Positioning for Success in US Exposures
Insights Gained from Machine Learning

Daniel Ung, CFA, CQF, CAIA, FRM
Head of Quantitative Research & Analysis
ETF Model Portfolio Solutions EMEA & APAC

Kartik Chawla
Senior Quantitative Research Analyst
ETF Model Portfolio Solutions EMEA & APAC

Jędrzej Miklaszewski
Quantitative Research Analyst
ETF Model Portfolio Solutions EMEA & APAC

Regardless of whether there is an improvement in market sentiment, one thing is clear. The economic outlook and financial markets could continue to be somewhat nebulous. For this reason, it is important for investors to exercise caution in their portfolio positioning. The analysis in this paper, which makes extensive use of machine learning insights, is designed to cater to investors looking for additional ideas in how to implement a regime-based tactical or a strategic asset allocation approach.

Introduction

In the most recent Global Market Outlook,[1] we highlighted that investors should be vigilant and adopt cautious portfolio positioning in the face of heightened liquidity risk and softening economic growth prospects. Over the last few years, the global economy and financial markets witnessed a tectonic shift from a world of abundant liquidity to one where liquidity was removed at breakneck speed. In our view, the intensity of the inflation surge can, at least in part, be attributed to the rapid increase in money supply in the aftermath of the COVID-19 pandemic. Moving on to 2024, we forecast that growth will slow although a US recession remains a real possibility.

Many of the observations noted in the Global Market Outlook are also confirmed through our textual analysis of the recent Federal Reserve documents — which encompass meeting minutes, press conference transcripts, speeches by Federal Reserve Board of Governors members among others. Unsurprisingly, the topic of inflation continued to take on importance in July 2023 (see the "word cloud" in Figure 1).

STATE STREET GLOBAL ADVISORS **SPDR**®

Based on this analysis, it is also abundantly clear that the way in which the Fed has sought to tackle inflation is through the application of monetary policy, rather than any other conventional or ad-hoc measures (see Figure 2). Interestingly, our text analysis also suggests that the Fed is now less worried about an imminent risk of inflation, as demonstrated by the reduced mention of the word "inflation" in Figure 2 and the generally more positive — albeit still negative — sentiment on the main topics, which are derived from Latent Dirichlet Allocation, a technique frequently used to identify the main topics in texts (see Figure 3). Additionally, the tone relating to "aggregate demand" and "financial markets" has seen the strongest improvement in sentiment.

Regardless of whether there is an improvement in market sentiment, one thing is clear. The economic outlook and financial markets could continue to be somewhat nebulous. For this reason, it is important for investors to exercise caution in their portfolio positioning. The analysis in this paper is designed to cater to investors looking for additional ideas in how to implement a regime-based tactical or a strategic asset allocation strategy.

Figure 1
"Word Cloud" of the Most Important Words in the Analysis of the Federal Reserve Documents in July 2023

Source: State Street Global Advisors, Board of Governors of the Federal Reserve System.

Figure 2
Change in the Top Words Being Mentioned in Federal Reserve Documents Between July 2021 and July 2023

■ July 2022 and July 2023   ■ July 2021 and July 2022

Source: State Street Global Advisors, Board of Governors of the Federal Reserve System.

**Change in Topic
Sentiment
Between July 2021
and July 2023**

- ■ Monetary Policy
- ■ Labour Market
- ■ Financial Markets
- ■ Aggregate Demand
- ■ Market Outlook
- ■ Inflation
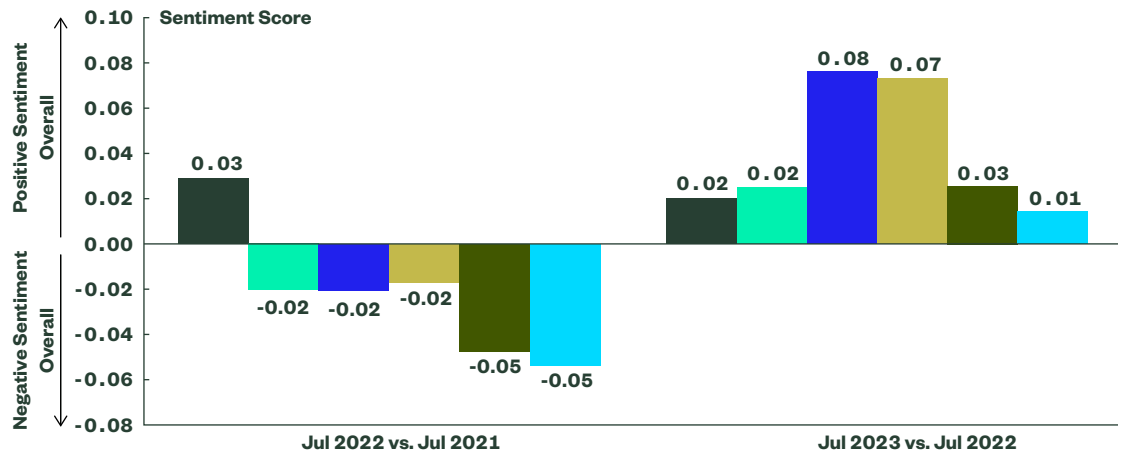
Source: State Street Global Advisors, Board of Governors of the Federal Reserve System, GitHub.[3]

Regime-Based Tactical Asset Allocation

A typical investment approach that investors may adopt is tactical asset allocation, which encourages adjustments to the blend of investment assets based on shorter investment horizons. This approach seeks to benefit from market trends or economic conditions by actively shifting a portfolio's allocations across or within asset classes. To shed light on the economic sensitivity of investment assets across economic regimes, we have carried out a historical analysis between January 1982 and July 2023 to define regimes constructed using select macroeconomic variables (namely, leading economic indicator,[4] real interest rate[5] and inflation[6]). The regimes are defined according to the Hidden Markov approach, a statistical technique that aims to model underlying regimes that are not directly observable but can be inferred from observed data. A variety of regimes with different numbers of states were fitted to the macroeconomic dataset to determine the optimal regime, based on its fit to the observed data.

