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Navigating the Future: Strategic Risk Management and Asset Allocation in Private Pension Funds

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Abstract

This thesis explores strategic risk management and asset allocation in private pension funds. It examines the foundational elements of pension funds, the variability in risk management practices, and the importance of sophisticated risk measures such as VaR and tracking error volatility. It provides a comprehensive literature review of the main asset allocation strategies adopted by asset managers, highlighting the advantages and challenges associated with each strategy. Through case studies of Vanguard and BlackRock, it highlights the effectiveness of Strategic Asset Allocation (SAA) over Tactical Asset Allocation (TAA) and the benefits of private market investments. Additionally, it discusses the growing role of government regulations and risk-based supervision in enhancing pension fund governance and stability. The study underscores the need for disciplined, long-term investment strategies to secure retirees' financial futures.

I) Introduction

1. The private pension funds industry and its rising importance in an aging society

A private pension fund is a plan into which individuals voluntarily and privately contribute from their earnings. Funds are organized financial vehicles designed to accumulate and invest contributions from individuals, to generate returns that can later provide a source of income during retirement. As funds invest in a diversified portfolio of assets, including stocks, bonds, and other financial instruments, they are typically managed by financial institutions, such as asset management firms, insurance companies or specialized pension fund managers. The organizational structure usually involves a board of trustees responsible for overseeing the fund's operations and ensuring compliance with regulatory requirements.

The significance and functions of private pension plans can vary depending on the country and its legislative framework. As remarked in a recent paper by Elsa Fornero, retirement income generally comes "from three sources: public pensions, private occupational pensions and private personal savings."[1]. But there exists a crucial distinction regarding the percentage by which private plans contribute to the overall retirement income. Private pension funds can either have a major and central role - usually accounting for more than half of the retirement income - or, contrarily, only supplement the pension given from mandatory social security.

Fornero observes that in countries like Italy and Germany, private pension fund represent "a marginal role" as most of the retirement provided to workers comes from national pension plans[2]. In these countries, private pensions traditionally existed only as a fringe benefit for privileged employees or sectors that were mainly financed by employers through their book reserves. As their role is marginal, private funds are still relatively unsophisticated.

On the other hand, in many northern European countries and the US, the first pillar only offers a basic income. In such countries, the retirement income provided by the first pillar is significantly lower than the earnings previously enjoyed during active life. The second pillar

[1] *See* Fornero et al. (2020) for a deeper analysis of the differences between European and American private pension funds.

[2] According to 2023 data from ISTAT and COVIP, of the 23,8 million workers in Italy only 5 million are self-employed. For these autonomous workers, only a small portion (1,6 million approximately) has the private pension as the first pillar in their retirement income (*casse previdenziali*). For all the remaining 22,2 million workers, private pension plans represent the second pillar.

represents an important complement to the first pillar, if not even the major source of income.[3] In the US private pensions are usually DC schemes arranged by the employer and receive contributions from both the employer and the employee. The social security scheme only provides a foundation as the majority of the retirement income comes from occupational or individual schemes. According to the American definition given on the official website of the Social Security, the "social security provides a guaranteed, cost-of-living adjusted income for life in retirement, and is only responsible for keeping older individuals out of poverty"[4]. In fact, Social Security was never meant to be the sole source of retirement income for American workers[5]. The second pillar - private group pension plans - is just as important as for social security. According to Ellis et. al.[6], altogether, roughly half of the american workforce does not participate in any plan. For those retirees without the first pillar, the retribution coming from private plans represents their only source of guaranteed income.

Pension funds have also gained much success due to the many advantages that they offer. The first advantage is represented by the favorable tax treatment. In most countries, pension contributions - for both the employee and the employer - and investment gains stemming from pension plans are not taxed at all or have a low tax rate. Informed workers will thus want to invest high portions of their reserves/salary in funds to pay less taxes. A second reason for becoming a member of a fund is the fund's cost efficiency. Rather than self-managing their own reserves, plan members can count on a team of finance professionals to manage their assets. Given a small fee, workers can have in return the security that their investment is professionally managed on a daily basis. Pension funds will also be able to enter in a variety of transactions that a single small investor cannot. The larger size of pension funds creates economies of scale that reduce management fees and make prediction more accurate (for example estimating mortality

[3] *See* Deutsche Bank Research, 2003, "Aging, the German Rate of Return and Global Capital Markets".
[4] In the US, as clearly stated on the official website of the American Social Security Administration, the Social Security Retirement benefit "replaces part of your income" and as "it may not replace all your income so it's best to identify other ways to pay for your monthly expenses as you age.". https://www.ssa.gov/retirement#:~:text=Social%20Security%20in,as%20you%20age.
[5] To give the reader a better understanding, as many as 30% of state and local government employees do not participate in Social Security at all - considering that for private employees this percentage tends to be significantly higher.
[6] *See* Ellis, Charles D., Alicia H. Munnell, and Andrew D. Eschtruth. 2014. *Falling Short: The Coming Retirement Crisis and What to Do About It*. New York, NY: Oxford University Press.

risk for a single investor is very difficult whereas estimating mortality risk for a pool of individuals, who often share many characteristics[7], is much simpler).

The importance of pension savings has increased dramatically in recent years, particularly as populations mature. Pension funds - both private and public - are confronted with a variety of retirement challenges associated with population aging, reflecting in part two long-term trends: increasing longevity and low and declining fertility rates. The growing importance of this sector reflects the growing number of risks faced by this sector, this is why it's crucial to meticulously identify and rank them. Across Europe, as pension liabilities increase - driven in part by the impending retirement of a significant number of baby boomers - the strain on public finances is becoming increasingly apparent. With the younger workforce grappling with stagnant wages and elevated unemployment rates, the sustainability of public pensions is at risk. Older European countries like Italy, Greece, and France display worrisome signs of impending fiscal imbalance. Currently, Italy illustrates the severity of the situation, with a ratio of approximately 60.6 retirees for every 100 workers[8]. Looking to the future, projections are even more concerning. According to some analyses[9], by 2050 there could be one retiree for every worker (1:1 ratio), due to the ongoing decline in birth rates and the aging population. But why should a private entity be worried for a public authority? Because such a scenario would exert unsustainable pressure on public finances, necessitating significant cuts in the pension system thus substantially increasing the importance vested by private funds in assuring pensioners a retirement. In anticipation of potential government actions to curtail pension benefits, the importance of the private savings pillar cannot be overstated. As such, private pension fund managers may enhance their prudence by incorporating additional layers of protection.

Furthermore, pension funds now represent major actors in the global financial landscape. As of 2018, per Bloomberg, global pension funds managed assets totaling an astounding $44 trillion.[10] Funds are increasingly managing larger portfolios and diversifying investments across

[7] Workers coming from the same sector will usually share the same income profile. The homogeneity in the income profile can allow for asset managers to tailor specific investment strategies. For example, estimates made in the U.S. have found that self-employed workers' income positively correlates with stock market returns. Therefore, a pension fund with many self-employed members should invest less in equities compared to a general pension fund. For a deeper analysis *see* Nicodano, G., Le scelte di portafoglio nel risparmio previdenziale, *Intervento al Convegno Inarcassa*, (2003).

[8] *See* https://www.truenumbers.it/pensionati-in-italia/

[9] *Id.*

[10] To put this into perspective, let's recall that the total world GDP in 2021 was approximately $93.86 trillion. Thus, global pension funds manage nearly half of the entire global economic output.

a broader range of sectors. Their investment strategies and asset allocations possess the capacity to shape global economic trends. Radical or unexpected changes in their asset allocation could cause financial distortions, potentially triggering a global crisis.

For such reasons, the role of private pensions has grown significantly in the past two decades. It is crucial to ensure that pension funds implement and monitor sound risk management practices. Following this trend, the complexity of funds risk management has significantly increased in recent years.

2. The licensing and creation process of Private pension funds

Licensing is the process through which a pension fund acquires the right to function and to avail of specific tax privileges. To ensure such a process, an unborn pension fund will have to register with relevant regulatory authorities and comply with financial regulations. To obtain the status of legal entity, managers of the fund will have to obtain necessary licenses, prepare essential documents, and establish internal controls. In most of the developed countries, before the launch of operations, the fund will have to be awarded a specific license. The object of licensing depends to a large extent on the pension fund construction used in each country — and for this reason it can vary heavily. As summarized by the International Organisation of Pension Supervisors (IOPS)[11], "there are three different types of pension fund constructions: the pension trust (mostly Anglo-Saxon countries), the pension fund with legal personality (such as the foundations, mutual associations and similar legal entities in countries such as Austria, Germany, Hungary, Italy (closed funds only) and the Netherlands), and pension funds without legal personality administered by pension fund managing companies (as in Bulgaria, Poland, Portugal, Slovakia, Spain, and Turkey). Pension trusts: The trust is a legal scheme whereby named people ("trustees") hold property on behalf of other people ("beneficiaries").".[12] Trustees are required when the pension fund is vested with legal personality. The trustee is the person or group of persons (in this case trustees) who is legally responsible for managing the assets of the pension fund. The trustee is often a lawyer, an investment professional or a syndicalist (usually for corporate plans) who must act in the exclusive interest of the pension members and beneficiaries.

[11] Formed in July 2004, the International Organization of Pension Supervisors (IOPS) was instigated by the Organisation for Economic Co-operation and Development (OECD) and the International Network of Pension Regulators and Supervisors (INPRS).

[12] *See* OECD and IOPS report "The licensing of pension entities in private pension entities" (2007). https://www.oecd.org/daf/fin/private-pensions/39035914.pdf

The majority of trustees' responsibilities pertain to making investment decisions. On this subject, the trustee must follow the *prudent investor rule* which states that he must act "in the best interest of the beneficiary by investing and managing trust assets "as a prudent investor would"".[13] The *prudent investor rule* specifically concerns the U.S. but very similar approaches are taken by most countries. On the other hand, when funds do not possess legal rights, they are referred to as pension fund management companies. This type of financial institution will only have to manage legally separated pension funds. Since the vast majority of large-sized funds fall into the former category, our study will focus on pension funds vested with legal rights - and therefore managed by trustees.

3. Types of Pension Funds: DB, DC, Open or Closed and the Asset Allocation Process

Private pension funds can be categorized into two main types: defined contribution (DC) and defined benefit (DB). In a DC plan, the amount contributed is defined, but the future benefits are not guaranteed. The final payout depends on the investment performance of the fund. Individuals bear the investment risk. On the other hand, in a DB plan, the future benefit is predetermined based on factors such as salary and years of service. The employer is responsible for ensuring that there are sufficient funds to meet the promised benefits. The two cases are linked by a strict logical relationship, whereby: If the pension fund sets the contribution amount, then it cannot also determine the size of the benefit, which will instead vary depending on the results of the management of the accumulated capital. If the pension fund sets the benefit amount, the uncertainty governing financial investment activity also requires a "degree of freedom" in this instance, represented by the ability to vary the contribution value[14]. Moreover, the management of the assets of a defined contribution fund can be of two types: pure or guaranteed. It is pure if the intermediary-manager does not provide any guarantee (except for the guarantee of their professionalism) regarding the outcome of their management activities. In this case, the members of the fund receive the final value of the managed capital, which is equal

[13] *See* the definition of *Prudent investor rule* at Legal Information Institute, Cornell Law School. https://www.law.cornell.edu/wex/prudent_investor_rule#:~:text=act%20in%20the%20best%20interest%20of%20the%20beneficiary%20by%20investing%20and%20managing%20trust%20assets%20%E2%80%9Cas%20a%20prudent%20investor%20would%E2%80%9D

[14] *See* Chartered Alternative Investment Analyst (CAIA) Level II Manual (2013), Chapter 4 "Pension Fund Portfolio Management", available at https://caia.org/sites/default/files/curriculum-download/caia_level_ii_chapter_4_march_2013.pdf .

to the sum of the contributions paid, increased by the returns and decreased by the losses. It is guaranteed if the intermediary manages the fund's resources while also providing a guarantee of a minimum return (which, in the case of mere return of capital, is zero). In this scenario, the intermediary, while still obligated to recognize all returns achieved through management, commits to covering any differences between the guaranteed and the actual returns (thus, in the case of a guarantee of return of capital, the commitment includes covering any losses incurred by the fund)[15].

Pension funds can assume different configurations depending on the establishing entity - distinguishing between closed and open funds[16]. Closed pension funds are the product of collective bargaining, promoted by entrepreneurs, workers, unions, and trade associations. Only workers belonging to a specific sector can access a closed pension fund - these are, in fact, sector-specific funds. The advantage of this type is that it is designed based on the needs of the worker group for which it is established. Open pension funds differ from the former because they are established directly by entities authorized to manage resources. These are privately managed funds. Open funds offer an alternative for those who are not satisfied with the results of their own closed membership fund and for those who do not have the possibility or the convenience to establish one.

