PGIM
MULTI-ASSET SOLUTIONS

COLLECTIVE DEFINED CONTRIBUTION (CDC) SCHEMES

Assessing Capacity for Alternative Investments

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As pension systems adapt to changing economics and demographics, there is growing interest in collective defined contribution (CDC) schemes as they offer a different approach to retirement savings compared to defined benefit (DB) schemes. Instead of providing a guaranteed pension payment, CDC schemes provide workers with a pot of money to use in retirement, alleviating corporate sponsors of the responsibility and cost associated with providing lifetime guaranteed benefit payments. The size of the pension pot can increase or decrease depending on factors such as investment returns and contribution levels. In CDC schemes, the fund is managed collectively, meaning that investment and longevity risks can be shared among participants, potentially making retirement outcomes more resilient to market shocks compared to individual defined contribution plans.[1]

For example, the Dutch pension system (the largest occupational pension system in the euro area[2]) is transitioning from a DB to a CDC model, following the Dutch legislature's approval of the Future of Pensions Act (Wet toekomst pensioenen – WTP).[3] This reform, which became effective in July 2023 with a transition period until January 2028, marks a significant shift in the Dutch pension sector and reflects a broader move towards more flexible and individualized pension planning. Similarly, in the UK, The Pensions Regulator recently approved the Royal Mail Collective Pension Plan as the UK's first CDC scheme.[4]

Many DB plans have dynamic asset and liability management strategies, aligning closely with the plans' funding ratios – an investment approach encouraged by strict regulation that steered funds towards risk-hedging and short-term stability and away from risk-taking and

1 Mirza-Davies, J., "Pensions: Collective Defined Contribution (CDC) schemes," House of Commons Library, April 2024.
2 "The structural impact of the shift from defined benefits to defined contributions", European Central Bank, 2024.
3 "The Netherlands to reform its pension system," Lockton Global Benefits, August 2023. Three types of CDC pension schemes will be allowed under the proposed new system: the solidarity contribution scheme, the flexible contribution scheme, and the contribution-capital scheme.
4 Pielichata, P., "Regulator stamps approval on Royal Mail's collective DC plan," April 2023.

long-term returns.[5] For a possible transition to a CDC model, plan managers may begin to adjust their hedging policies and asset mix to prepare for the new system. Since certain regulatory constraints are more stringent for a DB scheme than for a CDC scheme, CDC schemes have an opportunity to explore different asset mixes that were previously unattainable under DB schemes. Arguably, CDC schemes might take a longer-term investment strategy compared to regular DC schemes because they have a pooled mix of members which allows pooling across generations of both investment and longevity risk.[6] Therefore, a transition to CDC can alter the demand for certain asset classes and affect portfolio allocation.[7] **Specifical y, this transition may reshape portfolio construction and allow CDC plans to allocate more to alternative assets, in particular long-term infrastructure investments, to try to meet climate goals and respond to government demands to promote national welfare and energy resilience.**

We analyze and measure the capacity of CDC schemes to allocate to less liquid public assets (*e.g.*, some long-duration investment grade corporate bonds) or illiquid private assets (*e.g.*, infrastructure and private equity) in terms of how these assets may affect a scheme's liquidity properties and, importantly, the potential impact on retirement outcomes (*e.g.*, level and volatility of benefit payments). We demonstrate, in the context of allocating to illiquid infrastructure funds, that CDC schemes may have considerable capacity to take on more liquidity risk.

Collective Defined Contribution (CDC) Plans

A CDC plan combines elements of both DB and DC plans. In a CDC plan, contributions from both employees and employers are pooled together into a single, collectively managed fund. Unlike regular DC plans where each participant bears their own investment risk, in a CDC plan the investment risk is shared among all members. This intergenerational pooling can potentially lead to more stable retirement outcomes over time. Unlike DB plans, retirement benefits paid out in a CDC scheme are not fixed, as they depend on the performance of the collective fund. While this benefit variability is a feature of traditional DC plans, a CDC scheme offers a collectively managed framework which might help reduce retirement outcome volatility.[8]

CDC plans often aim for a target benefit level based on assumptions about investment returns and longevity. However, this target is not guaranteed and can change depending on the fund's performance. One of the goals of CDC plans is to achieve "fairness" between generations. By pooling risks and smoothing out returns, the plan seeks to provide equitable benefits to all members, regardless of when they retire.

We leverage the cash flow-based asset allocation framework, OASIS™, to help CDC schemes CIOs understand and measure the liquidity properties of their portfolios and quantify the tradeoff between portfolio performance and liquidity for various allocation levels to illiquid private assets. We also study the implications of greater allocations to illiquid alternatives on participants' expected retirement benefit payments.

Liquidity Challenges in Dutch Solidarity Schemes

For this analysis we examine the proposed Dutch CDC schemes. Specifically, three types of CDC pension schemes will be allowed under the proposed new system: the solidarity contribution scheme, the flexible contribution scheme, and the contribution-capital scheme. Since we cannot cover the entire Dutch CDC landscape in this analysis, we focus on the Dutch solidarity contribution scheme which offers features like collective risk sharing and a solidarity reserve.[9]

Dutch solidarity schemes face novel liquidity challenges. A solidarity scheme could face many unexpected liquidity demands which should be accounted for when evaluating its liquidity risk. Despite not having defined fixed liabilities, a scheme may need to hedge against fluctuating interest and FX rates, leading to potential mark-to-market (MTM) liquidity risk. However, many funds, particularly those with younger participants, may wish to increase allocations to alternative, illiquid private assets in an attempt to facilitate energy transition and promote impact investing. Roughly four in ten pension funds, based on a Schroders survey of 770 global institutional investors, plan to increase their exposure to private equity, infrastructure, and private debt.[10] These assets bring their own set of liquidity challenges which can compound, exacerbating liquidity risk especially during adverse market environments.

How can a CIO become comfortable with their private asset allocations in face of uncertain liquidity demands? In this paper, we conduct a case study on a Dutch solidarity scheme's shift towards increased allocation to illiquid private assets to illustrate how CIOs can better measure liquidity risk and make more informed asset allocation decisions while navigating this complex and evolving terrain.

5 Rundell, S., "What Dutch Pension Fund Reform Means for Fixed Income and Risk Allocations," Top1000funds, February 2024.
6 Mirza-Davies, J., "Pensions: Collective Defined Contribution (CDC) schemes," House of Commons Library, April 2024.
7 The structural impact of the shift from defined benefits to defined contributions," European Central Bank, 2024.
8 Hart, E., "The potential of Collective Defined Contribution pension schemes," Dentons, September 2023.
9 The solidarity contribution scheme involves a collective investment policy for current and future members, distributing financial gains and losses based on age-related rules. We discuss solidarity scheme's features in more detail on page 4.
10 Hoekstra, T. "Pension Funds to Continue Alternatives Buying Spree," by, October 6, 2023, Schroders.

Hypothetical Solidarity Scheme Portfolio

The purpose of the portfolio is to invest employee/employer contributions to provide workers with a pension benefit in retirement. For traditional DC plans, an individual's contributions grow over time and are then, at least conceptually, annuitized at retirement to provide retirement income throughout the participant's lifetime. The individual's retirement benefit is exposed to several risks: poor portfolio performance, interest rate volatility at the time of (possible) annuitization, and no opportunity to potentially increase retirement benefits throughout the lengthy retirement period by participating in riskier assets.

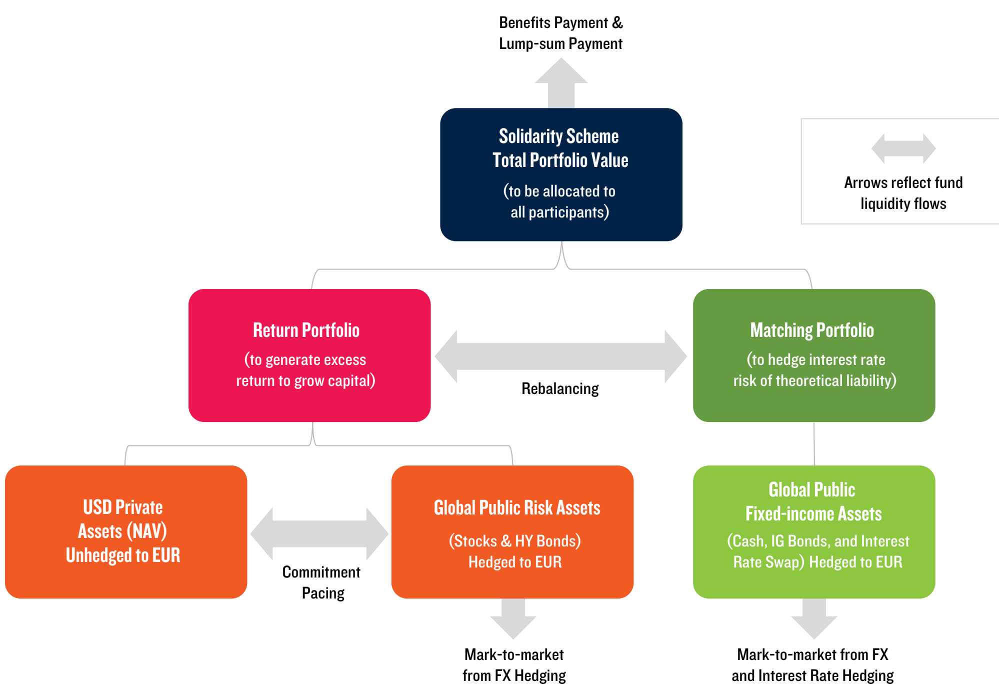
A CDC scheme attempts to improve upon the traditional DC plan in several ways. Throughout a worker's lifetime, they have declining exposure to riskier assets to try to improve retirement payments and have increasing exposure to hedging assets designed to protect retirement payments from interest rate fluctuations. In return for some retirement payment uncertainty, retired workers receive exposure to potentially higher returning assets. Finally, all investments are pooled ("intergenerational risk sharing") and contribution rates are flat across workers regardless of age ("intergenerational equity").[11]

A CDC portfolio can be divided into a "**return portfolio**" which seeks excess returns to grow capital by investing in risk assets (*e.g.*, stocks, high-yield bonds, and growth-oriented illiquid alternative assets) and a "**matching portfolio**" which contains investments to hedge against interest rate risk (*e.g.*, cash, government bonds, mortgages, investment-grade corporate bonds, and derivative instruments such as interest rate swaps). Although there is no defined liability in a solidarity scheme, plans still attempt to target stable retirement payouts and therefore need to hedge against the impact of interest rate fluctuations on future expected pension payments – through purchases of long-duration bonds or interest rate swaps (swap overlay).

