

WORKPLACE BENEFITS

Liability-driven investing: Benchmarking by asset class

Examining historical index performance

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Executive summary

Liability-driven investing (LDI) has grown in prominence in recent decades and is now a core component of investment strategies for defined benefit pension plans.¹ The investment strategy's growth in popularity has resulted from its effectiveness in both hedging interest rate risk and reducing pension funded status volatility. Pension plan assets and liabilities sit on corporate balance sheets and drive cash contribution requirements, accounting expense and some administrative expenses. As a result, many plan sponsors are interested in reducing funded status volatility for their plans, and LDI can be an effective tool to help meet that objective.

Investment grade² fixed income is typically the primary asset class utilized in LDI portfolios. Bond prices are inversely related to market interest rates. When interest rates fall, bond prices rise. Likewise, pension liabilities are also inversely related to market interest rates, since the determination of a current pension plan liability measure requires discounting projected benefit payments to the present using discount rates. Pension liabilities are typically discounted using the yields available on high-quality investment grade bonds, and those same bonds are commonly used to hedge the liabilities. With expected benefit payments often going decades into the future, pension liabilities tend to have long durations and are therefore quite sensitive to interest rates. LDI portfolios have traditionally been implemented by investing in fixed income securities that closely resemble the characteristics of the plan liability. The desired outcome is that the LDI assets and plan liability move together as market interest rates change.

LDI can help mitigate the interest rate risk associated with a plan liability, but plan sponsors often have additional goals. Underfunded or accruing plans, in particular, require greater asset growth to keep pace with the liability. Traditionally, equities and other return-seeking assets have been used to target investment growth independently of a plan's LDI portfolio. More recently though, some plan sponsors and investment managers have begun incorporating

Funded Status Standard Deviation

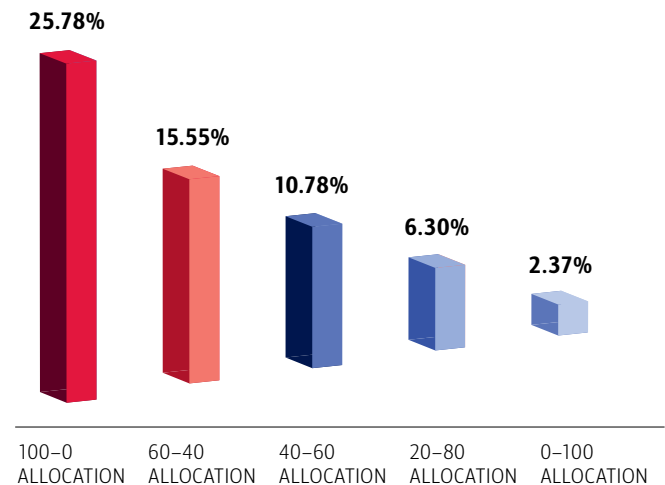


Figure 1: The chart above illustrates funded status standard deviation for a hypothetical pension plan invested x%-y% in return-seeking and LDI investments respectively. For illustrative simplicity, the return-seeking assets were taken as S&P 500 performance and the LDI performance was assumed to be the ICE BofA 15+ Year U.S. Corporate Index over the period 1/1/2018 –12/31/2022. For further simplicity, the return-seeking plan is assumed to be frozen with no contributions, benefit payments or any other expenses over the period. Past performance is no guarantee of future results. Source: Bank of America, 12/31/2024.

additional asset classes in LDI portfolios — with the goal of providing both growth and liability-hedging characteristics simultaneously. Some of these asset classes include real estate, high yield debt, commodities and private credit.

For plan sponsors focused on minimizing funded status volatility by implementing the tightest liability hedge possible, there's no substitute for investment grade debt. Given its common usage, it's classified as a **traditional LDI** asset class for the purposes of this analysis. Other plan sponsors might be willing to accept increased funded status volatility in exchange for potential surplus returns. For those under these circumstances, two other asset classes were identified that could potentially serve as LDI-growth hybrids: real estate and high yield debt. For ease of labeling, LDI-growth hybrids are designated as **LDI hybrid** asset classes.

¹ For the purposes of this analysis, the pension plan universe is taken as private, U.S.-based, and single-employer traditional and cash-balance qualified defined benefit plans. These plans typically provide lifetime annuities to participants upon retirement. Pension plans may be open to new participants, closed, or frozen. Some of the observations may be applicable to other types of pension plans but are beyond the scope of this analysis because of differences in accounting standards, laws and regulations.

² Investment grade debt refers to U.S. government debt securities and corporate bonds rated BBB/Baa or higher.

The analysis shows that these LDI hybrids have historically displayed some correlation with liability index proxies and exhibited surplus return potential. However, in certain market environments, hedging benefits may evaporate — negatively impacting a plan’s funded status. Plan sponsors intending to utilize LDI hybrids within their plans’ LDI portfolios must ensure that they understand the associated risks and the potential for greater funded status variability than expected. Other asset classes considered, including equities and commodities, demonstrated limited hedging benefits and were classified as **non-LDI** assets.

It should be noted that private credit was not explicitly analyzed in this exploration since sufficient historical index return data is unavailable. However, properly structured private credit arrangements could potentially play a role in LDI portfolios. Additionally, hedge funds weren’t analyzed in depth for the purposes of this analysis since there are a wide variety of hedge fund types and strategies — making any rendered LDI judgement of little use for a qualified defined benefit pension plan.

What is a pension liability?

Pension plans offer participants a defined benefit at retirement, typically in the form of a monthly annuity. For the plan, these future payments are represented by projected cash flows — a payment stream capturing the timing and amount of expected benefits to be paid. A pension plan’s liability is the present value of the projected cash flows discounted using certain interest rates. For statutory and regulatory reasons, commonly utilized interest rates are derived from investment grade corporate bond yield curves. As these curves change over time, the liability will fluctuate as well. LDI is all about investing in securities, typically bonds, with an interest rate exposure resembling that of the liability. When the LDI assets and plan liabilities mostly move together in response to changes in the referenced yield curve, interest rate risk is hedged and funded status volatility is reduced.

For more information on plan liabilities and LDI, please see our other available resources:

- [Foundations of liability-driven investing \(LDI\)](#)
- [Next-generation liability-driven investing](#)

Asset Classes

Asset Class Category	Traditional LDI	LDI Hybrid	Non-LDI
Investment grade debt	✓		
Equities			✓
Commodities			
Real estate		✓	✓
High yield debt			

Figure 2: Table displaying the broad categorization of asset classes. Source: Bank of America, 12/31/2024.

Purpose, motivation and backdrop

Defined benefit (DB) plan sponsors face numerous variable factors that impact their plan funding strategy and investment policy. A plan's funded status serves as an accepted approximator of a pension plan's overall health. The funded status is defined as the market value of plan assets, divided by the plan liability. This liability calculation is the present value of the projected future benefit payments made to participants. For single-employer pension plans, the discount rate used in the present value computation is generally informed by corporate bond yields. Liabilities are sensitive to changes in the yield curve with the potential consequence being undesirable changes in a plan's funded status — even in years of positive asset performance. Sharp drops in funded status can lead to large expenses and required plan contributions, whereas sharp gains may offer little immediate reward. Greater funded status predictability

can insulate sponsors from significant unexpected contributions, fees or penalties — all of which could adversely affect a company's income statement and balance sheet.

As stated in the executive summary, LDI can be an effective tool for managing plan funded status volatility and interest rate risk. Historical returns for investment grade debt resemble liability index proxy (see appendix) returns — typically resulting in a decreased funded status volatility as the allocation to LDI investments increases. Better funded plans and plans with larger allocations to LDI can more effectively hedge their liabilities and reduce funded status volatility. To better understand this, consider a hypothetical example demonstrating theoretical plan funded status volatility over the period 12/31/2005 to 12/31/2010.

Illustrative Funded Status Over Time

12/31/2005–12/31/2010

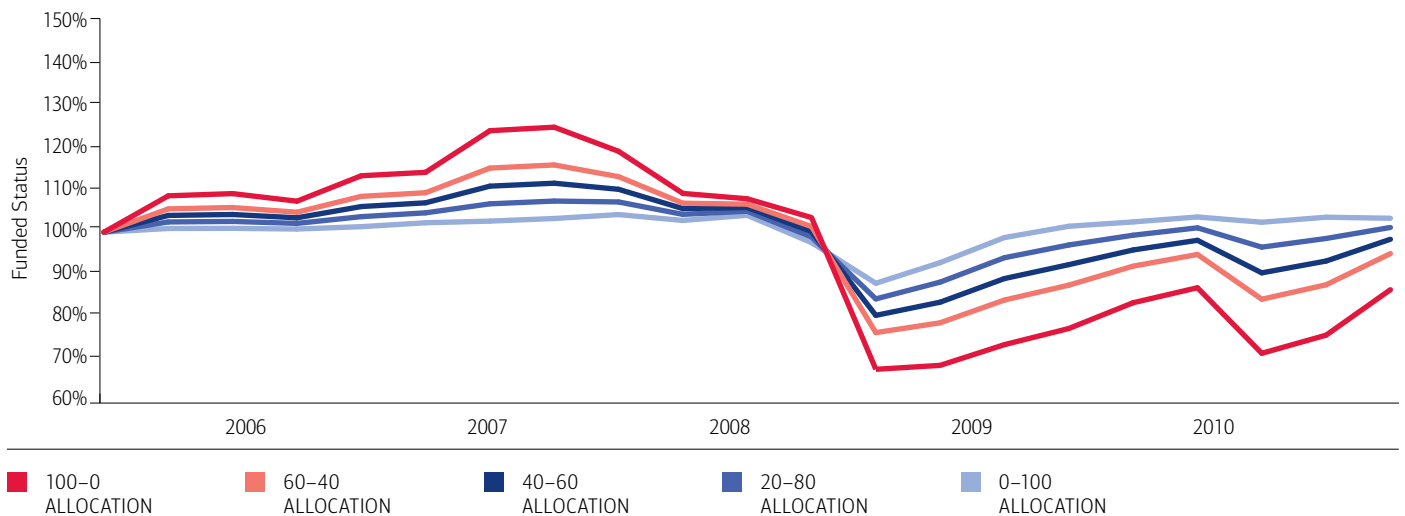


Figure 3: The performance period was selected to underscore the theoretical benefits of LDI investing during extreme market downturns. For other performance period analysis, see "Hypothetical effects of LDI" in the appendix. For this illustrative example, the plan is assumed to begin 100% funded with a liability of \$500 million. The return-seeking profile is approximated by S&P 500 performance. LDI performance is proxied by the ICE BofA 15+ Year U.S. Corporate Index. These were chosen for illustrative simplicity. For further simplicity the plan is assumed to be frozen with no benefit payments, contributions, or any other expenses over the period. Past performance is no guarantee of future results. Source: Bank of America, 12/31/2024.

In the years leading up to 2008, the return-seeking-forward portfolios achieved a higher rate of return than those incorporating greater levels of LDI, and funded status improved more rapidly. However, a drop in funded status occurred with the onset of the 2008 global financial crisis (GFC), a perfect storm for pension plans, as equities and interest rates fell together. The funded status drops for the equity-forward portfolios were more severe than in the LDI-forward allocations, and the standard deviations of funded status during the period were much smaller for portfolios containing more LDI.³ This wasn't merely because the plans with more LDI avoided equity losses, though that's certainly part of the story. The LDI allocations also produced positive absolute returns as interest rates fell.

In both practice and theory, investment grade debt provides the purest liability hedge. Due to its success at hedging plan liabilities and historical implementation in LDI portfolios, investment grade debt will be referred to as a **traditional LDI** asset class.

Closely matching the performance characteristics of the liability may provide too little investment return upside for some plan sponsors⁴ that may be interested in achieving long-term growth, hedging interest rate risk, and managing funded status volatility concurrently. Diversification within a portfolio is key to limiting volatility and optimizing performance within a risk-reward framework. To that end, any alternative asset class that could provide higher expected returns, equity risk diversification and some liability hedging benefits could be attractive to pension plan sponsors. This category of LDI-growth hybrid asset classes, or simply **LDI hybrids**, is defined here.

What is an LDI hybrid?

As defined herein, an LDI hybrid is an asset class that:

- Can contribute to interest rate hedging as evidenced by positive historical correlation with pension liability index proxies;
- Has the potential to provide long-term returns in excess of a plan's liability;
- Offers a reasonable historical tracking error relative to pension liabilities in most market environments, limiting the risk associated with large funded status declines.

The use of LDI hybrids isn't appropriate for all pension plan sponsors. For plan sponsors focused chiefly on hedging interest rate risk and minimizing funded status volatility, traditional LDI can be an ideal solution. While the identified LDI hybrids have exhibited a somewhat reliable relationship with market interest rates and pension liabilities, in certain market environments those hedging benefits may disappear. Given this, it's imperative that sponsors understand the limitations of LDI hybrids as hedging assets before including them in their plans' investment policies.

³ This trend of lower funded status volatility per higher LDI portfolio allocation holds in all selected time periods analyzed. See "Hypothetical effects of LDI" in the appendix.

⁴ For more on historical index liability correlation and surplus returns, see Figures 4 and 5 on subsequent pages.

Initial observations

Bank of America has reviewed historical asset class index performance data over the period 1Q 2000 through 4Q 2024. As previously outlined, investment grade debt — encompassing broad market, corporate and U.S. government debt — is taken as a traditional LDI asset class. All other analyzed asset classes will subsequently be considered for categorization as a traditional LDI asset, an LDI hybrid or a non-LDI asset class. For any given plan, the inclusion of an asset class will be dependent on plan sponsor goals, expectations, LDI interpretations and risk tolerance. For the purposes of this research, Bank of America examined 12⁵ market indexes and six⁶ liability index proxies of varying duration and credit quality. The asset classes included in the examination were equity, real estate, commodities, high yield debt, corporate debt,

broad market debt and U.S. Treasury securities. The included indexes were selected to represent different market segments (primarily U.S. markets), but certain notable asset classes were excluded due to availability-of-data limitations.

