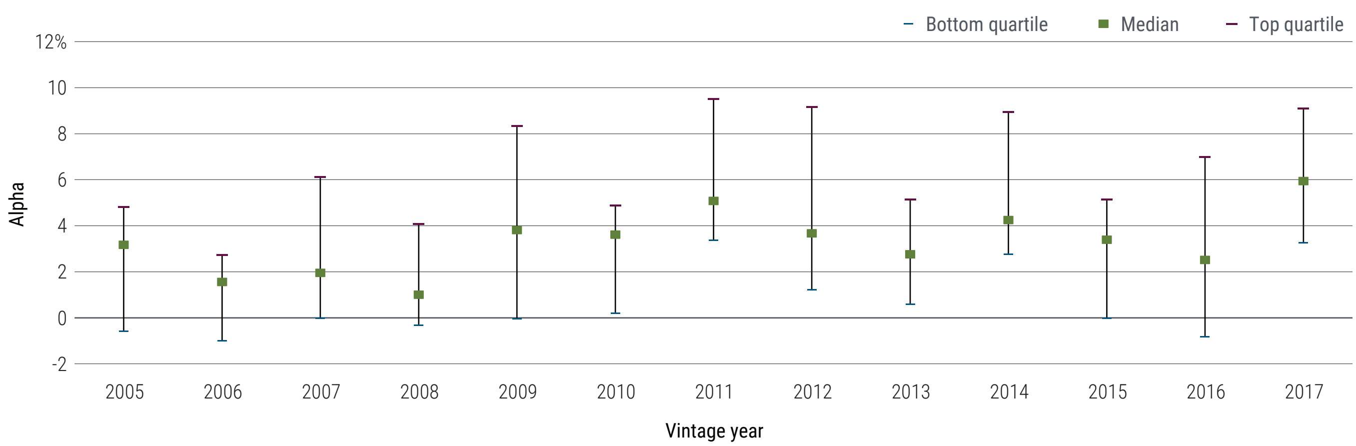
objectives. As the story goes, private debt would seem to offer the perfect opportunity.

Taking the leap from public to private markets comes with a cost, namely liquidity risk. As investors lock up capital in private investments, they forgo opportunities that may arise elsewhere. Much has been done to try to quantify the compensation investors should require for bearing liquidity risk.[6] These models are often cumbersome and unrealistic, requiring a host of assumptions and substantial complexity. Instead of focusing on the theory, it is perhaps better to understand what has been delivered in practice. In Exhibit 21, we plot the performance, by vintage year, of private debt investments[7] relative to an equivalent investment made in duration-hedged U.S. high yield. Though the risks underlying private investments do not perfectly map to those in the high yield credit space, the public benchmark does provide a useful perspective on the relative performance offered by private debt allocations.

While data on private debt fund performance is limited, the performance relative to high yield investments is nonetheless striking. Relative to duration-hedged U.S. high yield, alpha delivered by private debt managers has been consistently positive across vintage years and broadly aligns with the narrative around banking regulation. Furthermore, even the bottom quartile of managers have outperformed public high yield investments, underscoring the point that liquidity provisioning to these underserved markets is rewarded by outsize returns. Interestingly, and perhaps a validation of the theories underpinning appropriate compensation for liquidity risk, the empirical results generally align with the finding that investors should require 2%–4% excess returns for locking up capital between five and 10 years.[8]

There are, however, many challenges facing private debt investors today. Private markets lack transparency, and their risks are often not well understood. Investors do not have access to a long history of results over multiple cycles and must extrapolate from a fairly small sample of funds. Last, the amount of capital that is migrating to the private debt space is substantial, which should serve to compress returns going forward. It goes without saying, but deal sourcing, underwriting standards and portfolio construction are all critical determinants of success.

Exhibit 21: Historical alpha distribution of private credit funds



Source: PIMCO, Bloomberg and Preqin as of 31 December 2019

6 See Amihud and Mendelson (1986); Acharya and Pedersen (2005); Hibbert, Kirchner, Kretzschmar, Li and Alexander (2009); Ang, Papanikolaou and Westerfield (2014); Longstaff (2017); and Baz, Stracke and Sapra (2019) for details.

7 We include all funds within the categories of direct lending, distressed debt, mezzanine and special situations within the Preqin database.

8 See Longstaff (2017) and Baz, Stracke and Sapra (2019).

7. DESPERATELY SEEKING ALPHA: CAPITAL EFFICIENCY AND THE ACTIVE BOND ADVANTAGE

Given the compressed risk premia across many asset classes, most traditional institutional portfolios are poised to deliver returns well below the ambitious 7% target for many investors. To boost returns, some resort to shifts toward riskier assets, often at the expense of reduced liquidity and transparency, as well as increased drawdown potential.

Another common challenge investors face is the difficulty of accessing reliable and diverse sources of alpha. Ideally, the allocation of an alpha risk budget should be based on the best alpha opportunities available, but in reality it is often a byproduct of the asset allocation decision. As a result, investors may be forced to choose passive managers and be locked into "index-minus" returns, due to fees and expenses. For instance, consider exposure to large cap U.S. equities, a staple allocation in nearly all portfolios. Index funds and exchange-traded funds (ETFs) are often a popular choice, reflecting the challenge of generating consistent alpha in highly efficient markets.

Asset allocators facing these challenges are increasingly embracing capital-efficient strategies. At its core, capital efficiency is about benefiting from the depth and liquidity of the asset markets. Nowadays, investors can obtain exposure to many asset classes through synthetic instruments such as futures, forwards and total return swaps. These instruments require minimal upfront cash to obtain desired notional exposures, thereby freeing up remaining capital to pursue other policy objectives. For example, investors can design capital-efficient strategies that seek to increase portfolio return without necessarily increasing risk; separate alpha allocation from beta allocation; or increase allocation to diversifiers without taking capital away from other asset classes.

Fixed income assets often play an essential role in these capital-efficient solutions. One obvious reason is that many fixed income assets are natural diversifiers for equity risk. Another important reason, in our view, is that the bond market provides much better sources of alpha than the equity market in general.

Suppose that 10 years ago an institutional investor randomly picked an active fund to invest in and kept the investment in the active space in the same category if the fund was merged or liquidated. Exhibit 22 shows the probability that this investment would have outperformed the median passive peer today for the three largest Morningstar categories in fixed income and equity. More than half of the active bond mutual funds and ETFs beat their median passive peers after fees in two of the three categories over the past 10 years. In contrast, most active equity strategies in all three categories failed to beat their median passive counterparts during this period. In addition, in all three fixed income categories, the asset-weighted average returns for active funds are higher than their passive counterparts' over the past 10 years — yet the opposite is true for equity categories.

Exhibit 22: 10-year active versus passive fund performance

Morningstar category	Probability of outperformance over median passive peer	10-year average return: Active	Passive	Diff (bps)
High yield bond	76%	6.1%	5.6%	+47
Intermediate core bond	66%	4.1%	3.8%	+24
Short-term bond	44%	2.5%	2.3%	+17
Large growth	15%	15.9%	17.5%	-164
Large blend	8%	12.7%	13.9%	-123
Large value	24%	10.9%	11.5%	-59

Source: Morningstar and PIMCO as of 31 December 2020. Institutional share class for mutual funds. U.S. returns are net of fees. Figure is provided for illustrative purposes and is not indicative of the past or future performance of any PIMCO product.