Figure 1 illustrates a typical structure of a Dutch solidarity scheme portfolio. For the returns portfolio, Dutch pension schemes typically employ multi-asset, multi-currency investment strategies. The portfolio invests in both domestic and foreign assets, spanning both public and private markets. For simplicity, we assume all private investments are in USD unhedged to EUR, while public foreign assets are hedged to EUR.[12] All returns are assumed to be reported in EUR (€).

From time to time, the CDC scheme may need to raise cash to meet liquidity demands. Figure 1 also shows the plan's "**liquidity touchpoints**" where liquidity demands arise (and the CIO needs to use available cash or sell assets) within the structure of the scheme. The figure shows that liquidity touchpoints are ubiquitous, highlighting the complexity of liquidity management. Several scenarios can trigger liquidity needs: rebalancing between the matching portfolio and the return portfolio; capital calls arising from the private investment commitments which can be unexpected and lumpy; margin calls from interest rate and FX hedging activities; and there could be unexpected "lump sum" payments to participants besides any periodic benefit payments to retired workers.

Figure 1: Solidarity Contribution Schemes – Potential Liquidity Touchpoints



Source: PMA. For illustrative purposes only.

11 In the new rule, only flat rate contributions are allowed. We assume everyone contributes the same percentage of their assumed salary for the year regardless of their age.

12 We assume public USD assets are 75% hedged and other developed currency and emerging market exposures are 100% hedged to EUR.

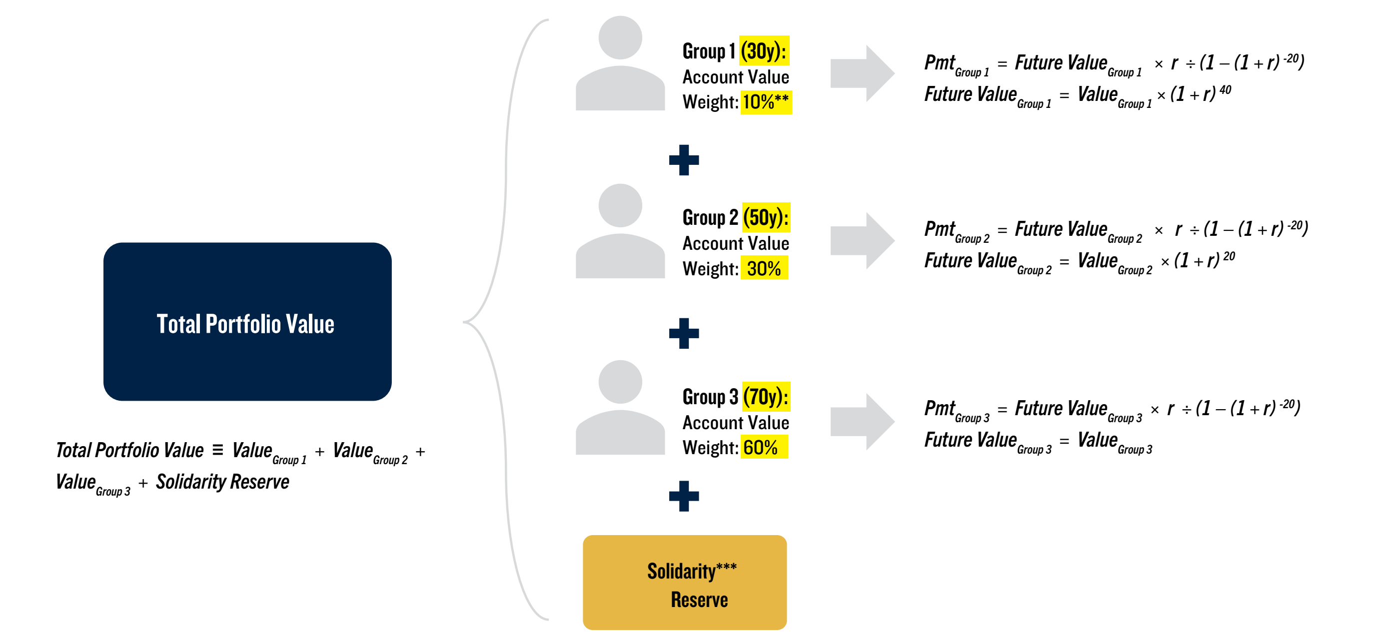
To help solidarity scheme CIOs understand the liquidity properties of their portfolio, we model a hypothetical scheme's periodic investment performance, including its cash inflows and outflows, under many potential future market paths.[13] This framework allows CIOs to evaluate their portfolios' liquidity risk – under different asset allocations – and identify circumstances when they need to consider making portfolio adjustments.

Modeling a Solidarity Scheme[14]

Key features of a solidarity scheme include: 1) A single collective investment policy that covers all participants; 2) No defined pension obligation – *i.e.*, participants do not accrue fixed pension entitlements – instead, they acquire a personal "share" in a collective asset that can fluctuate in value; 3) The pension benefit amount can be variable over time, even *after* retirement, based on investment outcomes; and 4) A Solidarity Reserve (a portion of the collective asset not assigned to any participant) which allows for extensive risk sharing among different generations and risk smoothing over time.

To capture this intergenerational dynamic, we assume the scheme has three groups of participants of 30y ("young workers" or Group 1), 50y ("middle-aged workers" or Group 2) and 70y ("retired workers" or Group 3). Workers and their employers periodically contribute to the scheme which increases the scheme's portfolio value (see Appendix). In addition, in each period, any gains or losses on the portfolio are distributed among the age groups according to predefined allocation rules (which constitutes the "risk sharing"). At any point, the account balance for each group can be translated into a stream of expected benefit payments starting at their retirement age (Figure 2). Here, we grow account values at the simulated 20y EUR nominal government bond yield, which accounts for both real growth and inflation, so that the benefit payments maintain their purchasing power over time.

Figure 2: Account Value and Benefit Payments



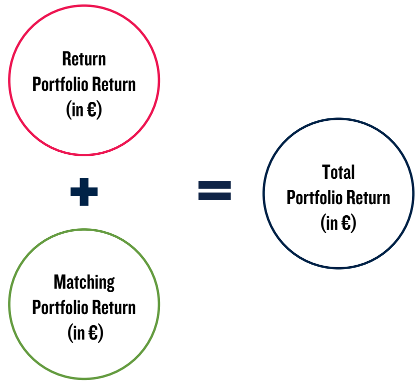
Note: For simplicity we assume benefits payments start at age 70y with a benefit period of 20y. Retirement age is currently 67y and will increase to 67y 3m in 2028. Weight is starting weights of the portion of the portfolio excluding the value of the solidarity reserve. Note: Yellow field indicates a parameter value that can be changed to conduct "what if" analysis. Source: PMA. Provided for illustrative purposes only.

Each period, the actual matching portfolio return (in €) and the actual return portfolio return (in €), sum to the total portfolio return (in €) – see Figure 3. The investment manager will be keen to keep the return portfolio and matching portfolio in a desired balance over time.

13 We simulate the risk and return of the public asset portfolio (*e.g.*, liquid public stocks and bonds) using the Moody's Analytics Economic Scenario Generator (Moody's ESG). See Real-World Scenario Generator | Moody's Analytics (moodysanalytics.com) for more details. To capture cash flow from private assets, we use the cash flow model developed by Takahashi and Alexander (2002) which is a deterministic model that captures the stylized pattern of limited partner (LP) capital contributions, distributions, and net asset values (NAVs). OASIS incorporates multiple types of private assets, such as private equity, infrastructure debt and equity, real estate, and private debt. See J. Shen *et al.*, "Asset Allocation and Private Market Investing," *Journal of Portfolio Management*, 2021 for details on private asset cash flow modeling.

14 This analysis builds upon WTW's very helpful interpretation of the rules. We (and others, too!) admit that some aspects are still not crystal clear and may continue to evolve, so we proceed with certain assumptions (see Appendix).

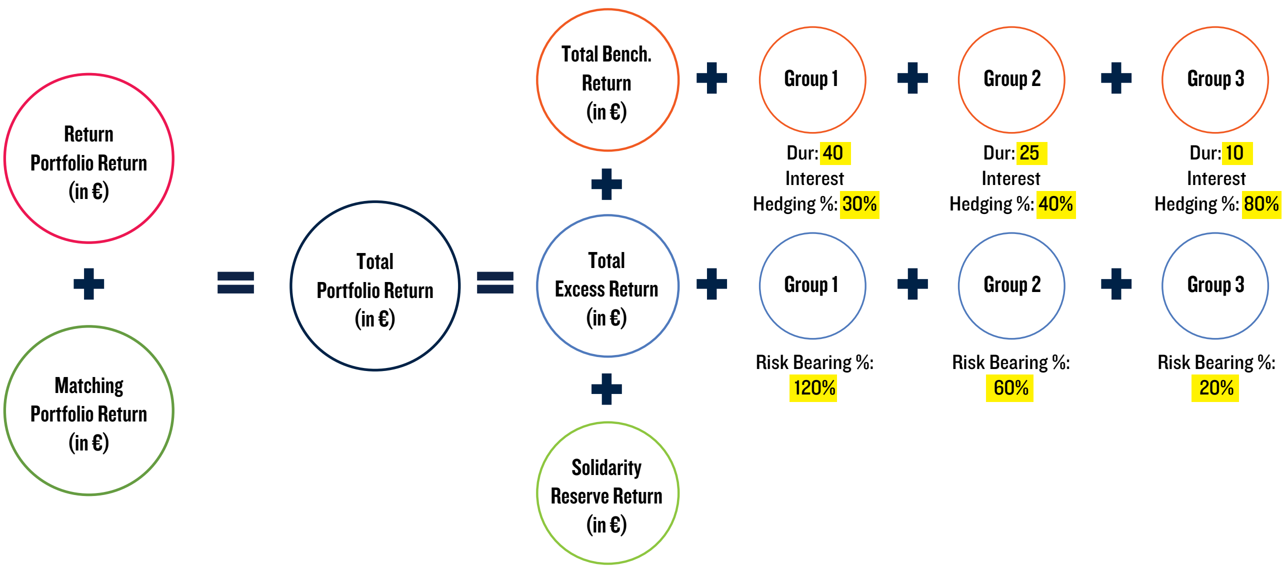
Figure 3: Total Portfolio: Return Portfolio + Matching Portfolio



Source: PMA. For illustrative purposes only.