Based on historical quarterly returns data, investment grade debt indexes have been the most correlated with liability index proxies over the full period examined and the most recent 10-year period. The high yield and real estate investment trust (REIT) indexes, over the same 10-year period, are relatively correlated with the liability index proxies, whereas the commodity and property indexes exhibit negative liability correlation. Equity indexes, while positively correlated with liabilities recently, haven't exhibited that correlation in earlier time periods.

Return Correlations with Pension Liabilities by Asset Class

Quarterly data: 1/1/2015–12/31/2024

Index	Liability AA—Medium	Liability A-AAA—Medium
ICE BofA 15+ Year U.S. Corporate Index	97.0%	98.2%
ICE BofA U.S. Corporate Index	93.0%	95.1%
ICE BofA U.S. Broad Market Index	94.3%	93.8%
ICE BofA U.S. Treasury Index	80.4%	77.5%
S&P 500 TR	45.9%	50.8%
Russell 1000 Value TR	35.3%	40.3%
Russell 1000 Growth TR	50.1%	54.4%
Russell 2000 TR	33.2%	38.3%
Bloomberg Commodity Index Total Return	-11.8%	-9.3%
MSCI U.S. REIT Gross TR	62.2%	65.1%
100% NCREIF Property	-20.7%	-22.7%
ICE BofA U.S. High Yield Index	54.4%	59.1%

Figure 4: Various index correlations to the Liability AA and A-AAA—Medium index proxies. Please refer to the Appendix section "Liability index proxy computation" for more information on the Liability AA and A-AAA - Medium index proxies.

Past performance is no guarantee of future results.

Source: Bank of America, 12/31/2024.

⁵ For detailed index inclusions and definitions, see the appendix.

⁶ See "Liability index proxy computation" in the appendix for a discussion of the liability index proxy measure. The tables in this section reference two liabilities representative of typical pension plans with performance based on the AA and A-AAA corporate yield curves.

When focusing solely on correlations with pension liabilities as shown above, investment in anything other than investment grade debt creates additional risk within a liability-hedging account — as the hedge strength will decline with the addition of more assets exhibiting less liability correlation than those they replace. However, when considering other measures beyond correlation, certain plan sponsors may see value in incorporating additional asset classes in an LDI portfolio. One of the principal benefits of expanding the LDI asset class universe is the created potential for more significant surplus returns above liability performance. To see this, consider the following surplus returns matrix of most recent 10-year quarterly performance.

Surplus Returns over Pension Liabilities by Asset Class

Quarterly data: 1/1/2015–12/31/2024

Index	Liability AA — Medium	Liability A-AAA — Medium
ICE BofA 15+ Year U.S. Corporate Index	0.4%	0.3%
ICE BofA U.S. Corporate Index	0.3%	0.3%
ICE BofA U.S. Broad Market Index	0.0%	0.0%
ICE BofA U.S. Treasury Index	-0.1%	-0.1%
S&P 500 TR	3.1%	3.0%
Russell 1000 Value TR	2.0%	2.0%
Russell 1000 Growth TR	4.0%	4.0%
Russell 2000 TR	2.1%	2.1%
Bloomberg Commodity Index Total Return	0.3%	0.3%
MSCI U.S. REIT Gross TR	1.4%	1.4%
100% NCREIF Property	1.2%	1.1%
ICE BofA U.S. High Yield Index	1.0%	1.0%

Figure 5: Various index surplus returns over the Liability AA and A-AAA — Medium index proxies.

Past performance is no guarantee of future results.

Source: Bank of America, 12/31/2024.

As expected, equities historically returned a surplus over a theoretical liability. Real estate, high yield and long-duration corporate indexes also provided excess returns over a 10-year period. Of course, when optimizing an asset allocation for a go-forward investment strategy, forward-looking expected returns are preferable to historical returns. This said, there’s a reasonable expectation that indexes carrying more risk are likely to provide long-term returns beyond that of fixed income.

In contrast, past period performance data suggests that an LDI portfolio constructed solely of investment grade fixed income carries a greater risk of experiencing gradual funded

status erosion, as bond investment performance could fail to keep pace with liability returns over lengthy time periods. Even if a perfect hedge were possible, the plan must pay expenses that will wear away funded status if the plan is making no contributions and earning no surplus. Theoretically, a plan could incorporate traditional LDI and other assets to find a portfolio correlation-surplus sweet spot. This could be appealing for plan sponsors that wish to mostly match liability performance and use potential surplus returns⁷ to maintain funded status over the long term. Consider the following figure to better understand the correlation and surplus tradeoffs across various asset classes.

⁷ With preference for surplus returns coming from asset classes that are also more correlated to a plan liability.

10-year Average Surplus vs. Correlation

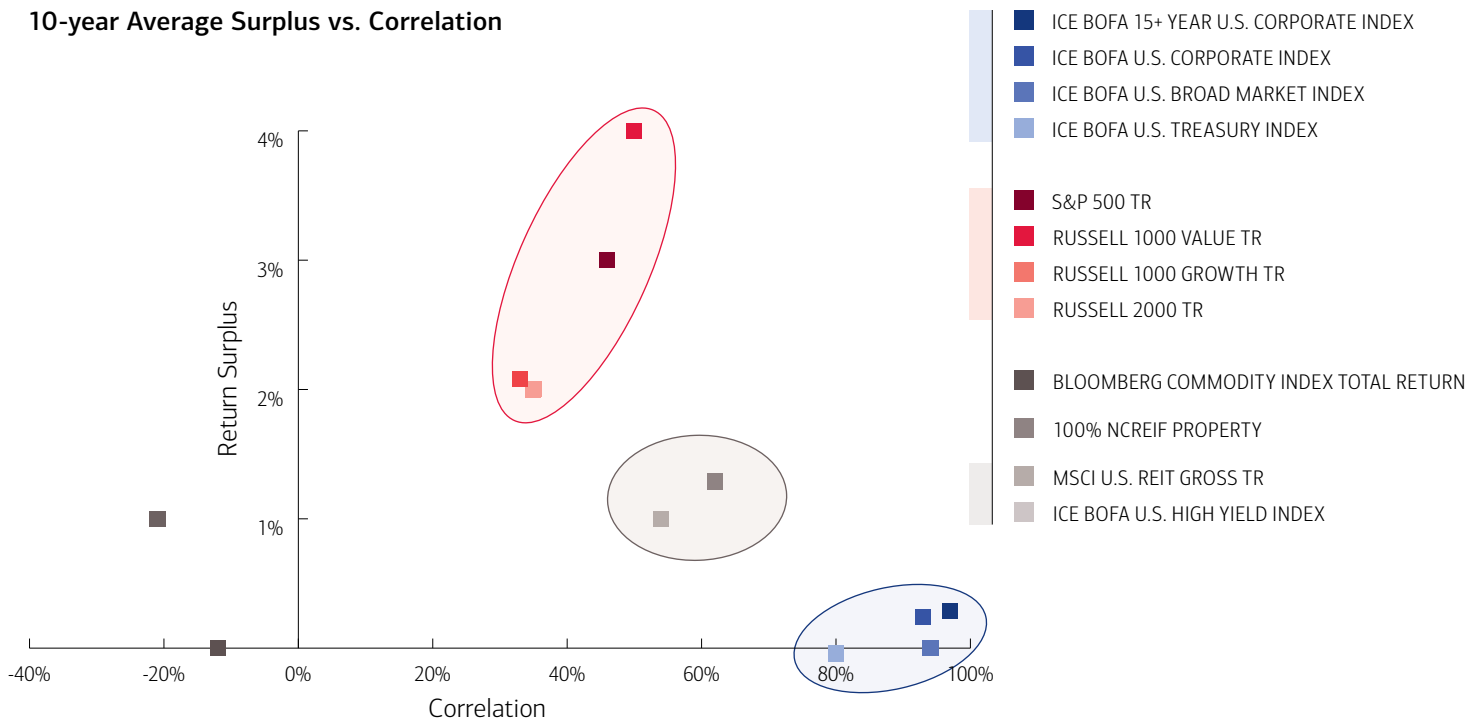


Figure 6: Index surplus returns vs correlation. (Relative to the Liability AA — Medium liability index proxy).
 Past performance is no guarantee of future results.
 Source: Bank of America, 12/31/2024.

In the chart above, investment grade debt provides high correlation to the hypothetical liability but offers little to no surplus. Equities provide the opposite, offering limited correlation but with a meaningful surplus. REITs and high yield debt sit somewhere in between, while commodities and property have behaved entirely differently. A plan sponsor looking for the tightest possible liability hedge may disqualify the in-between asset classes from LDI consideration due to their lower correlations with the liability. On the other hand, a plan sponsor looking for a combination of hedging benefits and enhanced returns could determine that those same assets could play a role as an LDI hybrid.

Analysis by asset class

Fixed income: Broad market, corporate and U.S. government debt

Based on the above analysis, investment grade debt has historically offered unmatched liability correlation statistics. Despite a lack of surplus returns relative to liability performance, investment grade fixed income securities have long been the most utilized holdings in LDI portfolios due to their success in hedging plan liabilities.

Asset class index liability correlations aren't fixed over time. This is due to market fluctuations, macroeconomic conditions and other factors. When determining whether a certain asset class is appropriate for an LDI portfolio, it's important to consider various market cycles and economic

environments. After all, correlations breaking down could result in significant funded status declines at times, even if overall correlation for the period is strong. While dips in performance and correlation are expected to occur occasionally, the degree and consistency of these shortfalls are an important point of examination.

To visualize the effectiveness of fixed income within an LDI portfolio on a rolling basis, see the below chart demonstrating rolling 20-quarter correlations between traditional LDI asset classes and a hypothetical Liability AA—Medium index proxy.⁸ While there are a few dips along the way, these asset classes have historically exhibited the highest levels of correlation to a pension liability index proxy.

Rolling Correlations: Investment Grade Debt with a Pension Liability

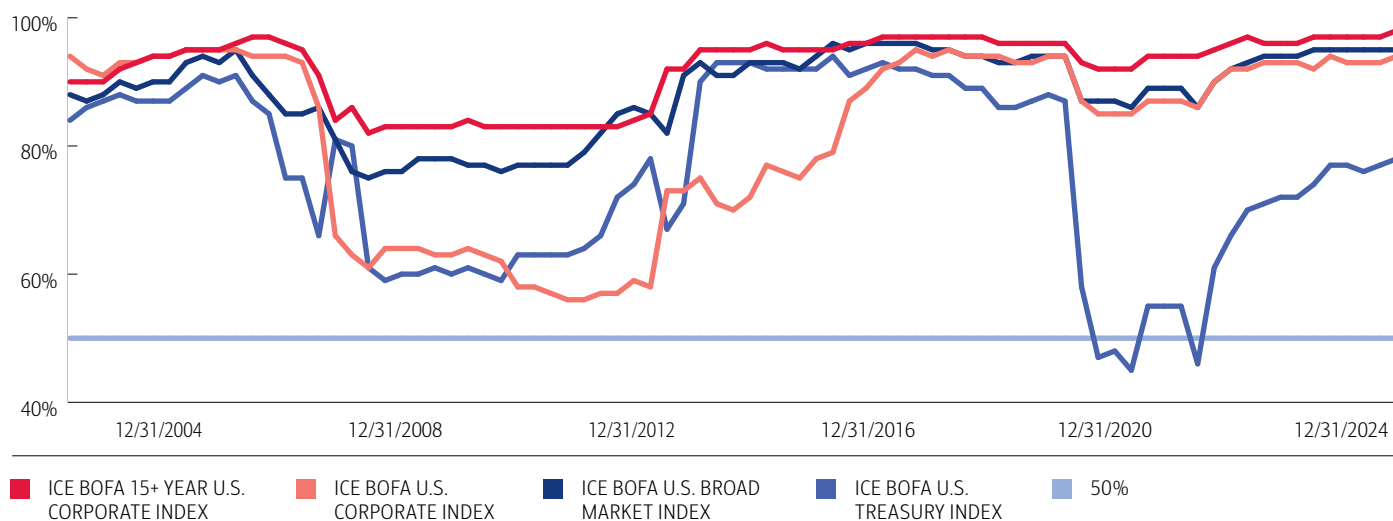


Figure 7: Investment grade fixed income index rolling correlations with the Liability AA—Medium index proxy. Past performance is no guarantee of future results. Source: Bank of America, 12/31/2024.

The broad U.S. fixed income market index and ICE BofA 15+ Year U.S. Corporate Index performed with a consistently high liability correlation and less variance in rolling correlations than the other examined indexes. All four indexes were less correlated with the liability in the years surrounding the GFC, with the ICE BofA U.S. Corporate Index taking until 2017 to return to its previous levels of observed correlation. This result is likely due to the combined effects of various foreign and domestic economic

disruptions occurring during 2012–2013.⁹ That said, overall investment grade debt rolling liability correlations remained very strong relative to those of other asset classes during the GFC¹⁰ and in all other periods examined. More recently, the U.S. Treasury Index has displayed the lowest 20-quarter rolling liability correlation. This trend is yet to fully reverse, but the most recent Treasury index returns indicate a correlation statistic returning to historical levels.

⁸ Unless otherwise stated, this liability index proxy will be used for all other charts, illustrations and graphics.

⁹ See "Effect of period length on statistical analysis" in the appendix for a discussion of how the choice of rolling correlation period length will effect the consistency of the rolling correlation graph.