Another distinction concerns the way in which funds allocate their assets. The two approaches are the in-house approach (internal managers) and the mandate/off-house approach (external managers). Following the former approach, the buying and selling decisions are directly made by the pension fund manager/trustee. On the other hand, in an externally managed pension fund, the assets are managed by external financial intermediaries to whom the pension trustee has given a legal mandate to manage its resources. This second is far more popular as specialized asset managers usually provide superior performance due to their superior financial skills. The in-house approach diminishes a fund's reliance on financial institutions for provisioning funds to pensioners. This method potentially offers higher returns as it eliminates fees payable to external asset managers and allows more autonomy in selecting asset allocation strategies. In recent years, a notable shift has occurred among private pension funds, moving from internal to external asset management processes. While this shift may simplify the adoption

[15] *See* Corvino and Saita (2001), "La definizione della strategia di investimento nei fondi pensione", *Il risparmio previdenziale e la sua gestione*, p.222, ISBN 88-86110-16-2.
[16] *Id*. p.220.

of a risk-based approach and facilitate the evaluation of asset manager performance, it has also complicated the overall landscape. When a pension fund assigns a mandate to a financial institution, it becomes essential to oversee a new and distinct entity: the asset manager. Under the in-house approach, enforcement is directed solely at fund managers whereas with an off-house approach, additional oversight is required for external financial institutions. In an in-house asset allocation, the investing entity is the same as the one legally bound to the pensioners. Conversely, in a mandate approach, a clear distinction exists between the fund's manager and the external asset manager. In the latter scenario, enforcement must extend to both the investment strategies chosen by external managers and the duty of oversight and monitoring the performance of these managers, a responsibility vested in the trustees and the fund's board. For mandated pension funds, the choice of not self-managing the resources imply that while pension funds will be the direct contacts for workers within the second pillar of the pension system, their interaction with capital markets can only be mediated through the services provided by a more traditional and already existing intermediary, such as the authorized manager. Consequently and in light of the increasing size of pension funds, there can be many principal (asset owner) and agent (asset manager) problems in pension funds.

In Italy, for example, the regulation of pension funds, introduced with the Legislative Decree No. 124 of April 21, 1993, imposes a prohibition on pension funds from directly managing their resources. Thus, the legislator has made a clear and straightforward choice, moving away from Anglo-Saxon models and avoiding the creation of a specific entity for the management of pension funds. Article 6, paragraph 1, of Legislative Decree 124/93[17] stipulates that the management of resources can only be conducted through specific agreements with authorized institutional investors: banks and S.I.M.s (investment management companies), insurance companies, and asset management companies.

The process through which asset managers and pension fund managers/trustees will define the asset allocation usually counts four steps. Firstly, the asset managers will start by proposing many different asset classes to the pension funds. The major asset classes consist of money market instruments (cash), fixed-income securities (bonds), stocks, real estate, precious

[17] Legislative decree of 04/21/1993 n. 124 - Regulations of supplementary pension schemes, pursuant to art. 3, paragraph 1 of law no. 23 October 1992. https://def.finanze.it/DocTribFrontend/getAttoNormativoDetail.do?ACTION=getArticolo&id={24616C92-E67C-4BFF-A277-928C1CF3908E}&codiceOrdinamento=200000600000000&articolo=Articolo%206#:~:text=Salva%20to%20 provvedimento,comma%201%2D%20 bis.

metals and lastly alternatives or other types of investments. Institutional investors such as pension funds will typically focus on the first four categories. The choices of the asset classes will be dictated by fund preferences and by their risk tolerance. This can be seen as the moment in which the pension fund gives the inputs to the machine, the asset manager. A DB fund, as it must obtain specific and predertimend guaranteed returns, will tend to invest in riskier assets such as stocks. On the other hand, a DC plan will usually set a maximum risk tolerance level upon which the asset manager will build a portfolio composition and optimize allocations. The second step will consist in specifying the capital market expectations. This step consists of using both historical data and economic analysis to determine the expectations of future rates of return over the relevant holding period on the assets to be considered for inclusion in the portfolio. After having estimated the returns, the asset manager will derive the efficient portfolio frontier. This step consists of finding portfolios that achieve the maximum expected return for any given degree of risk. Lastly, the asset manager will find the optimal asset mix, the outputs of this procedure. This step consists of selecting the efficient portfolio that best meets risk and return objectives while satisfying the constraints.[18]

II) An overview of risk management in private pension funds

1. The risk management process in a pension fund: risk management structure and good practices

Risk management represents one of the many crucial challenges that every business, company, organization, and even every human being, must face. In order to assure the continuity of a corporation functioning, a risk manager must identify, analyze, and respond to risk factors that form part of the life of a business[19]. Risk management offers the potential to reduce both the possibility of a risk occurring and its potential impact. As defined by the IOPS, risk management "can be defined as the process designed to provide reasonable assurance regarding the achievement of objectives in terms of: effectiveness, efficiency and resilience of operations;

[18] *See* Investments, Ninth Canadian Edition, ISBN-IO: 1-25-927193-5, p.925.
[19] *See* the definition of Risk Management, *Corporate Finance Institute*, May 2024. https://corporatefinanceinstitute.com/resources/career-map/sell-side/risk-management/risk-management/

reliability of financial reporting; and compliance with laws and regulations."[20]. Unforeseen events could range from having minor impacts - a small increase in operating costs for example - to having catastrophic consequences - such as a significant financial burden that could seriously harm the life of the fund. Is important to clarify that the term "risk" should not evoke a negative connotation. The demonization of the risk is an enemy of the intelligent investor[21]- or as in this case, the intelligent pensioner[22]. Without risks, opportunities cannot be created, and their proper management enables long-term sustainability.

One of the conceptual regulatory cornerstones is that every process in a private pension fund - from operational to strategic and decision-making processes - should be based on proper consideration of the relevant risks, thus employing what is commonly referred to as a *risk-based approach* (RBS).[23] According to the OECD definition, the RBS "refers to an integrated system, founded on preventative actions, with high strategic value, based on risks. The process should not involve just one policy or procedure performed at a certain point of time but should be continually operating at all levels of the organization, and involve all staff.".[24] The risk-based approach should encompass and shape every aspect of a fund's decision.

In light of these remarks, public and private supervising authorities - as the IOPS - have set up *good practices* to both help external managers manage the risks and help internal managers assess external management performances and oversee their actions. These *good practices*[25] and schemes aim to outline how managers practically tackle risk management.

[20] OECD/ IOPS "GOOD PRACTICES FOR PENSION FUNDS' RISK MANAGEMENT SYSTEMS", (Jan. 2011), p.2. Available at https://www.oecd.org/daf/fin/private-pensions/46864889.pdf.
[21] *See* Graham, B., *The Intelligent Investor*, 1949.
[22] Should we assume that all pensioners are financially savvy? Often, pensioners possess relatively low levels of financial literacy, which significantly limits the strategies pension funds can adopt for asset allocation. Although pension funds are designed to meet long-term financial goals for their members, many pensioners may focus primarily on short-term investment results. This focus can prompt fund managers to implement overly cautious strategies, potentially reducing overall returns. The literature on the matter tends to regard the financial literacy of plan members as a key element in the fund's management choices.
[23] *See* Marchisio, V., *Il processo di gestione dei rischi*, (2022), p.1.
[24] *See* Stewart, F. (2010), "Pension Funds' Risk-Management Framework: Regulation and Supervisory Oversight", OECD, Working Papers on Insurance and Private Pensions, No. 40, doi:10.1787/5kmlcz7qq3zx-en.
[25] See supra note 20 at p.3.

1.1. The stages of the risk management process

1.1.1. Context definition

It is the first step and it is fundamental. The better a risk manager knows the fund, the better it will protect it in the future and tailor his approach. It is essential to underline two key aspects. The first is that, at this level, there are entirely subjective and peculiar aspects of one's pension fund. Risk propensity and organizational models, in particular, are not defined from the top down but are the prerogative of administrators. The second is that the entire process derives from the characteristics of the fund: the complexity and aspects of the models adopted depend on the complexity and peculiarities of the fund itself. An effective risk-based approach should be adjusted on the fund's real nature and complexity. In this sense, regulations pay much attention to the funds specific characteristics - such as size, nature, scope, complexity, and organization.

1.1.2. Identification

It is the step of risk mapping where all risks that may impact the pension fund are identified. Identification can occur through various techniques, such as interviews, brainstorming, drawing on experience, and the expert judgment of those familiar with the specific context. It is important not to overlook any risks. For this reason, risk managers prepare a specific risk map containing the identification of the risk categories - and sub-risks - to which the fund is exposed based on the activities carried out within the various processes.

1.1.3. Analysis and measurement

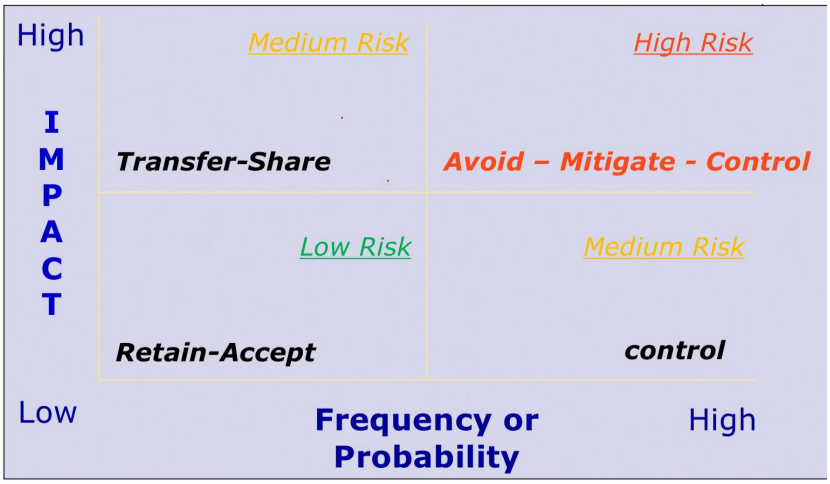
Risk analysis is a delicate phase and generally involves finding approaches dedicated to estimating the probability of occurrence and the impact of risky events. Managers will provide quantitative methodologies and alternatively or in combination, control or mitigation measures (hence qualitative methodologies). Where possible, interrelationships between risks are considered, assessing them both individually and on an aggregated basis. Regarding all risks not directly quantifiable through quantitative methods, the risk management function conducts a specific qualitative assessment, the results of which are documented appropriately and collected to serve as a basis for comparison for risk management analysis activities. The impact on the fund can be expressed in financial or economic terms, but in some cases, other types of analysis

and evaluation metrics may be used. If available, historical data can be considered. In this case as well, resorting to expert judgment is possible and advisable if there is no availability of data and solid statistical bases. Particular importance, in this phase, is given to conducting stress tests and scenario analyses. Stress tests and scenario analyses are quantitative techniques with which the risk management function assesses the fund's vulnerability as well as the performance and risk of financial management to extreme yet plausible events. These methodological approaches are designed to evaluate the effects on economic, asset, and financial conditions of specific events (stress tests) or of joint movements of a set of economic and/or financial variables under adverse scenario assumptions (scenario analysis). To ensure that the manager approach is rigorous, the tests are conducted periodically at predefined intervals and in the event of specific situations and/or events (e.g., natural disasters, pandemics, economic and/or financial crises) that could undermine the achievement of the fund's and/or participants' objectives.

1.1.4. Evaluation and treatment

Once the risks are listed and divided in categories, the managers will tackle them based on the following frequency/severity matrix. In this phase, managers will develop alternatives for risk response, determine the most appropriate response - based on the impact and the frequency of the risks and on the fund‘s tolerance level - and subsequently implement the corrective actions.

Table 1: Frequency-Severity Matrix



Risks will be divided into four groups: risks that can be retained and accepted (requiring no action); risks that should be transferred or shared (often accomplished with big and wealthy specific financial institutions such as reinsurers, for instance); risks that necessitate control; and finally, the most perilous risks, the ones that must be avoided. Based on each specific risk-profile in the matrix, management proposes approaches to monitor and tackle the risks. Furthermore, the evaluation phase allows for defining a priority order of intervention, becoming a fundamental strategic element. A fundamental role is played by the so-called 'risk appetite framework' (RAF), which defines, in accordance with the maximum assumable risk, the strategic plan and the internal self-assessment process of the fund's sustainability, in terms of: risk propensity (risk appetite); tolerance thresholds (risk tolerance); risk limits; risk governance policies. In this step, an amendment or a modification of the risk tolerance set up in the first step can be considered.

1.1.5. Cyclicity, Review, and Communication

The five steps mentioned above are not to be understood as stagnant compartments where each phase begins from the end of the previous one in a linear process. The entire process must be cyclical, subject to continuous revisions (data, models, context analysis...). Furthermore, it is important for risk managers to have continuous dialogue with administrators, risk area managers, and other parties involved in the life of the fund. To facilitate the communication of the risks with managers, risk managers must provide immediate keys and adequate indicators for understanding the evolution of risks and their management. Two extremely useful tools in this sense are the key risk indicator (KRI) and the key performance indicator (KPI). KRI is a risk indicator that measures the level or trend of a risk. It provides an ex ante measure by anticipating events that could impact performance. KPI is a performance indicator that measures the performance trend. It provides an ex post measure by conveying information about the achievement of a goal. Only following this approach the risk management process can play a fundamental role, not only at the operational level, but also at the strategic and planning levels.