The total portfolio return (in €) is then allocated to three components: Benchmark Return, Excess Return and Solidarity Return (Figure 4, explained below).

Figure 4: Total Portfolio Return Decomposition & Allocation



Source: PMA. For illustrative purposes only. Note: Yellow field indicates an investor input.

Benchmark Return: Hedging the interest rate exposure of a worker's accrued pension benefit has always been a prominent element of risk management in the Netherlands. However, in the new scheme, there is no defined pension liability for the plan to hedge! Nevertheless, a CDC assumes there is a "theoretical" liability (essentially, the present value of the anticipated, though not guaranteed, future benefit payments) that increases with a participant's age and fluctuates with changes in interest rates. The change in value of this theoretical liability multiplied by the interest hedging ratio is referred to as the **benchmark return** which is credited to each age group. **Note that the return on the matching portfolio *does not* directly translate into the benchmark return because the matching portfolio's return reflects actual in estment outcomes, while the benchmark return is a conceptual return designed for crediting purposes.** For each age group in each period, the benchmark return is a conceptual return that is calculated based their respective account value, current interest rate (r), interest rate change during the period (Δr), duration of future benefits payments (Dur) and their interest rate hedging ratio (%).[15] However, how much is hedged is conditional on age. Since workers near and in retirement are most exposed to interest rate risk, their portfolio's values receive most of any hedging benefit from the matching portfolio while young

15 The benefit duration (Dur) is essentially the assumed duration of the expected future stream of benefit payments for each age group that is translated from their respective current account balance. Given the beginning-of-the-period account value and how far into the future benefits commence, the return on the account value will be sensitive to the initial level of rates (carry) and the change in rates (market gain/loss) during the period. How sensitive a group's value is to the change in rates is the group's benefits duration (40 for 30y group 1; 25 for 50y group 2 and 10 for 70y group 3). For example, suppose a 30y-old worker has a current portfolio value whose future value at retirement will be affected by compounded interest rates over the next 40y. Consequently, a given decline in interest rates can have a large effect on expected future value (*i.e.*, Dur = 40). We assume the scheme hedges 30% of the interest rate exposure for this age group. Younger generations have a longer time horizon until retirement with benefits due further in the future and therefore have a longer benefits duration.

workers will be less hedged. Retired workers have 80% of their portfolio value hedged against interest rate risk while young workers – who have a long time to retirement and are in a better position to withstand interest rate volatility – have only 30% hedged. The total benchmark return then is the sum of each group's (and thus each member's) benchmark returns (Figure 5).

Figure 5: Benchmark Return

Total Benchmark Return (in €)

Group 1 Bench. Ret. (€)

$$\textit{Benchmark Return (€)}_{\textit{Group 1}} = \textit{Value}_{\textit{Group 1}} \times (r + \Delta r \times \textit{Interest Hedging Ratio \%}_{\textit{Group 1}} \times \textit{Dur}_{\textit{Group 1}})$$

+

Group 2 Bench. Ret. (€)

$$\textit{Benchmark Return (€)}_{\textit{Group 2}} = \textit{Value}_{\textit{Group 2}} \times (r + \Delta r \times \textit{Interest Hedging Ratio \%}_{\textit{Group 2}} \times \textit{Dur}_{\textit{Group 2}})$$

+

Group 3 Bench. Ret. (€)

$$\textit{Benchmark Return (€)}_{\textit{Group 3}} = \textit{Value}_{\textit{Group 3}} \times (r + \Delta r \times \textit{Interest Hedging Ratio \%}_{\textit{Group 3}} \times \textit{Dur}_{\textit{Group 3}})$$

$$\textit{Total Benchmark Return (€)} \equiv \textit{Benchmark Return (€)}_{\textit{Group 1}} + \textit{Benchmark Return (€)}_{\textit{Group 2}} + \textit{Benchmark Return (€)}_{\textit{Group 3}}$$

Source: PMA. For illustrative purposes only. Time subscripts t have been dropped for simplicity. However, r and Δr would change each quarter. We use simulated 20y EU government bond yield for r.

Excess Return: Similarly, the performance on the return portfolio does not directly translate into the **excess return**. Instead, total excess return is the residual component calculated by subtracting the total benchmark return from the total portfolio return (excluding the solidarity reserve return - discussed below). Total excess return is then distributed to each age group based on their account value and their assumed exposure to excess returns (*i.e.*, the risk bearing ratio (%)) – see Figure 6. All workers, including retired workers, have some exposure to excess returns, but to varying degrees depending on age. To do so, we assign a risk bearing ratio to each age group.[16] This age-related excess return distribution mechanism helps reduce benefit payment volatility as members age.

The excess return is a *residual* component (total portfolio return minus the initial solidarity reserve return (explained below) and minus the total benchmark return) distributed to each age group based on their account value and risk bearing ratio (%). The risk bearing ratio refers to how much of the total portfolio's excess return will be allocated to each of the three groups. We assume a risk bearing ratio of 120%, 60% and 20%, respectively, for groups 1, 2 and 3. This translates to group 1 bearing 60% of the total risk in excess return each period (= 120%/(120% + 60% + 20%), group 2 bearing 30%, and group 3 bearing 10%. The higher risk bearing ratio for younger generations since reflects their longer time until retirement, allowing them the chance to recover from potential short-term losses – with more time, they can ride out the higher volatility of investment returns that might offer higher longer-term returns.

Figure 6: Excess Return

$$\textit{Total Excess Return (€)} = \textit{Total Portfolio Return (€)} - \textit{Solidarity Return (€)} - \textit{Total Benchmark Return (€)}$$

$$\textit{Total Exposure to Excess Return} = [\textit{Value}_{\textit{Group 1}} \times \textit{Risk Bearing \%}_{\textit{Group 1}}] + [\textit{Value}_{\textit{Group 2}} \times \textit{Risk Bearing \%}_{\textit{Group 2}}] + \textit{Value}_{\textit{Group 3}} \times [\textit{Risk Bearing \%}_{\textit{Group 3}}]$$

Total Excess Return (€)

Group 1 Excess Return (€)

$$\textit{ER Allocation \%}_{\textit{Group 1}} = \textit{Value}_{\textit{Group 1}} \times \textit{Risk Bearing \%}_{\textit{Group 1}} \,/\, \textit{Total Exposure to Excess Return}$$

$$\textit{Excess Return (€)}_{\textit{Group 1}} = \textit{Total Excess Return (€)} \times \textit{ER Allocation \%}_{\textit{Group 1}}$$

+

Group 2 Excess Return (€)

$$\textit{ER Allocation \%}_{\textit{Group 2}} = \textit{Value}_{\textit{Group 2}} \times \textit{Risk Bearing \%}_{\textit{Group 2}} \,/\, \textit{Total Exposure to Excess Return}$$

$$\textit{Excess Return (€)}_{\textit{Group 2}} = \textit{Total Excess Return (€)} \times \textit{ER Allocation \%}_{\textit{Group 2}}$$

+

Group 3 Excess Return (€)

$$\textit{ER Allocation \%}_{\textit{Group 3}} = \textit{Value}_{\textit{Group 3}} \times \textit{Risk Bearing \%}_{\textit{Group 3}} \,/\, \textit{Total Exposure to Excess Return}$$

$$\textit{Excess Return (€)}_{\textit{Group 3}} = \textit{Total Excess Return (€)} \times \textit{ER Allocation \%}_{\textit{Group 3}}$$

Source: PMA. For illustrative purposes only.

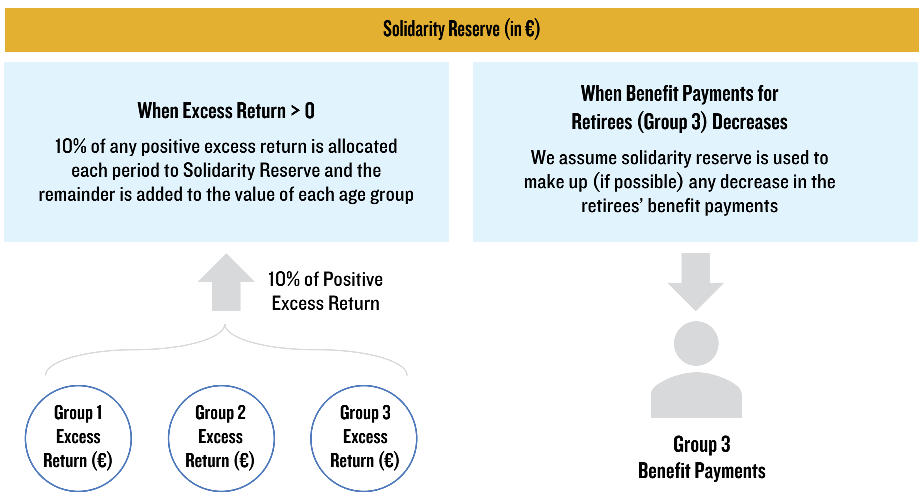
16 The risk bearing ratio could depend on the risk preferences of each plan member.

Solidarity Reserve & Return: In a solidarity scheme, pension assets are the "collective property" of the participants, with a portion assigned to each age group. However, there is a portion of the collective property that is not assigned to any group but remains a "collective asset" shared by all participants. This part of the collective assets is called the **Solidarity Reserve**.

The solidarity reserve helps allow for risk sharing between generations, resulting in more stable pension outcomes for everyone. Since funds are likely (but not required) to target stable payouts for pensioners, we *assume* the solidarity reserve balance is used to make up any decrease in the retirees' benefit payments until it is exhausted (Figure 7). In other words, if the performance of the portfolio is very poor – which would be painful for retired workers as their current pension benefit could be reduced – the solidarity reserve might be used to soften the blow.

The solidarity reserve is funded, initially, from contributions from employers (which could be from any funding surplus from the transitioning DB plan), and, thereafter, through a portion of any positive excess returns. No future employer contributions to the solidarity reserve will occur. For our example, we assume the solidarity reserve starts at 5% of total portfolio value, and in each period after, when excess returns are positive we assume 10% of the positive excess return is allocated to the solidarity reserve. These assumptions are flexible and can be modified for different investors. In addition, the solidarity reserve is required by rule to be capped at 15% of the total portfolio value and has a hard lower bound of 0% over the entire investment horizon. If the solidarity reserve were to hit 0%, it may subsequently increase depending on the magnitude of excess returns. Each period, we assume the solidarity reserve earns the same return (%) as the total portfolio. For example, if the total portfolio has a 6% return during a quarter, we assume the solidarity reserve does, too.

