PGIM

INSTITUTIONAL ADVISORY & SOLUTIONS

# REAL ASSETS, INFLATION & PORTFOLIO PERFORMANCE

February 2025

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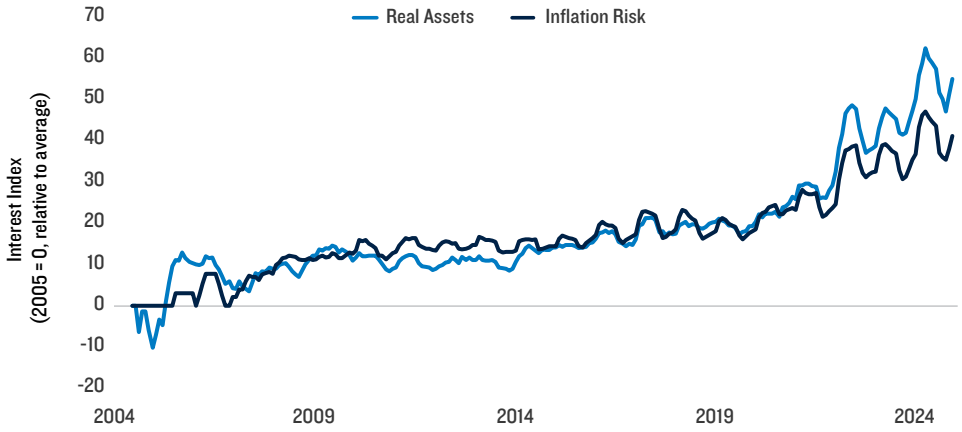
Although US headline inflation has moderated since peaking in mid-2022, core inflation has proven sticky, with service price increases having yet to fully retreat. Indeed, inflation concerns and focus on real assets continue to trend higher together (Figure 1).

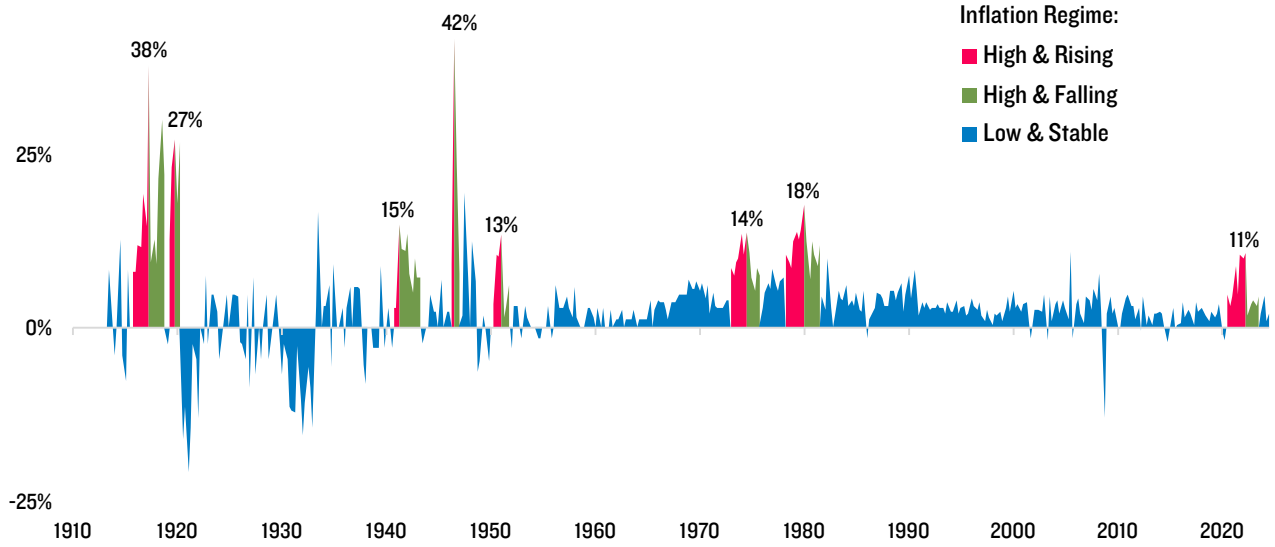
### Figure 1: Google Trends: Inflation Risk and Real Assets (2004-2024)




Note: Trailing 6m moving average relative to full sample average. Data are Google trend "all category" US search terms. Source: Google Trends (accessed 04Dec2024) and PGIM IAS. Provided for illustrative purposes only.

How should investors be thinking about inflation risk and their real asset allocations, having experienced the first US inflationary cycle since the mid-1970s? How worried should they be about persistently higher inflation or another spike? After all, US inflation has been low and stable for much of the last 50y (Figure 2, blue areas). That said, looking at more than a century of data, inflationary episodes, defined by a period of *high and rising inflation* (red areas) followed by a period of *high and falling inflation* (green areas) – a distinction that is critical for asset performance as we show below – are irregular but not rare; the US has experienced 8 inflationary cycles in the last 110 years. If the past is prologue, then investors may experience inflationary cycles a bit less than once a decade lasting about 3y, which is roughly 20% of the time (Figure 3).

## Figure 2: US CPI Inflation & Inflation Regimes (1913-2024)




Note: Inflation is the rolling annualized quarterly percent change in CPI. Inflationary episodes are determined *ex post* as 2ppt above the trailing 4Q average, with some quarters assigned a regime using our qualitative judgement to eliminate very short, transitory episodes of high inflation. In contrast, when formulating a *dynamic* real asset allocation strategy, a real-time, *ex ante* data driven rule is used that assumes only information available in each period and includes data release lags in assessing asset performance (see below for details). Source: Bureau of Labor Statistics, Haver Analytics and PGIM IAS. Provided for illustrative purposes only.

## Four key takeaways for CIOs, asset allocators, and risk managers are:

- Real assets merit consideration for inclusion in a balanced portfolio of stocks and bonds due to a "trinity" of characteristics: diversification, return enhancement, and inflation hedging. However, no single real asset embodies all these virtues.
- Historically, balanced portfolios that include an allocation to real assets alongside stocks and bonds have had higher average returns, lower volatilities, and better risk-adjusted returns relative to a benchmark portfolio of only stocks and bonds.
- However, performance has depended critically on the inflation environment. Relative to a stock/bond benchmark, portfolios with real assets have delivered positive active returns during periods of high and rising inflation but have been a drag on portfolio performance otherwise.
- A *dynamic* real asset allocation strategy, which allocates to real assets only *when inflation is high and rising*, could generate positive active returns when inflation is high and rising while eliminating periods of underperformance. But, generally, it does so with more volatility and lower risk-adjusted returns relative to a *static* buy and hold real asset strategy because the diversification benefits from allocating to real assets are only realized occasionally. (Historically, larger allocations to real assets during periods of high and rising inflation has generally led to higher returns and higher risk adjusted returns.)

## Figure 3: US Inflation Regimes (1913-2024)

| Inflation Regime | 1913-1970 | | | 1971-2024 | | | 1913-2024 | | |
|---|---|---|---|---|---|---|---|---|---|
| | Avg Inflation | Avg Chg in Inflation | Frequency | Avg Inflation | Avg Chg in Inflation | Frequency | Avg Inflation | Avg Chg in Inflation | Frequency |
| **High & Rising** | 14.9% | 19.7% | 8% | 10.0% | 6.1% | 11% | 12.2% | 14.6% | 9% |
| **High & Falling** | 15.4% | -13.0% | 9% | 8.5% | -6.1% | 7% | 12.5% | -10.4% | 8% |
| **Low & Stable** | 0.5% | | 83% | 2.9% | | 82% | 1.6% | | 82% |
| **All** | 2.8% | | 100% | 4.0% | | 100% | 3.3% | | 100% |

Note: Inflation is the rolling annualized quarterly percent change in CPI. Inflationary episodes are determined *ex post* as 2ppt above the trailing 4Q average, with some quarters assigned a regime using our qualitative judgement to eliminate very short, transitory episodes of high inflation. In contrast, when formulating a *dynamic* real asset allocation strategy, a real-time, *ex ante* data driven rule is used that assumes only information available in each period and includes data release lags in assessing asset performance (see below for details). Source: Bureau of Labor Statistics, Haver Analytics and PGIM IAS. Provided for illustrative purposes only.

To help investors prepare for the implications of future inflation, we explore several **motivations** for adding real assets to a portfolio – *diversification, return enhancement and inflation hedging* – and related portfolio construction **methods**, paying particular attention to the impact that inflationary regimes have on portfolio performance.

## The Diversity, Risk-Reward, & Inflation Hedging Characteristics of Real Assets

The "Real Asset" class has no set definition; it typically consists of a diverse range of assets that span the capital structure and includes both public and private assets. Understanding and exploiting the diversity of real assets lies at the heart of our established "RASA™" (Real Asset Sensitivity Analysis) framework that quantifies differences across real assets in terms of their exposures to macroeconomic risks (inflation and growth) and market risks (stock and bond returns).[1]

Although some investors rely on infrastructure, real estate and other alternative, illiquid private assets to manage inflation risk, we focus on public market real assets for two reasons (Figure 4). First and primarily because public assets tend to have price histories that extend back to the 1970s, capturing the two inflationary episodes in that period (*i.e.*, red and green areas in Figure 1). Moreover, the performance of private real asset benchmarks, unlike public asset benchmarks, typically does not accurately capture the "real world" performance of a given private real asset strategy, which depends on manager selection, manager skill, cash-flow timing (disbursements and capital calls), vintage, and the return from committed but uncalled capital.[2]

### Figure 4: Real Assets: Data History and Source

| Real Asset | Start Date | Source |
|---|---|---|
| Agriculture | 1971Q1 | GSCI |
| Energy | 1971Q1 | |
| Livestock | 1971Q1 | |
| Commodities* | 1970Q4 | GSCI, Foundation for Intl Business & Economic Research |
| Industrial Metals* | 1971Q1 | |
| Gold | 1970Q4 | DataStream |
| MLPs | 1974Q1 | |
| Infra Equities* | 1974Q1 | S&P, Datastream |
| Nat Res Equities | 1974Q1 | S&P |
| RE Debt | 1972Q4 | Giliberto-Levy |
| REITs | 1974Q1 | FTSE NAREIT |
| 10y TIPS | 1974Q1 | Bloomberg |
| 1y UST | 1971Q1 | US Treasury |
| Real Asset Basket | 1974Q1 | PGIM IAS |
| S&P 500 | 1971Q1 | S&P |
| 10y UST | 1971Q1 | US Treasury |
| 60/40 Portfolio | 1971Q1 | S&P, US Treasury |

Note: We backfill the infrastructure equities total returns (1974-2020) based on its historical (2000-2024) linear relationship with monthly pipelines & monthly utilities equity total returns obtained from Datastream. Similarly, we backfill the GSCI Commodities total returns (1971-1982) and the GSCI Industrial Metals total returns (1971-1976) based on their historical relationships with the FIBER Industrial Materials Crude Oil & Benzene total returns and the FIBER Industrial Materials Metals total returns obtained from Foundation for Intl Business & Economic Research, respectively. Source: PGIM IAS. Provided for illustrative purposes only.

