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Assessing Inflation: Theories, Policies and Portfolios

Executive Summary

- As inflation spiked in the second quarter of 2021, debate about its transitory or permanent nature became more heated. Yet, as is sometimes the case with broad controversies, a lack of definition goes with a lack of comprehension.
- Measured inflation can vary widely, depending on factors as diverse as the choice of a price index, hedonic price adjustments, and shelter and rent accounting. For example, the consumer price index tends to overstate inflation.
- Theories of inflation have undergone two major inflection points. The 1970s oil supply shock challenged the Phillips curve, and the collapse of money velocity after the 2008 financial crisis cast doubt on the quantity theory of money.
- Rounds of quantitative easing (QE) since 2008 have propped up asset prices but have not produced notable inflation. This raises a related misconception about QE: Money does not create credit; credit creates money. In addition, so long as policymakers are committed to balancing their budgets in the long run, helicopter money and modern monetary theory (MMT) are not inflationary per se.
- Currently, we believe there are fatter inflation tails than the market has expected. Longer term, there is a high probability that inflation will be contained. For investors who wish to hedge against inflation risk, we demonstrate the benefit of a portfolio approach.
- We conclude by proposing an asset allocation framework that accounts for a variety of macro scenarios over a five- to 10-year horizon. Salient positions are a private debt overweight and a public equity underweight.

1. INTRODUCTION

> *When you cannot measure it, when you cannot express it in numbers, your knowledge is of a meagre and unsatisfactory kind.* (Lord Kelvin, 1883)

Lord Kelvin may have been discussing electrical units, but it's difficult not to think of inflation, where a lack of definition goes with a lack of comprehension.

Analyses in this paper relate to the U.S. unless otherwise stated.

Inflation is defined as a general increase in the price index, itself a weighted average. To see why we are on slippery ground, consider a hypothetical small economy that trades apples and oranges (Exhibit 1).

Exhibit 1: Apples, oranges and inflation

	In year zero	
Item	Price (per pound)	Quantity (pounds)
Apples	3	100
Oranges	4	120
	In year one	
Item	Price (per pound)	Quantity (pounds)
Apples	2.6	120
Oranges	4.5	112

Source: PIMCO. **For illustrative purposes only.**

The price index can be calculated in a number of ways. For example, the Laspeyres Price Index uses base-year quantities, the Paasche Price Index uses final quantities, and the Fisher Price Index is a geometric mean of the Laspeyres and Paasche indices. Exhibit 2 shows the results using these three methods.

Exhibit 2: How Laspeyres, Paasche and Fisher indices measure inflation

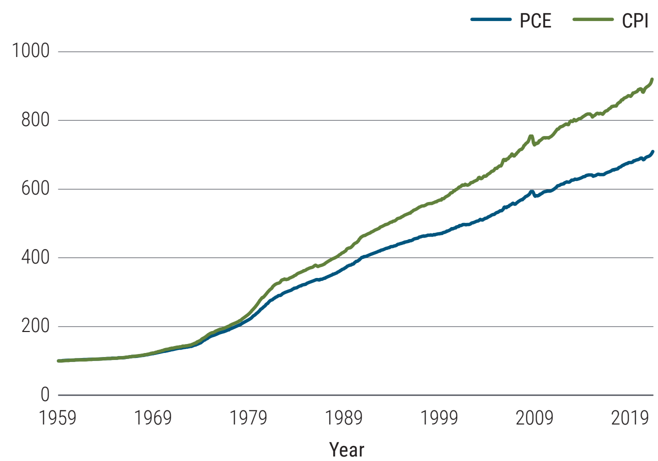
Index	Formula	Result
Laspeyres	$\frac{(2.6 * 100) + (4.5 * 120)}{(3 * 100) + (4 * 120)}$	1.026
Paasche	$\frac{(2.6 * 120) + (4.5 * 112)}{(3 * 120) + (4 * 112)}$	1.01
Fisher	$\sqrt{L * P}$	1.0177

Source: PIMCO

Depending on the index, inflation is 2.6%, 1.0% or 1.77%. This example illustrates (not unrealistically) the differences among indices. For instance, the Laspeyres index, typically used to calculate the consumer price index (CPI), overstates inflation; by the same token, inflation-linked bonds that are linked to CPI will earn a higher real yield once the Laspeyres index bias is taken into account, and CPI-linked contractual payments, such as Social Security benefits or indexed rents, end up being overstated.[1] The personal consumption expenditures index (PCE), by contrast, uses the Fisher index, which is also called the Fisher Ideal Index because it is a happy medium between the Laspeyres overestimate and the Paasche underestimate of inflation.[2] Exhibit 3 shows the difference between the CPI and PCE indices; the average annualized inflation from January 1959 to April 2021 is 3.6% using CPI and 3.2% using PCE.

Where does the Laspeyres index bias come from? As the price of a good increases, consumers tend to instead buy other goods with lower price increases. This so-called substitution effect is not accounted for in the Laspeyres index, which uses fixed base-year quantities.

Exhibit 3: CPI versus PCE index



Source: PIMCO and Haver Analytics as of 30 April 2021. PCE chain price index, seasonally adjusted. Consumer price index for all urban consumers: All items in U.S. city average, seasonally adjusted. Both series are normalized to have a value of 100 in January 1959.

Of course, there is much more to the difference between CPI and PCE inflation than base quantities and substitution effects. CPI tracks price data from household surveys, while PCE uses business surveys; CPI surveys out-of-pocket urban household expenditures, while PCE also measures expenditures by nonprofit institutions on behalf of households. These are only a few among many differences between the two most popular U.S. inflation measures.

Another major question: How does one adjust for quality? And assuming the so-called hedonic adjustments make sense, to what extent are quality adjustments really valued or needed by consumers? (Does your iPhone make you richer, and does your Facebook account make you happier?) To what extent are these enhancements part of planned obsolescence strategies by firms with market power?

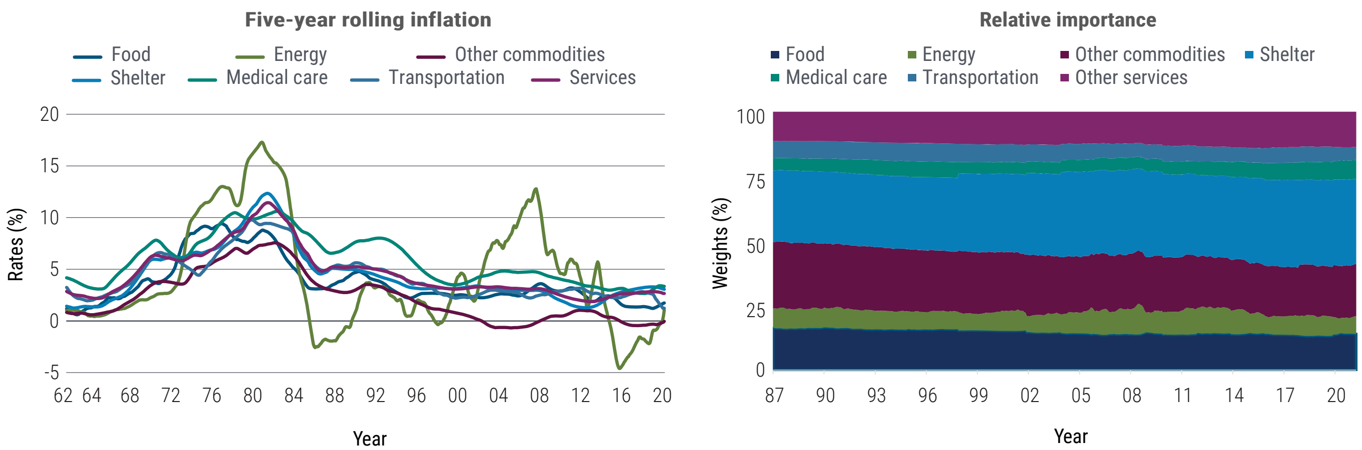
1 On a related note, in 1995 the U.S. Senate appointed the Boskin Commission to look into the potential bias embedded within CPI calculations. It was determined that the index overstated inflation by 1.3 percentage points per year before 1996; this implied that the federal budget had increased more than necessary to meet its CPI-linked contractual obligations.

2 For the reader's reference, the Fisher index is sometimes viewed as close to the (theoretical but unobservable) true cost of living, also called the Pollak–Konüs index (Pollak 1989, Diewert 1998).

Perhaps more important, what about accounting for free access – free news, quasi-free streaming of music and movies, free cultural goods? For inflation accounting purposes, this is a rather big fly in the ointment and an existential challenge for national statisticians. How do we factor in the near-zero marginal cost of information goods in a national accounting framework designed for a merchant economy? A related and not unimportant issue is how these questions affect the calculation of a "true" GDP. But that is beyond the scope of this paper.

In the U.S., CPI is frequently boiled down to a few broad sectors. Food (14%) and energy (7%), though small components of the index, contribute the most to the volatility of prices. For this reason, many policymakers focus on "core" CPI, which excludes food and energy, in order to establish a more stable and persistent baseline understanding of inflationary trends. Shelter (33%) is the largest and most controversially measured component of CPI, in part because it relies on imputing owners' equivalent rent, which is subjectively defined as the price at which a homeowner would rent out their home unfurnished without utilities.[3] Other commodities (20%), including household goods like autos and clothing, are the second-largest sector; the remaining sectors are healthcare (7%), transportation (5%) and other services (14%) (Exhibit 4).

Exhibit 4: Five-year rolling inflation and relative importance of different sectors



Source: PIMCO and Haver Analytics as of 30 April 2021. Inflation reflects CPI. Services includes shelter, medical care, transportation and other services.

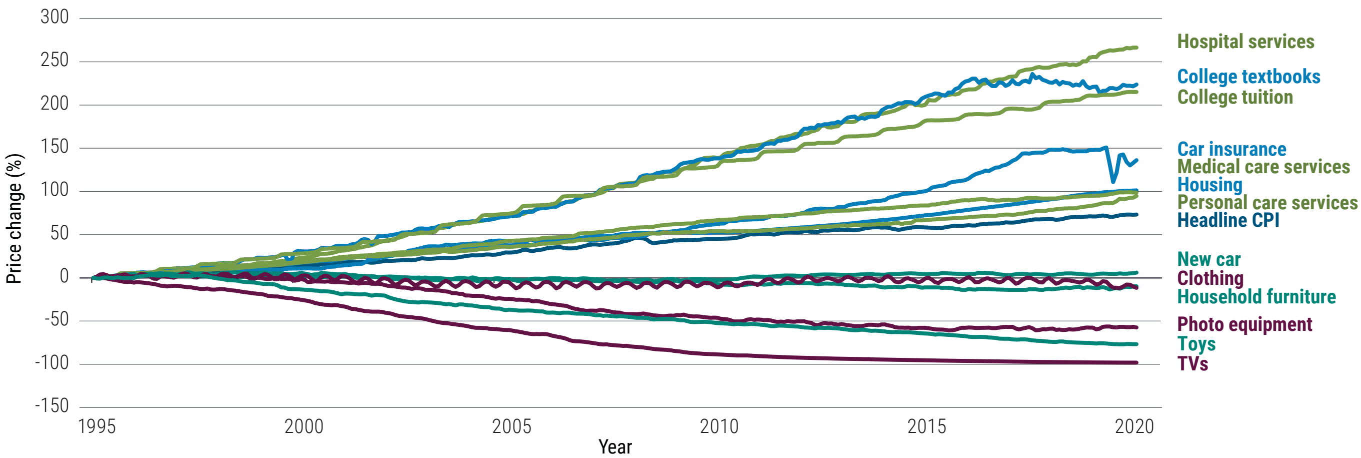
Viewing inflation through the lens of the underlying components provides insight into the myriad of economic factors involved. As noted, food and energy prices are unpredictable and volatile, determined not only by domestic conditions but also by global demand and noneconomic factors like weather. Rents depend on home prices, the supply of shelter and vacancies, as well as expenses related to mortgage rates and property taxes. Clearly, forecasting inflation is not a simple endeavor.

Let us stress an important point: Inflation is an increase in aggregate prices and a loss in purchasing power of one unit of currency, but it is not an increase in relative prices. Prices of individual goods and services frequently change without affecting inflation. Take productivity growth as an example. In recent decades, technological advancements have lowered goods prices (e.g., TVs, photo equipment, cars). But they have also increased wages and likely the prices of services (e.g., education, health services, housing) for which productivity growth has been more muted.[4] Exhibit 5 shows how price changes have differed across various goods and services over the past 26 years. Many structural changes (productivity growth, technology, demographics) have no doubt shifted relative prices over time, but their effect on inflation is far less clear.

3 The International Labour Office's (ILO's) Consumer Price Index Manual states that "the treatment of owner-occupied housing in consumer price indices (CPIs) is arguably the most difficult issue faced by CPI compilers." It acknowledges that "depending on the proportion of the reference population that are owner-occupiers, the alternative conceptual treatments can have a significant impact on the CPI, affecting both weights and, at least, short-term measures of price change."

4 Also known as "Baumol's cost disease."

Exhibit 5: Price change of selected U.S. consumer goods and services from January 1995 to December 2020



Sources: PIMCO and U.S. Bureau of Labor Statistics as of 31 December 2020

Shocks to inflation are typically characterized in one of two ways: cost-push or demand-pull. Cost-push inflation is easier to identify and corresponds to an increase in the cost of inputs in the manufacturing of products. Examples include an increase in energy prices, commodities prices or related costs of doing business, such as taxes and rent. Many attribute the onset of the Great Inflation in the 1970s to the spike in oil prices, which forced many manufacturers to pass on, or "push," these costs to the end buyer in the form of higher consumer prices.

Demand-pull inflation, on the other hand, is less understood and results from a general increase in demand for goods and services, which firms do not offset by increasing supply. These shocks are difficult to measure, as they often suffer from an endogeneity problem: feedback loops that make it difficult to separate cause and effect. In particular, demand may rise due to changes in consumer preferences – for example, animal spirits driven by increasing consumer confidence or other factors that induce greater spending behavior, such as monetary and fiscal policies. Disentangling a true demand-pull inflation shock from other macroeconomic impulses requires a general equilibrium model that in itself relies on many questionable assumptions.

While cost-push and demand-pull shocks are the spark that lights the inflation fire, macro imbalances and monetary and fiscal policies are the components that determine the magnitude and persistence of the resulting inferno. History offers many lessons in this regard.

2. HISTORY

Although inflation has been low and stable in most of the developed world over the past three decades, history is not short of examples of periods when inflation was high and volatile.

Germany in the 1920s is perhaps the best-known case. To fund the cost of World War I, Germany suspended the gold standard, increased its deficits and printed fresh money. After the war, the Treaty of Versailles and the subsequent London Schedule of Payments required Germany to pay significant reparations to the Allied Powers to cover war damages. Burdened with budget deficits, the German government resorted to even more money printing, which accelerated the depreciation of the country's paper currency and exacerbated inflation. In 1923, France and Belgium occupied the Ruhr region following missed reparation payments. The loss of production in the region and the strike that followed sent the paper mark into hyperinflation. Even though Germany's experience tends to receive the most attention, Austria, Hungary, Poland and Russia also suffered severe hyperinflation after World War I.

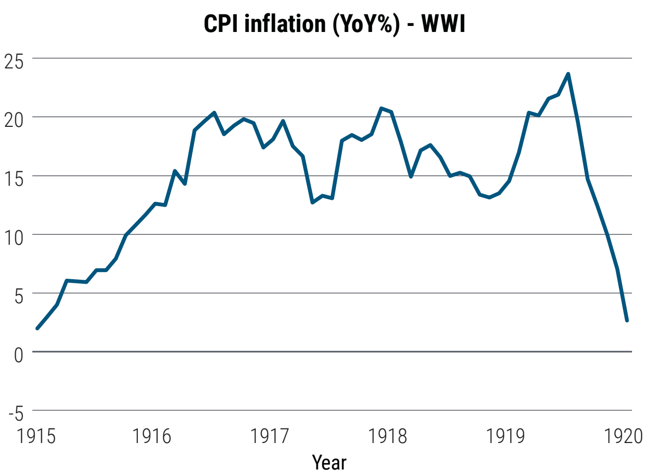
In the aftermath of World War II, countries such as China, Greece and Hungary suffered a similar fate. In fact, Hungary experienced the worst inflation in recorded history. To revive an economy that had lost most of its production capacity during the war, the government flooded Hungary with money. Between July 1945 and July 1946, the amount of currency in circulation rose by a factor of almost 2 quadrillion. At inflation's peak, prices doubled every 15 hours, at a monthly rate of 4.19×10^{16}%.