We believe the reason active bond strategies generally have been more successful than active equity strategies lies in the bond market's unique structure (see more detailed discussion in Baz, Mattu, Moore and Guo (2017)). For example, central banks, insurance companies and other noneconomic investors make up almost half of the more than $100 trillion global bond market. They typically have objectives other than maximizing returns and therefore leave alpha potential on the table for active bond managers. Unlike stocks, bonds mature after a number of years, leading to more turnover in the bond market. New securities make up around 20% of bond market capitalization each year, and they typically are offered at concessional pricing to drive demand. Structural tilts can also be an important source of durable added value. Think about duration, yield curve steepeners, high yielding currencies, high yield credit spreads, agency and nonagency mortgage spreads, volatility sales and liquidity premia – just to name a few. There is also a wide range of financial derivatives available to active bond managers that allow for potentially profitable expressions of investment themes: currency swap basis, futures basis, CDS-cash basis and to-be-announced (TBA) rolls are some examples. In addition, active bond managers can implement so-called smart strategies, such as carry, value and momentum, that have historically displayed substantially positive Sharpe ratios (see, for example, Baz et al. (2015)). Informational efficiencies make beating equity markets more difficult due to fewer opportunities of material mispricing, but that's not the case with fixed income.

There is one caveat, though. As empirically identified and emphasized in our earlier research (for example, Mattu, Devarajan, Sapra and Nikalaichyk (2016)), many active fixed income managers may be systematically exposed to extra credit risk; it can explain a nonnegligible portion of their alphas. Whether it is alpha or beta ex ante is debatable – hindsight is indeed a wonderful thing. However, pure alpha can coexist with increased correlation with credit, as discussed in Baz et al. (2018).

8. ON INFLATION, OUR INDECISION IS FINAL

When it comes to the future of fixed income, inflation is the obvious game changer. On the topic of inflation trends, our indecision is final. Maybe it is also justified. After all, a number of macro models of fiscal laxity show multiple equilibria with both high inflation and deflation as distinct possibilities.

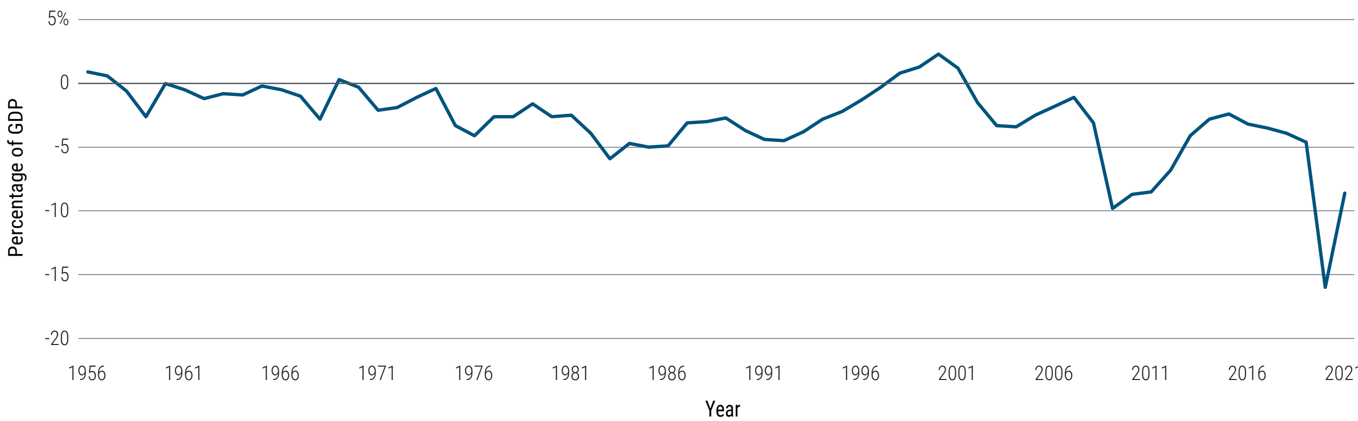
It is, of course, hard to argue for inflation when entire sectors of the global economy – think of retail, healthcare, airlines, restaurants, hotels, gyms and entertainment – are witnessing substantial deflationary pressure. As mentioned, macro fundamentals are dire, valuation ratios for risk assets are stretched, and leverage levels are staggering. All of these are first-order factors on the macro menu and likely to produce a deflationary outcome via economic fragility, risk sell-offs and deleveraging.

Over the medium to long term, however, one should keep an eye out for inflation, which could well be ignited in due course by policy – in particular, by the policy reaction to deflationary pressure. Consider this short list of inflation white swans:

Over the medium to long term, however, one should keep an eye out for inflation, which could well be ignited in due course by policy.

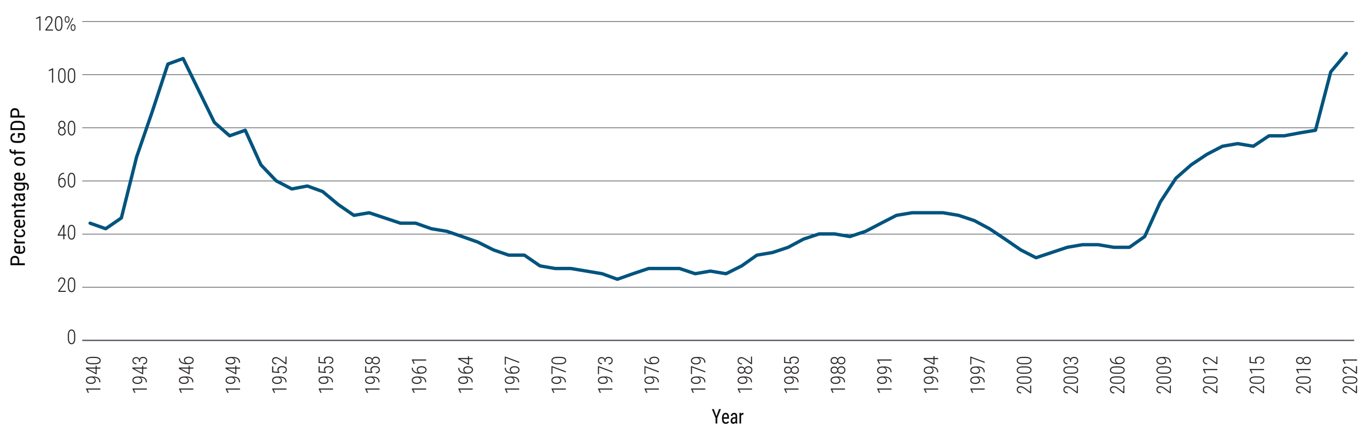
- **Fiscal dominance:** The U.S. budget deficit for fiscal year 2020 reached 16% of GDP, around 60% higher than the previous height of 9.8% in 2009, with the amount of federal debt held by the public as a percentage of GDP projected to increase drastically, from 79% in 2019 to 101% in 2020 and 108% in 2021 – a level not seen since World War II (see Exhibits 23 and 24). The soaring debt burden could

Exhibit 23: U.S. surplus/deficit as % of GDP



Source: PIMCO and Haver Analytics as of 8 January 2021. Includes projected data.