In speaking with institutional investors, motivations for including real assets in a balanced portfolio can be broadly categorized into one of three buckets: a desire for greater portfolio *diversification;* as a source of incremental *return;* and as an explicit *hedge against inflation risk*. Indeed, historically, real assets returns are not highly correlated to either stock or bond returns, tend to co-move with inflation, and tend to be much stronger when inflation is high and rising than in other periods.

An individual real asset with low correlation to stocks and bonds, high expected risk-adjusted returns, and a large positive sensitivity to inflation (*i.e.,* $\beta^{\,inflation}$) would be an ideal candidate for inclusion in a balanced stock/bond portfolio. However, there is no single real

1 See *What's in your Real Assets Portfolio: Introducing RASA™* (PGIM IAS, May 2021) for greater detail and *The PGIM Interactive Portfolio Construction Toolkit* for access to the RASA framework in real time. See Appendix 1 for data construction details.

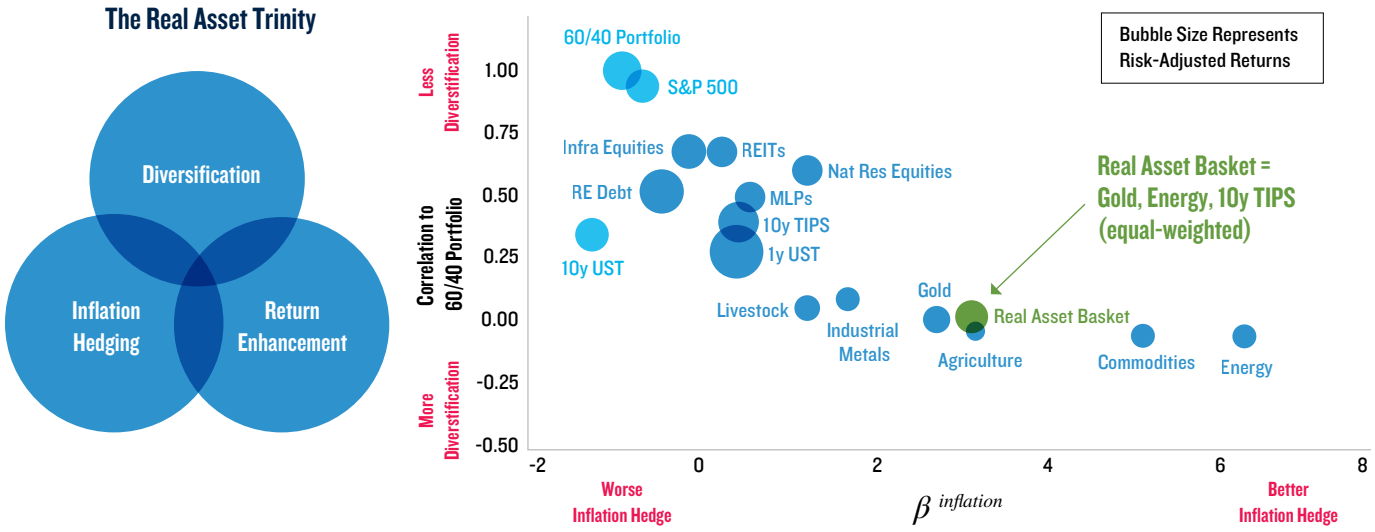
2 See *Private vs. Public Investment Strategies: Reported and Real-World Performance* (PGIM IAS, May 2023) for a discussion of the real-world performance of private assets.

asset that stands out along all three dimensions (Figure 5, with $\beta^{inflation}$ as a measure of inflation hedging on the x-axis, correlation to the 60/40 benchmark as a measure of diversification on y-axis, and risk-adjusted returns represented by the area of the circles). The real assets that are the most efficient inflation hedges have relatively lower risk-adjusted returns, while the real assets with more robust risk-adjusted returns tend to be more highly correlated to a portfolio of stocks and bonds, offering less in terms of a diversification benefit.

However, a **basket** of real assets can be constructed to capture these characteristics. A straightforward, easy-to-construct **Real Asset Basket**, which gives equal weight to Energy, Gold, and 10y TIPs, is negatively correlated to the 60/40 portfolio, has a large and significant $\beta^{inflation}$ (in contrast to the 60/40 portfolio's negative $\beta^{inflation}$), and with a mean-vol ratio of 0.7x, which is toward the high end of the group. The diversification, return, and hedging characteristics of the Real Asset Basket strike a good balance and make it an attractive candidate to include in a balanced stock/bond portfolio.

**Note, for ease of exposition, most of the results reported below are for the "Real Asset Basket" only** (defined as an equally weighted basket of Energy, Gold and 10y TIPs, constantly and costlessly rebalanced).[3]

## Figure 5: The Real Asset Trinity: Diversification, Inflation Hedging & Return Enhancement (1971-2024)



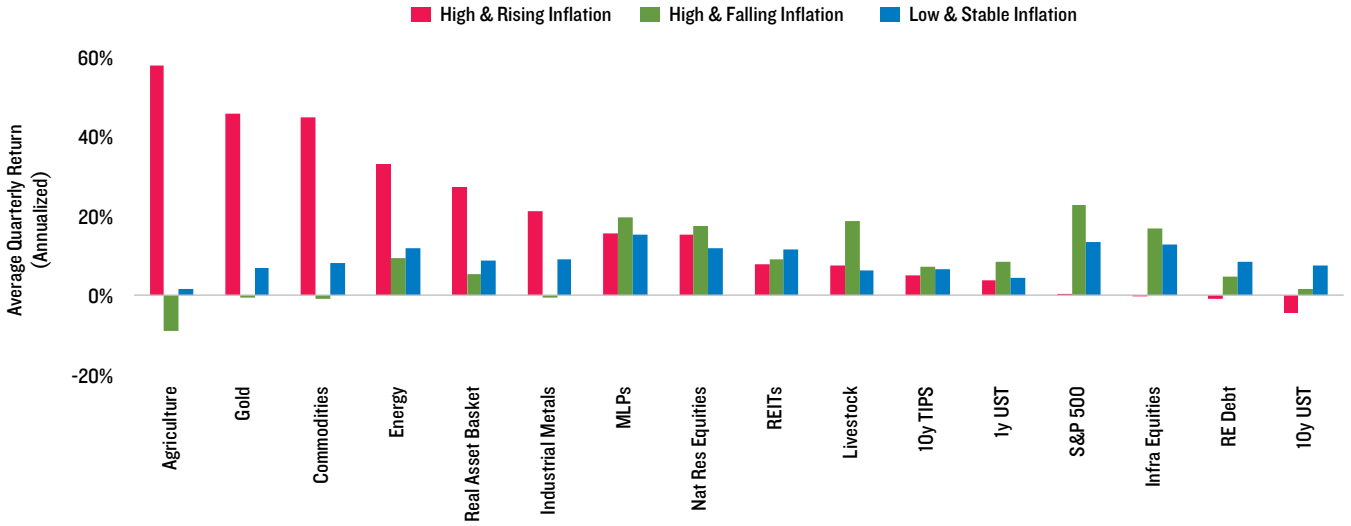

Note: Mean return and volatility are annualized and based on quarterly total returns using each asset's individual full history and ending in 2024. Correlations are between quarterly returns and calculated over the assets' full histories. Inflation $\beta^{inflation}$ is calculated by regressing each asset's returns on CPI inflation and CFNAI. Source: Bloomberg, Bureau of Labor Statistics, DataStream, Federal Reserve Bank of Chicago, Foundation for Intl Business & Economic Research, FTSE NAREIT, Giliberto-Levy, Haver Analytics, Standard & Poor's, U.S. Treasury and PGIM IAS. Provided for illustrative purposes only.

In addition, as Figure 6 illustrates, real asset total returns have been far stronger when inflation is climbing rapidly to a peak (red bars, with such periods identified *ex post*, in hindsight, as illustrated in Figure 1 above – a critical distinction that we will return to below) *vs.* when inflation is either falling back to normal from a peak (green bars) or is low and stable (blue bars). Interestingly, real asset return volatility has been similar regardless of the inflation backdrop (Figure 7). As for benchmark assets, Treasury returns have been negative during periods of rapidly rising inflation and stock returns are far weaker when inflation is climbing *vs.* other periods, underscoring the need to minimize inflation risk, boost returns, or to diversify the stock/bond portfolio during periods of high and rising inflation.[4]

3 Full results for individual real assets and for several other specifications of a real asset basket are in Appendix 2.

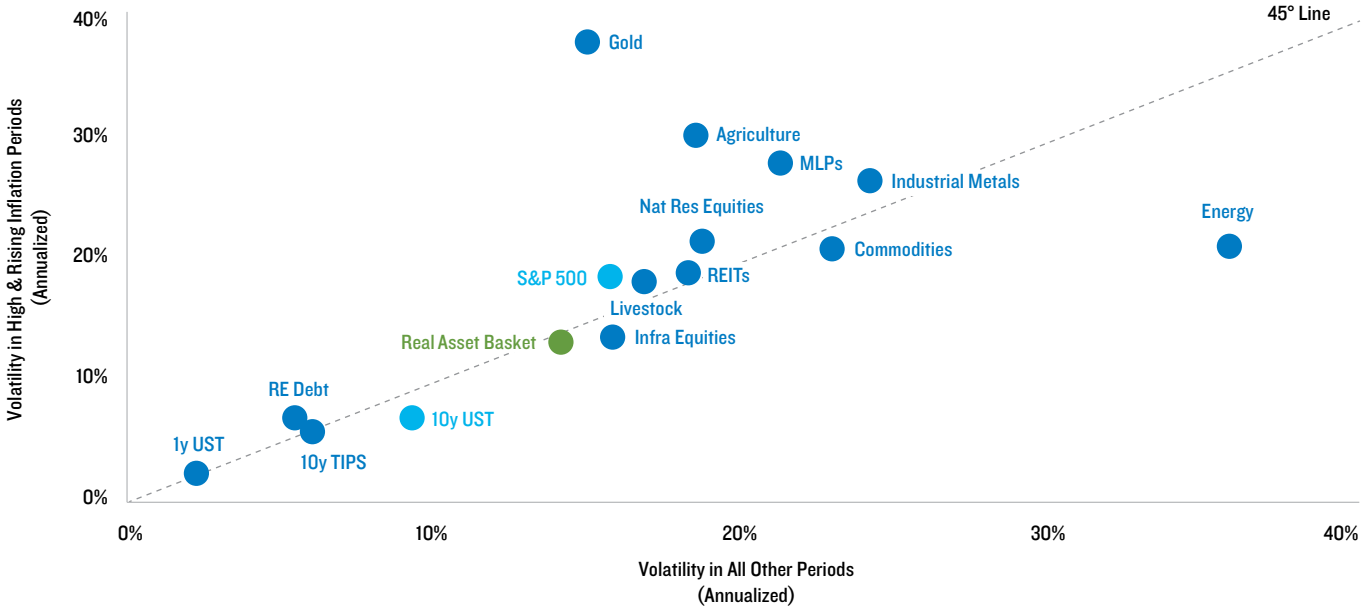
4 We focus on the relationship between real asset performance and inflationary regimes as defined by *realized* inflation as opposed to unexpected inflation for three (related) reasons. First, the quality of an inflation surprise measure is, by definition, only as good as the underlying model for inflation itself and it is hard to know what "the market" uses to form expectations, a difficulty compounded by needing to go 50 years back in time. Second, to the extent that inflation is persistent, changes in inflation can serve as a rudimentary proxy for inflation surprises. Indeed, the fact that real asset returns seem to be related to both the level and changes in inflation is *prima facia* evidence of this. Finally, unexpected inflation should have little persistence, making it difficult to invest on that basis.

