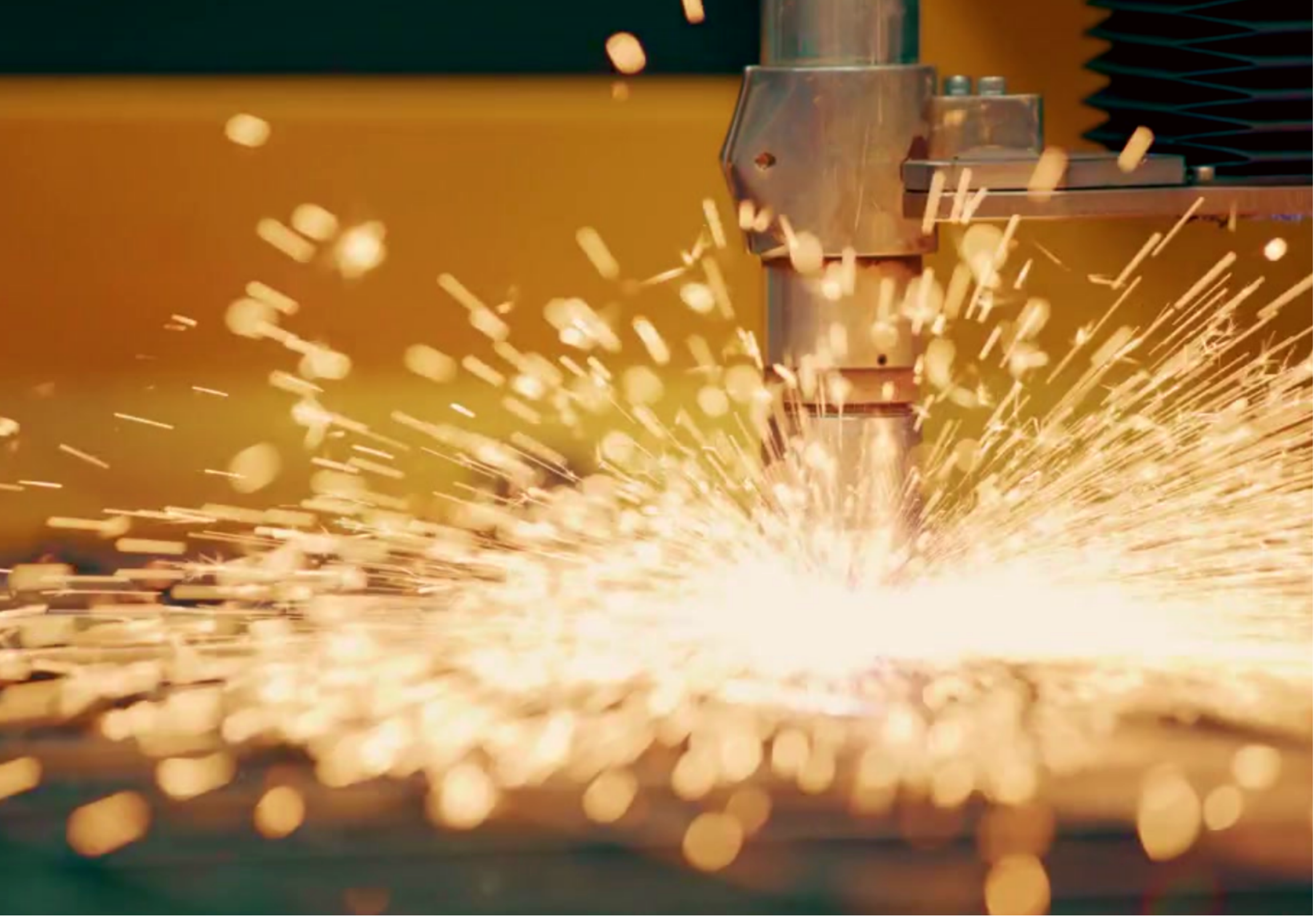

Capital Market Assumptions 2025

Our long-term return expectations for capital markets serve as key inputs into our strategic asset allocation process for multi-asset portfolios and provide context for shorter-term forecasting.

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Foreword

Each year, the Voya Multi-Asset Strategies and Solutions team crafts capital market forecasts for the upcoming decade. This process allows us to step back from daily market fluctuations and focus on long-term economic and financial trends that influence asset class returns and risks. These forecasts are crucial for setting our strategic asset allocations across multi-asset portfolios.

In our analysis, we examine a variety of macroeconomic and financial data series. For instance, **we consider how expectations for the labor force participation rate might affect potential GDP growth.** While our data do not specify the exact impact, the broader analysis helps shape our understanding of economic dynamics.

We also explore whether profit margins are likely to revert to the mean. Our analysis suggests that investments in artificial intelligence could lower the marginal costs of production and distribution, much like the IT revolution did. Furthermore, the advanced features of AI-enhanced products can justify premium pricing, thereby bolstering valuations. **Given the transformative potential of AI investments, we believe profit margins may not simply hold steady but could in fact grow, supporting the existing high valuations.**

To address the risks of relying on single-point estimates, we use blended estimates that combine our base-case forecasts and an alternative macroeconomic scenario. This technique ensures that our forecasts remain balanced—preventing over-optimism or excessive pessimism—while also incorporating dual risk estimates that may enhance the resilience of our portfolios.

Currently, the U.S. economy is transitioning towards below-trend GDP growth, influenced by previous Federal Reserve tightening, stricter bank lending standards and a stronger dollar. We expect these factors will lead to looser labor market conditions and continued moderation in wage and price inflation—which should, in turn, support further Fed rate cuts.

For the 10-year period (2025–2034), higher valuations and lower risk premiums point to below-average expected returns for equities. Our bond outlook has declined from our previous 10-year forecast due to lower starting yields versus the third quarter of 2023. However, **we expect returns for both stocks and bonds will generally outpace inflation,** offering attractive opportunities for asset allocators to generate alpha across and within asset classes, leveraging our strategic insights.

We hope this report will serve as a valuable tool in your decision-making process, and we wish you a prosperous 2025.

Sincerely,

Barbara Reinhard, CFA
Head of Asset Allocation

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Senior Quantitative Analyst

Summary of findings

Our Capital Market Assumptions (CMA) 2025 report details our research on asset class returns, standard deviations and correlations over the 10-year horizon from 2025 through 2034. These estimates represent key inputs into strategic asset allocation decisions for our multi-asset portfolios and provide context for shorter-term macroeconomic and financial forecasting.

Our base-case forecasts are informed by low potential gross domestic product (GDP) growth, reduced labor supply and elevated inflation. To avoid using a single-point-estimate forecast, we also incorporate an alternative scenario reflecting slightly better (or worse) macro inputs. Similar to last year, our alternative scenario is based on marginally higher productivity and a lower terminal federal funds rate.