Figure 7: Solidarity Reserve



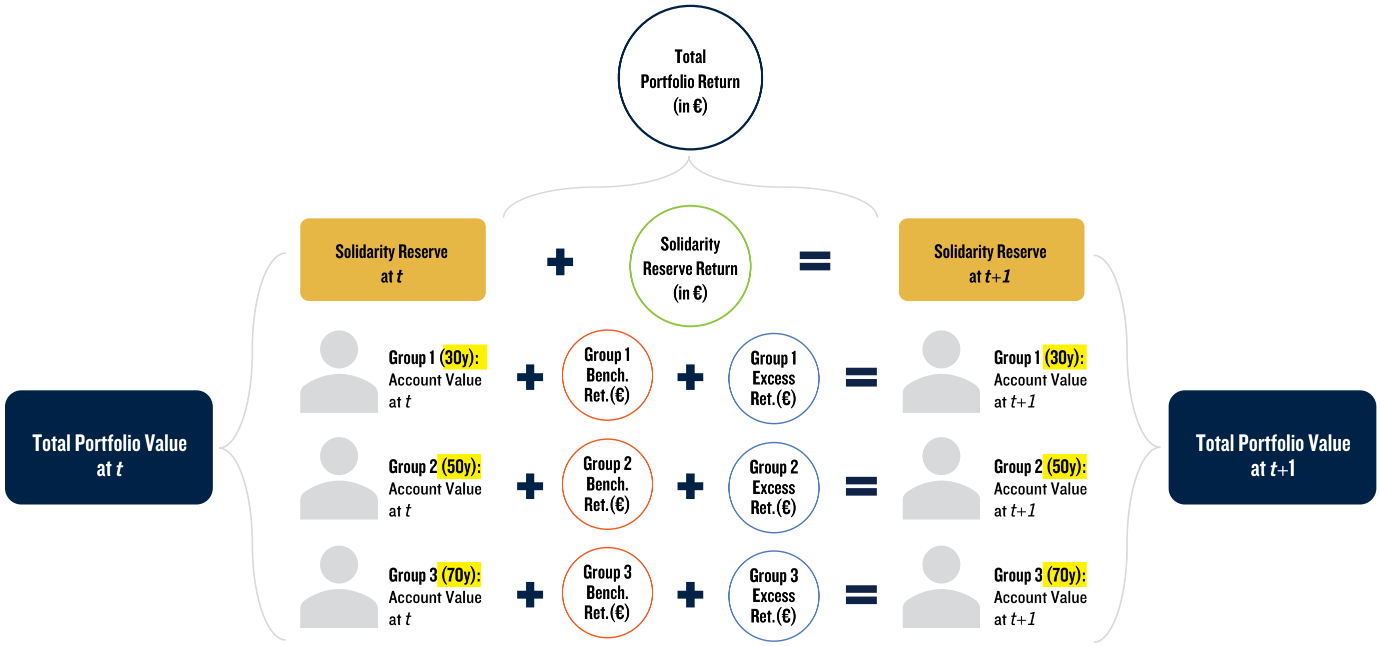
$$\textit{Solidarity Reserve Return (€)}_{t+1} = \textit{Solidarity Reserve Balance}_t \times \textit{Total Portfolio Return \%}_{t+1}$$

$$\textit{Solidarity Reserve Balance}_{t+1} = \textit{Solidarity Reserve Balance}_t + \textit{Solidarity Reserve Return (€)}_{t+1} \pm \textit{Cash Flow to Retirees' Benefit Payments/from Excess Return}_{t+1}$$

Source: PMA. For illustrative purposes only.

Figure 8 brings together the three components of a solidarity scheme. For each period, benchmark return, excess return, and solidarity reserve return sum (in €) to the total portfolio return (in €). Also, the beginning-of-the-period total portfolio value plus the total portfolio return equal the end-of-period total portfolio value (excluding contributions and distributions). At any point in time during the investment horizon, the account value of each age group and the solidarity reserve balance add up to the total portfolio value.

Figure 8: Bringing It Together



Source: PMA. For illustrative purposes only. Note: Yellow field indicates an investor input.

A solidarity scheme has many moving parts, making it complex to grasp at first. To better understand it, let us consider the experience of a 30y-old participant. This participant faces higher risk (*i.e.*, relatively high exposure to excess returns and relatively low exposure to benchmark returns) but also anticipates higher expected returns. For instance, the participant might expect their account balance to grow at an average annual rate of 8% but with considerable fluctuations year to year. This means that while they might see significant growth in their retirement savings, they should also be prepared for potential downturns. This volatility is a deliberate choice to shield older participants from similar risks. As members age and transition to the next group, the volatility in their expected retirement benefit diminishes, creating a smoother trajectory towards retirement.

When the same participant reaches 50y, the assumptions adjust to reduce risk exposure. Their expected annual return might decline to 5% but with significantly less volatility (*i.e.*, reduced exposure to excess returns and increased exposure to benchmark returns). By the time they join the 70y-old group they enjoy a more stable, though not entirely static, pension benefit perhaps growing at a lower, but steadier, 3% per year. This stability provides a sense of security, yet there is potential to benefit from excess returns if the market performs well.

Solidarity Schemes & Liquidity Risk

Liquidity events could have several adverse impacts on a solidarity scheme: 1) A CIO wants to avoid being a forced seller of assets at unfavorable prices to raise liquidity which could result in a lower portfolio value and reduced retirement benefits; 2) Liquidity events can lead to solidarity reserve losses and, thus, less effective "risk sharing" among plan participants; 3) The need to sell increasingly illiquid assets (*i.e.*, moving down the liquidity "waterfall") can incur significant transaction costs which eat into the scheme's returns; 4) Forced liquidation could lead to a concentrated portfolio (*e.g.*, with an unintended overweight to illiquid assets) and a deviation from the plan's target allocation ("rebalancing failure"); and 5) Liquidation for short-term liquidity purposes of assets that were meant for long-term benefits could conflict with the plan's long-term investment goals.

To illustrate our liquidity analysis, we consider a hypothetical solidarity scheme portfolio with a starting AUM of €7b. The portfolio is diversified with typical allocations to illiquid private assets such as private equity and private credit. Figure 9 sorts and ranks the portfolio's assets into different liquidity categories based on a CIO's subjective assessment of their "transactability" (*i.e.*, ease and cost of selling to meet liquidity needs). We assume, for this example, there are two liquid asset categories: Category 1, which includes 1A – cash and 1B – liquid passive public assets representing investments in equity and fixed income assets not expected to earn an alpha (*e.g.*, an ETF on a broad-based index fund) and Category 2 which includes actively-managed liquid public assets that earn an alpha (*e.g.*, a mutual fund or a liquid hedge fund strategy). Category 3 assets are the portfolio's illiquid private assets. We divide Category 3 into two parts: 3A, infrastructure equity (either open-end funds or direct investments) and 3B, private equity and private credit.

We consider two main scenarios: 1) a baseline scenario as shown in the "Baseline" column in Figure 9; and 2) an alternative asset allocation, where we decrease portfolio public equity allocation by 10 percentage points and increase infrastructure equity by 10 percentage points (as shown in the "Alternative Asset Allocation" column in Figure 9). Infrastructure may serve as a portfolio diversifier with its relatively low correlation to the public market. In addition, it could serve as a relative "liquidity provider" with the help of its stable income relative to other private assets. We use our infrastructure model to estimate infrastructure assets' cash flows in a way that accounts for both their age and sector, as well as their idiosyncratic behavior.[17]

Figure 9: Baseline and Alternative Asset Allocation Scenarios

Asset Type	Liquidity Level	Liquidity Level Description		Baseline: Asset — Return Portfolio	Baseline: Asset — Matching Portfolio	Alternative Asset Allocation: Asset — Return Portfolio	Alternative Asset Allocation: Asset — Matching Portfolio
(1) Liquid Passive	1A	Available for Liquidity (Cash Only)		N/A	3.0% (Cash)	N/A	3.0% (Cash)
	1B	Available for Liquidity (Stocks/Bonds)		30.0% (Equity)	37.0% (Govt. / Mortgage / IG Corporate)	20.0% ↓ (Equity)	37.0% (Govt. / Mortgage / IG Corporate)
(2) Liquid Active	2	Available for Liquidity if Level 1 is Exhausted		10.0% (HY)		10.0% (HY)	
(3) Illiquid	3A	Infrastructure		0%	N/A	10% ↑	N/A
	3B	LP NAV Unavailable for Liquidity	PE Buyout	17.5%		17.5%	
			Private Credit	2.5%		2.5%	

Source: PMA. For illustrative purposes only. Note: Yellow field indicates an investor input.

While we use infrastructure as an example since this asset class is gaining traction among investors, the model could incorporate other types of private assets, such as private equity, real estate and private credit. Our analysis is based on the capital market assumptions (CMAs) in the Appendix. These CMAs can be customized for different investors. We perform the analysis given both the portfolio's baseline asset allocation and the alternative asset allocation (with increased allocation to infrastructure). We rebalance the portfolio based on the plan's target asset allocation, asset-specific tolerance ranges and rebalancing frequency (see Appendix).