1.2. Quantitative method to measure Risks

Once the good practices and the systems to monitor are implemented, the second challenge consists in determining which methods are most suitable for placing limitations on the asset manager's freedom, without thereby hindering the achievement of the performance

objectives set. In this regard, there is a wide variety of potentially employable measures, which, with some simplification, can be classified into three main categories. *Sensitivity measures*, which identify risk in terms of the portfolio's sensitivity to shocks recorded by a risk factor to which the portfolio is exposed, such as duration, modified duration, or beta. *Absolute risk measures*, which define risk as the volatility of returns or market value of the portfolio, such as variance of returns, semivariance, or value at risk. *Relative risk measures*, which define risk as the volatility of deviations from the benchmark, such as tracking error volatility. A crucial distinction regarding the available tools to measure risk concerns the time employability of these measures. Indeed, risk measures can be divided in *ex ante* or *ex post* measures. After briefly describing how each method works, we will analyze the strengths and weaknesses of the most used risk measures: duration and modified duration, beta, volatility (standard deviation of returns), value at risk (VaR) and tracking error volatility (TEV).

1.2.1. Duration, Modified Duration and Beta

Sensitivity is the magnitude to which a financial instrument reacts to changes. Duration, modified duration and beta are the main tools used concerning sensitivity.

Duration (also known as Macaulay duration) is extremely helpful for managers of portfolios containing bonds. The duration of a bond measures the sensitivity of the bond's full price (including accrued interest) to changes in interest rates. Duration is useful as it provides a tool to determine the price volatility of a bond. The Macaulay duration calculates the weighted average time before a bondholder would receive the bond's cash flows. Conversely, the modified duration measures the price sensitivity of a bond when there is a change in the yield to maturity. Modified duration measures the first-order effect of yield variation. It provides a linear estimate (approximation) of the percentage price change for a bond given a change in its yield-to-maturity (YTM)[26].

Macaulay duration is calculated as follows:

[26] Much of the material taken for the Duration and Modified Duration has been taken from the *Lecture 2: Interest Rate Risk Management* of professor Pierre Saint-Laurent of HEC Montréal.

$$Macaulay\ Duration\ = \frac{\sum_{t=1}^{n} \times (PV \times CF) \times t}{Market\ Price\ of\ Bond}$$

$Where$:

$PV\ \times\ CF\ =\ Present\ value\ of\ coupon\ at\ period\ t$

$t\ =\ Time\ to\ each\ cash\ flow\ in\ years$

$n\ =\ Number\ of\ coupon\ periods\ per\ year$

Modified duration is calculated as follows:

$$Modified\ Duration\ = \frac{Macaulay\ Duration}{1+\frac{YTM}{n}}$$

$Where$:

$YTM\ =\ Yield\ to\ maturity$

$n\ =\ Number\ of\ coupon\ periods\ per\ year$

The percentage variation of a bond's price caused by the variation in YTM can be estimated by multiplying the modified duration by the YTM's variation.

$$\frac{\Delta P}{P} \approx\ \ -\ D^{*} \times\ \Delta y$$

$Where$:

$D^{*}\ =\ Modified\ Duration$

$\Delta y\ =\ Change\ in\ Bond\ Yield.$

The Modified Duration is the only variable in the equation that can be managed by changing the composition of the portfolio, which is why we can see it as a tool for risk management. The duration of a coupon increases when the YTM decreases. For a given maturity, duration increases when coupon rate decreases. For a given coupon rate, duration generally increases with maturity. It always increases with maturity for bonds sold at par or at a premium.

But rather than applying it singularly, fund managers will use portfolio duration - whether Macaulay or modified - as it provides a better tool to understand the overall picture. Portfolio duration is the weighted average of the weighted sum of individual durations. Let's provide a practical example to best explain how duration can help portfolio managers.

Suppose that a pension fund manager, forecasting a rise in interest rate, intends to decrease the duration of his bond portfolio to a new targeted modified duration of the portfolio equal to 10. Given the following portfolio:

$$Value\ of\ Bond\ portfolio\ =\ \$20\ Million$$
$$Total\ Modified\ Duration\ of\ the\ portfolio\ =\ 13,72$$

By using long-term government bonds he can quickly decrease the duration of his portfolio. The manager must first determine the dollar value of a basis point (DV01).

$$For\ the\ Current\ Portfolio\text{: }\$20M\ \times\ 13,72\ \times\ 0,0001\ =\ \$27\ 440$$
$$For\ the\ Targeted\ Portfolio\text{: }\$20M\ \times\ 10\ \times\ 0,0001\ =\ \$20\ 000$$
$$Difference\ between\ the\ targeted\ and\ the\ actual\ DV01\ of\ the\ portfolio\text{:}$$
$$\$20\ 000\ -\ \$27\ 440\ =\ -\ \$7\ 440$$

The manager must then apply the following hedge ratio to determine how many future contracts must be sold to obtain the targeted duration - supposing that the futures used are 30-Year Government of Canada Bond Futures (LGB)[27].

$$Price\ of\ the\ LGB\ =\ \$151,90$$
$$Hedge\ Ratio\text{:}$$
$$Number\ of\ LGBs\ =\ \frac{Targeted\ Portfolio\ DV01\ -\ Current\ Portfolio\ DV01}{LGB\ DV01}$$
$$\frac{-\ \$7\ 440}{\$151,90}\ \simeq\ -\ 48,9\ contracts$$
$$Number\ of\ LGBs\ to\ sell\ =\ 49$$

[27] For a more detailed version of this example *see* LGB Strategy: Reducing the Duration of a Bond Portfolio, Bourse de Montréal. https://www.m-x.ca/f_publications_en/lgb_strat1_en.pdf

Beta is another major tool in sensitivity analysis. It measures the systematic risk of a security, "which corresponds to the tendency of a security's returns to respond to swings in the broad market".[28] Fund managers use Beta to assess how much risk a stock adds to a portfolio. While a stock that closely tracks the market adds minimal risk to a portfolio, it also doesn't significantly increase the potential for higher returns[29]. For pension funds, which typically have long investment horizons, Beta may present some shortcomings. While Beta is extremely helpful in determining a security's short-term risk, it is less useful for assessing long-term risk. Since Beta is calculated using historical data points, it becomes less meaningful for investors aiming to predict a stock's future movements for long-term investments, given the inherent unpredictability of the future[30]. Additionally, a stock's volatility can change significantly over time, depending on factors such as the company's growth stage and other dynamics.

The advantages offered by these measures are their simplicity of use, managers familiarity with such measures and the possibility to immediately understand the impact of any new action - for example, it is easy to understand how the Modified duration of a portfolio varies following a change in securities' weights.

The major limitations of such measures are essentially three: the inability to provide a synthetic measure of the average cumulative risk assumed over a given period; the inability to capture all the risk profiles to which the portfolio is exposed; the inability to reliably synthesize the overall risk of diversified management strategies[31]. The first problem makes it impossible to use sensitivity measures, such as duration and beta, as ex-post risk measures, as they only serve as preventive measures. The other two limitations are perhaps even more relevant for our purposes as they represent a potential obstacle to the use of such measures for preventive purposes.

Firstly, these measures are not capable of capturing the entirety of the risks to which a portfolio is exposed. For example, managers can build bond portfolios with the same modified

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[28] *See* Investments, Ninth Canadian Edition, ISBN-IO: 1-25-927193-5, p.974.
[29] *See* Investopedia, What Beta Means for Investors, as of 31 May, 2024. https://www.investopedia.com/terms/b/beta.asp
[30] Simply acknowledging that what may happen tomorrow might never have occurred in the past is enough to contradict much of Beta's rationale. The market rollercoasters of recent years may prove that *Black Swan* events are far less rare than what we used to think. For an interesting allround analysis of the highly improbable and unpredictable *Black Swan* events and why humans tend to ignore their possibility, *see* Taleb, Nassim Nicholas, *The Black Swan: The Impact of the Highly Improbable,* (2007).
[31] *See* Corvino, G. L., Saita, F., (2001), "La definizione della strategia di investimento nei fondi pensione", *Il risparmio previdenziale e la sua gestione*, p.237, ISBN 88-86110-16-2.

duration as their benchmark but significantly more exposed to non-parallel shifts in the yield curve[32] or characterized by a decidedly higher credit risk[33]. Similarly, beta only captures the systematic risk of an equity portfolio, as if all the non-systematic risk components were by definition diversified in a fund that invests in a large number of securities. For example, assuming that we were able to distinguish firm-specific risk from sector risk, a portfolio with a large number of securities but concentrated in a few sectors can diversify a large part, but not all, of the non-systematic risk of individual securities. Indeed, while it will be possible to diversify to a large extent the risk associated with the specificities of individual companies, this will not be the case for sector-specific risk: and this risk is a component that a beta assessment of the portfolio would not always allow distinguishing.

Lastly, sensitivity measures generally do not allow for reliable measures for diversified managements, which include investments in domestic and international equity and bond sectors. Their role is limited to setting constraints on the individual component of the portfolio, without making clear, for example, the possible trade-offs between the share of a given sector in the total and its average risk level. It is unclear if and to what extent it is possible, if the share invested in equities is lower than that provided by the reference benchmark, to accept riskier than the average equity investments.

1.2.2. Volatility - Standard Deviation of Returns

Volatility is used to measure the risk that the price of a security changes. Volatility is based on the standard deviation of returns, it measures their dispersion. Investors use volatility to measure the likelihood that what will happen in the future will be different from what they expect - the discrepancy between the actual outcome and the expected return. In this sense, volatility is the rate at which the price of a security fluctuates for a given set of returns. It is important to note that volatility is a predictive measure and is based on past data. By averaging the squared deviations of its estimates, an investor will be able to make predictions. For example,

[32] Suppose for example a benchmark with a modified duration of 4 years. We could replicate the duration of the benchmark by creating a portfolio invested 50% in treasury bonds with a maturity of 6 months and 50% in securities with a maturity of 7,5 years. In such a scenario, if the yield curve was to move non-parallelly, by steepening, the changes in the market values of the portfolio and the benchmark would be noticeably different, despite having the same duration. For a more in-depth discussion of the exposure to the risk of non-parallel movements of the yield curve *see* Erzegovesi, L., (1990), *Strumenti e modelli quantitativi per la gestione obbligazionaria* and Fabrizi, P.L., *La gestione dei flussi finanziari nelle aziende di credito*, Giuffré, Milan, pp. 383-396.

[33] Which may require the introduction of additional constraints, such as minimum rating requirements for the securities to be included in the portfolio or compliance with a certain composition by maturity classes or duration.

an annualized volatility of 10% indicates that a stock price can increase or decrease by 10% in a year. One of the advantages of volatility is that it can be tailored for different horizons. We can indeed mesure daily, weekly, monthly or annualized volatility. While variance captures the dispersion of returns around the mean of an asset in general, volatility is a measure of that variance bounded by a specific time period. Furthermore, volatility allows managers to make correct investment decisions by providing a nature of risk - variability can be caused by economic changes, geopolitical events, market sentiment, etc… Indeed, volatility can be caused by many factors and for this reason it is crucial to understand its causes. Volatility is fundamental for managers as it allows them to create their optimal portfolios. By balancing risk - standard deviation or volatility - of a stock and return, managers can choose the portfolio that offers the highest expected return for a defined level of risk or the lowest risk for a given level of expected return[34] - ie. the efficient portfolio. An *intelligent investor* must not fear volatility but rather understand how it can use it to tailor its desired balance between risk and return. Pension funds, thanks to their deep pockets and to their nature of long-term investors, can tolerate particularly high levels of volatility. For this reason, it is crucial to first understand one's own investment time horizon before implementing any volatility management.

With respect to the limits of the sensitivity measures seen earlier, volatility represents one of the most consolidated solutions. Standard deviation allows to merge all risk components into a single measure and can also accurately measure the positive effect brought by diversification.

However, the volatility of returns is also subject to criticism[35]. Firstly, it can be argued that this measure does not consider a two-sided risk, meaning that, given an average return, it views both significantly higher and significantly lower returns compared to the average as equally negative events. To address this, some suggest using measures of semivariance, which only take into account the possibility of returns below the average return[36]. Secondly, the measure of return volatility is more complex to use ex ante, although, just as value at risk identifies the maximum potential loss of a portfolio over a given time horizon, it is not at all impossible to estimate the expected ex ante volatility of a diversified portfolio whose composition is known. The third noteworthy aspect is the need to define a time horizon over

[34] This distinction reminds us of the difference between Defined Benefit and Defined Contribution pension funds that we saw earlier.
[35] *See* Corvino and Saita (2001), "La definizione della strategia di investimento nei fondi pensione", *Il risparmio previdenziale e la sua gestione*, p.238, ISBN 88-86110-16-2.
[36] Or possibly below a given subjectively determined minimum acceptable return level.

which to measure returns for the purpose of calculating their volatility. Indeed, the time horizon impacts not only the volatility measure obtainable but also the risk-adjusted performance measures based on return volatility (such as the Sharpe ratio) that can be derived from it. In this respect, it is advisable that the measurement horizon is not too short, as it would likely be inconsistent to evaluate an investment strategy - often defined with reference to very long time horizons - based on daily return volatility.