Exhibit 24: U.S. federal debt held by the public as % of GDP

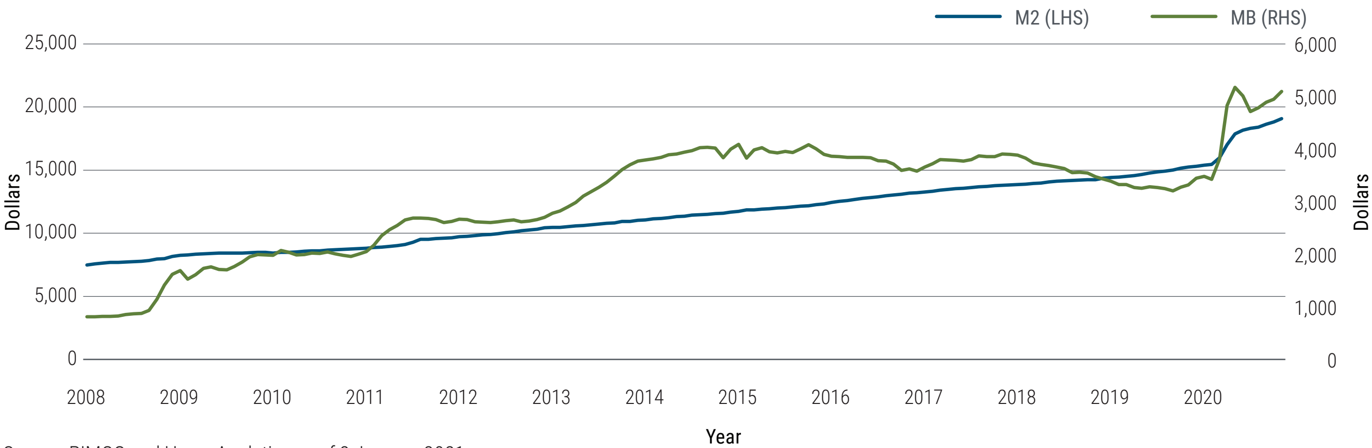


Source: PIMCO and Haver Analytics as of 8 January 2021. Includes projected data.

incentivize the government to let inflation run hot to “inflate away” the debt. Worse, if and when monetary financing of public debt occurs, we could witness a rapid erosion of central bank credibility and potential hyperinflation via a buildup in price expectations, capital flight, or both.

- **QE, banking multiplier and M2 growth:** Besides fiscal concerns, aggressive monetary policy adds pressure to inflation. In March 2020, the U.S. Fed cut the federal funds rate to zero and embarked on large-scale quantitative easing with unprecedented speed. Within five months, its balance sheet had expanded from $4.2 trillion at the end of February to almost $7 trillion at the end of July. To put this in context, the Fed’s balance sheet took almost seven years to increase from $900 billion in 2008 to $4.5 trillion in early 2015, in the aftermath of the global financial crisis (GFC). Exhibit 25 shows that both the monetary base and the M2 money stock increased drastically in early 2020. In particular, M2 grew by 17% between February and June 2020, with year-over-year growth of 23% in June, the highest in 50 years. As a

Exhibit 25: Money supply ($ trillions)



Source: PIMCO and Haver Analytics as of 8 January 2021

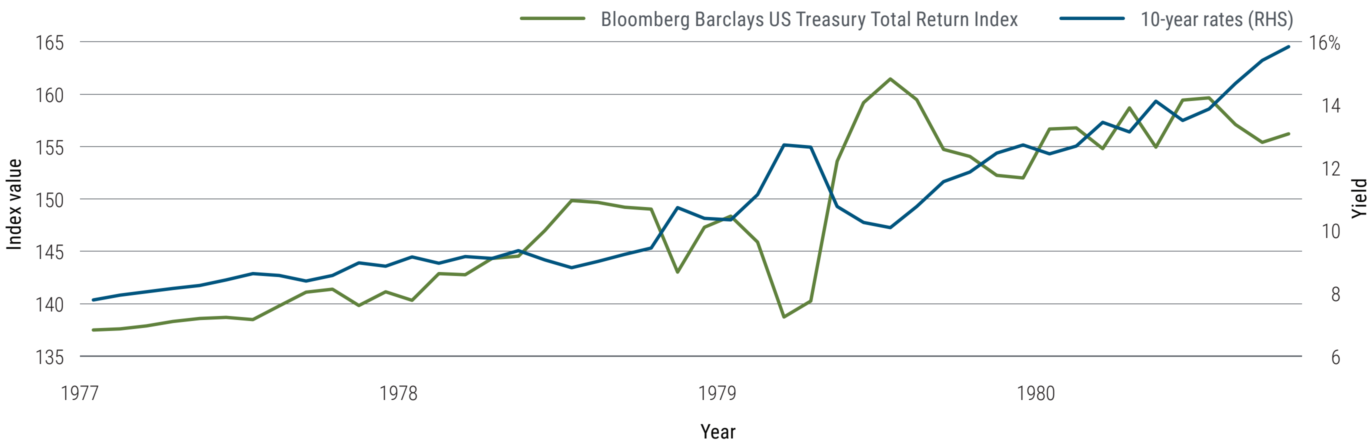
comparison, before 2020 the highest year-over-year M2 growth was 14% in 1976. Although this rapid growth in M2 may be due to corporations drawing on revolver loans, it is difficult to brush aside inflationary concerns when broad monetary aggregates signal a critical inflection point.

In addition, under the fractional reserve banking system, a dollar created by the central bank could lead to more than a dollar in the banking system over time, as it could be reloaned and redeposited over and over again – the so-called money multiplier effect. While banks might choose to hoard cash to build excess reserves and avoid bad loans as they did post-GFC, with the current reserve requirement at 0% and a relatively healthy banking sector, we could see the money multiplier affect broad money growth. Indeed, the jump in the M2 money supply may well be proof that the process has already started.

- **Excessive accommodation:** With inflation largely tame over the past 20 years, one could argue that the most likely inflationary scenario is one of continually excessive accommodation in the face of persistent economic weakness. Simply put, the underlying economy is not healthy enough for the U.S. Fed to raise rates. This "Fed behind the curve syndrome" could lead to either a brutal bear flattening of the yield curve or, worse, in the absence of a central bank reaction, a frenzy in price expectations, with a damaging impact on long bonds.

Rising inflation expectations usually lead to higher nominal rates and, naturally, fuel investor worries about negative returns. However, the initial negative return is not the full effect of rising rates, as gradually higher coupons can trump capital losses. Guo and Pedersen (2014) use an intuitive framework to show that the net impact of rising rates is positive over sufficiently long horizons. Furthermore, they show that unless the investor can foresee a sudden rate rise, attempts to time the market are likely to prove futile if the alternative investments have low returns. Indeed, historical rate hikes are not always associated with negative performance for fixed income. For example, Exhibit 26 shows that as the 10-year yield rose by 800 bps, from 7.8% at the beginning of 1978 to the height of 15.8% by September 1981, the Bloomberg Barclays US Treasury Total Return Index also increased by 13.6% (for an annualized return of 3.5%).