Once the "best" regime was determined, we then computed regime-based performance statistics for each of the assets under examination. The scope of the analysis encompasses US equity exposures, including broad equities, smart beta and sectors, and US fixed income, spanning US broad fixed income, corporate bonds, Treasury bills and others.

On the basis of the Hidden Markov analysis, the macroeconomic data can be reasonably captured in three states, notably 1) Strong Expansion, 2) Moderate Expansion and 3) Contraction (see Figure 4). In our analysis, the most common regime was Moderate Expansion — which accounted for 66% of the observations — followed by Contraction (22% of observations) and Strong Expansion (12% of observations) (see Figure 5).

Because the underlying economic environment of these phases is fundamentally different, we have elected to use different measures to assess the performance of assets in different regimes. In particular, in more challenging economic environments, risk is a much bigger concern and, for this reason, we have opted to place more emphasis on risk-adjusted return in contractionary phases.

Conversely, in environments where economic growth is decent and real interest rates are reasonable, risk is less of a worry and, in this instance, we have chosen to focus on absolute return numbers, most notably in strong and moderate expansionary phases. Regardless of whether the economic regime is expansionary or contractionary, it is also important to examine the "performance persistence" of the exposures in each economic regime, defined as the frequency of positive returns in a given regime.

Figure 4

Macroeconomic Regimes as Defined by a 3-State Hidden Markov Model
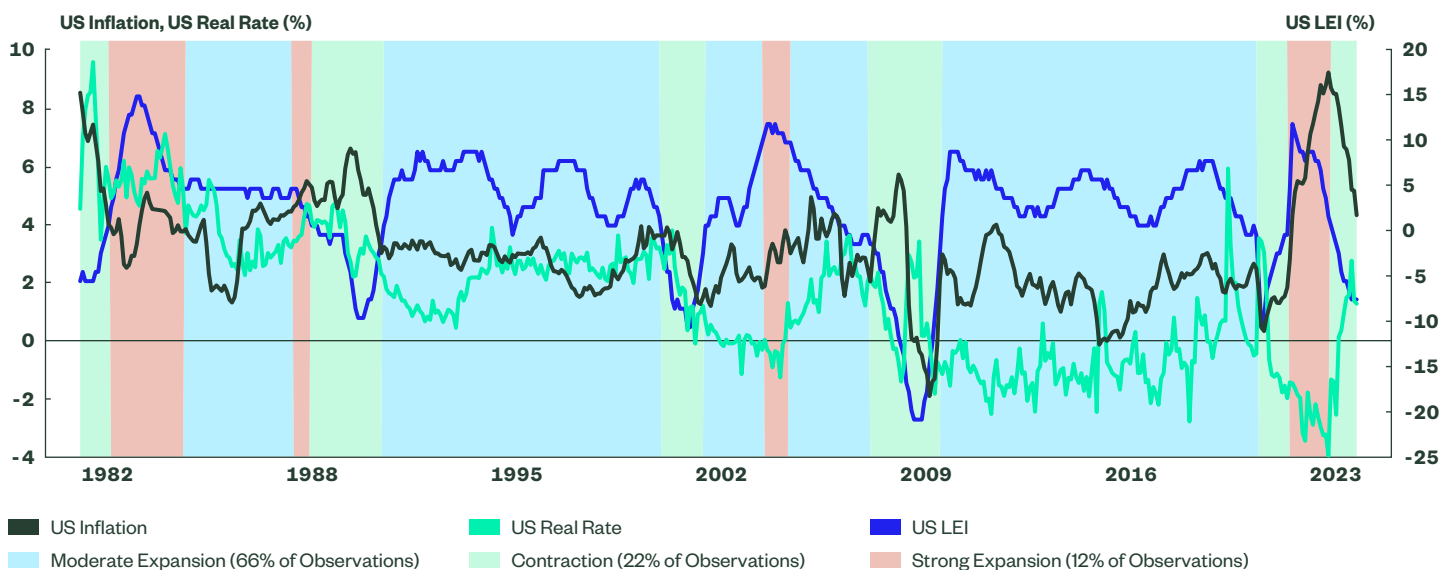
US Inflation, US Real Rate (%) — US LEI (%)

- ■ US Inflation
- ■ US Real Rate
- ■ US LEI
- ■ Moderate Expansion (66% of Observations)
- ■ Contraction (22% of Observations)
- ■ Strong Expansion (12% of Observations)

Source: State Street Global Advisors. Analysis based on monthly data from January 1982 to July 2023.

Figure 5

3-State Markov Regime Definition

Regime	Leading Economic Indicator (%)	Real Interest Rate (1 year) (%)	Inflation (%)	Number of Observations (%)
Strong Expansion	8.00	4.25	4.21	12.47
Moderate Expansion	4.00	1.07	2.38	65.79
Contraction	-6.00	2.08	4.12	21.73

Source: State Street Global Advisors. Analysis based on monthly data from January 1982 to July 2023.

We start off by examining the performance of the assets in the contractionary phase — which is also the current phase.[7] This phase covered periods of shrinking economic output, and often elevated inflation too, and included periods such as the Global Financial Crisis and the COVID pandemic and, given this, median risk-adjusted return is considered to be the most relevant measure to assess the performance of assets. Where the median performance between assets is indistinguishable, we would also use the performance persistence measure to "break the tie" and select the best performing asset.