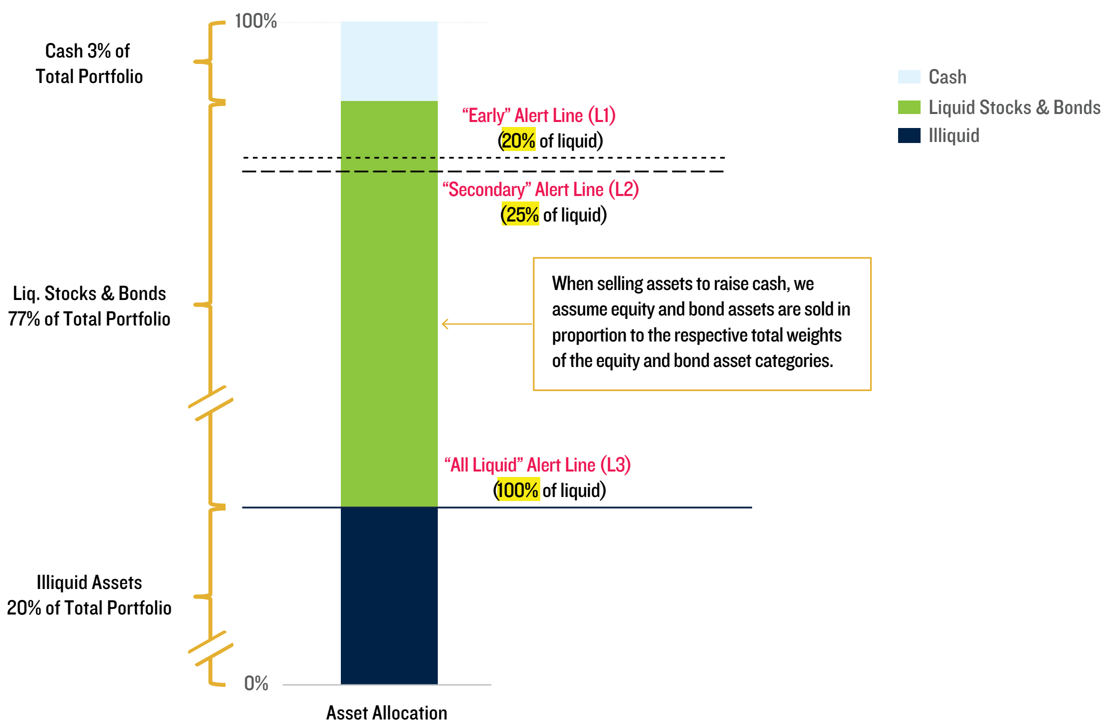
Liquidity Risk Measure

We first focus on the scheme's quarterly usage of liquid assets as a key portfolio liquidity risk measure. That is, the portion (%) of liquid assets consumed in a quarter, given the portfolio's structure, benefit payments, rebalancing rules, and private market activities. Figure 10 illustrates the assumed structure of the CIO's liquidity "waterfall" which specifies which asset categories serve as liquidity sources, and in which order. We quantify the likelihood of using up a certain portion of these liquid assets in a quarter and identified three liquidity alert lines with differing severity.

To study liquidity usage, we define an early alert line (or "**L1**") as when at least 20% of the total portfolio's liquid assets are used in a single quarter. And the secondary alert line (or "**L2**") as when at least 25% of the liquid assets must be sold to meet cash demands. The "All liquid" alert line (or "**L3**") is breached when *all* liquid assets are exhausted. CIOs can define their own liquidity alert lines.

17 Shen, J. and F. Blanc-Brude, "Building Portfolios with Infrastructure: Performance, Cash Flows & Portfolio Allocation." PMA and EDHEC*infra*, November 2022; and Shen, J., F. Blanc-Brude, and A. Chen, "Building Portfolios with Infrastructure: Performance, Cash Flows & Portfolio Allocation - Extended Summary." PMA and EDHEC*infra*, February 2023.

Figure 10: Liquidity "Waterfall" – Quarterly % Usage of Liquid Assets (Baseline)

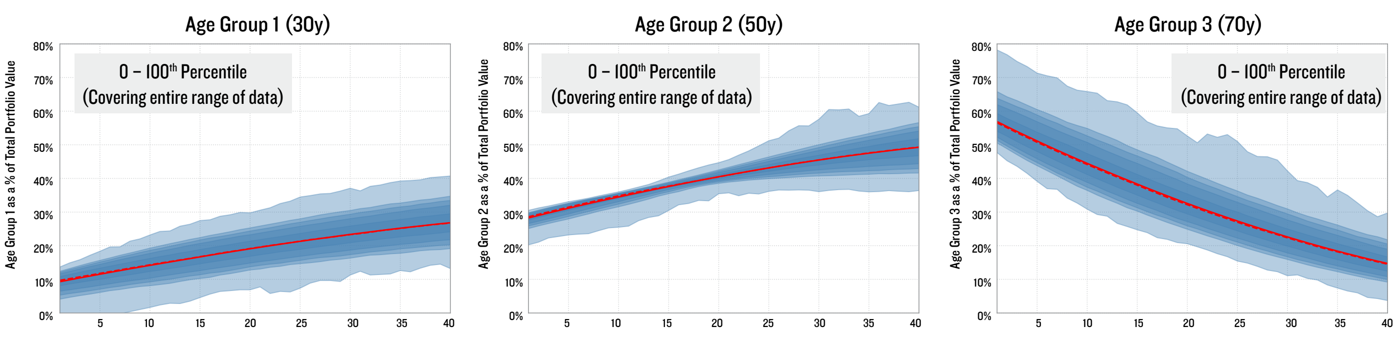


Source: PMA. For illustrative purposes only. Note: Yellow field indicates an investor input.

Results

Using OASIS, we first monitor the account balances, by age group, and their corresponding future expected benefit payments. Figure 11 shows the likely range of each age group's account balance over time. For example, the left panel labeled "Age Group 1 (30y)," shows the account balance as a percentage of the total portfolio value over time for the 30y-old group. The y-axis represents the account balance as a percentage of the total portfolio value and the x-axis represents the investment horizon from 0q (*i.e.*, now) to 40q (*i.e.*, 10y later). The shaded area (light to dark blue) represents the range of possible outcomes, covering the 0th to the 100th percentile of the data. The lighter areas indicate more extreme outcomes (both high and low). The dashed red line represents the median path of the account balance and the solid red line represents the average path. Due to working age contributions and retirement distributions, the relative weights of age groups 1 & 2 (non-retired workers) increase gradually while the weight for age group 3 (retirees) decreases.

Figure 11: Account Balance (as a % of Total Portfolio Value, Baseline)

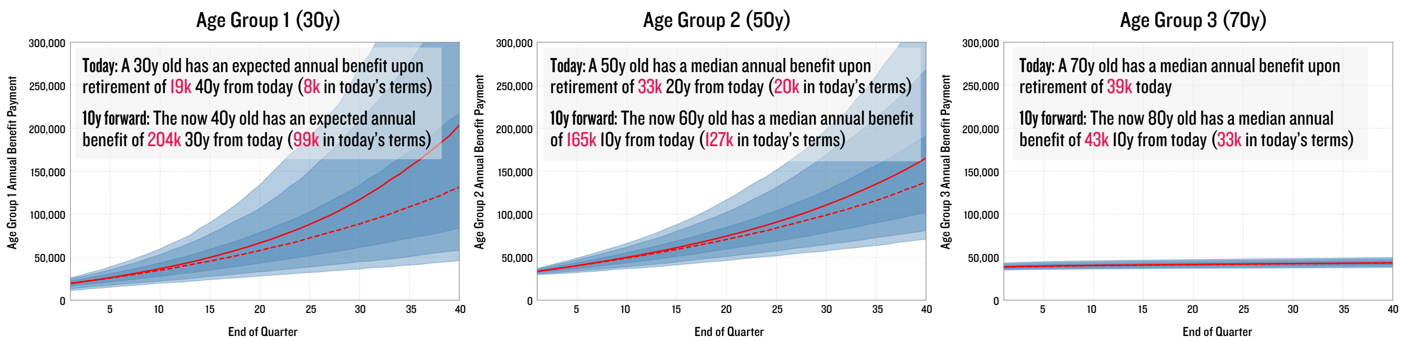


Source: PMA. For illustrative purposes only. Data as of 30 September 2023.

Figure 12 shows the likely range of benefit payments at retirement associated with the modeled account balance. We assume each worker retires at age 70y with a remaining 20y lifetime. This analysis helps CIOs monitor changes in participants' expected benefit payments in response to changing market conditions and member demographics, and evaluates if benefits fall within a reasonable range and if members are on track to meet their retirement needs.

We see higher growth (due to periodic contributions and higher exposure to investment risk and growth) in the non-retired generations' benefit payments, while benefits for retirees grow at a much slower pace with very little volatility. For example, the expected annual benefit upon retirement is €19,000 for a 30y-old given their account balance today (at the beginning of the investment horizon). In 10y, however, the expected annual benefit in 30y time for the now 40y-old would be €204,000, given their contributions and the modeled market performance over the next 10y. On the other hand, for a 70y-old the expected annual benefit upon retirement is €39,000 given their account balance today. In 10y, the expected annual benefit for the now 80y-old would be expected to grow to €43,000.

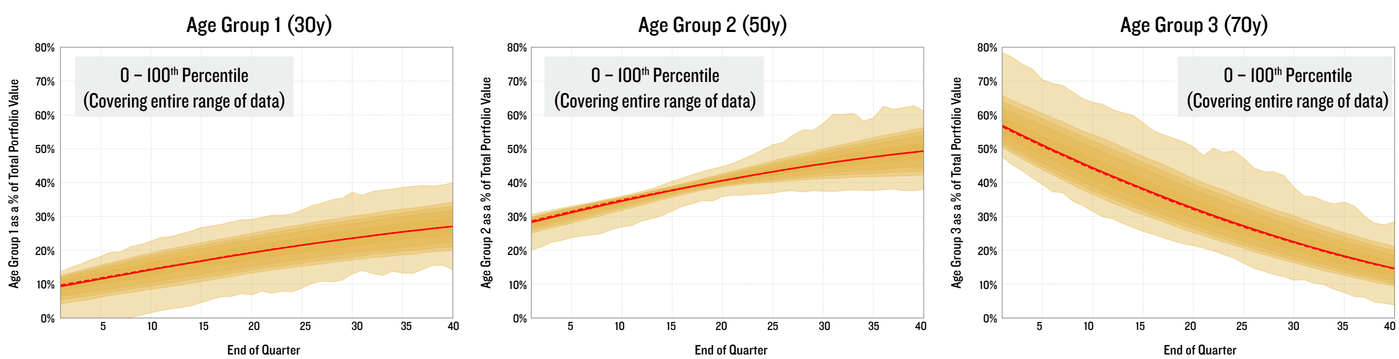
Figure 12: Member Expected Annual Benefit Payments at Retirement (Baseline)



Source: PMA. For illustrative purposes only. Data as of 30 September 2023.