1.2.3. VaR: Historical, Parametric and Monte Carlo simulation

If volatility looks at all the possible outcomes, value at risk (VaR) has the advantage of focusing solely on the downside risk of the portfolio's market value. VaR is a statistical measure of total portfolio risk. It is the worst loss at a certain specified confidence level over a certain specified time horizon. VaR deals primarily with “market risks": price changes of stocks, currencies, interest rates and commodities. With an estimate of the distribution of outcomes we can either ask about the probability of losing a given sum (what is the chance our loss exceeds $5M?) or ask, for a given probability, how much might we lose (what level of loss do we exceed with a 1% probability?)[37].

VaR can be computed following three different approaches: the historical simulation method (nonparametric method), the parametric method and the Monte Carlo simulation[38]. The historical simulation method is based on past data. By analyzing historical data on risk variables (stock returns, interest rates, exchange rates, etc…) we can calculate the gains and losses for a portfolio. For example, if we wanted to compute a portfolio VaR, assuming that we have a diversified portfolio, we should start by collecting data on the returns and then, by ranking it following a decreasing order, we would be able to make predictions, given a significance level, on the minimum losses. The parametric model follows a similar approach but, rather than ranking the returns, it calculates the parameters - average and standard deviation. Following such computations, we would have a table with each confidence level and its corresponding deviation from the average. Suppose we have a diversified portfolio of $100k in Canadian equities.

[37] To avoid confusion, VaR is a *minimum* extreme loss metric. VaR is not an expected loss nor does it reflect the maximum loss - the entire equity of an organization. VaR only states that, given a confidence level, the minimum that we can lose is a certain amount. However, VaR does not account for the worst-case scenarios beyond this confidence level. For instance, with a 95% confidence level, VaR excludes the losses that occur in the remaining 5% - which, funnily, are the most dangerous ones.

[38] Much of the material for this part has been taken from the *Lecture 3: Value at Risk* held by professor Pierre-Saint Laurent at HEC Montréal in September 2023.

Assuming that returns are normally distributed, we would first collect historical data on returns - say returns for the S&P 500 for the period 1957-2020. We would calculate the returns and the standard deviation.

Given the following values:

$Average\ return\ = 9,68$

$Stand.\ Dev.\ of\ the\ returns = 16,26$

For a 95% confidence level, we calculate the minimum loss for a 1-year horizon.

$VaR = \mu - \alpha\sigma$

$95\%\ confidence\ level\colon\ \alpha = 1,645$

$Var(95\%,\ 1\ year) = (0,0968 - 1,645 \times 0,1626) \times 100\,000 = \ -\$17\,068$

This would mean that, with a 95% confidence level, the minimum loss of our portfolio over a 1 year time horizon is $17 068.

The last approach to compute the VaR is also the one carrying the heaviest computational burden. In the Monte Carlo method, movements in risk factors are generated by random drawings from some distribution. This approach can be highly tailored and adapt to many different situations. But the flexibility provided by this approach also introduces certain disadvantages. A Monte Carlo VaR will heavily depend on the assumptions made by the analyst and for this reason, it is subject to model risk. To conduct a Monte Carlo simulation an analyst will specify a stochastic process for financial variables thanks to which fictitious price paths will be generated, for all variables of interest and for each desired horizon. Each of these generated results is subsequently used to compile a distribution of returns, from which VaR can be calculated.

While VaR represents a significant risk measure with considerable potential in asset management, it is important to highlight not only its strengths but also its potential weaknesses, as with any other measure. One of VaR's major advantages is its ease of understanding, which can facilitate dialogue between managers and fund management bodies when defining management characteristics, offering substantial benefits compared to less intuitive indicators

like return volatility. VaR, being a one-sided risk measure, also simplifies the aggregation of risks associated with different components of a diversified management line into a single measure. More clearly than return volatility, it can indicate the marginal risk contribution of each component. Furthermore, like in trading activities, VaR can be used both as a pre-risk limit and as a basis for determining risk-adjusted performance evaluations ex-post.

However, there are several practical issues[39]. Firstly, measuring the maximum potential loss over a much longer time horizon than traditional trading VaR measures is necessary. This involves deciding whether VaR should be interpreted as a potential loss relative to initial capital or, more appropriately, to a specific minimum amount at maturity. In the latter case, the "amount at risk" depends on the expected return rate of a set of financial assets, not just the volatility of returns, as in classic daily VaR estimates. Secondly, although VaR can serve as a benchmark for ex-post risk-adjusted performance, translating a series of daily VaR estimates into an equivalent annual VaR measure for performance comparison is unclear. Depending on how VaR is translated over extended horizons, the resulting measure can vary, leading to significantly different performance evaluations. Therefore, when using VaR as a risk measure, it is crucial to clearly state the methodological assumptions for both ex-ante and ex-post evaluations. Thirdly, VaR does not provide information about potential losses in extremely unfavorable events (e.g., the worst 1% of the portfolio's return distribution). This creates an additional control problem: theoretically, a manager might favor strategies that, while having the same VaR, are riskier due to potentially higher losses in rare cases exceeding VaR. Ideally, one should also account for the maximum loss. This could be done by introducing the *tail VaR*. It is possible to interpret tail var as an average of VaRs with different confidence levels. Tail VaR is formally expressed as:

$$E(X \mid X \ <- \ VaR)$$

This represents the expected loss conditional on exceeding VaR, addressing VaR's limitation of ignoring the distribution of returns in the worst 1% or 5% of cases. This limitation does not affect indicators like standard deviation, which consider the entire distribution of possible outcomes. Lastly, it's important to note that VaR's appeal, partly due to the sophisticated

[39] *See* Corvino, G.L., and Saita, F., (2001), "La definizione della strategia di investimento nei fondi pensione", *Il risparmio previdenziale e la sua gestione*, p.240, ISBN 88-86110-16-2.

estimation of potential maximum loss, should not overshadow the fact that the quality of VaR depends significantly on the assumptions made during its determination. For bond portfolios, precise mapping of cash flows provides a clear risk profile. However, for equity portfolios, using portfolio beta as the primary determinant of volatility raises concerns, reiterating criticisms of beta even when used as a basis for a more complex VaR measure. In this, much attention should be brought on volatility, as it represents a key input in any VaR calculation. The assumption that standard deviation is constant may be violated. As a consequence it is necessary to update volatility measures as VaR is computed[40].

1.2.4. Tracking Error Volatility

While return volatility and VaR are among the most important absolute risk measures, relative risk measures such as tracking error volatility (TEV) also serve as valuable alternatives for defining the constraints of a management strategy. TEV, which measures the volatility of the return differential between a portfolio and its benchmark over a given time period, is particularly useful for ex-post analysis. Ex-post, it provides valuable insights into the degrees of freedom exercised by the manager relative to the benchmark. However, predicting ex-ante the impact of specific deviations from the benchmark on the final TEV of a portfolio is more challenging and often relies heavily on experience.

For example, if a bond portfolio manager decides to overweight bonds maturing in three to five years compared to the benchmark, the impact on the portfolio's duration or VaR is straightforward to understand. However, assessing the immediate impact of this decision on the annual TEV is much more complex. This issue can be partially addressed by interpreting TEV through the lens of VaR. If the portfolio's risk is viewed as the likelihood of achieving results different and lower than the benchmark, it is conceptually possible to estimate a measure that could be termed "tracking error at risk" (TEaR), representing the maximum negative tracking error in the worst-case scenario. This could be calculated by considering the VaR of the manager's position, defined as the difference between a long position (portfolio assets) and a short position (the benchmark). Here, the short position represents the manager's "debt" to match the benchmark's performance. If the manager perfectly replicates the benchmark, the net position is zero. Otherwise, the risk of tracking error arises from the possibility that the underweighted

[40] For a deeper analysis on VaR shortcomings and alternative risk measures *see* Mcdonald, R. L. “Value at Risk” from Derivatives Markets, 2nd ed., Boston, Pearson Addison Wesley, 2006, p.832. ISBN 0-32-128030-X.

assets (short position) outperform the overweighted assets (long position) relative to the benchmark.

Regardless of how TEV is translated into a more practical ex-ante measure, it faces both criticism and significant observational challenges. One critique is whether it is appropriate to impose constraints on portfolios (and especially evaluate them ex-post) based on TEV. This approach incentivizes managers to minimize deviations from the benchmark, which may not always be efficient according to the mean-variance approach. Paradoxically, a portfolio achieving the same result as the benchmark with lower risk could be rated worse than a perfectly passive portfolio. The passive portfolio might have higher return volatility (and thus be less efficient) but could guarantee lower TEV, making it appear better if TEV is the sole criterion.

Another methodological issue with TEV, similar to return volatility, is the tracking error measurement interval between the managed portfolio and the benchmark. While a long-term analysis might reduce the measure's informativeness, daily observations could be significantly skewed by technical factors, such as different market value recording times or the presence of illiquid positions in one of the portfolios. For instance, consider a diversified bond portfolio compared to an international bond index. If the real portfolio's composition is very similar to the benchmark, but the fund values its portfolio at midday exchange rates while the benchmark uses rates from later in the afternoon, a slight depreciation of the lira against other currencies in the afternoon will be recorded by the benchmark the same day and by the managed portfolio the next day. Thus, on the first day, the portfolio will show a negative tracking error relative to the benchmark. If exchange rates remain stable the next day, the portfolio will reflect the previous day's currency appreciation, resulting in a positive tracking error. In this case, the observed TEV has nothing to do with the manager's intent to deviate from the benchmark[41]. Therefore, daily observations could overestimate the active risk (the risk associated with deliberate deviations from the benchmark composition) assumed by the manager.

[41] TEV could result in being negatively autocorrelated.

1.2.5. Funding ratio

Recently, a measure that has gained much popularity has been the funding ratio[42]. It is currently seen as one of the most important health indicators of a pension fund. Rather than being useful in the asset allocation process, the funding ratio plays a more crucial role as a general health check for a fund. The funding ratio - which is the value of a pension fund's assets divided by the value of its liabilities (pension benefits to be paid out) - reflects a pension fund's current financial position. This ratio is indeed crucial in risk management since it shows whether the pension fund holds enough reserves to pay out pension benefits – to its current and future members. To address this key indicator, most of the work done by risk managers will deal with the overseeing/structuring of the hedging portfolio. Risk managers will focus on controlling that the allocation of the assets have similar market risk exposures as its underlying liabilities. This approach known as LDI will be later described more in detail. Such an approach will guarantee that the movements in the assets value will be the same as the movements in their liabilities. This helps to ensure that the fund remains solvent. The strength of this tool is its incredible ease of understanding - not only for fund managers but also for fund members[43]. Nowadays, most of the funds have extremely high funding ratios. According to a recent study conducted by BlackRock, now, for the first time since 2007, american DB plans' average funding status is estimated to be over 95%[44].

[42] Another quasi identical mesure is the funded status. The funding ratio corresponds to the value of assets divided by the value of liabilities whereas the funded status is a difference between the value of the assets and the value of the liabilities. One is a ratio and the other is a difference.

[43] Most regulations require funds to disclose their funding ratio which members and workers can easily have access to assess the fund's financial solidity.

[44] *See* BlackRock, "Staying funded despite volatility", *Corporate Pensions*, (2024). In this study, BlackRock Client Insight Unit analyzed data from more than 200 U.S. corporate pensions. Available at: https://www.blackrock.com/institutions/en-us/insights/investment-actions/corporate-pensions-funding-ratios#:~:text=Now%20for%20the%20first%20time%20since%202007%2C%20DB%20plans%E2%80%99%20average%20funding%20status%20is%20estimated%20to%20be%20over%2095%25.

Figure 2: Summary of the strengths and weaknesses of different risk measures

Risk Measure	Strengths	Weaknesses
Duration and Modified Duration	Simplicity of use. Ease of understanding the impact of new decisions.	It does not measure the average cumulative risk. It does not consider credit risk. It does not take into account the risk of non-parallel movements. It does not allow for the evaluation of diversified management.
Beta	Simplicity of use. Ease of understanding the impact of new decisions.	It does not measure average cumulative risk. It does not consider the risk of strong sectoral exposures. It does not allow for the evaluation of diversified management.
Volatility - Standard Deviation of Returns	It evaluates the actual risk in all its components. It provides a measure of average cumulative risk. It allows for measuring the total risk of diversified management.	It considers risk as two-sided. Its translation into an ex-ante risk measure is possible but not easy to implement operationally.
Value at Risk (VaR)	It only focuses on downside risk. It can evaluate both ex-ante and ex-post risk. It can be constructed to assess a very high number of risk components. It allows for measuring the risk of	It is not always able to capture all risk components: it allows for understanding the average loss dimension in the case of losses exceeding the VaR. Even though it is possible to estimate the VaR

	diversified management. It enables determining the contribution of individual portfolio components to diversification (marginal VaR).	connected to credit risk, integrating this measure with the VaR related to market risks is not straightforward.
Tracking Error Volatility (TEV)	It measures risk as a deviation from the benchmark. It measures the total actual risk. It provides a measure of average cumulative risk. It can be translated into an ex-ante measure by introducing the 'tracking error at risk.	In its classic form, it would not be usable as an ex-ante measure. It pushes the manager to follow the benchmark even when it does not constitute an efficient portfolio.

