PGIM QUANTITATIVE SOLUTIONS

PORTFOLIO IMPLICATIONS OF A HIGHER US INFLATION REGIME

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AUTHORS

Lorne Johnson, PhD
Managing Director and
Head of Multi-Asset Portfolio Design

Marco Aiolfi, PhD
Managing Director and
Co-Head of Multi Asset

John Hall, CFA
Vice President and Portfolio Manager

George Patterson, PhD
CIO

Manoj Rengarajan, CFA
Principal and Portfolio Manager

Yesim Tokat-Acikel, PhD
Managing Director, Head of Multi-Asset
Research and Co-Head of ESG

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To learn more about our capabilities, please contact PGIM Quantitative Solutions by email at contactus@pgim.com or by phone in the US at +1 (866) 748-0643 or in the UK at +44 (0) 20-7663-3400

Executive Summary

In 2021 the rate of inflation in the US rose to 7.0%, the highest rate for any year since 1981. While most professional forecasters, including most members of the Federal Reserve (Fed), anticipate a reversion to the low inflation observed since the mid-1990s by 2023, there is a non-trivial probability that inflation and inflation uncertainty could stay elevated for at least the next few years. If such an environment were to persist, investors should be alert to the dynamics higher inflation introduces into the broader economy and ultimately, into asset returns. To evaluate the potential impact of a regime of higher inflation on portfolio returns, we look at both historical and forward-looking portfolio outcomes, assuming inflation remains elevated for the next five years. Traditional allocations to equities and bonds in an environment of elevated and uncertain inflation are likely to perform poorly in nominal and particularly in real terms. Investors should consider larger allocations to asset classes with a positive direct exposure to inflation, such as commodities and real estate, given their historical strength in high-inflation environments.

For Professional Investors only.

All investments involve risk, including the possible loss of capital.

I. Introduction

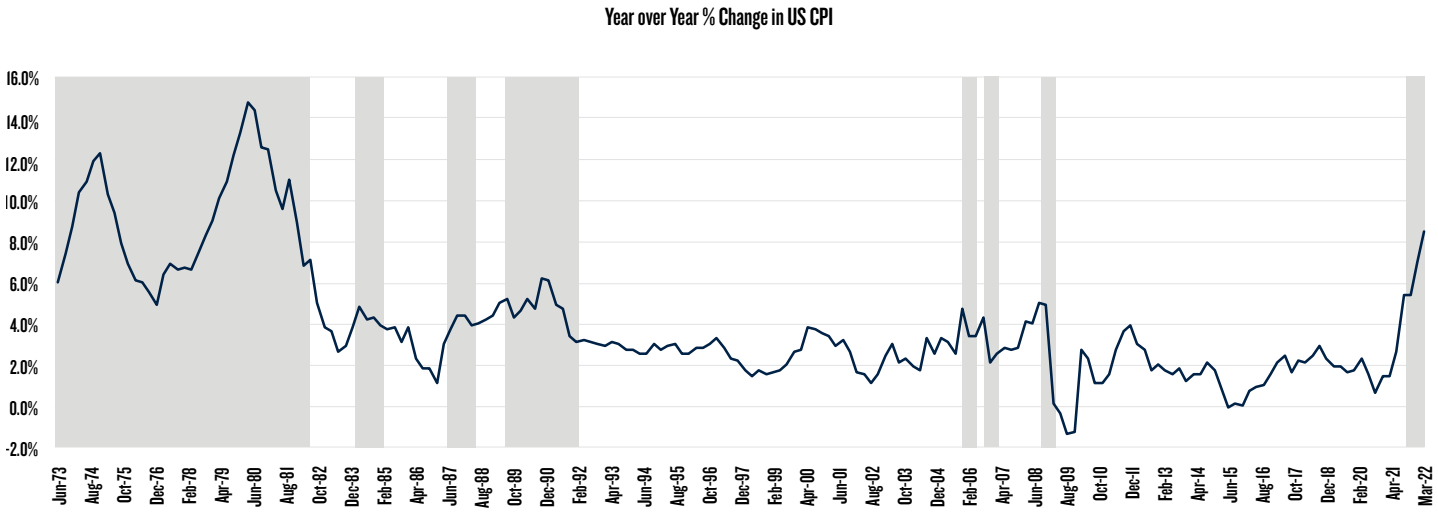
The US and developed market economies are experiencing the highest levels of inflation in more than a generation. Year-over-year headline Consumer Price Index (CPI) inflation in the US stood at 8.5% through March 2022, the highest level since December 1981. More persistent core inflation, which strips out volatile food and energy components, was at 6.5% in the same report. Bond yields have surged and asset classes have repriced in response to the seismic shift in the inflation regime. Historically, periods of high inflation have corresponded with very different return outcomes across asset classes than those witnessed over the last thirty years. In fact, prior to the COVID-19-induced downturn in 2020, sustained levels of inflation greater than 4% have been non-existent since the early 1990s.

The rise in US inflation through the end of 2021 was largely a demand-driven affair. Multiple rounds of generous fiscal stimulus and accommodative monetary policy to address the COVID-19 economic slowdown substantially bolstered household balance sheets. In a recent paper from the San Francisco Fed, Jorda et al (2022) estimate the impact of fiscal support measures alone increased US inflation by about 3% in 2021. With service spending options initially limited by pandemic restrictions, consumers instead shifted their spending to goods with relatively inelastic supply, resulting in large price rises in categories like used vehicles and furniture, which advanced by 37% and 14% respectively in 2021. As state governments relaxed pandemic restrictions throughout 2021, service spending and transportation demand also rebounded sharply, resulting in rises of 50% and 36% for gasoline and rental cars in 2021 following large price declines in 2020.