Key takeaways:

- The next decade will likely be characterized by returns below historical averages across all major asset classes.
- Developed market equities are likely to deliver mid-single-digit returns, with the U.S. stronger than most other comparable markets.
- Emerging market equities should underperform developed markets, with higher expected volatility.
- Bond return assumptions have declined from last year, remaining in the low single digits, assuming moves in bond term premiums and real interest rates will cap the upside return potential of fixed income assets.

Exhibit 1: 10-year return forecasts

2025–2034, in USD

	Expected returns (%)					
	Geometric mean	Arithmetic mean	Volatility (%)	Skewness	Kurtosis	Sharpe ratio
Equity index						
S&P 500	4.7	5.9	15.9	-0.52	1.0	0.21
Russell 1000 Growth	4.7	6.2	18.2	-0.45	0.7	0.21
Russell 1000 Value	4.5	5.6	15.4	-0.60	1.5	0.20
MSCI U.S. Minimum Volatility	4.1	4.7	11.8	-0.64	1.1	0.19
Russell 3000	4.7	6.0	16.2	-0.56	1.1	0.21
Russell Midcap	4.6	6.2	17.9	-0.61	1.4	0.20
Russell 2000	4.1	6.5	22.2	-0.53	1.4	0.18
MSCI EAFE	3.6	5.3	18.8	-0.26	0.2	0.15
MSCI World	4.6	5.8	15.7	-0.59	1.0	0.21
MSCI EM	2.1	5.4	25.2	-0.32	0.7	0.12
MSCI ACWI	4.5	5.7	15.8	-0.60	1.1	0.20
Alternative assets index						
Bloomberg Commodity	2.2	3.4	15.5	-0.45	1.7	0.06
FTSE EPRA/NAREIT Developed	3.3	5.4	20.6	-0.47	2.0	0.14
Fixed income index						
Barclays U.S. Aggregate	3.7	3.9	7.0	0.49	4.1	0.21
Barclays U.S. Government Long	3.8	4.6	13.1	0.22	0.5	0.16
Barclays U.S. TIPS	2.9	3.1	5.5	-0.92	4.1	0.11
Barclays U.S. High Yield	5.0	5.5	11.2	-0.42	4.1	0.27
Credit Suisse Leveraged Loan	6.9	7.0	7.2	-1.64	21.8	0.29
Barclays Global Aggregate	2.7	3.0	8.0	0.12	0.7	0.07
Barclays Global Aggregate ex U.S.	1.8	2.3	10.1	0.03	0.0	-0.01
JPMorgan EMBI+	6.7	7.6	14.0	-1.02	7.2	0.33
U.S. Treasury Bill 3-Month	2.4	2.4	1.0	0.98	1.4	0.00

As of 09/30/24. Source: Voya IM. Forecasts are subject to change.

Ten-year forecast for strategic asset allocations

Our forecasting approach assumes a process by which global economies and financial markets gradually move toward a steady-state equilibrium over 10 years. While real-world conditions won't perfectly align with this endpoint, we find this theoretical construct helps to anchor our analysis. A consequence of this approach is that our forecast does not assume any recessions or contractions during the 2025–2034 period.

With this framework in mind, let's delve into our economic views for the U.S. over the next decade.

Is U.S. productivity breaking out?

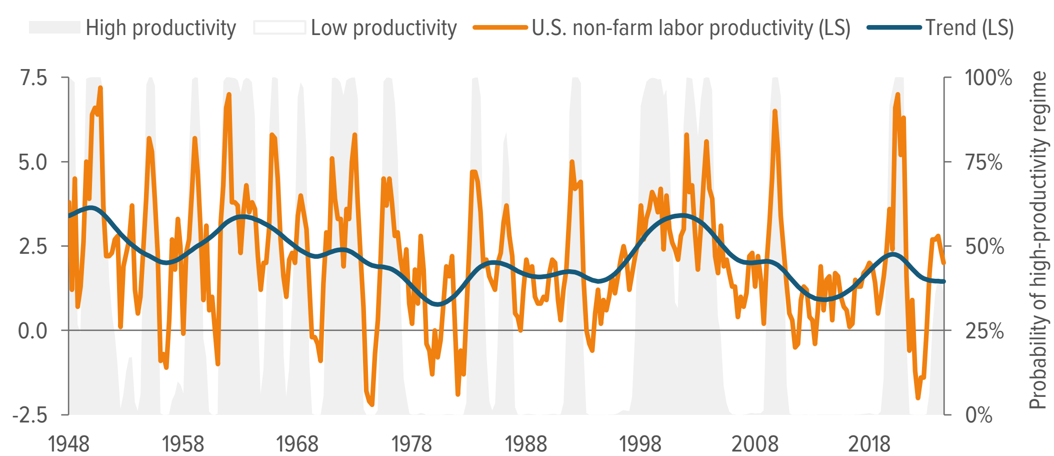
Though our model currently points to a low-productivity regime, we see potential for meaningful productivity improvements, driven by AI investments.

We expect the U.S. will be constrained by labor force growth but can achieve a somewhat higher and more sustained growth trajectory than it did in the previous business cycle. The key for the U.S. is to break out of the low-productivity regime that has held back the economy.

Productivity growth primarily comes from two sources: capital deepening and total factor productivity (TFP). The TFP is an indirect measure derived from breaking down real GDP growth—it's what's left after accounting for the contributions of capital and labor, often referred to as "Solow's residual." This residual can capture various elements such as technological advancements, improvements in labor effectiveness, the strength of property rights, and the quality of the workforce. It also encompasses cultural attitudes, including risk tolerance and high levels of confidence in the future, which can boost productivity through the TFP channel.

Labor force productivity growth typically alternates between high- and low-productivity regimes over time. To determine the current regime, we analyzed productivity data using a Markov model (Exhibit 2). The latest data show that U.S. productivity has stabilized following negative levels in 2022 but remains modest at 2.0% year over year through the third quarter of 2024. This level is consistent with a low-productivity regime. (Low-productivity regimes, indicated by non-shaded areas, average 1.0%, whereas high-productivity regimes in gray shading average 3.8%.) Using a Hodrick-Prescott filter to break down year-over-year productivity growth into trend and cycle components shows that the current trend of U.S. productivity growth is 1.2%.

Exhibit 2: Productivity growth remains low



As of 09/30/24. Source: Voya IM.

Our forecasting model uses a 60/40 blend of base-case economic assumptions and an alternative scenario reflecting a more favorable backdrop.

