CAPITAL MARKETS

Private Markets in Retirement Plans

Returns, Risks, and the Importance of Plan Design

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EXECUTIVE SUMMARY

The shift from defined benefit (DB) to defined contribution (DC) plans has fundamentally changed the allocation of investment and longevity risk in retirement systems. Under DC arrangements, the responsibility for investment decisions and outcomes—and the direct exposure to market risk and uncertainty—rests primarily with individual participants rather than plan sponsors. As a result, retirement income adequacy increasingly depends on participant contributions, participant asset allocation choices, fees, and realised investment performance.

This transition has heightened the importance of evaluating whether DC plan participants can achieve sufficient long-term returns to support their retirement needs. In this regard, there has been growing interest among retirement savings plan providers and policymakers in expanding allocations beyond equities and bonds to other types of investments, such as private market assets.

However, integrating private market assets into a DC plan introduces practical issues that are not present in public markets. These include liquidity risk, valuation methods, and fee transparency. Each can materially affect DC plan performance over time. While institutional investors often have the resources and expertise to evaluate these factors, retail investors may lack the same capabilities. This issue can create uncertainty on whether the additional complexity and costs of private market investments are justified by the potential for enhanced returns in a DC context, raising important policy considerations. It is therefore important to understand whether an increased allocation of private market assets in DC plans can help meet the retirement goals beneficiaries depend on.

In this study, we examine the allocation of DC plans to private market assets by modelling returns from a stylised DC plan portfolio with differing mixes of public equity, fixed-income, and private market assets. The private market asset classes under consideration include private equity, private debt, infrastructure, real estate, and venture capital. While there have been several other studies that look at this issue (which are addressed later in this paper), our analysis provides a multi-asset class perspective on private market performance by simulating monthly contributions to a diversified portfolio, while accounting for various model sensitivities.

We model the accumulation performance under a DC plan using a target-date fund (TDF) framework. In several jurisdictions, TDFs have been increasingly adopted as the default fund for DC plans, where the fund is tailored to the retirement time horizon of the individual member. We compare the performance of a TDF with public equities and bonds (denoted as the baseline TDF) with TDFs that also include private market investments. To evaluate TDF performance, we use Monte Carlo simulation to generate a range of possible accumulation outcomes. For simulations, we account for regular member

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contributions and changes in asset allocation over time. We then compare expected retirement wealth, downside outcomes, and net risk-adjusted returns in the DC plan between different TDFs.

Key Findings

The main results of our study can be summarised as follows:

1. *The impact of private market allocations on pension outcomes varies by asset class:*

   - Under a single private market asset class allocation, we find DC plans using TDFs with a small allocation to private markets show improved net risk-adjusted performance relative to the baseline TDF. The net risk-adjusted performance is measured under the mean annual Sharpe ratio, which we define for each TDF as the average annual Sharpe ratio across all accumulation pathways, generated under the Monte Carlo simulation.

   - The improvement in the mean annual Sharpe ratio appears across all private market asset classes we examine, with the highest mean annual Sharpe ratio observed in TDFs that allocate to private equity or venture capital. TDFs with allocations to private equity or venture capital also show a higher average end accumulation value and stronger upside performance, which we measure as the 95th percentile of the distribution of end accumulation values, compared to the baseline TDF. In contrast, TDFs with private debt, infrastructure, or real estate have a lower average end accumulation value compared to the baseline TDF. However, TDFs with allocations to private debt, infrastructure, and real estate also reduce the volatility of end accumulation values, making the mean annual Sharpe ratio higher than for the baseline TDF.

   - For a TDF with multiple private market asset allocations, instead of a single private market allocation, we find that an allocation to private debt, infrastructure, or real estate (defensive-type assets) with venture capital (growth asset) can lead to a higher mean annual Sharpe ratio (through lower volatility) compared with a TDF that only includes venture capital. However, for private equity, while adding private debt, infrastructure, or real estate decreases the volatility in end accumulation values, we find that the mean annual Sharpe ratio is also lower compared to the TDF with an allocation only to private equity. This suggests that the role of each private market asset class should be assessed not only on its standalone performance but also in combination with other private assets as part of a wider portfolio allocation.

   - Overall, the results suggest that private market allocations should be evaluated in the context of portfolio objectives and investor risk tolerance and return expectations. A TDF seeking to improve average end accumulation values may benefit from adding private equity or venture capital. By contrast, a TDF seeking to minimise the volatility of end accumulation values may find private debt, infrastructure, or real estate more beneficial. Combinations of growth and defensive private assets within a diversified default fund can lower the variability of performance and accumulation outcomes compared to allocating to a single private market asset class. Relative to the baseline TDF, performance improvements can arise from both single private market allocations and multi-asset private market allocations.

2. *The design of a DC plan matters as much as the private market allocation:* Changes to glide-path parameters (including the weighted allocation to equities and bonds) and time horizon of accumulation can meaningfully affect outcomes as much as or more than the allocation to private markets. Any allocation to private market assets should be assessed as part of the overall DC plan design, rather than treated as a standalone decision. Ultimately, contribution levels and the time horizon over which cash flows are compounded are the most important aspects of securing adequate retirement income.

Our results, as with any modelling paper, are grounded on the data available and assumptions made on accumulation/portfolio allocation. Various assumptions can be further explored, such as including other private market asset classes, the level of cash contributions, and weighted allocation in the glide path under the TDF. While there are limitations to the analysis, they do not invalidate the key takeaways. Our analysis clarifies what the results do and do not represent and points to extensions for future research.

Who Is This Report For?

While this work is relevant to a broad audience, it is especially important for three types of stakeholder.

- This work is relevant for DC plan providers and sponsors that provide retirement strategies either through TDFs or other multi-asset plans. At the regional level, the work is relevant for institutions including 401(k) plan sponsors in the United States, master trusts in the United Kingdom, and superannuation-style DC schemes such as those in Australia. The key message is that private market inclusion in DC plans should be carefully calibrated; it should account for portfolio construction considerations and associated costs, liquidity and fee constraints, retirement outcomes, and fiduciary governance. The practical implication is that any consideration of private markets must begin with a clear understanding of the role these assets are expected to play within the DC plan (e.g., higher returns, downside resilience, inflationary hedge, cash flow generation, or tax efficiency). With retirement readiness in mind, DC plans should be assessed on whether the chosen private market asset is compatible with liquidity needs and operational capacity.

- For policymakers and regulators, this report is relevant for those focusing on retirement system reform and retiree protection. Regulatory safe harbour (a law or regulation that protects a party from legal liability and regulatory sanction for inclusion of private assets in retirement plans), on its own, is insufficient to ensure satisfactory retirement outcomes. The key policy challenge is how to oversee both the scale of private market asset inclusion in DC plans and broader plan design features while preserving plan participant protection, market integrity, and confidence in the retirement system framework. The effectiveness of any reform therefore depends on the strength of the surrounding guardrails, including valuation standards, liquidity management, disclosure requirements, governance expectations, and conflicts of interest. From this perspective, incremental adoption through regulated wrappers, disciplined allocation limits, and clear supervisory expectations may offer the most credible route to balancing innovation with prudence.
- For participants in DC plans, consistent, regular cash contributions over long periods in DC plans lead to higher end accumulation outcomes than changes in private market allocations. Ultimately, the performance of the DC plan with private market allocation depends on whether it is carefully incorporated into a broader multi-asset fund design that supports the individual’s long-term retirement goals.

INTRODUCTION

Workplace retirement has steadily moved away from employer-guaranteed DB pensions toward participant-directed DC savings. According to the US Bureau of Labor Statistics (2025), 70% of workers in the US private sector have access to a DC plan versus 14% for a DB plan as of March 2025.[1] This shift is also reflected in other markets, such as the United Kingdom. According to The Pensions Regulator (2025), there were 29 million DC memberships in 2024 versus 5.8 million DB memberships in the United Kingdom. The transition from DB to DC reflects regulatory changes, the broader range of available investment strategies, and growing emphasis on employee responsibility for pension outcomes (Hymans Robertson 2025).

Many DC plans remain heavily concentrated in public market assets. While there has been some exposure to private market assets, such as the availability of REITs (real estate investment trusts) and liquid alternatives funds in DC plans, asset allocation remains anchored to public market assets. This is because public market assets help meet the liquidity needs of individual members (Gallary 2024). According to research from the Pensions Policy Institute, for UK master trust default options in 2025, 70% of assets are in listed equities, 14% in bonds, 2% in cash, and 14% in alternative assets (Okello and Garcia Requejo 2025). For the United States, data from the Defined Contribution Alternatives Association (DCALTA) and CEM Benchmarking Inc. (CEM) show the average asset allocation in 2024 as follows: DC plan sponsors in target-date funds hold 68.3% in public stock, 28.3% in fixed income, and the remaining in commodities, REITs, private real estate, private equity, risk parity, and hedge funds (DCALTA and CEM 2025). While DC plans include private market exposure, a narrow alternative allocation may forgo the diversification and return benefits available from the broader private market opportunity set. With the greater adoption of DC plans, individual members have greater accountability for how their investment decisions affect their financial outcomes and lifestyle.

Although wider access to private markets in DC plans represents a potential shift, private market asset classes, including private equity, have long been used in DB plans (US Department of Labor 2020). Such asset classes were included because investment decisions and associated risks in DB plans are managed and borne by the plan sponsor rather than the individual plan member. This enabled DB plans to make more illiquid and long-term allocations that were better suited to the complexities of private markets.

By contrast, DC plans face different design constraints because investment choices are directed by plan participants. In this regard, DC plans need to offer a clear and manageable menu of fund options, accounting for fee sensitivity, liquidity requirements, and fiduciary oversight. These features make the inclusion of private equity and other private market asset classes more

[1]See also www.bls.gov/charts/employee-benefits/percent-access-participation-takeup-retirement-benefits.htm.

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challenging in DC plans than in DB plans. However, because DC plans now cover a larger share of retirement savers than DB plans, as observed in the United States and United Kingdom, there is growing interest in expanding DC plan access to a wider universe of private market assets that can better meet the needs of DC plan participants.

A key reason for the growth of—and thus interest in—private markets is the post-2008 shift in the financial system. After the 2008 global financial crisis, the demand for stricter capital requirements and increased supervisory intensity made leveraged and illiquid lending less attractive to banks. This development allowed nonbank entities, such as private credit, to fill the space (see Wilson 2026; Preece and Wilson 2026). As a result, private markets (including private credit) have seen substantial growth. PitchBook forecasts that global private market assets under management (AUM) managed by general partners (GPs) will reach roughly $26.7 trillion by the end of 2030 (Schwartz and Fullerton 2026). In addition, from 2000 to 2022, the number of US private companies backed by private equity funds rose from less than 2,000 companies to more than 10,000, which is more than double the number of US public market companies as of 2022 (Goldman Sachs Asset Management 2025). This expansion has been driven in part by companies remaining private for longer, supported by their ability to raise sufficient capital outside public markets, which increases the importance of broader access to investment opportunities outside public markets.

If private market investments are to be successfully integrated in DC plans, they must show not only attractive returns but also robust governance. Key considerations on the performance of DC plans with private market assets include liquidity management, valuation methodology, pricing frequency, fee levels and transparency, and oversight. The risks associated with retail-based access to private market funds have already been observed during recent periods of market stress—for example, redemption restrictions in Blue Owl's private credit fund in 2026 (Gara and Platt 2026) and in Blackstone's Real Estate Income Trust from 2022 to 2024 (Bloomberg 2024). Such episodes illustrate the liquidity mismatch that retail investors are exposed to from private markets. Clayton and de Fontenay (2026) argue that the protections and liquidity offered to retail investors are at odds with the structure of private markets that made the asset class attractive. Hence, plan sponsors, trustees, and fiduciaries need to carefully consider the range of issues associated with private market assets when considering suitability and access for individual members in DC plans. As we highlight later, active discussions about the role of private markets in meeting fiduciary responsibility are happening in the United States, the United Kingdom, and Europe.