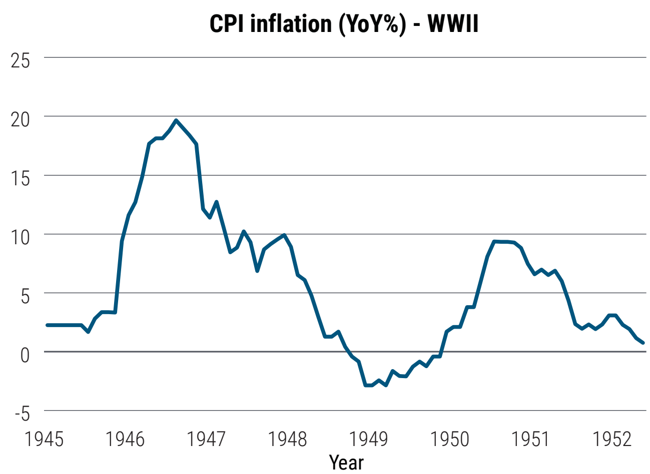
Many South American countries experienced long periods of high inflation and currency devaluation between the 1970s and the early 1990s. In Zimbabwe, failed land reform in the '90s led to a sharp drop in food production. Facing sanctions from the U.S. and the European Union, as well as expenses stemming from the country's involvement in the Second Congo War, the government printed money. Prices soon spiraled out of control, doubling every day for a period in 2008. This eventually led Zimbabwe to abandon its currency, and foreign currencies became legal tender.

Clearly, each of these hyperinflation episodes was unique. But some common themes emerge (often linked to wars and episodes of capital destruction): high fiscal deficits, loose monetary policy, plenty of money printing and a loss in the credibility of the monetary and fiscal policy institutions. Another lesson is that high inflation tends to feed on itself. If you expect prices to double tomorrow, you will likely run to the shop today, increasing demand and pushing prices even higher. Inflation becomes highly nonlinear. It's like shaking a ketchup bottle: Nothing initially comes out, but when it does, it's difficult to stop.

The United States has not experienced hyperinflation.[5] However, it did go through a few periods of high inflation, including the two world wars.[6] Monetary and fiscal policies played key roles in contributing to the price increases. Exhibit 6 shows rolling 12-month CPI inflation around World War I and World War II.

Exhibit 6: Rolling 12-month CPI inflation during WWI and WWII





Source: PIMCO and Global Financial Data as of 30 April 2021

During World War I, the U.S. Treasury issued Liberty bonds to finance war spending. The Federal Reserve (Fed) supported the effort by lending to member banks at low rates, provided that the loans were used to purchase government bonds. These policies eased credit conditions and promoted growth but at the same time put pressure on inflation. During the war, the money supply doubled while the gross national product increased by only about a quarter. Annual inflation reached its highest value of 24% in June 1920; overall, prices increased by more than 80% between December 1916 and June 1920, before the economy entered the postwar recession.

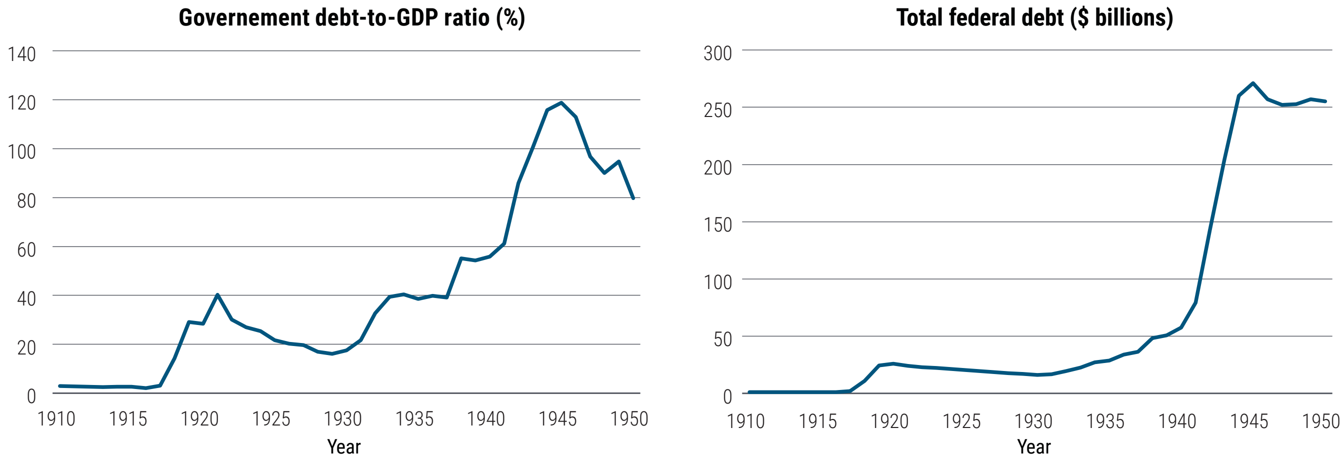
Fiscal and monetary policies again joined forces to finance World War II. The Fed pegged interest rates at low levels and created a preferential rate for loans secured by short-term government obligations. Exhibit 7 shows that government debt increased drastically during the war. Even though these policies were generally inflationary, the government managed to keep inflation in check during the war through price controls and rationing. However, the end of the war (and price controls)

5 There are different definitions for what is considered hyperinflation. For example, Cagan (1956) defines a hyperinflationary episode as starting in the month that the monthly inflation rate exceeds 50% and ending when the monthly inflation rate stays below 50% for more than a year.

6 Other examples include the aftermath of the Civil War and the Great Inflation of the 1970s, which we discuss in detail in the next section.

unleashed the previously suppressed inflation. But even with heightened inflation risk, the interest rate peg remained in place for over five years after the war ended. In early 1951, the Fed and the Treasury reached an agreement (the Treasury–Federal Reserve Accord) and the Fed regained its independence from fiscal concerns. This set the stage for the evolution of modern monetary policy.

Exhibit 7: Government debt-to-GDP ratio and total federal debt



Source: PIMCO and Global Financial Data as of 30 April 2021

3. A REVIEW OF INFLATION THEORIES

Monetary economics has a long history, and our aim is ambitious: to give a short overview of the modern theories of inflation and related policies from the 1970s onward, from Phillips curves to Taylor rules, from quantitative easing (QE) to helicopter money, from fiscal to monetary dominance and from Neo-Fisherian theory to modern monetary theory (MMT).

To understand the history, we start with the most fundamental constraint on monetary policy: the “impossible trinity,” or “trilemma,” in international economics. Developed by Mundell and Fleming in the early 1960s, the theory states that an economy can choose only two of the following three conditions: 1) a fixed exchange rate, 2) free movement of capital and 3) an independent monetary policy. If you pick an independent monetary policy and open borders for capital (e.g., the U.S. today), then you must float your exchange rate. Pick a fixed exchange rate and open borders for capital (e.g., within the euro area today), and you lose an independent monetary policy. Or pick an independent central bank and a fixed exchange rate (resembling China today), and you need to enforce capital controls.

The Bretton Woods system, established in 1944, constrained postwar monetary policy to focus on one dimension: exchange rates. Countries pegged their currencies (around a tight band) to the U.S. dollar, which the Federal Reserve in turn pegged to the price of gold. By anchoring currencies to gold, the system forced countries to maintain an equitable rate of exchange, preventing participants from competitively devaluing their currencies. With fixed exchange rates and restricted monetary policy, capital could not flow freely between countries. Nor did central banks have the flexibility to tighten or expand monetary policy, print money or freely set interest rates.

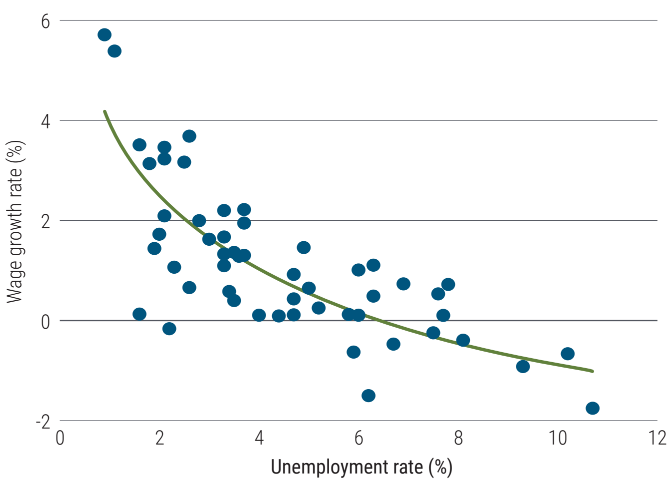
Bretton Woods collapsed in 1973, shortly after the Fed terminated the convertibility of the U.S. dollar to gold. The system had been fraught with problems. Imbalances grew on the back of the Vietnam War, and the U.S. eventually did not want to trade its domestic monetary policies for a fixed exchange rate system. Subsequently, many countries floated their currencies, marking the start of the journey ultimately leading to modern central banking.

3.1 Phillips curve

Under Bretton Woods, inflation was primarily determined by the business cycle and cost-push factors. Fiscal policy was important, but monetary policy largely took a back-seat role.

By the late 1960s, economists had come to accept an inflation paradigm documented by William Phillips, coined "the Phillips curve." Phillips (1958) observed a tight, inverse relationship between wage inflation and unemployment in the U.K. (Exhibit 8). The intuition was simple. If unemployment is low and the economy is operating near full production capacity, an increase in demand for goods and services cannot be met with an increase in output. Instead, prices have to adjust – consumer prices from higher demand for goods and services, and wages from higher demand for labor. Put differently, inflation was pro-cyclical.

Exhibit 8: The Phillips curve – rates of unemployment and wage growth in the U.K. from 1861 to 1913



Source: PIMCO and Global Financial Data as of 30 April 2021

The Phillips curve was soon put to the test. Oil prices spiked in 1973 following the Arab oil embargo, which raised inflation and lowered activity through higher production costs. Policymakers, released from the postwar Bretton Woods arrangement and informed by ideas from the Phillips curve, suddenly faced a policy trade-off: Cut unemployment and inflation would increase further; cut inflation and unemployment would edge even higher. In the end, they chose the former, printing more money and running higher deficits, perceiving the welfare costs of inflation lower than those of unemployment.

The result, however, was surprising. Inflation trended higher, as expected, but unemployment did not fall. The Phillips curve relationship broke down: For a given level of unemployment rate, inflation was higher. Similar dynamics occurred in the U.K.

What went wrong? As inflation trended higher, households, firms and workers began to incorporate expectations into their decision-making. Employees, foreseeing higher inflation tomorrow, demanded higher wages today. Firms, expecting higher inflation tomorrow, adjusted prices higher today. Economists soon realized that the Phillips curve was nothing more than a static, empirical relationship that failed to reflect forward-looking underlying causes. Soon after Paul Volcker became chairman of the Federal Reserve in 1979, the central bank killed inflation by doubling the federal funds rate (FFR) to 20% (sometimes called the "Volcker shock"), sending the U.S. economy into a deep recession.

With the breakdown of the static Phillips curve, economic research shifted gears. Perhaps the greatest movement to ever occur within the discipline is the rational expectations revolution inspired by the "Lucas critique." Lucas (1976) argued that economic policy determined on the basis of empirical relationships, like those of the original Phillips curve, is naive and fraught with errors. People are rational; they will change their behavior based on economic policy, and they will make decisions not just on the basis of what is currently unfolding in the economy but what they expect to unfold in the future. Expectations are key. With the Lucas critique and rational expectation being widely adopted, macroeconomic models evolved from being static (one period) to dynamic (multiple periods).

Soon thereafter, the New Keynesian Phillips curve (NKPC) was born. Derived from rigorous theoretical microeconomic foundations, the NKPC accounts for the key variable missing in the original Phillips curve relationship: inflation expectations:

$$\pi_t = \beta E_t[\pi_{t+1}] + \gamma(y_t - y_t^*). \quad (1)$$

Here, π_t is current inflation, $E_t[\pi_{t+1}]$ is inflation expected in the next period, and $y_t - y_t^*$ is the "output gap." The output gap is the deviation of current output from the sustainable long-run potential output that should be produced if all factors of the economy are in equilibrium. β is the household's discount factor and is close to 1. γ is positive and determined by other fundamental elements of the economy, including the level of "price-stickiness," whereby firms do not update prices every period (e.g., some prices are held stale or follow a simple indexing rule to past inflation).

The intuition is unchanged. Inflation is pro-cyclical. But if you expect higher inflation tomorrow, inflation will increase today for any given level of output gap. Exhibit 9 shows how the Phillips curve of the 1970s underwent level shifts consistent with this observation. As inflation expectations increased in the latter part of the decade, the curve consistently shifted upward.

Exhibit 9: Scatter plot of year-on-year inflation rate versus unemployment rate

Source: PIMCO and Haver Analytics. Quarterly observations from 1Q 1960 to 4Q 1983.

The Phillips curve remains, in various forms, a centerpiece of modern thinking. However, in more recent years, as inflation expectations have become more anchored around the Fed inflation target, the relationship between inflation and unemployment has become less tight. The Phillips curve appears to have flattened. Some attribute this to lower wage-bargaining power for employees (as a result of the decline of unionization) or to increased competition from globalization. Others argue that economists are underestimating the output gap. But it is also possible that the true underlying relationship is unchanged. The prices of more cyclical items, like housing, food and recreational goods, suggest the relationship is intact, as do regional estimates of the Phillips curve. That said, the thinking behind the Phillips curve has changed dramatically over the years, and this evolution will no doubt continue.

3.2 Taylor rule

The experience of the 1970s taught us one important lesson: Central banks cannot trade off inflation for unemployment unless inflation expectations are anchored. That raises the obvious question of how central banks can anchor inflation expectations.

The Taylor rule, attributed to the seminal work of John Taylor (1993), serves as a model benchmark for independent central banks:

$$i_t = \pi_t + r_t^* + \alpha_\pi(\pi_t - \pi_t^*) + \alpha_y(y_t - y_t^*). \tag{2}$$

Here, i_t is the short-term nominal interest rate set by the central bank, r_t^* is the real rate of interest determined in equilibrium, and π_t^* is the inflation target. We rewrite the equation in terms of the short-term real interest rate, $r_t = i_t - \pi_t$, and rearrange to:

$$r_t - r_t^* = \alpha_\pi(\pi_t - \pi_t^*) + \alpha_y(y_t - y_t^*). \tag{3}$$

The short-term real interest rate r_t differs from the long-term equilibrium real interest rate r_t^*, based on the deviation of current inflation from the target as well as the output gap. If inflation is above its target or the economy is producing more output than its long-run potential, then the short-term real interest rate rises by α_π or α_y, respectively. The weights of α_π and α_y determine the relative importance of inflation and growth in setting monetary policy.

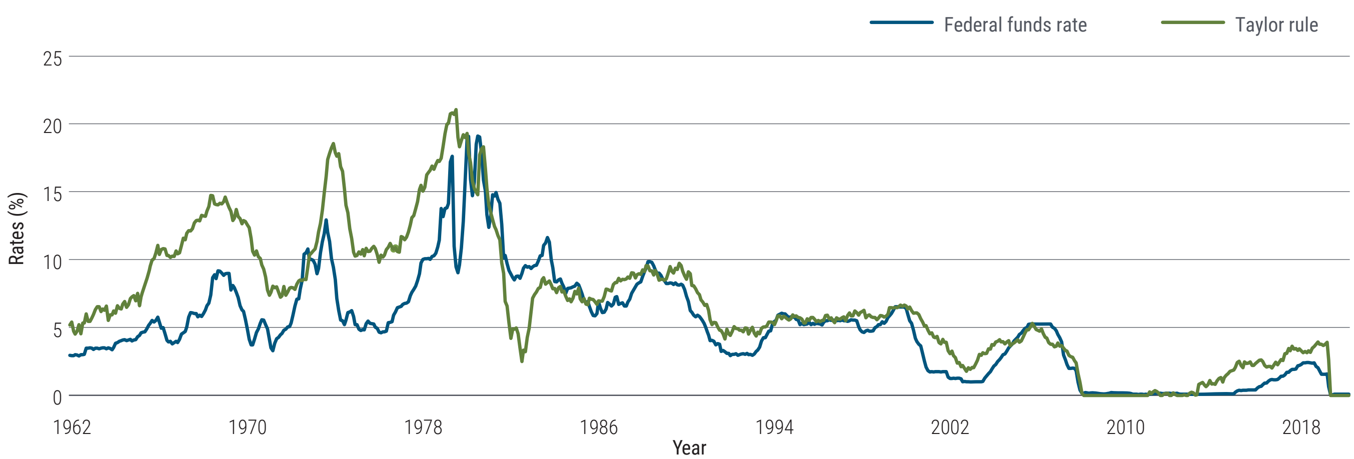
Now to the crux of the theory: For monetary policy to anchor inflation expectations, central banks need to act in an aggressive fashion, adjusting the nominal policy more than one-for-one with inflation. Technically, α_π must be positive. The intuition is simple. If inflation increases, the central bank must ensure the real interest rate increases in response, to incentivize people to save more and consume less, putting downward pressure on inflation. If α_π is negative, the real rate decreases, adding fuel to the fire by incentivizing more consumption, letting higher inflation feed on itself.

Credibility is key. Households are forward-looking, so central banks need to credibly commit to ex ante following the rule in future years, even if ex post they prefer to deviate.