Predictably, the assets that fared best were in the fixed income space — namely Treasury bills, US aggregate and US Treasury bonds — with a good level of performance persistence (70% or over) (see Figure 6). In the equities space, it is unsurprising to find that **defensive sectors, such as consumer staples and health care,** registered a strong level of risk-adjusted performance, around 0.26 on a median risk-adjusted return basis. Interestingly, **small caps also delivered a strong level of performance in this phase** both from the perspective of median risk-adjusted performance as well as performance persistence.

It is worth noting that, historically, **the US dollar[8] weakened during the Contraction and Moderate Expansion phases.** A possible explanation for the strength in the performance of small caps during the period of Contraction is that these companies generate more of their revenues within the country than through exports and this may help shield them from the impact of adverse foreign exchange moves. While there is the common belief that gold should perform strongly in challenging economic conditions, such as those typically witnessed in this phase, the performance was not consistent, as evidenced by the lacklustre performance persistence statistic (at just 55%).

Next, we examine the performance of these assets in the Medium and Strong Expansion phases. In these phases, risk is not much of a cause for concern. As such, the main yardstick against which the performance of assets is judged is the median absolute return in a given phase. Once again, performance persistence is given due consideration where the median performance of assets is very similar.

Turning first to the Medium Expansion phase, this is a period that is defined by moderate growth and inflation and covered most of the study period, representing 66% of all the observations. As expected, equities generally trumped fixed income in this phase. **Cyclical sectors, such as financials and technology, had a particularly good showing with a median absolute monthly return of more than 1.5% each in this regime; performance persistence was also reasonably strong. Value and small caps followed, as both fared well during this regime.** In the fixed income space, the best performing assets were US corporate bonds followed by US aggregate bonds. As could be anticipated, the performance of gold struggled in this phase (see Figure 7).

At 12% of the observations, the Strong Expansion phase, which is defined by strong growth and higher inflation, covered only a small proportion of the study period. **In this phase, the energy and technology sectors prospered, with an absolute monthly median return of about 2.8% apiece but energy had stronger performance persistence than technology** (see Figure 8). In respect of fixed income, US corporate bonds performed the best, as they did in the Medium Expansion phase and, once again, the performance of gold was underwhelming in this phase. Figure 9 summarises the best and worst performing assets under analysis in each of the identified Markov 3-state regimes.

Figure 6

Asset Class Risk-Adjusted Performance Under Current Economic Regime (Contraction)
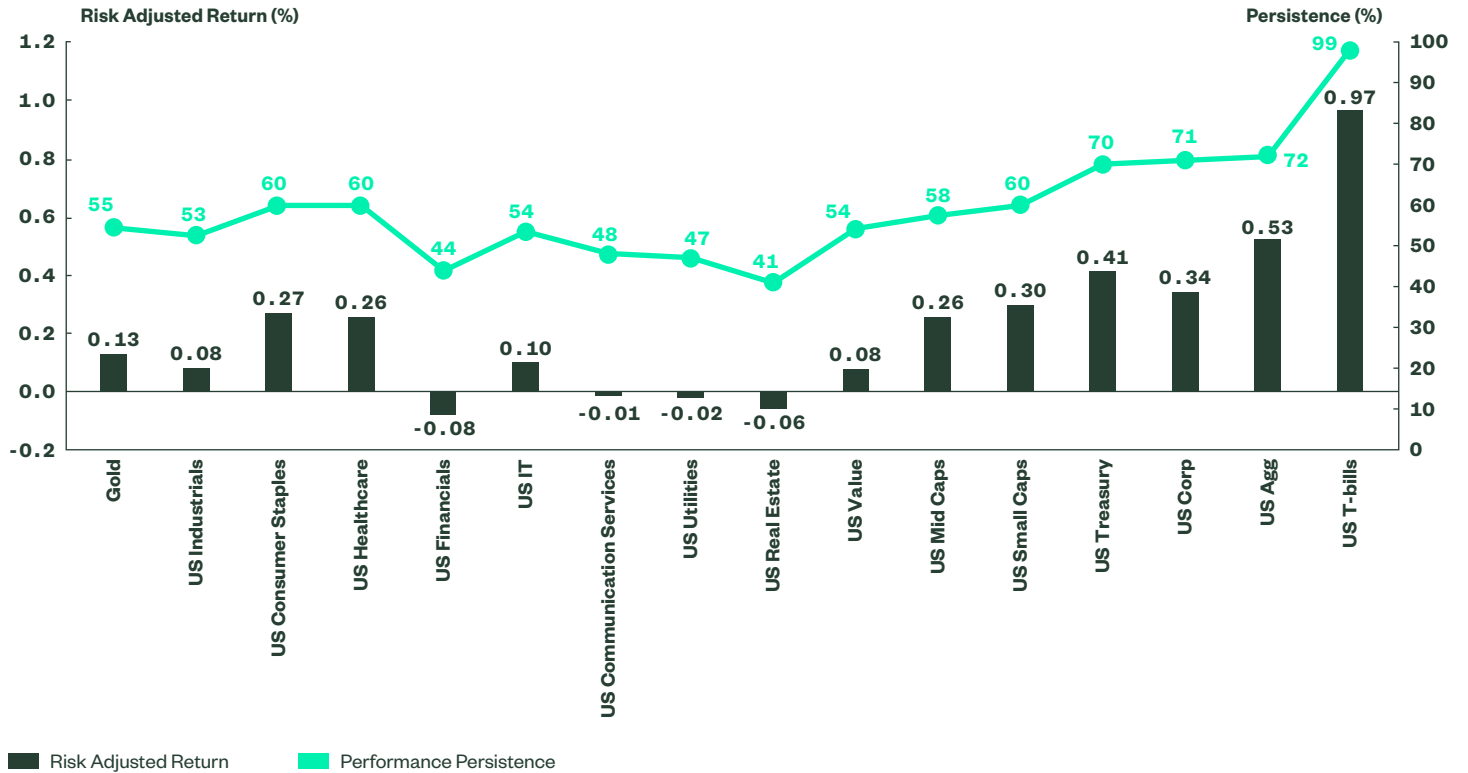
Source: State Street Global Advisors, Bloomberg Finance L.P., for the period January 1982 through July 2023. It is not possible to invest directly in index.
Past performance is not a reliable indicator of future performance. "US Large Caps" is represented by S&P 500 Index, "Gold" is represented by XAUUSD Spot Exchange Rate, "US Industrials" is represented by S&P 500 Industrials Sector GICS Level 1 Index, "US Consumer Staples" is represented by S&P 500 Consumer Staples Sector GICS Level 1 Index, "US Healthcare" is represented by S&P 500 Health Care Sector GICS Level 1 Index, "US Financials" is represented by S&P 500 Financials Sector GICS Level 1 Index, "US IT" is represented by S&P 500 Information Technology Sector GICS Level 1 Index, "US Communication Services" is represented by S&P 500 Communication Services Sector GICS Level 1 Index, "US Utilities" is represented by S&P 500 Utilities Sector GICS Level 1 Index, "US Real Estate" is represented by S&P 500 Real Estate Sector GICS Level 1 Index, "US Value" is represented by MSCI USA Value Exposure Select Net Return USD Index, "US Mid Caps" is represented by S&P Midcap 400 Index, "US Small Caps" is represented by Russell 2000 Index, "US Treasury" is represented by Bloomberg U.S. Treasury Total Return Unhedged USD, "US Corp" is represented by Bloomberg U.S. Corporate Total Return Value Unhedged USD, "US Agg" is represented by Bloomberg U.S. Agg Total Return Value Unhedged USD, "US T-bills" is represented by Bloomberg U.S. Tr Bills: 1–3 Months Total Return Index Value Unhedged.