As of March 2022, the trajectory of US inflation appears to be heading even higher in the short term as the Russian invasion of Ukraine and resultant sanctions by the US and other aligned governments sent commodity prices surging higher. In contrast to the demand-driven inflation described earlier, the sharp rise in commodity prices thus far in 2022 constitutes an untimely supply shock in an already elevated inflation environment. In response, the Fed revised its full-year 2022 PCE[1] inflation forecast from December 2021 to March 2022 from 2.6% to 4.3% and is now forecasting the policy rate to end 2022 at 1.9% versus 0.9% in December.

Looking forward, the Fed[2] projects US inflation to moderate materially, declining to 2.7% in 2023 and to 2% in the longer run, consistent with a view held by many that the current level of elevated inflation is transitory and not endemic. While a reversion to the Fed's 2% target is a possibility, there are additional near-term pipeline pressures that could work to keep inflation higher for an extended period. Single-family housing prices, which advanced 19.1%[3] for the year through January 2022, have yet to pass through meaningfully into the shelter component of CPI, which makes up approximately one-third of the index. Historically owners' equivalent rent has held a 67% correlation with lagged housing prices as reported by Arnott and Shakernia (2021), suggesting this component of inflation is likely to accelerate for a time going forward. Additionally, hourly wages advanced 5.6% through March 2022 with expectations that the rate of wage growth will move higher as the pace still considerably lags the current rate of inflation. In this scenario, employers will either need to absorb the wage hikes or pass them on to customers to protect margins.

Figure I: Year over Year % Change in US CPI Q2 1973 - Q1 2022



Source: US Bureau of Labor Statistics. Data as of 3/31/2022.

[1] Personal Consumption Expenditures Price Index
[2] Federal Reserve Summary of Economic Projections, March 16, 2022
[3] S&P CoreLogic Case-Shiller Home Price Index

Asset owners have become accustomed to investing amid relatively low inflation during the last thirty years. However, they are likely to confront more challenging portfolio outcomes in the presence of higher inflation. Our evaluation of nearly the last 50 years of US asset returns reveals very different outcomes for a range of public-market asset classes in regimes of elevated inflation versus what has been experienced from the early 1990s through 2020. To consider the forward-looking implications of such a regime, we modify our Capital Market Assumptions (CMA) framework to forecast asset class outcomes, assuming an average level of inflation of 5% for the next five years.[4] Without making a specific forecast as to what the level of inflation will be over the next several years, a deeper understanding of the implications of this scenario of elevated inflation persisting for several years on the expected returns of primary asset classes and the interactions between them could potentially help investors better position their portfolios.

II. Characteristics of Higher Inflation Economies

While the simultaneous demand-driven and supply-shock catalysts of today's inflationary environment could easily prove transitory, how policy makers and economic agents respond to inflation in the coming months will surely influence both inflation expectations and the probability that a regime of higher inflation becomes more endemic.

> Higher Inflation ➔ Higher Inflation Uncertainty (volatility) ➔ Higher Interest Rates (including more pronounced term premium) ➔ Higher Interest Rate Volatility ➔ Less Predictable Monetary Policy ➔ Higher Economic Uncertainty ➔ Lower Economic Growth

Historically, low and stable inflation, along with anchored inflation expectations, have been associated with greater short-term stability of economic output and higher long-term growth. In contrast, persistently high-inflation environments with unanchored inflation expectations have been associated with weak economic activity in the short-term and lower growth in the medium- to long-term. Persistently high inflation and inflation uncertainty distorts relative prices and creates uncertainty that discourages savings by households and impacts long-term decision making by businesses.

High-inflation environments are associated with higher volatility in inflation across both developed and emerging economies. A high- and volatile-inflation environment makes it extremely difficult for households and businesses to discern absolute price changes from relative price changes, thereby increasing uncertainty. High and volatile inflation also signal an inability for monetary and fiscal policies to ensure economic stability. These scenarios increase uncertainty about the future and discourage real investments. These are reflected in the financial markets via increased term premiums and higher interest rates. Similar to higher volatility in inflation during periods of higher levels of inflation, interest-rate volatility is also higher during periods when rates themselves have been high. For example, volatility of 10-year rates during the period from 1965-2000 was twice that of the subsequent 2000-2020 period.

In the presence of greater uncertainty around the future path of inflation, monetary policy becomes less predictable for both market participants and economic actors. Central banks are therefore more constrained in their ability to provide meaningful forward guidance, unlike during periods of stable/low inflation. Consequently, the odds of a negative monetary policy surprise also increase. Expansionary fiscal policy, which in many instances has been one of the drivers of higher inflation, will likely be unsustainable. As a result of these uncertainties, economic growth comes under pressure. If the uncertainties persist, inflation expectations – both among households and businesses – ultimately get unanchored. Wage-price spirals typically develop in such prolonged high-inflation environments, ultimately forcing significant abrupt monetary policy tightening which can result in sharp output losses and more frequent recessions.