Exhibit 10 compares the effective federal funds rate with the rate prescribed by the Taylor rule.[7] During the earlier period of 1962–1984, when policy was not as clearly guided by these principles (and in part determined by the Bretton Woods agreement), the average absolute difference between the FFR and the Taylor rule was 4.45 percentage points. The FFR was consistently too low during this period – in retrospect, a policy error, as dovish monetary policy added fuel to the economic shocks that sparked inflation. In the period 1985–2021, with a more fundamentally rigorous approach to setting interest rate policy, the average absolute difference between the FFR and the Taylor rule fell to 0.88 percentage point, corresponding to an 80% reduction in the absolute difference.

While the Taylor rule may be theoretically attractive, it contains many components that are difficult to measure and depend on latent, unobserved estimates of the economy's underlying state of equilibrium. Crucially, r_t^*, or "r-star", is one such variable. There has been a recent surge of interest in estimates for r^*, many concluding that it has been trending down in recent decades. A poor estimate for r_t^* can lead to large consequences, as it is a key input into the appropriate level of short-term nominal interest rates.

Exhibit 10: Fed funds rate versus Taylor rule rate



Source: PIMCO, Bloomberg and Laubach and Williams (2003) as of 28 February 2021

3.3 Closing the model

We close the model by adding aggregate demand.[8] Here, we express the aggregate demand equation (also known as the investment saving (IS) equation) in its New Keynesian format, which is the equation that underpins most modern central bank models:

$$y_t - y_t^* = E_t[y_{t+1} - y_{t+1}^*] - \lambda(r_t - r_t^*). \qquad (4)$$

The output gap today depends on the expectation of the output gap tomorrow and the real interest rate gap. As the real interest rate increases, consumers save more and consume less, for any given level of expectations for tomorrow.

To bring things full circle and understand how the Taylor rule anchors inflation, we work through the demand (IS) and supply (NKPC) equations that characterize the economic equilibrium. An increase in the real interest rate r_t above the long-run equilibrium rate r_t^* reduces output y_t via the aggregate demand (IS) channel, which in turn serves to put downward pressure on inflation via the NKPC channel. To further quantify the persistence of these knock-on effects requires heavier modeling machinery that lies outside the domain of this piece.

7 Here we use Laubach–Williams (2003) estimates for r_t^* and year-on-year U.S. CPI ex-food and energy for π_t, and substitute the output gap for the employment gap using the Okun's law approximation of $y_t - y_t^* \approx -2*(u_t - u_t^*)$. U.S. unemployment rate corresponds to u_t and the Congressional Budget Office's short-term natural rate of unemployment corresponds to u_t^*. $\alpha_\pi = \alpha_y = 0.5$. We floor the Taylor rule-prescribed policy at zero in the case of negative numbers.

8 See Appendix A for a model for the aggregate demand equation.

3.4. Quantitative easing

In simple terms, quantitative easing is a monetary policy instrument allowing central banks to inject money into the economy by buying existing government bonds (as well as mortgage and corporate bonds). All major central banks (the Fed, the European Central Bank, the Bank of England and the Bank of Japan (BoJ)) have used various forms of QE.

Here, we attempt to address a few salient questions. Are central banks printing currency in the process of QE? What is QE's impact on asset prices? And if money is being created, is it outright inflationary?

To answer the first question, it may be useful to understand how QE modifies the balance sheets of the central bank, commercial banks and the Treasury. Exhibit 11 shows stylized balance sheets of a central bank, a commercial bank and the government, and tracks the impact of a purchase of a Treasury bond by the central bank from the commercial bank.

- The central bank increases its assets by 100 while adding 100 to the commercial bank's reserves account at the central bank.
- The commercial bank shrinks its Treasuries holding by 100 while increasing its reserves account by 100. The commercial bank has entered an asset swap by exchanging a Treasury bond for a short-term loan. The net effects on the bank balance sheet are lower asset maturity and central bank credit risk in lieu of government credit risk.
- The government account remains unchanged.

Exhibit 11: How QE affects the balance sheets of the central bank, commercial bank and Treasury

Central bank

Assets		Liabilities	
Treasuries	+100	Reserves	+100
Other	–	Other	–
		Equity	
		Equity	–

Commercial bank

Assets		Liabilities	
Treasuries	-100	Deposits	–
Reserves	+100	Other	–
Other	–		
		Equity	
		Equity	–

Treasury

Assets		Liabilities	
Real assets	–	Treasuries	–
Other	–	Other	–
		Equity	
		Equity	–

Source: PIMCO. **For illustrative purposes only.**

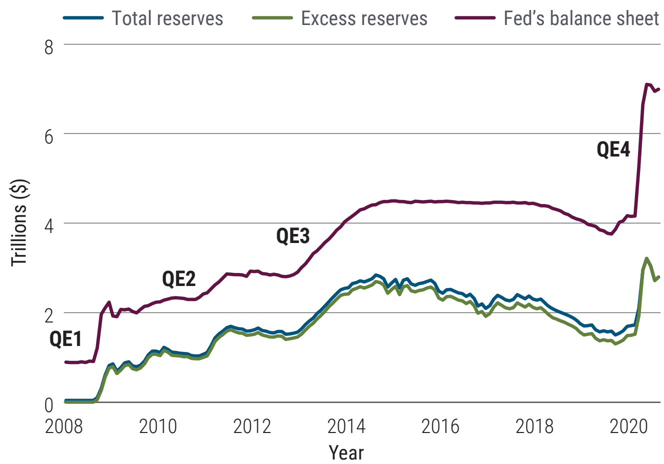
As can be seen, only the central bank balance sheet has expanded. On that same balance sheet, the currency account is unchanged, meaning the central bank did not print money. But base money (which includes currency and reserves) has increased by 100. Equity is unchanged on all the balance sheets.

How about broad money? Can't QE lead to rapid growth in the broad money supply? Yes, if you believe an old chestnut, the so-called money multiplier theory. In a fractional reserve system, an increase in base money – typically, commercial bank reserves at the central bank – induces an increase in bank loans. Banks do not want excess reserves that earn zero rates. They would much rather lend the funds, the theory goes, so they will lend to a bank that will in turn lend to a third bank, and so on. In this cascade of new loans, the only obstacle to infinite broad money creation is the ratio of required reserves to deposits. Defining the money multiplier as the ratio of incremental bank loans to incremental base money, the multiplier induced by this cascade of loans is $1 + (1 - r) + (1 - r)^2 + \cdots = \frac{1}{r}$, with r being the ratio of required reserves to deposits. So, for example, if r is 5%, then 100 in new base money in the process of QE could result in an incremental 2,000 in broad money. In the face of these large money multipliers, the market can be forgiven for feeling nervous about QE.

However, the money multiplier theory has not aged well, for a number of reasons. First, in the wake of the Great Recession, banks confront regulatory lending restrictions and are less than keen to lend aggressively. Second, reserves are now remunerated by a number of central banks, including the Fed. Positive interest rates on reserves will, of course, discourage the migration of reserves into new loans. Third, on a more substantive note, it is fair to say that, instead of new base money creating loans, bank loans create new money through a matching deposit in the bank borrower's account. A bank will not on-lend new reserves mechanically, as the theory of cascading loans suggests. Instead, it will optimize its lending decisions subject to constraints like borrowers' credit risk, desired reserves and the opportunity cost of lending (such as the incremental regulatory capital and the interest paid on excess reserves).[9] Exhibit 12 shows that reserves – in particular, excess reserves – increased with the Fed balance sheets during previous periods of quantitative easing.

9 Although QE does not directly increase broad money growth, it can do so indirectly if the ultimate seller of the asset is a nonbank entity (e.g., a pension fund or asset manager). Because central banks only buy assets from commercial banks, the banks can act as intermediaries, first buying an asset from a private nonbank entity, then selling it to the central bank through QE. In this case, QE indirectly increases broad money. However, that broad money creation comes from the first step rather than the second.

Exhibit 12: Reserves of depository institutions and the Fed balance sheet



Source: PIMCO and FRED as of 31 August 2020

A low money multiplier does not mean that QE was ineffectual. Quantitative easing affects asset pricing through three main channels:

- The portfolio balance: By reducing the available supply of long bonds, QE increases bond prices and reduces their yields. This in turn raises the bid on risk assets such as corporate bonds and equities.
- The signaling channel: QE can reinforce the belief that central banks remain accommodative; a hawkish policy would expose the central bank to severe capital losses on its bond inventories.
- The liquidity channel: QE is an effective liquidity backstop. By offering a "free" liquidity put option to investors, QE also boosts asset prices.

Now, to the question "Is QE outright inflationary?" On balance, perhaps surprisingly, QE's reflationary credentials disappoint for several reasons:

- From the money multiplier discussion, it appears that QE does not cause the kind of credit expansion predicted by money multiplier theory. Besides, QE is generally coincident with a period of recession or low growth, meaning that the demand for loans would be anemic.
- Although QE has caused asset price inflation, it does not result in goods and services inflation. If anything, asset price inflation is predictive of financial fragility, crash risk and deflation.

- In a similar vein, QE, by cheapening the cost of credit, has encouraged leverage. Total debt-to-GDP has increased from record levels in 2007 to even higher levels today. To the extent it is unsustainable, high leverage predicts deleveraging and heightened risks of deflation.
- Artificially low rates help zombie firms survive. This expands aggregate supply, which in turn causes deflationary pressures.
- With zero nominal rates, higher real yields are needed to entice investors to absorb higher quantities of reserves. And deflation is the only way to get positive real yields with zero nominal rates.

3.5 Monetarist theories of inflation

Quantitative easing is intimately linked to monetarist theories of inflation, which grew from Milton Friedman's research on the Great Depression and the shortcomings of Keynesian theory (see, for example, Friedman and Schwartz 1963). In particular, monetarists question the efficacy of the Keynesian government spending paradigm and advocate for the importance of price stability. They argue that, instead of active fiscal policy, monetary policy should inject money into (withdraw money from) the economy to counteract deflationary (inflationary) episodes. In this regard, too little or too much inflation is simply a consequence of too little or too much money floating around the economy.

Monetary economics is predicated on the relationship $MV = PQ$ where M is the total nominal amount of money in circulation, V is the velocity of money (how often it exchanges hands), P is the price level, and Q is an index of real expenditures. As the theory goes, if velocity V is stable and quantities Q are fixed in the long run, a doubling of the money supply M will lead to a doubling of prices P.

Despite its popularity in the 1970s and '80s, this framework is not short of problems. First and foremost, velocity V is not stable.[10] Look no further than the surge in the money supply, and accompanying collapse in V, in the aftermath of the 2008–2009 financial crisis. As discussed previously, most of the increase in the monetary base under QE is stuck in the banking sector rather than used in the purchase of goods and services. But there are deeper questions. What is M? There is not one definition. More to the point, can central banks control M? Yes, central banks can expand the monetary base with a keystroke. But broad money, which households use for consumption, is not within – at least, not directly within – central banks' reach. Moreover, reserves today pay interest, resembling overnight interest-bearing debt. Should Treasury bills be included in M? If so, what about longer-term bonds? The theory raises many unanswered questions.

But perhaps the biggest shortcoming is the absence of fiscal policy. Fiscal and monetary policies are, of course, intimately linked; every monetary action has fiscal implications. Higher interest rates, to give one example, raise the borrowing cost for the government, creating additional financing needs for the fiscal authority. Sargent and Wallace's seminal 1981 work describes a state of "fiscal dominance," in which tight monetary policy can perversely lead to higher inflation to ensure fiscal variables remain sustainable. Inflation would then largely become a fiscal phenomenon. Ultimately, the monetary and fiscal authorities need to coordinate their policies to pin down the price level. We explore these issues in the next section.

3.6 The importance of fiscal policy

But first, what is the distinction between fiscal and monetary policy? The answer is not obvious. The line between the two has become increasingly blurred. Today, both reserves and bonds pay interest. A central bank transfers its profits to the fiscal authority. And with QE, the balance sheets of the monetary and fiscal authorities are joined at the hip. Here, we offer a simple explanation to separate the two.[11] Monetary policy does not change net assets in private hands; it merely swaps assets (e.g., QE) or adds offsetting assets and liabilities (e.g., by lending to banks). Fiscal policy, in contrast, changes net assets in private hands through running deficits or surpluses. Consider a debt-financed tax cut, for instance: The government initially swaps money for a government bond with the private sector and then recycles the money back to the private sector through lower taxes. The result? A new asset (bond) in private hands.

To understand the role of fiscal policy, start with the government's consolidated budget constraint:

$$\frac{B_t}{P_t} = E_t\left[\sum_{i=0}^{\infty} \frac{S_{t+i}}{1 + R_{t+i}}\right] \tag{5}$$

where B_t is the nominal value of interest-paying government liabilities, P_t is the price level in the economy, R_t is the real

10 Note that $V = PQ/M$ is endogenous; it is simply the adjusting factor equating the two sides of the $MV = PQ$ equation.

11 Inspired by the literature on the fiscal theory of the price level. See, for instance, Cochrane (2014).

interest rate, and S_t is the government's primary surplus (that is, surplus excluding interest expenses). The real value of government debt equals the present value of future surpluses.[12]

In the conventional framework that underpins the inflation-targeting regime (monetary regime), the central bank can stabilize inflation via a Taylor rule only if the government never relies on inflation to stabilize its debt. In academic jargon, the fiscal authority must be Ricardian. For any given price level P_t, the government must adjust its primary balance S_{t+i}, now or in the future, to equate the two sides. A tax cut or spending hike today must be backed, in expectation, by a tax hike or spending cut tomorrow.

This has important implications for the private sector. Fiscal policy comes with no wealth effects; rational, forward-looking households will save a tax cut today in anticipation of a tax hike tomorrow. Put differently, newly issued government debt is only temporarily in private hands. It may be an asset today, but it is not wealth, as it comes with a future tax liability.

Today's institutional setup in inflation-targeting economies is designed to preserve this policy structure. Central banks are, by construction, independent from political pressures, and this allows them to set the interest rate path without considering its fiscal implications. Meanwhile, fiscal rules and watchdogs force fiscal authorities to be Ricardian, regardless of the level of interest rates. The responsibilities are clear: Inflation is kept in check by the central bank, and debt is kept in check by the fiscal authority.

This separation of duties makes intuitive sense. If the government were fiscally irresponsible, inflation would largely become a fiscal phenomenon – some emerging economies know this all too well. Suppose the government announced that it would never raise its primary balance to remain fiscally solvent. Instead, it would perpetually issue new government liabilities (bonds or reserves) to repay the old debt plus interest, never raising taxes or cutting spending to finance the growing nominal debt stock. It's easy to see that under such a scenario, in which the government "monetizes" its debt – that is, issuing liabilities that are not backed by future taxes – a Taylor rule would be powerless to stabilize prices.

Indeed, this is the logic embedded in the fiscal theory of the price level (FTPL), or the "fiscal regime." Here, fiscal policy is non-Ricardian: A tax cut today is not financed by a tax hike tomorrow but rather by rolling over government debt in perpetuity. The government's budget constraint is no longer a constraint but rather an identity: For any given level of primary balance S_{t+i}, now and in the future, the price level P_t adjusts to equate the two sides. In this regime, the central bank can no longer stabilize prices through a Taylor rule but instead passively keeps interest rates stable.[13] Here, the tables turn: Inflation is largely dictated by fiscal policy, and debt is held in check by the central bank keeping borrowing rates low.

Three points are in order. First, the fiscal regime is neither inflationary nor deflationary; it merely describes a regime in which active fiscal policy and debt largely dictate inflation. Second, a fiscal regime is only possible if the debt is denominated in its own currency. The government can only credibly issue new debt (reserves or bonds) not backed by future taxes if it is in control of its own printing press. And third, non-Ricardian fiscal policy now comes with wealth effects for the private sector. Rational, forward-looking households spend the tax cut today, as it is not offset by a tax hike tomorrow. Government debt is an asset permanently in private hands, not tied to any future tax liability. As such, the effects of fiscal policy naturally become larger in the fiscal regime. Franklin Roosevelt's New Deal of 1933–1939 is an example, some argue, of such a fiscal expansion.[14] Exhibit 13 summarizes the monetary and fiscal regimes.

Exhibit 13: Fed funds rate versus Taylor rule rate

		Monetary policy	
		Taylor rule	**No Taylor rule**
Fiscal policy	**Ricardian**	Monetary regime	No nominal anchor
	Non-Ricardian	Inflation/deflation spiral	Fiscal regime

Source: PIMCO. **For illustrative purposes only.**

12 The government's one-period budget constraint reads: $B_t = P_t S_t + Q_t B_{t+1}$ where $Q_t < 1$ is the nominal bond price. Divide by P_t, iterate forward, and impose the nonexplosive transversality condition to obtain the relationship.

13 Technically, α_π is negative.

14 See, for instance, Jacobson, Leeper and Preston (2019).

3.7 Neo-Fisherian effect

The phrase "fiscal regime" seems to suggest that monetary policy is ineffective. Far from it. In the short run, monetary policy still affects demand by raising and lowering the real interest rate. In the long run, however, its effects on inflation are the reverse of conventional logic.