Exhibit 26: U.S. Treasury bond performance and 10-year rates



Source: PIMCO and Bloomberg as of 31 August 2020

With inflation a concern for many fixed income assets, inflation-linked bonds (ILBs) provide a straightforward hedge against rising inflation. The cost of hedging using inflation-linked securities is generally attractive at the time of this writing. For example, while 10-year U.S. breakeven inflation had rebounded from the low of 0.5% in March 2020 to 2.0% at the end of 2020, it is still below average realized inflation, which stands at around 2.6%.[9] Additionally, with higher inflation tail risk in the wake of aggressive monetary and fiscal policy, hedging demand could push real yields further down.

9. THE IRONY OF HEDGING

One of the top reasons investors allocate to bonds is to diversify equity risk in their portfolios. In this section, we show that a potentially higher (less negative) equity beta for bonds may, ironically, lead to higher bond allocations when investors are targeting given levels of equity beta for their portfolio, either unconditionally or conditional upon equity drawdowns.

Over the past few decades, bonds have had low correlation with stocks and, perhaps more importantly, typically delivered positive returns when equity sold off. Baz et al. (2019) show that, while the stock-bond correlation has changed over time, with an average close to zero, bond returns have been positive in nearly all recessions since 1952, even during periods when stock-bond correlations were positive. Furthermore, Baz et al. (2019) show that bonds also have a negative equity beta conditional on equity drawdown, suggesting that bond returns are expected to increase with the size of equity drawdowns.

While duration could still have a negative correlation with equity, its hedging efficacy could be reduced because of the lower yield level today. Though the zero lower bound may be breached and yield could become negative, it shouldn't be a surprise that, with the 10-year yield sitting at around 100 bps today, yield has less room to move and duration returns are less volatile. Duration's equity beta can be written as

$$\beta = \rho \frac{\sigma_{dur}}{\sigma_{eq}}, \tag{3}$$

where ρ is the correlation between duration and equity and σ_{dur} and σ_{eq} are the volatilities for duration and equity, respectively.

9 Average year-on-year seasonally adjusted CPI inflation rate is calculated using monthly data from January 1985 to November 2020.

Assuming correlation and equity volatility remain the same, less volatile duration returns thus imply less negative beta. How does this impact the asset allocation decision? Perhaps counterintuitively. If investors use bonds to achieve portfolio diversification, then it might be optimal for them to allocate more to bonds when their hedging efficacy declines.

Let's consider an example in which the investor allocates between stocks and bonds such that the portfolio has the highest return possible while its beta is below a certain threshold. Exhibit 27 presents two scenarios:

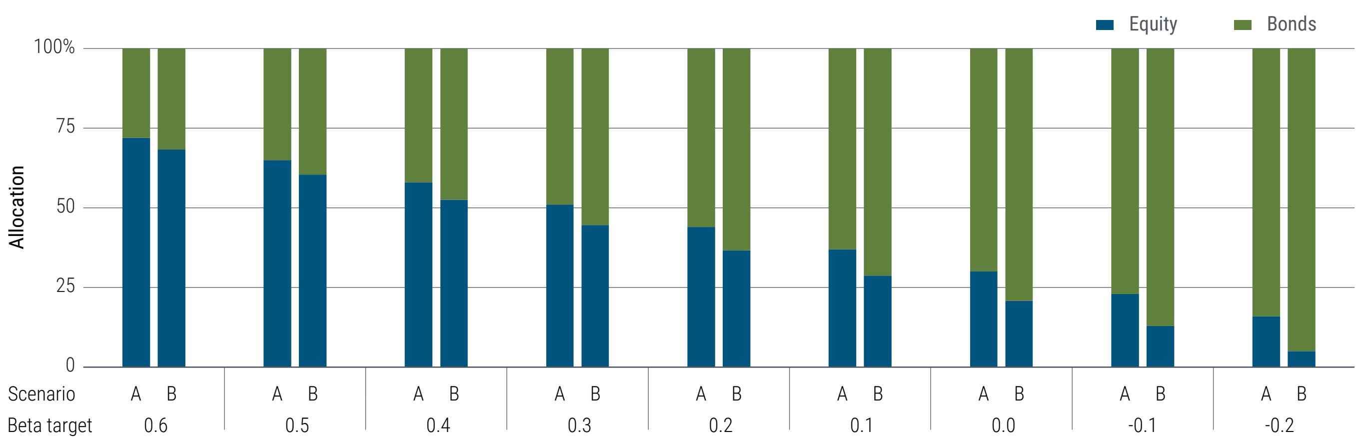
Exhibit 27: Assumptions on stock and bond return statistics

	Correlation	Duration vol	Equity vol	Beta
Scenario A	-0.25	0.82%	8.4%	-0.024
Scenario B	-0.25	0.49%	8.4%	-0.015

Source: PIMCO. **Hypothetical example for illustrative purposes only.**

Exhibit 28 shows the optimal allocations for equities and bonds for various beta targets.[10] In Scenario B, even though bonds are not as good a diversifier as in Scenario A, they still do a better job than the equity alternative, which has a beta of 1 by construction. Because of this, to achieve the same level of portfolio diversification one needs to allocate more, rather than less, to bonds.

Exhibit 28: Allocations to equity and bonds with various beta targets



Source: PIMCO. **Hypothetical example for illustrative purposes only.**

10 We use long Treasuries as a proxy for the bond portion of the portfolio. Specifically, we scale the duration returns by a factor of 18, which corresponds to the duration of the Bloomberg Barclays Long Treasury Index.

10. ASSET ALLOCATION AND MACRO SCENARIOS

Obviously, not all investors target given levels of equity beta for their portfolios. Even among those who do, there might be other, competing objectives and alternative equity risk diversifiers to consider. In this section, we look at the role of fixed income in asset allocation in a more heuristic way and show how an optimal portfolio may change for different macro scenarios.

The mean-variance-analysis framework of Markowitz (1952) is the foundation of modern portfolio theory and by far the most popular asset allocation model. The capital asset pricing model (CAPM) was derived from this framework with additional equilibrium assumptions. Despite mixed empirical evidence, CAPM equilibrium provides helpful neutral starting points for expected excess returns for assets globally (Black and Litterman (1992)).

We start by constructing a proxy for the global investable market portfolio, consisting of 11 broad asset classes for a U.S. investor (see Exhibit 29). We can derive the implied excess returns using a reverse optimization process:

$$\pi = \lambda \Sigma x_{\mathrm{mkt}} \tag{4}$$

where π is the implied excess return vector; Σ is the covariance matrix of asset returns; x_{mkt} is the vector of market capitalization weights; and λ is the market risk-aversion coefficient, which characterizes the risk/return trade-off at the market level. Note that the implied return vector is only unique up to a multiplier, the unknown λ, and therefore requires a normalization condition.

11 A more common alternative approach is to focus on the unconditional expected returns and covariance and perform one mean-variance optimization (Appendix 5 provides such an example). However, the heuristic approach tends to produce more diversified and stable portfolios, and allows investors to express their views by specifying probabilities on these scenarios.