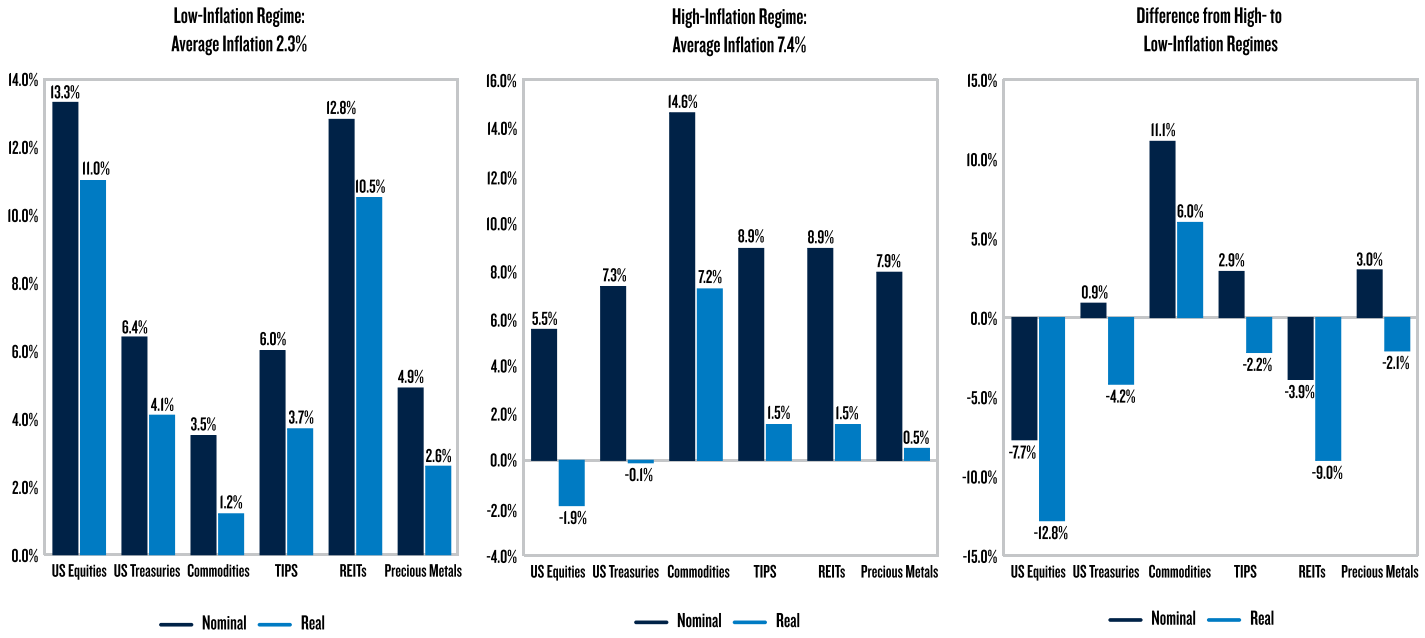
III. Observations on Historical Asset Price Behavior during Periods of Elevated Inflation

In a wide-ranging study Neville et al (2021) observe highly divergent outcomes for asset classes in high-inflation environments, which they define as periods when inflation is accelerating and/or greater than 5% annually since 1926. They find that financial assets, such as stocks and bonds, experience negative real returns in the high-inflation periods, while real assets, such as commodities, perform much better.

Our own evaluation of asset class performance during the period from 1973 to 2021, building on the results presented in Brundage et al (2021), finds that high-inflation regimes[5] correspond to comparably subdued returns for equities and nominal bonds relative to commodities. As presented in Table 1, in real terms, both equity and nominal bond returns are negative in periods where inflation is above 4%, while inflation hedging assets, such as Treasury Inflation-Protected Securities (TIPS), Real Estate Investment Trusts (REITs), precious metals, and commodities provide positive real returns. Commodities stand out with markedly improved nominal and real returns in the high-inflation regime versus the low-inflation regime.

[4] There can be no assurance that these forecasts/projections will be achieved.
[5] Defining a high-inflation regime as one where the annual price level is growing at greater than 4%.

Figure 2: Historical Return Outcomes in Low- and High-Inflation Regimes Q2 1973-Q4 2021



Sources: Datastream, Bloomberg, FactSet, PGIM Quantitative Solutions. Data as of 12/31/2021.

Understanding Asset Class Performance in Inflationary Regimes

Equities

Although the Fisher Model (1930) suggests that equities and nominal assets generally should provide a near-perfect inflation hedge, numerous studies have established a near-term negative relationship between inflation levels and surprises in equity market performance. Fama (1981) empirically confirms this negative relationship at monthly, quarterly, and annual horizons and hypothesizes it is attributable to the impact inflation has on the real variables that drive equity pricing. Boudoukh et al. (1994) also identify a negative relationship at shorter horizons both at the aggregate level and cross-sectionally for most equity market sectors but confirm a long run positive relationship between equity market performance and inflation.

While our evaluation here is limited to US equities, Neville et al (2021) find similar near-term negative dynamics for developed market equities in the UK and Japan in their survey of asset class performance during periods of elevated inflation. In the current environment, where the latest surge in anticipated inflation is dominated by a global supply shock to commodities, we expect even more commonality in the behavior of developed non-US and US equities.

Nominal Bonds

Nominal bond yields have a real component as well as an expected inflation component. As inflation expectations change, the inflation component of the yield, often called "the breakeven rate" adjusts. When inflation surprises to the upside, breakeven rates rise and bond prices decline, with prices declining more the higher the duration of the bonds. In the presence of higher inflation uncertainty, which generally accompanies higher rates of inflation, there is also likely to be a further rise in yields due to an increased term premium to protect longer-duration investors from inflation surprises. Ilmanen (2011) alternately calls this increased term premium an "Inflation Risk Premium" (IRP) and estimates it to have been as high as 3%-4% in the early 1980s before falling close to zero in the 2000s when the level of inflation uncertainty subsided. In general, nominal bond investors will suffer as inflation expectations in the market adjust higher and benefit as inflation expectations come down, with a further positive tailwind if inflation uncertainty coincidently adjusts lower.