Consider a permanent increase in the policy rate. When interest rates rise, the private sector receives higher interest on its assets (reserves and government bonds). As fiscal policy is non-Ricardian, the higher interest is not offset by a higher tax liability. So the private sector becomes wealthier in nominal terms, increasing demand and pushing consumer prices higher over time. Therefore, higher interest rates increase inflation – a result known as the neo-Fisherian proposition. Note the difference: Had fiscal policy been Ricardian, higher interest rates would have been offset by higher taxes, leaving the wealth of the private sector unchanged.

One can see this logic more easily in the Fisher equation:

$$i_t = r_t + E_t[\pi_{t+1}]. \qquad (6)$$

In the long run, nominal factors are independent of real factors (money neutrality). So for any given level of r^*, a higher interest rate must eventually correspond to higher inflation.[15] This is a long-run relationship. In the short run, nominal factors affect real variables, as prices are sticky – and, as such, inflation may decelerate in the short run (depending on the model) as the real interest rate increases.

The neo-Fisherian proposition has attracted a lot of interest in recent years. It is easy to see why. Since the financial crisis of 2008–2009, policy rates have been stuck near zero. Yet inflation has trended down, not up. Could inflation be low because interest rates are low? If so, the policy prescription to lift inflation would be very different. Negative interest rates would perversely lower inflation even further, extracting resources from the banking system and savers over time. Central banks would instead need to raise the policy rates to increase the nominal return on private sector assets.

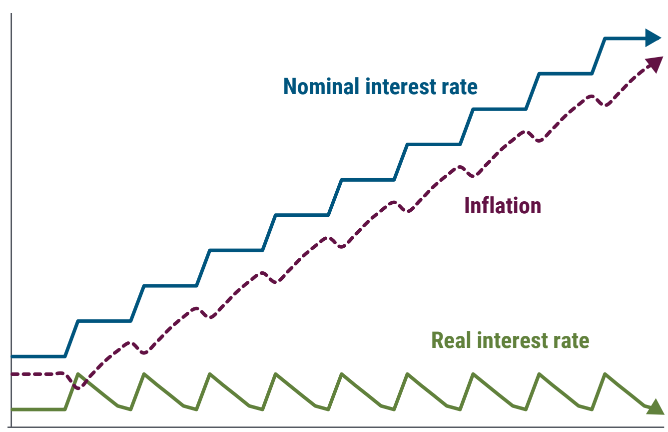
3.8 Coordination is key

Let's return to fiscal and monetary policy coordination. Both the monetary and fiscal regimes uniquely anchor inflation expectations. But what happens if monetary and fiscal policy fail to be coordinated?

If fiscal policy is Ricardian and monetary policy does not follow the Taylor rule (top-right in Exhibit 13), the economy loses its nominal anchor. Neither monetary nor fiscal policy pins down the price level. The increasing inflation of the 1970s is one such example.

If fiscal policy is non-Ricardian and monetary policy follows the Taylor rule (bottom-left in Exhibit 13), prices spiral out of control. Consider a fiscal expansion not backed by future taxes: Households become wealthier, increasing demand and pushing prices higher. The central bank, observing higher inflation but ignoring its causes, raises the policy rate aggressively in line with the Taylor rule. Higher interest rates in turn lead to higher inflation through the neo-Fisherian effect, triggering yet another interest rate hike via the Taylor rule. You get the picture. We would enter an inflationary spiral in which higher interest rates would cause higher inflation, and so on (Exhibit 14). (This all sounds very theoretical, but the idea is not as absurd as it sounds. Brazil's accelerating inflation of the early 1980s, some argue, was indeed a consequence of this lack of policy coordination.[16])

Exhibit 14: Inflation spiral



Source: PIMCO. **For illustrative purposes only.**

15 This does not hold in the monetary regime. Recall $\alpha_\pi > 0$ in the monetary regime, which is not compatible with an interest rate peg. The economy loses its nominal anchor, sending inflation to plus/minus infinity.

16 See, for instance, Loyo (1999).

How would policymakers be able to stop it? Either fiscal or monetary policy would have to blink. Either the fiscal authority would have to turn fiscally responsible, raising taxes or cutting spending aggressively in response to the higher interest rates, or, perhaps more controversially, the central bank would have to stop following a Taylor rule and not raise interest rates, thereby reducing the pace at which debt was accumulating.

3.9 Helicopter money

Helicopter money is frequently referred to as the ultimate monetary policy tool to lift inflation. Friedman (1969) presented the following parable: Suppose a helicopter dropped newly printed cash from the sky. Presumably, people would run to collect it and would spend at least some of it, increasing demand and eventually pushing consumer prices higher.

The modern-day helicopter could come in many forms. Central banks could directly credit household deposit accounts. They could hand fresh money to the fiscal authority to cut taxes. To be sure, both these forms are illegal in most jurisdictions to ensure fiscal policy stays responsible. More conventionally, however, the fiscal authority could cut taxes and finance the move by issuing a bond, which the central bank could buy in the secondary market through permanent QE. The result is the same in all scenarios: newly created money in the hands of the private sector.

Exhibit 15 shows the effects of the latter example on the stylized balance sheets:

- The government issues a bond, receives money from the private sector and recycles the money back to the private sector through lower taxation. Liabilities increase, assets remain unchanged, and equity falls.
- The central bank buys the bond from the private sector in the secondary market, issuing more reserves.
- The private sector initially swaps money for Treasuries when buying the bond in the primary market. It receives the money back from the government through lower taxation. Assets and equity increase. The central bank then buys the Treasuries with newly printed reserves.

Exhibit 15: Balance sheets of the Treasury, the central bank and the private sector with helicopter money

Treasury

Assets		Liabilities	
Real assets	–	Treasury	+100
Other	–	Other	–
		Equity	
		Equity	-100

Central bank

Assets		Liabilities	
Treasuries	+100	Reserves	+100
Other	–	Other	–
		Equity	
		Equity	–

Private sector

Assets		Liabilities	
Reserves	+100	Liabilities	–
Treasuries	–		
Other	–		
		Equity	
		Equity	+100

Source: PIMCO. **For illustrative purposes only.**

Note the difference between QE and helicopter money. QE, on its own, does not increase net assets (assets minus liabilities) in private hands; it merely swaps one government liability for another. But combine it with a fiscal deficit, and money in private hands increases, with no offsetting reduction in other assets. Equity increases.

Is this inflationary? Not so fast. We are back to where we started: a static, not forward-looking relationship, just like the static Phillips curve of the 1970s. Expectations matter. If the government hands you newly printed money today but tells you it will take it away from you tomorrow through higher taxes, presumably you will save it rather than consume it.

The distinction between monetary and fiscal policy is important here. Helicopter money is ultimately a fiscal transfer, as it adds net assets to private hands. What's more, a helicopter drop does not necessarily involve money. Indeed, the distinction between money and debt is blurry. Today, both pay interest. Both are liabilities on the government's consolidated balance sheet. Both are assets in private hands. The rational household would be indifferent about holding the two: Higher interest on reserves or bonds come with the same cost for the government (remember, the central bank remits its profits to the fiscal authority).

We offer the following definition of helicopter money: an increase in net assets (money or bond) in private hands that the government promises never to take away. In other words, the asset is permanent. The astute reader will see the link to the FTPL. A helicopter drop is equivalent to a non-Ricardian tax cut – a tax cut not backed by future taxes.

Since the pandemic started, governments have run unprecedented deficits, handing checks to households, directly in the U.S. and indirectly via firms and furlough schemes in Europe. Governments have issued bonds to finance this stimulus, initially bought by the private sector but thereafter quickly bought by freshly printed central bank reserves. Is this helicopter money? It depends. Yes, the private sector is sitting on fresh money. But whether it is permanent – non-Ricardian – depends on your expectation of whether the government will raise taxes or cut future spending to balance its books.

Again we ask: Is helicopter money inflationary? In sufficient size, presumably yes. But ultimately, like any tax cut, it depends on what households do with it. Even if you do not expect higher taxes tomorrow, there may be both cyclical (e.g., high uncertainty) and structural (e.g., longer life expectancy) reasons you would want to save a tax cut. Japan is a case in point. Despite decades of money-financed fiscal deficits, Japanese households have not spent frivolously, likely in part due to aging demographics (compounded by a perpetual Ricardian fiscal promise to always raise the value-added tax (VAT) in the future).

3.10 MMT

So far, we have based our review of monetary economics on conventional models and relationships: a Phillips curve describing the relationship between output and prices, an IS curve describing aggregate demand, and monetary and fiscal reaction functions providing a nominal anchor. This is a general equilibrium model. It describes how shocks propagate through the system and reflect the underlying preferences of households, firms and the government.

Modern monetary theory is something else. There are no equations but instead a number of identities. It is not forward-looking; it does not incorporate expectations. It argues with statements rather than supply and demand curves.

MMT starts with well-known facts. Governments need never default on debt denominated in their own currency; they can always print more money to repay the maturing debt. The theory explains sectoral balances: Your consumption is someone else's income. As a result, public sector deficits are private sector surpluses – or, put differently, public sector liabilities are private sector assets. More assets in private hands increase demand and spending. Too much spending may eventually lead to inflation if it pushes aggregate demand above the real capacity.

All of these claims are true, but they are far from new. FTPL shares the same tenets: There is no budget constraint but merely an identity; inflation, not debt or taxation, is the ultimate constraint on deficit spending; and government spending adds to private sector wealth. As a result, MMT is very similar to the concept of helicopter money.

MMT then ventures into normative, prescriptive statements of what governments should do. Proponents argue that economies tend to operate with spare capacity, so governments should always run large fiscal deficits, with no concern about debt or taxation – for example, by providing job guarantee schemes. Inflation is rarely a problem of excess government spending but instead a result of the monopolistic power of corporations, justifying more regulation. There is little or no role for monetary policy apart from keeping interest rates at zero, continually financing government deficits.

Many of these prescriptions are political in nature. We leave readers to form their own view. But we note that MMT stands out in its lack of rigor, and it leaves many questions unanswered. When does government spending run into the inflationary constraint? Where is full employment? MMT supporters argue that if fiscal spending overheats the economy, the government can quickly tighten the fiscal belt to bring inflation under control. History offers few such examples, however. High inflation has tended to feed on itself, especially when inflation expectations have de-anchored following passive monetary policies. The 1970s offer valuable lessons in this regard.

4. INFLATION RISK PREMIUM

Inflation risk management is paramount to economic policymaking and, on a micro level, to successful portfolio construction. After all, the fortunes of the retirement industry, individuals saving for retirement and other goals, and bond and equity investors hinge largely on inflation. In this section, we define the inflation risk premium as the difference between breakeven inflation and expected inflation.

How to forecast inflation? Expected inflation can be obtained from surveys, but surveys are fraught with issues, such as herding by survey participants, questionnaire biases and polling synchronicity, to name a few. With the advent of inflation-linked Treasury bonds in 1997, market participants began to use the breakeven inflation as a measure of expected inflation. Simply defined, breakeven inflation is the difference between the yield of a nominal government bond and the yield of an inflation-linked government bond of similar maturity. In a world where investors are neutral to risk and liquidity is ample, bondholders should be indifferent about choosing between inflation-linked bonds and nominal bonds. In such a world, real yields plus expected inflation equal nominal yields.

But this is generally not true. To understand why, consider the price of an umbrella when it is sunny versus the price of an umbrella when it rains. Clearly, one is willing to pay more for an umbrella when it rains. Being an insurance asset (an asset protecting against risk), an umbrella has a higher price if it is available when it rains, and therefore a lower expected return.

By contrast, an umbrella is a pro-cyclical asset if it's only available when the weather is sunny: Its price will be low and its expected return high.

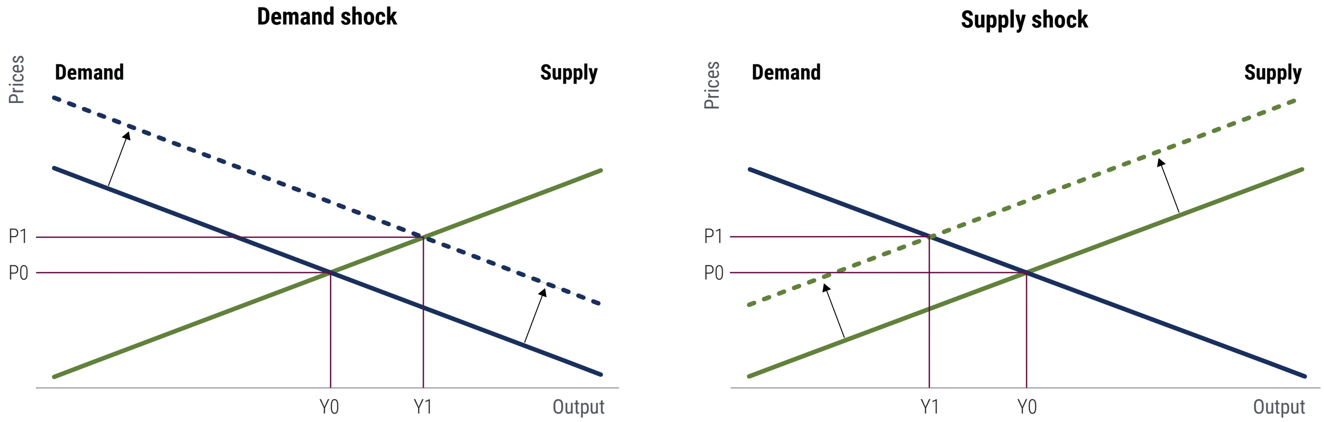
Same with bonds. What matters for the inflation risk premium is the covariance between growth and inflation. If the covariance is positive (economic growth and CPI inflation are positively correlated), the nominal yield will be low versus the real yield plus expected inflation, meaning the inflation breakeven will tend to be lower than expected inflation. This is called a negative inflation risk premium. Vice versa if the covariance is negative: The inflation breakeven will, on average, overestimate expected inflation, resulting in a positive inflation risk premium. For example, Piazzesi and Schneider (2006) show that the negative correlation between inflation and growth can explain the shape of the nominal term structure. In Appendix B, we show that under special conditions the inflation risk premium, defined as the difference between breakeven and expected inflation, is

$$\begin{aligned}\text{IRP} &= \text{Breakeven} - \text{ expected inflation} \\ &= -\frac{\text{Var(Nominal growth)} - \text{Var(Real growth)}}{2}\end{aligned} \quad (7)$$

The intuition is simple. If growth and inflation are positively correlated, a negative growth surprise is associated with a negative inflation surprise, meaning an outperformance of nominal bonds. Nominal bonds are "insurance assets" in this scenario. Because insurance is valued, their price is high and their yield is low relative to real yields. Conversely, if growth and inflation are negatively correlated, nominal bonds will underperform in a low growth environment. They are pro-cyclical assets and therefore risky. Their yield (expected return) will be high.

The correlation between growth and inflation is generally positive when economic shocks tend to be demand shocks. As illustrated in Exhibit 16, higher demand, all else equal, causes higher prices and higher quantities (positive correlation). Higher supply causes lower prices and higher quantities (negative correlation). In an environment where economic noise is driven by supply shocks (think of a 1970s-style oil embargo), inflation risk premia will be positive. When demand shocks dominate (think of the recessionary shock of 2008), inflation risk premia will tend to be negative.

Exhibit 16: Demand- and supply-driven inflation



Source: PIMCO. **For illustrative purposes only.**

Note that a normal Phillips curve generally implies a positive growth-inflation correlation. This in turn means that inflation risk premia will tend to be negative.

How does this analysis speak to today's environment? It is likely that in an environment where the fiscal stimulus is high and vaccinations lead to herd immunity, growth and inflation may be simultaneously high. Conversely, if the COVID-19 virus variants lead to another round of serious contagions, inflation and growth may fall. This is another way of saying that demand shocks probably dominate supply shocks.

If this is true, there are two implications. First, expected inflation is higher than suggested by breakevens. Second, inflation hedging (long inflation-linked bonds versus nominal bonds) has positive expected returns.

5. INFLATION: AN ASSESSMENT

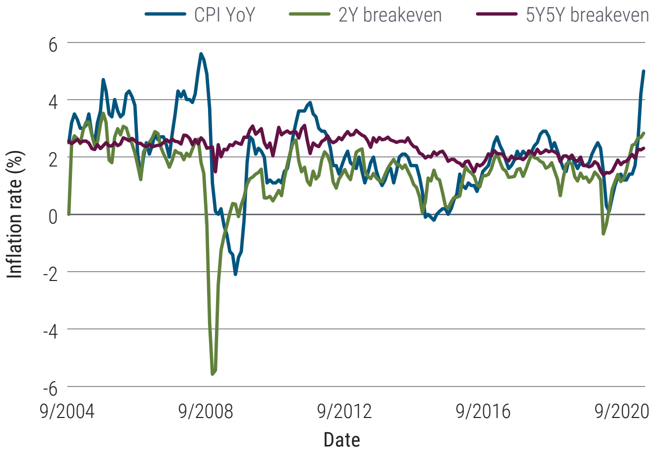
As we discuss below, the departure point for assessing inflation looks fundamentally different in the U.S. than in Europe and Japan; whereas in the U.S. the question appears to be whether the Fed loses control over inflation expectations, the challenge for most central banks in Europe and Japan is to create even a modicum of inflation.