It is crucial to understand how increased allocation to private market assets impacts DC plans because it informs whether DC plans serve and achieve their intended purpose. The adequacy of DC plans centers on retirement outcomes, lifestyle expectations, and how much members benefit from a system grounded in their own and their employers' contributions, investment choices, and growth. If private market assets are not well understood, it could result in allocations that are misaligned with the intended outcomes of the plan participant. This may create wide differences in retirement wealth across the spectrum of DC savers. Therefore, it is vital to carefully examine whether including private markets truly enhances or undermines the effectiveness of DC plans.

This report contributes to the existing literature by comparing several private market allocations within a single, consistent DC accumulation framework and by testing sensitivity to key glide-path assumptions. Our modelling is based on an approach that simulates plausible, real-world outcomes under realistic constraints. Our analysis considers the performance of private markets in DC plans across the following asset classes: private equity, private debt, infrastructure, real estate, and venture capital. We include these asset classes to represent some of the largest areas of investment in the private market universe. In terms of global AUM, S&P Global (2024), using data from Preqin, shows that as of 2023, the three largest private market asset classes are private equity ($5.3 trillion), private debt ($1.63 trillion), and real assets ($4.52 trillion), which include infrastructure and real estate.

We assess DC plan growth using a cash contribution model, assuming monthly contributions into the plan. The value of the DC plan is then based on the cash contribution and portfolio returns throughout the accumulation period. We assume that cash contributions go toward a TDF. A TDF represents a predetermined asset allocation that is tailored to the retirement stage of the individual member, where asset allocation varies over time. In our case, we construct a synthetic TDF (a hypothetical TDF that reflects key features of a TDF but is not an actual investable product) that is stylised and comprises indices on public and private market asset classes, adjusted for fees. We evaluate the performance of private markets in DC plans by evaluating various TDFs.

We include a baseline TDF that comprises only equities and bonds and compare the performance to a TDF with allocation to private markets. For further detail on TDFs, Vanguard provides a guide on how it constructs its TDFs, accounting for asset allocation, risk preferences, and member profile (Daga, Aliaga-Díaz, Zahm, Zhu, Hassett, and Banis 2022).

To assess long-term accumulation under each glide path, we use a Monte Carlo simulation framework. We use a Monte Carlo approach because it offers a robust basis to evaluate portfolio strategies and understand the long-term implications for retirement planning. Under this approach, we generate multiple pathways representing different scenarios of accumulation. From the distribution of end accumulation values, we compare expected outcomes, tailed performance, and net risk-adjusted performance across TDF designs. Further details are provided in the Methodology section.

RESEARCH BACKGROUND

In this section, we describe the main aspects of private markets that can affect DC plans, how this study fits in the relevant literature, and the policy landscape explored in our research.

Private Market Characteristics

We provide background on the following aspects of private markets: fees, valuation, cash flow structures, liquidity, and proxy-based exposure. We view these as the key aspects of private markets that can impact DC plan performance.

Private market funds come with higher fees than public market funds. They often carry a 2/20 fee model—2% management fees and 20% performance fees for returns in excess of a hurdle rate. An empirical study by Lim (2024) using a dataset with 10,791 private capital funds examined the costs for investors to access private markets. The author found that the proportion of total fees paid that relate to non-performance-related management fees ranged from 53% to 75%.

Other researchers have also studied the issue of fees in private markets. Begenau and Siriwardane (2022), for example, analysed the variation in investment fees across various US private market funds and found that within the same fund, some investors pay lower fees than other investors. This disparity is typically due to differences in investor size (i.e., capital commitment), but it also comes from differences in negotiation skill and bargaining power (Begenau and Siriwardane 2022). These factors raise questions about whether the net-of-fees performance of private assets is sufficient in a DC plan context to justify the additional costs over public market assets.

It is also important to note that not all private market funds use the same type of fee structures. The 2/20 fee structure, for example, is characteristic of private markets associated with institutional closed-end drawdown funds; evergreen-type funds, however, have different fee structures. Others have noted that the fee structure for private markets in DC plans will likely be lower than that used for institutional investors. This is the result of the bargaining power of plan sponsors that need to accommodate participants switching and rebalancing their plans and the incentives for asset managers to gain access to DC plans (Cerulli Associates and DCALTA 2025).

Another difference between private and public markets is the method of valuation. Valuation occurs less frequently and transaction prices are less observable in private markets compared with public markets. Private markets rely on mark-to-model techniques, whereas public markets use mark-to-market approaches based on transparent transaction prices. The limited frequency of

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trading and the appraisal-based approaches for private market valuation result in a lack of price discovery, raising questions about whether such valuations reflect the inherent risks of the fund. Such valuation risks matter, particularly in interval-type fund structures accessible to retail investors in which investors buy and redeem shares under those valuations. However, in other types of funds, such as drawdown funds, valuations matter less when the fund performance is based on the capital provided from the GP back to the limited partners (LPs).

Valuation-related risks have already been highlighted by regulators. In 2025, the UK Financial Conduct Authority (FCA) published a report on private market valuation practices and noted there may be inappropriate pricing of private market assets due to "insufficient [valuation] expertise, focus, or poorly managed conflicts of interest" (FCA 2025). Warren Buffett (2003) has described private market valuations as "mark-to-myth," highlighting concerns about how values are determined. Others argue that fund managers remain conservative in their reporting, understanding that in order to raise capital for their next fund, they must underpromise and overdeliver on performance (Private Market International 2020).

Cash flows for private markets also differ from public markets. Tradable, public securities have observable prices and cash flows, such as dividends and coupon streams, allowing for accurate, current valuation and periodic rebalancing. In comparison, private markets are driven by capital calls, staged development, distributions, and exit calls. The infrequency of cash flow data can lead to data lags that affect private market valuations. In 2025, a Bain & Company report noted in the case of infrastructure funds that the illiquidity and irregularity of cash flows were built for large institutional investors, compared with broad and scaled distribution suited for retail investors (Olsen, Jones, Rodrigues, Rainey, and Habbel 2023). It is therefore important to account for such cash flows either through various adjusted methods or by estimating flows using public market equivalents. We note, however, that cash flow concerns are primarily for drawdown-type funds rather than evergreen funds, in which capital can be quickly deployed.

Although access to private market assets historically has been limited, it has started to increase. Initially, access was largely restricted to long-term institutional investors that could invest in large sizes, tolerate illiquidity, and benefit from bespoke dealings. Current offerings, however, allow retail investors to gain access to private market assets either through their pension plans or through wealth platforms and other advisory channels. Retail investment vehicles include business development companies and real estate investment trusts. These vehicles provide retail investors exposure to private markets, while allowing limited liquidity for investor redemptions (typically either quarterly or semi-annual redemption windows).

However, the participation of retail investors introduces liquidity demands that may exceed the liquidity offered through these types of retail-based private market vehicles. This liquidity mismatch risk can result in regulatory and litigation issues. Clayton and de Fontenay (2026) note that private market vehicles offered to retail investors differ from those offered to institutional investors. In this regard, it is unclear whether these retail-based vehicles reflect the same quality of exposures to private market assets as those held by institutional investors.

Another way for retail investors to gain exposure to private markets is through listed publicly traded shares of firms that manage private market funds, such as KKR, Apollo, or BlackRock. This approach can be attractive because listed shares preserve daily liquidity and can serve as a practical proxy for private market exposure. Still, the broader use of listed shares is fundamentally different than directly holding the private market asset: The share price of alternative asset management firms reflects not only the performance of the firm's private market funds but also the economics of the management company itself, including balance sheet investments, capital efficiency and profitability, and broader equity market factor exposure (market beta). In this regard, investing in listed alternative managers is an imperfect proxy for direct private market holdings given the variable link between underlying fund performance and listed share price returns.

Literature Review

The literature suggests that moderate allocations to private assets within DC plans can improve long-horizon outcomes, subject to implementation costs and product fees. These existing studies largely focus on private equity or a narrow combination of private market assets.

We examine the literature and explain how our research differs from previous work. First, we evaluate five private market asset classes within a consistent TDF framework, where we account for realistic monthly salary contributions over a dynamic glide path. Then, we isolate the contribution of private market allocation compared to plan design by further testing sensitivities to key glide-path parameters. Our sensitivity analysis shows how much variation in retirement outcomes is driven by the private market allocations compared to the plan design.

Greig, Aliaga-Diaz, Daga, Hahn, Grim, and Xu (2025) examine whether private assets can improve DC retirement outcomes in a TDF framework. The study evaluates private assets through the lenses of investment merit, plan sponsor suitability, and implementation design, and it models hypothetical TDFs with 10% and 20% allocations to private assets over a 40-year savings horizon. They find a 10%–20% allocation to private assets could increase retirement wealth by about 7%–22% and retirement income by roughly 5%–15% after fees. The paper stresses that outcomes depend heavily on manager quality, long holding periods, and the ability of participants to remain invested through periods of illiquidity and dispersion in returns.

Our paper differs from that of Greig et al. (2025) in that we examine TDFs across a range of designs, varying the time horizon, the asset allocation, and the transition period from equities to bonds. Understanding the sensitivity of TDF design for our results is important. By doing so, we show how changes in the design of the TDF affect both the end accumulation values and the relative contribution of the private market allocation in a TDF compared with the baseline TDF.

Reibel (2017) investigates whether adding private equity to a custom 45-year TDF can improve retirement outcomes without increasing the fund's overall risk profile. The study applies a mean–variance optimisation framework to compare a standard TDF with one that includes private equity while holding expected risk constant. The author finds that an allocation of 7.1% to private equity in the first 30 years of the glide path increases expected annual returns by 0.27%, and this compounds into an 8.7% increase in total savings at retirement. The paper shows that even modest allocations to private equity can enhance long-term retirement accumulations if it is embedded within a disciplined glide-path design and evaluated over a sufficiently long horizon.

While we also examine TDF performance with private equity, we extend the analysis to a wider set of private market asset classes. This broader scope allows us to assess whether different private market allocations improve TDF performance across multiple metrics.

Magyera, Nefouse, and Tovrov (2025) estimate that adding private equity and private credit to a DC target-date strategy could increase expected returns by around 50 bps per year over the life of the strategy. This would raise participant balances by roughly 15% over 40 years, while also improving diversification and offering access to private assets' stable cash flows and inflation protection. Their work stresses that practical concerns such as fees, liquidity, transparency, cash drag, and fiduciary oversight are central to implementation.

While, as Magyera et al. (2025) show, higher end accumulation values are an important measure of DC plan performance, they represent only one way to evaluate the performance of TDFs with private market allocations. Our study extends this perspective by covering a broader range of private market asset classes and by assessing performance across multiple metrics, including tail outcomes in end accumulation values and the net risk-adjusted performance under the mean annual Sharpe ratio.

Antonelli (2025) examines whether a more diversified TDF that includes private equity, private credit, and real assets can improve projected retirement income outcomes relative to a more traditional stock-and-bond-based TDF. The main finding is that a more diversified TDF with private market allocation can improve expected long-term retirement income by about 8% and reduce downside outcomes by about 6%, relative to a traditional TDF. The author concludes that a moderate exposure to private markets and other alternative assets can yield diversification benefits and improve retirement income outcomes. Although the study focuses on the United States, the policy discussion includes how such jurisdictions as the United Kingdom, the EU, and Australia are also examining how private market allocations could be incorporated into DC plans.

Our work contributes to the discussion in Antonelli (2025) in two ways. First, it provides a brief global context for policy developments around private asset allocations in DC plans. Second, it introduces a modelling framework that incorporates core features of TDF design that are used in DC plans across multiple jurisdictions.

More broadly, as Rosov (2020) notes, combining private and public market assets can strengthen portfolio diversification and enhance the long-term performance of DC plans. While taken from a European perspective, Rosov (2020) identifies key issues that should be considered in the expansion of private markets in DC plans, including value for money, eligible assets, disclosure, and pooling resources. Our results also suggest an improvement in the net risk-adjusted performance measured under the mean annual Sharpe ratio from an increased allocation to private markets. However, this improvement varies depending on the size of the weighted allocation to the private market asset class in the TDF.