2. Risk identification and definition: Main risks faced by pension funds

We will now examine the main risks faced by private pension funds, dividing them into categories, presenting the main sub-risks within each category and ranking them according to a frequency/severity approach.

2.1. Financial risks

This category encompasses all risks that can negatively affect the asset, economic, and financial performance of the fund, including losses due to excessive concentration on a counterparty. This category is mostly related to the moves in the markets and interest rates. This macro-category includes interest rate risk, equity risk, spread risk, currency risk, property risk, concentration risk, liquidity risk, and counterparty risk.

Investment or market risk

This is the risk of losses due to adverse movements in interest rates and other market prices - leading to underfunding in DB plans and low balances in DC accounts. The investment risk is commonly noted as one of the biggest risks pension funds bear, even if its relevance varies

depending on the country. Countries that have more developed funds will tend to have higher investments in the capital markets and thus have an increased attention to market risk, compared to less developed countries in which the amount invested is far lower. Italian pension funds, which tend to be less developed than their English or American peers, invest significantly lower percentages of their assets in the capital markets, preferring to keep more assets in cash and deposits. The impact coming from this risk factor is substantial since it affects the core activity of a pension fund, its ability to pay its members. Its frequency, looking at past years financial markets roller coasters, is to be considered medium-high.

Liquidity/Solvency Risk

The risk that a pension fund will run out of reserves and will be unable to meet its financial obligations — mostly the benefits promised to the members. To avoid this situation a fund must always maintain a high funding ratio as to have sufficient assets to meet its liabilities. The liquidity of a pension fund is a crucial aspect since it affects the core business of the fund, providing money to their members. This risk is tightly related to the investment risk and it shares the same position in the risk matrix.

Liabilities risk

The risk category includes those events that either directly impact the member, or whose occurrence results in an increase in the fund's liabilities and the consequent insufficiency of the resources needed to meet the benefits to be provided. Among these are: longevity risk, mortality risk, disability/morbidity risk, catastrophe risk, expense risk.

Longevity risk

The rise in life expectancy over the last century has given rise to a new economic and market risk known as longevity risk, particularly affecting the insurance and private pension sectors. This risk stems from the likelihood that the population, or specific subgroups covered by a pension plan, may outlive expectations, leading to prolonged retirement periods and increased pension payouts. Longevity risk hinges on unforeseen improvements in life expectancy, posing potential financial challenges for pension plans, insurers, governments, corporations, and retirees alike. The assessment of longevity risk is tied to mortality rates, reflecting the number of deaths

within a population over a specific timeframe. As mortality rates decrease and life expectancy rises, longevity risk becomes more pronounced. The critical issue with longevity risk lies not in the improvement of life expectancy itself, but rather in the combination of two factors: the uncertainty surrounding the upward trend in life expectancy and the potential variations in this uncertain trend. Due to the unpredictable and rapidly evolving nature of future life expectancy changes, there is a high probability of change for longevity risk. The impact of longevity risk is extremely high as even small changes in future mortality rate can have very negative consequences. As we can see in graph 1, a small decrease in future mortality rate (here of 1%), can raise the cost of providing an inflation-linked pension by 11%.

Graph 1: The impact of an expected decrease in future mortality rates of 1% below expectations (per year)

	45-year-old pre-retirement	65-year-old retiree (pensioner)
Impact on life expectancy	+2.7 years	+1.0 years
Impact on cost of providing a fixed pension	+7%	+3%
Impact on cost of providing an inflation-linked pension	+11%	+5%

Source: Coughlan,G., Blake, D., *Longevity Risk and Hedging Solutions*

Therefore, it is the uncertainty surrounding future life expectancy trends that makes longevity risk a major challenge to control for pension funds.

2.2. Operational risks

Operational risk is defined as the risk of loss "resulting from inadequate or failed internal processes, people and systems or from external events"[45], whether deliberate, accidental, or natural, that has resulted, could result or could have resulted in a loss or a gain[46]. The losses arise from poorly-designed or implemented processes, from individuals making errors or poor decisions due to negligence, lack of skills/knowledge, or deliberate actions. The cause could also come from systems that are flawed, incorrectly used or compromised and from external events that mean a service cannot be produced or delivered. For our case an example could be that, due to a compromised system, the proceeds from the investments cannot be delivered to the members. Operational risk arises from failures in transactions with counterparties, ineffective decision making, and inadequate or insufficient human and technical resources. Examples include transaction processing, outsourcing and cooperation, expenses, staff and information management. This category can be subdivided into the following sub-risks: internal fraud, external fraud, personnel management, relationships with members/sponsors/beneficiaries, damage to tangible assets, business interruption and system failures, process management, compliance/legal, cyber risk, outsourcing.

IT Risk

IT risk is the risk arising from "inadequate information technology and processing in terms of manageability, exclusivity, integrity, infrastructure, controllability and continuity".[47] An example could be a cyber attack on the database of a pension fund, putting at risk sensitive data of the fund's members. In the last two decades, in pension funds as more generally in all financial institutions, this risk has been increasingly important due to the digitization processes. Still, the impact is to be considered medium-low but the recent surge in cyber attacks - independently from the sector - shows that risk should be controlled. Risk managers should ensure that IT risks are correctly addressed and that a defensive system is present - and, must the defensive measures fail, ensure that a plan b is in place. As both the severity and frequency are very high, IT risk should be carefully managed.

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[45] *See* OECD/ IOPS "GOOD PRACTICES FOR PENSION FUNDS' RISK MANAGEMENT SYSTEMS", (Jan. 2011), p.2. Available at https://www.oecd.org/daf/fin/private-pensions/46864889.pdf.
[46] The definition is taken from a presentation held in HEC Montréal on November 10, 2023, by BNP PARIBAS managers François Guay and Kenya Sposito on the risk management process.
[47] *See* supra note 44.

2.3. Business risks

This risk category, which also includes strategic risk, is the risk of losses stemming from the strategic choices/decisions of the fund, and reputational risk, which is the risk of losses resulting from damage to the fund's reputation.

2.4.Emerging risks

An emerging risk is any evolving or changing risk, stemming from a pre-existing issue/problem that is only considered a risk today due to new knowledge about it or changes in the context and/or the way it manifests. This risk category, though very rare, may result in serious damages to the funds integrity. This macro-category of risk includes all those risks deriving from factors related to environmental, social, and governance (ESG) issues, extreme events, pandemics, natural disasters, and economic changes.

Contagion and related party/ integrity risk

The risks to an entity's business as a result of close association with another entity – the risks may be direct through financial exposure or indirect through reputation damage. This sub-category is often correlated to both financial and operational risks.

As defined by the IOPS, "integrity risk is the risk arising from ethical standards — for example injury of third parties liability, an ambiguous relationship of the fund with other financial institutions in the same group; insider trading, tax evasion, money laundering, fraud.".[48] The widely promoted ESG principles of responsible investment are now a key indicator of the integrity risk. Global environmental guidelines are shaping investment policies and risk management practices, forcing fund's risk managers to adapt. In addition, the increasing social attention to ecologic matters is increasing the volatility of firms involved or related to fossil fuel activities which is raising funds overall investment risks. The increasing importance of ESG and the growing public concern make the severity medium/high and the frequency may be still deemed as low.

[48] *See* IOPS Toolkit for Risk-Based Pensions Supervision, 2012, p.20. Available at : https://www.iopsweb.org/rbstoolkit/Module3identifyingrisks.pdf?_gl=1*1xo6k7r*_ga*NTcxMzA0ODU0LjE3MTY3NDYwOTY.*_ga_MBTGG7KX5Y*MTcxNzI4MzU4Ni42LjEuMTcxNzI4MzYwNS4wLjAuMA.

III) Fund Asset Allocation: Literature review

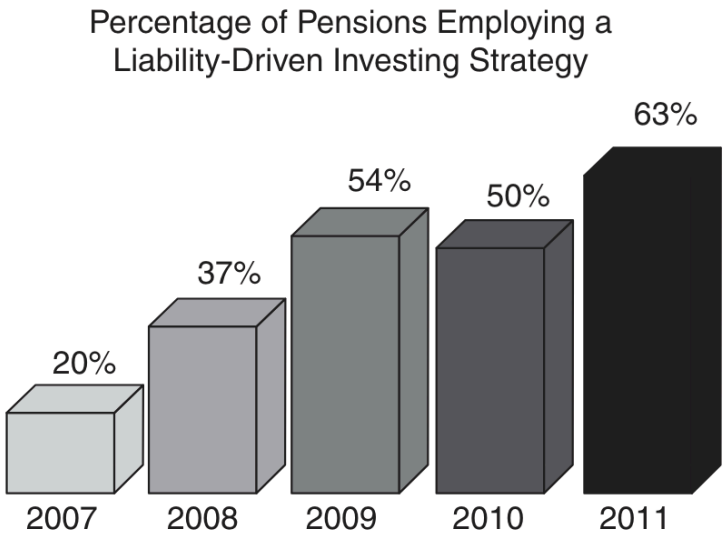
After seeing which risks affect pension funds and how those risks can be measured, we will now analyze what mostly influences the risk profile of a fund, its investment strategy. Which approach and strategy do funds follow to allocate their assets?

1. Liability-Driven Investments (LDI)

1.1. Overview of LDI Strategy

Over the last twenty years the approach that has become the accepted standard is the liability-driven investing (LDI). LDI is an investing strategy focused on managing investment portfolios to meet future liabilities. This approach aims to minimize surplus volatility by constructing a portfolio of assets that generate returns closely aligned with the fluctuations in the plan's liabilities. Nowadays, the overwhelming majority of funds - and other institutions with long-term obligations such as insurance companies - have adopted this approach.

Graph 2: Poll Results of Pension Management Research Panel Liability-Driven Investing



Survey Source: “5th Annual Liability-Driven Investing (LDI) Poll: More Plan Sponsors Using LDI Than in Years Past,” SEI Institutional Solutions, December 2011.

LDI involves constructing a portfolio that can generate returns closely correlated with the liabilities, thereby minimizing the risk of a funding shortfall. Key goals of LDI include ensuring that the duration of assets matches the duration of liabilities, reducing fluctuations in the difference between asset and liability values, protecting the portfolio against changes in interest rates that affect the value of liabilities, and ensuring that the portfolio can handle inflation-linked liabilities. In an LDI strategy, the assets hedge the risk faced by the liabilities - mostly interest rate risk and inflation risk - as they are designed to match all (or a portion) of the risks. With this approach, the fund’s funding ratio is significantly protected from volatility arising from changes in the liability valuation. In this sense, the two main tools used in LDI strategies are bonds and derivatives.

Hedging interest rate and inflation risk can be done by investing in fixed income assets such as government and corporate bonds. The most used are traditional fixed rate and inflation-linked bonds. Bond utilities lie in the fact that their movements are strictly opposed to the fund’s liabilities. By holding a portfolio of bonds a fund can protect itself from changing interest rates/yields. If long-term interest rates fall, then a fund’s liabilities will rise. This will then be offset by a similar rise in the value of the bonds that are held and thus one offsets the other and vice versa. The same beneficial solution occurs with changes in the inflation rate. An increase in inflation will raise the liability value and the value of an inflation-linked bond, as the future inflation-linked coupon payments are expected to be higher. The simplest way to immunize pension liabilities is to invest in a corporate bond portfolio with a duration matching that of the liabilities. However, bonds are also subject to some limitations. The first is represented by the fact that the bonds are scarce - especially for the bonds that pension funds are looking for. There is a scarcity of long-dated and ultra-long-dated bonds for pension funds to set against their long-dated liabilities. Furthermore, corporate bonds introduce credit risk as private institutions don't present the same creditworthiness of national banks. A second second problem is that bonds are expensive. In order to buy bonds a fund needs to raise cash by selling growth

assets - equities, property, hedge funds positions, etc… - and by doing so the fund is sacrificing potential performance[49].

Another useful solution is offered by derivatives. The derivative that has gained the higher popularity is the swap. A swap is an agreement between two parties to exchange one flow of payments for another. In this case, the two parties are the pension fund and their counterparty, an investment bank. The usefulness of swaps lies in their ability to offer similar advantages to those of bonds while presenting different limitations. As with bonds, swap can hedge inflation and interest rate risk. As with bonds, the value of a swap will change if the market interest rate changes. Let's suppose that a pension fund enters into an interest rate swap with an investment bank. If the price of a 10 year interest rate swap is quoted at 2% the fund would have to pay the counterparty variable interest for 10 years. For example, if 10 year interest rates rise to 3% the 2% 10 year swap we own will fall in value. The opposite is true. For example if rates were to fall to 1% we would receive a fixed interest of 2% and have to pay only 1%. Indeed, swaps present the same advantages offered by bonds. The movement in rates and therefore, in the value of our swap, present exactly the same behavior as exhibited by pension's liabilities. On the other hand, as opposed to bonds, swap presents some big advantages regarding the capital requirements. As swap doesn't require any upfront payment and it allows funds to manage their liability risk without tying up significant amounts of capital - usually by selling growth assets thus hindering potential performance[50].