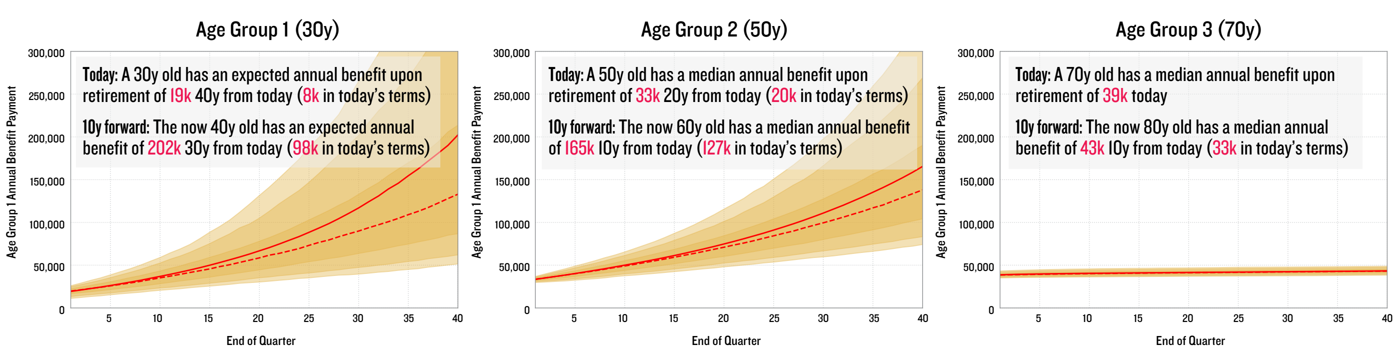
We show the same picture for the alternative asset allocation (Figures 13 & 14, where we reallocate 10 percentage points of public equity to infrastructure equity investments). Retirement benefits are slightly improved across age groups due to the higher expected return from infrastructure investments.[18]

Figure 13: Account Balance (as a % of Total Portfolio Value, Alternative Asset Allocation)



Source: PMA. For illustrative purposes only. Data as of 30 September 2023.

Figure 14: Member Expected Annual Benefit Payments (Alternative Asset Allocation)



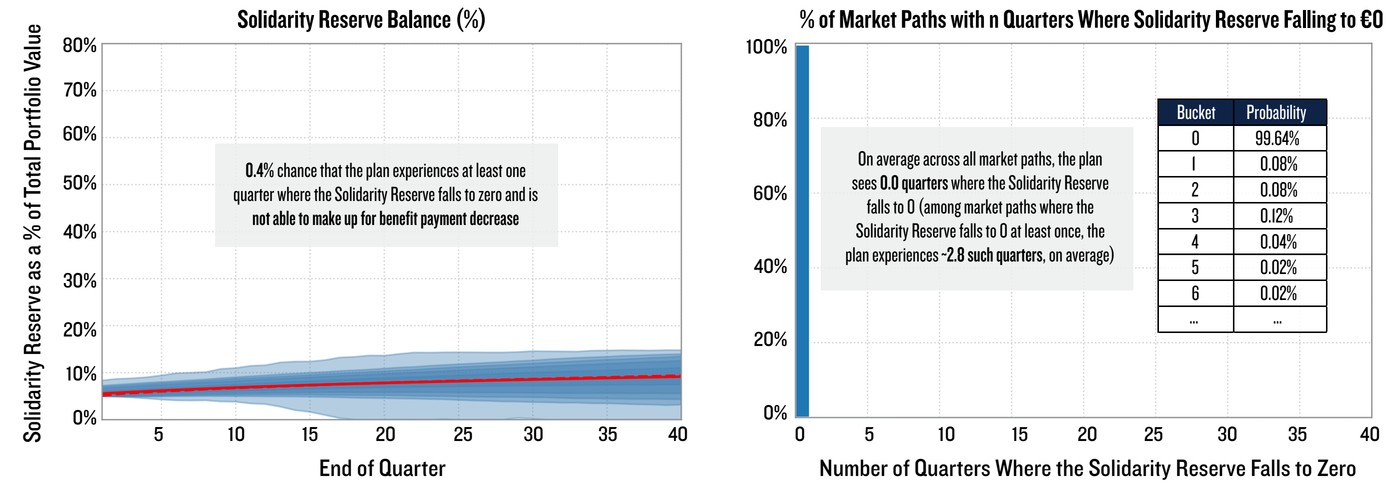
Source: PMA. For illustrative purposes only. Data as of 30 September 2023.

18 See Appendix A4 for details on the modeled return and volatility, by asset class.

CIOs may also wish to monitor the balance of the solidarity reserve to make sure the intergenerational risk sharing is functioning effectively and to meet regulatory guidelines.[19] CIOs may wish to avoid events where the solidarity reserve falls to zero and is, therefore, not available to possibly buffer decreases in payments to retired workers. OASIS helps model the solidarity reserve balance given different asset allocations and other scenarios to see the impact on the solidarity reserve. Liquidity risk can undermine the effectiveness of the solidarity reserve when CIOs are forced to sell assets at unfavorable prices to meet cash demands. This depletes the reserve via reduced, or negative, excess returns, and ultimately reduces the reserve's ability to cover unexpected shortfalls or stabilize pension payouts.

Figure 15 shows that under the baseline scenario there is a 0.4% chance that the scheme experiences at least one quarter where the solidarity reserve falls to zero. On average, the plan sees ~2.8q where the solidarity reserve is at €0 over a 10y horizon, given the occurrence of such an event.

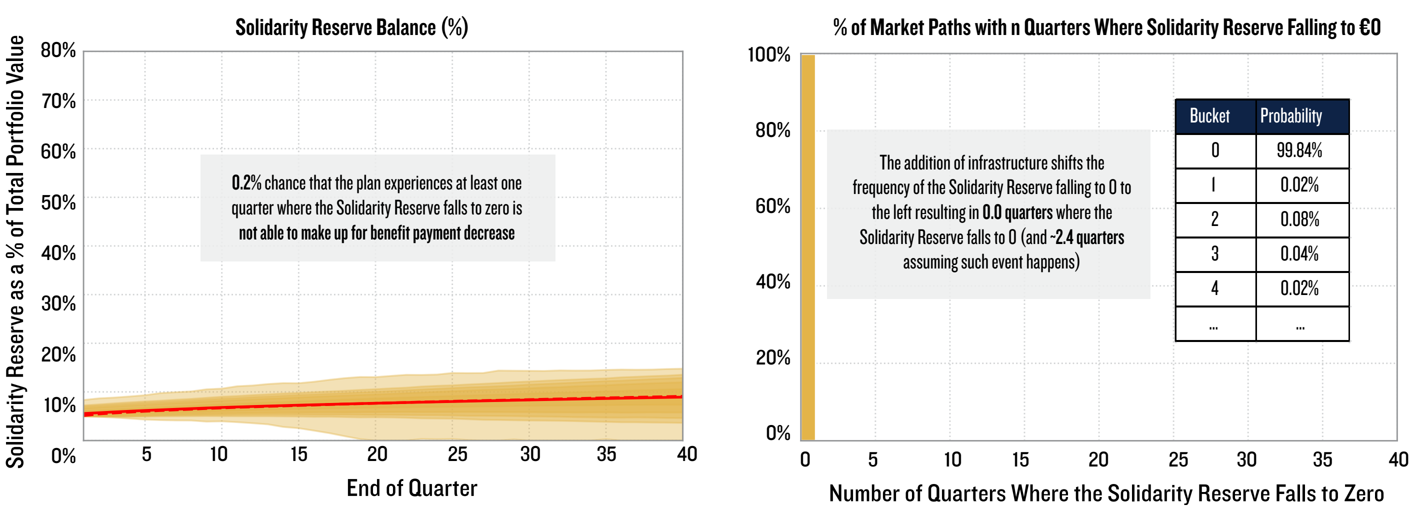
Figure 15: Modeling the Solidarity Reserve (Baseline)



Source: PMA. For illustrative purposes only. Data as of 30 September 2023.

In the alternative asset allocation (Figure 16), which includes the 10% portfolio allocation shift to infrastructure, the plan is less likely to see the solidarity reserve falls to €0. There is a slightly lower (0.2%) chance that the scheme experiences at least one quarter where the solidarity reserve falls to zero.

Figure 16: Modeling the Solidarity Reserve (Alternative Asset Allocation)



Source: PMA. For illustrative purposes only. Data as of 30 September 2023.

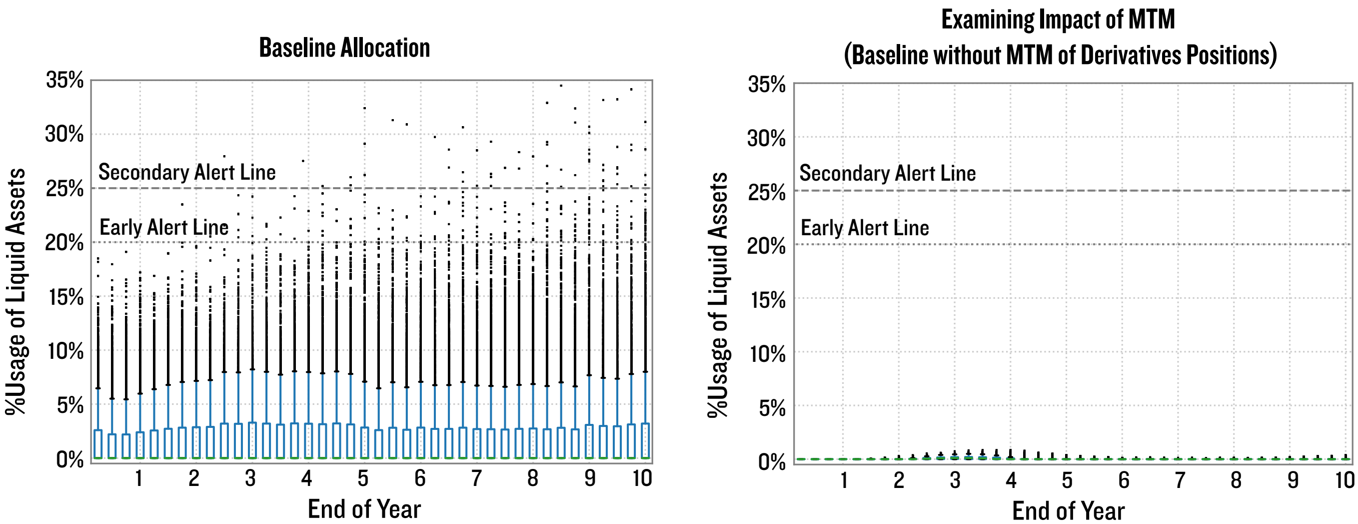
19 According to the guidelines, the solidarity reserve in the Dutch pension system can hold a maximum of 15% of the pension fund's total assets. But we do not find any statement that the fund must maintain a specific positive threshold other than to say that the fund should have a sufficient buffer to absorb shocks to help maintain more predictable pension benefits in the face of market volatility.