While our productivity model shows that we are currently in a low-productivity regime, it's important to note that these models rely on backward-looking data. Going forward, we see potential for meaningful positive change in productivity driven by artificial intelligence (AI). Investments in AI have the potential to drive productivity into an advanced state by dramatically lowering the marginal costs of production and distribution, similar to the productivity gains seen during the IT revolution.

By automating complex tasks, optimizing workflows and enabling rapid data analysis, AI can streamline operations across industries, allowing teams to accomplish more in less time. Moreover, the enhanced features of AI-powered tools allow workers to perform high-value tasks more efficiently and effectively, supporting both the speed and quality of outputs. As AI technology continues to evolve, it will likely amplify productivity by freeing up resources, enhancing precision, and enabling real-time adjustments in production and distribution processes, ultimately creating a faster and more adaptive economy.

Economic projections

As in past years, our CMA 2025 forecast considers both "base" and "alternative" scenarios, leveraging S&P Global's economic modeling capabilities.[1] These two scenarios capture the most important upside and downside risks facing the global economy and markets over the forecast horizon. Furthermore, in response to client demand, and following guidance from organizations such as the Task Force on Climate-Related Financial Disclosures (TCFD), we have continued to include climate scenarios into our economic forecasts. (See Appendix, page 12: "Accounting for climate change.")

Exhibit 3: 10-year economic forecasts variables

	2034 forecast
U.S. GDP growth	**2.1%**
Inflation (CPI-U)	2.4%
CPI ex food and energy	2.4%
Federal funds rate	2.4%
10-year U.S. treasury yield	3.1%
Profit share	9.3%
Savings rate	5.4%

As of 09/30/23. Source: Voya IM, S&P Global. Forecasts are subject to change.

Our **base case** forecasts 2.0% U.S. GDP growth through 2034, driven by below-trend productivity growth and subdued labor force growth. The **alternative scenario** assumes modest gains in output per hour, largely driven by TFP gains as labor shifts away from brick-and-mortar to more productive firms. It also assumes a higher dividend payout ratio, higher inflation, and that the Fed allows the economy to run somewhat hotter than in the base case. Under these assumptions, returns for risk assets are modestly higher in the alternative scenario than in the base case.

Assigning a 60/40 weighting to the base and alternative scenarios, respectively, we estimate a 10-year U.S. GDP growth trend of 2.1%. The 2034 values from this forecast (Exhibit 3) align with our long-term, steady-state estimates for key U.S. economic variables. From these top-down economic projections, we are able to determine asset class risk and return estimates.

Return estimates

For U.S. equities, we estimate earnings and dividends for the S&P 500 Index based on macroeconomic assumptions in our 60/40 blended scenario. Our earnings growth projections are bound by the neoclassical principle that profits as a share of GDP stabilize at a long-run equilibrium rather than increasing indefinitely. We then employ a dividend discount model to calculate the Index's fair value for each year in our forecast period.

[1] S&P Global is an independent research firm that provides a comprehensive global macroeconomic model, linking 68 individual country models with key global drivers of performance. The model accounts for 95% of global GDP, covering 250–500 time series per country.

For other equity indexes (including global REITs), we use a single-index factor model that derives beta sensitivities for each asset class versus the market portfolio from our forward-looking covariance matrix estimates (Exhibit 4). By definition, beta is the ratio of covariance to variance. (See Appendix, page 8: "Covariance and correlation matrixes.") The return for each equity asset class is determined by adding the risk-free interest rate to a specific risk premium, which is a function of our beta sensitivity estimate and market risk premium forecasts (Exhibit 1, page 3).

For U.S. bonds, we use our blended-scenario interest rate projections to determine expected returns across different durations. These return estimates are calculated by combining the current yield with any capital gains or losses, which depend on duration and the expected change in yields. We use a similar process for non-U.S. bonds, but we add an adjustment for expected currency movements. For credit-related fixed income, our return expectations incorporate yield spreads along with forecasts for default and recovery rates.

Glide path assumptions for target date strategies

Long-run equilibrium return assumptions inform how we determine an optimal asset mix over time for our target date products.

Whereas our strategic asset allocations are guided by 10-year forecasts, our target-date glide path assumptions rely on long-run equilibrium return assumptions spanning much longer periods, typically 40 years. In this extended timeframe, we think of the economy as existing continuously in a steady state—unlike the 10-year forecast, where it is *transitioning* toward this state.

We define a "steady-state" economy as:

- GDP growth is at its trend rate.
- Inflation is at target.
- Unemployment is at a level where inflation does not accelerate.
- The real interest rate equals the "natural" rate of interest—neither contractionary nor inflation inducing.
- All capital and goods markets are in equilibrium.

These forecasts use a building block methodology. Starting with our expectations for real short-term yield and inflation, we generate a risk-free rate forecast and, from that, derive all equity and fixed income assets by adding the relevant risk premium. For U.S. equities, the risk premium is derived from the Gordon growth model, representing the sum of the dividend yield and the nominal earnings growth rate in excess of the risk-free rate. Forecasts for non-U.S. equities add an international equity risk premium. Government bond forecasts are the sum of the risk-free rate and an appropriate term premium, while corporate bond forecasts add a credit risk premium.

In theory, all risk premiums tend to revert to a long-run equilibrium, as the economy is in a steady state. This mean reversion occurs because investment opportunities fluctuate over time. Given that the pace of new information varies, return volatility and covariance also fluctuate in the short term. Our econometric work, along with that of academic researchers, confirms the stationarity of various risk premiums. This evidence supports our assumption that average risk premiums, term premiums and credit spreads remain constant in the long-run equilibrium (Exhibit 5).

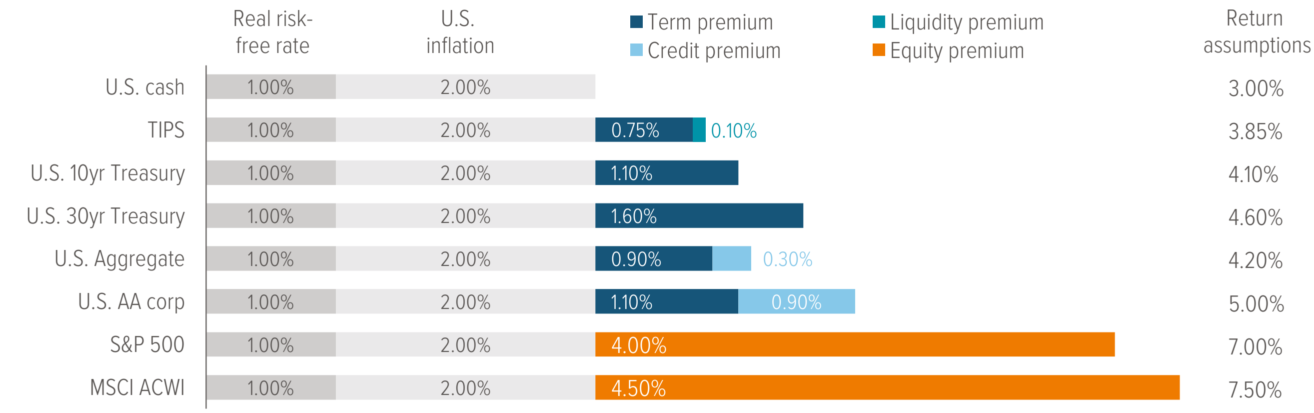
Exhibit 4: 10-year forecasted correlations matrix