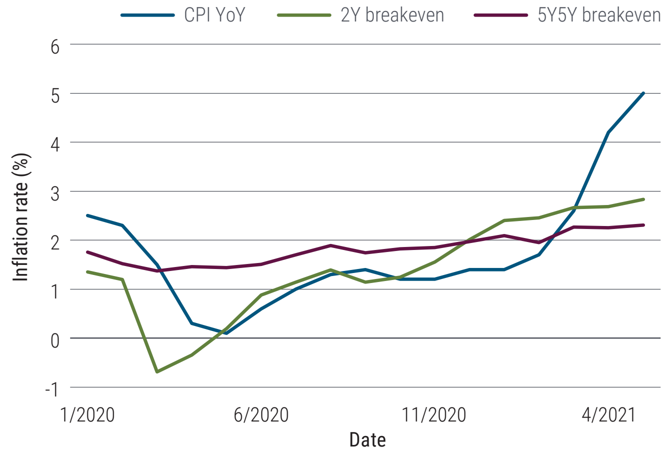
Before discussing inflation scenarios, a few remarks are in order. First, the left panel of Exhibit 17 shows that if one looks at the time-series of realized inflation and two-year breakeven inflation since 2004, the pandemic crisis barely registers compared with the deflationary impulse of the subprime crisis. Second, the left panel of Exhibit 17 shows that the long-term five-year, five-year forward inflation breakevens have been remarkably stable in the face of both the subprime and the pandemic crises. In other words, the market does not appear to give much credence to an inflation regime change scenario. The Fed credibility has not been tainted or even questioned in spite of much policy activism.

Short term, as a path for exiting the pandemic becomes clearer, so does the consensus case for inflation. Inflation sentiment seems to have gotten well ahead of realized inflation. Indeed, looking at more recent data (right panel of Exhibit 17), at the end of February 2021 the two-year inflation breakeven is 110 basis points (bps) above January 2020, whereas actual CPI inflation is 60 bps below CPI inflation in January 2020. Furthermore, the Google search trends shown in Exhibit 18 certainly confirm, if not amplify, inflation anxieties. So what gives?

Reasons for this discrepancy – that is, reasons for worrying about inflation – abound. With vaccinations ramping up and possible herd immunity in sight, it is reasonable to look for a quick spike in employment activity in precisely those sectors that suffered from social distancing: retail, airlines, hotels, restaurants and healthcare, to name a few. "Revenge" expenditure is likely forthcoming. On the fiscal side, the pandemic-related stimulus checks resemble helicopter money, possibly creating inflationary pressures to erode the growing nominal debt stock. More important, policymakers are closely coordinating the fiscal and monetary impulse in what appears to be a fiscal regime, with non-Ricardian spending and a Fed committed to passively keeping rates low, at least in the short run, deviating from standard Taylor principles. The political

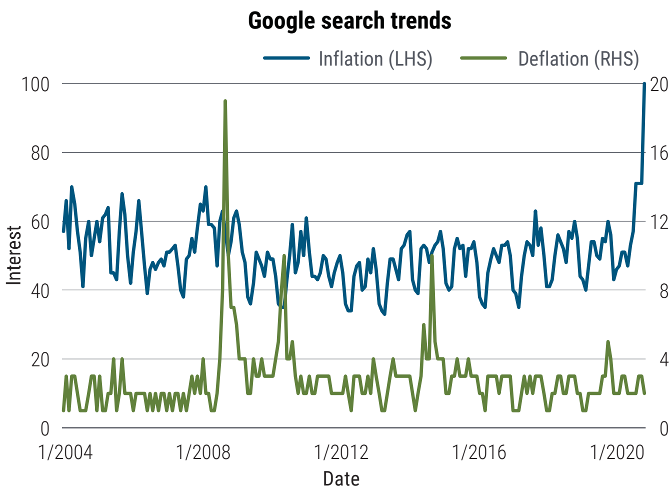
Exhibit 17: Realized versus breakeven CPI inflation

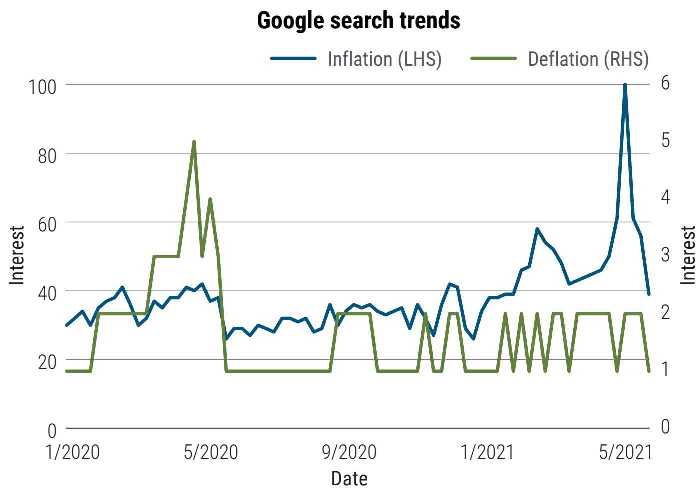




Source: PIMCO and Google as of 31 May 2021

Exhibit 18: "Inflation" versus "deflation" Google search trends



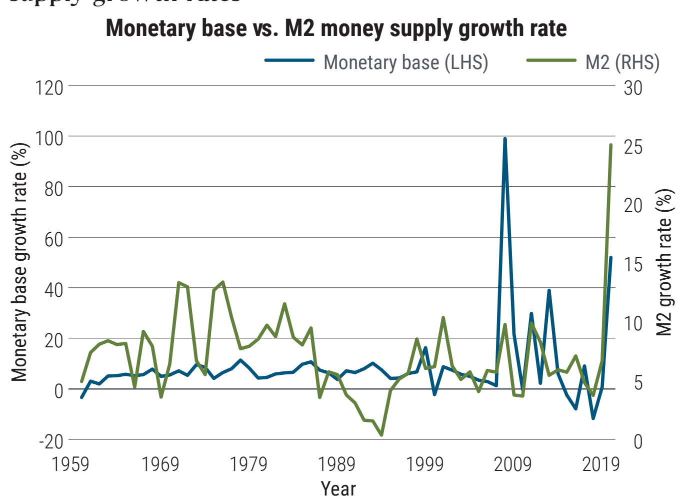


Source: PIMCO and Google as of 31 May 2021

structure creates inflationary risks, too, with Democratic control of the presidency, the Senate and the House making future stimulus far easier to enact.

On the international side of the macro ledger, reduced trade flows, declining dollar carry and a weaker dollar have added to inflation concerns. Last, broad money growth is higher than it has ever been in the long sample, as shown in Exhibit 19. Monetarists should be worried. Even in the heyday of quantitative easing, a decade ago, exponential growth in the money base could not induce high growth in M2. This appears to have changed in the wake of the pandemic.

Exhibit 19: Annual monetary base versus M2 money supply growth rates



Source: PIMCO and Haver Analytics as of 31 December 2020

Though all these arguments have merit, it is important to remember an overarching fact of life: The Phillips curve has been horizontal for a long while, not least because the Fed is viewed as capable of credibly anchoring inflationary expectations. Proof of that, if one is needed, is the virtual absence of reaction of the five-year, five-year inflation breakeven to both inflationary and deflationary fevers over the past 15 years or so. After all, the Fed has promised to react to any durable deviation of CPI inflation from acceptable levels (presumably 2.5%), despite tolerating some wiggle room to the upside. Of course, the Taylor rule is not a law of physics; central banks have been known to disappoint, and central bank independence is always a hard-won battle in the face of political pressures to overspend. But the Fed's anti-inflationary credentials remain largely intact, despite rumors to the contrary.

The debt worries are likely overstated as well. True, government debt has ballooned since the start of the pandemic. But with trend GDP growth far exceeding real (inflation-adjusted) borrowing costs, the debt-to-GDP ratio will not be on an ever-increasing path, even with inflation unchanged.

Maybe more important, one should also recall that, away from elevator economics (e.g., noisy data), the "heavy" variables are deflationary.

First, capacity destruction will not be reversed quickly post-pandemic. Firms may question their prior business models in light of the COVID-19 experience and wonder whether they can do more with less. Even if hiring restarts in earnest, we can still presume that the labor supply is elastic and that wage pressures are unlikely to be excessive.

Second, U.S. risk equity is more than fully priced. Asset price inflation is, if anything, predictive of goods and services deflation. After all, major deflations over the past 100 years – the U.S. in the 1930s, Japan in the 1990s, the U.S. in 2008–2009 – succeeded periods of expensive risk assets. Valuation metrics for the S&P 500, as seen in Exhibit 20, are living in the tails and may well favor a deflationary scenario if they decide to revert to a long-term mean.

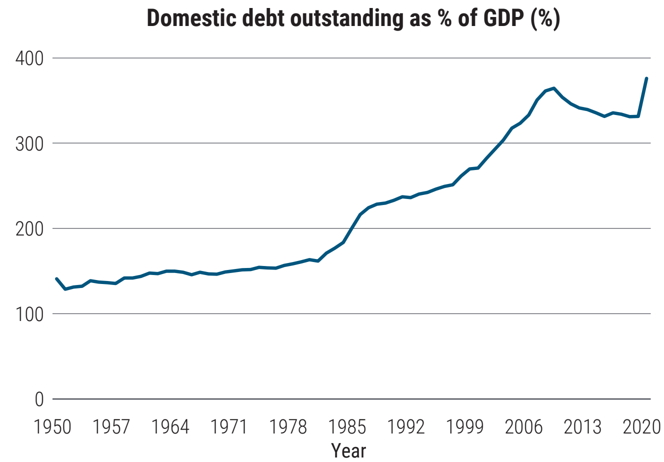
Exhibit 20: Standard valuation metrics for the S&P 500

	CAPE	Dividend yield	Tobin's Q
Current	33.77	1.58%	2.64
Average	17.13	4.31%	0.85
Percentile	98%	97%	100%

Source: Robert Shiller's website and the Board of Governors of the Federal Reserve System as of 31 December 2020.

Third, leverage: Total debt as a proportion of GDP is at a historical high in the U.S. (Exhibit 21) and in most advanced economies. High leverage tends to predict a deflationary outcome via deleveraging.

Exhibit 21: U.S. total debt-to-GDP



Source: PIMCO and Haver Analytics as of 31 December 2020

So, on balance, we feel the inflation scare is a bit overdone. As highlighted in our *Cyclical Outlook*, notwithstanding a temporary bump in inflation in the coming quarters, we expect inflation to settle close to the Fed's target by the end of 2022. Further out, we see three possible scenarios at a five-year horizon:

1. Inflation settles around 2% because expectations are kept in check by the Fed's credibility. The Fed reacts in classic fashion to inflationary shocks: a series of rate hikes resulting in a bear flattening of the yield curve and higher real yields, in turn forcing inflation down, but not without havoc in risk assets.

2. Inflation settles below 1.5%, either because risky markets sell off with disinflationary consequences or because fiscal fatigue kicks in, resulting in a sharp fiscal contraction. The Fed fails to counteract the disinflation, constrained by the lower bound on its policy rate.

3. Inflation settles above 2.5%–3.0%, but the Fed does not have the stomach to confront it properly. Why would that happen? Either because 1) asset markets are seen as overly sensitive and are a higher priority than inflation, 2) the Fed is coerced into keeping rates low and monetizing deficits through fiscal dominance or 3) the inflation shock is a supply shock and the Fed is conflicted about its inflation and growth mandates. In this scenario, the Fed is seen as behind the curve, and risks of everlasting inflation and damage to the Fed's reputation could cause a change in the inflation regime for a while.

Assigning probabilities to each scenario is a perilous exercise, but at the risk of oversimplification, we see the first scenario as our firm base case, with roughly equal probabilities for the tail scenarios. As we note in our *Secular Outlook*, however, the tails have become fatter since the start of the pandemic, largely as upside and downside risks to future fiscal policy have increased.

5.1 Global inflation

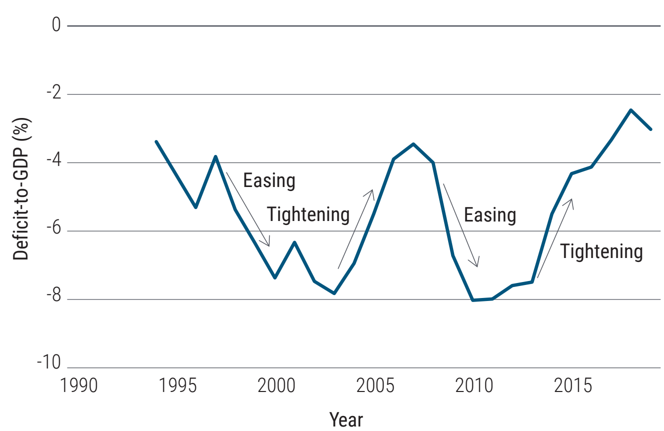
What about other countries? Many themes are global in nature: fiscal and monetary authorities holding hands, ballooning debt, elevated asset prices (though less so than in the U.S.) and soaring saving stocks. But there are important differences. On balance, across the developed world, medium-term inflationary risks look highest in the U.S., followed by the U.K., the euro area and Japan.

Start with Europe. As elsewhere, the region's inflationary prospects depend largely on the future fiscal and monetary policy mix. Here, a big regime shift looks unlikely. Monetary policy is largely out of bullets, especially in the euro area. And while fiscal policy is unlikely to repeat the austerity plans of 2011–2014, we doubt it will remain meaningfully stimulative after the pandemic. In some countries – Italy, for example – fiscal capacity is limited, constrained to at least some extent by fiscal rules. Other countries, like Germany, have ample fiscal space, but they are less likely to use it. In the context of a monetary union, this may prove problematic, as Italy and much of Southern Europe need lower wages than in Northern Europe to compete. Unless Germany is willing to create domestic inflation, through stimulus or otherwise, Italian labor market reforms may increase deflationary pressures in the eurozone. Last, the euro area experience provides another important lesson: Once inflation expectations fall short of the target for multiple years, they easily become entrenched, feeding into lower inflation prints.

This is even more true for Japan, where inflation expectations have been anchored at zero for decades. At face value, a lack of fiscal and monetary efforts cannot be blamed: Government debt is more than 250% of GDP, deficits have been in the high single digits for decades, and the BoJ has monetized about half of the outstanding debt. Yet the private sector has mostly saved, not consumed, the additional assets. Why? Three (not mutually exclusive) explanations may be at play, none of them likely to change any time soon. First, aging demographics: As people approach retirement, they tend to save more, demanding more assets. Viewed through this lens, the fiscal deficits may merely reflect higher saving demand from the private sector rather than an exogenous increase in government spending. (Remember, it takes two to tango: A private sector surplus is a public sector deficit, holding external trade constant.) Indeed, stripping out cyclical effects, Japanese fiscal policy has hardly been expansionary in recent decades (Exhibit 22). Second, the fiscal deficits have been highly Ricardian. The government has repeatedly backed ongoing deficits by ex ante promises of future VAT hikes. In this context, it's no surprise that households have not spent frivolously, just as predicted by conventional theory. Third, let's not forget the long-run neo-Fisherian principle that low rates potentially cause low inflation by decreasing the return on private sector assets (after all, it's hard to argue that three decades does not constitute a long run).

Yet with Japanese debt-to-GDP very high, the country is subject to significant inflationary right tails in the long run, as unpleasant fiscal arithmetic may prevail and the growth of the money supply may be driven by government deficits.

Exhibit 22: Japan's structural (cyclically adjusted) deficit (% of GDP)



Source: PIMCO and the International Monetary Fund as of 13 October 2020

6. EXPECTED INFLATION AND ASSET PRICES

How does inflation affect asset prices? Let's consider an illustrative example in which we regress the excess return of different assets on the change in two-year breakeven inflation and the change in five-year, five-year forward breakeven inflation:

$$\text{excess return from } t \text{ to } t+1 = \beta_1 \text{change in 2-year BE} + \beta_2 + \beta_2 \text{ change in 5y-5y forward BE.} \quad (8)$$

The first right-hand variable can be thought of as a proxy for shocks to short-term inflation, and the second as changes in the longer-term inflation expectation. The correlation between the two variables is positive (around 0.5) but far from unity. This moderately positive correlation implies that investors view short-run and long-run inflation quite differently.[17]

We consider five asset classes: equities, commodities, Treasuries, Treasury Inflation-Protected Securities (TIPS) and real estate investment trusts (REITs). Exhibit 23 shows the regression results.[18] Two things are worth noting. First, equities, commodities, TIPS and REITs all provide inflation-hedging benefits, as their returns are positively correlated with breakeven changes; nominal bonds provide no such benefit. Second, different assets respond differently to the two breakeven changes: equities, REITs and TIPS respond more to short-term inflation, nominal bonds respond more to longer-term inflation, and commodity returns co-move positively with both short- and long-term inflation shocks.