This work adds to the research from CFA Institute on private markets from the perspective of pensions, which has not been explored. For example, Deane (2024) provides a global survey of CFA Institute members on governance issues related to private markets. Although most respondents believe some governance practices can be improved, they view governance problems with private markets as not significant. Knox (2025) examines various risks associated with the inclusion of private assets in pension plans and how to reduce the probability of adverse scenarios, including poor investment returns, volatility of investment returns, uncertainty arising from DC systems, and adverse risks that individuals face during retirement. Cui, Pham, and Ruthbah (2025) examine the efficacy of the 60/40 equity/bond portfolio in Australian- and US-based pension schemes. They find significant differences in retirement savings generated from a traditional 60/40 portfolio due to such factors as gender and the performance of market returns early during retirement. The study underlines the limitations and variability of retirement outcomes, even from traditional portfolio constructs that exclude private assets, and encourages more nuanced retirement planning.

Overall, the literature shows that a small allocation to private market assets in a target-date fund can increase expected returns and improve retirement outcomes. However, most studies examine performance for one or two private market asset classes, that is usually measured under a single measure. Our study broadens the analysis, including five different private market asset classes, evaluated across multiple metrics.

Policy Landscape

Across the globe, regulators are converging on approaches to the inclusion of private market assets in DC savings plans at different paces of adoption. The United States is using ERISA and DOL fiduciary guidance to reduce uncertainty for DC plans. In the EU, the revised European Long-Term Investment

Fund regime, or ELTIF 2.0, provides a regulated fund wrapper for long-term and private market assets, while the Institutions for Occupational Retirement Provision (IORP) II directive maintains the existing prudential framework for occupational pension funds under the prudent person rule. The United Kingdom has taken a more pension-specific route through the Mansion House agenda and the consolidation of DC schemes. The Hong Kong SAR regulatory framework enables private market access through authorised private equity funds with clear investment caps to limit exposure. Australia already accommodates private markets within DC-style retirement savings plans, with policy attention focused on valuation, liquidity, and governance. Overall, the policy direction is broadly consistent with accommodating private assets in DC plans, but each jurisdiction is advancing in its own way.

The EU and the United Kingdom

In the EU, it is important to distinguish between pension fund rules and product-access rules. IORP II is the existing occupational pension framework. It does not create a new mandate for private market allocations, but it can accommodate them when trustees satisfy the prudent person rule, portfolio-level liquidity requirements, diversification standards, and risk governance obligations. The more recent EU development is ELTIF 2.0, which makes long-term and private market assets more accessible through a regulated, EU-passportable fund structure, including for retail investors, with suitability, disclosure, depositary, and liquidity-management safeguards.

The United Kingdom sits further toward policy activism. Rather than treating private markets as a niche permissibility question, UK policymakers have tied DC reform to asset allocation and consolidation. As stated by Jones, Galante, Hsu, Silva, and Dunbar (2025) in a CFA Society United Kingdom report, the private market push in DC plans in the United Kingdom has been driven by a domestic productive investment objective. This has been reflected in the Mansion House agenda, a voluntary agreement by the largest UK pension providers, in which 10% of DC default funds should be allocated toward private markets by 2030, with at least 5% of the total comprising UK private assets. The UK approach appears to increase the probability of adoption, but it also raises the bar on demonstrating value for money, robust governance, and credible liquidity design inside default funds.

The United States

On 30 March 2026, the US Department of Labor (DOL) proposed a rule that would establish a clearer fiduciary framework for including alternative investments in 401(k) plans. By reducing regulatory uncertainty and potential litigation risk for plan fiduciaries, the proposal could encourage asset managers—some of which had already been moving toward the retailisation of private markets—to accelerate efforts to expand private market offerings within defined contribution plans. The US approach remains anchored in the Employee Retirement Income Security Act (ERISA) of 1974, which embeds a prudent-person fiduciary standard in statute and is elaborated through DOL regulations and guidance.[2] The ERISA regulation framework focuses on fiduciary process instead of categorical asset approval. In other words, it is not the DOL's role to specify the appropriate asset classes for retirement savings plan participants. SEC rules matter mainly at the level of the investment vehicle, such as registered funds' liquidity and valuation requirements, rather than as the core source of 401(k) fiduciary permission.

The current US question is not whether 401(k) plans can hold private investments but whether plan fiduciaries can prudently conclude that private investments improve outcomes net of fees consistent with necessary liquidity, valuation integrity, and participant understanding. The focus in the United States is private market investments incorporated into TDF default investments. Even with a more permissive policy direction, however, meaningful constraints remain. Open-end registered funds are still subject to SEC liquidity rules that generally prohibit them from holding more than 15% of net assets in illiquid investments, and they must report and remediate any breach of that threshold.[3] Wiek, Stanford, and Criswell (2025) also argue that broader adoption of private market assets in 401(k) plans will be slow due to cost, limited transparency, and product complexity—all of which could challenge investor comprehension and comfort. Hence, the US debate becomes less about "approval" and more about determining whether investment structures can accommodate regular liquidity, transparent pricing, and other investor protections.

Asia-Pacific

The regulatory framework surrounding pensions and private markets in Hong Kong SAR is more conservative and rule based. The Mandatory Provident Fund Schemes Authority (MPFA) maintains a prescribed permissible investment framework with qualitative and quantitative limits on assets designed explicitly to reduce avoidable risks, including those tied to liquidity and valuation (MPFA 2024). In May 2025, the MPFA allowed mandatory provident funds to invest in private equity funds listed in Hong Kong SAR and authorised by the Securities and Futures Commission, with approvals on a case-by-case basis. It also introduced an initial cap that limits total investment in the new private equity class to a maximum of 10% of a fund's net asset value (Chuang 2025). While not an endorsement of broad private market access for retail participants, it is an incremental expansion that keeps the exposure inside a listed, regulated wrapper and sets explicit sizing discipline.

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[2]US Code of Federal Regulations, Title 29, Subtitle B, Chapter XXV, Subchapter F, Part 2550, § 2550.404a-1, "Investment Duties," www.ecfr.gov/current/title-29/subtitle-B/chapter-XXV/subchapter-F/part-2550/section-2550.404a-1. www.law.cornell.edu/cfr/text/29/2550.404a-1.

[3]US Code of Federal Regulations, Title 17, Chapter II, Part 270, § 270.22e-4, "Liquidity Risk Management Programs," www.ecfr.gov/current/title-17/chapter-II/part-270/section-270.22e-4.

Australia sits at the other end of the spectrum. Large superannuation funds already treat unlisted infrastructure, property, private equity, and private credit as established building blocks for long-horizon portfolios. The regulatory posture therefore is not about “allowing” private markets but preventing governance weakness from turning private market opacity into member harm, especially in a unit-priced system where valuation affects entry and exit fairness. The Australian Prudential Regulation Authority’s (APRA’s) December 2024 thematic review on unlisted asset valuation and liquidity risk management makes the stance clear. APRA expects timely and reliable valuation information, strong board oversight, conflict management, clear revaluation triggers, and credible liquidity frameworks under Prudential Standard SPS 530 Investment Governance (APRA 2024).

These policy developments show that the debate is shifting from whether private markets should be included in DC plans to the conditions in which they can be included prudently. Across jurisdictions, the common considerations are fees, liquidity, valuation, diversification, governance, and participant protection, where regulatory accommodation alone does not establish investment merit.

METHODOLOGY

We model the inclusion of private market assets in DC plans via a stylised TDF. The model includes three main components: a cash contribution schedule (based on the profile of the individual member); a TDF glide path representing the allocation of assets in the DC plan; and a Monte Carlo approach to simulate returns and evaluate pathways of accumulation.

We denote an individual member that provides cash contributions into the DC plan by allocating a proportion of the member's salary at the start of the month. We incorporate monthly cash contributions to reflect the regular contributions that individual members and employers typically make to a DC plan. Cash contributions are used to subscribe to funds, which invest in assets. In this case, we assume that the individual member only subscribes to one type of multi-asset fund—a TDF. However, the analysis could be extended to include multiple funds or other types of funds in the DC plan, such as balanced or managed funds.[4]

The TDF is constructed across three main asset classes: equity, bonds, and private markets. Public market exposures are represented with exchange-traded funds (ETFs), and private market exposures are represented with global private market indices. We include private markets across the following asset classes: private equity, private debt, infrastructure, real estate, and venture capital. The returns are net of fees, based on closed-end drawdown funds, and denominated in US dollars. In this regard, they should be considered a proxy for private market access, with further details on fee incorporation and the return series provided in the Data section and in the appendix of this report. Each TDF has a dynamic allocation; initially there is a large allocation to equities that shifts to bonds near the end of the accumulation period. Where private markets are included, there is a fixed allocation across the entire period and equity and bond allocations are proportionally adjusted.[5]

Next, we use a simulation approach. We generate a set of returns (under an assumed distribution) for the underlying assets that leads to changes in fund performance. Under the TDF, changes in asset prices under the generated returns are followed by cash contributions into the fund that lead to changes in the value of the DC plan over the accumulation period. We simulate cash contributions and asset return across the accumulation period, where the pathway of accumulation represents one sample. Then, we generate multiple

[4]In practice, plan participants may hold more than one fund over time. This can happen when participants change employers, enroll in a new DC plan, or do not actively consolidate previous contributions into a single fund. As a result, their retirement outcomes may reflect exposure to multiple funds rather than one TDF throughout the accumulation period. Future analysis could therefore examine participant-level portfolio outcomes across multiple funds and plan arrangements.

[5]In practice, a TDF could vary the private market allocation along the glide path. For example, if private equity is considered riskier than equity, in the final years of accumulation the allocation to private equity could decrease. Such an approach would also recognise that illiquid assets require time to sell and are less suited to decumulation than to accumulation. However, different approaches depend on the private market asset class, which can be explored in future work.

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samples to obtain a distribution of end accumulation values. In this case, we assume the individual member always provides monthly cash contributions into the DC plan with no pauses, early withdrawals, or additional lump-sum contributions (e.g., bonuses).

We assume contributions to the DC plan span a 40-year period. Such a profile represents a typical employee with early contributions starting at age 25 and an expected retirement age of 65. For this profile, we assume an initial starting salary equal to $25,000 (with no prior allocation or transfers into the DC plan). For example, another study also uses a 40-year accumulation period and $25,000 starting salary for contribution,[6] where starting salaries can vary depending on the individual's job, location, and age, as well as other factors. Because the model framework is flexible, this analysis can be calibrated assuming a different starting salary.[7]

For the cash contribution, we assume an annual contribution equal to 10% of the salary. The 10% contribution is represented by a 5% contribution from the employer and 5% from the employee. The actual salary contribution rate can vary between countries. In the United Kingdom, for example, a (combined) minimum contribution of 8% is typical, with employers obligated to contribute at least 3%.[8]

In comparison, in the United States, there is no set minimum plan contribution required by federal law. Reports show that in 2025, the contribution rate for 61% of US DC plans was 4% or higher (see Vanguard 2025). Based on the assumed profile and starting salary level, the initial cash contributions into the retirement savings plan (from both the individual member and the employer) equal $208.33 per month. This amount is calculated by dividing the initial annual salary of $25,000 by 12 and applying the assumed 10% total contribution rate: ($25,000/12) × 10% = $208.33.

We assume that cash contributions into the DC plan are pretax (i.e., salary contributions are from the employee's gross pay before income tax is applied). The taxation treatment of pension contributions varies depending on the jurisdiction and the pension scheme, which the employee is subscribed to or chooses. As a result, there is no single taxation assumption that can be used for a global study. While we do not account for tax deductions in this study, tax treatment becomes important when accounting for both accumulation and withdrawal outcomes in a given jurisdiction.

[6]www.pm-research.com/content/iijpormgmt/35/3/61.