## Figure 6: Total Returns in High & Rising, High & Falling and Low & Stable Inflation Periods (1971-2024)




Note: Inflationary episodes are determined *ex post* as 2ppt above the trailing 4Q average, with some quarters assigned a regime using our qualitative judgement to eliminate very short, transitory episodes of high inflation. In contrast, when formulating a *dynamic* real asset allocation strategy, a real-time, *ex ante* data driven rule is used that assumes only information available in each period and includes data release lags in assessing asset performance (see below for details). Source: Bloomberg, Bureau of Labor Statistics, DataStream, Federal Reserve Bank of Chicago, Foundation for Intl Business & Economic Research, FTSE NAREIT, Giliberto-Levy, Haver Analytics, Standard & Poor's, U.S. Treasury and PGIM IAS. Provided for illustrative purposes only. Past performance is no guarantee or reliable indicator of future results.

## Figure 7: Real Asset Volatility in High & Rising Inflation Periods *vs.* Other Periods (1971-2024)



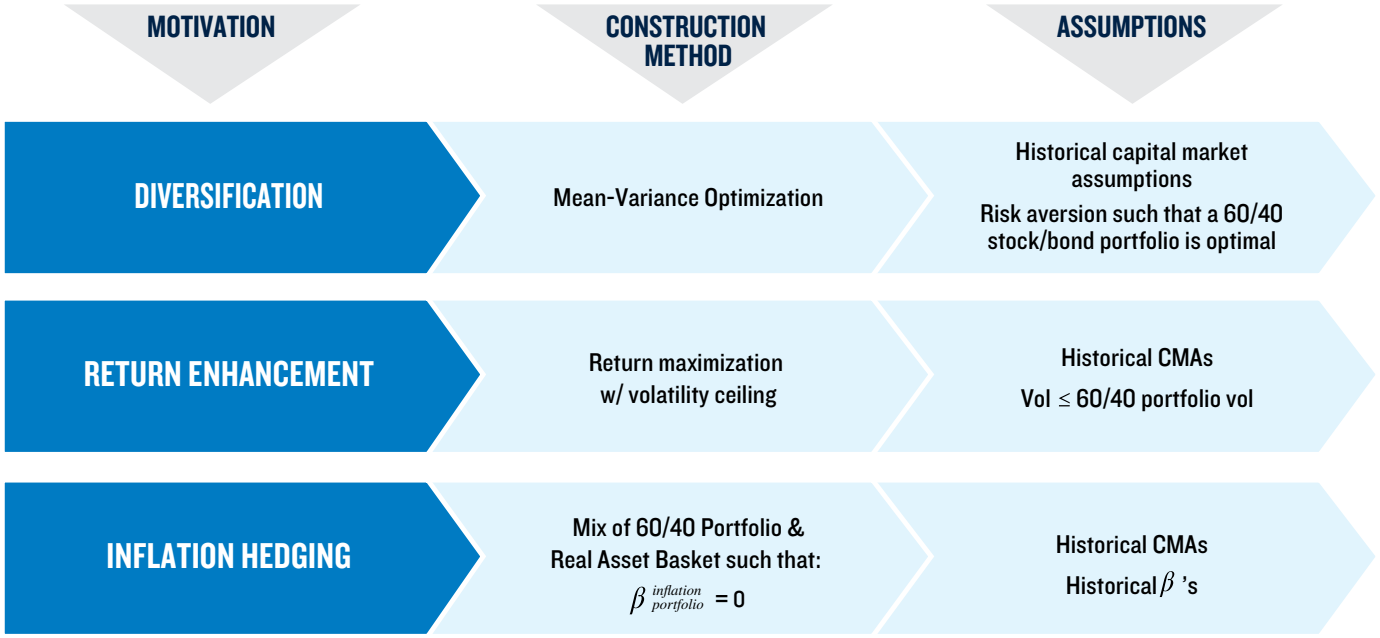

Note: Inflationary episodes are determined *ex post* as 2ppt above the trailing 4Q average, with some quarters assigned a regime using our qualitative judgement to eliminate very short, transitory episodes of high inflation. In contrast, when formulating a *dynamic* real asset allocation strategy, a real-time, *ex ante* data driven rule is used that assumes only information available in each period and includes data release lags in assessing asset performance (see below for details). Source: Bloomberg, Bureau of Labor Statistics, DataStream, Federal Reserve Bank of Chicago, Foundation for Intl Business & Economic Research, FTSE NAREIT, Giliberto-Levy, Haver Analytics, Standard & Poor's, U.S. Treasury and PGIM IAS. Provided for illustrative purposes only.

## Building Balanced Portfolios with Real Assets: Three Motivations and Three Methodologies

Each of the three investor *motivations* for adding (a basket of) real assets to a stock-bond portfolio – diversification, inflation hedging, return enhancement – can be connected to a portfolio construction *methodology* (Figure 8).

- **Diversification:** Adding a basket of real assets to diversify a stock-bond portfolio via mean-variance optimization using capital market assumptions (CMAs) based on historical performance and a tolerance for risk that would make a 60/40 portfolio optimal. We run the optimization with and without a 20% cap on the allocation to real assets (leverage and short sales are disallowed).
- **Return Enhancement:** Adding a basket of real assets to boost the expected return of a stock-bond portfolio by maximizing returns subject to a volatility target (set at less than or equal to the volatility of a 60/40 portfolio) and using CMAs based on historical performance. We run this optimization with and without a 20% real asset cap.
- **Inflation Hedging:** Adding a basket of real assets with $\beta^{inflation} > 0$ to offset the 60/40 portfolio's negative $\beta^{inflation}$, meaning that the *relative* allocation to stocks and bonds does not change and a basket of real assets is added alongside a fixed relative allocation of stocks and bonds. Weights are chosen so that the portfolio's overall exposure to inflation, $\beta^{inflation}_{portfolio}$ (which is equal to $weight_{60/40} \times \beta^{inflation}_{60/40} + weight_{Real\ Asset\ Basket} \times \beta^{inflation}_{Real\ Asset\ Basket}$ is equal to zero.

### Figure 8: Motivations and Portfolio Construction Methods for Including Real Assets in a Stock-Bond Portfolio




Over the last 50y, looking across all three motivations and methodologies for adding the Real Asset Basket to a portfolio of stocks and bonds, **allocating to a basket of real assets improves portfolio performance relative to a 60/40 portfolio of stocks and bonds alone.**

On a quarterly basis over the last 50y, Stock/Bond/Real Asset Basket portfolios have had *higher* returns, *lower* volatilities and *higher* risk adjusted returns relative to a 60/40 portfolio of only stocks and bonds (Figure 9). For example, for investors that are looking for diversification and using mean-variance optimization to add real assets to their portfolio, the optimal allocation to real assets is 36% (alongside a 49% allocation to stocks and a 15% allocation to bonds). This leads to *higher* average returns of 10.3% (*vs.* 9.7% for the 60/40 stock-bond benchmark) and lower volatility (9.8% *vs.* 10.4%), boosting risk-adjusted returns to 1.05 (*vs.* 0.93). Results are similar for other motivations and methodologies.

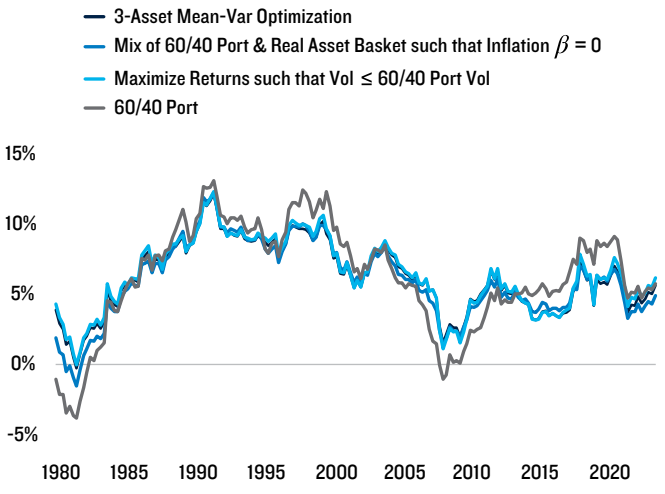
## Figure 9: Stock/Bond/Real Asset Basket Portfolio Construction & Quarterly Performance (annualized, 1971-2024)

| Motivation | Stock/Bond/Real Asset Basket Portfolio Construction Method | Allocation | | | Mean | Vol | Mean/Vol | Sortino Ratio | Expected Active Return *vs.* 60/40 |
|---|---|---|---|---|---|---|---|---|---|
| | | Real Asset Basket | Stock | Bond | | | | | |
| Diversification | 3-Asset Mean-Var Optimization | 20% cap | 54% | 26% | 10.1% | 9.6% | 1.05 | 1.52 | 0.3% |
| | | 36% | 49% | 15% | 10.3% | 9.8% | 1.05 | 1.39 | 0.5% |
| Inflation Hedging | Mix of 60/40 & Real Asset Basket such that Inflation $\beta = 0$ | 24% | 46% | 31% | 9.8% | 8.7% | 1.12 | 1.69 | -0.1% |
| Return Enhancement | Maximize Returns such that Vol ≤ 60/40 Vol | 20% cap | 60% | 20% | 10.3% | 10.4% | 0.99 | 1.36 | 0.6% |
| | | 37% | 54% | 9% | 10.5% | 10.4% | 1.00 | 1.27 | 0.8% |
| Benchmark | 60/40 | 0% | 60% | 40% | 9.7% | 10.4% | 0.93 | 1.46 | 0.0% |

Note: Mean is the annualized average of quarterly returns. Vol is the annualized volatility of quarterly returns. Portfolios are rebalanced quarterly at zero cost. Source: Bloomberg, Bureau of Labor Statistics, DataStream, Federal Reserve Bank of Chicago, Foundation for Intl Business & Economic Research, FTSE NAREIT, Giliberto-Levy, Haver Analytics, Standard & Poor's, U.S. Treasury and PGIM IAS. Provided for illustrative purposes only. Past performance is no guarantee or reliable indicator of future results.