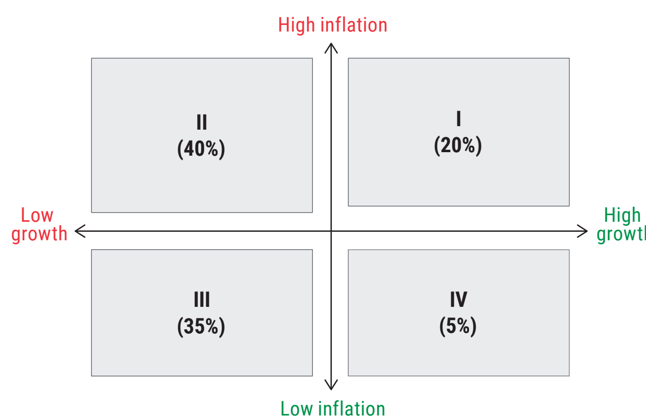
Exhibit 29: Asset classes and implied returns

Asset class	Weight	Implied return
U.S. equity	26%	5.8%
Non-U.S. DM equity	12%	6.3%
EM equity	11%	6.9%
US Agg	16%	0.5%
Global Agg ex-US	23%	1.5%
Global high yield	2%	3.4%
Global ILB	2%	1.8%
Commodity	2%	4.2%
Real estate	4%	5.2%
Private equity	3%	8.3%
Private debt	1%	3.2%

Source: Bloomberg, Preqin and PIMCO as of December 2020. **Hypothetical example for illustrative purposes only.** Implied returns are normalized such that the portfolio return is equal to that under PIMCO capital market assumptions (as of December 2020). Non-U.S. assets are unhedged. Appendix 4 provides a list of proxies for the assets. Figure is provided for illustrative purposes and is not indicative of the past or future performance of any PIMCO product.

Now posit there are four possible macroeconomic scenarios for the next five years (see Exhibit 30). The investor has subjective views on the probabilities of the scenarios. Because each scenario has its own return and risk implications, how can the investor express their views on the likelihood of each scenario? One heuristic approach is to find the optimal portfolio for each scenario, based on the conditional expected returns and covariance, and average the portfolios using the subjective probabilities as weights.[11]

Exhibit 30: Macroeconomic scenarios



Source: PIMCO. **Hypothetical example for illustrative purposes only.**

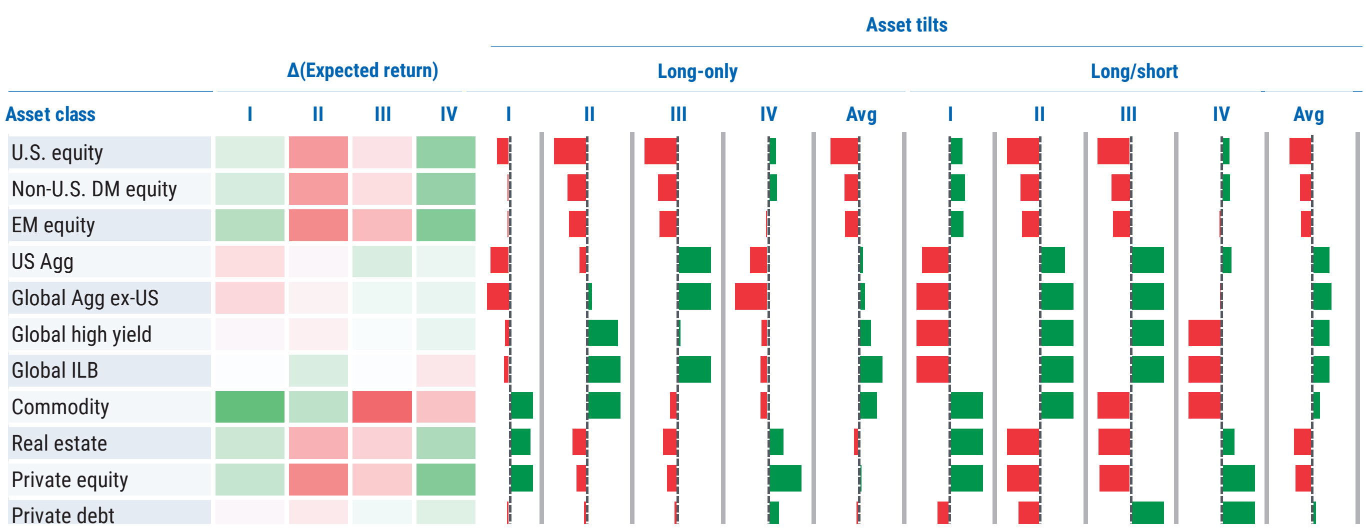
To do that, we first assume the CAPM-implied returns are consistent with the market expectations for future real GDP growth and inflation. Then we can estimate the conditional expected asset returns under each scenario, based on estimated sensitivities of risk factors to real GDP growth and inflation surprises versus market expectations. The heat map in Exhibit 31 shows the changes in expected returns relative to the implied returns by asset and scenario. Intuitively, global ILBs and commodities respond positively to inflationary scenarios, but nominal bonds respond negatively. Equities perform better in high growth and low inflation environments, and vice versa.

However, a higher return does not necessarily translate to a higher weight under that scenario. What matters most is relative returns across assets. With the estimated scenario-specific expected returns and covariance, we find the optimal portfolio with the maximum Sharpe ratio under two types of constraints: long-only and long/short. Exhibit 31 shows the asset tilts relative to the market portfolio under the two sets of constraints. The long-only constraints restrict the downward tilts for assets with small weights in the market portfolio, causing asymmetry in the ranges of potential tilts. The long/short version allows symmetric +/- 10% tilts for each asset, and the overweight/underweight is less likely to be truncated asymmetrically.

Finally, we estimate the weighted average of the scenario-specific asset tilts with the investor's subjective probabilities for the scenarios. There are differences between the long-only and long/short versions, but directionally they both tilt toward assets with inflation protection, such as global ILBs and commodities. This is not surprising, given the investor's subjective view on inflationary scenarios (60% total probability). Despite the high probability of inflation assumed, the average portfolio overweights nominal bonds against equities. This is due to the bearish view on GDP growth (75% probability of low growth), which favors bonds versus the procyclical assets.

One caveat is that the optimal portfolio weights can be sensitive to the model assumptions, which is well-known for mean-variance optimization. In addition, the constraints affect the optimal portfolios, in the magnitude and occasionally even the direction of the tilts. For example, in Scenario IV the optimizer may want to underweight global high yield, global ILBs and commodities as much as allowed. However, the long-only constraints mean there is very little room to do so and therefore force the optimizer to underweight core bonds in order to overweight some of the procyclical assets.

Exhibit 31: Expected returns and asset tilts under various scenarios



Bar lengths represent the amount we tilt the corresponding asset under different scenarios (green indicates an increased allocation, and red means a decreased allocation).

Source: PIMCO. **Hypothetical example for illustrative purposes only.** Figure is provided for illustrative purposes and is not indicative of the past or future performance of any PIMCO product.

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APPENDIX 1: MOSTLY SUPPORTIVE FUNDAMENTALS

A.1.1: Interest rates in the Solow–Swan model

Start with a profit-maximizing firm with standard production function $F(K, L) = K^{\alpha}(AL)^{1-\alpha}$.

In equilibrium, the return on capital equals the marginal productivity of capital, which is given by:

$$R = \frac{\partial F}{\partial K} = \alpha K^{\alpha-1}(AL)^{1-\alpha} = \alpha \frac{Y}{K}. \quad \text{(A.1)}$$

If the capital stock (K) depreciates at a constant rate δ and the households save a fixed fraction (s) of the total output, then the dynamic of capital stock follows: $\dot{K}=sY - \delta K$.