[7]Note that our assumptions on salary, accumulation period, or any other modelling assumptions are not specific to a given jurisdiction. While DC plan design may change depending on the jurisdiction and the DC plan available to the employee, we apply an approach that reflects the core features of a DC plan. For example, some jurisdictions, such as the United States, often have relatively higher combined employee and employer contribution levels than those assumed in other markets. Our baseline assumptions are intended to be broadly representative rather than jurisdiction specific, and the modelling framework can readily be adapted to reflect different contribution rates, plan designs, retirement ages, and other jurisdiction-specific characteristics. In this regard, investigations into any of the mentioned aspects can be explored in future work.

[8]See www.gov.uk/workplace-pensions/what-you-your-employer-and-the-government-pay.

We also account for changes in salary over the accumulation period. We adjust the salary annually under an assumed salary growth rate of 2.5%, comprising 2% linked to a target inflation rate and a 0.5% drift rate in real wage growth. Based on our profile assumptions, the monthly cash contribution from the individual member and employer increases from $208.33 in the first year to $213.50 in the second year. This is calculated by applying the assumed 2.5% annual salary growth rate to the first-year monthly contribution: $208.33 × 1.025 = $213.50. The salary is assumed to increase year on year until the end of the accumulation period. End accumulation values should therefore be interpreted as nominal retirement wealth rather than inflation-adjusted purchasing power.[9]

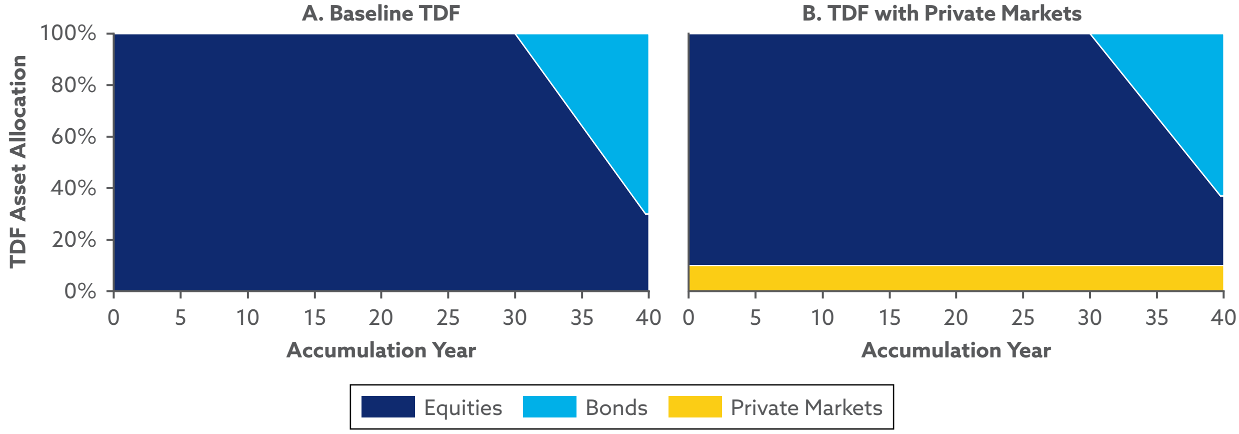
As noted earlier, we assume our DC plan follows a TDF structure. The TDF in our analysis is a stylised fund with a dynamic asset allocation strategy that is tailored to the retirement horizon of the individual member. A TDF is particularly suitable in a DC plan setting because it reflects the member's long-term investment horizon, where allocations are adjusted as retirement approaches. We denote the TDF that comprises only equities and bonds as the baseline TDF, which is used as a benchmark for evaluating the performance of TDFs that include private market assets. In practice, TDFs may include assets other than equities, bonds, or private market assets, such as commodities, investment trusts, or derivatives.

The baseline TDF allocation follows a specified glide path over the accumulation period that includes allocation only to equities and bonds. We assume at the start of the investment horizon that the glide path has a relatively high allocation to equities, reflecting the greater return potential of equities over the long term. As the member approaches retirement, the allocation gradually shifts toward bonds and away from equities. A higher allocation to bonds reflects the desire for lower return volatility to reduce the downside risk as the member nears the end of accumulation. In this regard, the glide path is growth focused, with equities in the early stages of accumulation, before moving to focus on lower downside risk with higher bond exposure in the later stages.

The glide path is shown in **Exhibit 1**, representing the baseline TDF (Panel A) and the TDF with private market allocations (Panel B). For the baseline TDF, based on an accumulation period of 40 years, we assume an allocation only to equities in the first 30 years. Then, in the last 10 years, we apply a linear monthly adjustment to the weighted allocation under the glide path such that the individual ends the accumulation period at year 40 with a 30% allocation to equities and a 70% allocation to bonds. For the TDF with private market allocations, the glide path is similar, except we assume a constant allocation of 10% to only one private market asset class across the entire accumulation period. The allocation to equities and bonds is proportionally adjusted, but as

[9]Note that the assumed 2% inflation rate and 0.5% real wage growth rate are stylised inputs. Actual inflation outcomes may vary over the accumulation period depending on the jurisdiction, macroeconomic conditions, and any changes to the central bank's inflation target. Similarly, real wage growth can differ across participants based on such factors as occupation, career progression, age, and location. These variations would affect salary growth and, in turn, the level of cash contributions made into the DC plan over time.

Exhibit 1. Glide Path for the Baseline TDF and a TDF with Private Market Allocation



in the baseline TDF, there is a shift 10 years from retirement from equities to bonds. This results in an asset allocation at the end of the accumulation period of 27% equities, 63% bonds, and 10% private markets.

We construct a TDF for each private market asset class, giving us five TDFs, each with the sole inclusion of the private market asset, along with the baseline TDF. We consider a TDF for each private market asset class to compare the differences in performance of private markets in DC plans and to see how each compares to the baseline TDF. Later, we also include analysis that explores TDF performance with multiple private market asset allocations and how results compare to a TDF with only a single private market allocation.[10]

On a quarterly basis, the portfolio is rebalanced after cash contributions so that holdings are equal to the target allocation. In months where no rebalancing occurs, cash is allocated across assets to minimise the deviation between the current asset holdings and the target allocation. Specifically, cash is allocated to assets that are underweighted in the portfolio. If allocating the full cash contribution across underweighted assets leads to the portfolio exceeding the target weight, then only the quantity of cash needed to meet target allocations is used. Any remaining cash is proportionally allocated across all assets, based on the target weight, so that contributions are always fully invested.[11]

[10]Note that different transition periods and end-state allocations can be chosen—for example, a five-year transition from equities to bonds that leads to a 50% allocation in equities and 50% in bonds. While values can vary, what is consistent across the literature is that the transition period from equities to bonds is shorter than the preceding accumulation phase. In addition, the target allocation at the end of accumulation carries a higher weight in fixed income than equities. This is reflected in the TDF designs in Greig et al. (2025) and Reibel (2017), whose approach we follow here. As part of the sensitivity analysis, we explore variations in glide-path design and assess how these affect the performance of both the baseline TDF and TDFs with private market allocations.

[11]Our results do not include fees that relate to plan administration, individual service fees, transaction costs, trading costs, or rebalancing costs, which vary across pension plans and markets. These factors are small relative to the core choices of contribution level, asset allocation, and glide-path dynamics.

For example, given holdings of ($200, $300) across two assets and a target allocation of (50%, 50%), the portfolio totals $500. With a cash contribution of $100, the target holding per asset becomes 0.5 × ($500 + $100) = $300. Asset 1 is underweighted by $100, and Asset 2 is at target, so the full cash contribution is allocated to Asset 1, resulting in holdings of ($300, $300). With a larger cash contribution of $200, the target holding becomes 0.5 × $700 = $350 per asset. Asset 1 has a shortfall of $150, and Asset 2 has a shortfall of $50, totalling $200. The cash is allocated proportionally: ($150/$200) × $200 = $150 to Asset 1 and ($50/$200) × $200 = $50 to Asset 2, resulting in holdings of ($350, $350).

In quarters where a full rebalance does occur, assets are bought and sold such that holdings match the target allocation. While we choose this approach for rebalancing, other approaches can be considered, e.g., monthly rebalancing or a threshold rebalancing based on the total deviation of weights under a given threshold.

We use a Monte Carlo approach to simulate 10,000 pathways of accumulation for each TDF. This includes the baseline TDF and five TDFs that include private assets, where a distribution of end accumulation values is generated for each TDF.[12] The Monte Carlo approach generates multiple pathways from a series of returns based on an underlying distribution. We assume the distribution is based on a multivariate normal distribution, where the mean, volatility, and correlations are determined by historical data of included assets (further detail is provided in the Data section). The multivariate normal distribution assumes a normal distribution of returns, where the correlation between assets is incorporated into the generated returns.

Based on our assumed investor profile and TDF, we can illustrate this model with numerical values. In the first month of the first year of accumulation, the individual member contributes $208.33 into the DC plan at the start of the month (based on the previously stated initial salary and salary contribution). Then, under the multivariate normal distribution, assume that the fund generates a return of 5% in the first month (i.e., one illustrative accumulation pathway under the distribution of returns, accounting for the underlying assets and weighted allocation). From this return, the DC plan would have a nominal value of the cash contribution and fund return of $208.33 × 1.05 = $218.70 at the end of the first month.

In the subsequent month, if fund returns generated under the distribution are equal to 4%, the nominal value of the DC plan at the end of the second month equals ($218.70 + $208.33) × 1.04 = $444.10. Month by month, we continuously simulate monthly returns, accounting for the cash contribution, glide path (that will lead to changes in the fund returns), and salary growth until we have reached the end of the accumulation period. Once we have generated

[12]We use 10,000 Monte Carlo simulation paths to provide stable estimates for the performance metrics considered in this study. Increasing the number of paths beyond 10,000 produces negligible changes in the estimated mean, volatility, and 5th and 95th percentile accumulation values, indicating that the simulation results have converged for the purposes of the analysis.

one pathway for the DC plan accumulation, we again simulate another pathway of accumulation, following the steps as before. We continue with simulations until we have generated 10,000 accumulation pathways for each TDF. Then, from these samples, we analyse the distribution of the end accumulation values for the TDF and how it compares to the baseline TDF and other TDFs with the singular inclusion of the private market asset.

We recognise that the modelling abstracts away from some practical features of private market investing. In particular, the modelling framework assumes that investors can gain and adjust exposure to the given private market index at specified rebalancing dates (such as via evergreen funds or other types of semi-liquid fund structures). In practice, private market allocations are subject to important implementation frictions, including fund availability, capital call and distribution timing, lock-up effects, and valuation lags. The results should therefore be interpreted as a *scenario-based representation* of broad asset class behaviour, rather than as a fully implementable strategy. Despite these constraints, the analysis is intended as an initial study of the longer-run role and trend characteristics of private markets within portfolio construction, while recognising that actual investor experience may differ because of these real-world constraints.

DATA

For private markets, we use the PitchBook global indexes for private equity, private debt, infrastructure, real estate, and venture capital. The PitchBook private market indexes represent quarterly returns of closed-end private market funds that are net of fees.[13] The data used for equities, bonds, and private markets are all denominated in US dollars. The appendix provides details on index construction, the desmoothing method applied, and conversion from quarterly to monthly returns to accommodate the cash contribution model.