Exhibit 23: Regression results with changes in breakeven inflation

	Equity	Commodity	Treasury	TIPS	REIT
Changes in 2-year breakeven	**0.65**	**0.34**	-0.04	**0.53**	**0.61**
Changes in 5-year, 5-year forward breakeven	0.07	**0.45**	**-0.48**	-0.07	-0.08
Adjusted R2	0.48	0.49	0.25	0.24	0.31
Sum of coefficients	0.72	0.79	-0.52	0.46	0.53

Source: PIMCO and Bloomberg. Monthly data of annual returns and breakeven changes from January 2005 to March 2021. All variables are rescaled and expressed in terms of z-scores. Numbers in bold are statistically significant at 5% level.

There are two potential issues with these regressions. One, we have only a short sample of data on breakeven inflation. Two, breakeven inflation may not be a good proxy for expected inflation in the presence of a time-varying inflation risk premium. To address both issues, we switch to the one-year-ahead GDP inflation expectation from the Philadelphia Fed's Survey of Professional Forecasters (SPF) to proxy for expected inflation. Compared with breakeven, this series, available since 1970, is a more explicit measure of expected inflation. We define the following variables:

- Realized inflation: CPI inflation over one year $\left(\frac{CPI_{t+1}}{CPI_t}\right)$
- Expected inflation: one-year-ahead SPF inflation expectation, $E_t\left(\frac{CPI_{t+1}}{CPI_t}\right)$
- Inflation surprise: difference between realized and expected inflation $\frac{CPI_{t+1}}{CPI_t} - E_t\left(\frac{CPI_{t+1}}{CPI_t}\right)$
- Changes in expected inflation: $E_{t+1}\left(\frac{CPI_{t+2}}{CPI_{t+1}}\right) - E_t\left(\frac{CPI_{t+1}}{CPI_t}\right)$

Before turning to the empirical evidence, we briefly discuss how each of these variables may affect asset returns.[19] To do so, we first note that

$$\text{Realized nominal return between } t \text{ and } t+1 = \frac{P_{t+1} + D_{t+1}}{P_t} \quad (9)$$

where P is price and D is dividend. All else equal, the return is higher when P_{t+1} and/or D_{t+1} is high or when P_t is low. We then use the simple Gordon growth formula $(P = \frac{D}{R-g})$ to make three points on how inflation affects nominal prices and dividends. All variables are nominal.

17 Due to the potential multicollinearity problem, we also report the sum of the two coefficients.

18 Equity is proxied by the S&P 500 Total Return Index; Treasury is proxied by the Bloomberg Barclays US Treasury Total Return Index; TIPS is proxied by the Bloomberg Barclays US Treasury Inflation Notes Total Return Index; REIT is proxied by the FTSE Nareit Equity REITS Total Return Index; and commodity is proxied by the Bloomberg Commodity Index. To calculate excess returns, we subtract one-year yield from the total returns.

19 Fama and Schwert (1977) examined how returns respond to expected inflation, unexpected inflation and changes in expected inflation. Equity has received the most attention, and many have documented a negative correlation between equity returns and all three inflation measures (e.g., Stulz 1986).

First, expected inflation is reflected in nominal asset prices; therefore, all else equal, it does not affect realized nominal excess returns. Second, as inflation expectations are embedded in nominal prices, changes in expectations lead to changes in prices and realized returns. For example, an increase in expected inflation leads to a higher nominal yield and therefore a negative nominal bond return. Changes in expected inflation should not directly impact real assets, as higher nominal rates R should be offset by higher nominal growth g. However, if an increase in expected inflation leads to Fed reaction and higher real rates, thus higher $R - g$, then it would also have a negative impact on real assets such as equities (see Baz et al. 2021). Third, an inflation surprise could affect realized returns to the extent that the surprise leads to higher inflation expectations and the Fed responds with higher real yield. For real assets, higher than expected inflation could also mean higher than expected nominal cash flows D_{t+1}, thus higher realized return.

We now turn to the empirical results. Many papers in the literature consider a simple "inflation beta" by regressing excess returns onto realized inflation:[20]

$$\text{excess return from } t \text{ to } t+1 = \alpha + \beta_1 \text{realized inflation} + \varepsilon_{t+1}. \qquad (10)$$

We modify this regression in two ways. First, because realized inflation can be decomposed into expected inflation and an inflation surprise, and because expected inflation should not affect excess returns, we focus on inflation surprise rather than realized inflation. Second, we also control for GDP growth surprise, as inflation is closely linked to economic activity.[21] For example, we are likely to see a positive (negative) correlation between the two in a demand-pull (cost-push) inflation. We run the following regression:

$$\text{excess return from } t \text{ to } t+1 = \alpha + \beta_1(\text{inflation surprise}) + \beta_2(\text{growth surprise}) + \varepsilon_{t+1}. \qquad (11)$$

Exhibit 24 shows the regression results. Commodities and TIPS provide inflation-hedging benefits, as a positive inflation surprise co-occurs with higher returns.[22] On the other hand, nominal bonds and equities are not good inflation hedges; returns for these assets are lower in periods with higher than expected inflation.[23] REITs have negative but statistically insignificant inflation beta. Except for equities (and to some extent REITs), the results in Exhibit 24 confirm those in Exhibit 23.

Exhibit 24: Regression results with inflation and growth surprises

	Equity	Commodity	Treasury	TIPS	REIT
Constant	**0.09**	0.02	**0.00**	**0.03**	**0.09**
Inflation surprise	**-1.98**	**7.48**	**-1.31**	**1.68**	-1.07
Growth surprise	**3.28**	1.30	**-0.70**	**-0.68**	**3.00**
Adjusted R2	0.20	0.41	0.31	0.14	0.11

Source: PIMCO, Haver Analytics and Bloomberg as of 30 April 2021. Quarterly observations of annual returns from 1970 for equity, commodity and Treasury. Returns for REIT, Treasury and TIPS start in 1971, 1973 and 1997, respectively. Inflation (growth) surprise is defined as the difference between realized one-year CPI inflation (GDP growth) and one-year-ahead SPF inflation (GDP growth) expectation. Numbers in bold are statistically significant at 5% level.

As discussed earlier, changes in expected inflation should also affect returns (Fama and Schwert 1977). To distinguish between the effect of inflation surprise and changes in the inflation expectation, we consider the following regression:

$$\begin{aligned}\text{excess return from } t \text{ to } t+1 \;=\;& \alpha + \beta_1(\text{inflation surprise}) + \beta_2(\text{changes in expected inflation}) \\ & + \beta_3(\text{growth surprise}) + \varepsilon_{t+1}.\end{aligned} \qquad (12)$$

20 See, for example, Fama and Schwert (1977), Bekaert and Wang (2010), and Ang, Brière and Signori (2012).

21 We follow Pedersen and Guo (2014). See also Bekaert and Wang (2010).

22 An alternative way to think about betas for TIPS is to decompose them into a real yield component and an inflation-adjustment component. The latter should have an inflation beta of 1.

23 Removing expected inflation and adding in growth surprise do not have a material effect on the inflation surprise beta. See Appendix C for additional results.

Exhibit 25 shows the regression results. For all assets, the signs on the two inflation variables are the same, suggesting that assets that hedge against inflation surprise also hedge against changes in expected inflation. However, some of these results may be unexpected – for example, one would expect changes in nominal yields to respond to changes in expectation rather than pure (backward-looking) surprise. Also notice that once we control for changes in expected inflation, the negative inflation beta for equity is no longer statistically significant.

Even though, theoretically, inflation surprise and changes in expected inflation should have different impacts on asset returns and the former could be a proxy for the latter, Exhibit 25 shows that, empirically, it may be difficult to disentangle the two effects using the available data. Therefore, for practical purposes, a framework similar to that of Equation 11 can sufficiently capture how inflation affects asset returns.

Exhibit 25: Regression results with inflation and growth surprises and changes in expected inflation

	Equity	Commodity	Treasury	TIPS	REIT
Constant	**0.09**	0.03	**0.02**	**0.03**	**0.09**
Inflation surprise	-1.93	**6.68**	**-1.22**	**1.34**	-1.40
ΔExpected inflation	-0.16	2.90	-0.33	2.31	1.20
Growth surprise	**3.29**	1.16	**-0.69**	**-0.75**	**2.95**
Adjusted R2	0.19	0.41	0.31	0.14	0.10

Source: PIMCO, Haver Analytics and Bloomberg as of 30 April 2021. Quarterly observations of annual returns from 1970 for equity, commodity and Treasury. Returns for REIT, Treasury and TIPS start in 1971, 1973 and 1997, respectively. Inflation (growth) surprise is defined as the difference between realized one-year CPI inflation (GDP growth) and one-year-ahead SPF inflation (GDP growth) expectation. Change in expected inflation is defined as the difference between one-year-ahead SPF inflation expectations. Numbers in bold are statistically significant at 5% level.

While the returns of these assets respond to inflation, other factors, such as valuation, could be important determinants. An asset might be a good inflation hedge, but if it is already expensive, then there might be limited room for further price appreciation. To take these factors into account, we expand Equation 12 and add in carry and value as right-hand-side variables:[24]

$$\begin{aligned}\text{excess return from } t \text{ to } t+1 \quad &= \quad \alpha + \beta_1(\text{inflation surprise}) + \beta_2(\text{changes in expected inflation}) \\ &\quad + \beta_3(\text{growth surprise}) + \beta_4 \text{carry}_t + \beta_5 \text{value}_t + \varepsilon_{t+1} \end{aligned} \tag{13}$$

Exhibit 26 shows the regression results for U.S. equity as well as selected commodities and commodity currencies.[25] Most of the commodity-related assets perform well in periods with higher than expected inflation (positive inflation surprise beta). One noteworthy observation is that equity also has a positive and significant beta to an inflation surprise, even though the beta to a change in expected inflation remains negative. This suggests that equity may actually perform better in periods with higher than expected inflation once we control for valuation, and that equity may provide some hedging benefits against inflation surprise when it is not overvalued. On the other hand, the coefficient on changes in expected inflation is negative (but statistically insignificant), which could be consistent with the idea that rising inflation expectations may lead to Fed reaction – hence, bad news for equity investors.[26] We should point out that even though equities may have positive beta to inflation surprise using regression specified by Equation 13, they may not be good inflation-hedging assets due to their high valuations.

24 For equity, we define raw carry as $\left(\frac{Fut_{t,T_1}}{Fut_{t,T_2}} - 1\right) \times \frac{365}{T_2 - T_1}$, then adjust for seasonality by computing the average difference between the raw carry and its one-year moving average at time t for all the business days in the month. Commodity carry is defined as $\frac{Future_{1Mon} - Future_{1YR}}{Future_{1YR}}$; FX carry is defined as $4 \times \left(\frac{Spot}{3M\ Forward} - 1\right)$.

25 To save space, we do not report the constant term and the coefficient on growth surprise. The latter is positive and significant for equity and negative and significant for gold.

26 Due to data availability for carry and value, the equity samples used in Exhibits 24 and 25 are not the same. However, if we repeat the regression in Equation 12 using the shorter sample, inflation surprise beta is negative and insignificant (-0.72), and the results are qualitatively similar to those in Exhibit 24.

Exhibit 26: Regression results controlling for carry and value

	Equity	Crude	Gold	Wheat	Corn
Inflation surprise	**3.49**	**22.05**	**5.46**	3.21	**8.91**
ΔExpected inflation	-8.92	1.11	-2.06	-8.59	-12.11
Value	**15.09**	**-0.22**	-0.05	-0.21	0.16
Carry	**2.61**	0.04	**2.59**	0.11	-0.58
Adjusted R2	0.50	0.54	0.29	0.03	0.08

	Australian dollar	Canadian dollar	Norwegian krone	New Zealand dollar
Inflation surprise	**4.01**	**4.24**	**6.03**	2.18
ΔExpected inflation	-7.10	-5.09	**-9.17**	7.03
Value	**-0.32**	-0.10	**-0.22**	**-0.34**
Carry	**4.56**	1.61	**2.26**	**3.86**
Adjusted R2	0.34	0.30	0.36	0.31

	Brazilian real	Chilean peso	Colombian peso	Russian ruble	South African rand
Inflation surprise	**7.85**	**8.77**	3.71	**5.99**	**4.20**
ΔExpected inflation	-19.89	-7.53	-5.44	-10.22	4.43
Value	-0.10	**-0.61**	-0.14	-0.17	**-0.42**
Carry	0.16	**2.07**	-0.59	0.15	**3.95**
Adjusted R2	0.23	0.43	0.11	0.29	0.46

Source: PIMCO, Haver Analytics and Bloomberg. The regressions include a constant term as well as growth surprise. Inflation (growth) surprise is defined as the difference between realized one-year CPI inflation (GDP growth) and one-year-ahead SPF inflation (GDP growth) expectation. Change in expected inflation is defined as the difference between one-year-ahead SPF inflation expectations. Numbers in bold are statistically significant at 5% level.

Overall, the regressions in this section provide three results. First, commodities, TIPS and commodity currencies all provide inflation-hedging benefits while results for REITs are mixed. Second, it is important to distinguish between inflation surprise (pure price-level shocks) and changes in expected inflation (which could lead to Fed reaction and changes in real rates). Last, once we account for valuation, equity may have the potential to hedge against inflation surprise, leaving nominal bonds as the one major asset class that is more susceptible to inflation risk.

7. INFLATION-HEDGING PORTFOLIO

How do we hedge a portfolio for inflation? As we showed in the previous section, different assets have different inflation-hedging properties and different risk and return characteristics. Thus, instead of using one or two individual strategies, it might be beneficial to combine multiple strategies into a portfolio, which could lead to a higher Sharpe ratio with similar or even improved inflation-hedging properties. Formally, we consider the following optimization problem:

$$\max wR \tag{14}$$

subject to

$$w\beta^{inf} > \bar{\beta}^{inf} \tag{15}$$

$$\sum w_i \leq \bar{w} \tag{16}$$

$$w^T \Sigma w \leq \bar{\sigma} \tag{17}$$

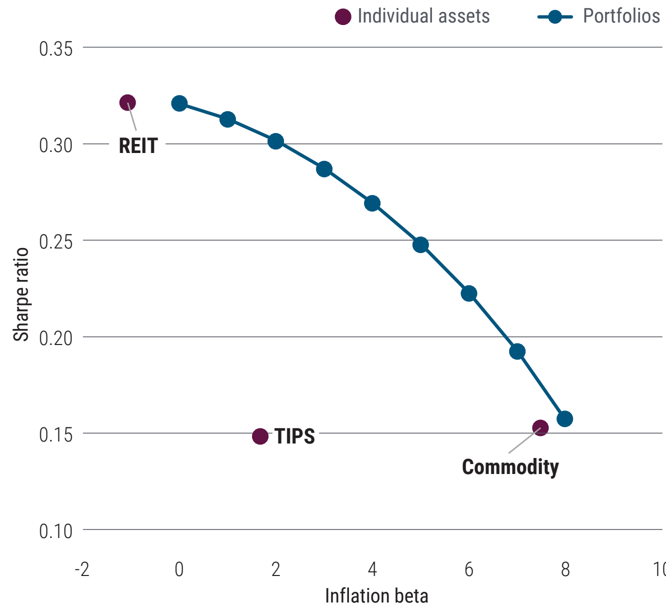
Equations 14 and 15 are the main objectives – maximize return while achieving a certain level of protection, specified by $\bar{\beta}^{inf}$.[27] Equations 16 and 17 are leverage and volatility constraints. One can also include additional constraints such as equity beta.

27 Depending on the regression specifications, there could be multiple inflation betas for an asset. For simplicity, we use only a single beta in the basic optimization problem but note that one can add in alternative beta measures as constraints.

In the following examples, we consider three assets that are typically used for inflation-hedging purposes: TIPS, commodities and REITs (for simplicity, we use the same index proxies shown above). For illustrative purposes, we consider the inflation beta with respect to inflation surprise, controlling for growth surprise (Equation 11 and Exhibit 26). For the optimization, we consider the following constraints: The portfolio can have 1) up to 30% leverage and 2) volatility less than 18%. Exhibit 27 plots the inflation beta versus the Sharpe ratio for optimal portfolios with different inflation beta targets, as well as for the three individual assets. The results highlight the benefit of the portfolio approach, as they show that the optimal portfolios have the potential to deliver better return and/or hedging benefits compared with individual asset classes.