In addition to *quarterly nominal* performance metrics, asset owners may care about their terminal *real* wealth and their ability to preserve purchasing power as captured by *long-run real returns.* Interestingly, here the benefits of an allocation to the Real Asset Basket are not as readily apparent. For a $100 initial investment, median 10y real terminal wealth of a 60/40 portfolio is about $10 *higher* than portfolios that include the Real Asset Basket, although with a bit more dispersion (as measured by the inter-quartile range. Figure 10). However, including the Real Asset Basket leads to markedly better downside tail performance. A 60/40 portfolio loses purchasing power more than five percent of the time (*i.e.*, the 10y real terminal wealth in the 7th percentile and below are negative), whereas including the Real Asset Basket preserves real wealth even for the worst 1st percentile of outcomes.

## Figure 10: 10y Real Returns & 10y Terminal Real Wealth (1980-2024)




| Trailing 10y Terminal Real Wealth per $100 Initial Investment | | | | |
|---|---|---|---|---|
| Percentile | 3-Asset Mean-Var Optimization | Mix of 60/40 Port & Real Asset Basket such that Inflation $\beta = 0$ | Maximize Returns such that Vol ≤ 60/40 Port Vol | 60/40 Port |
| 1st | $107 | $94 | $109 | $70 |
| 5th | $123 | $114 | $124 | $90 |
| 25th | $153 | $150 | $156 | $156 |
| 50th | $180 | $180 | $183 | $190 |
| 75th | $223 | $220 | $227 | $235 |
| 95th | $255 | $257 | $261 | $301 |
| 99th | $299 | $305 | $300 | $328 |
| IQR | $70 | $70 | $71 | $78 |
| Average | $183 | $179 | $186 | $184 |

Note: Portfolios are rebalanced quarterly at zero cost. Mean is the annualized average of quarterly returns. Vol is annualized volatility of quarterly returns. Source: Bloomberg, Bureau of Labor Statistics, DataStream, Federal Reserve Bank of Chicago, Foundation for Intl Business & Economic Research, FTSE NAREIT, Giliberto-Levy, Haver Analytics, Standard & Poor's, U.S. Treasury and PGIM IAS. Provided for illustrative purposes only. Past performance is no guarantee or reliable indicator of future results.

However, realized performance over a full 50y history is only half the story. As illustrated above, the performance of real assets during ***high and rising inflation*** periods (the red area in Figure 1) has differed markedly from performance in non-inflationary periods (green and blue areas in Figure 1). This impacts portfolio performance too. **Allocating to real assets boosted portfolio during periods of high and rising inflation but was a portfolio drag otherwise.**

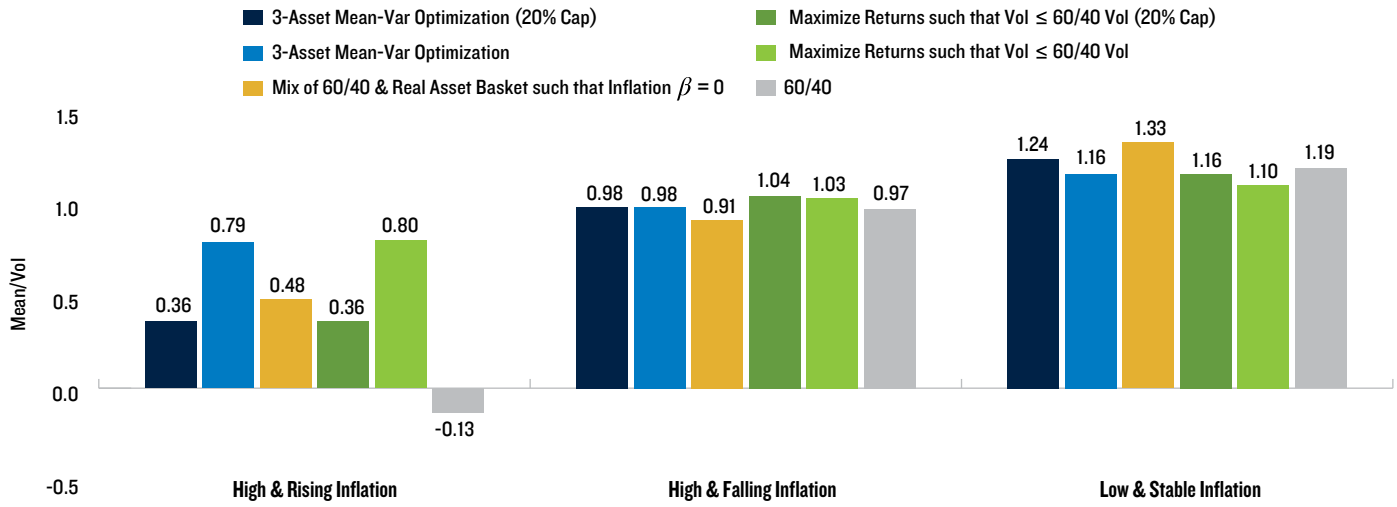
*During high and rising inflationary episodes* an allocation to the Real Asset Basket has generated positive active returns (on an annualized basis) ranging from 5.6% to 10.9% *vs.* the 60/40 benchmark, which had negative returns on average (Figure 11, top panel). In contrast, *outside of high and rising inflationary episodes*, active returns were mostly *negative*. During periods of high and rising inflation, risk-adjusted returns were modest but positive for portfolios that include an allocation to the real asset basket and negative for the stock/bond benchmark (Figure 11, bottom panel). In periods of *high and falling inflation* and in periods of *low and stable inflation,* risk-adjusted returns for portfolios that include an allocation to the Real Asset Basket were roughly in line with those of the 60/40 stock/bond benchmark.[5]

In summary, over the last 50y, Stock/Bond/Real Asset Portfolios have delivered higher average quarterly returns with less volatility than a 60/40 Stock/Bond benchmark, and, hence, higher risk-adjusted returns. They have also provided tail protection to the long-term *real* purchasing power of investors, with 10y real terminal wealth positive even for the worst 5th and 1st percentiles of outcomes (unlike the 60/40 portfolio where real terminal wealth is negative at the 7th percentile and below). However, active returns to Stock/Bond/Real Asset portfolios were positive only during periods of *high and rising inflation* and were a drag otherwise (*vs.* a 60/40 Stock/Bond portfolio).

In this context, **how should a CIO think about the trade-off between long-term outperformance driven by sporadic periods of large positive active returns *vs.* steady and small underperformance most of the time?**

## Figure 11: Portfolio Performance by Inflation Regime (inflation regimes determined *ex post*, 1971-2024)

| Stock/Bond/Real Asset Basket Portfolio Construction Method | Real Asset Basket Allocation | Expected Active Return *vs.* 60/40 | | | Mean | | | Vol | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | High & Rising (11%) | High & Falling (7%) | Low & Stable (82%) | High & Rising (11%) | High & Falling (7%) | Low & Stable (82%) | High & Rising (11%) | High & Falling (7%) | Low & Stable (82%) |
| 3-Asset Mean-Var Optimization | 20% cap | 5.6% | -0.4% | -0.4% | 4.0% | 13.4% | 11.1% | 11.1% | 13.6% | 9.0% |
| | 36% | 10.2% | -0.7% | -0.6% | 8.6% | 13.0% | 10.8% | 10.9% | 13.3% | 9.3% |
| Mix of 60/40 & Real Asset Basket such that Inflation β = 0 | 24% | 6.3% | -1.9% | -0.7% | 4.7% | 11.8% | 10.7% | 9.9% | 13.0% | 8.1% |
| Maximize Returns such that Vol ≤ 60/40 Vol | 20% cap | 5.9% | 0.8% | -0.1% | 4.3% | 14.7% | 11.4% | 12.0% | 14.2% | 9.8% |
| | 37% | 10.9% | 0.2% | -0.5% | 9.3% | 14.1% | 11.0% | 11.6% | 13.7% | 10.0% |
| 60/40 | 0% | 0.0% | 0.0% | 0.0% | -1.5% | 13.9% | 11.5% | 12.1% | 14.3% | 9.6% |




Note: Inflationary episodes are determined *ex post* as 2ppt above the trailing 4Q average, with some quarters assigned a regime using our qualitative judgement to eliminate very short, transitory episodes of high inflation. In contrast, when formulating a *dynamic* real asset allocation strategy, a real-time, *ex ante* data driven rule is used that assumes only information available in each period and includes data release lags in assessing asset performance (see below for details). Source: Bloomberg, Bureau of Labor Statistics, DataStream, Haver Analytics, Standard & Poor's, U.S. Treasury and PGIM IAS. Provided for illustrative purposes only. Past performance is no guarantee or reliable indicator of future results.

5 Results for different risk preference and benchmark choices (*e.g.*, a *more* risk-averse investor for whom a 40/60 portfolio of stocks and bonds is optimal and a *less*-risk averse investor for whom an 80/20 stock-bond portfolio is optimal) are in Appendix 2.

## Dynamic Real-Asset Allocation Strategies: Allocating to Real Assets when Inflation is High & Rising

To address the episodic drag of real assets on portfolio performance, we investigate devising an easily implementable *dynamic* real asset allocation strategy to minimize periods of negative active returns. Said differently, is there a timing strategy – based on *ex ante* information and free of look-ahead bias – that makes it possible to allocate to real assets dynamically only during periods of *high and rising inflation*, protecting the portfolio during inflationary periods while avoiding periods of underperformance when inflation is less of a concern? While it is easy to identify high & rising (red) periods *ex post*, the challenge is to identify them *ex ante* and then allocate accordingly. In attempting to do so, we use inflation data available in real time and a simple-to-implement rule (detailed in the Box 1 below), **allocating to real assets when inflation is high and rising** (persistently) **and holding a benchmark stock-bond portfolio otherwise.**

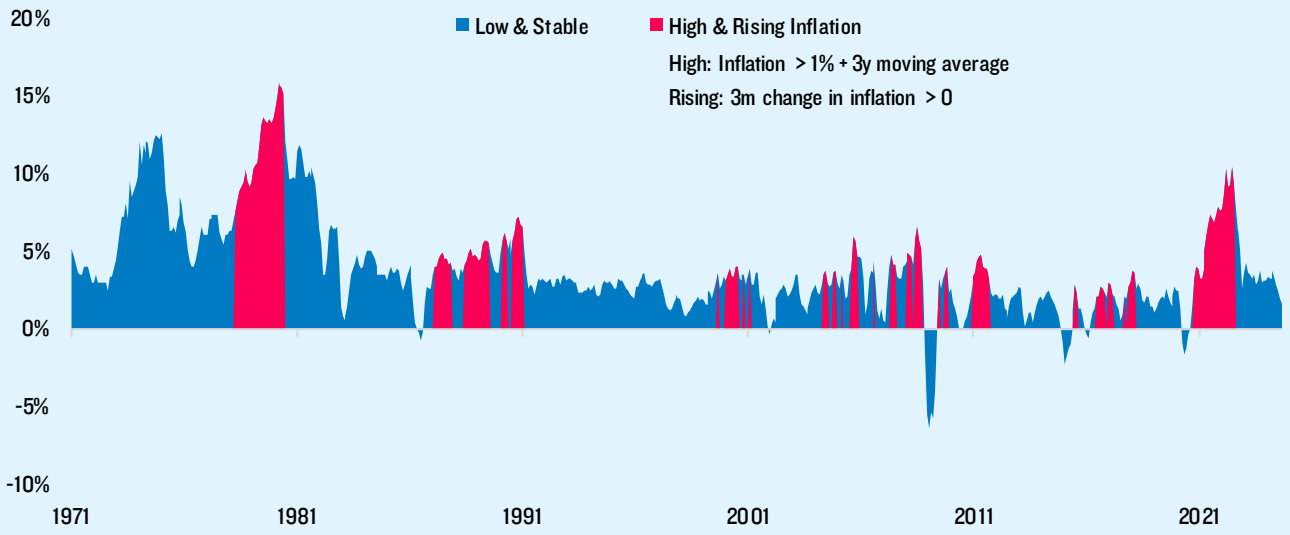
### BOX 1: DYNAMIC REAL ASSET ALLOCATION STRATEGY DETAILS

For a dynamic strategy backtest to be informative regarding the costs and benefits of allocating to real assets, the strategy has to be easy to implement, follow a clear set of plausible rules and rely only on information that would be available to the asset allocator in real time. The details of the proposed dynamic strategy are:

- **Data:** Monthly headline CPI.
- **Real-time:** Month "***t***" data are released in the *middle* of month $t + 1$ so that the allocation decision takes effect in month $t + 2$.
- **Inflation:** Defined as the rolling monthly annualized 6m %-change in CPI.
- **High:** A threshold level of inflation that a CIO would have – in real time – considered high. We examine **three** threshold rules for determining "high" inflation: inflation > 4%, inflation > 6% and inflation that is 1 percentage point greater than the 3y trailing moving average (which is a more cumbersome rule but provides a contemporaneous view of what *would have* been considered high at the time).
- **Rising**: Defined as a positive 3m change in inflation. To ensure persistence of inflation regimes, we allow for a bit of "wiggle" room. If month $t - 1$ inflation was high and rising (*i.e.,* the 6m %-change in CPI was above the threshold and the 3m change in inflation was positive) and in month $t$ inflation is high but falls by a little bit (a decline of 1% or less), we continue to hold the Real Asset Basket. If in month $t + 1$ the change in inflation is negative again, the inflation episode is considered over and we exit; if the change in inflation is positive, we continue to hold the basket of real assets.
- **Allocate:** To limit the number of portfolios to track, we focus on the inflation hedging rationale and choose to allocate 20% to the Real Asset Basket and 80% to the 60/40 portfolio (*i.e.*, stock, bond and real asset weights of 48%, 32% and 20%, respectively) in inflationary periods and 0% to the Real Asset Basket otherwise (other allocation choices are reported in Appendix 2). We assume that portfolio changes can be done instantly and at zero cost. (Note an inconsistency in dynamically allocating to real assets during periods of high and rising inflation, the real asset weight comes from the analysis above that depends on full history CMAs, not CMAs specific to periods of high and rising inflation.)
- **Benchmark:** A static 60/40 stock/bond portfolio (rebalanced monthly at zero cost).

Using the real-time criteria described here, periods of high and rising inflation are frequent and sometimes as short as a single month (Figure 12, which illustrates one possible inflation "rule" and Figure 13, which examines several such rules). Note, in our view, short periods of time where an assessment of the data would have seemed to suggest the onset of a period of high and rising inflation, only to be reversed a month or two later is a "feature" not a "bug." Such false positives are natural pitfalls that face market participants when assessing economic risks in "real time."

## Figure 12: US CPI Inflation (high and rising inflation episodes determined *ex ante* for a single inflation rule*, 1971-2024)




Note: Inflation is rolling monthly 6m %-change in CPI. Rule is inflation > 1% + trailing 3y moving avg. Ex ante regimes are determined only information available in each period and includes data release lags in assessing asset performance. Source: Bureau of Labor Statistics, Haver Analytics, PGIM IAS. For illustrative purposes only. *Summary statistics for other inflation rule choices are in Figure 12.

## Figure 13: High and Rising Inflation Episode Characteristics (identified *ex ante*, 1971-2024)

| Episode Determination Rule | No. of Episodes | Total Length (m) | Frequency | Average Length (m) | Frequency of... | | |
|---|---|---|---|---|---|---|---|
| | | | | | 1m-Episode | 2m-Episode | ≥ 3m-Episode |
| 1ppt > Trailing Moving Avg & Rising | 27 | 166 | 26% | 6 | 26% | 11% | 63% |
| Inflation > 4% & Rising | 22 | 175 | 27% | 8 | 14% | 5% | 82% |
| Inflation > 6% & Rising | 11 | 102 | 16% | 9 | 18% | 0% | 82% |

Note: In determining inflation regimes, only information available at each time period and includes data release lags in assessing asset performance. Source: Bureau of Labor Statistics, Haver Analytics, PGIM IAS. For illustrative purposes only.

The proposed dynamic strategy – allocating to the Real Asset Basket only when inflation is high & rising and holding the 60/40 portfolio otherwise – should preserve inflation-regime outperformance and eliminate underperformance in non-inflationary periods. But is it possible to identify inflationary episodes in real time and still be able to capture real asset outperformance? In other words, if inflationary regimes are identified imprecisely and with a lag, is real asset outperformance persistent and large enough to still benefit the portfolio?

To assess the success of dynamic allocation strategies, realized performance of the dynamic strategies are compared to both (1) a static buy and hold 60/40 Stock/Bond portfolio and (2) a static 48/32/20 Stock/Bond/Real Asset portfolio that is *always* fully allocated to the Real Asset Basket (with results for other optimal portfolios and for individual real assets in Appendix 2).

Looking across three different real time inflation "rules," over the last 50y, a *dynamic* real asset allocation strategy based on identifying periods of high and rising inflation in "real time" has delivered (Figure 14):

- *Higher* returns, *lower* volatility, and *higher* risk-adjusted returns relative to a *static* Stock/Bond benchmark, but…
- *Higher* returns, *higher* volatility, and *lower* risk-adjusted returns relative to a *static* Stock/Bond/Real Asset Basket benchmark

## Figure 14: Dynamic Stock/Bond/Real Asset Basket Portfolio Performance by *ex ante* Inflation Regime (1971-2024)

| Allocation Strategy | Stock / Bond / Real Asset Weights (%) | | | Performance | | | | Average Active Return *vs.* Static | |
|---|---|---|---|---|---|---|---|---|---|
| | High & Rising | All Other | Inflation Rule | Mean | Vol | Mean/Vol | Sortino Ratio | Stock/Bond | Stock/Bond/ Real Asset Basket |
| **Static** Stock/Bond | 60 / 40 / **0** | | N/A | 10.1% | 10.0% | 1.01 | 1.52 | N/A | 0.0% |
| **Static** Stock/Bond/Real Asset Basket | 48 / 32 / **20** | | N/A | 10.1% | 8.7% | 1.15 | 1.71 | 0.0% | N/A |
| **Dynamic** Stock/Bond/ Real Asset Basket (as determined by inflation regime) | 48 / 32 / **20** | 60 / 40 / **0** | Inflation 1ppt Above Trailing Moving Avg & Rising | 10.6% | 9.6% | 1.10 | 1.68 | 0.5% | 0.5% |
| | | | Inflation > 4% & Rising | 10.5% | 9.4% | 1.12 | 1.72 | 0.5% | 0.5% |
| | | | Inflation > 6% & Rising | 10.4% | 9.6% | 1.08 | 1.65 | 0.3% | 0.3% |

Note: Portfolios are rebalanced quarterly at zero cost. Mean is the annualized average of quarterly returns. Vol is annualized volatility of quarterly returns. Source: Bloomberg, Bureau of Labor Statistics, DataStream, Federal Reserve Bank of Chicago, Foundation for Intl Business & Economic Research, FTSE NAREIT, Giliberto-Levy, Haver Analytics, Standard & Poor's, U.S. Treasury and PGIM IAS. Provided for illustrative purposes only. Past performance is no guarantee or reliable indicator of future results.

While the dynamic strategy is designed to eliminate negative active returns in non-inflationary periods while still outperforming when inflation is high & rising and protection is needed most, it has some drawbacks. Because it requires a real time (*i.e.*, ex ante) read of the inflation data, it is susceptible to false positives and does not always capture peak real asset returns, diluting outperformance during periods of high & rising inflation (when compared to real asset returns during inflationary periods when looking back with hindsight). More critically, because the Real Asset Basket is often not in the portfolio, the volatility reducing diversification benefits of including a third asset alongside stocks and bonds is also often absent. Hence, the dynamic portfolio has higher volatility than the *static* Stock/Bond/Real Asset Basket portfolio.

So, the choice of a static real asset portfolio *vs.* a dynamic real asset portfolio reduces to the inexorable tradeoff between risk and return. The dynamic portfolio boosts return by avoiding periods of underperformance, but at the cost of a less diversified portfolio.

This drawback raises an interesting possibility. If the issue is that the *reward* to a dynamic real asset allocation strategy does not fully compensate the investor for the incremental *risk* that comes with the loss of diversification, what if an investor could *engineer even higher returns during periods of high & rising inflation?* In other words, what if an investor chooses to "lean in" to real assets when they are most expected to outperform, with the goal of boosting inflationary regime returns to "pay" for the loss of diversification in non-inflationary periods? (This can be thought of as a backdoor way of recognizing that if CMAs were restricted just to inflationary periods when real asset returns are highest, optimal allocations would likely be higher, addressing the inconsistency that is inherent in using *full-period* CMAs and resulting optimal weights to allocate to real assets during periods of *high and rising inflation* when returns are much higher.)

Indeed, as the dynamic inflationary period allocation to the Real Asset Basket *increases*, returns increase (Figure 15). As the dynamic allocation climbs into the 40% to 60% range – which may be implausibly high for many funds – the pickup in returns outpaces incrementally higher vol and pushes risk-adjusted returns above that of the static Stock/Bond/Real asset portfolio.