For equities, we use a global equity ETF (Vanguard Total World Stock ETF) that tracks the FTSE All-World Index. The FTSE All-World Index includes large- and mid-capitalisation stocks globally and is market-capitalisation weighted. For bonds, we use a global government bond ETF (iShares Global Government Bond) that tracks the FTSE Group-of-Seven (G7) Index. The index includes government bonds in developed markets. We use ETFs as opposed to the theoretical index to capture the practical costs and real-world returns obtainable for investors in liquid public markets. For equities and bonds, we use monthly total returns. We use data between 1 January 2010 and 31 December 2024, representing 15 years of data.[14]

Exhibit 2 shows the total monthly return series statistics for the equities, bonds, and private market indices in our dataset. These summary statistics and their definitions are as follows:

- **Mean return**—the geometric mean of monthly returns over the period
- **Mean volatility**—the standard deviation of monthly returns over the period
- **Minimum return**—the lowest monthly return value over the period
- **Maximum return**—the largest monthly return value over the period
- **Skewness**—the level of asymmetry in the return distribution
- **Excess kurtosis**—the heaviness of tails in the distribution relative to the kurtosis under the normal distribution
- **ACF(1)**—the autocorrelation function of lag 1, representing the correlation of the return series compared with the return series lagged by one month
- **Maximum drawdown**—the largest observed percentage decline in the value of the asset from the highest to the subsequent lowest point

[13]Note that private market assets used in DC plans may deviate from the class of private market assets used in this study because private market assets for DC plans need to account for the needs of plan participants, including private market vehicles that can quickly deploy capital and low-fee structures. However, the PitchBook indexes allow us to capture broad trends across private market asset classes at the global level that are otherwise not readily available from fund-level data.

[14]Although 15 years of return data may not capture the whole distribution of private market returns, it provides a meaningful sample for this study. It spans a full economic cycle and captures the post-2008 environment in which private markets expanded significantly as an asset class.

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Exhibit 2. Total Monthly Return Series Statistics for Equity, Bond, and Private Market Indices, 1 January 2010–31 December 2024

Return Series	Mean Monthly Return (%)	Volatility (%)	Min. (%)	Max. (%)	Skewness	Excess Kurtosis	ACF(1)	Max. Drawdown (%)
Private Equity	1.10	2.01	−7.16	7.40	−0.65	4.92	0.61	−19.98
Private Debt	0.71	1.26	−3.71	3.81	−0.75	2.75	0.54	−10.73
Infrastructure	0.70	0.78	−1.61	2.43	−0.45	0.59	0.66	−3.42
Real Estate	0.71	1.55	−3.23	4.07	−0.22	−0.31	0.66	−13.82
Venture Capital	0.74	4.39	−10.62	14.43	−0.02	1.36	0.64	−52.18
Equity	0.75	4.35	−14.76	12.37	−0.38	0.83	−0.12	−25.52
Bond	0.14	2.4	−6.81	13.69	1.13	5.18	−0.05	−23.20

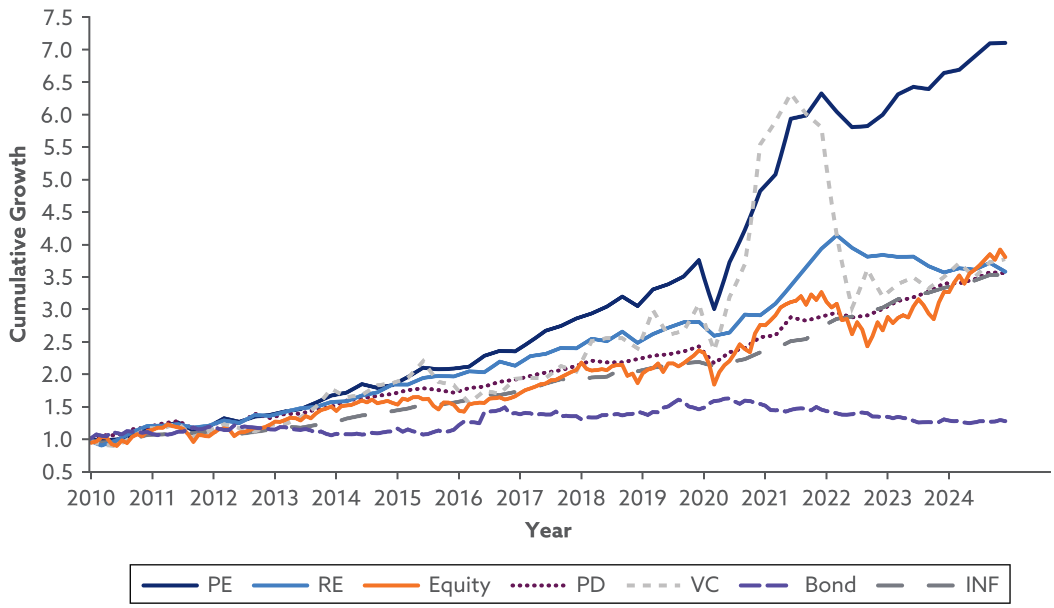
Exhibit 2 shows that the mean monthly returns are highest for private equity (1.10%), followed by equity (0.75%) and venture capital (0.74%). However, these higher returns are accompanied by greater volatility, particularly in venture capital (4.39%) and equity (4.35%). Venture capital also has the largest maximum drawdown (−52.18%) and the greatest range in returns among private market assets (minimum of −10.62% and maximum of 14.43%), indicating that it is the riskiest segment of the private market universe. Infrastructure offers moderate returns with comparatively lower volatility and drawdowns, indicating a more stable risk profile. Most private market asset classes show negative skewness and elevated kurtosis, indicating exposure to downside tail events. The first-order autocorrelation across all private market assets is higher relative to equities and bonds because of the desmoothing method applied, where adjustments to the return series are based on the first-order autocorrelation.

The use of a multivariate normal distribution to simulate returns is intended as a tractable approximation to the long-run behaviour of asset classes, rather than capturing short-term return dynamics. A multivariate normal distribution simulation-based approach is also used by Cui et al. (2025), who conducted Monte Carlo analysis to study retirement outcomes over long horizons. As in Cui et al. (2025), we also simulate returns based on a multivariate normal distribution, recognising the parsimonious and transparent framework of this approach for scenario analysis. However, using this approach assumes that returns are normally distributed, which may not be fully reflected in the data. In the Sensitivity Analysis section, we explore other approaches, such as the bootstrap approach, to construct an empirical distribution, which does not assume returns are normally distributed. In this regard, the model should be interpreted as a baseline tool for long-term projections, with the recognition (as observed in the data) that actual return distributions may show skewness and excess kurtosis.

Exhibit 3 represents a cumulative growth plot per dollar invested for the equity, bond, and private market asset classes in our dataset. The plot shows steady growth in returns across all asset classes (except bonds) before 2020. Beginning in 2020, there is a steep increase in venture capital and private equity. After 2021, the cumulative growth of venture capital drastically decreases while equity continues to increase, resulting in the highest end value across all asset classes and representing a return of approximately seven times the initial investment over the 15-year period. In contrast, bonds show the lowest fluctuation and magnitude in cumulative growth across all asset classes, as one would expect given the perceived safety of this asset class. Overall, the data show the return-enhancing potential of private markets alongside their higher tail risk and drawdown exposure.

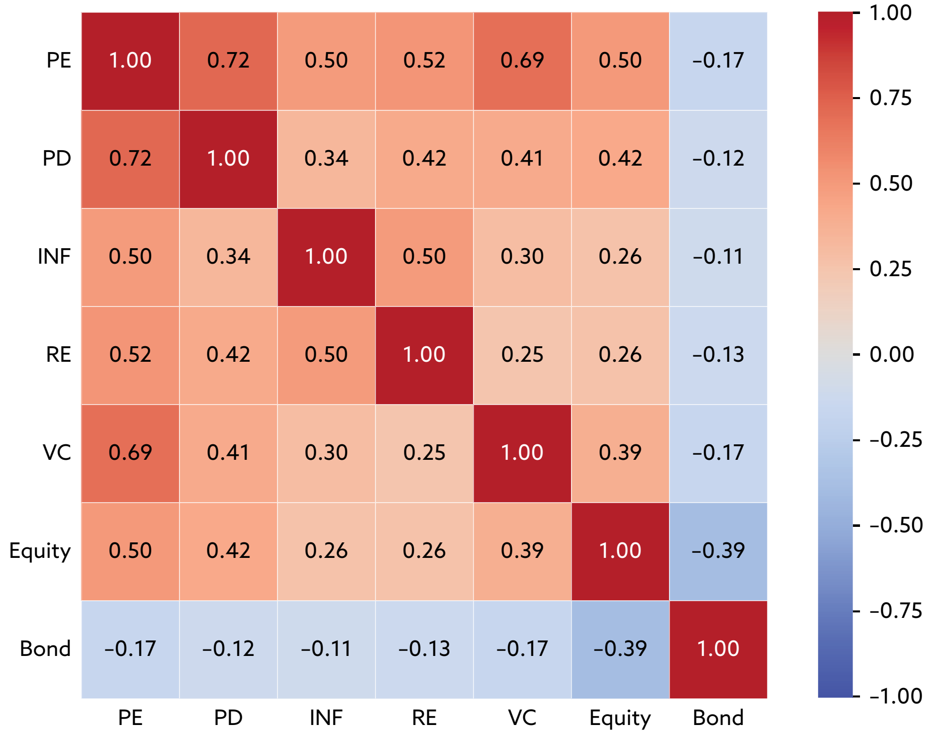
In **Exhibit 4**, we plot the correlations between the equity, bond, and private market asset classes over the whole period. There is a relatively low pairwise correlation between equity and infrastructure (0.26) and equity and real estate (0.26). However, equity does show a higher correlation with private equity (0.50), which highlights the variation in the level of diversification in private markets. Bonds show negative correlation with all asset classes, pointing to their portfolio diversification benefits. Notably, the pairwise correlations between bonds and private market assets (ranging from −0.11 to −0.17) are lower in magnitude than the correlation between equities and bonds (−0.39).

Exhibit 3. Cumulative Growth of Return Series for Equity, Bond, and Private Market Assets, 1 January 2010–31 December 2024



Note: PE = private equity; PD = private debt; INF = infrastructure; RE = real estate; VC = venture capital.

Exhibit 4. Correlation Plot of the Return Series for Equity, Bond, and Private Market Indices, 1 January 2010–31 December 2024



While we only consider TDFs with a single private market asset class, correlations between private market assets can vary. This is illustrated in Exhibit 4 by the high correlation between private equity and private debt (0.72) compared to the relatively low correlation between venture capital and real estate (0.25). The correlation values highlight how different combinations of the respective private market asset classes can impact the performance of the DC plan.

RESULTS

We evaluate DC plan performance for the baseline TDF and the TDF with a 10% private market allocation. For this analysis, we consider a 10% private market allocation in the TDF to only one private market asset class. For all TDFs, we assume the same individual member profile for cash contributions, including assumptions on salary contribution, salary growth, and the time horizon of accumulation. For each TDF, we generate samples representing pathways of accumulation under a Monte Carlo approach to produce a distribution of accumulation outcomes, as noted earlier.

We evaluate DC plan performance using the following metrics:

- **Term mean**—the average end accumulation value of the DC plan across all samples.
- **Term volatility**—the standard deviation of end accumulation values in the DC plan across all samples.
- **Term P5**—the end accumulation value, which corresponds to the 5th percentile across all samples: One can interpret the term P5 value as a 5% probability in which the end accumulation value is below the given value, across all samples.
- **Term P95**—the term value of the DC plan accumulation value corresponding to the 95th percentile across all samples: The term P95 value can be considered a 5% probability for which the end accumulation value exceeds the given value, across all samples.
- **Sharpe (annual) mean**—an average of the annual Sharpe ratio across all samples: Across the accumulation period, we assume the risk-free rate used for the Sharpe ratio is equal to 3%. This is a stylised proxy based on US short-term Treasuries, given that portfolio returns are modelled in US dollars.[15]

We first present the initial results to show whether private market allocation in TDFs can improve DC plan performance. We then perform a sensitivity analysis varying the allocation to private markets and TDF glide-path design and discuss how these results compare to the baseline TDF and initial results. Summary statistics for the sensitivity analysis are provided in Exhibit A2 in the appendix.

Initial Results

Exhibit 5 represents trajectories of the DC plan performance for the respective TDFs averaged across all pathways (Panel A) and trajectories of the difference in DC plan accumulation values between a given TDF with private market

[15]Note that this is a simplifying assumption that provides a consistent benchmark for comparing risk-adjusted performance across TDFs, which is broadly consistent with Antonelli (2025).