Figure 7
**Asset Class Absolute
Performance Under Moderate
Expansion Regime**

Source: State Street Global Advisors, Bloomberg Finance L.P., for the period January 1982 through July 2023. It is not possible to invest directly in index.
Past performance is not a reliable indicator of future performance. "Gold" is represented by XAUUSD Spot Exchange Rate, "US Energy" is represented by S&P 500 Energy Sector GICS Level 1 Index, "US Materials" is represented by S&P 500 Materials Sector GICS Level 1 Index, "US Financials" is represented by S&P 500 Financials Sector GICS Level 1 Index, "US IT" is represented by S&P 500 Information Technology Sector GICS Level 1 Index, "US Utilities" is represented by S&P 500 Utilities Sector GICS Level 1 Index, "US Real Estate" is represented by S&P 500 Real Estate Sector GICS Level 1 Index, "US Value" is represented by MSCI USA Value Exposure Select Net Return USD Index, "US Mid Caps" is represented by S&P Midcap 400 Index, "US Small Caps" is represented by Russell 2000 Index, "US Treasury" is represented by Bloomberg U.S. Treasury Total Return Unhedged USD, "US Corp" is represented by Bloomberg U.S. Corporate Total Return Value Unhedged USD, "US Agg" is represented by Bloomberg U.S. Agg Total Return Value Unhedged USD, "US T-bills" is represented by Bloomberg U.S. Tr Bills: 1–3 Months Total Return Index Value Unhedged.

Figure 8

Asset Class Absolute Performance Under Strong Expansion Regime
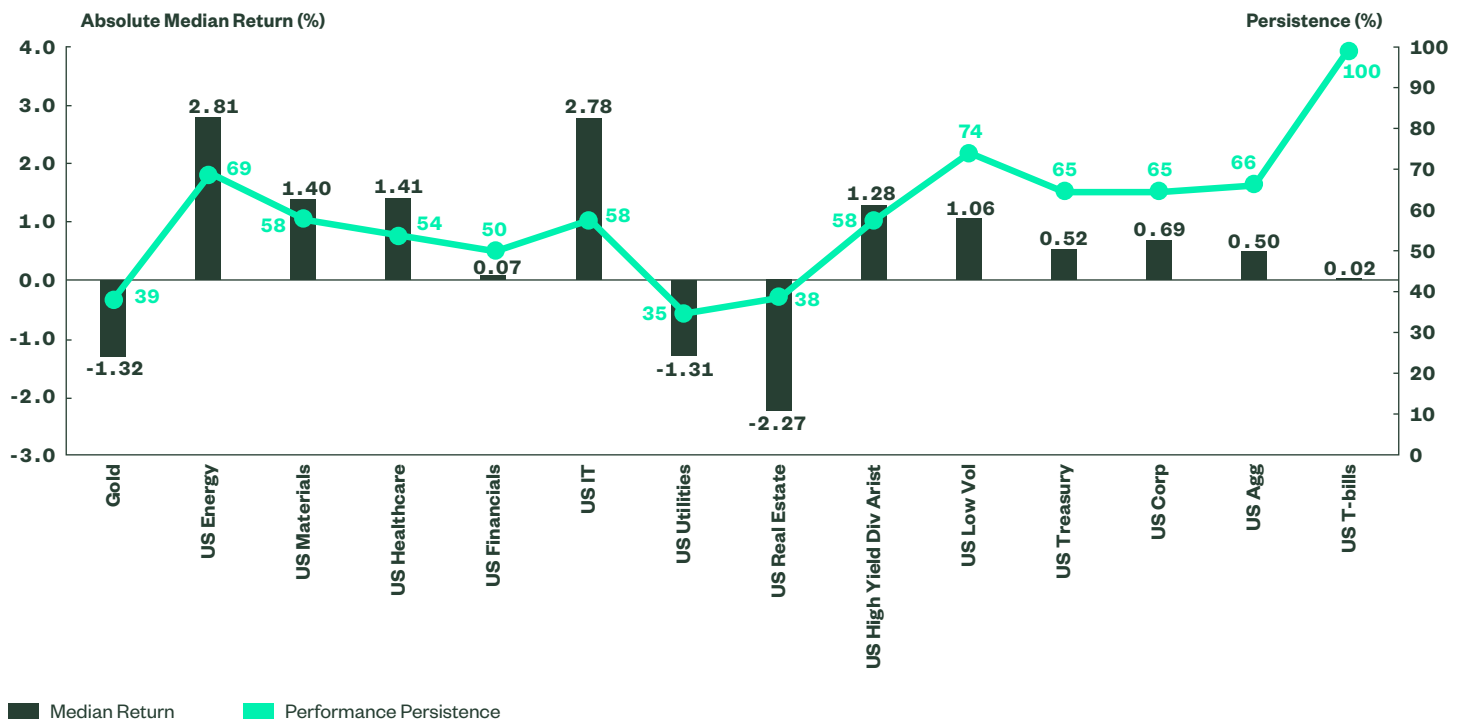
Absolute Median Return (%) / Persistence (%)