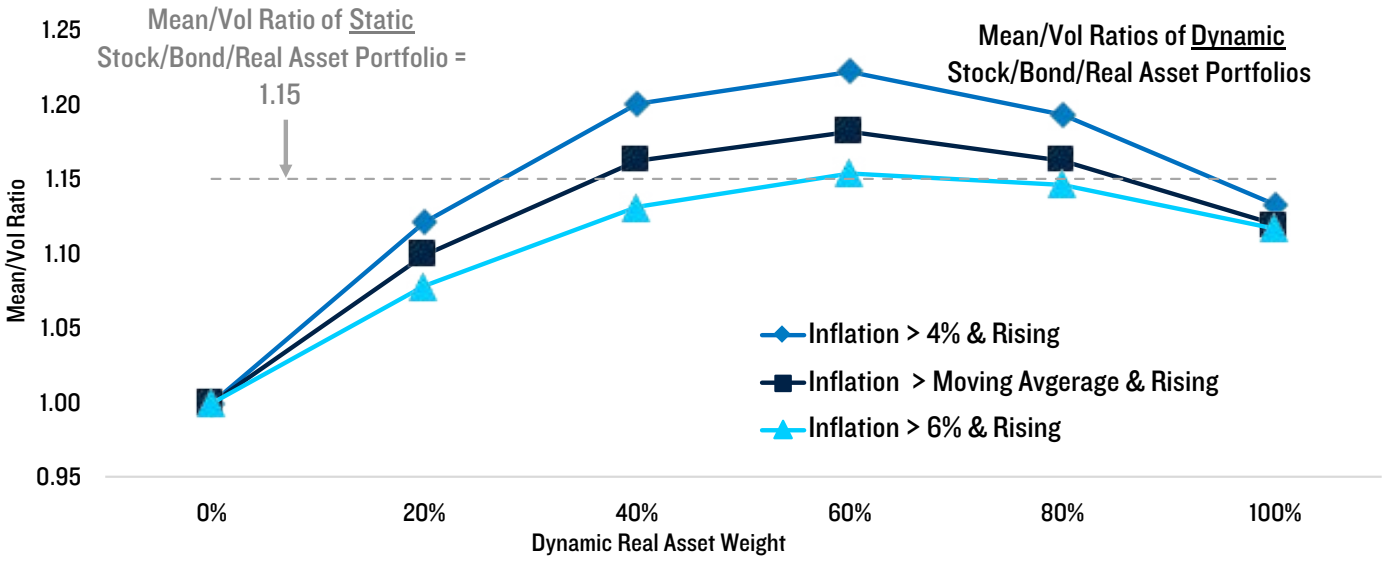
At low levels of real asset allocation, returns in the inflationary period are not sufficient to boost the risk-reward ratio of the strategy above that of a static Stock/Bond/Real Asset portfolio. However, as the allocation to real assets increases, there is a return boost that outpaces volatility, up to a point.

## Figure 15: Dynamic Stock-Bond-Real Asset Basket Portfolio Performance by *ex ante* Inflation Regime: "Leaning In" to Real Assets (1971-2024)

| Allocation Strategy | Stock / Bond / Real Asset Weight (%) | | | Performance | | | | Expected Active Return *vs.* | |
|---|---|---|---|---|---|---|---|---|---|
| | High & Rising | All Other | Inflation Rule | Mean | Vol | Mean/Vol | Sortino Ratio | Stock/Bond | Stock/Bond/ Real Asset |
| **Static Stock/Bond** | 60 / 40 / **0** | | N/A | 10.1% | 10.0% | 1.01 | 1.52 | N/A | 0.0% |
| **Static Stock/Bond/ Real Asset** | 48 / 32 / **20** | | N/A | 10.1% | 8.7% | 1.15 | 1.71 | 0.0% | N/A |
| **Dynamic Stock/Bond/ Real Asset** | 48 / 32 / **20** | 60 / 40 / **0** | Inflation 1ppt Above Trailing Moving Avg & Rising | 10.6% | 9.6% | 1.10 | 1.68 | 0.5% | 0.5% |
| | 36 / 24 / **40** | | | 11.1% | 9.6% | 1.16 | 1.80 | 1.0% | 1.1% |
| | 24 / 16 / **60** | | | 11.7% | 9.9% | 1.18 | 1.84 | 1.6% | 1.6% |
| | 12 / 8 / **80** | | | 12.3% | 10.6% | 1.16 | 1.84 | 2.2% | 2.2% |
| | 0 / 0 / **100** | | | 12.9% | 11.5% | 1.12 | 1.82 | 2.8% | 2.8% |

Note: Portfolios are rebalanced quarterly at zero cost. Mean is the annualized average of quarterly returns. Vol is annualized volatility of quarterly returns. Source: Bloomberg, Bureau of Labor Statistics, DataStream, Federal Reserve Bank of Chicago, Foundation for Intl Business & Economic Research, FTSE NAREIT, Giliberto-Levy, Haver Analytics, Standard & Poor's, U.S. Treasury and PGIM IAS. Provided for illustrative purposes only. Past performance is no guarantee or reliable indicator of future results.

## Figure 16: Dynamic Real Asset Allocations and Risk-Adjusted Returns for Different Inflation Identification Strategies (1971- 2024)




Source: Bloomberg, Bureau of Labor Statistics, DataStream, Federal Reserve Bank of Chicago, Foundation for Intl Business & Economic Research, FTSE NAREIT, Giliberto-Levy, Haver Analytics, Standard & Poor's, U.S. Treasury and PGIM IAS. Provided for illustrative purposes only. Past performance is no guarantee or reliable indicator of future results.

As Figure 16 illustrates, the incremental improvement from "leaning in" to real assets based on the inflation signal is hump shaped, increasing as the allocation to the Real Asset Basket during periods of high and rising inflation rises from 0% (the 60/40 stock-bond portfolio) to about 60%, before deteriorating. This pattern is evident across a variety of inflation "rules." A 40% to 60% dynamic allocation to real assets boosts returns enough in inflationary periods to push the mean/vol ratio above that of the static stock-bond-real asset strategy (despite the loss of diversification in non-inflationary periods). Beyond that, volatility rises further but returns do not keep pace.

## CIO Takeaways

Having experienced an extended period of high inflation for the first time in several decades, and with the economic forces that supported a decades-long period of low and stable inflation perhaps in flux, market participants remain focused on inflation risks and the potential role of real assets in helping manage that risk.

In our conversations with investors, motivations for allocating to real assets can be broadly categorized into three buckets: portfolio diversification, return enhancement, and inflation risk hedging. Indeed, historically, real asset returns are driven in large part by their exposure to inflation, are not highly correlated to either stocks or bonds, are not highly correlated to each other, and tend to outperform during inflationary episodes.

In our view, each one of these motivations can be related to a method for constructing a Stock/Bond/Real Asset portfolio. In building these optimal portfolios and assessing their performance, there are several key messages to take away:

1. **Real assets have a place in a balanced portfolio.** Looking back over the last 50 years, Stock/Bond/Real Asset Basket portfolios have outperformed benchmark Stock/Bond portfolios. An allocation to the Real Asset Basket in the 20% range could protect real terminal (10y) wealth from being eroded in worst-case scenarios.

2. **Portfolio performance depends on inflation regime.** Including a Real Asset Basket alongside stocks and bond has generated significant positive active returns during past periods of high and rising inflation (*vs*. a 60/40 Stock/Bond benchmark). However, when inflation is falling or is low and stable, allocating to the Real Asset Basket was a drag on portfolio performance, with negative active returns.

3. **A dynamic real asset allocation strategy could concentrate returns in high & rising inflationary periods and mitigate drag otherwise** A strategy of *dynamically* allocating to the Real Asset Basket alongside stocks and bonds when inflation is high and rising only (according to a simple, real time, data-based "rule") could outperform a *static* 60/40 Stock/Bond portfolio, delivering higher returns at lower volatility and without protracted periods of negative active returns.

4. **…but a dynamic real asset allocation strategy sacrifices some diversification.** A *dynamic* real asset allocation strategy could also deliver higher average returns relative to a *static* stock/bond/real asset portfolio but with a bit more volatility. The cost of only *episodically* including real assets is that their diversification benefit is absent most of the time, which is a headwind to risk-adjusted returns. An aggressive allocation to the Real Asset Basket when real-time inflation is high and rising could boost returns and improve the risk-reward tradeoff.

## Acknowledgments

We wish to thank Dr. Taimur Hyat (PGIM) for his valuable comments and suggestions.

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# Appendix 1: RASA™ – Real Asset Data, Performance & Risk Metric Construction Details

The specific assets typically included in the "real assets" asset class are quite diverse, spanning the capital structure and including both public and private assets. We focus mostly on public market real assets because they tend to have price histories that extend back to the 1970s, covering the two inflationary episodes in that period, and because the performance of a private real asset benchmark does not capture the "real world" performance of a private real asset strategy, which depends on manager skill, manager selection, cash-flow timing (disbursements and capital calls), vintage, and the return from committed but uncalled capital.) Data construction details, data sources and time histories are summarized in Figure A1.

Note, for a handful of real assets (the commodities index, the industrial metals index and infrastructure equities marked with *) price histories back to the 1970s are based on combining several data series together. Backfilling is based on regressing the preferred but shorter price series on the data with longer histories "in sample" and then using the estimated parameters to project the preferred series backward.

## Figure A1: Real Assets: Data Sources and Performance Metrics (1971-2024)

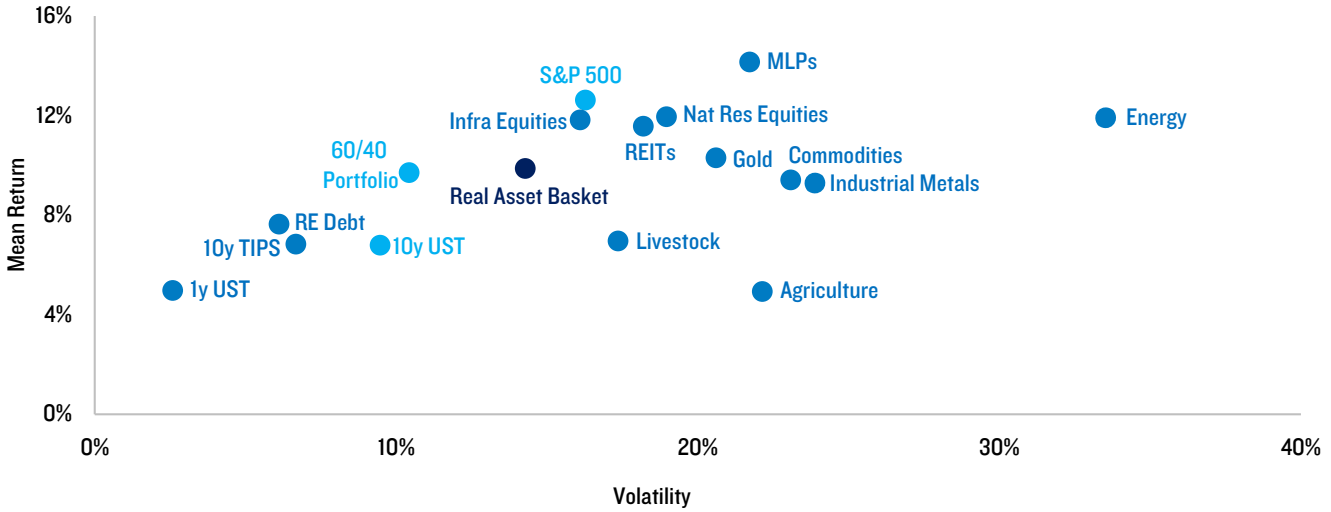
| Real Asset | Start Date | Mean Return | Vol | Mean/Vol | Correlation with... | | Inflation $\beta$ | Source |
|---|---|---|---|---|---|---|---|---|
| | | | | | S&P 500 | 10y UST | | |
| Agriculture | 1971Q1 | 4.9% | 22.1% | 0.22 | -0.01 | -0.08 | 3.16 | GSCI |
| Energy | 1971Q1 | 11.9% | 33.5% | 0.36 | 0.05 | -0.28 | 6.31 | |
| Livestock | 1971Q1 | 7.0% | 17.4% | 0.40 | 0.10 | -0.12 | 1.20 | |
| Commodities* | 1970Q4 | 9.5% | 23.1% | 0.41 | 0.04 | -0.27 | 5.12 | GSCI, Foundation for Intl Business & Economic Research |
| Industrial Metals* | 1971Q1 | 9.3% | 23.8% | 0.39 | 0.17 | -0.20 | 1.68 | |
| Gold | 1970Q4 | 10.3% | 20.6% | 0.50 | -0.04 | 0.13 | 2.72 | Datastream |
| MLPs | 1974Q1 | 14.2% | 21.7% | 0.65 | 0.52 | 0.00 | 0.53 | |
| Infra Equities* | 1974Q1 | 11.9% | 16.0% | 0.74 | 0.65 | 0.19 | -0.18 | S&P, Datastream |
| Nat Res Equities | 1974Q1 | 12.0% | 19.0% | 0.63 | 0.71 | -0.16 | 1.20 | S&P |
| RE Debt | 1972Q4 | 7.6% | 6.1% | 1.25 | 0.28 | 0.71 | -0.50 | Giliberto-Levy |
| REITs | 1974Q1 | 11.5% | 18.2% | 0.63 | 0.71 | 0.04 | 0.20 | FTSE NAREIT |
| 10y TIPS | 1974Q1 | 6.9% | 6.6% | 1.03 | 0.13 | 0.76 | 0.39 | Bloomberg |
| 1y UST | 1971Q1 | 5.0% | 2.6% | 1.92 | 0.06 | 0.63 | 0.37 | US Treasury |
| Real Asset Basket | 1974Q1 | 9.9% | 14.3% | 0.69 | 0.04 | -0.04 | 3.12 | PGIM IAS |
| S&P 500 | 1971Q1 | 12.6% | 16.3% | 0.77 | 1.00 | -0.02 | -0.74 | S&P |
| 10y UST | 1971Q1 | 6.8% | 9.5% | 0.71 | -0.02 | 1.00 | -1.32 | US Treasury |
| 60/40 Portfolio | 1971Q1 | 9.7% | 10.4% | 0.93 | 0.93 | 0.35 | -0.97 | S&P, US Treasury |