However, just like in risk management, the better a manager knows the fund, the better they will invest its money. Fund managers and external asset managers must have a thorough understanding of the fund to effectively tailor the investment strategy - and the subsequent asset allocation. For this reason, the initial step in selecting an investment strategy is to understand the fund's liability cashflow profile. The liability cashflow profile is the schedule of the payments that the fund is projected to have to make during its lifetime to its members. Based on factors such as the length of service, salary, accrual rate and age, the fund's actuary will calculate the cash flow projections for the scheme's lifetime. The actuary also considers the fund's investments when determining the assumptions used to value the liabilities. The crucial point lies in the fact that the investment choices strongly influence the liabilities of a pension scheme as

[49] *See* "LDI Explained", BMO Global Asset Management, (2018), p.17. https://www.bmogam.com/uploads/2021/06/bf77d0fc81b9310168bcb5280e7ebf1e/ldi-explained.pdf
[50] *See* Id. at p.18.

they set the discount rate used. The asset mix determines the expected return which is used to discount the liabilities to calculate their present value. This makes determining the right asset mix paramount. Choosing a riskier mix will allow investors to expect higher returns and thus reduce the present value of liabilities and vice versa. However, as we know with higher return comes higher risk - higher volatility. Therefore, finding the optimal mix requires balancing risk and return.

1.2. LDI Portfolio Structure

Having decided to reduce liability risk, scheme trustees are then faced with choices regarding the portfolio structure. There are many different ways in which funds can choose to structure their portfolio. The main ways are pooled funds, segregated portfolio and bespoke funds.

A pooled fund is an investment vehicle where multiple investors combine their resources to invest collectively in a diversified portfolio. Pooled funds can represent a particularly effective solution when investors share similar characteristics, such as risk tolerance and investment horizon, which asset managers exploit to boost returns[51]. Each investor's profit is proportional to their contribution. In the context of medium-sized pension funds, pooled funds represent the most common portfolio structure. The main advantages of this solution are economies of scale and diversification. Economies of scale allow for lower trading costs per dollar of investment, while diversification reduces risk. Pooled funds can be tailored to propose different leverage levels. Most providers offer real and nominal funds with various maturity profiles, allowing investors to pick the funds that best match their unique liabilities. By investing in a pooled fund, pension funds can benefit from professional management at a reduced cost[52]. This includes lower transaction costs, reduced management fees, and access to investment opportunities that might not be available to smaller, individual investors. Furthermore, the large size of pooled funds ensures the ability to easily enter or exit positions, which is crucial during liquidity crises. Lastly, pooled fund performance can be easily tracked as they are required to disclose regular reports, ensuring they meet their investment objectives.

[51] On the other hand, ensuring that not all investors in a pooled fund share the same characteristics can be extremely beneficial during times of margin calls. This diversification helps prevent all investors from being simultaneously affected by a single macroeconomic factor.
[52] *See* "LDI Explained", BMO Global Asset Management, (2018), p.32.
https://www.bmogam.com/uploads/2021/06/bf77d0fc81b9310168bcb5280e7ebf1e/ldi-explained.pdf

A second portfolio structure is the segregated portfolio - also known as separate account. In this solution, the pension fund's investments are held separately to those of other investors via the client's own custodian. This structure allows for a high degree of tailoring. The hedging strategy will be run within the pension scheme's portfolio, with the advice and support of the LDI manager. The instruments and facilities used in LDI, such as interest rate swaps and treasury bonds, are held by the pension scheme, which is a direct counterparty to the bank. Since segregated mandates require customisation, asset managers historically offered them to only the larger schemes. A recent development showed that segregated portfolios are becoming increasingly popular among smaller funds. As reported by Nathan Tipping[53], minimum assets under management (AUM) for customized hedging slashed from around £400m to £75m. The new wave of segregated funds came as the pension industry remarked that segregated funds generally without the gilt (ie. UK government bond) crisis better than pooled funds. In a matter of weeks, the UK 20-year spot curve jumped from 3,3% to a peak of 5% in October 2022. This jump caused a wave of collateral calls in LDI funds which "only halted once the Bank of England intervened"[54].

Graph 3: UK Government 20-year nominal spot curve

[53] *See* Tipping N., "Asset Managers Offer Tailored LDI to Smaller Pension Schemes." Risk.net, 2023, www.risk.net/investing/7957868/asset-managers-offer-tailored-ldi-to-smaller-pension-schemes.
[54] *See* Id.

Source: PWC, “One year on from the gilt crisis - what’s changed and what next?”, (2023). https://www.pwc.co.uk/pensions/insights/one-year-on-from-gilt-crisis-what-has-changed-and-what-next.html#:~:text=This%20is%20 because%20the%20wall,the%20end%20of%20September%202023.

According to the author, the large number of actors within pooled funds “can slow the process of recapitalising the fund” when funds must call collateral following yield movements. In this sense, segregated funds offer better solutions as they are smaller. Indeed, segregated funds’ utility lies in their ability to be tailored to the pension necessities. Segregated funds can incorporate a variety of non-LDI derivative strategies, such as FX hedging, equity protection, and synthetic equity. Such funds can efficiently share the collateral pool across different strategies, thereby reducing the total collateral needed and increasing overall efficiency. Furthermore, the investment guidelines can be adjusted regularly, with additional sub-portfolios introduced to address evolving client requirements. The major limitation of this portfolio is that it is costly to implement and manage. The high degree of tailoring requires a team of analysts fully focused on a single client thus raising management costs and incresign governance responsibilities as funds managers must oversee both the custodian and the investment portfolio. Derivative trading documents will be in the client's name, but most LDI managers will handle the negotiation and maintenance of these documents on behalf of clients.

The third commonly used portfolio is the bespoke fund. This portfolio option, which shares many characteristics with segregated funds due to their similar tailoring possibilities, is designed for the exclusive use of a single client. The fund will be built upon the preferences of a single client. Custody is provided within the fund, eliminating the need for the client to have their own custodian.

It is important to note that, although it offers the maximum tailoring feature, trading documents are still issued in the name of the fund. The extensive customization will result in increased management fees and expenses. These costs typically range from 0.02% to 0.04% per annum, although the exact amount will vary based on the size and complexity of the portfolio.

Having established a comprehensive understanding of the LDI strategy and its core objectives, it is essential to explore how traditional investment approaches can be integrated within an LDI framework. How can LDI be integrated with the traditional dynamic asset allocation approaches laid down by Perold and Sharpe more than thirty years ago? By examining

the buy-and-hold strategy, the constant proportion portfolio insurance (CPPI) and option-based portfolio insurance approaches (OBPI), we can gain valuable insights into how these methods align with and enhance the principles of LDI. Furthermore, understanding the interplay between these investment strategies and LDI will provide a foundation for discussing emerging trends and innovations in the field. We will now observe what are the main approaches used to manage portfolios once they are in place.

2. Dynamic Strategies for Asset Allocation and LDI

Most portfolios contain risky assets. Movements in the markets will cause the value of the portfolio to change. How can managers rebalance the portfolio following such changes? The foundations regarding the dynamics strategies were laid off 30 years ago by André F. Perold and William F. Sharpe but they are still up to date and used by funds. The main approaches are the buy-and-hold, the constant mix, the constant-proportion and the option-based portfolio insurance. A passive (buy-and-hold) investment strategy requires purchasing a well diversified portfolio without searching for asset mispricing and without portfolio re-balances (or with minor or predetermined rebalances). On the other hand, an active (or dynamic) investment strategy requires investigating asset prices to purchase a portfolio of undervalued assets (selectivity) and engage in portfolio re-balances aimed at exploiting movements in the market portfolio (market timing). These strategies correspond to different types of asset allocation: strategic, passive, and dynamic (or active).

A strategic asset allocation involves setting long-term target allocations based on goals and risk tolerance. Strategies like buy-and-hold and constant-mix align with LDI by maintaining these targets and ensuring that the portfolio matches the liability profile over time. A passive asset allocation aims to match market returns with minimal active management. Buy-and-hold strategies can also fit this approach, providing stable growth and periodic rebalancing to align with LDI objectives. Dynamic asset allocation involves frequent adjustments based on market conditions. CPPI and option-based portfolio insurance are dynamic strategies that adjust asset allocations to protect against downside risks and capitalize on growth opportunities - as opposed to buy-and-hold approach. A dynamic strategy can also be integrated with an LDI approach. The rationale for using such an approach with an LDI approach is that a dynamic allocation could offer better returns as a result of rebalancements and thus, outperform a passive approach.

2.1. Buy-and-Hold Strategy

The buy-and-hold strategy involves purchasing securities and holding them for a long period, regardless of market fluctuations. A buy-and hold is characterized by an initial mix that is bought and then held. Based on the risk tolerance of the fund, the asset allocation can change slightly but it will be mainly composed of 60% bonds (mostly treasury bills and solid corporations) and 40% equity. The lower the risk tolerance, the higher the portion invested in bonds as they are usually regarded as safer assets. The holdings are generally specified by the pension manager/trustee to which the investment bank will suggest the matching securities. As opposed to dynamic strategies, buy-and-hold strategies are "do-nothing" strategies: regardless of the assets value no rebalancing will be required. The features of this approach are that it makes the portfolio value linearly related to the stock market, that the upside potential is unlimited and that it is considered safe as the "portfolio value will never fall below the value of the initial investment in bonds".[55] Buy-and-hold strategy allows advantages are its simplicity, the reduced transaction costs and the (possible) long-term capital growth. Its main drawbacks are that it lacks the flexibility to respond to changing market conditions (which can also be seen as an advantage) and that this approach could cause potential mismatches with liabilities in case of significant market shifts.

Buy-and-hold approach aligns closely with strategic asset allocation, where a long-term target allocation is set based on the fund's goals, risk tolerance, and investment horizon. The portfolio is very rarely adjusted, except for occasional rebalancing to maintain the target allocation[56]. Buy-and-hold can also be seen as a form of passive asset allocation, where the portfolio is set and left to grow with minimal intervention, aiming to match market returns rather than outperform them. This approach is widely used by funds to support LDI by providing a stable asset base that matches the duration of liabilities. This long-term stability helps ensure that assets grow in line with liabilities, reducing the need for frequent adjustments and minimizing surplus volatility.

2.2. Constant-Mix Strategy

[55] *See* Sharpe, W. F., & Perold, A. F. (1988). Dynamic Strategies for Asset Allocation. Financial Analysts Journal, 44(1), 16-27, p.149. https://doi.org/10.2469/faj.v44.

[56] One of the few examples of rebalancing could be in the case of treasury bond repo which will be automatically rolled to maintain the status-quo.

The constant-mix strategy maintains a fixed proportion of the portfolio in different asset classes. When market movements cause these proportions to change, the portfolio is rebalanced back to the original proportions[57]. Following this approach, funds portfolios will be largely static as they will be designed and modified to maintain a fixed ratio. As opposed to buy-and-hold, constant-mix strategies are dynamic strategies to investment decision-making. Following changes in the value of assets held in the portfolio, purchases and sales are required to return to the desired mix. In general, rebalancing of constant-mix strategy requires the purchases of stock as they fall in value and vice-versa. Another important point concerns the rebalancing threshold. At the beginning of the investment, the manager will need to set limits upon which an active rebalancing is required. Let's consider an example to clarify how this strategy works. Let's suppose that an investor has put $60 in stocks and $40 in treasury bills and wishes to maintain this 60/40 constant-mix. Now assume that the stock market declines by 10%. The investor stocks are now worth $54, giving a total portfolio value of $94 - supposing that bills kept the same value. The new mix is now 57/43[58]. To return to the initial mix, the portfolio must now have to invest $56,4 in stocks.Thus the investor should purchase $2,40[59] of stocks obtaining the money from selling a comparable amount of bills. It is interesting to note that in either bullish or bearish markets a constant-mix investor will always have less money than a buy-and-hold companion. Why then would anyone want to adopt such a strategy? To answer this question, one must understand market movements. In our simplified example, we only considered a single bearish market movement. However, in reality, markets are highly volatile, with rapid and frequent upward and downward trends. In such volatile markets the constant-mix strategy can offer returns outperforming the ones offered by the buy-and-hold approach. Indeed, if a scenario where the market moved down from 100 to 90 and then it came back to 100 the constant-mix investor would be better off. Conversely, if the market moves from 100 to 90 and then 80, a constant-mix investor will lose more than a buy-and-hold one. Which strategy wins overall? There is not a winning strategy overall but different approaches can fit different market movements. A constant-mix strategy will outperform a buy-and-hold strategy in a flat but oscillating market. The value of the assets owned by a constant-mix investor will depend on both the final level of the stock market and on the manner in which the market moved. Thus, it is

[57] *See* supra note 55 at p.151.
[58] 54/94 ≈ 57,4%.
[59] $56,40 - $54,00 = $2,40

important to note that a constant-mix strategy will be preferable only when the market, after numerous fluctuations, ultimately returns to a point close to its starting level. Conversely, a buy-and-hold approach is more advantageous when the market experiences significant movement in only one direction.