Asset	Median Return	Persistence
Gold	-1.32	39
US Energy	2.81	69
US Materials	1.40	58
US Healthcare	1.41	54
US Financials	0.07	50
US IT	2.78	58
US Utilities	-1.31	35
US Real Estate	-2.27	38
US High Yield Div Arist	1.28	58
US Low Vol	1.06	74
US Treasury	0.52	65
US Corp	0.69	65
US Agg	0.50	66
US T-bills	0.02	100

■ Median Return ■ Performance Persistence

Source: State Street Global Advisors, Bloomberg Finance L.P., for the period January 1982 through July 2023. It is not possible to invest directly in index. Past performance is not a reliable indicator of future performance. "Gold" is represented by XAUUSD Spot Exchange Rate, "US Energy" is represented by S&P 500 Energy Sector GICS Level 1 Index, "US Materials" is represented by S&P 500 Materials Sector GICS Level 1 Index, "US Consumer Discretionary" is represented by S&P 500 Consumer Discretionary Sector GICS Level 1 Index, "US Healthcare" is represented by S&P 500 Health Care Sector GICS Level 1 Index, "US Financials" is represented by S&P 500 Financials Sector GICS Level 1 Index, "US IT" is represented by S&P 500 Information Technology Sector GICS Level 1 Index, "US Communication Services" is represented by S&P 500 Communication Services Sector GICS Level 1 Index, "US Utilities" is represented by S&P 500 Utilities Sector GICS Level 1 Index, "US Real Estate" is represented by S&P 500 Real Estate Sector GICS Level 1 Index, "US High Yield Div Arist" is represented by S&P High Yield Dividend Aristocrats Index, "US Treasury" is represented by Bloomberg U.S. Treasury Total Return Unhedged USD, "US Corp" is represented by Bloomberg U.S. Corporate Total Return Value Unhedged USD, "US Agg" is represented by Bloomberg U.S. Agg Total Return Value Unhedged USD, "US T-bills" is represented by Bloomberg U.S. Tr Bills: 1–3 Months Total Return Index Value Unhedged, "US Low Vol" is represented by S&P 500 Low Volatility Index.

Figure 9

Best and Worst Performing Assets in Each Macroeconomic Regime

		Contraction	Medium Expansion	High Expansion
Top 3		T. Bills	US Financials	US Energy
		US Agg	US IT	US IT
		US Treasury	Russel 2000	US Materials
Bottom 3		US Industrials	Gold	US Utilities
		US Financials	US Real Estate	Gold
		US Comm. Services	US Utilities	US Real Estate

Source: State Street Global Advisors, Bloomberg Finance L.P., for the period January 1982 through July 2023. It is not possible to invest directly in index. Past performance is not a reliable indicator of future performance. "Gold" is represented by XAUUSD Spot Exchange Rate, "S&P 500" is represented by S&P 500 Index, "S&P 400" is represented by S&P Midcap 400 Index, "US Industrials" is represented by S&P 500 Industrials Sector GICS Level 1 Index, "US Energy" is represented by S&P 500 Energy Sector GICS Level 1 Index, "US Financials" is represented by S&P 500 Financials Sector GICS Level 1 Index, "US Communication Services" is represented by S&P 500 Communication Services Sector GICS Level 1 Index, "US Utilities" is represented by S&P 500 Utilities Sector GICS Level 1 Index, "US Real Estate" is represented by S&P 500 Real Estate Sector GICS Level 1 Index, "US Corp" is represented by Bloomberg U.S. Corporate Total Return Value Unhedged USD, "US Agg" is represented by Bloomberg U.S. Agg Total Return Value Unhedged USD, "US T-bills" is represented by Bloomberg U.S. Tr Bills: 1–3 Months Total Return Index Value Unhedged, "US Low Vol" is represented by S&P 500 Low Volatility Index.

## Strategic Asset Allocation: Role of Hierarchical Clustering in Portfolio Construction

Another typical investment approach is strategic asset allocation, whereby the investor sets target allocations for various assets and rebalances the portfolio periodically. This normally makes up the bulk of the investments and is invariably formed on the basis of long-term asset class forecasts. A successful strategic asset allocation is often based on achieving robust diversification through a risk-return trade-off and is often done through quadratic programming methodologies, such as the Markowitz mean-variance portfolio optimisation techniques. However, these methodologies come with their own challenges. For example, the optimised solutions generated from them may be highly susceptible to small changes in the input data and the "out-of-sample" (real life) performance may be poor.