Also, suppose labor (L), or the number of workers, and technology grow at rates n and g – that is, $A_t = A_0 e^{gt}$ and $L_t = L_0 e^{nt}$.

Define $k = K/AL$ and $y = Y/AL$ as capital and output per effective worker. Then k will grow at

$$\dot{k} = \frac{\dot{K}}{AL} - k(n+g). \quad \text{(A.2)}$$

Plug in $\dot{K} = sY - \delta K$ and we obtain $\dot{k}= sy - (\delta + n + g)k$ where $y = Y/AL$ is output per effective worker. At the steady state, capital per unit of effective labor does not change – that is, $sy = (\delta + n + g)k$. Therefore, at the steady state:

$$\frac{K}{Y} = \frac{k}{y} = \frac{s}{\delta + n + g} \quad \text{(A.3)}$$

and the marginal productivity of capital, or return on capital, is:

$$R = \alpha \frac{\delta + n + g}{s}. \quad \text{(A.4)}$$

A.1.2 Ramsey–Cass–Koopmans model

The setup of this model is mostly similar to the Solow–Swan model, with one major difference: Instead of assuming a constant saving rate, consumption and saving are determined by the households.

Firm perspective

Assume a profit-maximizing firm with a constant return to scale production function $Y(t) = F(K(t), A(t)L(t))$. Each period, the firm pays wage $W(t)$ and rental rate $R(t)$ for each unit of labor and capital it uses. Define capital and output per unit of effective labor $k = K/AL$, $y = Y/AL$. From the firm’s perspective, we can derive the following two optimality conditions:

$$R(t) = F_K(K(t), A(t)L(t)) \quad \text{(A.5)}$$

$$W(t)=F_L(K(t), A(t)L(t)) \quad \text{(A.6)}$$

As in the Solow–Swan model, we assume labor (L) and technology (A) grow at rates n, g, and the capital stock (K) depreciates at a constant rate of δ.

Household perspective

Suppose $C(t)$ is the time t per capita consumption. The aggregate budget constraint for households is given by

$$\dot{K}(t) = W(t)L(t) + r(t)K(t) - C(t)L(t) \quad \text{(A.7)}$$

where $r(t) = R(t) - \delta$ is the return on capital for the households and $\dot{K}(t) = \frac{dK(t)}{dt}$. This equation tells us that the change in capital stock (additional saving) equals labor plus capital incomes less consumption.

By definition,

$$\dot{k}(t) = \frac{\dot{K}(t)}{A(t)L(t)} - \frac{K(t)}{A(t)L(t)}\left(\frac{\dot{L}(t)}{L(t)} + \frac{\dot{A}(t)}{A(t)}\right) \quad \text{(A.8)}$$

Plug Equation A.7 into Equation A.8 and we can rewrite the budget constraint as

$$\dot{k}(t) = (r(t) - n - g)k(t) + w(t) - c(t) \quad \text{(A.9)}$$

where $c(t) = \frac{C(t)}{A(t)}$ and $w(t) = \frac{W(t)}{A(t)}$. To impose the No-Ponzi condition, we also require $\lim_{t\to\infty} k(t)e^{-\int_0^t (r(s)-n-g)ds} \geq 0$.

Consider the following utility function as

$$U_{original} = \int_0^\infty e^{-\rho t} u(C(t))L(t)dt \quad \text{(A.10)}$$

where ρ is the subjective discount rate and $u(C)$ is the instantaneous utility function given by

$$u(C(t)) = \frac{C(t)^{1-\theta}}{1-\theta} \quad \theta > 0, \theta \neq 1. \quad \text{(A.11)}$$

$U_{original}$ can thus be written as

$$U_{original} = A_0^{1-\theta} L_0 \int_0^\infty e^{-(\rho-n-g(1-\theta))t} \frac{c(t)^{1-\theta}}{1-\theta} dt \quad \text{(A.12)}$$

Because $A_0^{1-\theta} L_0$ is just a constant, we consider the optimization instead:

$$\max_{\{c_t\}} U = \int_0^\infty e^{-\hat{\rho} t} u(c(t))dt \quad \text{(A.13)}$$

with $\hat{\rho} = \rho - n - g(1-\theta)$, and subject to budget constraint $\dot{k}(t) = (r(t) - n - g)k(t) + w(t) - c(t)$.

It can be shown that the optimality conditions for this problem are given by

$$u'(c(t)) - \mu(t) = 0 \quad \text{(A.14)}$$

$$\hat{\rho}\mu(t) - \mu(t)(r(t) - n - g) = \dot{\mu}(t) \quad \text{(A.15)}$$

with the transversality condition $\lim_{t\to\infty} k(t)\mu(t)e^{-(\rho-n-(1-\theta)g)t} = 0$.

Differentiating Equation A.14 with respect to t and divided by $\mu(t)$ on both sides:

$$\frac{u''(c(t))}{u'(c(t))} \times \dot{c}(t) = \frac{\dot{\mu}(t)}{\mu(t)}. \quad \text{(A.16)}$$

Plug in Equation A.15 and $\hat{\rho}$ and note that $\frac{u''(c(t))}{u'(c(t))} = -\theta c(t)^{-1}$ we get:

$$\frac{\dot{c}(t)}{c(t)} = \frac{r(t) - \rho - g\theta}{\theta}. \quad \text{(A.17)}$$

At the steady state, $\dot{c}(t) = 0$ which leads to

$$r^* = \rho + g\theta. \quad \text{(A.18)}$$

A.1.3: Interest rates in a basic consumption model

Consider an agent that maximizes lifetime consumption:

$$\max_{C_t, C_{t+1}} U(C_t) + e^{-\rho} E_t[U(C_{t+1})] \quad \text{(A.19)}$$

subject to $C_t + e^{-r} C_{t+1} = W$.

Standard Lagrangian optimization yields the following result:

$$e^r = \frac{1}{E_t\left[e^{-\rho}\frac{U'(C_{t+1})}{U'(C_t)}\right]}. \quad \text{(A.20)}$$

Hence, $r = -lnE_t(M_{t+1})$ with $M_{t+1} \equiv e^{-\rho}\frac{U'(C_{t+1})}{U'(C_t)}$.

Assuming a CRRA utility of consumption $U(C_t) = \frac{C_t^{1-\theta}}{1-\theta}$, we get

$$E_t\left[e^{-\rho}\frac{U'(C_{t+1})}{U'(C_t)}\right] = e^{-\rho}E\left[\left(\frac{C_{t+1}}{C_t}\right)^{-\theta}\right]. \quad \text{(A.21)}$$

Now assume that consumption follows a lognormal random walk: $C_{t+1} = C_t e^{g - \frac{\sigma^2}{2} + \sigma\epsilon}$.[12] Recalling that

12 The pricing equation A.21 still holds with aggregate stochastic consumption; see, for example, the representative agent framework in Lucas (1978).