¹⁰ See "Index correlations during the GFC" in the appendix for more detailed graphics regarding asset class correlations during the GFC.

To a large extent, the time periods where certain fixed income indexes underperform as a hedging vehicle can be explained by considering how credit spreads were changing in the markets. For example, at the onset of the GFC, credit spreads widened significantly, which prevented corporate bond rates from falling with Treasury rates. This led Treasuries to outperform liabilities during that time period, though correlation was reduced. During recovery periods where credit spreads were tightening, the reverse effect was observed. Treasuries didn't benefit during these periods as they have no exposure to credit spreads. Ultimately, this analysis shows that Treasuries on their own aren't ideal for LDI implementations but retain a strong enough correlation to still be considered traditional LDI.

A notable drawback of investment grade debt is that it generally has provided lower surplus returns over the liability when compared with other asset classes. The following chart demonstrates historical 20-quarter rolling surplus returns. The ICE BofA 15+ Year U.S. Corporate Index has clearly displayed the highest overall surplus returns on a rolling basis. This, in addition to the index's excellent liability correlation, makes it the "gold standard" for all LDI asset class indexes included in this analysis. This said, surplus returns on a 20-quarter rolling basis can be negative and have never exceeded 1% over the period. This implies that pension asset returns matching the ICE BofA 15+ Year U.S. Corporate Index may not be enough to preserve funded status over time.¹¹

Rolling Surplus Returns: Investment Grade Debt over a Pension Liability

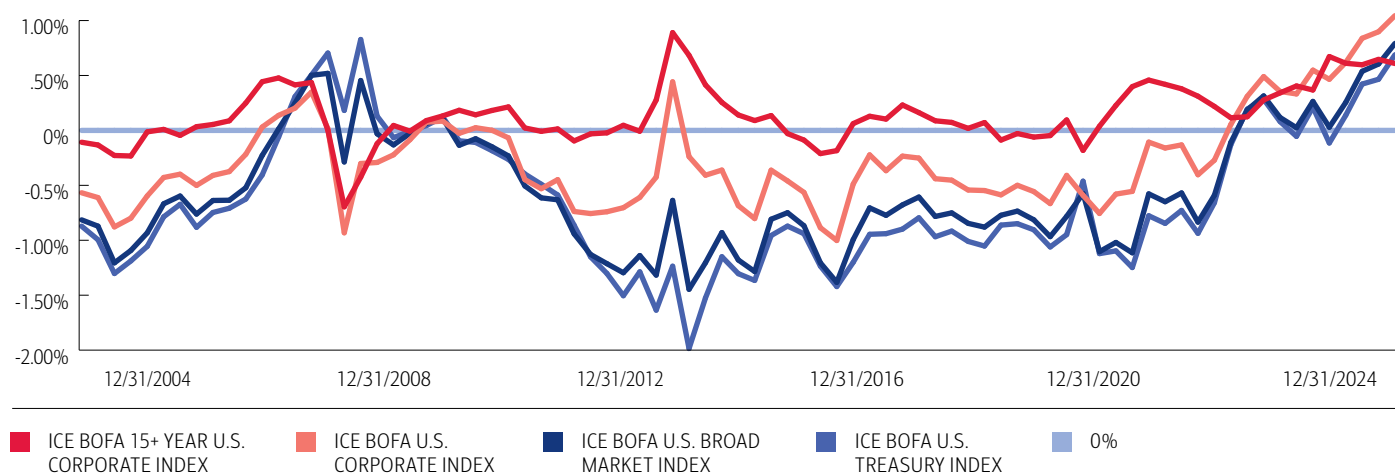


Figure 8: Investment grade fixed income index rolling surplus returns over the Liability AA—Medium index proxy. Past performance is no guarantee of future results. Source: Bank of America, 12/31/2024.

Regarding the credit spread point made previously, U.S. Treasury indexes performed better, on a surplus return basis, during the GFC than both corporate indexes, which likely is indicative of a "flight to quality" during the period.¹² This suggests that, while long-duration corporate debt may be the LDI asset class gold standard, there's a place for U.S. Treasuries in a traditional LDI portfolio. A carefully constructed mix of corporate and governmental bonds matching key liability characteristics including duration, credit quality and yield will likely provide a tighter hedge than any fixed income index individually.

¹¹ The potential for long-term funded status depreciation increases after considering additional drags on plan assets, such as plan expenses and the timing of benefit payments.
¹² However, in years such as 2014, the indexes tracking broad-based and U.S. government debt significantly underperformed corporate debt indexes on a rolling surplus basis.

Equities

Unsurprisingly, historic equity performance is less correlated with liability index proxies than many of the other asset classes examined. That said, equity and liability performance have been increasingly correlated in recent years. While changes in interest rates don't directly impact equity securities in the same manner as fixed income investments, there are reasons to expect some indirect impact from interest rates on equities. Though equity valuation methods vary, one commonly used model involves discounting future

cash flows — either expected dividends or earnings — to the present day. Interest rates also impact borrowing costs and costs of capital, which are critically important for some companies. More recently, interest rate levels have been associated with the level of accommodativeness of Federal Reserve Policy. Lower interest rates have been supportive of financial markets generally, whereas tightening cycles with rising interest rates have negatively impacted equities along with other investments. This may partially explain the more recent observations of positive correlations between equities and liability index proxies.

Rolling Correlations: Equities with a Pension Liability

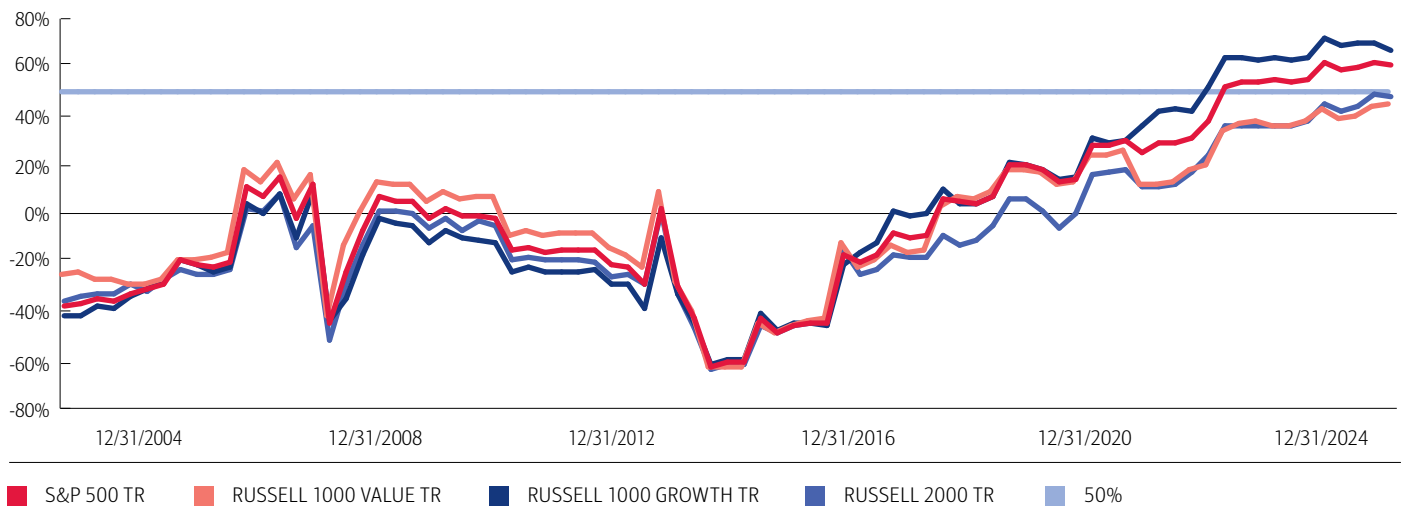


Figure 9: Equity index rolling correlations with the Liability AA — Medium index proxy. Past performance is no guarantee of future results. Source: Bank of America, 12/31/2024.

Pictured above is an example of the recent correlation increase between equity and liability AA — Medium Index proxy. As seen in the chart, the Russell 1000 Growth TR Index displayed the highest recent rolling 20-month correlation overall. In earlier time periods, the Russell 1000 Growth TR Index exhibited mostly negative correlations with pension liabilities, and no equity indexes provided consistently positive correlations. Given the marked inconsistency of any hedging benefits, labeling equities as an LDI hybrid would be inappropriate. Equity indexes do offer positive rolling surplus figures, but that's both unsurprising and alone not sufficient to justify inclusion in an LDI portfolio.

With little tangible evidence supporting the continuation of recent equity-liability correlation trends, equity is categorized as a non-LDI asset class. Equity performance has historically been volatile and often not correlated with pension liabilities. Simply put, better liability-hedging alternatives exist, and thus equity is categorized as a non-LDI asset class. Of course, equities can play a role in pension portfolios as a growth asset, but their specific inclusion within an LDI portfolio would be difficult to justify based on this analysis alone.

Commodities

The label “commodities” is wide ranging, and the asset class comprises many different types of investments (including but not limited to physical commodities, options, futures and commodity funds). Commodities are typically included within investment portfolios to increase diversification, but they’re typically left out of LDI portfolios. Indeed, looking at Bloomberg Commodity Index Total Return historical data, there’s no evidence to suggest a consistent positive correlation with liability performance.

Rolling Correlations: Commodities with a Pension Liability

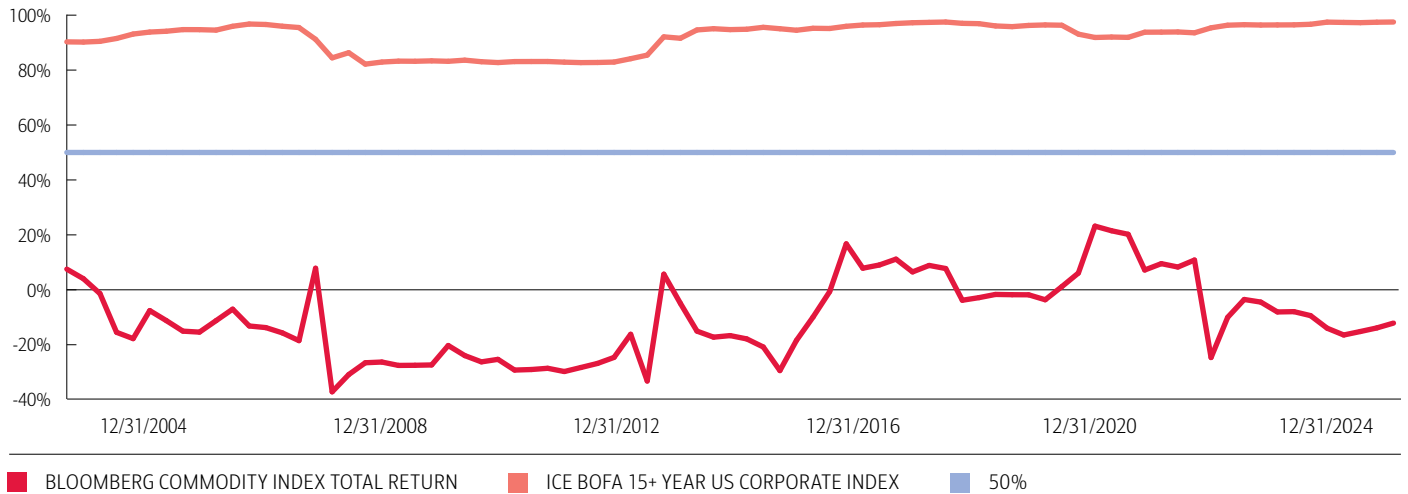


Figure 10: Bloomberg Commodity Index Total Return rolling correlation with the Liability AA—Medium index proxy. Past performance is no guarantee of future results. Source: Bank of America, 12/31/2024.

The above graphic shows the rolling 20-quarter correlation between commodities and the liability AA—medium index proxy. The commodity index fails to exhibit any consistent correlation trend, and the rolling correlation is never higher than 0.25. For reference, the ICE BofA 15+ Year U.S. Corporate Index is included to further demonstrate the large gap existing between commodity and corporate debt liability correlations. Furthermore, surplus returns are generally more negative than positive,¹³ implying that the commodity index, which already displays poor liability correlation, can confidently be labeled a non-LDI asset class.¹⁴

¹³ Noted in appendix: “Bloomberg Commodity Index Total Return Rolling Surplus Chart.”

¹⁴ Commodity investments are hard to amalgamate under one umbrella. The index explored within this paper clearly falls short of meeting the outlined LDI criteria, but other data may support the use of other commodity investments as an LDI-type asset. That said, nothing in this analysis exists to imply this is the case.

Real estate

Like commodities, it's difficult to lump all real estate investments into one bucket, making it challenging to then render an LDI classification judgement. For the purpose of analysis, real estate comprises two broad categories: REITs, which are publicly traded companies that own, operate or finance properties; and private real estate, which involves direct investment in residential and commercial properties.

Theoretically, real estate has some bond-like features in the form of relatively predictable payment streams that are expected to be received far into the future. One way of approximating the value of a real estate investment is to calculate the discounted present value of rent less expenses expected to be received over the lifetime of the property — implying a stream of future cash flows. Additional sensitivity to interest rates results from the fact that financing is generally involved in transactions, straining buyers in higher interest rate environments. Though real estate may exhibit some bond-like features, investors generally expect real estate to provide higher returns

than fixed income due to the risk and illiquidity involved. Therefore, it's worthy of potential LDI hybrid consideration because it has the potential to offer both positive correlation and excess investment performance relative to the liability index proxies.