One way to overcome these shortcomings is through the use of a hierarchical risk clustering algorithm, as originally proposed by de Prado in 2016.[9] The algorithm makes use of graph theory and unsupervised machine learning techniques to build diversified portfolios by acknowledging the hierarchical nature of the investment universe in such a way that similar assets, defined by a similarity measure — like correlation — are grouped together so that the benefits of diversification can be optimally achieved within the allocation of assets. Additionally, this technique addresses other shortcomings associated with the Markowitz technique.

Among the adaptations of hierarchical clustering, the one that has gained the most traction was advanced by Raffinot (2018),[10] which combines de Prado's original hierarchical risk parity approach and Raffinot's (2017)[11] hierarchical clustering-based asset allocation approach. The main steps for this approach include: 1) tree clustering, which involves grouping assets on the basis of their similarity[12] and 2) the assignment of weights across different clusters and within each cluster. Different weighting schemes can be employed to allocate weights across different clusters and within them. A diagrammatic representation of this asset allocation process is shown in Figure 10 by way of a dendrogram.

Figure 10
Dendrogram Based on an Equally Weighted Hierarchical Clustered Portfolio in July 2023

■ Cluster 1
■ Cluster 2
■ Cluster 3
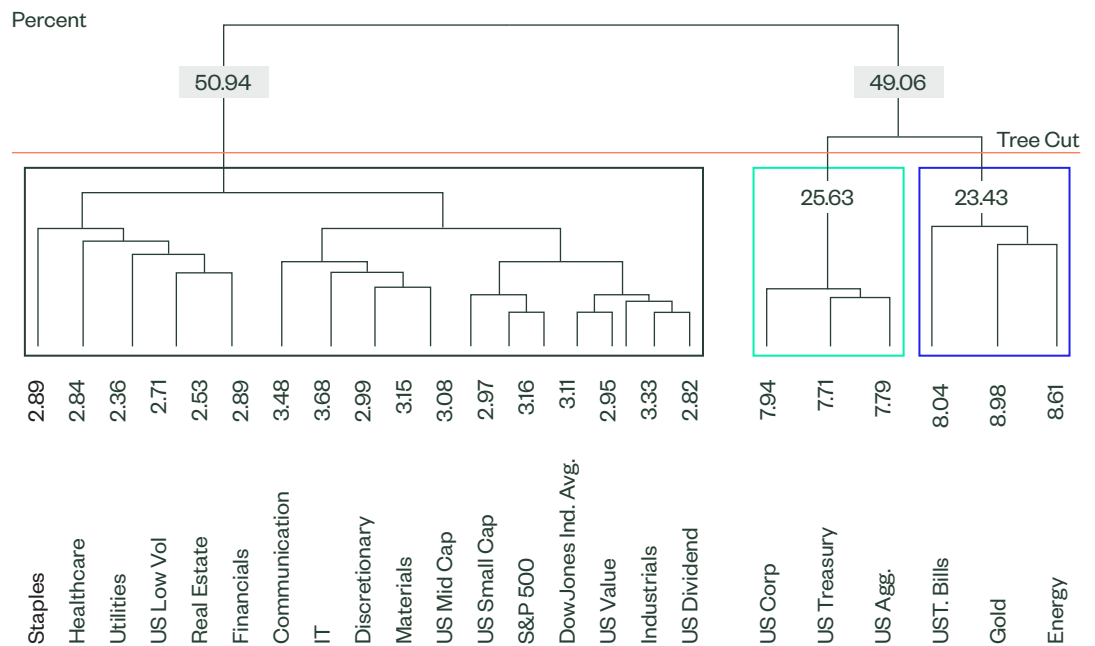
Source: State Street Global Advisors, Bloomberg. The numbers above are weights and they are calculated on the basis of weekly return data between October 2002 and July 2023.The strategy was last rebalanced in October 2022 with an equal weight allocation within each cluster i.e. 2.94% to each asset in cluster 1 and 8.33% to each asset in cluster 2 and 3. The current weights have drifted from the equal weight allocation since the last rebalance period of October 2022. It is not possible to invest in directly an index. The equity exposure comprises of 18 building blocks. "S&P 500" represents S&P 500 Index. "Dow Jones Ind. Avg" represents Dow Jones Industrial Average Index. "US Mid Cap" represents S&P 400 Midcap Index. "US Small Cap" represents Russell 2000 Index. "Discretionary" represents S&P 500 Consumer Discretionary Index. "Staples" represents S&P 500 Consumer Staples Index. "Energy" represents S&P 500 Energy Index. "Financials" represents S&P 500 Financials Index. "Healthcare" represents S&P 500 Health Care Index. "Industrials" represents S&P 500 Industrials Index. "IT" represents S&P 500 Information Technology Index. "Materials" represents S&P 500 Materials Index. "Real Estate" represents S&P 500 Real Estate Index. "Communications" represents S&P 500 Communication Services Index. "Utilities" represents S&P 500 Utilities Index. "US Value" represents MSCI USA Value Exposure Select Net Return USD Index. "US Low Vol" represents S&P 500 Low Volatility Index. "US Dividends" represents S&P High Yield Dividend Aristocrats Index. The Fixed Income exposure comprises of 4 building blocks. "US Agg." represents Bloomberg U.S. Agg Total Return Value Unhedged USD. "US T.Bills" represents Bloomberg U.S. Tr Bills: 1–3 Months TR Index. "US Corp" represents Bloomberg U.S. Corporate Total Return Value Unhedged USD. "US Treasury" represents Bloomberg U.S. Treasury Total Return Unhedged USD. The precious metals exposure comprises of 1 building block. "Gold" represents Gold Spot $/Oz.

Aside from the asset allocation methodology, another consideration is the types of assets that are eligible for inclusion in the asset allocation process. Selecting a list of assets from a restricted area is likely to impair a portfolio's potential to reap the full benefits of diversification and, with this in mind, it is necessary to include a sufficiently wide range of ("unassociated") assets in the portfolio mix.