2025–2034

	S&P 500	Russell 1000 Growth	Russell 1000 Value	MSCI U.S. Minimum Volatility	Russell 3000	Russell Midcap	Russell 2000	MSCI EAFE	MSCI World	MSCI EM	MSCI ACWI	Bloomberg Commodity	FTSE EPRA Nareit Developed	Bloomberg U.S. Aggregate	Bloomberg U.S. Government Long	Bloomberg U.S. TIPS	Bloomberg U.S. High Yield	Credit Suisse Leveraged Loan	Bloomberg Global Aggregate	Bloomberg Global Aggregate ex U.S.	JPMorgan EMBI+	U.S. Treasury Bill 3-Month
S&P 500	1.00	0.96	0.95	0.90	1.00	0.95	0.84	0.70	0.96	0.53	0.95	0.30	0.67	0.24	0.10	0.26	0.59	0.35	0.26	0.23	0.45	0.06
Russell 1000 Growth	0.96	1.00	0.83	0.83	0.96	0.92	0.83	0.66	0.92	0.52	0.91	0.27	0.60	0.23	0.11	0.25	0.56	0.32	0.24	0.22	0.43	0.04
Russell 1000 Value	0.95	0.83	1.00	0.89	0.95	0.93	0.81	0.69	0.92	0.51	0.91	0.32	0.69	0.23	0.07	0.24	0.58	0.37	0.26	0.23	0.45	0.07
MSCI U.S. Minimum Volatility	0.90	0.83	0.89	1.00	0.89	0.86	0.73	0.65	0.87	0.48	0.86	0.26	0.69	0.32	0.21	0.30	0.55	0.35	0.34	0.29	0.49	0.09
Russell 3000	1.00	0.96	0.95	0.89	1.00	0.97	0.88	0.70	0.97	0.54	0.95	0.31	0.68	0.24	0.09	0.26	0.60	0.36	0.26	0.23	0.46	0.06
Russell Midcap	0.95	0.92	0.93	0.86	0.97	1.00	0.93	0.70	0.94	0.55	0.93	0.35	0.69	0.23	0.08	0.26	0.62	0.39	0.26	0.23	0.47	0.05
Russell 2000	0.84	0.83	0.81	0.73	0.88	0.93	1.00	0.63	0.84	0.52	0.84	0.32	0.64	0.16	0.02	0.19	0.60	0.37	0.19	0.18	0.41	0.02
MSCI EAFE	0.70	0.66	0.69	0.65	0.70	0.70	0.63	1.00	0.86	0.57	0.86	0.36	0.72	0.22	0.07	0.23	0.52	0.33	0.44	0.49	0.40	0.07
MSCI World	0.96	0.92	0.92	0.87	0.97	0.94	0.84	0.86	1.00	0.59	0.99	0.35	0.74	0.25	0.09	0.27	0.61	0.37	0.35	0.34	0.47	0.07
MSCI EM	0.53	0.52	0.51	0.48	0.54	0.55	0.52	0.57	0.59	1.00	0.70	0.35	0.58	0.07	-0.05	0.17	0.48	0.31	0.18	0.20	0.58	0.06
MSCI ACWI	0.95	0.91	0.91	0.86	0.95	0.93	0.84	0.86	0.99	0.70	1.00	0.37	0.76	0.23	0.07	0.27	0.63	0.38	0.34	0.34	0.52	0.07
Bloomberg Commodity	0.30	0.27	0.32	0.26	0.31	0.35	0.32	0.36	0.35	0.35	0.37	1.00	0.28	-0.02	-0.13	0.21	0.27	0.29	0.16	0.22	0.20	0.01
FTSE EPRA Nareit Developed	0.67	0.60	0.69	0.69	0.68	0.69	0.64	0.72	0.74	0.58	0.76	0.28	1.00	0.28	0.16	0.29	0.56	0.37	0.39	0.39	0.52	0.04
Bloomberg U.S. Aggregate	0.24	0.23	0.23	0.32	0.24	0.23	0.16	0.22	0.25	0.07	0.23	-0.02	0.28	1.00	0.89	0.59	0.23	0.03	0.79	0.57	0.40	0.16
Bloomberg U.S. Government Long	0.10	0.11	0.07	0.21	0.09	0.08	0.02	0.07	0.09	-0.05	0.07	-0.13	0.16	0.89	1.00	0.56	0.09	-0.15	0.68	0.48	0.30	0.07
Bloomberg U.S. TIPS	0.26	0.25	0.24	0.30	0.26	0.26	0.19	0.23	0.27	0.17	0.27	0.21	0.29	0.59	0.56	1.00	0.31	0.20	0.58	0.49	0.35	-0.02
Bloomberg U.S. High Yield	0.59	0.56	0.58	0.55	0.60	0.62	0.60	0.52	0.61	0.48	0.63	0.27	0.56	0.23	0.09	0.31	1.00	0.57	0.23	0.20	0.44	0.05
Credit Suisse Leveraged Loan	0.35	0.32	0.37	0.35	0.36	0.39	0.37	0.33	0.37	0.31	0.38	0.29	0.37	0.03	-0.15	0.20	0.57	1.00	0.05	0.05	0.22	0.05
Bloomberg Global Aggregate	0.26	0.24	0.26	0.34	0.26	0.26	0.19	0.44	0.35	0.18	0.34	0.16	0.39	0.79	0.68	0.58	0.23	0.05	1.00	0.96	0.38	0.12
Bloomberg Global Aggregate ex U.S.	0.23	0.22	0.23	0.29	0.23	0.23	0.18	0.49	0.34	0.20	0.34	0.22	0.39	0.57	0.48	0.49	0.20	0.05	0.96	1.00	0.31	0.09
JPMorgan EMBI+	0.45	0.43	0.45	0.49	0.46	0.47	0.41	0.40	0.47	0.58	0.52	0.20	0.52	0.40	0.30	0.35	0.44	0.22	0.38	0.31	1.00	0.09
U.S. Treasury Bill 3-Month	0.06	0.04	0.07	0.09	0.06	0.05	0.02	0.07	0.07	0.06	0.07	0.01	0.04	0.16	0.07	-0.02	0.05	0.05	0.12	0.09	0.09	1.00

As of 09/30/24. Source: Voya IM. Projections are subject to change.