On average, the plan sees ~2.4q where the solidarity reserve falls to €0 over a 10y horizon. This improvement is likely due to infrastructure investments offering a relatively large and stable income return with low correlation to public market movements.[20] Conversely, public equity can be volatile and typically provides lower income returns. During periods of liquidity stress, infrastructure investments may enhance portfolio liquidity, thanks to its stable cash flows.[21]

We specified the liquidity alert lines in Figure 10. Figure 17 (upper left panel) shows the distribution of the plan's quarterly liquid assets usage over the next 10y. Each dot above these two dotted lines (Early Alert Line "L1" and Secondary Alert Line "L2") represents a liquidity event when the portfolio breached either the L1 or L2 lines under a market path. Figure 17 (lower left panel) also summarizes how often these events happen for the plan. Across the 5000 market paths, 5.5% of the time the baseline portfolio hits L1, and 1.3% of the time it sees at least one L2 event over 10y. For the baseline portfolio, the all-liquid line (L3) is never touched.

Most of the unexpected liquidity demands arise from the mark-to-market of derivatives positions (for FX and interest rate hedging). To see this, we show the quarterly liquidity usage without derivatives mark-to-markets. As a result, none of the liquidity alert lines are ever touched over the modeled investment horizon (Figure 17, right panels).

Figure 17: Quarterly % Usage of Portfolio Liquid Assets & Liquidity Events



Liquidity Events	Flag	Probability
Hit Early Alert Line (use up 20% of all liquid assets)	L1	5.5%
Hit Secondary Alert Line (use up 25% of all liquid assets)	L2	1.3%
Hit All Liquid Alert Line (exhaust all liquid assets)	L3	0.0%

Liquidity Events	Flag	Probability
Hit Early Alert Line (use up 20% of all liquid assets)	L1	0.0%
Hit Secondary Alert Line (use up 25% of all liquid assets)	L2	0.0%
Hit All Liquid Alert Line (exhaust all liquid assets)	L3	0.0%

Source: PMA. For illustrative purposes only. Note: Yellow field indicates an investor input. Data as of 30 September 2023.

Note: The box extends from the lower to upper quartile values of the data, with a line at the median. The whiskers extend from the box to show the range of the data, *i.e.*, 1.5 × IQR (the interquartile range (Q3-Q1)). The upper whisker will extend to last datum less than Q3 + 1.5 × IQR. Similarly, the lower whisker will extend to the first datum greater than Q1 – 1.5 × IQR. Beyond the whiskers, data are considered outliers and are plotted as individual points.

CIOs face another potential critical liquidity demand: the need to shift portfolio allocation, perhaps regularly, between asset classes (*e.g.*, equity *vs.* bonds) to maintain target weights and to manage risk. As a liquidity risk measure, we evaluate the probability of **rebalancing failures** (*i.e.*, when the CIO is unable to rebalance the portfolio to target allocation within specified tolerance ranges – due largely to periods of sharply divergent private and public asset performance) over the 10y investment horizon. For example, if equity (public and private) significantly outperforms fixed income (public and private), and a large portion of the portfolio is allocated to illiquid alternatives which cannot be quickly sold or adjusted, the CIO may be unable to rebalance the portfolio back to the target equity *vs.* fixed income allocation.

Instead of rebalancing each asset class back to target, we assume that the CIO is more concerned if they cannot stay close to the relative allocation between equity (public and private equity) and fixed income (all fixed income plus cash) asset categories. Therefore, we treat equity and fixed income assets as separate single asset categories, and rebalance them back to their respective targets, every quarter. We define "rebalancing failure" as only when the equity and fixed income categories cannot be rebalanced to targets. In other words,

20 Shen, J. and F. Blanc-Brude, Building Portfolios with Infrastructure: Performance, Cash Flows & Portfolio Allocation. PMA and EDHEC*infra*, November 2022; and Shen, J., F. Blanc-Brude, and A. Chen, "Building Portfolios with Infrastructure: Performance, Cash Flows & Portfolio Allocation Summary." PMA and EDHEC*infra*, February 2023.

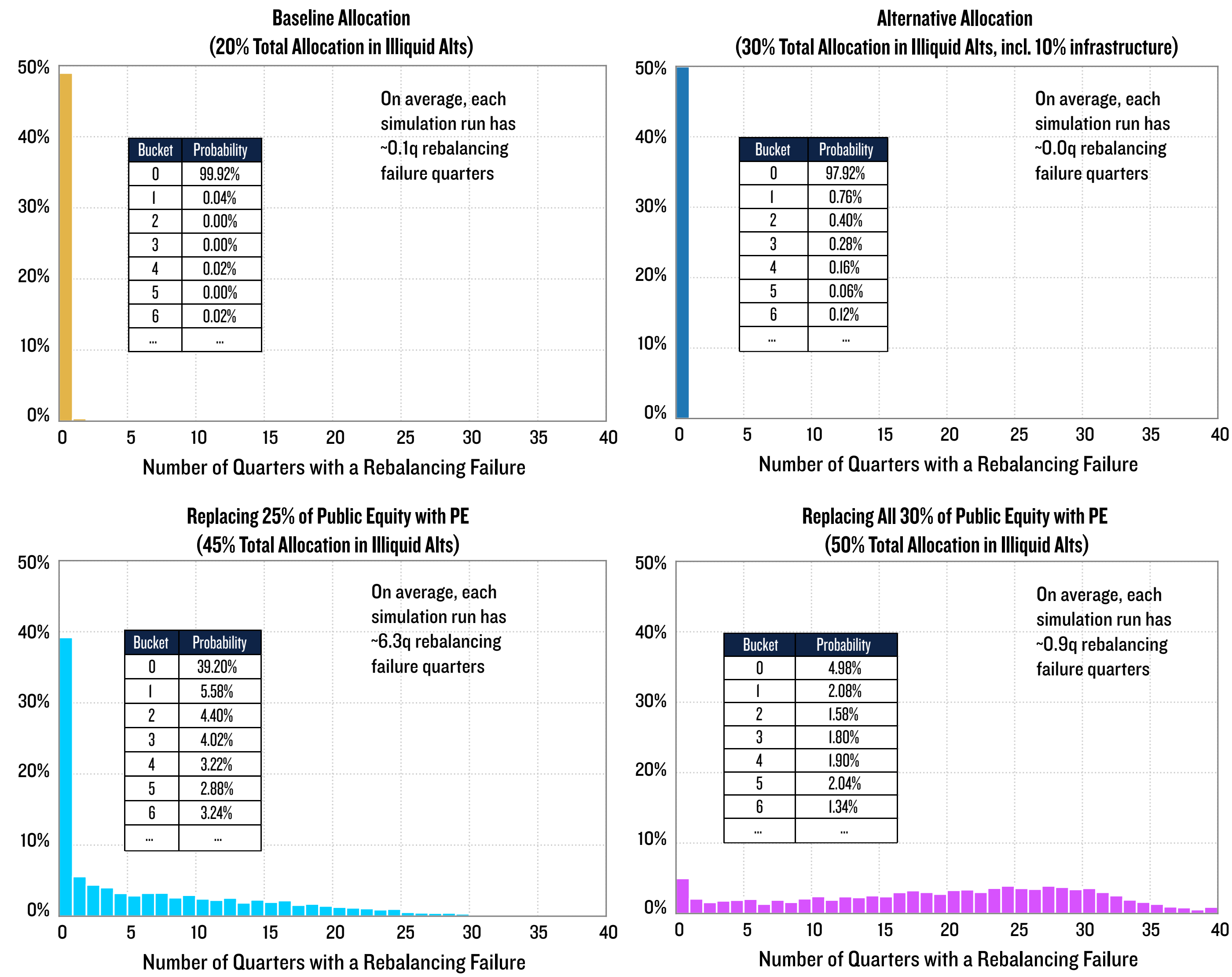
21 Other private asset types may exhibit different liquidity properties.

we do not flag the event when an individual asset class (*e.g.*, public equity alone) deviates from its target within tolerance ranges but, instead, focus on the two asset categories (*i.e.*, public and private equity) together. In addition, we assume that private assets cannot be transacted – either sold or bought. See Appendix A2 for details in the plan's target asset allocation, asset-specific tolerance ranges and rebalancing frequency.

Given the rebalancing tolerance ranges we examine the impact of increasing portfolio allocation to illiquid private assets. Figure 18 shows that for the baseline scenario with 20% private assets, each 40q market path has, on average, around 0 rebalancing failure quarters (Figure 18, upper left panel). Under the alternative asset allocation where we replace 10% of public equity with infrastructure (so, 30% total allocation in private investments), we see on average around 0.1 rebalancing failure quarters (Figure 17, upper right panel).

To examine the impact of even higher allocations to illiquid alternatives, we consider two additional scenarios. Under the "**high allocation to illiquid alternatives**" scenario where we replace 25% of public equity with PE (so, 45% total allocation in illiquid alternatives), we encounter approximately 6 rebalancing failure quarters out of 40q and about 40% of the market paths do not experience any rebalancing failures (Figure 18, lower left panel). Under the "**extremely high allocation to illiquid alternatives**" scenario where we replace all 30% of public equity with PE (50% total allocation in illiquid alternatives), the portfolio experiences significantly more rebalancing failures with an average of 19 rebalancing failure quarters out of 40q (Figure 18, lower right panel). As shown, liquidity risk is often not linear and may not increase proportionally along with the allocation to illiquid assets. Instead, there can be inflection points where liquidity risk suddenly spikes.[22]

Figure 18: Impact of Increasing Private Assets, % of Market Paths with n Rebalancing Failures[23]



Source: PMA. For illustrative purposes only. Data as of 30 September 2023.

22 Teng, M. and A. Chen, "Super Funds & Master Trusts: In a World of Member Switching, Early Release Schemes & Climate Calamities." PMA, March 2022.

23 The histograms represent the probability of experiencing a certain number of quarters with rebalancing failures over a 40q (10y) horizon based on 5000 simulated market paths. Each bar shows the percentage of simulations that resulted in a specific number of quarters with rebalancing failures. For example, if 50 out of the 5000 simulated market paths show that the plan experiences 2q with rebalancing failures, the height of the bar at "2 quarters" will be 1% (since 50/5000 = 1%).