Constant-mix is a form of dynamic asset allocation as it involves regular rebalancing in response to market movements, though it does not actively seek to capitalize on these movements beyond maintaining the set ratios. To some extent, a constant-mix proportion can also be considered a semi-passive allocation. This is because rebalancing thresholds are usually predetermined and fixed, making the rebalancing process in a constant-mix strategy a relatively mechanical action. Constant-mix can be beneficial for LDI by ensuring that the asset allocation remains aligned with the liability profile. Regular rebalancing helps manage risk and return, maintaining the portfolio's alignment with the liabilities' duration and cash flow requirements.

2.3. Constant-Proportion Portfolio Insurance (CPPI)

CPPI involves maintaining a dynamic mix of a risky asset and a safe asset, where the proportion invested in the risky asset is a constant multiple of the cushion (the difference between the portfolio value and a floor value). The amount invested in stock will be determined by the following formula:

$$Dollars\ Invested\ in\ Stocks = m(Assets - Floor)$$

Where m is a fixed multiplier[60]. CPPI strategy is a revisited version of the constant-mix approach with multiples greater than one. CPPI simply keeps the exposure to equities a constant multiple of the cushion. To implement such a strategy the fund manager must first select a multiplier and, more importantly, choose a floor. The choice of the floor will greatly influence the strategy and must be thus precisely calculated by looking at the liability cashflow profile faced by the fund. This floor will grow at the treasury bill rate of return and must initially be lower than the total assets. As we have seen with the buy-and-hold strategy, CPPI offers zero tolerance for the risk offered by stocks below a specified floor. However, in a CPPI strategy, tolerance for risk increases more rapidly above the floor than with buy-and-hold strategy. In a rising market, CPPI

[60] *See* supra note 55 at p.154.

increases exposure to risky assets, potentially increasing returns. In a declining market, it reduces exposure, protecting the portfolio. CPPI can provide a balance between growth and protection, but may involve higher transaction costs and complexity - with respect to a buy-and-hold strategy for example. But a crucial distinction with respect to the constant-mix concerns the rebalancing. If with the constant-mix we buy stocks as their value falls, in a CPPI approach, we buy stocks as they rise and sell them as they fall. One of the advantages offered by CPPI is its safety. CPPI guarantees that the amount invested will never become less than the floor. This protective and highly beneficial feature is due to the adaptive nature of CPPI. For example, if stocks were to decline an investor following this approach would invest more in bills, reducing at maximum its exposure to zero. However, such a strategy may not be always feasible. A limitation could arise in the event in which the market was to drop instantaneously. In such a scenario, the investor would not have the time to rebalance and therefore his asset would decrease in value. The speed of the drop will be determined by the multiplier. More generally, the market can drop by as much as 1/m without rebalancing before threatening the floor. In a rising market, the CPPI strategy excels. It involves purchasing more stocks as their prices increase, with each additional investment yielding significant returns. However, in a stagnant market, a CPPI strategy tends to underperform. This is due to the same reason constant-mix strategies thrive—market reversals. These reversals negatively impact CPPI strategies because they involve selling during market dips only to watch the market recover, and buying during peaks only to see the market decline. A variation of the CPPI occurs when a multiplier greater than one is not allowed. In this scenario, the formula may call for investing more than total assets in stocks. If such leverage is not permitted, the CPPI formula becomes:

$$Dollars\ invested\ in\ Stocks\ =\ Min[m(Assets\ -\ Floor),\ Assets]$$

As with the constant-mix strategy, CPPI is a dynamic strategy. CPPI frequently adjusts the asset mix based on market conditions to protect the portfolio while seeking growth. This strategy is not passive, as it involves active adjustments to maintain the proportionate allocation in response to market changes. CPPI is well-suited for LDI as it dynamically adjusts the asset allocation to protect against downside risk while aiming to achieve growth. This ensures that the

portfolio can meet liability payments even in adverse market conditions, maintaining the alignment between assets and liabilities.

2.4. Option-Based Portfolio Insurance (OBPI)

OBPI uses derivatives to hedge against potential losses. The first passage to implement an OBPI strategy concerns setting an investment horizon and a targeted floor value at the horizon. Once this passage is complete, a well structured OBPI will allow the investor to obtain similar results as if he had invested in a portfolio composed of bills and call options. The benefits of OBPI are that it enhances risk management, that it has the potential for additional income through premiums - as with CPPI - and that it offers an extremely tailored hedging. With respect to pension funds, OBPI presents two major drawbacks. The first is represented by its complexity. Implementing an OBPI strategy requires a sophisticated understanding of derivatives which raises the overall complexity in execution and management. Such a feature tends to scare fund managers/trustees from adopting it. It is important to remember that fund managers and trustees are accountable to their members and must be able to clearly explain the strategy the fund is pursuing[61]. The second concerns OBPI time-dependency. If it's true that OBPI offers highly customized hedging, it is often considered overly tailored because it is too dependent on a specific investment horizon.With a traditional OBPI strategy, for any given cushion, the exposure to assets changes as time passes - reaching 100% of the asset value at horizon. Such peculiarity renders the OBPI strategy calendar-dependent and differentiates it from a CPPI strategy where the exposure depends on the size of the cushion. The calendar-time dependency of OBPI is particularly acute when the strategy “expires' ' at the horizon, because a new set of rules must be then put in place. The long-term nature of pension funds means that the horizon provided by an OBPI strategy will almost always be shorter than what the fund requires. These drawbacks lead to OBPI being rarely used by pension funds, despite its potential to offer valuable solutions for managing downside risk.

Option-based insurance is dynamic by nature, as it involves active adjustments and hedging in response to market movements and changes in portfolio risk exposure. Option-based portfolio insurance enhances LDI by providing targeted risk management tools. This strategy

[61] Let’s also recall that a part of the fund's success comes from its size (AUM), which is influenced by the number of members it manages to attract. The more complex a strategy, the harder it will be to explain it to the fund's members.

helps hedge against specific risks associated with liabilities, such as interest rate changes or market volatility, ensuring that the portfolio remains aligned with liability payments and minimizing the risk of funding shortfalls.

From our analysis it may seem apparent that the crucial distinction between the different investment approaches concerns rebalancing. The strategy that we have presented are based on three types of rebalancing: do nothing, no rebalancing at all (buy-and-hold); buy stocks as they fall and sell as they rise (constant-mix); sell stocks as they fall and buy as the rise (CPPI). Do nothing strategies are the easiest as they require no action. They offer straight line payoff diagrams.

Constant-mix strategies, due to the fact that they buy stock as they fall, will not protect the investor from downside risk and will poorly perform in bullish markets. For the same reason, constant-mix will offer excellent returns in flat but oscillating markets. On the other hand, CPPI strategies will present the opposite features. This strategy will perform badly in flat but oscillating markets but offer good downside protection and perform well in bullish markets.

The bottom line is that there is no universally superior strategy. Funds typically present their characteristics and predetermined risk tolerance threshold (expressed as a function of an appropriate cushion). Based on this information, the asset manager will tailor a specific approach.

IV) Recent Trends and Insights on Funds Investment Choices and Risk Management Practices

If the LDI approach was initially simple and unsophisticated, it has today grown to involve more diverse investment categories. More recently, more complex ways to reduce surplus risk have been introduced. Pension clients are looking for excess yield, diversification or may just have high conviction in asset classes like private credit which can provide both cash flow production and growth in complement with rate strategies. BlackRock, the world largest

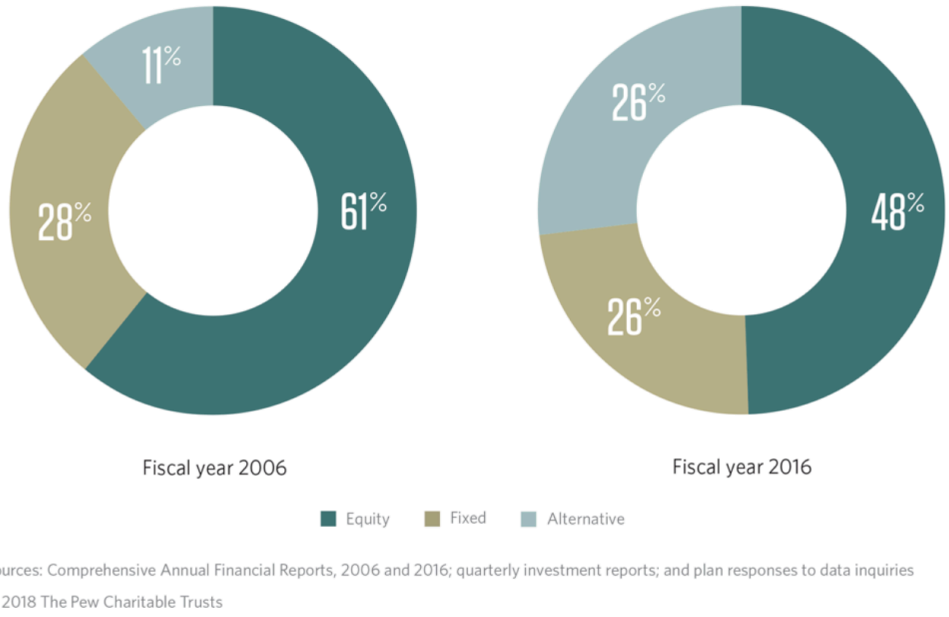
asset-manager, has been a long-time advisor of *enhanced credit classes* - "debt instruments which may offer routine coupon or loan repayments and exposure to credit beta"[62].

1. The growing role of Private markets

1.1. Private Market Growth Amidst Stagnation of Traditional Securities

The rapid rise of alternative and non-listed asset classes has been one of the most remarkable phenomena in the institutional investment space in recent years - both in private and public pension funds (see graph 4). The demand for investments in private markets (PM) has grown and is expected to continue growing in the future.

Grap 4: Average Public Pension Asset Allocation, 2006 and 2016.



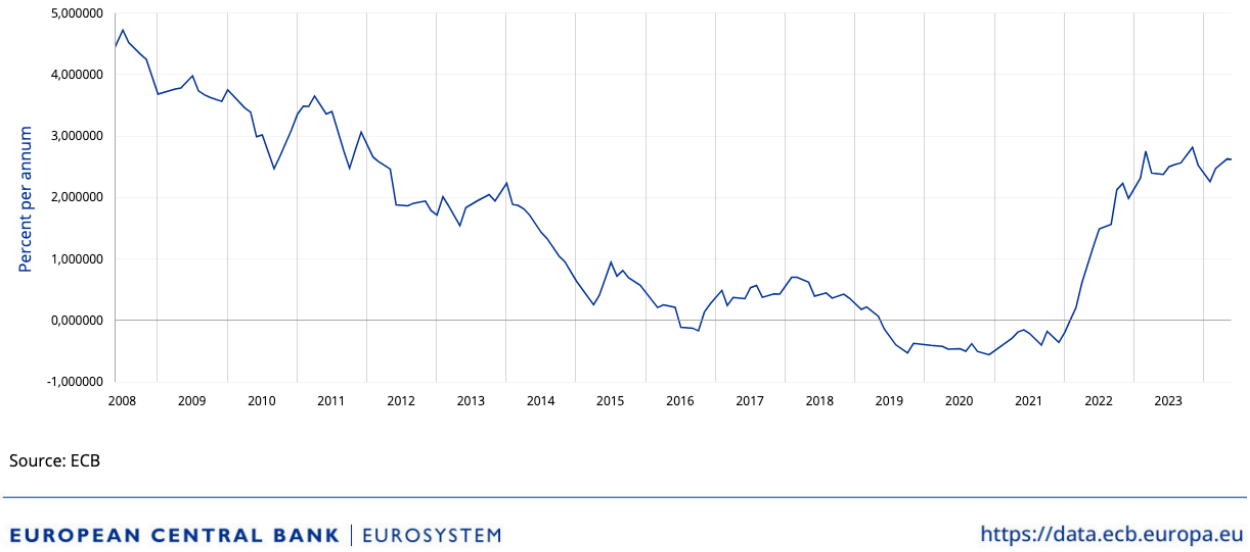
Combined with the shift towards more low-cost passive management for public equity and fixed income holdings,[63] this trend is contributing to a profound transformation of the

[62] *See* BlackRock, "Beyond Bonds: The role of enhanced credit in pension LDI", (2024). https://www.blackrock.com/institutions/en-us/insights/enhanced-credit-for-corporate-pensions
[63] *See* Revesz, R. "UK Govt. Leading Way for Pensions Using Passives." Journal of Indexes, (2014), ETF.com.

financial ecosystem as a whole[64]. In a context of increasingly low returns (see graph 5) that are also below the inflation level, even for long maturities, pension investors must seek alternative investment opportunities to protect the real value of their resources. The backdrop in listed securities occurred as a consequence of a growing disinfection for actively managed public equity. This new trend highly contradicts the past approach, where actively managed portfolios were seen as the favorite investment category for institutional investors. In particular, financial literature showed that actively managed funds weren't offering excessive returns. Michael Jensen, was the first to critically examine the ability of actively managed mutual funds to outperform the market[65]. His 1968 paper has significantly contributed to the growing disaffection with actively managed public equity. In particular, the introduction of the "Jensen's Alpha", which calculates the risk-adjusted returns of mutual funds relative to a benchmark (usually the market portfolio), showed that the average mutual fund generated a negative alpha, implying that most funds failed to beat the market after accounting for risks. Mark Carhart's 1997 study[66] and Fama and French[67] (2010) further confirmed Jensen's findings, showing that actively managed funds do not outperform their benchmarks after fees. This findings were confirmed, more recently, by the underperformance of unusually high proportion of actively managed equity portfolios in 2008-2013[68]. Many European pension funds who had bought US or European large-cap equity assets had to wait until January 2013 to sell their investment to outperform inflation, without even considering management fees.