Source: Bloomberg, DataStream, Federal Reserve Bank of Chicago, Foundation for Intl Business & Economic Research, FTSE NAREIT, Giliberto-Levy, Haver Analytics, Standard & Poor's, U.S. Treasury and PGIM IAS. Provided for illustrative purposes only.

Figure A1 also presents risk metrics that relate to the three motivations for owing real assets – diversification, return enhancement and inflation hedging. Return, volatility and correlation calculations are as usual – using quarterly total returns. We estimate each real asset' beta to inflation based on our existing "RASATM" (Real Asset Sensitivity Analysis) framework. Each real asset's returns are regressed on CPI inflation and CFNAI with the coefficients reported in Figure A1.

RASA risk metrics for a wider range of real assets are available to clints on line via PGIM's CIO Interactive Portfolio Construction Toolkit that presents (annually updated) asset-level exposures to key macroeconomic and market risk factors, allowing users to evaluate their real assets allocation to determine if a chosen benchmark is aligned with investor objectives, compare investors' real assets portfolio to peer portfolios, and conduct "what-if" analysis to fine tune allocation within the real asset portfolio.

## Figure A2: The Efficient Frontier (1971-2024)




Note: Mean return and volatility are annualized and based on quarterly total returns using each asset's individual full history and ending in 2024Q4. Source: Bloomberg, DataStream, Federal Reserve Bank of Chicago, Foundation for Intl Business & Economic Research, FTSE NAREIT, Giliberto-Levy, Haver Analytics, Standard & Poor's, U.S. Treasury and PGIM IAS. Provided for illustrative purposes only. Past performance is no guarantee or reliable indicator of future results.

# Appendix 2: Portfolio Construction and Performance – Alternative Real Asset Baskets, Alternative Risk Preferences & Individual Real Assets

## Figure A3: Performance of Stock/Bond/Real Asset (Gold & Energy) Basket Portfolios (1971-2024)

| Motivation | Stock/Bond/Real Asset Basket Portfolio Construction Method | Allocation | | | Mean | Vol | Mean/Vol | Expected Active Return *vs.* 60/40 |
|---|---|---|---|---|---|---|---|---|
| | | Real Asset Basket | Stock | Bond | | | | |
| Diversification | 3-Asset Mean-Var Optimization | 20% Cap | 53% | 27% | 10.2% | 9.7% | 1.05 | 0.5% |
| | | 26% | 51% | 23% | 10.3% | 9.9% | 1.04 | 0.6% |
| Return Enhancement | Mix of 60/40 & Real Asset Basket such that Inflation $\beta = 0$ | 18% | 49% | 33% | 10.0% | 9.2% | 1.09 | 0.3% |
| Inflation Hedging | Maximize Returns such that Vol $\leq$ 60/40 Vol | 20% Cap | 58% | 22% | 10.5% | 10.4% | 1.00 | 0.8% |
| | | 27% | 54% | 19% | 10.5% | 10.4% | 1.01 | 0.8% |
| Benchmark | 60/40 | 0% | 60% | 40% | 9.7% | 10.4% | 0.93 | 0.0% |

Source: Bloomberg, DataStream, Federal Reserve Bank of Chicago, Foundation for Intl Business & Economic Research, FTSE NAREIT, Giliberto-Levy, Haver Analytics, Standard & Poor's, U.S. Treasury and PGIM IAS. Provided for illustrative purposes only. Past performance is no guarantee or reliable indicator of future results.

## Figure A4: Performance of Stock/Bond/Real Asset (Gold, Energy, 1y UST) Basket Portfolios (1971-2024)

| Motivation | Stock/Bond/Real Asset Basket Portfolio Construction Method | Allocation | | | Mean | Vol | Mean/Vol | Expected Active Return *vs.* 60/40 |
|---|---|---|---|---|---|---|---|---|
| | | Real Asset Basket | Stock | Bond | | | | |
| Diversification | 3-Asset Mean-Var Optimization | 20% Cap | 54% | 26% | 9.9% | 9.4% | 1.05 | 0.2% |
| | | 32% | 50% | 18% | 10.0% | 9.4% | 1.06 | 0.3% |
| Return Enhancement | Mix of 60/40 & Real Asset Basket such that Inflation β = 0 | 24% | 46% | 31% | 9.6% | 8.5% | 1.13 | -0.1% |
| Inflation Hedging | Maximize Returns such that Vol ≤ 60/40 Vol | 20% Cap | 61% | 19% | 10.2% | 10.4% | 0.98 | 0.5% |
| | | 33% | 57% | 10% | 10.3% | 10.4% | 0.99 | 0.6% |
| Benchmark | 60/40 | 0% | 60% | 40% | 9.7% | 10.4% | 0.93 | 0.0% |

Source: Bloomberg, DataStream, Federal Reserve Bank of Chicago, Foundation for Intl Business & Economic Research, FTSE NAREIT, Giliberto-Levy, Haver Analytics, Standard & Poor's, U.S. Treasury and PGIM IAS. Provided for illustrative purposes only. Past performance is no guarantee or reliable indicator of future results. Past performance is no guarantee or reliable indicator of future results. Past performance is no guarantee or reliable indicator of future results.

## Figure A5: Performance of Stock/Bond/Real Asset Basket Portfolios *vs.* 80/20 Benchmark (1971-2024)

| Motivation | Stock/Bond/Real Asset Basket Portfolio Construction Method | Allocation | | | Mean | Vol | Mean/Vol | Expected Active Return *vs.* 80/20 |
|---|---|---|---|---|---|---|---|---|
| | | Real Asset Basket | Stock | Bond | | | | |
| Diversification | 3-Asset Mean-Var Optimization | 20% Cap | 74% | 6% | 10.9% | 12.5% | 0.87 | 0.4% |
| | | 37% | 63% | 0% | 10.9% | 11.8% | 0.93 | 0.3% |
| Return Enhancement | Mix of 80/20 & Real Asset Basket such that Inflation β = 0 | 21% | 63% | 16% | 10.5% | 10.9% | 0.96 | -0.1% |
| Inflation Hedging | Maximize Returns such that Vol ≤ 80/20 Vol | 20% Cap | 78% | 2% | 11.0% | 13.2% | 0.84 | 0.5% |
| | | 22% | 78% | 0% | 11.1% | 13.2% | 0.84 | 0.5% |
| Benchmark | 80/20 | 0% | 80% | 20% | 10.5% | 13.2% | 0.80 | 0.0% |

Note: Mean-variance optimization assumes a risk aversion parameter such that an 80/20 portfolio is optimal when using full history data to form CMAs. Return maximization constraint is that portfolio volatility is <= that of a 80/20 benchmark stock/bond portfolio. Inflation hedging is a mixture of the 80/20 portfolio and the real asset basket such that the net inflation beta = 0. Source: Bloomberg, DataStream, Federal Reserve Bank of Chicago, Foundation for Intl Business & Economic Research, FTSE NAREIT, Giliberto-Levy, Haver Analytics, Standard & Poor's, U.S. Treasury and PGIM IAS. Provided for illustrative purposes only. Past performance is no guarantee or reliable indicator of future results.

## Figure A6: Performance of Stock/Bond/Real Asset Basket Portfolios *vs.* 40/60 Benchmark (1971-2024)

| Motivation | Stock/Bond/Real Asset Basket Portfolio Construction Method | Allocation | | | Mean | Vol | Mean/Vol | Expected Active Return *vs.* 40/60 |
|---|---|---|---|---|---|---|---|---|
| | | Real Asset Basket | Stock | Bond | | | | |
| Diversification | 3-Asset Mean-Var Optimization | 20% Cap | 34% | 46% | 9.1% | 7.6% | 1.20 | 0.4% |
| | | 36% | 31% | 39% | 9.2% | 7.6% | 1.22 | 0.5% |
| Return Enhancement | Mix of 40/60 & Real Asset Basket such that Inflation β = 0 | 26% | 30% | 45% | 9.0% | 7.4% | 1.23 | 0.3% |
| Inflation Hedging | Maximize Returns such that Vol ≤ 40/60 Vol | 20% Cap | 45% | 35% | 9.7% | 8.6% | 1.12 | 0.9% |
| | | 33% | 41% | 26% | 9.8% | 8.6% | 1.14 | 1.1% |
| Benchmark | 40/60 | 0% | 40% | 60% | 8.7% | 8.6% | 1.02 | 0.0% |

Note: Mean-variance optimization assumes a risk aversion parameter such that an 40/60 portfolio is optimal when using full history data to form CMAs. Return maximization constraint is that portfolio volatility is <= that of a 40/60 benchmark stock/bond portfolio. Inflation hedging is a mixture of the 40/60 portfolio and the real asset basket such that the net inflation beta = 0. Source: Bloomberg, DataStream, Federal Reserve Bank of Chicago, Foundation for Intl Business & Economic Research, FTSE NAREIT, Giliberto-Levy, Haver Analytics, Standard & Poor's, U.S. Treasury and PGIM IAS. Provided for illustrative purposes only. Past performance is no guarantee or reliable indicator of future results.