Real Assets

We define real assets as assets that are understood to have inflation hedging properties, even if they have no "real" component as would a physical asset. TIPS, REITs, precious metals, and a diversified portfolio of commodities have all performed better historically than equities and nominal bonds in real terms during regimes of higher inflation, though there is a wide dispersion in outcomes among these real assets. Only commodities have performed better in both nominal and real terms in higher-inflationary periods versus low-inflation periods. TIPS and precious metals both have better nominal returns in higher-inflation periods than in lower-inflation periods, though lower real returns. REITs, while still delivering positive real returns in higher-inflation periods, underperform on both a nominal and real-return basis compared to their performance in lower-inflation periods.

Precious metals, specifically gold and silver, have historically been used as means to back currencies at fixed proportions, contributing to inflation (deflation) when the supply of the backing metals grew faster (slower) than output. With nearly all modern currencies now on a fiat standard, precious metals have more recently been considered an alternative store of value when the value of a currency is depreciating, particularly in high-inflation environments.

Correlations

In addition to divergent outcomes for asset class returns in high- and low-inflation regimes, the relationship between asset classes as measured by correlation also shows considerable divergence across regimes as presented in Table 1. The evolution of stock/bond correlations from positive in the period from the 1970s and 1980s to negative in the period since is investigated thoroughly in Shen and Weisberger (2021) and is consistent with our results in high- and low-inflation regimes: a positive correlation of 0.3 exists between US Treasuries and equities during periods of high inflation and a negative correlation of -0.3 during periods of lower inflation. Also notable is the behavior of some other asset class pairs. For example, in low-inflation periods, commodities have a positive correlation of 0.3, though in high-inflation periods they provide a diversifying exposure to equities with a correlation of -0.3.

Table 1: Full Sample Correlations and Conditional Correlations by Inflation Regime - Q2 1973-Q4 2021

Full Sample

Asset Class	US Treasuries	US Investment Grade Bonds	US Equities	TIPS	Commodities	REITs	Precious Metals
US Treasuries	1.00	0.65	-0.06	0.77	-0.20	0.03	0.03
US Investment Grade Bonds		1.00	0.44	0.70	-0.03	0.47	0.05
US Equities			1.00	0.08	-0.01	0.65	0.00
TIPS				1.00	0.10	0.17	0.23
Commodities					1.00	0.10	0.42
REITs						1.00	0.06
Precious Metals							1.00

Low Inflation (Yellow)/Elevated Inflation (Blue)

Asset Class	US Treasuries	US Investment Grade Bonds	US Equities	TIPS	Commodities	REITs	Precious Metals
US Treasuries	1.00	0.84	0.26	0.89	-0.14	0.23	-0.01
US Investment Grade Bonds	0.46	1.00	0.50	0.77	-0.17	0.47	-0.01
US Equities	-0.26	0.41	1.00	0.27	-0.30	0.76	0.03
TIPS	0.68	0.61	-0.06	1.00	0.05	0.21	0.18
Commodities	-0.29	0.19	0.28	0.14	1.00	-0.27	0.48
REITs	-0.08	0.52	0.61	0.18	0.39	1.00	0.07
Precious Metals	0.09	0.18	-0.02	0.29	0.32	0.08	1.00

Sources: Datastream, Bloomberg, FactSet, PGIM Quantitative Solutions. Data as of 12/31/2021.

IV. Developing Capital Market Assumptions for a Regime of Elevated Inflation

To consider the forward-looking implications of an elevated average-inflation scenario for the next five years for asset class outcomes, we turn to PGIM Quantitative Solutions' Capital Market Assumptions (CMAs) framework. CMAs underpin the long-run outlook for strategic allocations in our individual strategies and multi-asset portfolios. They are the product of a highly systematic process for generating consistent projections across the capital markets.

We update our CMAs each quarter to provide 10-year expectations for the most widely held equity, fixed income, and non-traditional asset classes, measuring both return and risk. Our investment professionals begin with evolving asset class fundamentals and macroeconomic assumptions at the country level. For each asset class we decompose local return expectations into three broad categories: income, growth, and valuation adjustment. We also forecast relative currency adjustments for investors in different domiciles to allow for conversion to hedged or unhedged returns.

Adjusting the 10-year CMA methodology to a five-year methodology required isolating the first five years of our macroeconomic assumptions and omitting the remainder. Since the final five years of the forecast is a period where inflation has largely normalized back to the Fed's target, the base case inflation forecast over five years is higher than that of the 10-year forecast.

One consequence of this adjustment is the passthrough of inflation in our CMAs to the growth component of many asset classes. Our 10-year equity forecast, for example, includes a 100% inflation passthrough, consistent with long-horizon empirical results. When considering a shorter five-year forecast horizon, we re-evaluated the shorter-term five-year performance of available asset classes from 1973-2021 to help determine an appropriate inflation passthrough. As discussed in more detail in the appendix, we assume a reduced inflation passthrough to equity returns as in our base forecasts, while assuming a 100% passthrough of inflation into commodity prices.