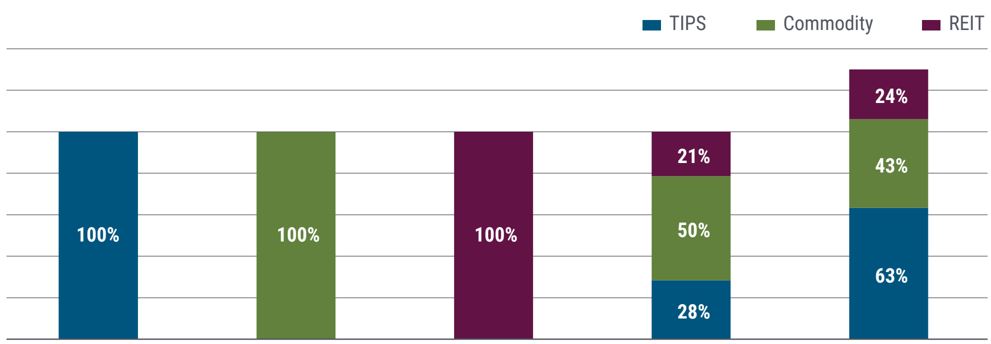
What do these optimal portfolios look like? Exhibit 28 shows the allocations and statistics for two optimal portfolios, as well as for the three individual assets. Both portfolios have a target inflation beta of 4, and one of them allows for a 30% leverage.[28] The exhibit shows that both optimal portfolios are well diversified and have improved return and/or hedging properties compared with the single assets.

Exhibit 27: Inflation versus Sharpe ratio for individual assets and portfolios



Source: PIMCO and Bloomberg as of 31 March 2021. **Hypothetical example for illustrative purposes only.** Exhibit is provided for illustrative purposes and is not indicative of the past or future performance of any PIMCO product.

Exhibit 28: Portfolio allocations



	TIPS	Commodity	REIT	Portfolio 1 (no leverage)	Portfolio 2 (30% leverage)
Estimated returns[1]	1.09%	3.02%	6.35%	3.19%	3.33%
Estimated volatility[2]	4.99%	17.48%	18.67%	12.00%	12.00%
Sharpe ratio[3]	0.15	0.15	0.32	0.24	0.25
Equity beta vs. S&P 500	0.02	0.66	0.89	0.53	0.51
Inflation beta	1.67	7.48	-1.07	4.00	4.00

1 For indices, return estimates are the five-year capital market assumption and 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.

2 See Appendix G for additional information regarding volatility estimates.

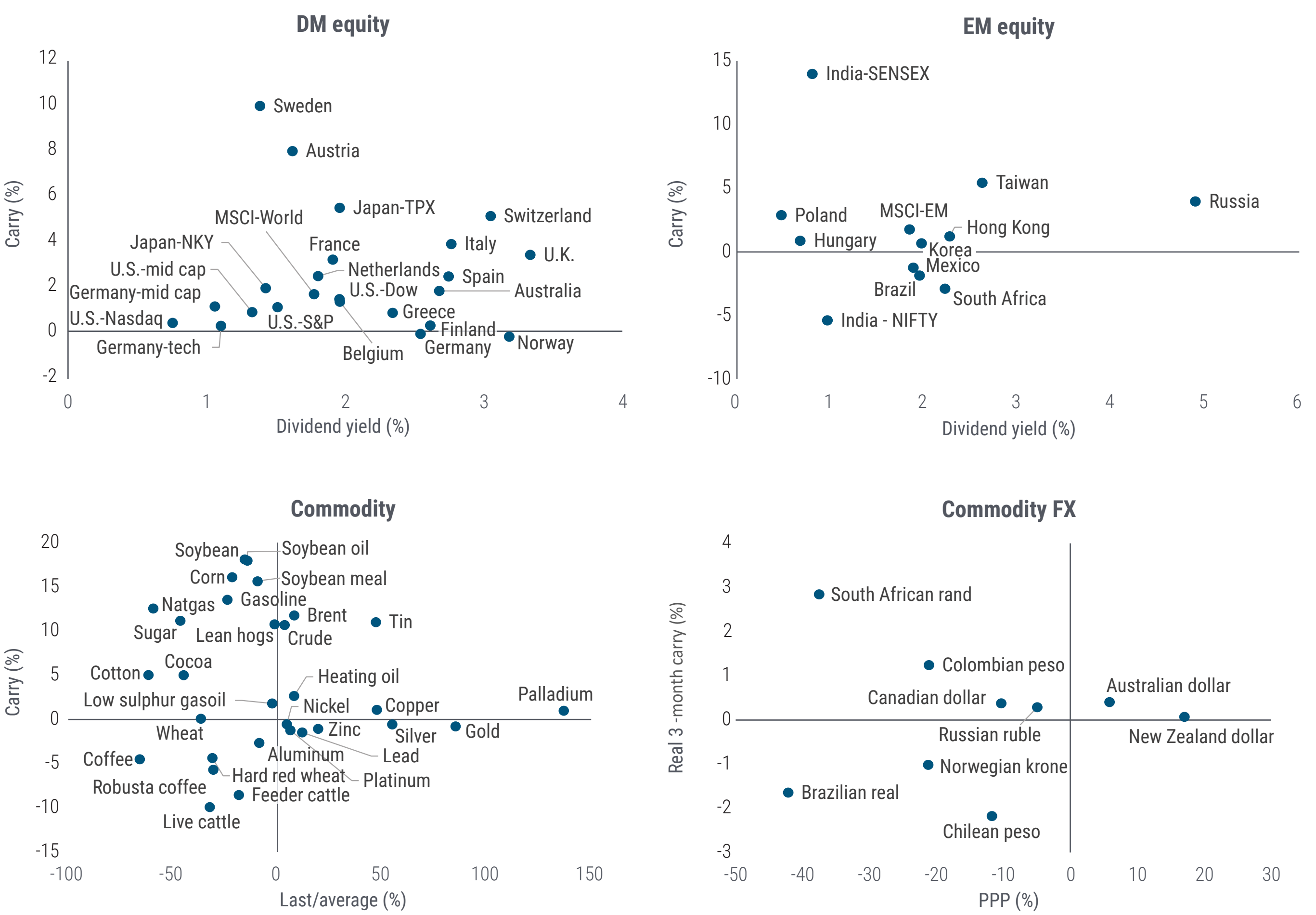
3 The Sharpe ratio is defined as (estimated portfolio return - estimated cash return) / estimated volatility. Estimated cash return = 0.35%.

Source: PIMCO and Bloomberg as of 31 March 2021. **Hypothetical example for illustrative purposes only.** The exhibit is provided for illustrative purposes and is not indicative of the past or future performance of any PIMCO product.

28 In the previous example (Exhibit 27), we allow the optimal portfolios to have higher volatility in order to have a better comparison with the individual assets (REIT and commodity); in this example, we choose a tighter volatility constraint of 12%.

As previously discussed, investors should be aware of valuation when thinking about an asset's inflation-hedging property, as an overvalued asset might not be able to deliver desirable hedging results if the force of mean reversion dominates. Exhibit 29 shows the current carry and value of different equity indices, commodities and commodity currencies. One simple modification that might potentially improve the portfolios shown in Exhibit 28 would be to tilt the commodity allocation toward individual commodities with higher carry and value (natural gas, corn, gasoline, etc.).

Exhibit 29: Carry and value for different assets



Source: PIMCO and Bloomberg as of 28 February 2021. See Appendix F for additional details on proxies.

7.1. Portfolio construction

Now that we have shown the benefit of the portfolio approach, the next question is what roles these assets could play in an investor's portfolio. Here, we look at the role of inflation-hedging assets in a more heuristic way and show how the optimal allocation differs under different scenarios. This approach can be summarized as follows (see Baz et al. (2021) for more details):

1. Construct a proxy for the world investible market portfolio, and calculate the capital asset pricing model (CAPM)-implied return of each asset class in the portfolio.[29]
2. Define four macro scenarios – growth/inflation higher/lower than the market consensus for the next five to 10 years. Under each scenario, we estimate the conditional estimated expected returns of each asset class and calculate the portfolio that achieves the highest Sharpe ratio.[30]
3. Average the four optimal portfolios using the subjective scenario probabilities to incorporate the investors' view.

Exhibit 30 shows the market weights of the 13 asset classes and their implied returns, and Exhibit 31 shows the four scenarios and their probabilities.

Exhibit 30: Asset classes and implied returns

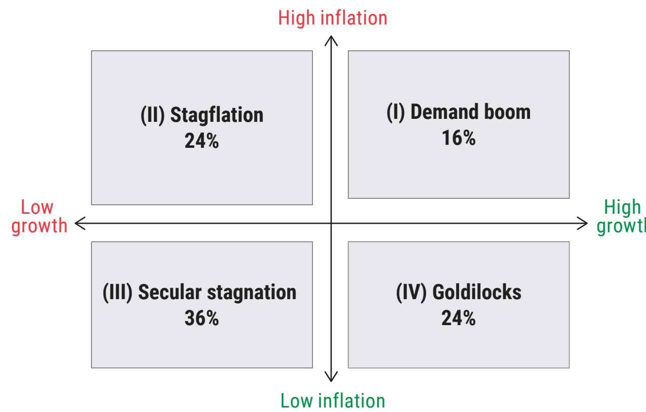
Asset classes	Market portfolio weight	Implied return
U.S. equity	23.7%	5.5%
Non-U.S. DM equity	15.6%	6.1%
EM equity	13.4%	7.3%
U.S. Aggregate	13.5%	0.4%
Global Aggregate ex-U.S.	21.0%	1.5%
Global high yield	1.7%	3.3%
Global ILB	1.8%	1.8%
Commodity	1.5%	4.9%
Real estate	4.0%	5.9%
Private equity	2.7%	8.1%
Private debt	0.5%	3.0%
Private infrastructure	0.4%	6.3%
Private natural resources	0.1%	8.6%

Source: PIMCO, Bloomberg, Preqin and GPR as of May 2021. **Hypothetical examples for illustrative purposes only.** Non-U.S. assets are unhedged. Appendix D provides a list of proxies for the assets. Exhibit is provided for illustrative purposes and is not indicative of the past or future performance of any PIMCO product.

29 Implied returns = $\lambda \Sigma w$ where w is the market capitalization weights and Σ is the covariance matrix. λ is a scaler, which is chosen such that the portfolio return is equal to that under PIMCO's capital market assumptions.

30 We assume the CAPM-implied returns are consistent with the market expectation of future real GDP growth and inflation; we then calculate the conditional returns using the CAPM-implied returns as well as the estimated sensitivities of risk factors to real GDP growth and inflation surprises.

Exhibit 31: Macroeconomic scenarios



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

The heat map in Exhibit 32 shows the changes in expected returns relative to the implied returns for different assets under each scenario. As expected, inflation-hedging assets such as global inflation-linked bonds (ILBs) and commodities have higher expected returns in the inflationary scenarios. However, a higher return does not necessarily translate to a higher optimal weight under that scenario. What matters most is relative returns across assets under each scenario. To calculate the optimal portfolios, we consider both long-only constraints and long-short constraints. Exhibit 32 shows the asset tilts with respect to the market portfolio under each scenario, as well as the probability-weighted average of the four scenarios.

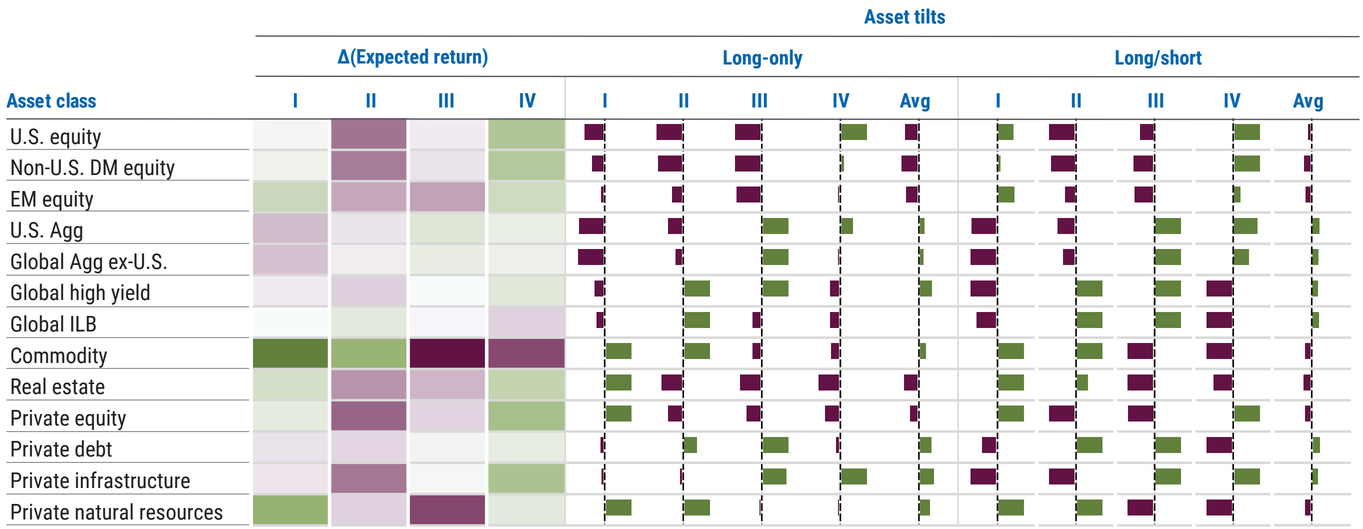
On the one hand, the long-short portfolio tilts toward global ILB and private debt.[31] On the other hand, while the long-only portfolio tilts toward commodity and private natural resources, the long-short portfolio tilts away from them.[32] Overall, these results show that inflation-hedging assets have an important role in the overall portfolio, even when the total probability of lower than expected inflation is high at 60%. Furthermore, we should note that these results reflect the current view on the macro scenarios, and the allocations are subject to change as the view evolves.[33]

31 The average long-short and long-only portfolios also tilt toward private infrastructure; however, this asset class receives higher weights under the low inflation scenarios (secular stagnation and Goldilocks).

32 The scenario-specific portfolios tilt away from commodities and natural resources in the low inflation scenarios (secular stagnation and Goldilocks). However, because the market weights on these assets are relatively small, the negative tilts in the long-only portfolios are limited, and the probability-weighted portfolio still overweights these assets. On the other hand, the negative tilts are larger in the long-short portfolios; as the total probability of low inflation scenarios is high at 60%, the probability-weighted portfolio tilts away slightly from commodities.

33 Appendix E provides an example of an alternative approach that focuses on the unconditional expected returns..

Exhibit 32: Expected returns and asset tilts under various scenarios



Source: PIMCO as of May 2021. **Hypothetical examples 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 A: MACROECONOMIC FOUNDATIONS FOR AGGREGATE DEMAND (AD) EQUATION

The AD equation stems from the households' demand for investments and from market-clearing. (Without specifying the full equilibrium model, we will assume that consumption equals output to close the formulation of the AD equation.)

Here, we use the utility function $u(c_t, n_t) = \frac{c_t^{1-\sigma}}{1-\sigma} - \theta n_t$, which is separable in consumption c_t and hours worked n_t. The household gets positive utility from consuming more and negative utility from working more.