Considering historical performance, the correlation table in the “Initial observations” section established that the correlation between real estate¹⁵ and liability index proxies has historically been less strong than that of investment grade debt. The type of real estate investment appears to matter though. The REIT Index has displayed a much higher overall historical correlation with pension liabilities than the property index tracking private real estate performance. Also of note, since 2015, the REIT Index liability correlation has remained elevated consistently, which is similar to what was observed for equities. This might suggest that there's a systemic driver in recent market cycles causing more correlation across several asset classes. Although equities have exhibited a higher liability correlation in the most recent years, when looking at the full performance period, the REIT Index has been more correlated to pension liabilities overall.

Rolling Correlations: Real Estate with a Pension Liability

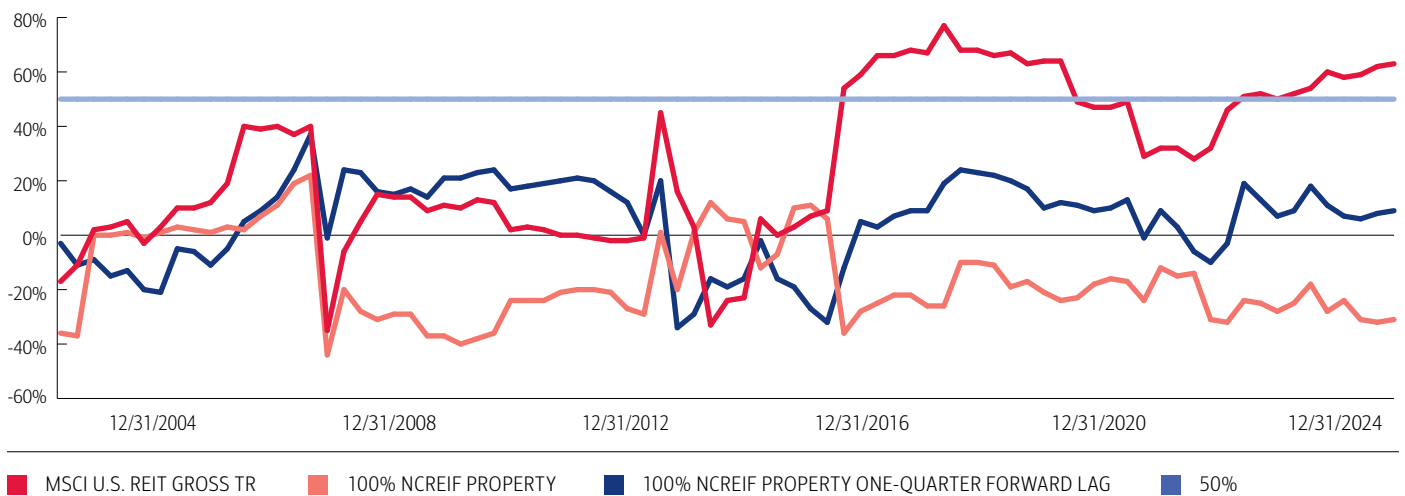


Figure 11: Various real estate index rolling correlations with the Liability AA — Medium index proxy. Past performance is no guarantee of future results. Source: Bank of America, 12/31/2024.

¹⁵ The real estate indexes included and referenced for the purpose of this analysis are taken as the 100% NCREIF Property (the property) index and MSCI US REIT Gross TR (the REIT) index. For more on the real estate indexes observed, see the appendix index definitions.

Property index returns have been negatively correlated with the liability index proxy in recent years and haven't exhibited strong correlation with the liability index proxy generally. However, the property index does exhibit stronger correlations if measured with a one-quarter forward lag.¹⁶ This is likely attributable to the mark-to-market nature of many property value assessments — which may reflect smoothed valuations within certain performance periods. The effects of the quarter lag on rolling correlations are observable in Figure 11.

This is noted as it's important to better understand property-liability performance, but it does little to change the non-lagged results for two important reasons. First,

while the forward lag rolling correlations are stronger and generally more aligned with non-lagged REIT correlations, they're still significantly weaker than traditional-LDI asset correlations; and second, lagged performance is of limited value when it comes to hedging the liability on a real-time basis.

When looking at surplus returns, results appear to be somewhere between those of investment grade debt and equity indexes. That is, real estate tends to return more than investment grade fixed income (and by extension the liability index proxies) but less than equities over long periods of time. However, real estate returns are also more volatile than fixed income, though with less severe historically observed negative surpluses than equities.

Rolling Surplus Returns: Real Estate over a Pension Liability

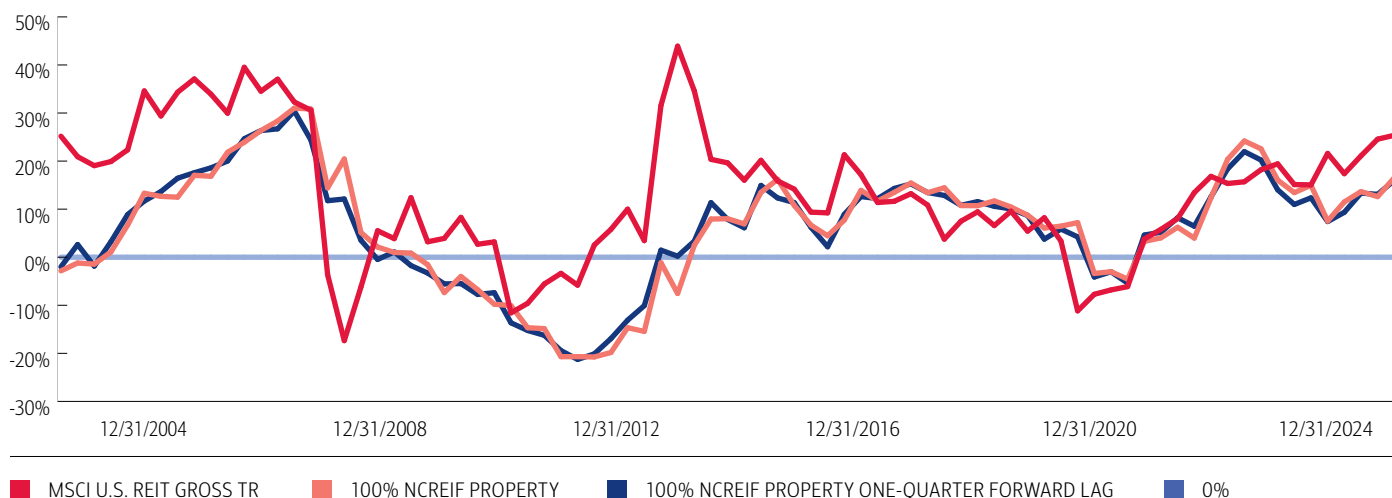


Figure 12: Various real estate index rolling surplus returns over the Liability AA — Medium index proxy. Past performance is no guarantee of future results. Source: Bank of America, 12/31/2024.

Perhaps unsurprisingly real estate indexes (adjusting for lags where appropriate) offer historical correlation and surplus statistics that place them somewhere between equities and investment grade debt. For plans seeking a tight liability hedge, the correlation between REITs and the liability index proxies may be too weak to include them in an LDI portfolio. However, real estate has provided a historical blend of correlation and surplus returns relative to the liability that neither investment grade fixed income nor public equities can provide alone.

To uncover more about the use-cases when real estate may be an effective LDI hybrid, let's next consider historical tracking error and least squares statistics. Tracking error and least squares are statistical measures that capture the standard deviation and the squared value of quarterly return differences relative to pension liability changes respectively. More simply, both measures essentially punish large deviations between historical asset returns and liability returns over a given quarter. Both measures are provided for each asset class in the following tables.

¹⁶ One-quarter forward lag performance is computed by utilizing future quarter performance in the current period. (See mathematical definitions in the appendix for a more precise definition.)

Additional Statistical Metrics Relative to a Pension Liability by Asset Class

Quarterly data: 1/1/2015–12/31/2024

Index	Tracking Error	Least Squares
ICE BofA 15+ Year U.S. Corporate Index	1.6%	1.1%
ICE BofA U.S. Corporate Index	2.6%	2.7%
ICE BofA U.S. Broad Market Index	3.2%	4.1%
ICE BofA U.S. Treasury Index	3.7%	5.4%
S&P 500 TR	7.2%	24.3%
Russell 1000 Value TR	7.9%	26.3%
Russell 1000 Growth TR	7.9%	31.2%
Russell 2000 TR	10.3%	43.8%
Bloomberg Commodity Index Total Return	7.0%	20.7%
MSCI U.S. REIT Gross TR	6.4%	17.1%
100% NCREIF Property	5.7%	13.4%
100% NCREIF Property one-quarter forward lag	4.8%	9.8%

Figure 13: Asset Class tracking error and least squares statistics were computed relative to the Liability AA — Medium index proxy. See the appendix for mathematical definitions. Past performance is no guarantee of future results. Source: Bank of America, 12/31/2024.

As expected, investment grade debt assets have lower tracking error and least squares statistics, whereas equities display higher values. In the earlier analysis, it was observed that the REIT Index held a correlation and surplus return edge over the property index. Yet, the property index outperformed the REIT Index on a tracking error and least squares statistics basis and performed surprisingly well relative to all non-fixed-income indexes examined. The data suggests that while REIT performance has been relatively correlated with a liability index proxy, it occasionally exhibited wild differences in returns (such as in 2008). In contrast, the property index sometimes moved opposite the liability but generally remained within a similar return range over the examined period.

This additional analysis supports the categorization of real estate broadly as an LDI hybrid. The fact that real estate exhibits both hedging and return surplus characteristics when compared to the liability puts the asset class in a unique position where it's neither traditional LDI nor non-LDI. That said, the correlations and surpluses can be unpredictable, and manager know-how as well as experience will likely be a significant factor in real estate selection within any LDI portfolio.

High yield debt

High yield debt is an asset class that falls within fixed income broadly, but it distinctly features low credit quality and wide credit spreads, implying that the probability of default is meaningful. These bonds are priced at a discount given the associated risk, and the returns tend to be driven more by changes in perceived credit quality and associated spreads rather than changes in risk-free interest rates. Pension liabilities are discounted at rates that include both risk-free rates and credit spreads, so it's reasonable to expect some correlation with pension liabilities. Indeed, high yield debt has historically often been correlated with pension liabilities, though there have been periods of negative correlation as well.

Rolling Correlations: High Yield Debt with a Pension Liability

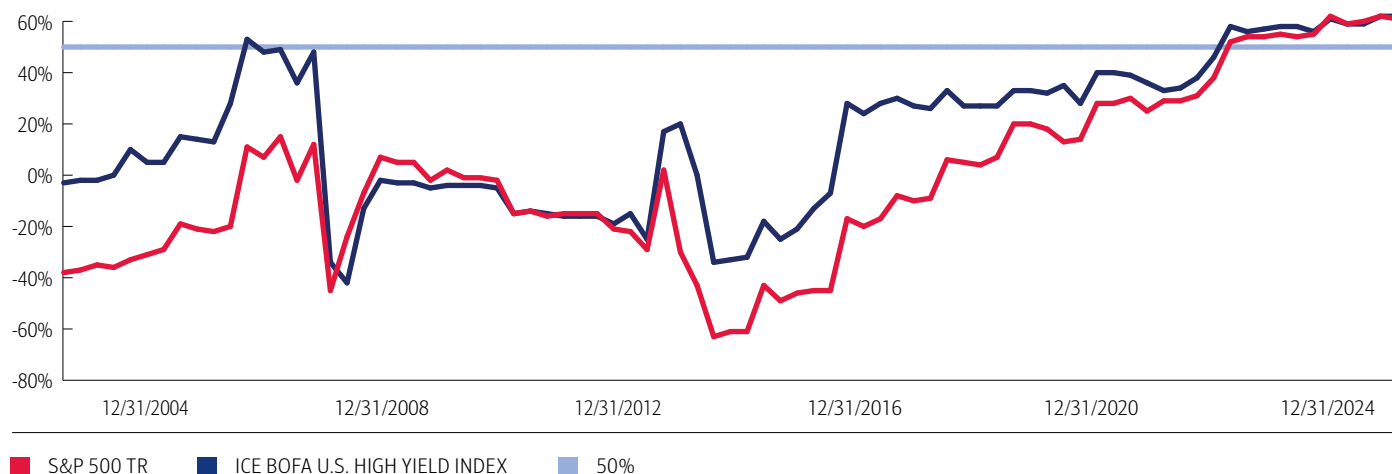


Figure 14: ICE BofA High Yield Index and S&P 500 TR rolling correlations with the Liability AA—Medium Index proxy. Past performance is no guarantee of future results. Source: Bank of America, 12/31/2024.

One interesting observation is that the high yield index rolling liability correlation graph closely resembles the equity rolling correlation plots depicted in Figure 9. To see this, consider the above exhibit of rolling liability correlation for both the S&P 500 and the ICE BofA U.S. High Yield Index. High yield bonds and equities are themselves highly correlated. High yield spreads tend to tighten in good economic times when equities are rallying and to widen when fears or economic downturns impact financial markets more broadly. Importantly, though, high yield debt liability correlation is equal to or greater than that of the S&P 500 during nearly every observation period.

While high yield debt has often offered improved historical liability correlation relative to equities, that increased correlation historically has come at the price of lower historical surplus returns. In terms of returns exceeding liability performance, the historical upside isn't as high as equities, but the downside magnitude is slightly less in periods where a negative surplus exists. Like real estate, high yield debt appears to offer mildly positive correlations

and surplus returns relative to the liability index proxies. These features support the categorization of high yield debt as an LDI hybrid. Like the use-cases for real estate, the applicability of high yield debt within an LDI portfolio may be episodic or dependent on plan-specific circumstances.