When considering the elevated inflation regime, we used a 5% average inflation assumption. CPI inflation of 5% over a five-year horizon is hardly without historical precedent in the US, most recently occurring from 1981-1986 (and nearly occurring again from 1987-1992). Inflation was rising over 10% year-over-year through most of 1981 before gradually easing to below 2% by the end of the year after Fed Chairman Paul Volcker tightened interest rates. With March 2022 CPI rising by 8.5% year-over-year, the economy is not yet at those levels. However, much of the current outlook depends on how quickly the Fed can get inflation under control. An elevated inflation scenario implies the Fed continues to struggle to get inflation under control. The March 2022 Summary of Economic Projections from the Fed forecast the range of PCE inflation[6] to be roughly 3.7% to 5.5% in 2022, but projected it to fall in 2023 (2.2% to 3.5%), 2024 (2% to 3%), and normalize at the 2% target over the longer-term. However, if inflation is at or above the higher end of the Fed's 2022 inflation range, and rate hikes are too slow to bring it down, then inflation expectations could become unmoored, making it more difficult to bring inflation down going forward. Nevertheless, the elevated inflation scenario is meant to represent one of many possible future outcomes, rather than the average outcome. More details on the adjustments made to generate the five-year forecast are available in the appendix.

Forecast outcomes at a five-year horizon for low-inflation and high-inflation regimes are presented in Table 2. US equities, US Treasuries, and investment grade bonds all show a deterioration in expected returns in a high-inflation regime compared to a low-inflation regime. All real assets have improved returns in the high-inflation regime, consistent with a greater assumed inflation passthrough. Commodities and precious metals show improved forecast return outcomes of greater than 6%, while return outcome improvements for TIPS and REITs are more modest at around 1.5%. On a real-return basis, US Treasuries, investment grade bonds, and TIPS are all forecast to deliver negative real returns in both high- and low-inflation regimes, consistent with initial conditions of negative real interest rates.

[6] On average, CPI inflation is modestly higher than PCE inflation.

Table 2: Five-Year Capital Market Assumptions for Low- and High-Inflation Regimes							
	Low-Inflation Regime			High-Inflation Regime			Difference in Forecast
Asset Class	Annualized Return	Volatility	Return/Risk	Annualized Return	Volatility	Return/Risk	
1. US Equities	7.0%	16.0%	0.50	5.5%	17.6%	0.27	-1.5%
2. US Treasuries	2.1%	5.4%	0.36	1.4%	6.9%	-0.11	-0.7%
3. US Investment Grade Bonds	2.8%	6.4%	0.43	1.5%	11.7%	-0.02	-1.3%
4. Commodities	2.4%	14.8%	0.22	8.9%	24.5%	0.39	6.5%
5. TIPS	2.3%	5.0%	0.44	3.9%	9.0%	0.21	1.6%
6. REITs	5.1%	18.6%	0.35	6.5%	16.8%	0.33	1.4%
7. Precious Metals	4.2%	13.7%	0.36	10.7%	30.4%	0.43	6.5%
Additional Assumptions							
Inflation	2.5%			5.0%			2.5%
Cash Rate in 5 Years	0.5%			4.8%			4.3%
10 Yr Treasury Yield in 5 Years	1.8%			6.1%			4.3%

Sources: Datastream, Bloomberg, FactSet, PGIM Quantitative Solutions. Data as of 12/31/2021.

V. Expected and Historical Portfolio Outcomes

Given the important impact elevated inflation and inflation surprises have on asset class outcomes, we next look to evaluate historical and forecast portfolio outcomes in regimes of lower and higher inflation. We focus on two representative portfolios: 1) A balanced fund with 55% equities, 35% bonds and a 10% allocation to a basket of real assets consisting of TIPS, commodities, and REITs and 2) A real assets portfolio equally weighted between TIPS, commodities, and REITs. This real asset portfolio allocation serves as the benchmark for PGIM Quantitative Solutions' Real Asset Strategy.

Table 3 presents the historical and expected outcomes for each of the portfolios in low- and high- inflation regimes. To calculate portfolio statistics, a conditional covariance matrix is used, sampling from the above 4% and below 4% inflation threshold for each inflation regime. It is notable that both portfolios have considerably higher returns than forecasts. The discrepancy can in part be explained by the very challenging initial conditions for fixed income assets that are just above historically low yield levels, coincident with elevated equity valuations.

Comparing the outcomes of balanced portfolio between the two inflation regimes, we note significantly lower risk-adjusted returns in the high-inflation regime, both on a forecast and historical basis, with negative real-return outcomes.

Table 3a: Forecast and Historical Outcomes for Balanced Portfolio in Low- and High-Inflation Regimes				
Portfolio Allocations			Portfolio Characteristics	
Asset Class	Asset Weight		Low-Inflation Outcome	High-Inflation Outcome
US Equities	55.0%	Expected Nominal Annualized Return	5.3%	4.6%
US Treasuries	25.0%	Expected Real Annualized Return	2.8%	-0.4%
US Investment Grade Bonds	10.0%	Expected Volatility	9.4%	11.4%
Commodities	3.0%	Expected Sharpe Ratio	0.59	0.25
TIPS	4.0%			
REITs	3.0%	Historical Nominal Annualized Return	10.9%	7.0%
Precious Metals	0.0%	Historical Real Annualized Return	8.6%	-0.4%
		Historical Volatility	9.4%	11.4%
Equities	55.0%	Historical Sharpe Ratio	0.89	0.03
Fixed Income	35.0%			
Real Assets	10.0%			

Sources: Datastream, Bloomberg, FactSet, PGIM Quantitative Solutions. Data as of 12/31/2021.