Exhibit 5: Long-run equilibrium return assumptions



As of 09/30/24. Source: Voya IM. Assumptions are subject to change.

Appendix: Notes on methodologies

Covariance and correlation matrixes

Matrixes of estimated asset class covariance and correlation are the foundation of our asset class standard deviation forecasts. This differs from return forecasting, as correlations tend to wander over time. Using a historical average or an exponentially weighted methodology—which emphasizes recent observations within a long-term history—could result in risk forecasts that reflect the past but bear little resemblance to the future.

Therefore, our asset class risk forecasts are represented in the return covariance matrix—a crucial component of our capital market assumptions process.

Consider the example of stocks and bonds. Over the past 20 years, the correlation between the S&P 500 Index and Bloomberg U.S. Aggregate Bond Index was -0.02. But what does that tell you about the relationship between these two asset classes during unusual or extreme market conditions? During normal periods within that 20-year span, the correlation was -0.10, but it shifted to +0.07 during unusual periods (Exhibit 6).

Accounting for these unusual correlation patterns helps us more accurately assess the durability of diversification among asset classes. We capture these atypical periods in our standard deviation and correlation forecasts using an academic framework known as "turbulence."

Measuring financial turbulence

The turbulence framework we use to estimate return correlations and standard deviations traces back to the pioneering work of statistician Prasanta Chandra Mahalanobis in the early 20th century. Mahalanobis developed a formula to analyze human skull similarities among Indian castes and tribes, which evolved into the "Mahalanobis distance"—a groundbreaking measure that accounted for both standard deviations and correlations among datasets.[2]

More than 70 years later, Mark Kritzman and Yuanzhen Li adapted this concept to introduce "financial turbulence."[3] They defined this as a state in which asset prices, given their historical return patterns, exhibit unusual behavior such as extreme price movements. Financial turbulence often coincides with heightened risk aversion, illiquidity and price declines for risky assets. We have used this turbulence framework—focusing on the unusualness of returns and their correlations—to forecast risk measures in our capital market assumptions.

Turbulence can be computed for any set of asset classes. Revisiting our example of U.S. stocks and bonds, the returns of the S&P 500 Index and the Bloomberg U.S. Aggregate Bond Index can be visualized as an elliptical equation (Exhibit 6). The ellipse's center represents the average joint returns of the two assets classes, while its boundary is a level of tolerance that distinguishes normal from turbulent observations. This threshold is an ellipse rather than a circle because it accounts for the covariance of the asset classes.

[2] Mahalanobis, P., "On the Generalized Distance in Statistics," *Proceedings of the National Institute of Sciences of India* vol. 2 no. 1 (1936): 49–55.
[3] Kritzman, M. and Y. Li, "Skulls, Financial Turbulence, and Risk Management," *Financial Analysts Journal* vol. 66 no. 5 (2010): 30–41.

Financial turbulence analysis helps us better assess the durability of asset class diversification by capturing unusual correlation patterns.

The idea captured by this measure is that periods are considered turbulent not just when returns are unusually high or low, but also when they move contrary to expected patterns based on the average correlation.

Turbulence and portfolio construction

The boundary between normal and turbulent periods, as depicted in Exhibit 6, isn't fixed—it evolves over time. Our process identifies turbulent market regimes by estimating a covariance matrix specifically for periods of market stress, using a Markov model. This model classifies regimes rather than relying on arbitrary thresholds, which could miss the sustained nature of volatility shifts (Exhibit 7).

To pinpoint turbulent market regimes, we make use of the concept of multivariate outliers within a return distribution. This involves examining how an asset class's return deviates from the average, along with its volatility and correlation with other asset classes. We then estimate separate covariance matrixes for normal and turbulent market periods. These matrixes are combined using weights to express views about the likelihood of each normal or turbulent regime and differing risk attitudes.

Our strategic asset allocation portfolios use a 60% normal and 40% turbulent weighting. While turbulent regimes occur only 30% of the time, we overweight them to 40% to address structural issues such as globalization, demographics and global central bank interventions, which are prevalent today. This overweighting also increases assumed risks, resulting in a more conservative matrix that prioritizes diversification during volatile periods.

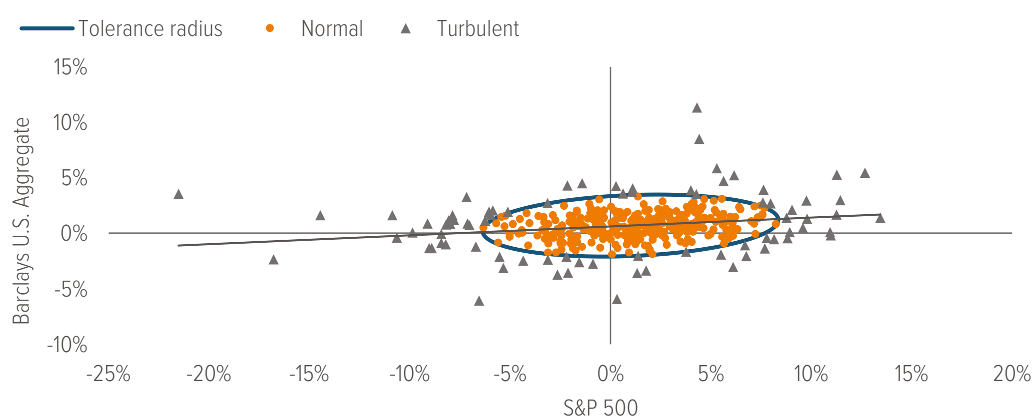
From this blended covariance matrix, we extract the implied correlation matrix and standard deviations for each asset class. In our view, this process helps create a strategic asset allocation portfolio that can account for the empirical evidence of shifting correlations over time.

Time dependency of asset returns and its effect on risk estimates

Recent research indicates that expected asset returns fluctuate in relatively predictable ways, with changes often persisting over extended periods. Consequently, changes among investment opportunities—encompassing all possible combinations of risk and return—are also persistent. Below are the economic reasons behind this return predictability, its implications for strategic asset allocation, and the adjustments we have made to account for it in our estimation process.

Exhibit 6: It is critical to account for non-normal observations by considering correlations

Normal and turbulent periods of stock and bond correlations, 20 years ended 09/30/24



As of 09/30/24. Source: Voya IM.

The relationship between valuation components and predictable economic variables generally leads to predictable expected returns.

We attribute the predictability of financial asset returns primarily to the business cycle, which itself is persistent, making real economic growth somewhat predictable. This persistence is due to the shared qualities of its components: consumption, investment and government expenditures.