For example, one specific role for high yield debt in an LDI portfolio may be as a compliment to Treasury STRIPS. Treasury STRIPS are often used to hedge ultra-long duration pension liabilities because they have very long durations themselves. However, a shortcoming of Treasury STRIPS in this context is that, with no exposure to credit risk, they don't typically provide yields as large as pension discount rates or hedge the credit spread risk embedded in pension liabilities. High yield debt has very concentrated exposure to credit spreads and, as the name implies, higher yields. Therefore, a small allocation to high yield debt may theoretically improve some of the hedging characteristics of an LDI portfolio concentrated in Treasury STRIPS.

Rolling Surplus Returns: High Yield Debt over a Pension Liability

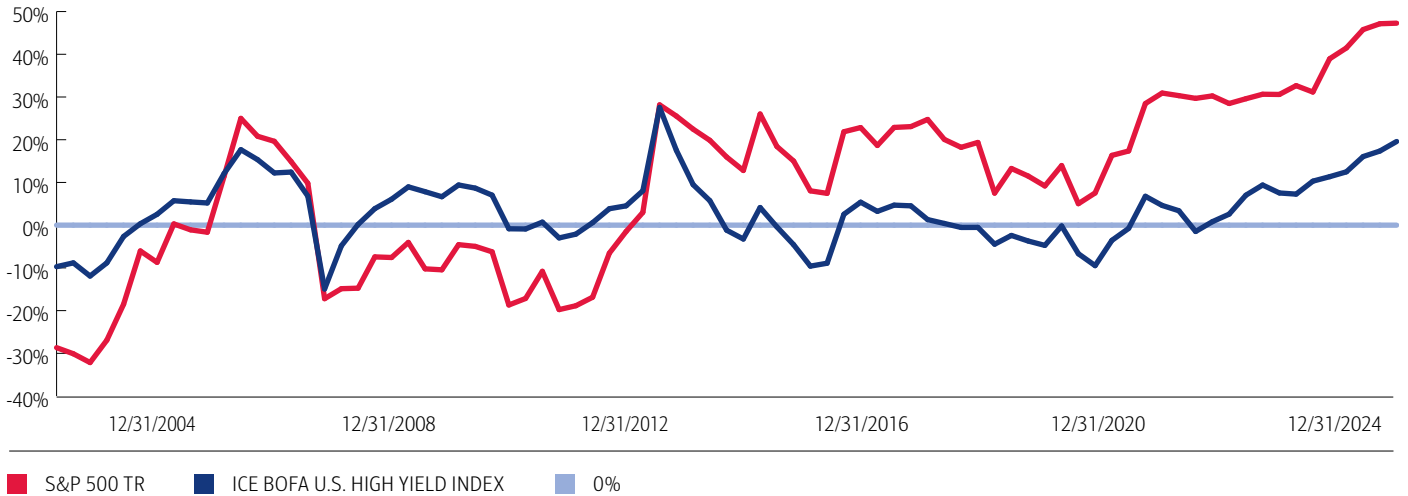


Figure 15: ICE BofA High Yield Index, ICE BofA 15+ Year U.S. Corporate Index and S&P 500 TR rolling surplus returns over the Liability AA – Medium index proxy. Past performance is no guarantee of future results. Source: Bank of America, 12/31/2024.

Given the fair correlation, adequate historical surplus returns and embedded bond characteristics, high yield debt may be categorized as an LDI hybrid. It could be considered for use in an LDI portfolio for plan sponsors that understand and accept the associated risks. This would theoretically allow the LDI portfolio a slight return surplus upside while sacrificing a potentially manageable level of correlation. However, it's important sponsors know that an LDI portfolio composed of securities from asset classes other than U.S. investment grade debt may experience a greater degree of funded status volatility than anticipated.¹⁷

¹⁷ Supported by the historical low levels of rolling correlation for all asset classes other than investment grade debt. While periods of solid correlation exist, no evidence exists to suggest that this would hold in more volatile market environments.

Key takeaways

Even within an LDI strategy that incorporates LDI hybrids, traditional LDI assets will likely make up the bulk of the LDI portfolio — for the simple reason that no other asset class provides a comparable liability correlation and hedge.

Looking beyond investment grade debt, additional asset classes may be able to play a role in LDI portfolios depending on plan sponsor objectives. Real estate¹⁸ has offered historical excess returns over a hypothetical liability with compelling tracking error and least squares statistics. Additionally, high yield debt offers a combination of surplus return potential and hedging benefits — especially with regard to credit spreads. If a plan sponsor wishes to utilize LDI hybrids in an LDI strategy, real estate and high yield debt may be viable options for enhancing returns without accepting the same level of downside risk associated with equities. It's imperative plan sponsors understand that this doesn't create a free surplus. Rather, potential excess long-term returns are coupled with greater funded status volatility risk.

One major limitation of this research is that it fails to capture actively managed customized LDI portfolio performance and hard-to-obtain index data. The examination of index data is a useful starting point, but it should be noted that this analysis doesn't consider the effects of illiquid and private investments, any tactical investment strategies utilized, derivative hedging strategies, or any hypothetical superior due diligence employed to potentially screen underperforming assets from the broad indexes analyzed.¹⁹

For an LDI portfolio incorporating anything other than traditional LDI asset classes, there's a worst-case scenario. Such an instance would be a situation where the liability grows as interest rates fall, but LDI hybrid assets underperform. In this case, LDI assets may decline in value, and the liability's effect on funded status would be amplified. (When looking at real estate, this scenario occurred in 2008 — both for property and REIT Indexes.)²⁰

Taking this data into account and establishing a framework for LDI implementation is a nuanced task for any plan sponsor. There are two key points to take away from this discussion. The first is that no asset class has proven more correlated with hypothetical liability index proxies than investment grade debt. The other is that instances may exist where incorporating other assets in an LDI portfolio could be a viable strategy, but plan sponsors should be aware of the rationale behind such strategies and their inherent risks.

In many ways this reduces to a risk-reward conversation, the question in this instance being, "Within the investment portfolio, where does the risk go?" The answer will be based on the interpretation of an LDI strategy within the context of a sponsor's unique pension plan. Before making any decisions, plan sponsors should review their organizational risk, the information presented within, and any other pertinent factors in order to best implement a robust LDI strategy.

¹⁸ Referring to a strategic mix of property and REIT asset classes.

¹⁹ The exclusion of private credit is a notable limitation since it arguably falls under the broad umbrella of fixed income.

²⁰ See "Asset class performance in various time periods" in the appendix for details.

Appendix

Asset class index definitions

S&P 500 TR: The S&P 500 Index covers the 500 largest companies that are in the United States. These companies can vary across various sectors. The S&P 500 is one of the most important indexes in the world as it widely tracks how the U.S. stock market is performing. The S&P 500 has had several major drawdowns that have been greater than 40% during recessionary periods, including in 1974, 2002 and 2009.

Russell 1000 Value TR: The Russell 1000 Value Index is an index that tracks large cap value stocks. This benchmark is important for investors who might tilt their investments toward large cap value. Value stocks, in comparison to growth stocks, are considered companies with a stable cash flow and a more mature business model. The Russell 1000 Value historically has smaller drawdowns compared to the S&P 500, but lower performance as well.

Russell 1000 Growth TR: The Russell 1000 Growth Index is an index that tracks large cap growth stocks. This benchmark is important for investors who might tilt their investments toward large cap growth. Growth stocks, in comparison to value stocks, are considered companies with more growth potential and a higher risk profile. The Russell 1000 Growth historically has larger drawdowns compared to the S&P 500, but higher performance as well.

Russell 2000 TR: The Russell 2000 tracks the roughly 2000 securities that are considered to be U.S. small cap companies. The Russell 2000 serves as an important benchmark when investors want to track their small cap performances versus other-sized companies. The Russell 2000 tends to have a larger standard deviation in comparison to the S&P 500. However, it also tends to yield larger returns in positive market environments.

Bloomberg Commodity Index Total Return: The Bloomberg Commodity Index is calculated on an excess return basis and comprises futures contracts on 22 physical commodities. It reflects the return of underlying commodity futures price movements.

100% NCREIF Property: Produced quarterly, the NCREIF Property Index (NPI) shows real estate performance returns using data submitted by its Data Contributor Members. The NPI is a quarterly, unleveraged composite total return for private commercial real estate properties held for investment purposes only. All properties in the NPI have been acquired, at least in part, on behalf of tax-exempt institutional investors and held in a fiduciary environment.

MSCI U.S. REIT Gross TR: The MSCI U.S. REIT Index is a free float-adjusted market capitalization weighted index that comprises equity REITs. The index is based on the MSCI USA Investable Market Index (IMI), its parent index, which captures the large, mid and small cap segments of the USA market. With 118 constituents, it represents about 99% of the U.S. REIT universe, and securities are classified under the Equity REITs Industry (under the Real Estate Sector) according to the U.S. Industry Classification Standard (GICS®), have core real estate exposure (that is, only selected Specialized REITs are eligible) and carry REIT tax status.

A note on real estate indexes: Real estate investments can come in a variety of different forms, so defining the indexes being considered here is important to level set. The NCREIF Property Index consists of commercial properties acquired, at least in part, on behalf of tax-exempt entities. The underlying properties include apartments, hotels, industrial, office and retail properties. It's a private real estate index, meaning it's based on direct investment in managed operating real estate. The REIT Index, in contrast, consists of real estate investment trusts. The underlying property types can be quite similar. The important distinction here is that REITs are publicly traded on exchanges. An investment in a REIT is actually an investment in the equity of a company that manages real estate. Because REITs are publicly traded, they're considerably more liquid than private real estate investments. This trading may also lead to more volatility in their pricing and more correlation with public equities, weakening their potential as an equity diversifier, though arguably, private real estate may be just as volatile but without the price changes being observable.

ICE BofA U.S. High Yield Index: The ICE BofA U.S. High Yield Index tracks the performance of U.S.-dollar-denominated, below-investment-grade-rated corporate debt publicly issued in the U.S. domestic market. To qualify for inclusion in the index, securities must have a below-investment-grade rating (based on an average of Moody's, S&P and Fitch) and an investment-grade-rated country of risk (based on an average of Moody's, S&P and Fitch foreign currency long-term sovereign debt ratings). Each security must have greater than one year of remaining maturity, a fixed coupon schedule and a minimum amount outstanding of \$100 million.

ICE BofA U.S. Corporate Index: The ICE BofA U.S. Corporate Index tracks the performance of U.S.-dollar-denominated, below-investment-grade-rated corporate debt publicly issued in the U.S. domestic market. To qualify for inclusion in the index, securities must have an investment grade rating (based on an average of Moody's, S&P and Fitch) and an investment-grade-rated country of risk (based on an average of Moody's, S&P and Fitch foreign currency long-term sovereign debt ratings).

ICE BofA U.S. Broad Market Index: The ICE BofA Global Broad Market Index tracks the performance of investment grade debt publicly issued in the major domestic and eurobond markets, including sovereign, quasi-government, corporate, securitized and collateralized securities.

ICE BofA U.S. Treasury Bill Index: The ICE BofA U.S. Treasury Bill Index measures the performance of U.S.-dollar-denominated U.S. Treasury bills publicly issued in the U.S. domestic market.

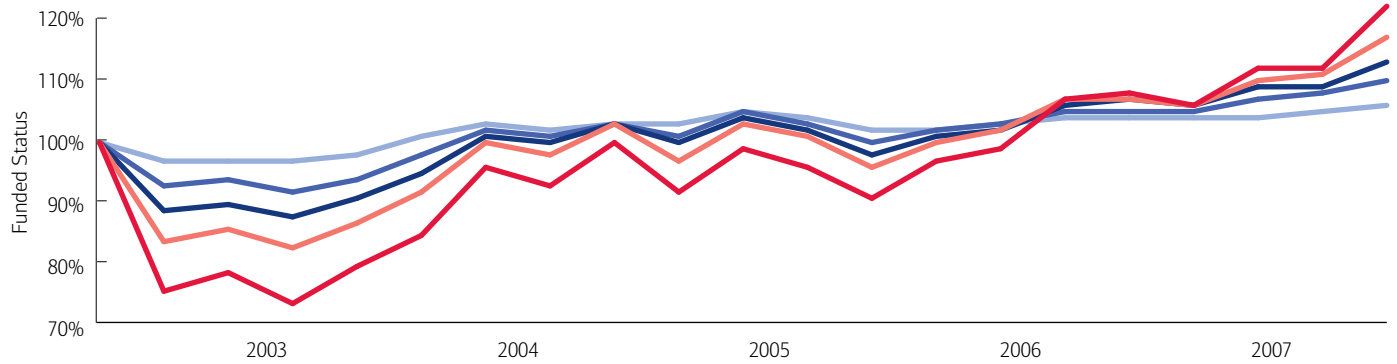
ICE BofA 15+ Year U.S. Corporate Index: The ICE BofA 15+ Year U.S. Corporate Index tracks the performance of U.S.-dollar-denominated investment grade corporate debt publicly issued in the U.S. domestic market with a remaining term to final maturity greater than 15 years.

Hypothetical effects of LDI: Illustrative blended return seeking and LDI portfolio examples

The following charts illustrate rolling funded status, minimum funded status and funded status standard deviation over various time periods. In all periods, the LDI-forward portfolios performed with the lowest standard deviation and highest minimum funded status over the period.