To assess the potential role of hierarchical clustering techniques in strategic asset allocation, we have created annually rebalanced portfolios consisting of a diverse range of exposures and examined the performance between October 2002 to July 2023. While it is possible to adopt a variety of weighting schemes as mentioned above, we have adopted a simple equal-weight weighting scheme in the analysis below.[13] The exposures in scope for the analysis include equities (such as broad equity market exposures, sectors, smart beta), fixed income (such as broad fixed income exposures, investment grade corporate bonds) as well as commodities (such as gold).

To adjudicate on whether hierarchical clustering techniques are worth considering in strategic asset allocation, we would examine traditional performance measures — such as risk and return — but additionally we would assess the level of portfolio concentration, through measures such as the diversification ratio or the number of effective bets. The reason for this is that a reduction in risk per se does not mean that the portfolio is well-diversified, especially when it invests all of its capital in a few of the least (historically) volatile assets. To reap the genuine benefits of diversification, it is vital to observe both a reduction in risk and a lack of concentration at the same time.

Analysis Results

Overall Performance

Figure 11 shows the results of the hierarchical clustered equal-weighted portfolio against the equal-weighted portfolio. From the results in the table, **it is clear that the hierarchical clustered portfolio mostly exhibited better risk-adjusted returns than the a simple equally weighted portfolio of all the exposures over various time frames.**[14] The only exception was seen during the second half of the analysis period when the risk-adjusted returns decreased marginally from 1.04 to 0.98 and this is primary driven by a lower absolute return offset by a substantial reduction in risk (c. ~30%). In addition, the fall in risk can also be observed in the extreme statistic measures, as evidenced by a lower conditional value-at-risk and a lower maximum drawdown. **Most importantly, the amelioration in the risk profile did not come at the expense of portfolio concentration,** as shown in the portfolio concentration statistics in the table below.

Figure 11

Performance Statistics of the Hierarchical Clustered Portfolio Against Equally Weighted Portfolio Over Different Time Periods

Period	Strategy	Return/ Risk	Returns (ann.) (%)	Volatility (ann.) (%)	Maximum Drawdown (%)	Conditional VaR (95%)	Diversification Ratio *	No. of Effective Bets**	Maximum Contribution to Risk (%)
All period (Oct-02 to July-23)	Hierarchical Clustered Portfolio	0.69	6.90	9.90	27.02	-3.23	1.35	15.92	1.51
	Equal Weight	0.59	8.30	14.00	44.84	-4.63	1.29	16.54	1.39
Second half (Mar-13 to July-23)	Hierarchical Clustered Portfolio	0.98	8.60	8.70	11.39	-2.16	1.32	16.43	0.42
	Equal Weight	1.04	13.30	12.70	16.25	-3.35	1.28	16.54	0.31
First half (Oct-02 to Feb-13)	Hierarchical Clustered Portfolio	0.41	4.30	10.60	18.50	-3.79	1.37	16.23	0.61
	Equal Weight	0.24	3.80	16.00	29.89	-5.78	1.28	16.54	0.41

Source: State Street Global Advisors, Bloomberg Finance L.P. Results are based on weekly return data between October 2002 and July 2023. Past performance is not a reliable indicator of future performance.*Diversification ratio is computed as the weighted average risk of each asset, adjusted by portfolio risk. **The number of effective bets (No. of Effective Bets) represents the average number of uncorrelated investments computed in line with methodology introduced in Meucci et al (2015).[15]

Crisis Period Performance

From the previous analysis, the hierarchical clustered portfolio delivered an overall stronger risk-adjusted return, driven mostly by a significant reduction in risk. The next question to pose is whether the hierarchical clustered portfolio coped well during periods of acute risk. To understand this, we analysed the performance of the hierarchical clustered portfolio against the equal-weighted portfolio during a few key crisis events from recent years. **The results in Figure 12 suggest that the hierarchical clustered portfolio consistently exhibited significantly lower risk and generally achieved higher returns during these crises, assuming that there was no concentration risk.**

Figure 12

Performance Statistics of the Hierarchical Clustered Portfolio Against Equally Weighted Portfolio Over Different Time Periods

Event	Start Date	End Date	Returns (Annualised)		Risk (Annualised)	
			Hierarchical Clustered Portfolio (%)	Equal Weight (%)	Hierarchical Clustered Portfolio (%)	Equal Weight (%)
Global Fin. Crisis	01.05.2008	28.02.2009	-25.94	-42.30	19.27	29.29
Euro Debt Crisis	01.04.2011	30.11.2011	4.40	-2.63	9.01	18.06
Taper Tantrum	01.05.2013	31.08.2013	-1.95	0.20	6.95	9.50
Covid Pandemic	01.02.2020	31.03.2020	-16.30	-23.05	51.10	58.77
DM rate hike	01.01.2022	30.09.2022	-13.67	-16.82	10.03	16.71