Historical and forecast portfolio outcomes for the real asset portfolio are presented in Table 3b. Not surprisingly, given the historical and forecast outcomes at the asset class level reviewed earlier, the real asset portfolio has materially better return outcomes in the higher-inflation regime. Likewise, it has much better performance in the higher-inflation regime than the benchmark balanced fund portfolio on both a historical and forecast basis.

Table 3b: Forecast and Historical Outcomes for Real Assets Portfolio in Low - and High-Inflation Regimes

Portfolio Allocations	
Asset Class	Asset Weight
Commodities	33.3%
REITs	33.3%
TIPS	33.3%
Precious Metals	0%

Portfolio Characteristics		
	Low-Inflation Outcome	High-Inflation Outcome
Expected Nominal Annualized Return	3.8%	7.5%
Expected Real Annualized Return	1.3%	2.5%
Expected Volatility	9.8%	9.6%
Expected Sharpe Ratio	0.41	0.59
Historical Nominal Annualized Return	7.9%	11.9%
Historical Real Annualized Return	5.6%	4.5%
Historical Volatility	9.8%	9.6%
Historical Sharpe Ratio	0.55	0.52

Sources: Datastream, Bloomberg, FactSet, PGIM Quantitative Solutions. Data as of 12/31/2021.

Optimized Portfolios

To generate more attractive forecast portfolio outcomes relative to benchmark, it is a common practice by practitioners to build portfolios with constrained mean-variance optimization. To see the impact of optimization on the balanced and real assets portfolios, we build two portfolios for the balanced portfolio: one with fairly tight constraints, and one with more relaxed individual asset and group constraints and a single optimization for the lower breadth real assets portfolio. For both opportunity sets, we also allow for an off-benchmark allocation to precious metals that have attractive inflation exposure. Our criteria for selecting portfolios on the efficient frontier is to select portfolios with the highest return (at least as high a risk-adjusted return as the benchmark portfolio). Again, a conditional covariance is used for each inflation scenario, sampling from quarters in high- and low-inflation regimes, respectively. Constraints for the optimizations are presented in table 4.

Table 4a: Asset Level and Group Constraints for Balanced Portfolio Optimization

		Narrow Constraints		Wide Constraints	
Asset Class	Benchmark Weight	Lower Bound	Upper Bound	Lower Bound	Upper Bound
Fixed Income					
US Treasuries	25%	15%	35%	15%	35%
US Investment Grade Bonds	10%	5%	15%	5%	15%
Equities					
US Equities	55%	45%	65%	45%	65%
Real Assets					
TIPS	4%	2%	6%	0%	8%
Commodities	3%	1%	5%	0%	8%
REITs	3%	1%	5%	0%	8%
Precious Metals	0%	0%	4%	0%	6%
Group Constraints					
Fixed Income		25%	35%	20%	45%
Equities		45%	65%	45%	65%
Real Assets		5%	15%	0%	25%

Table 4b: Asset Level Constraints for Real Assets Portfolio Optimization			
Asset Class	Benchmark Weight	Lower Bound	Upper Bound
TIPS	33%	23%	43%
Commodities	33%	23%	43%
REITs	33%	23%	43%
Precious Metals	0%	0%	10%

Sources: Datastream, Bloomberg, FactSet, PGIM Quantitative Solutions. Data as of 12/31/2021.

Results for the balanced portfolio under the two sets of optimization constraints for the low-inflation regime are presented in Table 5a. Given the stronger forecast returns for US equities relative to fixed income and real assets in the low-inflation scenario, the optimization seeks to enhance return while maintaining risk-adjusted return by allocating more to equities under both sets of constraints and reducing allocations to both fixed income and real assets.

Table 5a: Forecast and Historical Outcomes for Optimized Balanced Portfolio in Low-Inflation Regime Under Different Constraints

Portfolio Allocations

Asset Class	Benchmark Weight	Narrow Constraints Optimized	Wider Constraints Optimized
US Equities	55.0%	61.8%	63.3%
US Treasuries	25.0%	24.9%	24.4%
US Investment Grade Bonds	10.0%	5.0%	5.0%
Commodities	3.0%	1.0%	0.0%
TIPS	4.0%	2.1%	0.0%
REITs	3.0%	1.2%	1.3%
Precious Metals	0.0%	4.0%	6.0%
Equities	55.0%	61.8%	63.3%
Fixed Income	35.0%	29.9%	29.4%
Real Assets	10.0%	8.2%	7.3%

Portfolio Characteristics

Low-Inflation Outcome

	Benchmark	Narrow Constraints Optimized	Wider Constraints Optimized
Expected Nominal Annualized Return	5.3%	5.7%	5.8%
Expected Real Annualized Return	2.8%	3.2%	3.3%
Expected Volatility	9.4%	10.0%	10.2%
Expected Sharpe Ratio	0.59	0.59	0.59
Historical Nominal Annualized Return	10.9%	11.1%	11.2%
Historical Real Annualized Return	8.6%	8.8%	8.9%
Historical Volatility	9.4%	10.0%	10.2%
Historical Sharpe Ratio	0.89	0.86	0.86

Sources: Datastream, Bloomberg, FactSet, PGIM Quantitative Solutions. Data as of 12/31/2021.