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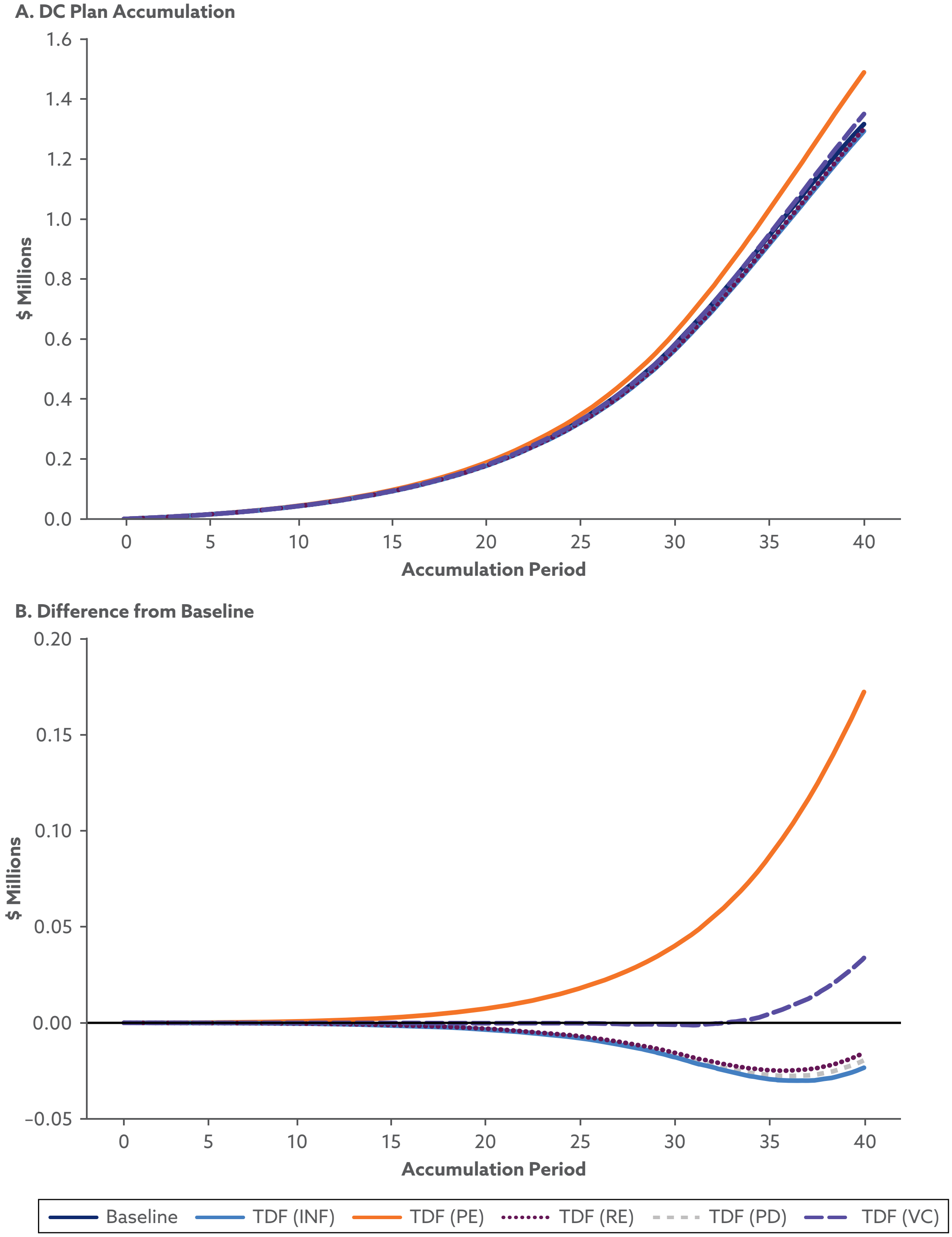
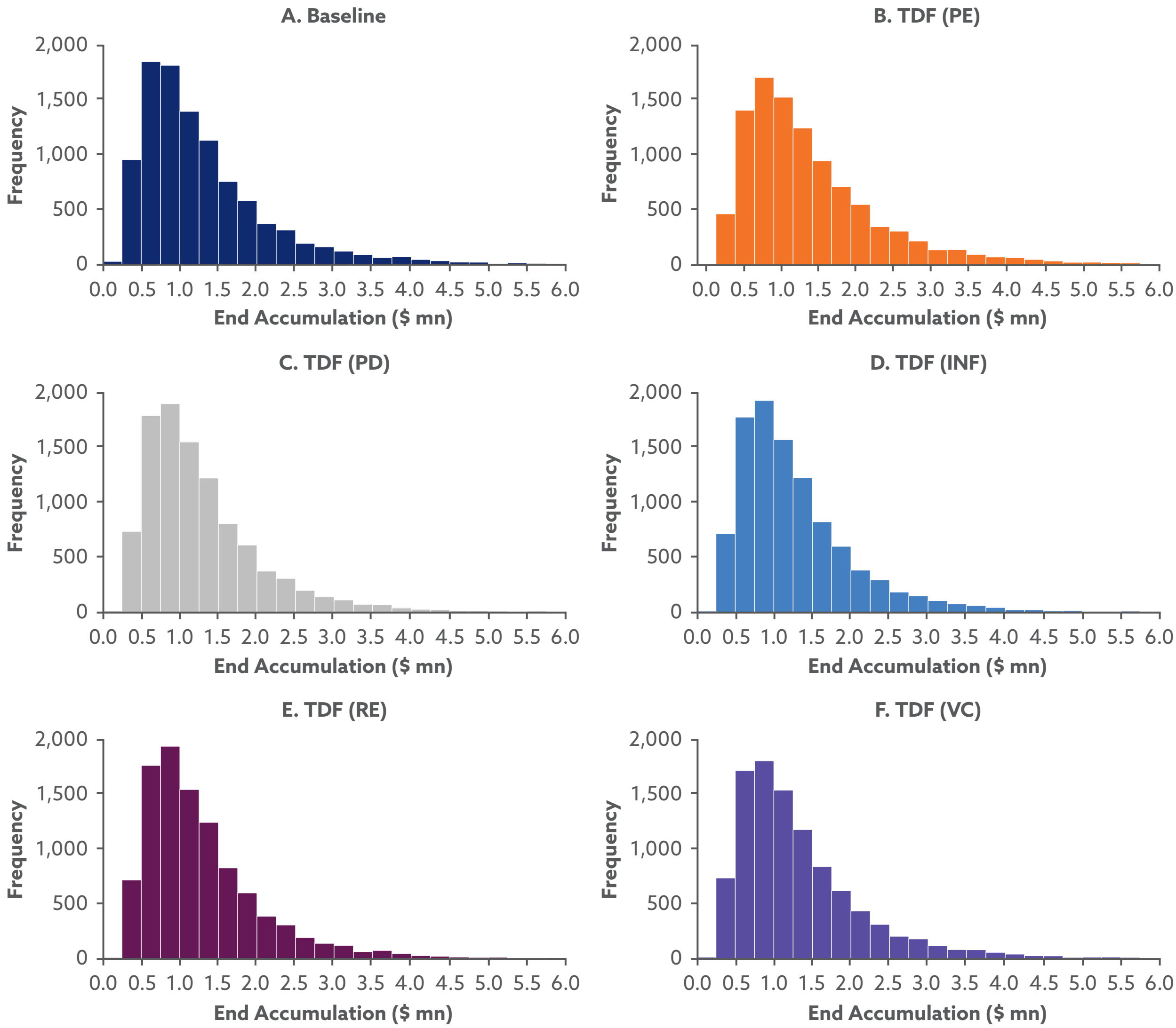
Exhibit 5. Trajectories of the Average DC Plan Accumulation Value for Baseline TDF and TDFs with Various Private Market Allocations



Note: Each TDF denoted with a private market abbreviation represents a TDF that has allocation to only that private market asset class.

allocation and the baseline TDF (Panel B). For the difference with respect to the baseline TDF, higher values indicate higher accumulation values of the TDF with private market assets relative to the baseline TDF. For example, TDF (PE) represents a TDF that has an allocation to equities, bonds, and private equity, where the allocation follows the glide path shown in Exhibit 1. **Exhibit 6** represents histograms for the distribution of end accumulation values across the various TDFs under the Monte Carlo approach. **Exhibit 7** represents summary statistics across different DC plans for the metrics described below.

Exhibit 6. Distribution of End Accumulation Values, Baseline TDF vs. TDF with Private Market Allocation (Monte Carlo Approach)



Note: Each TDF denoted with a private market abbreviation represents a TDF that has allocation to only that private market asset class.

Exhibit 7. DC Plan Performance for Various TDFs (Monte Carlo Approach)

TDF	Term Mean ($ millions)	Term Volatility ($ millions)	Term P5 ($ millions)	Term P95 ($ millions)	Sharpe Ratio Mean (annual)
Baseline	1.316	0.939	0.414	3.069	0.462
PE	1.489	0.977	0.506	3.324	0.531
PD	1.297	0.824	0.457	2.855	0.500
INF	1.293	0.812	0.458	2.829	0.503
RE	1.301	0.823	0.457	2.851	0.502
VC	1.350	0.902	0.451	3.032	0.493

Note: For TDFs with private market allocations, we assume a 10% allocation to the private market asset class.

In Panel A of Exhibit 5, the TDF with private equity and the TDF with venture capital show an increase in average end accumulation values compared to the baseline TDF. The graph shows that there is little variation in DC plan values over the first 30 years of the investment horizon, as one would expect, reflecting the fixed 100% equity allocation in the baseline TDF and the 90/10 equity/private market allocation in the other TDFs. As the period of accumulation increases, there is a greater distinction between TDFs with private market allocations and the baseline TDF. This is observed with private equity, which shows marginal outperformance over this period compared to other TDFs. We find that the higher accumulation values in the TDF with private equity are consistent with the higher average returns in private equity compared to equity, as shown earlier in Exhibit 2.

The results presented in Exhibit 5 show that a 10% private market allocation over 30 years does not materially affect DC plan outcomes compared to the baseline TDF. Where outcomes differ, however, is in the last 20 years, particularly in the final 10 years of the investment horizon as the portfolio is successively rebalanced. After 30 years, under our glide-path assumption, the TDF is rebalanced quarterly, substituting equities for bonds to end the period, resulting in a 30/70 equity/bond split in the baseline TDF and a 27/63/10 split in the TDFs with private markets (which hold private assets fixed at 10%). After 30 years of accumulation, average growth slows as the glide path shifts across all DC plans from equities toward bonds, reducing fund returns and volatility.

Exhibit 6 shows a histogram representing the distribution of end accumulation values for each TDF, and Exhibit 7 shows summary statistics for each distribution.

Collectively, the exhibits highlight the differences in the risk–return profiles of the TDFs. Exhibit 7 shows that the TDF with private equity includes the highest term mean ($1.489 million) but also the broadest range in end accumulation values. Relatively, the term mean for the TDF with private equity is 13% higher than the term mean of the baseline TDF ($1.316 million), representing a difference of $173,000 in nominal wealth. In the histogram, the TDF with an allocation to venture capital also displays a wide distribution (Exhibit 6). This is consistent with our earlier observations about the performance variability of this asset class (shown in Exhibit 2), though its term mean ($1.35 million) is lower than that for private equity. For the TDFs with private debt, infrastructure, and real estate, distributions have lower dispersion across end accumulation values. We find histograms shown in Exhibit 6 are right skewed (i.e., private equity and venture capital), indicating there are scenarios where end accumulation values can be very high.

It is notable that the mean annual Sharpe ratio is higher for all TDFs that incorporate private markets than for the baseline TDF, illustrating the risk-adjusted return benefits from the inclusion of private markets. In the case of infrastructure and real estate, the Sharpe ratio improvement compared to the baseline TDF comes from lower volatility, with Exhibit 7 showing the lowest term volatility from the TDFs that incorporate these asset classes. For the tail-end performance, while the term P95 value for infrastructure and real estate is lower than for other private market allocations, the term P5 value is similar to that for private debt and higher than that for venture capital.