Consumers don't like abrupt changes in their lifestyles and therefore tend to smooth their consumption, using borrowing or savings to maintain spending when facing a temporary income shock. (Robert Hall formalized this idea by showing that consumers will optimally choose to keep a stable path of consumption equal to a fraction of their present discounted value of human and financial wealth.[4]) Investment, the second component of GDP, is sticky, as corporate investments in projects are usually long term in nature. Government expenditures also have a low level of variability.

Over a medium-term horizon, negative serial correlation sets in, as the growth phase of the cycle is followed by a contraction, which subsequently is followed by renewed growth.[5]

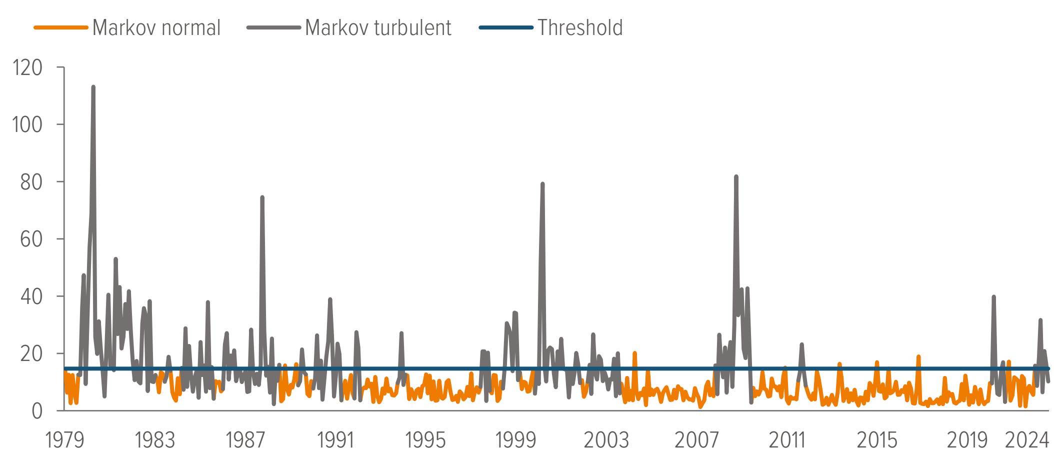
To understand how the predictability of economic variables leads to predictable asset returns, consider stocks. Equity values are determined as the discounted present value of future cash flows, dependent on four factors:

1. **Expected cash flows:** tend to move with the business cycle
2. **Expected market risk premium:** peaks at business cycle troughs (when consumers are trying to smooth consumption and are less willing to take risks with their income) and troughs at business cycle peaks (when people are more willing to take risks)
3. **Expected market risk exposure ("beta"):** changes over time and is a function of a company's capital structure (risk increases with leverage, which is related to the business cycle)
4. **Term structure of interest rates:** determines the risk-free rate, reflecting expectations for real interest rates, real economic activity and inflation (all connected to the business cycle)

These links to the business cycle mean that returns for equities—and for financial assets in general—are predictable, to an extent. Risk premiums of many assets tend to be high when macroeconomic conditions are challenging and low when conditions are good.

Exhibit 7: Both means and variances matter when determining if observations are turbulent

Turbulence across asset classes



As of 08/31/22. Source: Voya IM.

[4] Hall, R., "Stochastic Implications of the Life-Cycle-Permanent Income Hypothesis: Theory and Evidence," *Journal of Political Economy* vol. 86 (1978): 971–988.

[5] Poterba, J. and Summers, L., "Mean Reversion in Stock Prices: Evidence and Implications," *Journal of Financial Economics* vol. 22 (1988): 27–60.

Correcting for autocorrelation helps avoid bias toward less-volatile asset classes.

Autocorrelation biases portfolios toward low-volatility asset classes

The predictability of returns manifests itself in statistics through autocorrelation. In time series of returns, autocorrelation describes the degree to which values at a point in time are anchored by previous values. A positive autocorrelation indicates that high returns tend to be followed by high returns (market momentum), whereas a low autocorrelation means that high returns tend to be followed by low returns (mean reversion).

Traditional mean-variance analysis assumes that returns are not time dependent and prices follow a random walk, meaning that expected returns are constant (zero autocorrelation) while realized short-term returns are unpredictable. This implies that volatilities and cross-correlations among assets do not change with the investment horizon. Therefore, annualized volatility calculated from monthly data (scaled by the square root of 12) should be equal to the volatility from quarterly data (scaled by the square root of 4).

The presence of autocorrelation invalidates this scaling rule, because the sample standard deviation estimator is biased. Positive autocorrelation causes an underestimation of true volatility, and it also biases the cross-correlation matrix. As a result, the risk/return tradeoff can vary significantly between long and short investment horizons.

In a multi-asset portfolio where different asset classes have varying degrees of autocorrelation, not correcting for the bias in volatilities and correlations results in suboptimal mean-variance portfolios. Asset classes with low volatilities, such as hedge funds, emerging market equities and non-public-market assets (e.g., private equity and private real estate) may receive excessive allocations.

Adjusting for autocorrelation bias

One way to correct the autocorrelation effect is a direct approach that involves adjusting the sample of estimators of volatility, correlation and all higher moments. This approach becomes quite complex beyond the first two moments. We prefer an indirect method: cleaning the data of autocorrelation, which allows for the use of standard estimators to calculate the moments of the distribution.

The first step is to estimate and test the statistical significance of autocorrelation in our data series. Using monthly returns from 1979 to 2014, we estimated first-order autocorrelation as the regression slope of a first-order autoregressive process. We then tested its significance using the Ljung-Box Q statistic, which follows a chi-square distribution with k degrees of freedom ($k = 1$ for first-order serial correlation).[6] About 80% of our return series showed positive and statistically significant first-order serial correlation at the 10% significance level.[7]

Khandani and Lo show empirically that positive return autocorrelation indicates illiquidity across a broad set of financial assets, including small cap stocks, corporate bonds, mortgage-backed securities and emerging market investments.[8] In a frictionless market, predictability in returns can be quickly exploited and eliminated. Autocorrelation is the sole illiquidity measure that applies to both public and private securities and requires only return data to calculate.

6 Ljung, G.M. and Box, G.E.P., "On a Measure of Lack of Fit in Time Series Models," *Biometrika* vol. 65, (1978): 297–303.

7 The p-value is the probability of rejecting the null hypothesis of no serial correlation when it is true (i.e., concluding that there is serial correlation in the data when in fact serial correlation does not exist). We set critical values at 10% and thus reject the null hypothesis of no serial correlation for p-values <10%.