$E_t\left(e^{-\theta\sigma\epsilon}\right) = e^{\frac{\theta^2\sigma^2}{2}}$, it follows immediately that

$$r = \rho + \theta g - \frac{\theta(\theta+1)\sigma^2}{2}. \qquad \text{(A.22)}$$

A.1.4: Long and Plosser simple RBC model

In this model, we assume there is a representative agent that maximizes the time 0 discounted utility of future consumptions:

$$\max E_0 \left[\sum_{t=0}^{\infty} \beta^t \pi^t u(c_t)\right] \qquad \text{(A.23)}$$

where $u()$ is a utility function, c_t is consumption at time t, β^t represents a time preference between utility consumed today versus time t, and π^t represents the probability the agent survives up until time t.

The agent can choose to either consume today or invest in order to consume in the future. The budget constraint facing the agent is as follows:

$$c_t + k_{t+1} \leq z_t k_t^{\alpha} \equiv y_t \qquad \text{(A.24)}$$

where k_{t+1} corresponds to the amount of consumption goods invested for use in production tomorrow and production occurs according to the technology $z_t k_t^{\alpha}$. Here z_t represents a "technology shock" that affects overall production and y_t corresponds to overall production obtained from investing k_t units of capital. As the agent will always consume and invest all production, the budget constraint is binding. The agent must choose the optimal level of capital (which also determines consumption) in order to maximize the discounted value of utility. Substituting $c_t = z_t k_t^{\alpha} - k_{t+1}$ and differentiating with respect to k_{t+1} gives the optimal decision for investing at time t

$$u'(c_t) = E\left[\beta\pi u'(c_{t+1})\left[\alpha\frac{y_{t+1}}{k_{t+1}}\right]\right]. \qquad \text{(A.25)}$$

Under log utility, rearranging terms we get

$$\frac{k_{t+1}}{c_t} = \alpha\beta\pi E\left[\frac{y_{t+1}}{c_{t+1}}\right] \qquad \text{(A.26)}$$

so that the ratio of investment to consumption today is a constant fraction of the expected ratio of output to consumption tomorrow. This is one of the rare cases where the economy has a closed-form solution. Letting w represent the fraction of output allocated toward consumption today (and $1 - w$ correspond to the fraction of output allocated toward investment), we can solve this problem for w

$$\frac{1-w}{w} = \alpha\beta\pi\frac{1}{w}, \qquad \text{(A.27)}$$

which implies that $w = 1 - \alpha\beta\pi$ and therefore $c_t = (1-\alpha\beta\pi)y_t$ and $k_{t+1} = (\alpha\beta\pi)y_t$. The equilibrium real interest rate is one whereby one unit of investment today pays off $1 + r_t^*$ units of consumption in every state of the world tomorrow:

$$1 = \beta\pi E\left[\frac{c_t}{c_{t+1}}(1 + r_t^*)\right]. \qquad \text{(A.28)}$$

From this relationship, we can see that:

- An increase in longevity/survival π results in a lower r^*.
- An increase in the value of utility tomorrow versus today, β, results in a lower r^*.
- A technology shock that makes the economy more productive (increasing consumption growth) increases r^*.

A.1.5: Interest rate relationship with different factors in different models

		Solow–Swan	Ramsey–Cass–Koopmans	Basic consumption model	Long and Plosser simple RBC model
α	Elasticity of output with respect to capital	$+(\delta+n+g>0)$ $-(\delta+n+g<0)$			
δ	Capital depreciation rate	+			
n	Labor growth rate	+			
g	Technology growth rate/ consumption growth rate	+	+	+	
s	Saving rate	–			
ρ	Time preference discount rate		+	+	$+(\beta=e^{-\rho})$
θ	Degree of relative risk aversion		$+(g>0)$ $-(g<0)$	$+(\theta\leq\frac{g}{\sigma^2}-\frac{1}{2})$ $-(\theta>\frac{g}{\sigma^2}-\frac{1}{2})$	

APPENDIX 2: PROXIES FOR THE EQUITY RISK PREMIUM

First, we show why the real equity yield is equal to the earnings yield under certain conditions, using a framework of the Gordon growth model.

A stock index price P is the present value of its dividends, with the initial dividend D growing at a real rate g and discounted at a real equity yield r:

$$P=\int_0^\infty De^{gt}e^{-rt}dt=\frac{D}{r-g}. \qquad (A.29)$$

Hence,

$$r=\frac{D}{P}+g. \qquad (A.30)$$

With R designating the real bond yield, the equity risk premium is

$$ERP=r-R=\frac{D}{P}+g-R. \qquad (A.31)$$

With i the real internal rate of return and b the earnings retention rate, ($b=\frac{E_R}{E}$ where E_R is the retained earnings and E is the earnings), g can be written as

$$g=bi. \qquad (A.32)$$

This is true, as dividend growth is equal to earnings growth, $g=\frac{dE}{E}$ and earnings grow at the real internal rate of return achieved on retained earnings, so $i=\frac{dE}{E_R}$.

Firms will keep investing until the real internal rate of return matches the real equity yield; hence, $i=r$. We thus have

$$P=\frac{D}{r-br}=\frac{D}{r(1-b)}=\frac{E}{r}. \qquad (A.33)$$

Therefore,

$$\frac{E}{P}=r. \qquad (A.34)$$

To the extent that real dividend growth, the real bond yield and real GDP growth are equal, the equity risk premium can be approximated by the dividend yield as well.

APPENDIX 3: PROBABILITY OF EQUITY OUTPERFORMING TREASURIES

Assume the value of the stock (including any continuously paid and reinvested dividend) S_t follows a geometric Brownian motion:

$$dS_t=\mu S_t dt+\sigma S_t dW_t \qquad (A.35)$$

where W_t follows a standard Brownian motion. Then we have

$$S_T = S_0 e^{\left(\mu-\frac{1}{2}\sigma^2\right)T+\sigma\sqrt{T}Z} \tag{A.36}$$

where Z follows a standard normal distribution.

Assume the value of the zero-coupon Treasury bond with maturity T follows:

$$B_T = B_0 e^{rT}. \tag{A.37}$$

The probability for the stock to outperform the T-bond at the end of the horizon T is

$$\begin{aligned} & P\left(\frac{S_T}{S_0} > \frac{B_T}{B_0}\right) \\ & = P\left(e^{\left(\mu-\frac{1}{2}\sigma^2\right)T+\sigma\sqrt{T}Z} > e^{rT}\right) \\ & = P\left(\left(\mu-\frac{1}{2}\sigma^2\right)T+\sigma\sqrt{T}Z > rT\right) \\ & = P\left(Z > -\left(\frac{\mu-\frac{1}{2}\sigma^2-r}{\sigma}\right)\sqrt{T}\right) \\ & = \Phi\left(\left(\frac{\mu-\frac{1}{2}\sigma^2-r}{\sigma}\right)\sqrt{T}\right) \end{aligned} \tag{A.38}$$

where Φ is the cumulative distribution function for the standard normal distribution.