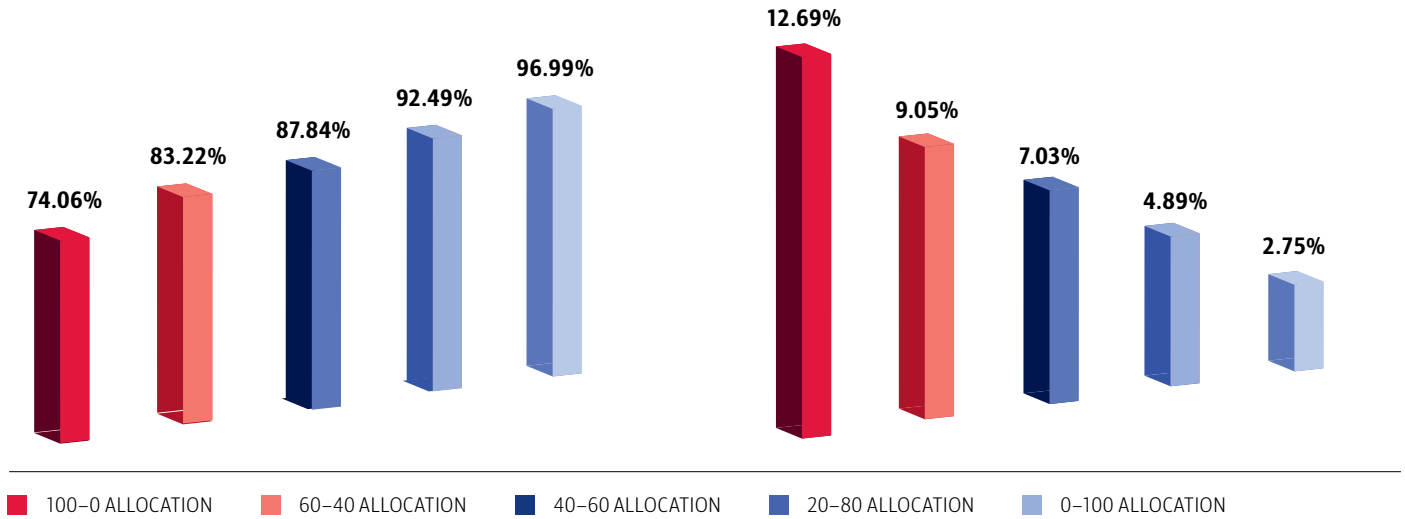
Illustrative Funded Status Over Time

06/30/2002–06/30/2007



Minimum Funded Status Over Period

Funded Status Standard Deviation Over Period

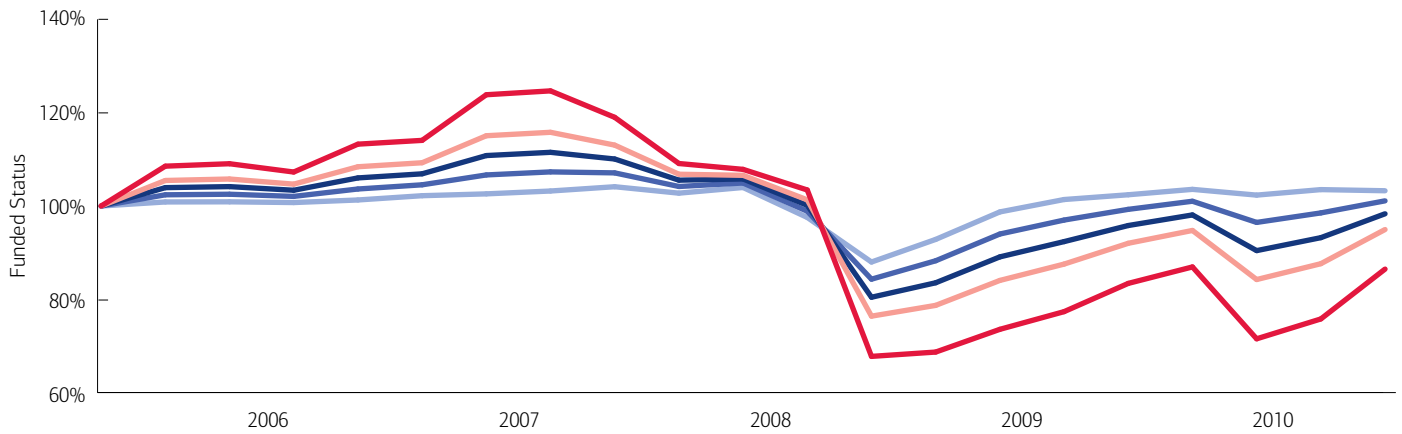


Figures 16, 17 and 18: The charts above illustrate funded status vs. time, minimum funded status and funded status standard deviation over the labeled time period. All three charts reference a hypothetical pension plan invested x% — y% in return-seeking and LDI investments respectively. For simplicity, the return-seeking assets were taken as S&P 500 performance, and the LDI performance was assumed to be the ICE BofA 15+ Year U.S. Corporate Index. These were chosen for illustrative simplicity. For further simplicity, the plan is assumed to be frozen with no benefit payments, contributions or any other expenses over the period. Past performance is no guarantee of future results.

Source: Bank of America, 12/31/2024.

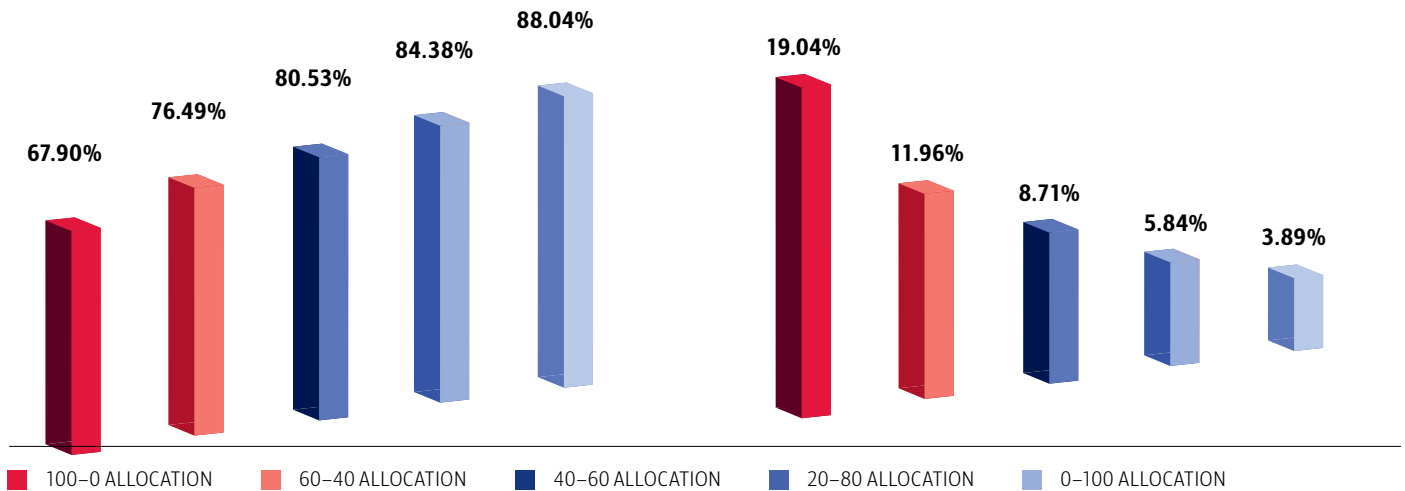
Illustrative Funded Status Over Time

01/01/2006–12/31/2010



Minimum Funded Status Over Period

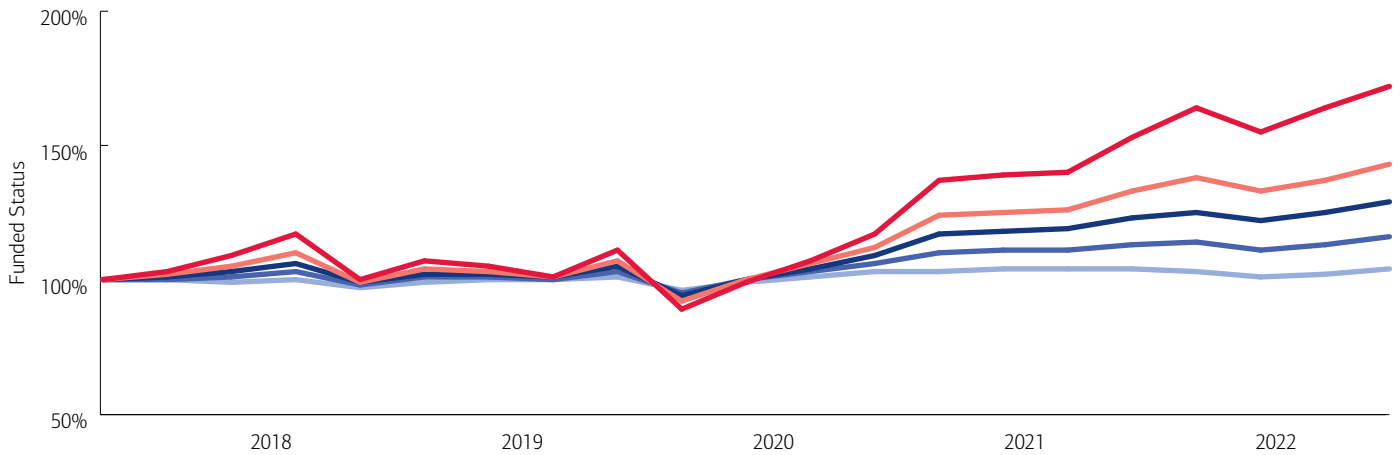
Funded Status Standard Deviation Over Period



Figures 19, 20 and 21: The charts above illustrate funded status vs. time, minimum funded status and funded status standard deviation over the labeled time period. All three charts reference a hypothetical pension plan invested x% — y% in return-seeking and LDI investments respectively. For simplicity, the return-seeking assets were taken as S&P 500 performance, and the LDI performance was assumed to be the ICE BofA 15+ Year U.S. Corporate Index. These were chosen for illustrative simplicity. For further simplicity, the plan is assumed to be frozen with no benefit payments, contributions or any other expenses over the period. Past performance is no guarantee of future results.
Source: Bank of America, 12/31/2024.

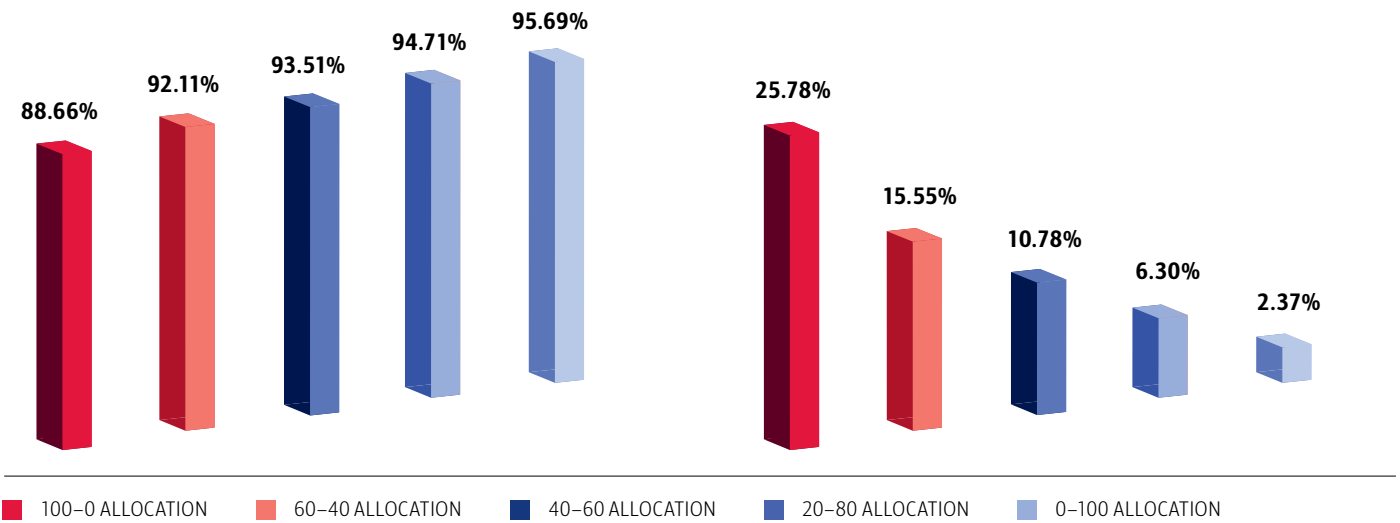
Illustrative Funded Status Over Time

01/01/2018–12/31/2022



Minimum Funded Status Over Period

Funded Status Standard Deviation Over Period



Figures 22, 23 and 24: The charts above illustrate funded status vs. time, minimum funded status and funded status standard deviation over the labeled time period. All three charts reference a hypothetical pension plan invested x% — y% in return-seeking and LDI investments respectively. For simplicity, the return-seeking assets were taken as S&P 500 performance, and the LDI performance was assumed to be the ICE BofA 15+ Year U.S. Corporate Index. These were chosen for illustrative simplicity. For further simplicity, the plan is assumed to be frozen with no benefit payments, contributions or any other expenses over the period. Past performance is no guarantee of future results.

Source: Bank of America, 12/31/2024.