Results for the balanced portfolio under the two sets of optimization constraints for the elevated-inflation regime are presented in Table 5b. Here, the improvement in expected return for the optimized portfolios is more meaningful than in the low-inflation scenario. Further, in the lesser-constrained optimization, the resulting portfolio takes a maximum allocation of 25% in real assets relative to the 10% benchmark weight. The improvement in expected return from the benchmark is 1.5% versus an improvement of just 0.5% in the low-inflation scenario optimizations. The results indicate that in an environment of elevated inflation, there is an argument to be made for broader constraints that allow for a greater weighting to real assets.

Table 5b: Forecast and Historical Outcomes for Optimized Balanced Portfolio in High-Inflation Regime Under Different Constraints

Portfolio Allocations				Portfolio Characteristics			
				High-Inflation Outcome			
Asset Class	Benchmark Weight	Narrow Constraints Optimized	Wider Constraints Optimized		Benchmark	Narrow Constraints Optimized	Wider Constraints Optimized
US Equities	55.0%	60.0%	51.2%	Expected Nominal Annualized Return	4.6%	5.6%	6.1%
US Treasuries	25.0%	20.0%	18.8%	Expected Real Annualized Return	-0.4%	0.6%	1.1%
US Investment Grade Bonds	10.0%	5.0%	5.0%	Expected Volatility	11.4%	11.8%	10.9%
Commodities	3.0%	5.0%	8.0%	Expected Sharpe Ratio	0.25	0.33	0.39
TIPS	4.0%	2.0%	3.0%				
REITs	3.0%	4.0%	8.0%	Historical Nominal Annualized Return	7.0%	7.4%	8.1%
Precious Metals	0.0%	4.0%	6.0%	Historical Real Annualized Return	-0.4%	0.0%	0.7%
				Historical Volatility	11.4%	11.8%	10.9%
Equities	55.0%	60.0%	51.2%	Historical Sharpe Ratio	0.03	0.06	0.11
Fixed Income	35.0%	25.0%	23.8%				
Real Assets	10.0%	15.0%	25.0%				

Sources: Datastream, Bloomberg, FactSet, PGIM Quantitative Solutions. Data as of 12/31/2021.

Results for the optimized real assets portfolio for a low-inflation regime are presented in Table 6a. Given the lower expected returns for real assets in a lower-inflation environment, these portfolios do not provide returns that are as attractive as the balanced portfolio. Optimization tilts the portfolio towards REITs and precious metals and results in a 0.5% improvement in portfolio expected returns.

Table 6a: Forecast and Historical Outcomes for Optimized Real Assets Portfolio in Low- and High-Inflation Regimes Under Different Constraints

Low-Inflation Benchmark and Optimized Real Assets Portfolio					
Portfolio Allocations			Portfolio Characteristics		
Asset Class	Benchmark	Optimized		Benchmark	Optimized
Commodities	33.3%	23.0%	Expected Nominal Annualized Return	3.8%	4.3%
Precious Metals	0.0%	10.0%	Expected Real Annualized Return	1.3%	1.8%
REITs	33.3%	43.0%	Expected Volatility	9.8%	10.6%
TIPS	33.3%	23.0%	Expected Sharpe Ratio	0.41	0.43
			Historical Nominal Annualized Return	7.9%	8.8%
			Historical Real Annualized Return	5.6%	6.5%
			Historical Volatility	9.8%	10.6%
			Historical Sharpe Ratio	0.55	0.60

Sources: Datastream, Bloomberg, FactSet, PGIM Quantitative Solutions. Data as of 12/31/2021.

Results for the optimized real assets portfolio for a high-inflation regime are presented in Table 6b. Here, the expected and historical outcomes are materially superior to that of the balanced portfolio. The optimization increases the expected return by 0.8% by allocating to precious metals and REITs and away from TIPS and commodities.

Table 6b: Forecast and Historical Outcomes for Optimized Real Assets Portfolio in Low- and High-Inflation Regimes Under Different Constraints

High-Inflation Benchmark and Optimized Real Assets Portfolio

Portfolio Allocations			Portfolio Characteristics		
Asset Class	Benchmark	Optimized		Benchmark	Optimized
Commodities	33.3%	27.6%	Expected Nominal Annualized Return	7.5%	8.3%
Precious Metals	0.0%	10.0%	Expected Real Annualized Return	2.5%	3.3%
REITs	33.3%	39.4%	Expected Volatility	9.6%	10.5%
TIPS	33.3%	23.0%	Expected Sharpe Ratio	0.59	0.62
			Historical Nominal Annualized Return	11.9%	11.7%
			Historical Real Annualized Return	4.5%	4.3%
			Historical Volatility	9.6%	10.5%
			Historical Sharpe Ratio	0.52	0.46

Sources: Datastream, Bloomberg, FactSet, PGIM Quantitative Solutions. Data as of 12/31/2021.

VI. Conclusion

A regime of higher inflation and higher-inflation expectations, such as the one that has emerged in 2022, has important implications for investor outcomes, particularly if inflation is likely to stay elevated for a period of years. Strategic allocations like a 60/40 split between equities and nominal bonds have historically delivered negative real returns in periods of elevated inflation. Our forward-looking CMA framework incorporating an assumption of 5% inflation for the next five years also indicates that it would be challenging for a traditional balanced portfolio concentrated in stocks and bonds to deliver positive real returns. The good news is that there are public market allocation options to real assets that perform materially better than stocks and nominal bonds in higher-inflation regimes, both on a historical and forward-looking basis. While a 100% allocation to real assets may not be palatable or possible for many asset owners, adjusting portfolio rules to allow greater allocations to real assets can meaningfully improve expected portfolio outcomes in an elevated inflation regime.