APPENDIX 4: PROXIES FOR RISK MODELING

Asset class	Proxy
U.S. equity	Russell 3000 Index
Non-U.S. DM equity	MSCI World ex USA Index
EM equity	MSCI Emerging Markets Index
US Agg	Bloomberg Barclays US Aggregate Bond Index
Global Agg ex-US	Bloomberg Barclays Global Aggregate ex-USD Index
Global high yield	Bloomberg Barclays Global High Yield Index
Global ILB	Bloomberg Barclays World Government Inflation-Linked Bond Index
Commodity	Bloomberg Commodity Total Return Index
Real estate	PIMCO private real estate model
Private equity	PIMCO private equity model
Private debt	PIMCO broad private credit model

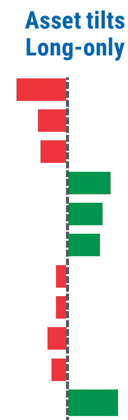
PIMCO models are not investable and are provided as a proxy for the asset class.

APPENDIX 5: PORTFOLIO OPTIMIZATION BASED ON UNCONDITIONAL INPUTS – AN EXAMPLE

Suppose an investor has views on the expected returns of assets that are unconditional on scenarios. Depending on their confidence in the views relative to the CAPM-implied returns, the investor can blend the information from the market portfolio and their views to come up with a set of blended expected returns (Black and Litterman 1992). Exhibit A5.1 shows an example of when the investor has the same confidence (or uncertainty) in CAPM-implied returns and the views.

Exhibit A5.1: The Black–Litterman model

Asset class	Market portfolio	Implied returns	Sample CMAs	Blended returns
U.S. equity	26%	5.8%	5.3%	5.5%
Non-U.S. DM equity	12%	6.3%	5.9%	6.1%
EM equity	11%	6.9%	6.2%	6.6%
US Agg	16%	0.5%	1.0%	0.8%
Global Agg ex-US	23%	1.5%	2.1%	1.8%
Global high yield	2%	3.4%	2.8%	3.1%
Global ILB	2%	1.8%	1.2%	1.5%
Commodity	2%	4.2%	3.0%	3.6%
Real estate	4%	5.2%	6.6%	5.9%
Private equity	3%	8.3%	8.8%	8.6%
Private debt	1%	3.2%	5.9%	4.6%



Source: PIMCO. **Hypothetical example for illustrative purposes only.**

Asset tilts are relative to the market portfolio. PIMCO capital market assumptions are based on the product of risk factor exposures and projected risk factor premia which rely on historical data, valuation metrics and qualitative inputs from senior PIMCO investment professionals. Figure is provided for illustrative purposes and is not indicative of the past or future performance of any PIMCO product.

A “safe haven” asset is an investment that is perceived to be able to retain or increase in value during times of market volatility. Investors seek safe havens to limit their exposure to losses in the event of market turbulence.

The terms “cheap” and “rich” as used herein generally refer to a security or asset class that is deemed to be substantially under- or overpriced compared to both its historical average as well as to the investment manager’s future expectations. There is no guarantee of future results or that a security’s valuation will ensure a profit or protect against a loss.

A "risk-free" asset refers to an asset which in theory has a certain future return. U.S. Treasuries are typically perceived to be the "risk-free" asset because they are backed by the U.S. government.

This paper includes hypothetical assumptions and scenarios. HYPOTHETICAL PERFORMANCE RESULTS HAVE MANY INHERENT LIMITATIONS, SOME OF WHICH ARE DESCRIBED BELOW. NO REPRESENTATION IS BEING MADE THAT ANY ACCOUNT WILL OR IS LIKELY TO ACHIEVE PROFITS OR LOSSES SIMILAR TO THOSE SHOWN. IN FACT, THERE ARE FREQUENTLY SHARP DIFFERENCES BETWEEN HYPOTHETICAL PERFORMANCE RESULTS AND THE ACTUAL RESULTS SUBSEQUENTLY ACHIEVED BY ANY PARTICULAR TRADING PROGRAM.

ONE OF THE LIMITATIONS OF HYPOTHETICAL PERFORMANCE RESULTS IS THAT THEY ARE GENERALLY PREPARED WITH THE BENEFIT OF HINDSIGHT. IN ADDITION, HYPOTHETICAL TRADING DOES NOT INVOLVE FINANCIAL RISK, AND NO HYPOTHETICAL TRADING RECORD CAN COMPLETELY ACCOUNT FOR THE IMPACT OF FINANCIAL RISK IN ACTUAL TRADING. FOR EXAMPLE, THE ABILITY TO WITHSTAND LOSSES OR TO ADHERE TO A PARTICULAR TRADING PROGRAM IN SPITE OF TRADING LOSSES ARE MATERIAL POINTS WHICH CAN ALSO ADVERSELY AFFECT ACTUAL TRADING RESULTS. THERE ARE NUMEROUS OTHER FACTORS RELATED TO THE MARKETS IN GENERAL OR TO THE IMPLEMENTATION OF ANY SPECIFIC TRADING PROGRAM WHICH CANNOT BE FULLY ACCOUNTED FOR IN THE PREPARATION OF HYPOTHETICAL PERFORMANCE RESULTS AND ALL OF WHICH CAN ADVERSELY AFFECT ACTUAL TRADING RESULTS.

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Return assumptions are for illustrative purposes only and are not a prediction or a projection of return. Return assumption is an estimate of what investments may earn on average over the long term. Actual returns may be higher or lower than those shown and may vary substantially over shorter time periods.

Past performance is not a guarantee or a reliable indicator of future results.

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All investments contain risk and may lose value. Investing in the **bond market** is subject to risks, including market, interest rate, issuer, credit, inflation risk, and liquidity risk. The value of most bonds and bond strategies are impacted by changes in interest rates. Bonds and bond strategies with longer durations tend to be more sensitive and volatile than those with shorter durations; bond prices generally fall as interest rates rise, and low interest rate environments increase this risk. Reductions in bond counterparty capacity may contribute to decreased market liquidity and increased price volatility. Bond investments may be worth more or less than the original cost when redeemed. **Equities** may decline in value due to both real and perceived general market, economic and industry conditions. **Private debt** involves an investment in non-publically traded securities which may be subject to illiquidity risk. Portfolios that invest in private credit may be leveraged and may engage in speculative investment practices that increase the risk of investment loss. **Swaps** are a type of derivative; swaps are increasingly subject to central clearing and exchange-trading. Swaps that are not centrally cleared and exchange-traded may be less liquid than exchange-traded instruments. **Derivatives** may involve certain costs and risks, such as liquidity, interest rate, market, credit, management and the risk that a position could not be closed when most advantageous. Investing in derivatives could lose more than the amount invested. **Diversification** does not ensure against loss. **Management risk** is the risk that the investment techniques and risk analyses applied by an investment manager will not produce the desired results, and that certain policies or developments may affect the investment techniques available to the manager in connection with managing the strategy.

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Alpha is a measure of performance on a risk-adjusted basis calculated by comparing the volatility (price risk) of a portfolio vs. its risk-adjusted performance to a benchmark index; the excess return relative to the benchmark is alpha. **Beta** is a measure of price sensitivity to market movements. Market beta is 1. The **correlation** of various indexes or securities against one another or against inflation is based upon data over a certain time period. These correlations may vary substantially in the future or over different time periods that can result in greater volatility. The **credit quality** of a particular security or group of securities does not ensure the stability or safety of an overall portfolio. The quality ratings of individual issues/issuers are provided to indicate the credit-worthiness of such issues/issuer and generally range from AAA, Aaa, or AAA (highest) to D, C, or D (lowest) for S&P, Moody's, and Fitch respectively.

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