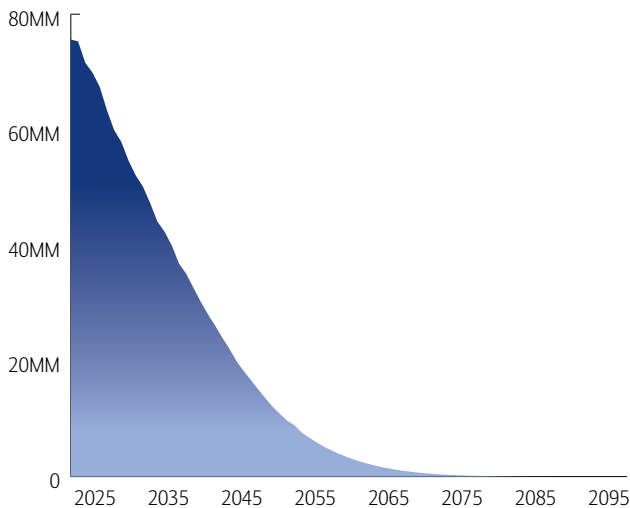
Liability index proxy computation

Index measuring a plan liability: The liability index proxy used for this analysis was constructed from hypothetical pension cash flows and changes in the ICE BofA AA1-AA3 U.S. Corporate Index yield curve over the performance period. Other cash flow streams (accounting for different pension plan cash flow profiles) and the ICE BofA AAA-A3 U.S. Corporate Index yield curve were explored as well, and none of the alternative indexes yielded materially different

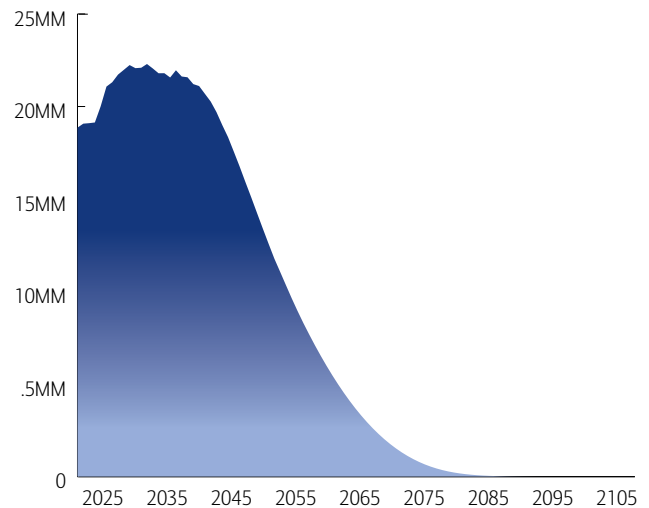
results. Thus, the “liability” index (AA—Medium) proxy was taken as representative of a typical pension plan liability. The A-AAA Medium liability index proxy is also occasionally referenced to indicate that slight differences in statistics exist when a different yield curve is referenced, but no such changes affect the conclusions outlined within the paper.

The liability cash flow profiles analyzed in this paper are shown below.

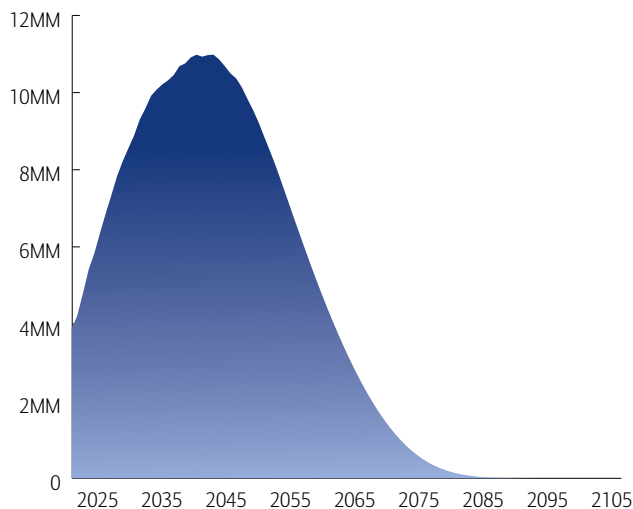
Liability Cash Flow Profile — Short



Liability Cash Flow Profile — Medium



Liability Cash Flow Profile — Long



It should be noted that the liability index proxy is similar to the ICE BofA Average U.S. Pension Plan AAA-A Corporate Curve Discounted Index, which is a subset of the ICE BofA U.S. Corporate Master Index and tracks the performance of U.S.-dollar-denominated, investment-grade-rated corporate debt publicly issued in the U.S. domestic market. This subset includes all securities with a given investment grade rating AAA. Correlation statistics for the liability index proxy and ICE BofA Average U.S. Pension Plan AAA-A Corporate Curve Discounted Index are shown in Figure 28.

Figures 25, 26 and 27: These charts illustrate the cash flows used for variously sized pension plan profiles utilized in the construction of the short, medium and long liability index proxies used throughout this analysis.

Source: Bank of America, 12/31/2024

Pension Plan Index Return Correlation with Pension Liability Index Proxies

Quarterly data: 1/1/2015–12/31/2024

Index	Liability AA — Medium	Liability A-AAA — Medium
ICE BofA Average U.S. Pension Plan AAA-A Corporate Curve Discounted Index	99.5%	99.7%

Figure 28: Ten-year correlation between the ICE BofA Average U.S. Pension Plan AAA-A Corporate Curve Discounted Index and the Liability AA — Medium and Liability A-AAA — Medium index proxies respectively. Past performance is no guarantee of future results. Source: Bank of America, 12/31/2024.

Rolling Correlation: ICE BofA Average U.S. Pension Plan AAA-A Corporate Curve Discounted Index with a Pension Liability

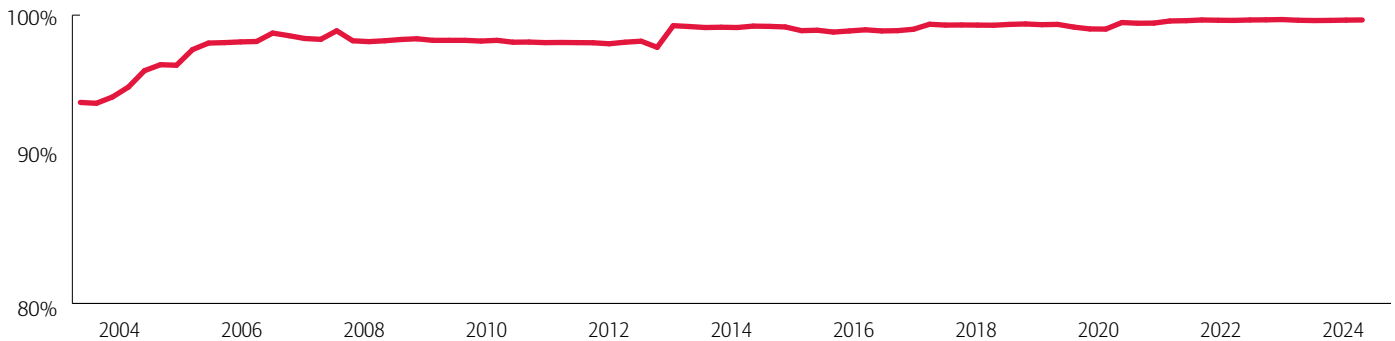


Figure 29: Rolling 20-quarter ICE BofA Average U.S. Pension Plan AAA-A Corporate Curve Discounted Index and Liability AA — Medium index proxy return correlation. Past performance is no guarantee of future results. Source: Bank of America, 12/31/2024.

Index correlations during the GFC

The GFC marked a “perfect storm” for pension plans, as both equity values and interest rates fell. The fact that investment grade debt indexes experienced reduced rolling correlation during this period demonstrates that no analyzed asset class is immune to periods of poor performance or low liability correlation. However, investment grade debt has historically outperformed all other asset classes, on a correlation basis, over all examined time periods. To see this during the GFC, take a look at the below chart.

Rolling Correlations: Various Asset Classes with a Pension Liability

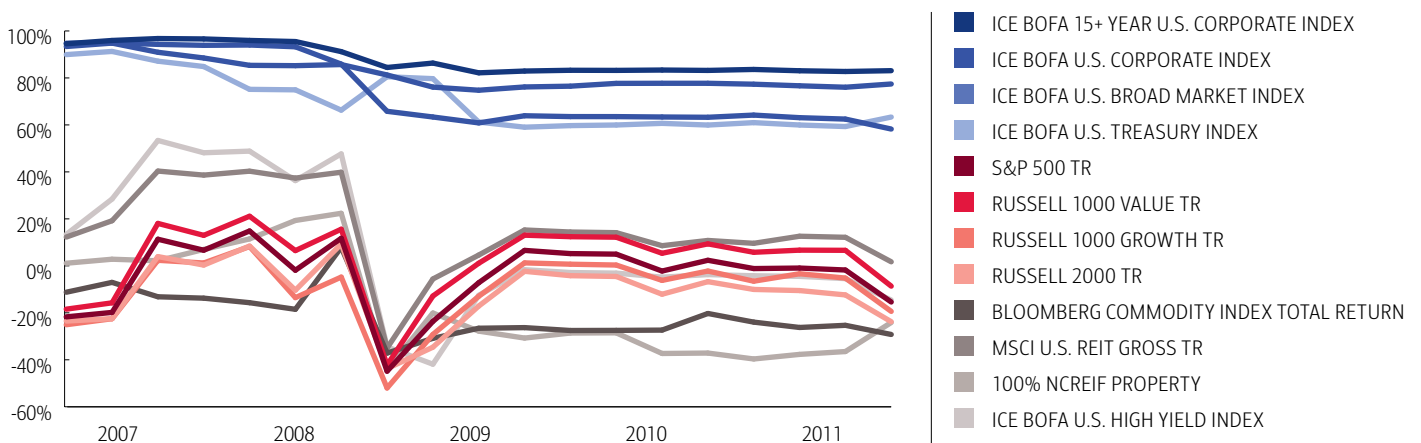


Figure 30: This chart examines the 20-quarter rolling correlations of all asset class indexes specifically analyzed. The rolling period starting dates run from 3/1/2007 to 12/31/2011. All indexes exhibited a dip in rolling correlation at some point in the timeline, but the dips for the investment grade debt indexes were less dramatic. Past performance is no guarantee of future results. Source: Bank of America, 12/31/2024.

Effect of period length on statistical analysis

Rolling Correlations: Investment Grade Debt with a Pension Liability — Shorter Rolling Period

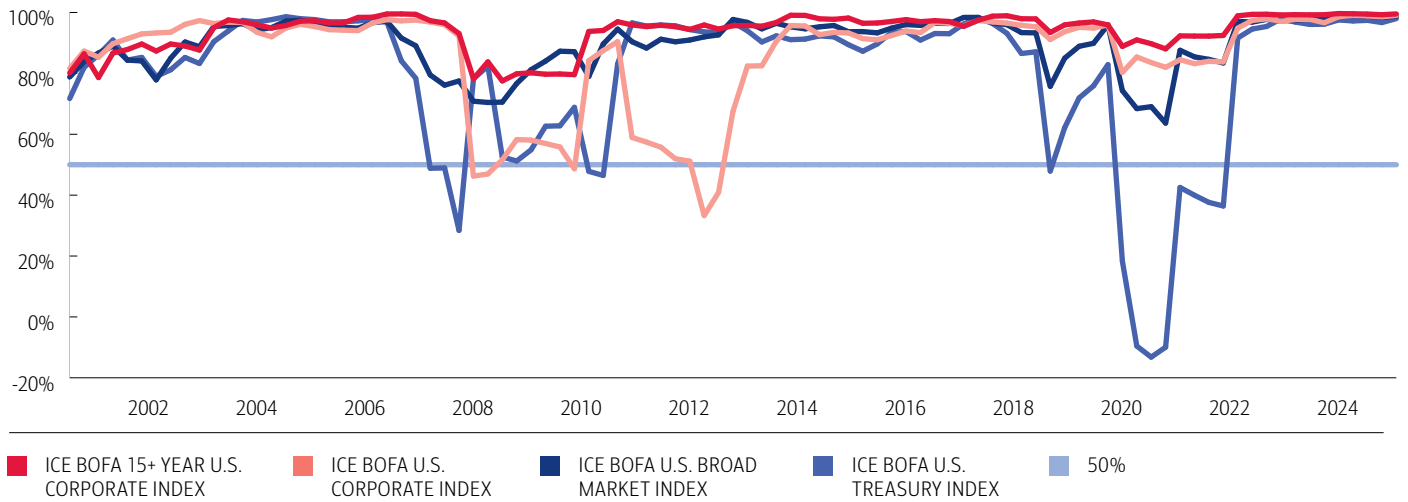


Figure 31: As might be expected, decreasing the rolling correlation period length generally decreases the consistency of the rolling correlation value through time. As seen in the figure, decreasing the rolling correlation period to eight quarters significantly alters the rolling correlation graphs for investment grade debt (when compared to Figure 7). Rolling correlation over longer periods generally smooths correlations, so the 20-quarter rolling charts might not show strong evidence of short-term dips in correlation that quickly correct. In this instance, increasing the correlation period from eight to 20 quarters (referencing Figures 31 and 7, respectively) spreads the short-term rolling correlation dips out over longer time periods — thus making the dips less severe. Past performance is no guarantee of future results. Source: Bank of America, 12/31/2024.