8 Khandani, A.E. and Lo, A., "Illiquidity Premia in Asset Returns: An Empirical Analysis of Hedge Funds, Mutual Funds, and US Equity Portfolios," *Quarterly Journal of Finance* vol. 1 (2011): 205–264.

Physical climate risks include direct economic impacts from climate events such as wildfires, extreme weather and flooding.

Energy transition risks reflect the economic ripple effects of policy actions taken to reduce carbon emissions.

Both risk factors are important to consider when making long-term forecasts.

Since the vast majority of the return series we estimate exhibit autocorrelation, we apply the Geltner unsmoothing process to all of them, correcting for first-order serial correlation. We do this by subtracting the product of the autocorrelation coefficient (ρ) and the previous period's return from the current period's return, and then dividing by 1-ρ. This transformation has no impact on the arithmetic return, but it does affect the geometric mean due to its sensitivity to volatility. Therefore, this correction is important for long-horizon asset allocation portfolios.

Accounting for climate change

According to the International Monetary Fund and other respected institutions, the ecological impact of climate change poses significant economic risks.[9] Even though business cycles and event stresses will continue to dominate global economic outcomes, climate change is a material issue that could become increasingly important. Therefore, both physical and transition risks associated with climate change should be considered when making forecasts. Physical risks are often best incorporated at the security level, although they are more easily connected to certain countries and asset classes, such as real estate.

There are three key channels through which climate change could theoretically influence capital market assumptions:

- **Macro:** Climate-related factors influence consumer behavior, investment needs, financing, supply chains, cross-border trade and stranded assets. These are primarily related to transition risk, driven by government policies and market forces. These impacts directly affect GDP growth and inflation, with the magnitude partly determined by advances in productivity-enhancing technologies.
- **Fundamentals:** Top-line output establishes the base for corporate earnings, with profit margins being the other key factor. While the transition will affect industries differently, the overall effects are hard to predict. Thus, we maintain our approach of assuming profit margins mean-revert to equilibrium.
- **Repricing:** Changes in valuation are the most difficult to gauge, as the factors that determine valuations at a given moment and over time are highly uncertain—especially for broad asset classes such as U.S. large cap equities, which is the level at which we forecast our CMA. While certain sectors may deserve higher valuations than others and capital may shift towards more "sustainable" investments, predicting relative pricing changes based on inherent "greenness" is challenging, particularly across countries. Instead of comparing asset class carbon footprints by sector, sustainability should be assessed at the industry level or below. Therefore, premiums and discounts for factors such as climate change should be applied to individual companies within their respective groups. As a result, our efforts focus primarily on macro and some fundamental inputs.

To assess the effects of changes in climate-related macro and fundamental inputs, we collaborated with S&P Global to develop likely climate scenarios and expected economic outcomes. While numerous climate scenarios are possible and investors should stress-test portfolios against various possibilities, only one will actually happen. Therefore, we focused on the most probable scenario (named "Inflections" in Exhibit 8) and integrated those assumptions into our global economic models for the base and alternative scenarios that form the backbone of our CMA.

[9] International Monetary Fund, www.imf.org/en/Topics/climate-change/climate-and-the-economy#publications, accessed 10/31/22.

A fractured geopolitical landscape and national self-interest are preventing the type of global coordination to seriously address climate risks.

However, accelerating investments in renewable energy sources to meet surging electricity demand suggest incremental progress toward decarbonization.

The climate scenarios (Exhibit 8) are updated annually and developed within the context of achieving net-zero carbon emissions by 2050. As this is a longer horizon than our 10-year CMA, they must be rescaled. However, they help us capture important developments along different temperature pathways.

No country is on track to meet net-zero targets by 2050 due to the lack of binding climate commitments, technological gaps and geopolitical strains. The current trajectory points to a 2.5°C temperature rise above preindustrial levels by 2100 (Exhibit 9). In this base scenario, global emissions in 2050 return to readings from the early 2000s, but geopolitical issues and national self-interest hinder international cooperation and force adaptation. The price of carbon emissions and related government policies are crucial for reducing emissions. To reach net-zero, emitting greenhouse gases (GHG) must become more expensive than alternative means of production.

Like climate change itself, the economic impact will be gradual, with a modest difference across most scenarios, making the effect on our capital market assumptions minor. The exception is the "Discord" scenario, where countries turn inward, climate policies are inconsistent, and decarbonization efforts stall, resulting in limited meaningful action. In this scenario, global growth takes a significant hit. Over the 10-year forecast, economic damage is mostly due to the series of crises that underlie the geopolitical tensions preventing climate change mitigation rather than climate change itself. Over longer periods, the risk of major and potentially irreversible physical costs increases.

One thing is clear from our analysis: Addressing the negative externality of climate change improves the outlooks for growth and most risk assets compared with inaction. Incorporating climate change views into our forecasts provides a more complete picture of the world, helping us generate better estimates.

Over the past year, we have incorporated several major shifts into all five long-term outlooks based on global political, economic and market events.

- The crisis management period, initially expected to conclude in the mid-2020s, has been extended into the late 2020s. The post-Cold War world order has evolved into a more fragmented landscape, with nations increasingly prioritizing their own interests over shared global values. This shift has led to less predictable international relations and a rise in geopolitical division and conflict.
- The energy transition faces greater challenges in OECD countries due to cost inflation, higher interest rates, permitting constraints and regulatory barriers. As a result, short-term fossil energy use and carbon emissions are higher than previously expected, delaying substantial emission reductions until the late 2020s or early 2030s.
- China stands out as a bright spot. Despite downward revisions in economic growth expectations, driven by demographic trends and economic evolution, China's aggressive pursuit of renewable energy and electric vehicle (EV) projects offsets these slowdowns. This commitment is driving significant progress in the energy transition.
- The surge in forecasted energy demand may accelerate investments in alternative energy sources, even as the political and geopolitical landscape becomes more fractured and uncertain, and as fossil fuel usage increases in the near term. While climate targets are unlikely to be fully achieved, the base-case scenario shows incremental but sustained progress in global decarbonization and energy transition.