Summary

As global pension systems consider transitioning from a defined benefit (DB) to a collective defined contribution (CDC) model, the implications for asset management and participant outcomes can be significant. As such, CDC schemes, exemplified by the Dutch solidarity schemes, are gaining traction due to their ability to mitigate individual risks through collective management and long-term, higher expected return, investment strategies.

For pension funds, this reform introduces new challenges and opportunities in portfolio management. These plan managers now face the task of revising their investment strategies to accommodate the greater variability in pension payments. This involves a potential increase in allocations to illiquid alternatives like infrastructure equity which not only provides potentially higher expected returns and portfolio diversification but, for some investors, also aligns with environmental, social, and governance goals. Moreover, the relaxation of previous regulatory constraints offers an opportunity to explore higher allocations to illiquid alternatives that were previously unattainable under DB schemes, which could lead to improved financial resilience and potentially enhanced pension outcomes for participants. However, this shift must be navigated carefully to balance the pursuit of higher returns against the risk of reduced liquidity.

We leverage our cash flow-based asset allocation framework, OASIS, to help solidarity scheme CIOs understand the liquidity properties of their portfolio and quantify the tradeoff between portfolio performance and liquidity risk of increased allocations to illiquid alternative assets. Our findings indicate that, in the context of our examples, solidarity schemes have substantial capacity to increase allocations to illiquid assets.

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Appendix

A1. Other Assumptions

Assuming a starting total portfolio value of €7b, with 21,000 members in total and 7,000 in each age group. We assume a neutral view on future PE performance versus public equity and neutral PE fund selection skill. For PE and private credit funds, we assume a dynamic commitment pacing strategy that keeps the allocation to private assets around the target over the 10y investment horizon. In the alternative asset allocation scenario, we assume for infrastructure equity an open-ended fund structure with direct infrastructure assets diversified across sectors. We assume the allocation ramps up from 0% to 10% during the first 2y of the 10y investment horizon.

Assuming Group 1 and Group 2 contribute 33% of salary annually into the plan. We assume benefits payments start at age 70 for simplicity and assume the benefit period is 20y. We assume a random probability (P) that each period 1% of participants will take out a 10% lump-sum amount and that those assets leave the plan. We use the 20y government bond yield as the reference interest rate for calculating the theoretical benchmark return and for interest rate hedging purposes.

Figure A1: Solidarity Contribution Scheme Intergenerational Allocation Rule Assumptions[1]

	Starting Capital Weight %	Duration	Interest Hedging %	Risk Bearing %
Age Group 1	10%	40	30%	120%
Age Group 2	30%	25	40%	60%
Age Group 3	60%	10	80%	20%

Source: PMA. For illustrative purposes only. Note: Yellow field indicates an investor input.

A2. Summary of Rebalancing Rules (Baseline)

We rebalance the total portfolio based on the plan's target asset allocation, asset-specific tolerance ranges and rebalancing frequencies. For baseline scenario, we assume fixed target portfolio weights for the 10y horizon. Equity and fixed income assets are treated as single asset categories, respectively, and are rebalanced quarterly back to targets. Private assets are not subject to rebalancing. "Rebalancing failure" is defined as when equity and fixed income categories cannot be rebalanced to targets.

Figure A2: Summary of Rebalancing Rules (Baseline)

<table>
<tr><th colspan="2">Asset Class</th><th colspan="2">Target Portfolio Weights</th><th colspan="2">Assumed Tolerance Range (+/-)</th><th colspan="2">Rebalancing Frequency</th></tr>
<tr><td rowspan="2">Equity Assets</td><td>Passive Equity</td><td rowspan="2">47.5%</td><td>30%</td><td rowspan="2">0%</td><td>5%</td><td rowspan="2">Quarterly</td><td>Quarterly</td></tr>
<tr><td>Private Equity</td><td>17.5%</td><td>N/A</td><td>No Rebalancing</td></tr>
<tr><td rowspan="4">Fixed Income Assets</td><td>Cash</td><td rowspan="4">52.5%</td><td>3%</td><td rowspan="4">0%</td><td>5%</td><td rowspan="4">Quarterly</td><td>Quarterly</td></tr>
<tr><td>Passive Fixed Income</td><td>37%</td><td>5%</td><td>Quarterly</td></tr>
<tr><td>Active Fixed Income</td><td>10%</td><td>5%</td><td>Quarterly</td></tr>
<tr><td>Private Credit</td><td>2.5%</td><td>N/A</td><td>No Rebalancing</td></tr>
</table>

Source: PMA. For illustrative purposes only. Note: Yellow field indicates an investor input.

A3. What-If Analysis Results: Baseline *vs.* Alternative Allocation

Figure A3 shows a summary of the results comparing the alternative asset allocation scenario to the baseline scenario. Compared to the baseline scenario, the alternative scenario sees an improvement in the average annualized horizon return of approximately 10bp/y.

As a tradeoff, however, the portfolio is exposed to higher liquidity risk. For example, the probabilities of touching L1 and L2 liquidity alert lines are higher. Also, we see slightly bigger sustained liquidity drawdowns under the alternative scenario. However, the probability of the solidarity reserve falling to zero decreases somewhat.

It is important to note that our estimation of infrastructure equity returns is based on a relatively short period of historical data (since 2015). During this timeframe, infrastructure assets demonstrated exceptional performance compared to other asset classes.

1 These assumptions build upon WTW's example in illustrating the rules.

This outstanding performance may be attributed to increased investor interest in infrastructure for stable income and portfolio diversification. For comparative purposes, we have included a scenario in which we apply a haircut to the forward-looking returns of infrastructure assets (see Figure A4). This adjustment assumes a normalization of infrastructure returns in the future, when the risk and return profile of infrastructure assets aligns more closely with those of other asset classes.

Figure A3: Summary of Performance and Risk

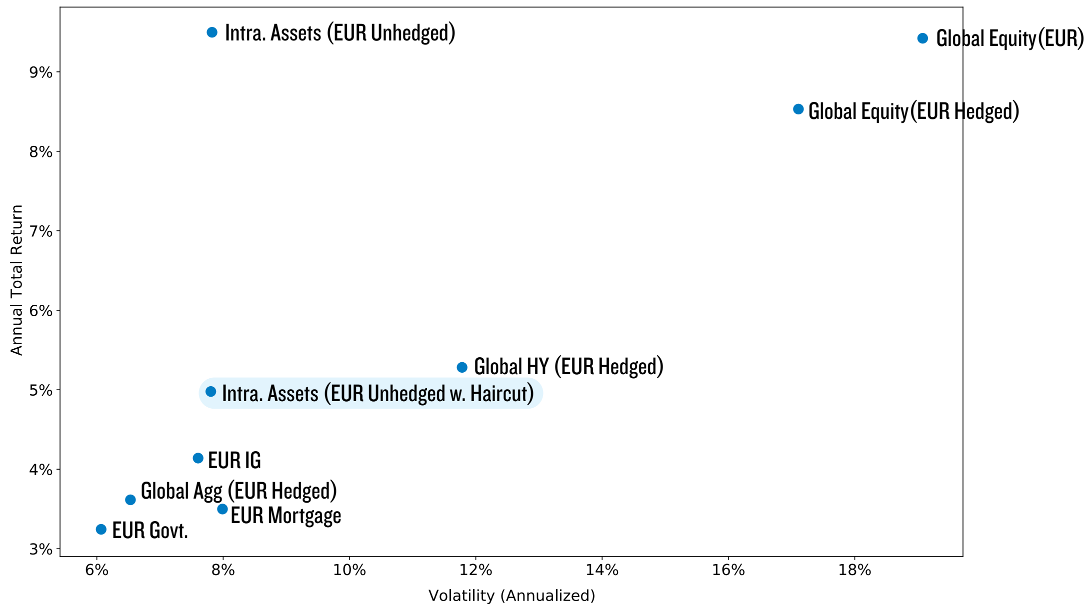
Performance				
		Baseline Asset Allocation	Alt. Asset Allocation (+10% Infra. Allocation)	Alternative Asset Allocation (+10% Infra. Allocation w. Haircut)
Avg. Horizon "Return"		9.3%/y	9.4%/y	9.1%/y
Risk				
Liquid Asset Drain	Probability of Hitting "Early" Alert Line L1 (Use up 20% of all liquid assets)	5.5%	11.0%	11.6%
	Probability of Hitting "Secondary" Alert Line L2 (Use up 25% of all liquid assets)	1.3%	3.1%	3.3%
Rebalancing Failures	Avg. Number of Rebalancing Failures over 10y	0	0.1	0.1
Solidarity Reserve Falls to 0	Probability of Solidarity Reserve Falling to 0 at least once	0.4%	0.2%	0.3%
	Avg. Quarters where the Solidarity Reserve Falls to 0 (if it happens)	2.8	2.4	2.2
12m Liquid Asset Drawdown	Avg. Max-Drawdown	-20.5%	-22.3%	-22.6%
	Worst 5% Expected Max-Drawdown	-36.2%	-38.3%	-38.7%
	Worst 1% Expected Max-Drawdown	-44.2%	-47.0%	-47.5%

Source: PMA. For illustrative purposes only. Data as of 30 September 2023. Note: Avg. Horizon "Return" accounts for retirement contributions and distributions.

A4. Annual Total Return *vs.* Volatility – 10y Simulation

Figure A4 illustrates the relationship between simulated annual total return and volatility for asset classes held in the modeled portfolio over a 10y period. Notably, infrastructure equity assets show higher returns, but moderate volatility, compared to other asset classes. This is because estimated infrastructure returns are derived from simulations based on historical data, specifically from 31 March 2015 to 31 December 2023, a period where infrastructure assets demonstrated exceptional returns coupled with moderate risk. However, market environments are subject to change and future returns and risks may differ significantly from those observed historically. We acknowledge that the favorable historical performance of infrastructure assets may not be replicated in future periods. Users of this framework can easily incorporate their own capital market assumptions.

Figure A4: Annual Total Return *vs.* Volatility – 10y Simulation



Source: PMA. For illustrative purposes only. Data as of 30 September 2023.

Note: For infrastructure price returns, we link its price returns to simulated public market returns using data starting from 31 March 2015 to 31 December 2023. For Infra. Assets (EUR Unhedged w. Haircut), we apply a -4.5%/y adjustment to the modeled forward-looking infrastructure income returns so its risk and return relationship is more similar to other asset classes.

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