Rolling Correlations: Various Asset Classes with a Pension Liability — Shorter Rolling Period

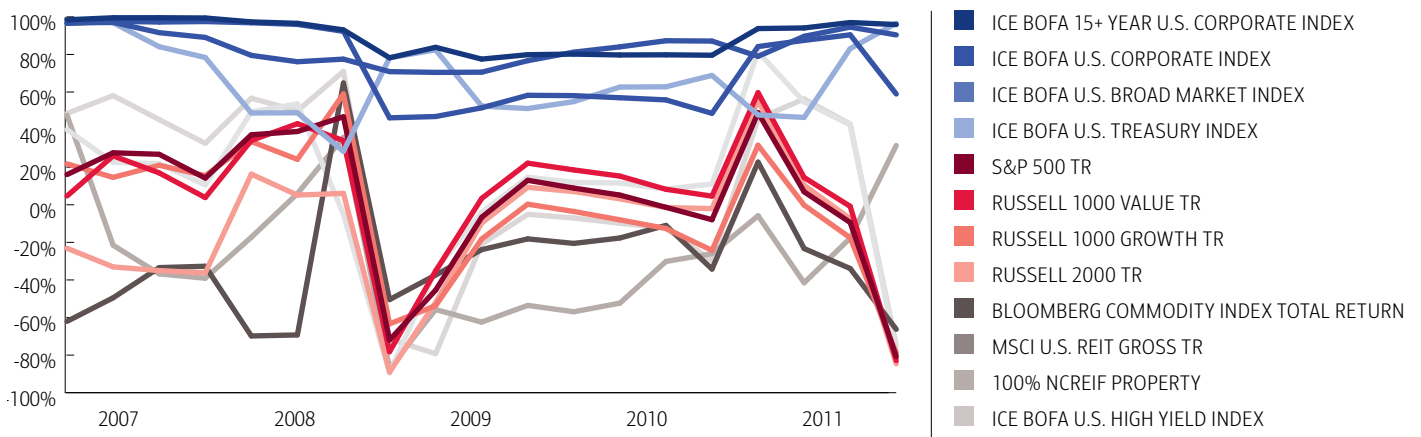


Figure 32: This chart is identical to Figure 30 with one exception: The rolling period is shortened to eight quarters from 20. The resulting graph features a higher sensitivity to individual quarter data (since the period is shorter and each quarter is a larger portion of the total time frame). As a result, the line graph features more noise for all indexes. Note that the GFC was a particularly volatile and unusual period, so differences in the eight- and 20-quarter rolling correlation charts are particularly apparent. Past performance is no guarantee of future results. Source: Bank of America, 12/31/2024.

Bloomberg Commodity Index Total Return rolling surplus chart

The Bloomberg Commodity Index Total Return rolling surplus chart further confirms the classification as a non-LDI asset class. Low rolling surplus and correlation, in addition to low tracking error and least squares statistics, allow for a clear classification, at least in the case of this particular commodity index.

Rolling Surplus Returns: Commodities over a Pension Liability

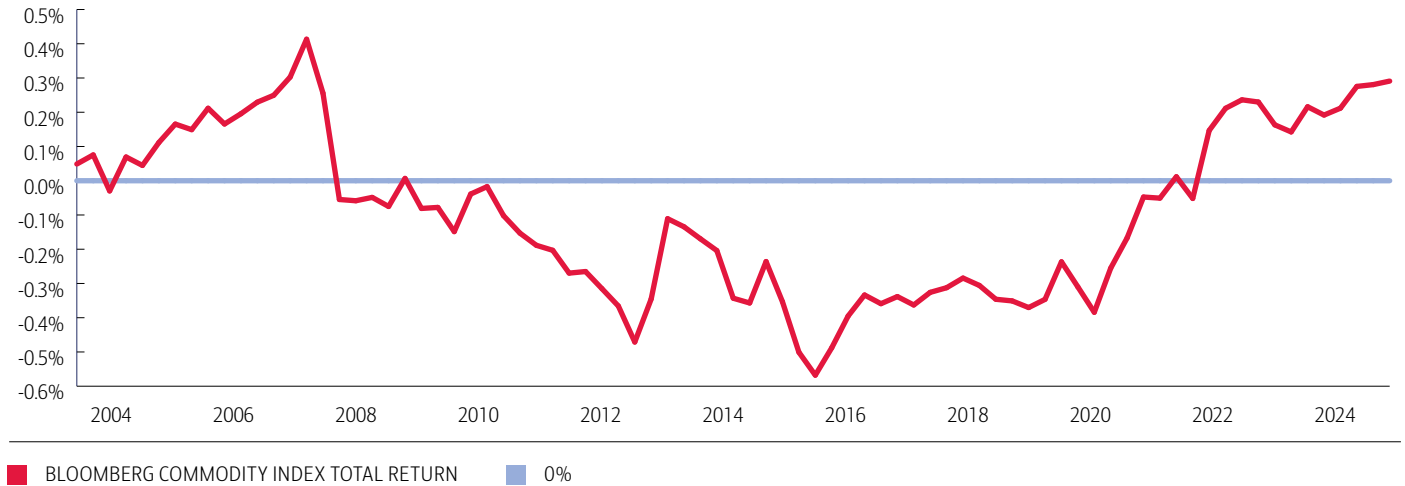


Figure 33: Bloomberg Commodity Index Total Return rolling surplus return over the Liability AA—Medium index proxy. Past performance is no guarantee of future results. Source: Bank of America, 12/31/2024.

Asset class performance in various time periods

Rolling Correlations: Various Asset Classes with a Pension Liability

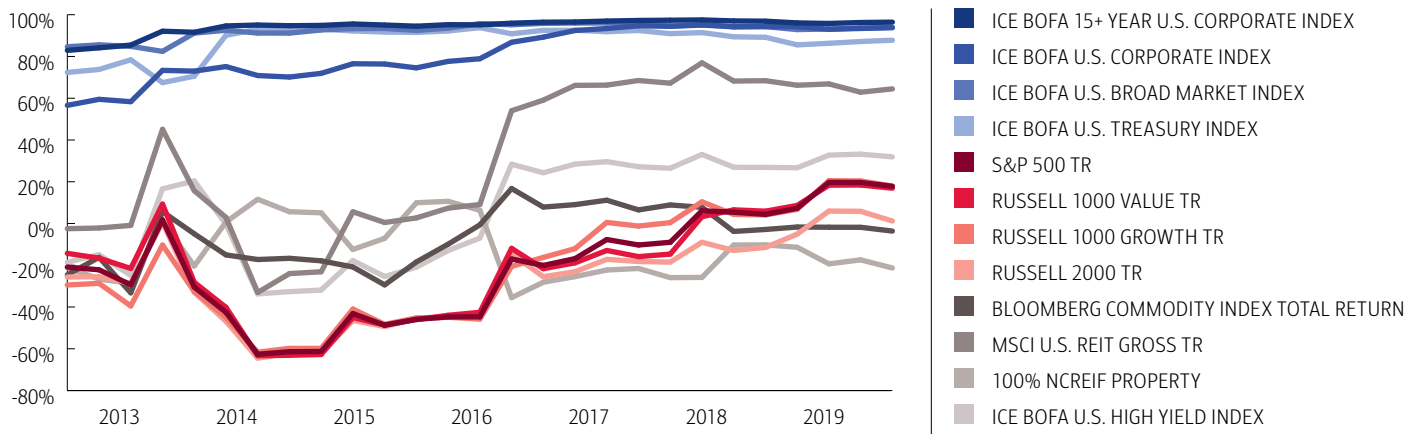


Figure 34: Rolling 20-quarter liability AA—Medium correlations post GFC for all indexes, 1/1/2013–12/31/2019. Past performance is no guarantee of future results. Source: Bank of America, 12/31/2024.

Rolling Correlations: Various Asset Classes with a Pension Liability

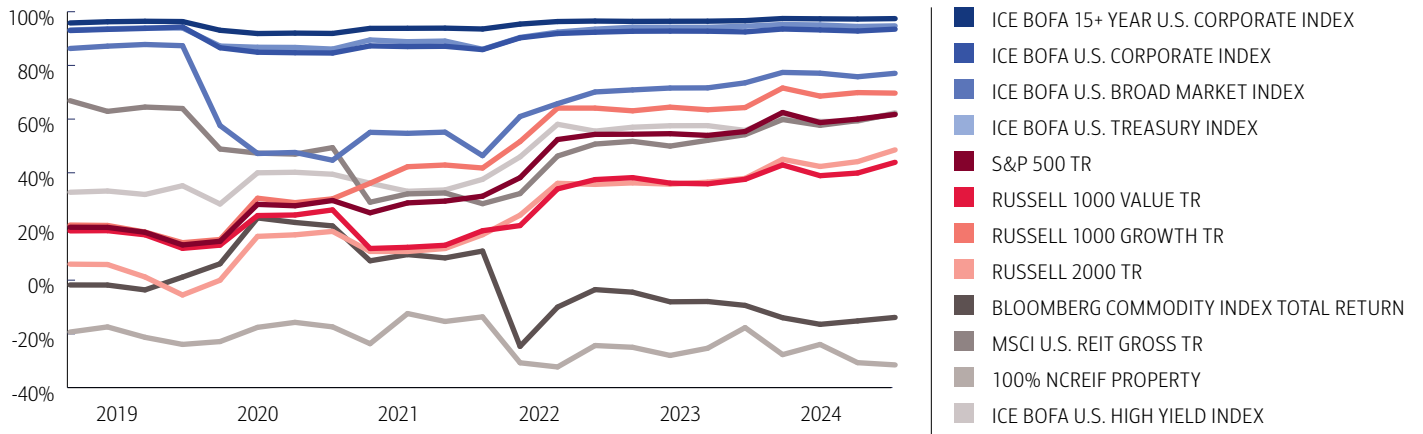


Figure 35: Rolling 20-quarter liability AA — Medium correlations for all indexes. 1/1/2019 –12/31/2024.
 Past performance is no guarantee of future results.
 Source: Bank of America, 12/31/2024.

Glossary

Correlation(x,y) — The covariance between two variables divided by the product of individual variable standard deviations.

Covariance(x,y) — A measure of joint variability in two variables.

Discount rate (or interest rate) — The rate used to discount expected future benefit payments to plan participants for the purpose of determining the present value of the plan liability.

Duration — A measure of the plan's liability sensitivity to changes in interest rates based on a long-term projection of the plan's expected benefit payments. Specifically, it's the percent change in the liability due to a 1% change in the discount rate used to measure the liability; for example, for a plan with a duration of 14, the liability would be expected to increase 14% when the discount rate drops 1%.

Expense — The amount of pension cost recognized on an employer's financial statements under GAAP accounting.

Funded status — The value of the plan assets divided by the plan liabilities, expressed as a percentage. The ERISA funded status is used to determine annual contribution requirements; the PBO funded status is used for financial statement purposes under GAAP accounting.

Least squares(x,y) — The sum of the squared differences of all variable pairs.

Liability — The present value of future pension obligations based on valuation assumptions/methods and benefits that reflect participants' service accrued to date and projected pay. The liability is forecasted based on sensitivity analysis of interest rate changes using the plan's duration.

Liability-driven investing (LDI) — The process of strategically investing fixed income assets in such a way that changes in interest rates have the same relative impact on the fixed income assets and plan liabilities.

Present value — The value of future cash flows discounted to a single point in time using a fixed interest rate.

Projected benefit obligation (PBO) — An estimate of the present value of the future liability of an employee's pension benefit.

Standard deviation — A statistical measurement of dispersion about an average that depicts how widely the returns varied over a certain period of time.

Surplus(x,y) — The sum of the differences between two variables divided by the number of variable pairs.

Tracking error(x,y) — The standard deviation of the difference between two variables.

Further mathematical definitions

$$\text{Correlation}(x,y) = \frac{\text{Cov}(x,y)}{\sigma_x \sigma_y}$$

Covariance(x,y) = $\text{Cov}(x,y) = \sum_{i=1}^N \frac{(x_i - \bar{x})(y_i - \bar{y})}{N-1}$; where the means for the two variables x and y are denoted as \bar{x} and \bar{y} respectively.

$$\text{Least squares}(x,y) = \sum_{i=1}^N (x_i - y_i)^2$$

Standard deviation(x) = $\sigma_x = \sqrt{\frac{\sum_{i=1}^N (x_i - \bar{x})^2}{N-1}}$; where $\sum (x_i - \bar{x})^2$ is the square of the sum of the differences in observation value (x_i) and mean (\bar{x}) over the number of all observations (N).

$$\text{Surplus}(x,y) = \frac{\sum_{i=1}^N (x_i - y_i)}{N}$$

Tracking error(x,y) = standard deviation(x-y) = σ_{x-y}

(As a general convention for formulas with two parameters, index returns are used as the x variable and the liability index proxy returns are used as the y variable).

Explanation of the one-quarter forward lag described in note 17

Generally, time and performance data are organized as pairs (t, x_t), where t is the point in time and x_t is the performance data corresponding to that time period.

For a forward lag, the data is then paired as (t, x_{t+1}), where the next period's performance is paired with the current period time. When calculating the two-parameter statistics above, a pair is normally grouped as (x_i, y_i) at each time $i = t$. Under the one-month forward lag approach, the pairs entered in the computations are instead grouped as (x_{i+1}, y_i) for each time $i = t$.

(All data used in this analysis is quarterly, so each time period $t+1$ represents the subsequent quarter relative to quarter t .)

Important investment information

Investing involves risk, including the possible loss of principal. Investments in foreign securities or sector funds, including technology or real estate stocks, are subject to substantial volatility due to adverse political, economic or other developments and may carry additional risk resulting from lack of industry diversification. Funds that invest in small or mid-capitalization companies experience a greater degree of market volatility than those of large-capitalization stocks and are riskier investments. Bond funds have the same interest rate, inflation and credit risks associated with the underlying bonds owned by the fund. Generally, the value of bond funds rises when prevailing interest rates fall and falls when interest rates rise. Investing in lower-grade debt securities ("junk" bonds) may be subject to greater market fluctuations and risk of loss of income and principal than securities in higher rated categories. There are ongoing fees and expenses associated with investing. Bear in mind that higher return potential is accompanied by higher risk.

Index risk

It is not possible to invest directly in an index.

Commodities risk

Investing in commodities or the securities of companies operating in the commodities market involves a high degree of risk, including leveraging strategies and other speculative investment practices that may increase the risk of investment loss, including the principal value invested. Investments may be highly illiquid and subject to high fees and expenses.

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Investments in real estate securities can be subject to fluctuations in the value of the underlying properties, the effect of economic conditions on real estate values, changes in interest rates, and risks related to renting properties, such as rental defaults.

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