Source: State Street Global Advisors, Bloomberg. Results are based on weekly return data between October 2002 and July 2023. Past performance is not a reliable indicator of future performance. The equity exposure comprises of 18 building blocks. "S&P 500" represents S&P 500 Index. "Dow Jones Ind. Avg" represents Dow Jones Industrial Average Index. "US Mid Cap" represents S&P 400 Mid Cap Index. "US Small Cap" represents Russell 2000 Index. "Discretionary" represents S&P 500 Consumer Discretionary Index. "Staples" represents S&P 500 Consumer Staples Index. "Energy" represents S&P 500 Energy Index. "Financials" represents S&P 500 Financials Index. "Healthcare" represents S&P 500 Health Care Index. "Industrials" represents S&P 500 Industrials Index. "IT" represents S&P 500 Information Technology Index. "Materials" represents S&P 500 Materials Index. "Real Estate" represents S&P 500 Real Estate Index. "Communications" represents S&P 500 Communication Services Index. "Utilities" represents S&P 500 Utilities Index. "US Value" represents MSCI USA Value Exposure Select Net Return USD Index. "US Low Vol" represents S&P 500 Low Volatility Index. "US Dividends" represents S&P High Yield Dividend Aristocrats Index. The Fixed Income exposure comprises of 4 building blocks. "US Agg." represents Bloomberg U.S. Agg Total Return Value Unhedged USD. "US T.Bills" represents Bloomberg U.S. Tr Bills: 1–3 Months TR Index. "US Corp" represents Bloomberg U.S. Corporate Total Return Value Unhedged USD. "US Treasury" represents Bloomberg U.S. Treasury Total Return Unhedged USD. The precious metals exposure comprises of 1 building block. "Gold" represents Gold Spot $/Oz. It is not possible to invest in directly an index. "GFC" points to Global Financial Crisis which started in 2008."Euro Debt Crisis" refers to the Eurozone crisis of 2011. "Taper Tantrum" points to the spike in US yields during 2013 due to US Fed announcement of future tapering of the quantitative easing. "Covid Pandemic" points to the global pandemic started in 2020 caused by the spread of corona virus. "DM rate Hike" refers to one of the fastest rate hikes by global central banks to tackle inflation in 2022.

Performance in Macroeconomic Regimes

In this final section, we analysed how a hierarchical clustered portfolio performed under different macroeconomic regimes, defined using Markov hidden regimes on the basis of leading economic indicators, real interest rates and inflation. Consistent with our definition of the regimes in the previous section, we have identified three separate macroeconomic regimes: 1) Strong Expansion, 2) Moderate Expansion and 3) Contraction.

Results in Figure 13 demonstrate that the hierarchical clustered portfolio performed the best during the contractionary phase, driven by stronger returns but most crucially a considerable risk reduction (to the tune of 2% on a median basis) and the combination of these led to a sizeable risk-adjusted return. In regards to the expansion phases, the risk-adjusted return of the clustered hierarchical portfolio remained competitive in the medium expansion phase but lagged the equal-weighted portfolio in the strong expansionary phase.

As highlighted in the previous section, risk is generally not a great cause for concern in expansionary phases and, therefore, it may be appropriate to focus more on absolute return numbers. In terms of the absolute return, the hierarchical clustered portfolio did well in the Strong Expansion phase but trailed in the Medium Expansion phase and thus we cannot draw definitive conclusions from these results.

Figure 13

Performance Statistics of the Hierarchical Clustered Portfolio Against Equally Weighted Portfolio in Different Macroeconomic Regimes

Regime	Strategy	Median Monthly Returns (%)	Volatility (%)	Risk Adjusted Returns	Performance Persistence (%)
Contraction	Hierarchical Clustered Portfolio	0.65	4.50	0.13	56.86
	Equal Weight	0.36	6.70	0.09	58.82
Medium Expansion	Hierarchical Clustered Portfolio	0.65	1.90	0.34	67.47
	Equal Weight	1.03	2.60	0.31	66.27
High Expansion	Hierarchical Clustered Portfolio	0.41	2.10	0.02	58.85
	Equal Weight	0.38	3.10	0.03	53.19

Source: State Street Global Advisors, Bloomberg Finance L.P. Results are based on weekly return data between October 2002 and July 2023. Past performance is not a reliable indicator of future performance.

Endnotes

1   *Midyear 2023 Global Market Outlook: Preparing for a Path Less Certain,* State Street Global Advisors. May 2023.

2   The Latent Dirichlet Allocation (LDA) is a probabilistic model used in natural language processing for topic modelling where it assigns topics to documents and words to topics based on the distribution of words across topics.

3   Federal Reserve Minutes Topic and Sentiment Modelling adapted from https://github.com/JonnyFLDN/Federal-Reserve-Minutes-Topic-and-Sentiment-Modelling.

4   The Leading Economic Indicator is based on yearly change of the Conference Board Leading Economic Index (LEI)®.

5   The real interest rate is based on the 1 year real interest rate, as reported on the St. Louis Fed website.

6   Inflation is based on yearly change of U.S. Bureau of Labour Statistics, Consumer Price Index for All Urban Consumers: All Items in U.S. City Average, Federal Reserve Bank between 1982 and July 2004 and St. Louis zero-coupon inflation indexed swap for 1 year maturity afterwards.

7   As of July 2023.

8   Measured by the US Dollar Index. Source: Bloomberg L.P. US Dollar Index tracks average exchange rate between the US Dollar and basket of major world currencies.

9   de Prado (2016), Building Diversified Portfolios that Outperform Out-of-Sample, Social Science Research Network.

10   Raffinot (2018), The Hierarchical Equal Risk Contribution in Portfolio, AXA IMI.

11   Raffinot (2017), Hierarchical Clustering-Based Asset Allocation, Journal of Portfolio Management.

12   Typical similarity measures include correlation, conditional value-at-risk, amongst others. The optimal number of clusters is chosen to avoid statistical overfitting and can be determined using 'gap analysis'.

13   The cluster and individual asset weights can be based on countless measures and, depending on whether the focus is on risk or the type of risk, different risk-return profiles can be achieved. The purpose here is not to ascertain the 'best' measure to be used in the weighting scheme but rather to assess if there are any potential benefits to using a hierarchical clustering approach in the allocation of smart beta building blocks.

14   The results are consistent with the findings in spdr-machine-learning-smart-beta-case-study.pdf (ssga.com).

15   Meucci et al (2015). Risk Budgeting and Diversification Based on Optimised Uncorrelated Factors. ERN: Optimisation Techniques; Programming Models; Dynamic Analysis (Topic).