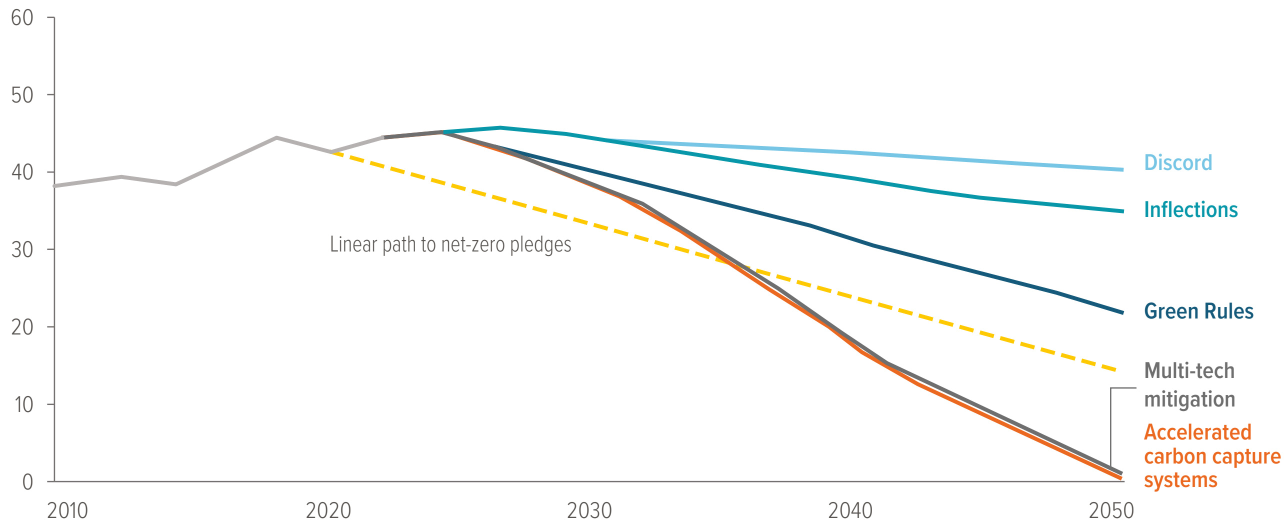
Exhibit 8: Climate scenarios

	Net-zero 2050 scenarios		Realistic scenarios		
	Accelerated carbon capture systems (CCS)	Multi-tech mitigation (MTM)	Green Rules (optimistic scenario)	Inflections (base case)	Discord (pessimistic scenario)
Implied temperature rise[a]	+1.5°C	+1.5°C	+1.8°C	+2.5°C	+3.1°C
General themes	**High carbon capture:** Broad global use of CCS in both energy and non-energy sectors.	**Low carbon capture:** Supply diversification, electrification and renewables dominate as key drivers.	**Crisis backlash and strong government policy:** Societal reactions to chronic crises drive significant government actions, leading to revolutionary transformation toward a sustainable low-carbon economy.	**Market forces and national self-interest:** Societal, market and government forces drive fundamental change in energy use and emissions pathways.	**Weak markets and policies:** Political instability and isolationist trends inhibit governments, increase market uncertainty and slow the energy transition.
International cooperation	**Strong:** Recognition that CCS can help accomplish decarbonization goals using existing infrastructure while saving jobs.	**Strong:** Intense policy and societal intent to minimize fossil fuel use across all sectors. Incentives widely used to foster green hydrogen.	**Strong:** Cooperation strengthens in response to strong public demands to address security concerns, which are increasingly linked to climate change.	**Mixed:** The global balance of power is more broadly distributed than it has been in almost a century. National interests are central.	**Weak:** International relations suffer from chronic domestic political division and weakness, sowing mistrust and isolationism.
Economic environment	**Moderate:** Costs of rapid acceleration of expensive carbon capture keep economic growth slightly below that of "Green Rules."	**Moderate:** Costs of a rapid shift away from hydrocarbons and abandonment of existing facilities keep economic growth below "Green Rules" for some period.	**Mixed:** Economic disruptions and hardships arise in the short term due to initial policy disorder and the costs of forced energy transition. Over time, conditions are established to encourage private investment.	**Moderate:** The return to pre-2020 average growth levels masks underlying long-term structural shifts in the global economy.	**Weak:** Escalating cross-border tensions and prolonged political and economic fallout undermine governmental stability and erode market confidence globally.
Climate policy	**Very strong:** Significant global policy coordination. High carbon prices to incentivize use of carbon capture, with global carbon markets reaching $200 per MtCO2e (real 2023 US$) by 2040.	**Very strong:** Significant global policy coordination. Moderately high carbon prices reach $150 per MtCO2e (real 2020 US$) by 2040, supplemented by incentives and mandates to reduce fossil fuels.	**Very strong:** Political pressure and national security interests eventually drive nations to cooperate on global standards and protocols for GHG emissions across the world and promote clean energy technologies, business models and lifestyles. **Some G20 countries move much closer to net-zero goals but do not meet them.**	**Strong:** Climate policy moves forward strongly but remains driven more by national interests than global goals, hindering the effectiveness of international coordination on standards and conventions and consistency of net-zero programs and efforts. **G20 countries do not meet net-zero goals.**	**Weak to moderate:** Climate policy is fragmented as many countries become more inwardly focused and decarbonization efforts lose political momentum in the face of chronic economic uncertainty and weakness. **Many countries abandon net-zero goals.**

As of 11/15/24. Source: Voya IM. a) Implied temperature rise is the estimated increase in global average temperatures above pre-industrial levels by 2100. The Paris Agreement targets limiting warming to well below 2°C—ideally 1.5°C.

Exhibit 9: Net global greenhouse gas emissions

$MtCO_2e$, thousands



As of 09/30/24. Source: S&P Global Commodity Insights.

About Voya Multi-Asset Strategies and Solutions

Voya Investment Management's Multi-Asset Strategies and Solutions (MASS) team, led by Chief Investment Officer Barbara Reinhard, manages the firm's suite of multi-asset solutions designed to help investors achieve their long-term objectives. The team consists of 17 investment professionals who have deep expertise in asset allocation, manager research and selection, quantitative analysis and portfolio implementation. Barbara also leads the asset allocation team, which is responsible for constructing strategic asset allocations based on its long-term views. The team also employs a tactical asset allocation approach, driven by market fundamentals, valuation and sentiment, which is designed to capture market anomalies and reduce portfolio risk.

A note about risk

The principal risks are generally those attributable to stock and bond investing. The value of an investment is not guaranteed and will fluctuate. Equity investments are subject to market, issuer and other risks. Market Risk: Securities may decline in value due to factors affecting the securities markets or particular industries. Issuer Risk: The value of a security may decline for reasons specific to the issuer, such as changes in its financial condition. Bonds are also subject to Market and Issuer risk, as well as interest rate, credit, prepayment, extension and other risks. Bonds have fixed principal and return if held to maturity but may fluctuate in the interim. Interest Rate Risk: When interest rates rise, bond prices fall; bonds with longer maturities tend to be more sensitive to changes in interest rates. Foreign securities: Foreign investing poses special risks including currency fluctuation, economic and political risks not found in investments that are solely domestic. These risks are generally intensified in emerging markets. Additional risks include, but are not limited to: Other Investment Companies' Risks, Price Volatility Risks, Inability to Sell Securities Risks, Securities Lending Risks, Investment Model Risks, Liquidity Risk and Market Capitalization Risk.

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