## Figure A7: Dynamic Strategy Portfolio Performance: Alternate Portfolios & Real Asset Baskets (1971-2024)

| Allocation Strategy | Stock / Bond / Real Asset Weight (%) | | | Performance | | | | Expected Active Return *vs.* static | |
|---|---|---|---|---|---|---|---|---|---|
| | High & Rising | All Other | Inflation Rule | Mean | Vol | Mean/Vol | Sortino Ratio | Stock-Bond | Stock/ Bond/ Real Asset |
| **Static** Stock/Bond | 60 / 40 / **0** | | N/A | 10.1% | 10.0% | 1.01 | 1.52 | N/A | 0.0% |
| **Static** Stock/Bond/ Real Asset | 48 / 32 / **20** | | N/A | 10.1% | 8.7% | 1.15 | 1.71 | 0.0% | N/A |
| **Dynamic** Stock/Bond/ Real Asset | 48 / 32 / **20** | 60 / 40 / **0** | Inflation 1ppt Above Trailing Moving Avg & Rising | 10.6% | 9.6% | 1.10 | 1.68 | 0.5% | 0.5% |
| | 49 / 15 / **36** (3-Asset Mean-Var Optimization) | | | 11.1% | 9.9% | 1.12 | 1.66 | 1.0% | 1.1% |
| | 46 / 31 / **24** (Mix of 60/40 & Real Asset Basket such that Inflation $\beta = 0$) | | | 10.7% | 9.6% | 1.11 | 1.70 | 0.6% | 0.6% |
| | 54 / 9 / **37** (Maximize Returns such that Vol ≤ 60/40 Vol) | | | 11.2% | 10.2% | 1.10 | 1.60 | 1.1% | 1.1% |
| | 48 / 32 / **20** (Real Asset Basket = Gold & Energy; equal-weighted) | | | 10.8% | 9.7%% | 1.11 | 1.69 | 0.7% | 0.8% |
| | 48 / 32 / **20** (Real Asset Basket = Gold, Energy & 1y UST; equal-weighted) | | | 10.5% | 9.5% | 1.10 | 1.70 | 0.4% | 0.5% |

Note: Portfolios are rebalanced quarterly at zero cost. Mean is the annualized average of quarterly returns. Vol is annualized volatility of quarterly returns. Source: Bloomberg, Bureau of Labor Statistics, DataStream, Federal Reserve Bank of Chicago, Foundation for Intl Business & Economic Research, FTSE NAREIT, Giliberto-Levy, Haver Analytics, Standard & Poor's, U.S. Treasury and PGIM IAS. Provided for illustrative purposes only. Past performance is no guarantee or reliable indicator of future results.

## Figure A8: Optimal Portfolio Weights, Portfolio Performance: Individual Real Assets (1971-2024)

| Motivation | Stock/Bond/Real Asset Basket Portfolio Construction Method | Real Asset | Allocation | | | Mean | Vol | Mean/ Vol | Mean | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Real Asset | Stock | Bond | | | | High & Rising | High & Falling | Low & Stable |
| Diversification | 3-Asset Mean-Var Optimization | Agriculture | 0% | 60% | 40% | 9.7% | 10.4% | 0.93 | 57.6% | -9.0% | 1.7% |
| | | Energy | 13% | 53% | 34% | 10.4% | 9.9% | 1.05 | 65.5% | 12.9% | 11.6% |
| | | Livestock | 8% | 57% | 35% | 9.6% | 10.1% | 0.96 | 7.6% | 18.7% | 6.3% |
| | | Commodities | 16% | 54% | 30% | 9.9% | 9.8% | 1.01 | 44.5% | -0.9% | 8.0% |
| | | Industrial Metals | 13% | 53% | 34% | 9.8% | 10.0% | 0.98 | 33.8% | -7.9% | 9.2% |
| | | Gold | 24% | 56% | 20% | 10.3% | 10.5% | 0.98 | 45.5% | -0.5% | 6.9% |
| | | MLPs | 30% | 41% | 29% | 10.7% | 11.9% | 0.90 | 15.4% | 19.4% | 15.0% |
| | | Infra Equities | 37% | 38% | 26% | 10.2% | 11.4% | 0.89 | -0.4% | 16.7% | 12.6% |
| | | Nat Res Equities | 18% | 43% | 38% | 9.7% | 10.3% | 0.95 | 15.2% | 17.4% | 11.8% |
| | | RE Debt | 53% | 47% | 0% | 9.5% | 9.1% | 1.04 | -0.9% | 4.8% | 8.3% |
| | | REITs | 22% | 43% | 36% | 9.7% | 10.7% | 0.91 | 7.8% | 9.0% | 11.5% |
| | | 10y TIPS | 29% | 55% | 16% | 9.5% | 9.8% | 0.97 | 4.9% | 7.2% | 6.5% |
| | | 1y UST | 0% | 60% | 40% | 9.7% | 10.4% | 0.93 | 3.9% | 8.5% | 4.5% |
| | | Real Asset Basket (Gold, Energy, TIPS) | 36% | 49% | 15% | 10.6% | 9.9% | 1.07 | 36.8% | 6.4% | 8.5% |
| | | Real Asset Basket (Gold, Energy, 1y UST) | 32% | 50% | 18% | 10.0% | 9.4% | 1.06 | 26.5% | 5.7% | 7.7% |
| | | Real Asset Basket (Gold, Energy) | 26% | 51% | 23% | 10.3% | 9.9% | 1.04 | 39.1% | 4.3% | 9.4% |
| Return Enhancement | Mix of 80/20 & Real Asset Basket such that Inflation $\beta = 0$ | Agriculture | 23% | 46% | 31% | 8.6% | 9.4% | 0.91 | 57.6% | -9.0% | 1.7% |
| | | Energy | 10% | 54% | 36% | 10.2% | 9.8% | 1.05 | 65.5% | 12.9% | 11.6% |
| | | Livestock | 45% | 33% | 22% | 8.3% | 9.9% | 0.84 | 7.6% | 18.7% | 6.3% |
| | | Commodities | 16% | 50% | 34% | 9.7% | 9.3% | 1.04 | 44.5% | -0.9% | 8.0% |
| | | Industrial Metals | 33% | 40% | 27% | 9.6% | 11.0% | 0.87 | 33.8% | -7.9% | 9.2% |
| | | Gold | 26% | 44% | 29% | 9.8% | 9.5% | 1.04 | 45.5% | -0.5% | 6.9% |
| | | MLPs | 65% | 21% | 14% | 11.5% | 16.2% | 0.71 | 15.4% | 19.4% | 15.0% |
| | | Infra Equities | 100% | 0% | 0% | 10.6% | 16.0% | 0.66 | -0.4% | 16.7% | 12.6% |
| | | Nat Res Equities | 45% | 33% | 22% | 10.2% | 12.8% | 0.80 | 15.2% | 17.4% | 11.8% |
| | | RE Debt | 100% | 0% | 0% | 7.4% | 6.1% | 1.22 | -0.9% | 4.8% | 8.3% |
| | | REITs | 83% | 10% | 7% | 10.0% | 16.3% | 0.61 | 7.8% | 9.0% | 11.5% |
| | | 10y TIPS | 71% | 17% | 11% | 7.6% | 6.5% | 1.16 | 4.9% | 7.2% | 6.5% |
| | | 1y UST | 73% | 16% | 11% | 6.4% | 3.9% | 1.65 | 3.9% | 8.5% | 4.5% |
| | | Real Asset Basket (Gold, Energy, TIPS) | 20% | 48% | 32% | 10.0% | 8.9% | 1.12 | 36.8% | 6.4% | 8.5% |
| | | Real Asset Basket (Gold, Energy, 1y UST) | 24% | 46% | 31% | 9.6% | 8.5% | 1.13 | 26.5% | 5.7% | 7.7% |
| | | Real Asset Basket (Gold, Energy) | 18% | 49% | 33% | 10.0% | 9.2% | 1.09 | 39.1% | 4.3% | 9.4% |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Inflation Hedging** | Maximize Returns such that Vol ≤ 80/20 Vol | Agriculture | 0% | 60% | 40% | 9.7% | 10.4% | 0.93 | 57.6% | -9.0% | 1.7% |
| | | Energy | 13% | 56% | 30% | 10.6% | 10.4% | 1.01 | 65.5% | 12.9% | 11.6% |
| | | Livestock | 7% | 61% | 33% | 9.8% | 10.5% | 0.93 | 7.6% | 18.7% | 6.3% |
| | | Commodities | 16% | 60% | 24% | 10.1% | 10.6% | 0.95 | 44.5% | -0.9% | 8.0% |
| | | Industrial Metals | 13% | 58% | 29% | 10.0% | 10.6% | 0.95 | 33.8% | -7.9% | 9.2% |
| | | Gold | 24% | 56% | 20% | 10.3% | 10.4% | 0.99 | 45.5% | -0.5% | 6.9% |
| | | MLPs | 26% | 39% | 35% | 10.3% | 10.9% | 0.95 | 15.4% | 19.4% | 15.0% |
| | | Infra Equities | 30% | 36% | 34% | 9.8% | 10.5% | 0.94 | -0.4% | 16.7% | 12.6% |
| | | Nat Res Equities | 19% | 45% | 37% | 9.8% | 10.5% | 0.93 | 15.2% | 17.4% | 11.8% |
| | | RE Debt | 42% | 58% | 0% | 9.9% | 10.5% | 0.95 | -0.9% | 4.8% | 8.3% |
| | | REITs | 21% | 42% | 37% | 9.6% | 10.5% | 0.91 | 7.8% | 9.0% | 11.5% |
| | | 10y TIPS | 21% | 60% | 18% | 9.7% | 10.4% | 0.93 | 4.9% | 7.2% | 6.5% |
| | | 1y UST | 0% | 60% | 40% | 9.7% | 10.4% | 0.93 | 3.9% | 8.5% | 4.5% |
| | | Real Asset Basket (Gold, Energy, TIPS) | 37% | 54% | 9% | 10.8% | 10.6% | 1.03 | 36.8% | 6.4% | 8.5% |
| | | Real Asset Basket (Gold, Energy, 1y UST) | 33% | 57% | 10% | 10.3% | 10.4% | 0.99 | 26.5% | 5.7% | 7.7% |
| | | Real Asset Basket (Gold, Energy) | 27% | 54% | 19% | 10.5% | 10.4% | 1.01 | 39.1% | 4.3% | 9.4% |
| **Benchmark** | 60/40 | | 0% | 60% | 40% | 9.7% | 10.4% | 0.93 | -1.5% | 14.2% | 11.0% |

Note: Portfolios are rebalanced quarterly at zero cost. Mean is the annualized average of quarterly returns. Vol is annualized volatility of quarterly returns. Source: Bloomberg, Bureau of Labor Statistics, DataStream, Federal Reserve Bank of Chicago, Foundation for Intl Business & Economic Research, FTSE NAREIT, Giliberto-Levy, Haver Analytics, Standard & Poor's, U.S. Treasury and PGIM IAS. Provided for illustrative purposes only. Past performance is no guarantee or reliable indicator of future results.

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20250212-4232742