VII. Appendix

Capital Market Assumption Methodology Changes

The PGIM Quantitative Solutions' Capital Market Assumptions (CMAs) provide 10-year expectations for the most widely held equity, fixed income, and non-traditional asset classes, measuring both return and risk. Focusing on the shorter five-year period in this paper requires methodological changes to our standard 10-year approach. The most straightforward adjustment is to change the GDP growth and inflation forecasts to use a five-year horizon, rather than 10-year. In addition, the CMAs incorporate a valuation component where we assume that some interest rates and valuation measures partially mean revert over the forecast horizon. These components were adjusted to mean revert over a shorter horizon. Together, these changes are used to generate the baseline low-inflation forecast.

Other adjustments in addition to the baseline forecast were required to generate the high-inflation forecast. The US economy is assumed to be constrained by a supply shock that raises the inflation forecast to the 5% level, while GDP growth is assumed to be 25 basis points (bps) weaker than in the base case. We also adjusted the interest rate assumptions (boosting the equilibrium real rate by 100bps and removing mean reversion in short-term yields) to provide more realistic cash returns in an inflationary environment.

Our baseline CMAs would pass through the higher inflation assumption discussed above 100% to equities. However, we assume that over a shorter horizon in a higher-inflation environment, only 50% of inflation would pass through to equity returns. Similarly, we assume a 100% passthrough of inflation into commodity returns and a 100% passthrough of the inflation shock (inflation less the baseline inflation) into TIPS returns.

Regression analysis helped motivate the above changes to the inflation passthrough assumptions. Quarterly returns for each of the asset classes from 1973-2021 were regressed against two sets of macroeconomic variables: 1) US GDP and inflation, and 2) US GDP and inflation surprises[7]. Due to concerns about autoregression and potential for the relationship between returns and macroeconomic variables to occur over many periods, we follow the recommendation from Dimson (1997) to include on the right-hand side of the regression the lead and lag of each of the above variables and present the sum.

Table 7 provides the results of this analysis. For US equities, the beta versus either inflation or inflation surprise is negative, rather than positive, but there is a significant amount of uncertainty in the estimate of that parameter. While the negative coefficient is a concern, the larger uncertainty helps justify our decision to reduce the passthrough from our baseline forecast, rather than zero it out. The regression results also suggest very strong inflation betas of commodities and precious metals. The 100% passthrough assumed above is relatively more conservative than history would suggest. As a robustness check, the regressions were also repeated with rolling three-year and five-year returns against rolling three-year and five-year macroeconomic variables. These rolling regressions were, on balance, in line with the results above and did not cause us to question our passthrough assumptions. Regressions splitting the history into the first and second half were also performed. Splitting the history in half helped reveal the instability of the equity inflation beta estimate (negative in the first half, positive in the second), which helped justify our decision to only modestly change it from the baseline.

Table 7: Dimson Beta of Returns vs. Macroeconomic Variables (1973-2021)

Asset Class	Parameter	Regression 1		Regression 2	
		GDP	CPI	GDP Surprise	CPI Surprise
US Equities	Coefficient	2.87	-0.25	4.9	-0.87
	Standard Error	0.9	0.76	1.78	1.77
US Treasuries	Coefficient	-0.63	-0.15	-0.99	-1.57
	Standard Error	0.29	0.28	0.68	0.61
US Investment Grade Bonds	Coefficient	0.48	-0.67	0.73	-2.87
	Standard Error	0.44	0.35	0.96	0.93
Commodities	Coefficient	3	4.13	3.73	10.58
	Standard Error	1.05	0.97	2.3	2.22
TIPS	Coefficient	-0.58	0.61	-0.58	1.01
	Standard Error	0.37	0.31	0.76	0.71
REITs	Coefficient	3.9	0.69	4.32	0.73
	Standard Error	0.89	0.81	1.93	1.95
Precious Metals	Coefficient	-1.52	2.6	-0.06	8.26
	Standard Error	1.03	0.93	2.32	2.26

Sources: Datastream, Bloomberg, FactSet, PGIM Quantitative Solutions. Data as of 12/31/2021.

As a robustness check, the regressions were also repeated with rolling three-year and five-year returns against rolling three-year and five-year macroeconomic variables. These rolling regressions were, on balance, in line with the results above and did not cause us to question our passthrough assumptions. Regressions splitting the history into the first and second half were also performed. Splitting the history in half helped reveal the instability of the equity inflation beta estimate (negative in the first half, positive in the second), which helped justify our decision to only modestly change it from the baseline.

[7] The "surprise" variables are constructed by subtracting the Philadelphia Federal Reserve Survey of Professional Forecasters current quarter forecast from each macroeconomic variable.

Data Sources		
Asset Class	**Index**	**Data Sources**
US Treasuries	Bloomberg-Barclays US Treasury Total Return Index	Datastream
US Investment Grade Bonds	Bloomberg-Barclays US Corporate Total Return Index	Datastream
US TIPS	Bloomberg-Barclays US TIPS All Maturity Total Return Index spliced with Pond and Mirani [2009] TIPS performance prior to April 1997; Bloomberg-Barclays US Treasury US TIPS for periods thereafter	Bloomberg, Datastream
US Equities	S&P 500 Total Return Index	Datastream
US REITs	FTSE Nareit Equity REIT Total Return Index	Datastream
Precious Metals	S&P GSCI Precious Metals Index	FactSet
Commodities	Bloomberg Commodity Total Return Index	Bloomberg

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