For robustness, we also provide summary statistics on the performance of the TDFs using a bootstrap approach. The results from using the bootstrap approach and how they compare to the Monte Carlo results are provided in Exhibit A1 in the appendix. We use this approach to assess how assumptions of normality under the Monte Carlo approach impact projected end accumulation values. However, we recognise that neither approach accounts for the serial correlation in private market returns, which can be an extension for future work. Consistent with the Monte Carlo results, the bootstrap analysis also indicates a mixed effect of private market allocation on TDF performance. The main difference between the two methods is in the magnitude of the DC plan estimated outcomes. Apart from the mean annual Sharpe ratio, where values are higher under the bootstrap approach, all other performance metrics show lower values under the bootstrap method than for the Monte Carlo approach.

Comparing the performance across the various TDFs with private market allocations, the results are broadly consistent for both approaches. Private equity and venture capital have the highest term mean accumulation values. Infrastructure, real estate, and private debt have the lowest term volatility. Sharpe ratios for the TDFs with private market allocations are all higher than that for the baseline. Although the magnitudes differ between the methods, the bootstrap results preserve a similar relative ordering of TDF performance across private market allocations.

Allocation to Multiple Private Market Assets

In this section, we consider the performance of DC plans when TDFs include allocations to multiple private market assets. Instead of allocating 10% to a single private market asset class, as in the initial results, we consider TDFs that allocate 5% to a growth-oriented private market asset and 5% to a defensive-oriented private market asset throughout the accumulation period. We examine this allocation to evaluate how portfolios with growth and defensive-based assets balance long-term return objectives with downside risk. Extending this to private markets allows us to assess whether combining higher-return private assets with more defensive private assets can improve retirement outcomes relative to allocation to a single private market asset class.

For example, under the single private market allocation used in the initial results, the TDF holds a 90/10 allocation to equities and private markets during the first 30 years. Over the final 10 years, this transitions to a 27/63/10 allocation to equities, bonds, and private markets. Under the growth-and-defensive private market allocation, the total private market allocation remains 10%, but it is split evenly between the two private market categories. A TDF with a multi-private market allocation therefore holds a 90/5/5 allocation to equities, growth-oriented private market assets, and defensive-oriented private market assets during the first 30 years. In the final 10 years, this transitions to a 27/63/5/5 allocation to equities, bonds, growth-oriented private market assets, and defensive-oriented private market assets.

We categorise private market assets as growth or defensive using only the asset classes included in this paper. Specifically, we categorise private equity and venture capital as growth-based private market assets and private debt, infrastructure, and real estate as defensive-based private market assets. The characterisation of the private market asset classes used here is based on the return summary statistics from Exhibit 2: Growth assets (PE, VC) are associated with high mean returns and high volatility, and defensive assets (INF, RE, PD) have lower mean returns and volatility relative to other private market assets. With the low correlation between growth and defensive private market assets, a combination of the two types could improve TDF performance.[16]

As in the initial results, we assume the allocation to private market assets is constant throughout the accumulation period and that the dynamic allocation to equities and bonds under the TDF glide path remains the same. We assume that the starting salary ($25,000) and salary contribution (5% from employee and 5% from employer) remain the same. In addition, we use the Monte Carlo approach to evaluate outcomes by generating 10,000 accumulation pathways for each TDF, where the return distribution is assumed to be a multivariate

[16]While we assume a 5% constant allocation to growth and defensive private market assets, this allocation is only one option among many. Other values or other approaches for which allocations are determined can also be considered (e.g., a dynamic allocation between growth and defensive private market assets or a portfolio optimisation-based approach). In addition, beyond private market assets, other types of defensive assets could be included in the TDF, such as gold, other commodities, or derivatives (hedging).

normal distribution. We evaluate the performance under the same metrics as shown in Exhibit 7.

In **Exhibit 8**, summary statistics are denoted based on the abbreviated private market asset class included. For example, PE + PD represents a 5% allocation to private equity and a 5% allocation to private debt within the TDF; abbreviations similarly apply to all other private market asset combinations. Accounting for all pairwise combinations between growth and defensive private market assets yields the six possible combinations shown in the exhibit.

The results shown in Exhibit 8 are mixed. The multi-private market asset allocation pairings show that combining a growth-oriented and a defensive-oriented private market asset improves some performance metrics and weakens others relative to a TDF holding a single private market asset. Relative to the baseline values, the term mean, term P5, and Sharpe mean of all multi-asset private market portfolios are higher, with the term volatility being lower. Across all metrics, the term P95 value is the only metric on which the baseline exceeds some multi-asset portfolios, as observed with all venture capital portfolios and the private equity plus infrastructure portfolio.

In the case of private equity shown in Exhibit 8, we find the term volatility (<$0.9 million) is lower when including defensive-based private market assets than the term volatility when only private equity is included ($0.977 million, per Exhibit 7), as expected. However, including defensive private market assets alongside private equity decreases the term mean and term P95 compared to the corresponding TDF with private equity only, reflecting the lower proportion of growth assets in the TDF. Correspondingly, Exhibit 8 shows a slightly lower mean annual Sharpe ratio (<0.52) compared with the TDF with only private equity (0.531, per Exhibit 7).

For venture capital in Exhibit 8, however, the inclusion of defensive private market assets marginally improves the mean annual Sharpe ratio (>0.497)

Exhibit 8. DC Plan Performance for Various TDFs (Monte Carlo Approach)

TDF	Term Mean ($ millions)	Term Volatility ($ millions)	Term P5 ($ millions)	Term P95 ($ millions)	Sharpe Mean (annual)
Baseline	1.316	0.939	0.414	3.069	0.462
PE + PD	1.389	0.897	0.481	3.079	0.515
PE + INF	1.387	0.890	0.482	3.06	0.517
PE + RE	1.391	0.896	0.482	3.071	0.517
VC + PD	1.323	0.861	0.455	2.94	0.497
VC + INF	1.321	0.854	0.456	2.931	0.499
VC + RE	1.325	0.860	0.456	2.942	0.498

relative to the TDF that includes only venture capital (0.493, per Exhibit 7). Although the term mean and term P95 values are lower than those of the TDF with an allocation only to venture capital, other metrics improve. In particular, term volatility is lower and term P5 is higher. This suggests that combining venture capital with defensive private market assets can reduce volatility in end accumulation outcomes and improve tail performance.

Overall, the results shown in Exhibit 8 suggest that the choice of defensive private market asset can affect performance metrics, but its impact is relatively limited when paired with growth-oriented private market assets. In this context, infrastructure, real estate, and private debt appear to have broadly similar effects in the multi-private market TDFs examined. Thus, our findings suggest that the design of TDFs with multiple private market allocations should account not only for the return distribution between public and private market assets but also for the interaction among different private market asset classes.

Private Market Allocation (20%)

We next consider DC plan performance among various TDFs when there is a 20% allocation (instead of 10% as assumed in the initial results) to only one private market asset over the 40-year investment horizon. All other parameters, including the salary contribution and growth under the TDF, remain unchanged. The glide path is similar to that shown in Exhibit 1, except that for the first 30 years, there is an 80% allocation to equities and a 20% allocation to private markets instead of a 90/10 split. Then, in the last 10 years of accumulation, there is a linear reallocation of assets from equities to bonds. The end accumulation for equites, bonds, and private markets is equal to 24/56/20, with the private market allocation remaining constant across the whole period.

We again use a Monte Carlo approach to generate 10,000 accumulation pathways for each TDF under a multivariate normal distribution for asset returns, using the same data values as in the initial results. To evaluate DC plan performance, we use the same metrics as in Exhibit 7. In addition, we include the relative change from corresponding values in the initial results.

As shown in **Exhibit 9**, the results when increasing the allocation to private markets appear mixed. For the TDF with private equity, we find a higher term mean ($1.684 million), which is 28% higher relative to the baseline TDF ($1.316 million) and 13% higher than the term mean for the TDF with a 10% allocation to private equity. In addition, the term P95 ($3.6 million) and term P5 ($0.616 million) values are higher for private equity than for the baseline TDF, representing an 8.3% increase in term P95 and a 21.74% increase in term P5 relative to initial values. However, the increased allocation to 20% private equity also increases the term volatility ($1.014 million), which is 3.79% higher relative to initial values. Finally, the mean annual Sharpe ratio with private equity (0.61) is 14.9% higher than the mean annual Sharpe ratio under initial values. The magnitude of the relative increase in values under a 20% private market

Exhibit 9. DC Plan Performance for Various TDFs with 20% Allocation to Private Markets (Monte Carlo Approach)

TDF	Term Mean ($ millions)	Term Volatility ($ millions)	Term P5 ($ millions)	Term P95 ($ millions)	Sharpe Mean (annual)
Baseline	1.316	0.939	0.414	3.069	0.462
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
PE	1.684	1.014	0.616	3.6	0.61
	(13.10)	(3.79)	(21.74)	(8.30)	(14.88)
PD	1.278	0.72	0.502	2.653	0.544
	(−1.46)	(−12.62)	(9.85)	(−7.08)	(8.80)
INF	1.27	0.697	0.508	2.601	0.554
	(−1.78)	(−14.16)	(10.92)	(−8.06)	(10.14)
RE	1.285	0.719	0.506	2.658	0.55
	(−1.23)	(−12.64)	(10.72)	(−6.77)	(9.56)
VC	1.385	0.881	0.486	3.029	0.521
	(2.59)	(−2.33)	(7.76)	(−0.10)	(5.68)

Note: Relative changes from corresponding values in the initial results in Exhibit 7 are represented in parentheses as a percentage (positive numbers represent an increase from initial results and negative a decrease).

allocation compared to a 10% allocation is highest for private equity across all private market assets.

Exhibit 9 also shows mixed performance for private debt. The term mean ($1.278 million) under the 20% private equity allocation is lower relative to the baseline TDF and 1.5% lower than under the 10% allocation for the corresponding TDF (shown in Exhibit 7). However, this does lead to a lower term volatility and higher term P5 value compared to initial values. Overall, there is a higher mean annual Sharpe ratio for private debt (0.544), which is 8.8% higher relative to initial values.

For infrastructure and real estate, we find that the term mean for both infrastructure ($1.27 million) and real estate ($1.285 million) is slightly lower under a 20% allocation than the initial values. Like private debt, there is a decrease in the term P95 value but an increase in the term P5 value relative to initial values. As with other private market asset classes, the mean annual Sharpe ratio for infrastructure (0.554) and real estate (0.55) is higher than initial values and also higher than the baseline TDF value.

Venture capital is the only private market asset in which the TDF term mean increases and the term volatility decreases. The term mean ($1.385 million) and the mean annual Sharpe ratio (0.521) are higher under the 20% allocation than the corresponding initial VC values in Exhibit 7. The term volatility is also lower (0.881) relative to the initial values. For the tail performance, the term P5 value ($0.486 million) is also higher, although the term P95 value ($3.029 million) shows a small decrease relative to the initial values.

Overall, the results show that increasing the private market allocation increases net risk-adjusted performance and decreases downside risk compared to a 10% allocation in the corresponding asset class. However, among other metrics, there appears to be a mixed performance.

Sensitivity Analysis

To assess the sensitivity of these results to our glide-path assumptions, we consider three changes to the glide-path design. Each sensitivity analysis changes only one parameter relative to the baseline specification, where all other parameter inputs and glide-path assumptions remain the same as in the initial results. Specifically, we (1) reduce the equity-to-bond transition period from 10 years to 5 years; (2) change the end-state allocation from 30/70 to 50/50 between equities and bonds, which for TDFs with private market allocations implies a shift from 27/63/10 to 45/45/10 in equities, bonds, and private markets; and (3) reduce the accumulation period from 40 years to 30 years, under which equities are held for the first 20 years before a linear transition to bonds over the final 10 years. For each analysis, the private market allocation remains constant at 10% in all cases.