Consider the usual problem facing households that must choose between consuming today and investing (here, in bonds that pay a real interest rate):

$$\max_{c_t, b_{t+1}} E_0 \left[\sum_{t=0}^{\infty} \beta^t u(c_t, n_t) \right].$$

Subject to the budget constraint that consumption plus bond investments (net of maturing bond investments from last period) must be less than or equal to income from work and interest payments from bonds,

$$c_t + b_{t+1} - b_t \leq w_t n_t + r_{t-1} b_t.$$

The Lagrangian for this problem is

$$L = E_0 \sum_{t=0} \beta^t \left(u(c_t, n_t) + \lambda_t (w_t n_t + (1 + r_{t-1}) b_t - c_t - b_{t+1})\right).$$

Setting the derivative of L with respect to c_t to zero gives the first-order optimality condition for consumption:

$$u_c(c_t) = \lambda_t.$$

Note that $u_c(c_t)$ represents the partial derivative of the utility function with respect to consumption. Setting the derivative of L with respect to b_{t+1} to zero gives the first-order optimality condition for choice of bonds:

$$\lambda_t = \beta(1 + r_t) E_t[\lambda_{t+1}].$$

Combining the two first-order conditions results in another representation for the optimal choice of bonds:

$$u_c(c_t) = \beta\big[(1 + r_t) E_t[u_c(c_{t+1})]\big].$$

Note that under our utility specification $u_c(c_t) = c_t^{-\sigma}$ or, dropping expectation for now, $c_t^{-\sigma} = \beta[(1 + r_t) c_{t+1}^{-\sigma}]$. Taking logs and rearranging:

$$\sigma \ln(c_{t+1}) - \sigma \ln(c_t) = \ln(\beta) + \ln(1 + r_t).$$

Next we take a first-order Taylor expansion around the steady state. Steady state corresponds to the choice of consumption that would occur absent uncertainty (a constant determined in equilibrium, not fully specified here, as we're only working with the households' problem):

$$\begin{aligned} \sigma \ln(c) + \frac{\sigma}{c}(c_{t+1} - c) - \sigma \ln(c) - \frac{\sigma}{c}(c_t - c) \\ = \ln(\beta) + \ln(1 + r) + \frac{1}{1 + r}(r_t - r). \end{aligned}$$

Note that in steady state of this simple example $1 + r = \frac{1}{\beta}$ means $\ln(1 + r) = -\ln(\beta)$. Here, we denote hatted variables as percent deviation from steady state $\hat{c}_{t+1} = \frac{c_{t+1} - c}{c}$ and also add expectations to time $t + 1$ variables:

$$E_t[\hat{c}_{t+1}] - \hat{c}_t = \frac{1}{\sigma(1 + r)}(r_t - r).$$

If we assume that all output is consumed, so that $\hat{c}_t = \hat{y}_t$, we get the familiar AD equation in

$$\hat{y}_t = E_t[\hat{y}_{t+1}] - \frac{1}{\sigma(1 + r)}(r_t - r).$$

This loosely maps to the usual AD equation. If steady state corresponds to potential output, then the hatted variables correspond to the output gap, so we get the usual form that relates the real interest rate to economy-wide output:

$$y_t - y_t^* = E_t[y_{t+1} - y_{t+1}^*] - \gamma(r_t - r_t^*).$$

APPENDIX B: INFLATION RISK PREMIA

Consider an agent choosing the amount of nominal bonds they purchase to optimize utility:

$$\max_{B_t} u(C_t) + E_t \beta u(C_{t+1})$$

subject to:

$$C_t = E_t - B_t$$

$$\Pi_{t+1}\, C_{t+1} = B_t I$$

where C_t is the real consumption at t, E_t is the initial real endowment, B_t is the amount of nominal bonds purchased (B_t is the control variable), Π_{t+1} is the (stochastic) gross rate of inflation between t and $t + 1$, and I is the (known) gross nominal interest rate. Then the first-order condition dictates that:

$$u'(C_t) = E_t\left[\beta u'(C_{t+1}) \frac{I}{\Pi}\right]$$

or

$$E_t\left(\frac{M_{t+1}}{\Pi}\right) = I^{-1}$$

with the stochastic discount factor $M_{t+1} \stackrel{\text{def}}{=} \frac{\beta u'(C_{t+1})}{u'(C_t)}$. Consider the case of log utility:

$$u(C) = \log(C).$$

In this case, $M_{t+1} = \beta\left(\frac{C_{t+1}}{C_t}\right)^{-1}$. Now define log consumption growth $\log \frac{C_{t+1}}{C_t} = g_{t+1}$ and log inflation $\log \Pi_{t+1} = \pi_{t+1}$, and assume that log consumption growth and log inflation are jointly lognormally distributed:

$$\begin{bmatrix} g_{t+1} \\ \pi_{t+1} \end{bmatrix} \sim N\left(\begin{bmatrix} \mu_c \\ \mu_\pi \end{bmatrix}, \begin{bmatrix} \sigma_c^2 & \sigma_{c\pi} \\ \sigma_{c\pi} & \sigma_\pi^2 \end{bmatrix}\right).$$

Thus, the first-order condition $E_t\left(\frac{M_{t+1}}{\Pi}\right) = I^{-1}$ can be rewritten as:

$$\begin{aligned} \log I^{-1} = -\, i = \log E_t\left(M_{t+1} \frac{1}{\Pi_{t+1}}\right) \\ = \log \beta E_t[\exp(-g_{t+1} - \pi_{t+1})]. \end{aligned}$$

With the lognormal assumption, we arrive at the following equation for the log nominal interest rate:

$$i = -\log\beta + \mu_c - \frac{1}{2}\sigma_c^2 + \mu_\pi - \frac{1}{2}\sigma_\pi^2 - \sigma_{c\pi}.$$

This can be rewritten as (real interest rate $r = -\log E[M_{t+1}]$):

$$i - r - E[\pi] = -\frac{1}{2}(\sigma_\pi^2 + 2\sigma_{c\pi}) = -\frac{1}{2}(\sigma_\pi^2 + 2\sigma_{c\pi} + \sigma_c^2 - \sigma_c^2).$$

Note that $\sigma_\pi^2 + 2\sigma_{c\pi} + \sigma_c^2 = Var(\pi + c)$, or the variance of nominal consumption growth. Suppose breakeven inflation captures the difference between nominal and real rates. Then it implies:

$$\text{Breakeven} - \text{expected inflation} = -\frac{\text{Var(Nominal growth)} - \text{Var(Real growth)}}{2}.$$

APPENDIX C: ADDITIONAL REGRESSION RESULTS

Exhibit A1 shows the results from the following regression:

$$\text{excess return between t and t+1} = \alpha + \beta_1(\text{expected inflation}) + \beta_2(\text{inflation surprise}) + \varepsilon_{t+1}.$$

APPENDIX D: PROXIES FOR RISK MODELING

Asset classes	Proxy
U.S. equity	Russell 3000 Index
Non-U.S. DM equity	MSCI World ex USA Index
EM equity	MSCI Emerging Markets Index
U.S. Aggregate	Bloomberg Barclays US Aggregate Bond Index
Global Aggregate ex-U.S.	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
Private infrastructure	PIMCO private infrastructure model
Private natural resources	PIMCO private natural resource model

The risk factor exposures for the private natural resources model are estimated through a regression on the Cambridge Private Equity Index. Industry exposures are mapped to the exposure of the S&P Energy index. We unsmooth returns to remove the bias from accounting-based reporting.

Exhibit A1: Regression results

	Equity	Commodity	Treasury	TIPS	REIT
Constant	**0.11**	0.05	**0.04**	**0.16**	0.09
Expected inflation	-0.85	-1.06	-0.30	**-6.46**	-0.20
Inflation surprise	-1.73	**7.67**	**-1.27**	0.83	-1.08
R2	0.04	0.41	0.25	0.18	0.00

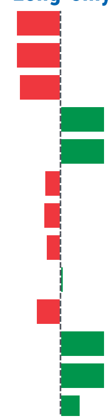
Source: PIMCO and Bloomberg as of 30 April 2021. Numbers in bold are statistically significant at 5% level.

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

Suppose that instead of views on scenarios, the investor instead has views on the expected returns of the various assets. In this case, they can blend their views with information from the market portfolio to come up with a set of blended expected returns (Black and Litterman (1992)). Exhibit A2 shows an example using PIMCO's capital market assumptions (CMAs) as the subjective views. In this case, the inflation-hedging assets, such as global ILB and commodity, become less attractive and the portfolio tilts away from these assets.

Exhibit A2: The Black-Litterman model

Asset class	Market portfolio	Implied returns	Sample CMAs	Blended returns	Asset tilts Long-only
U.S. equity	23.7%	5.5%	5.3%	5.4%	
Non-U.S. DM equity	15.6%	6.1%	5.9%	6.0%	
EM equity	13.4%	7.3%	6.2%	6.8%	
U.S. Agg	13.5%	0.4%	1.0%	0.7%	
Global Agg ex-U.S.	21.0%	1.5%	2.1%	1.8%	
Global high yield	1.7%	3.3%	2.8%	3.0%	
Global ILB	1.8%	1.8%	1.2%	1.5%	
Commodity	1.5%	4.9%	3.0%	3.9%	
Real estate	4.0%	5.9%	6.5%	6.2%	
Private equity	2.7%	8.1%	8.8%	8.4%	
Private debt	0.5%	3.0%	5.9%	4.5%	
Private infrastructure	0.4%	6.3%	7.5%	6.9%	
Private natural resources	0.1%	8.6%	9.8%	9.2%	



Source: PIMCO as of March 2021. **Hypothetical example for illustrative purposes only.** Exhibit is provided for illustrative purposes and is not indicative of the past or future performance of any PIMCO product.

APPENDIX F: EQUITY PROXIES

Equity indices are as follows: U.S. - S&P is the S&P 500 index, U.S. - Dow is the Dow Jones Industrial Average index, U.S. - mid cap is the S&P MidCap 400 Index, U.S. - Nasdaq is the Nasdaq-100 index, Australia is the S&P/ASX 200 index, Austria is the Austrian Traded Index, France is the CAC index, Finland is the OMX Helsinki 25, Germany - tech is the TecDAX index, Japan - NKY is the Nikkei 225 index, Norway is the OBX Index, Greece is the FTSE/Athex Large Cap index, Italy is the FTSE MIB index, Switzerland is the Swiss Market Index, Netherlands is the AEX index, Germany - mid cap is the MDAX index, MSCI - World is the MSCI World index, Japan - TPX is the Tokyo Stock Price Index, Belgium is the BEL 20 index, U.K. is the FTSE 100 Index, Germany is the DAX index, Sweden is the OMX Stockholm 30 index, Spain is the IBEX 35 index, Hong Kong is the Hang Seng Index, Korea is the KOSPI 200 Index, Poland is the WIG20 index, Mexico is the S&P/BMV IPC index, South Africa is the FTSE/JSE Top40 Index , India - SENSEX is the BSE SENSEX index, Brazil is the Bovespa Index, Russia is the RTS Index, Taiwan is the Taiwan Capitalization Weighted Stock Index, Hungary is the Budapest Stock Exchange Budapest Stock Index, India - NIFTY is the NIFTY 50 index, and MSCI - EM is the MSCI Emerging Markets Index.

APPENDIX G: ESTIMATED VOLATILITY FOR EXHIBIT 28

We employ a block bootstrap methodology to calculate volatilities. We start by computing historical factor returns that underlie each asset class proxy from January 1997 through the present date. We then draw a set of 12 monthly returns within the dataset to produce an annual return number. This process is repeated 25,000 times to have a return series with 25,000 annualized returns. The standard deviation of these annual returns is used to model the volatility for each factor. We then use the same return series for each factor to compute covariance between factors. Finally, volatility of each asset class proxy is calculated as the sum of variances and covariance of factors that underlie that particular proxy. For each asset class, index or strategy proxy, we will look at either a point in time estimate or a historical average of factor exposures in order to determine the total volatility. Please contact your PIMCO representative for more details on how specific proxy factor exposures are estimated.

The analysis contained in this paper is based on hypothetical modeling. 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 or strategy.

One of the limitations of hypothetical performance results is that they are generally prepared with the benefit of hindsight. In addition, hypothetical trading or modeling does not involve financial risk, and no hypothetical example 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, all of which can adversely affect actual results. No guarantee is being made that the stated results will be achieved.

The allocation models presented here are based on what PIMCO believes to be generally accepted investment theory. They are for illustrative purposes only and may not be appropriate for all investors. The allocation models are not based on any particularized financial situation, or need, and are not intended to be, and should not be construed as, a forecast, research, investment advice or a recommendation for any specific PIMCO or other strategy, product or service. Individuals should consult with their own financial advisors to determine the most appropriate allocations for their financial situation, including their investment objectives, time frame, risk tolerance, savings and other investments.

Figures are provided for illustrative purposes and are not indicative of the past or future performance of any PIMCO product.

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.

We employed a block bootstrap methodology to calculate volatilities. We start by computing historical factor returns that underlie each asset class proxy from January 1997 through the present date. We then draw a set of 12 monthly returns within the dataset to come up with an annual return number. This process is repeated 25,000 times to have a return series with 25,000 annualized returns. The standard deviation of these annual returns is used to model the volatility for each factor. We then use the same return series for each factor to compute covariance between factors. Finally, volatility of each asset class proxy is calculated as the sum of variances and covariance of factors that underlie that particular proxy. For each asset class, index, or strategy proxy, we will look at either a point in time estimate or historical average of factor exposures in order to determine the total volatility. Please contact your PIMCO representative for more details on how specific proxy factor exposures are estimated.

All investments contain risk and may lose value. **Equities** may decline in value due to both real and perceived general market, economic and industry conditions. 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. Investing in **foreign-denominated and/or -domiciled securities** may involve heightened risk due to currency fluctuations, and economic and political risks, which may be enhanced in **emerging markets**. **Inflation-linked bonds (ILBs)** issued by a government are fixed income securities whose principal value is periodically adjusted according to the rate of inflation; ILBs decline in value when real interest rates rise. **Treasury Inflation-Protected Securities (TIPS)** are ILBs issued by the U.S. government. **Sovereign securities** are generally backed by the issuing government. Obligations of U.S. government agencies and authorities are supported by varying degrees, but are generally not backed by the full faith of the U.S. government. Portfolios that invest in such securities are not guaranteed and will fluctuate in value. **High yield, lower-rated securities** involve greater risk than higher-rated securities; portfolios that invest in them may be subject to greater levels of credit and liquidity risk than portfolios that do not. **Commodities** contain heightened risk, including market, political, regulatory and natural conditions, and may not be appropriate for all investors. The **value of real estate** and portfolios that invest in real estate may fluctuate due to: losses from casualty or condemnation, changes in local and general economic conditions, supply and demand, interest rates, property tax rates, regulatory limitations on rents, zoning laws, and operating expenses. **REITs** are subject to risk, such as poor performance by the manager, adverse changes to tax laws or failure to qualify for tax-free pass-through of income. **Private credit** 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. **General risks about private equity and hedge fund strategies:** The strategies involve a high degree of risk and prospective investors are advised that these strategies are suitable only for persons of adequate financial means who have no need for liquidity with respect to their investment and who can bear the economic risk, including the possible complete loss, of their investment. Investors should **consult their investment professional** prior to making an investment decision.

Bloomberg Barclays Global Aggregate ex-USD Index provides a broad-based measure of the global investment-grade fixed income markets. The major components of this index are the Pan-European Aggregate and the Asian-Pacific Aggregate Indices. The index also includes Eurodollar and Euro-Yen corporate bonds and Canadian Government securities. **Bloomberg Barclays Global High Yield Index** is a component of the Multiverse Index, along with the Global Aggregate index. It represents the U.S. High-Yield, Pan-European High-Yield, U.S. Emerging Markets High-Yield, CMBS High-Yield, and Pan-European Emerging Markets High-Yield indices. **Bloomberg Barclays U.S. Aggregate Index** represents securities that are SEC-registered, taxable, and dollar denominated. The index covers the U.S. investment grade fixed rate bond market, with index components for government and corporate securities, mortgage pass-through securities, and asset-backed securities. These major sectors are subdivided into more specific indices that are calculated and reported on a regular basis. **Bloomberg Barclays US Treasury Inflation-Linked Bond Index** measures the performance of the US Treasury Inflation Protected Securities (TIPS) market. Federal Reserve holdings of US TIPS are not index eligible and are excluded from the face amount outstanding of each bond in the index. **Bloomberg Barclays U.S. Treasury Index** is a measure of the public obligations of the U.S. Treasury. **Bloomberg Barclays World Government Inflation-Linked All Maturities Bond Index** measures the performance of the major government inflation-linked bond markets. The index is designed to include only those markets in which a global government linker fund is likely to invest. This makes investability a key criterion for inclusion in the index. Markets currently included in the index (in the order of age) are, the UK (1981), Australia (1985), Canada (1991), Sweden (1994), U.S. (1997), France (1998) and Italy (2003). **Bloomberg Commodity Index** is an unmanaged Index composed of futures contracts on a number of physical commodities. The index is designed to be a highly liquid and diversified benchmark for commodities as an asset class. The futures exposures of the benchmark are collateralized by US T-bills. **FTSE National Association of Real Estate Investment Trusts (NAREIT) Equity Index** is an unmanaged market weighted index of tax qualified REITs listed on the New York Stock Exchange, American Stock Exchange and the NASDAQ National Market System, including dividends. **MSCI World ex-USA Index** captures large and mid-cap representation across 22 of 23 Developed Markets (DM) countries, excluding the United States. With 964 constituents, the index covers approximately 85% of the free float-adjusted market capitalization in each country. **MSCI Emerging Markets Index** captures large and mid-cap representation across 27 Emerging Markets (EM) countries. With 1,397 constituents, the index covers approximately 85% of the free float-adjusted market capitalization in each country. The **Russell 3000 Index** is an unmanaged index generally representative of the U.S. market for large domestic stocks as determined by total market capitalization, which represents approximately 98% of the investable U.S. equity market. **S&P 500 Index** is an unmanaged market index generally considered representative of the stock market as a whole. The Index focuses on the large-cap segment of the U.S. equities market. It is not possible to invest directly in an unmanaged index.

Real Estate is a custom model is designed to mimic the risk and return characteristics of an investment in levered, private opportunistic real estate based on the corresponding indices from Preqin and Cambridge Associates. Note that historical volatility on illiquid assets is understated as they are not regularly marked to market. **Private Equity** is a custom model where risk factor exposures are estimated through a regression on the Cambridge Private Equity Index. Adjustments are made to equity risk and liquidity consistent with empirical research on private equity managers. Note that historical volatility on illiquid assets is understated as they are not regularly marked to market. **Private Credit** is a custom model that represents an investment in broadly diversified private credit assets. This includes levered and unlevered exposures to residential credit, consumer finance, specialty accounts receivables financing, commercial real estate debt and private corporate lending. Note that historical volatility on illiquid assets is understated as they are not regularly marked to market. Private Infrastructure is a custom model is designed to mimic the risk and return characteristics of an investment in private infrastructure. Note that historical volatility on illiquid assets is understated as they are not regularly marked to market. **Custom models:** Models are provided as a proxy for asset classes where a market index is not available and are not intended or generally made available for investment purposes.

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