As before, we use a Monte Carlo approach to generate 10,000 pathways for each TDF, where the return distribution is based on a multivariate normal distribution. Summary statistics for the sensitivity analysis can be found in Exhibit A2 in the appendix.

Across these sensitivity tests, glide-path design choices can shift outcomes at least as much as—and in some cases more than—changes in the private market allocation. Decreasing the equity-to-bond transition to five years raises the term mean between 22% and 26% for all TDFs but also increases the term volatility, as expected. Moving to an equal weighting between equities and bonds at the end of the accumulation period leads to a small increase in both the term mean and term volatility, while leaving the relative ranking in performance metrics between TDFs with private market allocations largely unchanged.

Decreasing the accumulation horizon to 30 years has the largest impact on performance, with the term mean falling by around 65% and the term P95 value sharply decreasing for all TDFs. This finding reflects the loss of compounding of cash flows and returns over 10 years and illustrates that time horizon is one of the most critical components of DC pension plan outcomes. Overall, the sensitivity results show that time horizon and glide-path structure are first-order drivers of retirement outcomes. Private market allocations should therefore be assessed as part of the broader DC plan design.

CONCLUSION

The results show that TDFs with a private market allocation can improve the mean annual Sharpe ratio relative to the baseline TDF. Under a single private market allocation, private equity generates the highest term mean, followed by venture capital, reflecting the growth-oriented nature of these assets and their higher risk profile. By contrast, private debt, infrastructure, and real estate (defensive-type assets) contribute more to lowering term volatility and reducing downside risk.

When two private market asset classes are included in a TDF, the change in accumulation outcomes relative to a single allocation depends on which private market assets are included. Generally, a mix of growth and defensive private assets serves to lower the variability of performance and accumulation outcomes across TDFs, with only modest changes to Sharpe ratios compared to holding only one private market asset class. These findings suggest that private market allocations should be selected based on the desired improvement in a given performance metric. Plan sponsors should clearly communicate to investors the risk-reducing or return-enhancing nature of the various combinations of private assets in a given TDF product so that investors can make informed product choices that are suitable for their risk tolerance and return expectations.

Importantly, glide-path design—particularly the time horizon of accumulation and the equity-to-bond transition period—can have a larger impact on retirement outcomes than the private market allocation itself. This highlights the fact that allocating to private markets should not be treated as a standalone decision but should be evaluated as part of the plan design. Time horizon is arguably the most significant contributor to the delivery of retirement outcomes that individual members expect.

This analysis has important implications for industry stakeholders. For DC plan providers and sponsors, private market inclusion in fund offerings, including default funds, should recognise that not all private market exposures are equal. Inclusion of private markets requires careful selection of funds and calibration of product design, along with clear disclosures and educational tools, to enable DC plan members to make informed choices. For individual DC plan members, contribution discipline and investment time horizon can matter more than whether a TDF allocates to private markets. Members should have access to transparent disclosures and key features documents on which asset classes are included, the size of the allocation, and the associated fees since not all private market exposures improve end accumulation equally. Finally, for policymakers and regulators, oversight should extend to TDF design, particularly in default funds, with scrutiny on fee transparency, liquidity standards, and glide-path adequacy.

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APPENDIX

Here we provide further information on how we constructed the private market indexes using the PitchBook private market indexes, as well as details on the bootstrap approach and sensitivity analysis.

PitchBook Indexes

The PitchBook private market indexes are constructed from cash flow and valuation data for active, finite-life, closed-end drawdown funds, with returns reported net of fees and expenses. Index returns are calculated as pseudo-time-weighted quarterly returns, with index membership reconstituted quarterly and historical values restated as new data arrive. For a full description of the index construction methodology, the "PitchBook Fund Benchmarks Data and Methodology" publication (September 2025) provides further detail.[17] Using these indices, we provide descriptions of the desmoothing methods and conversion from quarterly to monthly returns, which we use on the data.

Because appraisal-based valuations are used, fund returns may be smoothed, which may overestimate the risk-adjusted performance of the asset class. We hence apply a desmoothing technique across all private market indices, where we adjust returns based on a first-order autocorrelation correction. The first-order autocorrelation is the correlation of the return series with the lagged return series by one time step. Using the approach by Geltner (1993), the desmoothed return is equal to the original return minus the return in the previous time step multiplied by the autocorrelation, where the whole expression is divided by 1 minus the autocorrelation. Based on this adjustment, the higher the first-order autocorrelation, the higher the magnitude of returns and the higher the volatility of the return series. Note that while other desmoothing approaches can also be applied, we chose this approach for its transparency, where assumptions on the multi-lag and proxies are not required.

For example, assume that the quarterly returns in March 2026 are 3%, the December 2025 quarterly returns are 2%, and the estimated first-order autocorrelation for the whole return series is 0.4. Then, the desmoothed quarterly return for March 2026 is equal to $(0.03 - 0.4 \times 0.02)/(1 - 0.4)$, which is approximately equal to 3.67%. In the case where the quarterly returns for March 2026 are negative, equal to −3%, with the December 2025 quarterly returns and first-order autocorrelation remaining the same, then the desmoothed quarterly returns in March 2026, $(-0.03 - 0.4 \times 0.02)/(1 - 0.4)$, would approximately equal −6.33%. As illustrated in the numerical examples, desmoothing leads to a wider range of returns that increase the volatility of the return series.

After applying the desmoothing method, we convert the desmoothed quarterly private market returns into monthly returns using a simple equal monthly

[17] Further information and clarification requests can be sent to benchmarks@pitchbook.com.

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compounding approach. The resulting returns will represent desmoothed monthly returns that are based on the desmoothed quarterly returns. As with the desmoothing method chosen, we use the equal monthly compounding approach because it is transparent and avoids assumptions on proxy dependence and model noise.

Assume that the desmoothed quarterly returns are equal to 5% for the end of March 2026. Then we convert these returns into monthly returns, where, for our example, we would have monthly returns for the given quarter of $(1 + 0.05)^{1/3} - 1$, approximately equal to 1.64%. This monthly return would then represent the desmoothed monthly return for each month in the quarter, such that the monthly returns for January, February, and March in 2026 would all equal 1.64%. We apply the equal monthly compounding approach for each quarter, until we convert the whole desmoothed quarterly return series into a desmoothed monthly return series.

Bootstrap Approach

A Monte Carlo approach is used in the main analysis, with asset returns assumed to follow a multivariate normal distribution that generates a range of accumulation scenarios. An alternative approach is bootstrapping, which generates return paths by sampling directly from the empirical distribution of observed returns. Compared to a Monte Carlo simulation, a bootstrap approach has the advantage of not imposing a parametric distribution, where the generated return series preserves properties of the historical data (e.g., skewness and kurtosis). To illustrate the difference, suppose the observed return series is (0.1, 0.2, 0.3). Under a Monte Carlo approach, one would estimate the mean return (0.2) and the volatility (0.08) and then simulate new returns from the implied normal distribution. Based on a Monte Carlo approach, a possible simulated return series with a length of three might equal (0.23, 0.19, 0.26). Under a bootstrap approach, individual returns are sampled with replacement from the empirical series itself. Using the same example return series of (0.1, 0.2, 0.3), a generated return series under the bootstrap approach could equal (0.1, 0.1, 0.3) or (0.3, 0.2, 0.2).

Performance for the various TDFs using the bootstrap approach is shown in **Exhibit A1**.

As in the Monte Carlo analysis, each simulated path is then used to evaluate accumulation outcomes for the TDFs, with end accumulation values compared across the various TDFs. Although the bootstrap method may retain the tailed behaviour of the return series, the resampling relies entirely on the historical sample; so, the simulated scenarios remain backward looking in nature. This backward analysis does not incorporate structural changes in the asset class that could lead to differing future outcomes. In comparison, a Monte Carlo approach is more suitable for forward-looking analysis. Nevertheless, we use the bootstrap as a robustness check and to assess the impact of normality assumptions on results.

Exhibit A1. DC Plan Performance for Various TDFs (Bootstrap Approach)

TDF	Term Mean ($ millions)	Term Volatility ($ millions)	Term P5 ($ millions)	Term P95 ($ millions)	Sharpe Mean (annual)
Baseline	1.196	0.682	0.474	2.432	0.462
PE	1.376	0.760	0.561	2.755	0.530
PD	1.197	0.620	0.511	2.332	0.499
INF	1.191	0.599	0.521	2.287	0.503
RE	1.202	0.621	0.515	2.345	0.502
VC	1.290	0.789	0.486	2.695	0.495

Summary Statistics from the Sensitivity Analysis

Exhibit A2 provides the complete summary statistics for sensitivity analysis of DC plan performance in this study. We conduct three sensitivity analyses, as described in the Sensitivity Analysis section. For each analysis, we assume all other glide-path design and parameter choices remain the same as in the initial results.

Exhibit A2. DC Plan Performance Summary Statistics for Various TDF Parameter Settings (Sensitivity Analysis)

TDF	Term Mean ($ millions)	Term Volatility ($ millions)	Term P5 ($ millions)	Term P95 ($ millions)	Sharpe Mean (annual)
Equity-to-bond transition (5 years)					
Baseline	1.654	1.346	0.44	4.083	0.473
	(25.68)	(43.34)	(6.28)	(33.04)	(2.38)
PE	1.829	1.358	0.534	4.325	0.537
	(22.83)	(39.00)	(5.53)	(30.11)	(1.13)
PD	1.593	1.15	0.481	3.706	0.509
	(22.82)	(39.56)	(5.25)	(29.81)	(1.80)
INF	1.588	1.133	0.487	3.678	0.512
	(22.82)	(39.53)	(6.33)	(30.01)	(1.79)
RE	1.598	1.149	0.486	3.722	0.511
	(22.83)	(39.61)	(6.35)	(30.55)	(1.79)
VC	1.658	1.254	0.479	3.962	0.502
	(22.81)	(39.02)	(6.21)	(30.67)	(1.83)

(continued)

Exhibit A2. DC Plan Performance Summary Statistics for Various TDF Parameter Settings (Sensitivity Analysis) (*continued*)

TDF	Term Mean ($ millions)	Term Volatility ($ millions)	Term P5 ($ millions)	Term P95 ($ millions)	Sharpe Mean (annual)
Equity-to-bond allocation (50/50)					
Baseline	1.423	1.049	0.433	3.362	0.47
	(8.13)	(11.71)	(4.59)	(9.55)	(1.73)
PE	1.597	1.081	0.526	3.604	0.537
	(7.25)	(10.64)	(3.95)	(8.42)	(1.13)
PD	1.391	0.912	0.475	3.094	0.506
	(7.25)	(10.68)	(3.94)	(8.37)	(1.20)
INF	1.387	0.898	0.477	3.077	0.51
	(7.27)	(10.59)	(4.15)	(8.77)	(1.39)
RE	1.395	0.911	0.478	3.098	0.509
	(7.23)	(10.69)	(4.60)	(8.66)	(1.39)
VC	1.448	0.999	0.47	3.297	0.499
	(7.26)	(10.75)	(4.21)	(8.74)	(1.22)
Years of accumulation (30 years)					
Baseline	0.46	0.244	0.197	0.927	0.46
	(−65.05)	(−74.01)	(−52.42)	(−69.79)	(−0.43)
PE	0.505	0.248	0.228	0.977	0.531
	(−66.08)	(−74.62)	(−54.94)	(−70.61)	(0.00)
PD	0.459	0.218	0.213	0.872	0.499
	(−64.61)	(−73.54)	(−53.39)	(−69.46)	(−0.20)
INF	0.458	0.215	0.214	0.868	0.503
	(−64.58)	(−73.52)	(−53.28)	(−69.32)	(0.00)
RE	0.46	0.218	0.214	0.873	0.501
	(−64.64)	(−73.51)	(−53.17)	(−69.38)	(−0.20)
VC	0.471	0.234	0.211	0.914	0.492
	(−65.11)	(−74.06)	(−53.22)	(−69.85)	(−0.20)

Note: The numbers in parentheses represent the relative percentage increase (positive number) or decrease (negative number) in the value above relative to the initial results.

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