Graph 5: Yield curve spot rate, 10-year maturity - Government bond, nominal, all issuers whose rating is triple A - Euro area, Daily - businessweek. ECB Data Portal, 24 May of 2024.

[64] *See* Bazi, V. and Firzli, M. N., The New Drivers of Pension and SWF Investment in Private Equity (July 2, 2014). Revue Analyze Financière 2014, Available at SSRN: https://ssrn.com/abstract=3878871
[65] *See* Jensen, M. C. (1968). The Performance of Mutual Funds in the Period 1945-1964. Journal of Finance, 23(2), 389-416.
[66] *See* Carhart, M. M. (1997). On Persistence in Mutual Fund Performance. Journal of Finance, 52(1), 57-82.
[67] *See* Fama, E. F., & French, K. R. (2010). Luck versus Skill in the Cross-Section of Mutual Fund Returns. Journal of Finance, 65(5), 1915-1947.
[68] *See* Revesz, R. "UK Pensions Lose £1.7Bn on Failing Active Funds." Journal of Indexes, (2014), ETF.com.



Consistent with the typical long-term investment horizon of pension funds and their resulting liability cashflow profile, funds seek for instruments capable of offering an illiquidity premium as the most coherent source of portfolio diversification, thus expanding the allocation to PM. The number and types of investments in this category have steadily increased over the past decade, now encompassing a wide range of strategies and vehicles that are often heterogeneous in terms of objectives, risks, legal form, and technical characteristics.

PM investments offer many diverse and peculiar advantages. The first advantages concern diversification. These investments provide traditional statistical diversification due to their partial decorrelation with listed securities. Additionally, they can deliver superior risk-adjusted returns over extended periods, access to early-stage industries, and fiscal incentives for investments in small and medium-sized enterprises, startups, and innovative technologies.

It is also important to note that PM investment cna present major drawbacks. The illiquidity characteristic, shared by PM investments, forces investors to add at least three more levels of complexity to the investment and risk management process[69].

The first is generated by the difficulty of providing stable forecasts of risk and return for such an investment - unlike the with the solid input available for traditional investments. For example, consider the way in which one can obtain and use the necessary database to model

[69] *See* Corvino G. L., "Private Markets Investments: La definizione della strategia di investimento ed il suo controllo", *Governance dei fondi pensione e regolamentazione Iorp 2,* (2022), p.119. ISBN 978-88-15-38248-1.

exposure to European equities compared to the database available for modeling exposure to European private equity. In the first case, it is sufficient to choose the market benchmark that best represents the target exposure to obtain a public, homogeneous, and complete reference database; in the second case, it is - by definition - impossible to find a coherent public reference database. The rational investor must therefore resort to private databases which, although they have reached excellent qualitative and quantitative levels in recent years, still cannot be homogeneous with respect to what interests the investor (in terms of duration, vintage, target returns, types of companies included by the managers in their scope of activity, characteristics and history of the investment team, etc.). Investing in PM requires relying on less solid and objective data, thereby increasing overall risk as the models used become less reliable.

A second complexity arises from the challenge of integrating illiquid investments into the traditional strategic asset allocation. Given the inherent risks of illiquid investments, they require adjustments to the strategic asset allocation to prevent excessive exposure. Traditional portfolio optimization techniques are not equipped to structurally and comprehensively account for liquidity risk. Therefore, these techniques must be enhanced to avoid arbitrary limits that could result in either excessively high and undesired risk levels or the loss of valuable sources of returns and diversification.

A third complexity arises from the time requirements of private market investments. Unlike traditional securities, where a pension fund can almost instantly purchase stocks on the market, investments in private markets cannot be executed immediately. Since investment opportunities that may be attractive to private equity fund managers are, by definition, not immediately available and purchasable (if they were, the illiquidity premium mentioned in the previous point would inevitably be low and, therefore, unattractive), the capital that the pension fund commits to invest in the fund is actually transferred to the fund only when such investments are about to be concretely realized. If this was not the case and the committed capital was transferred immediately, it would sit idle, inflating the Net Asset Value (NAV) of the fund without being invested effectively. This could lead to poor performance records in the databases, harming the fund's reputation. If this were not the case, these availability would increase the NAV of the fund without being able to be invested at rates consistent with the reference asset class, thereby generating reputational problems because the databases mentioned in point 1 would record disappointing returns. For example, let’s suppose that a pension fund commits $10

million to a private equity fund. The fund manager doesn't take the full $10 million immediately. Instead, they request portions of this capital as they find suitable companies to invest in. If the manager finds a promising investment six months later, they might call for $2 million. This process continues until the full commitment is used. When the manager sells an investment, the proceeds are returned to the pension fund promptly, rather than holding the cash until the end of the fund's life. This cycle of capital calls and distributions means that investors in private equity funds not only lack control over the value of their investments but also over their temporal profile. This peculiarity requires the pension fund to meticulously plan and manage its liquidity and investment timing, thereby increasing the overall complexity.

Lastly, it is important to remember that, despite their many advantages, funds should not overinvest in PM. Once a PM investment matures, investors must have the opportunity to sell their ventures and collect the proceeds. Efficient public equity markets are crucial for providing the necessary liquidity (through IPOs, sales, or mergers) and for offering the valuation metrics required for funds to successfully exit their private equity investments[70].

1.2. Asset Managers' Views

Very recent trends indicate that the ongoing shifts in the roles of public and private markets are likely to persist. Recent trends indicate that an increasing number of firms are seeking funding through private markets, attracted by their typically less stringent and regulated solutions, thereby creating more opportunities for private market investors. BlackRock, as one of the leading actors in this space, exemplifies this trend[71]. As remarked by Michael Dennis, head of Asia Pacific alternative strategy & capital markets for BlackRock, during the G7 Pensions Global Financial Forum held in December 2020, "private markets are becoming larger, deeper and more complex."[72]. Pension funds' quest for yields will "coincide with the secular shift towards private markets.". Dennis further argued that marrying credit markets and infrastructure "gives pension funds a powerful asset mix". Another interesting point discussed by Dennis concerned the environmental, social, and governance (ESG) investments. In his view, the green

[70] The investment horizon typically spans from 8 to 10 years.
[71] *See* Business Times. (2023). "BlackRock triples annual investment in APAC private assets". Retrieved from https://www.businesstimes.com.sg/international/global/blackrock-triples-annual-investment-apac-private-assets
[72] *See* Weeks, D. and Firzli, M. N., Private Markets, Infrastructure and Venture Capital in the Post-COVID Era: The Pension Perspective. Institutional Investment Research, Working Papers Series, (2021), Available at SSRN: https://ssrn.com/abstract=3806645.

regulation tightening that will be seen over the next decade - across most jurisdictions - will reshape "fundamentally all financial markets over the world"[73]. This phenomenon will foster more investment in renewable energy assets[74] (infrastructure) and green tech (Private Equity and Venture Capital (VC)). Indeed, green infrastructure investments can be ideal for pension funds as they provide long-term real returns that align well with the funds' liabilities. A practical example of this strategy can be seen in Australia. Both public and private Australian pension funds were early adopters of infrastructure investments and now offer excellent returns and solid funding ratios. Nick Sherry, founder and former Australian Minister of Superannuation & Corporate Law, attributes the financial success of Australian funds to diversification and the extra yield provided by private markets, which he identifies as one of the key factors driving their strong performance.

1.3. BlackRock's Example: The Role of Enhanced Credit in an LDI Approach

How can a fund actually invest in private markets? A successful example is proposed by BlackRock, the world's largest asset manager with $10 trillion in assets under management. BlackRock's Client Insight Unit[75] (CIU), by using its analytical platform, *Aladdin*, can propose solutions for bespoke client engagements, offering tailored portfolio diagnostics based on enhanced credit asset classes ("debt instruments which may offer routine coupon or loan repayments and exposure to credit beta.``). According to BlackRock, enhanced credit classes can offer enhanced returns, diversification and liquidity benefits and high level of customization[76]. By looking at the vast universe of possible investment BlackRock believes that risk-adjusted returns of enhanced credit assets is superior. As we can observe in the graph 6, enhanced asset classes (highlighted in the two dotted rectangles) tend to have higher yield spreads compared to traditional assets, reflecting their lower risk.

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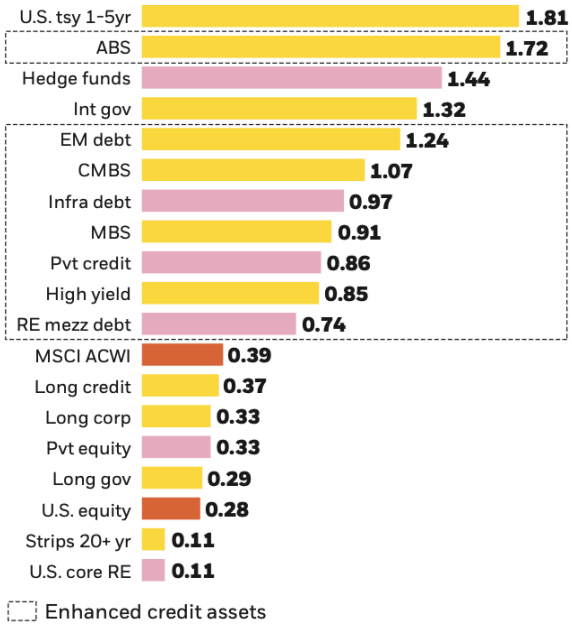
[73] *See* supra note 60 at p.4.
[74] *See* Washington, T., "Storage Companies Pivotal for Mitigating Energy Transition Risk," S&P Global, 26 Jan. 2021, report quoting Singapore Economic Forum (SEF) experts. https://www.spglobal.com/commodityinsights/en/market-insights/latest-news/oil/012621-storage-companies-seen-pivotal-for-mitigating-energy-transition-risk
[75] From BlackRock's website "Client Insight Unit (CIU) is a team of portfolio solutions specialists that partners with our institutional clients and consultants to help them solve their investment challenges".
[76] For a full analysis of enhanced credit classes and their advantages for pension funds *see* BlackRock, "Beyond bonds: The role of enhanced credit in pension LDI", available at https://www.blackrock.com/institutions/en-us/literature/whitepaper/beyond-bonds.pdf

Graph 6: Risk-adjusted returns of main asset classes

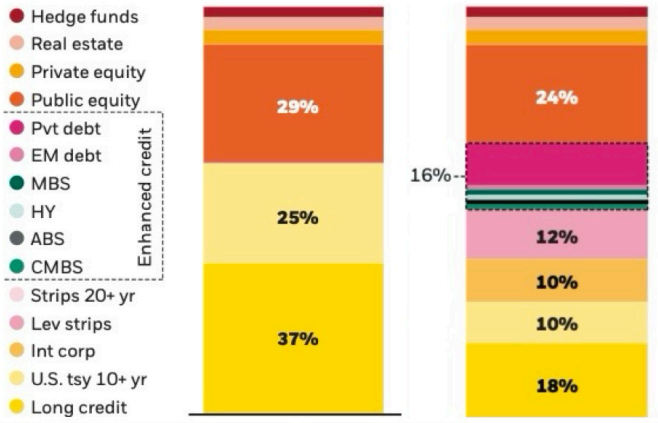


Source: BlackRock, as of November 2023 based on BlackRock's Capital Market Assumptions (CMA) and *Aladdin*.

Furthermore, BlackRock advocates for integrating LDI hedging goals with enhanced credit assets to construct effective liability-driven strategies. Portfolio construction combining LDI and enhanced credit classes would focus on three major elements. First, Key Rate Duration (KRD) Hedging ensures that the portfolio remains well-hedged against yield curve fluctuations, with fixed-rate instruments like mortgages and infrastructure debt providing essential rate exposure. Second, Capital Efficiency is achieved through the use of STRIPS and derivative rate instruments, which free up capital for higher-yielding credit strategies, enhancing yield and improving the hedge ratio. Finally, Collateral Management addresses the need for sufficient liquidity during stress periods, ensuring that the portfolio can sustain leverage and meet cash requirements without forced sales of growth assets. By modeling stress events, LDI managers can balance illiquid and liquid credit assets, maintaining stability and growth potential in the portfolio. This integrated approach provides diversification, yield enhancement, and effective risk management, making it beneficial for private pension fund asset allocation. Below we

consider an illustrative pension fund (Portfolio 1) which is 104% funded with 62% of assets in liability hedging fixed income and 38% allocated to equity and other growth strategies[77]. Portfolio 2 shows a modified Portfolio 1 asset allocation with 16% of the total assets invested in enhanced credit assets.

Graph 7: Portfolio comparison of different asset allocation



Portfolio	Portfolio 1	Portfolio 2
Expected portfolio return	5.6%	6.1%
Expected portfolio risk	9.6%	9.8%
Expected surplus risk	5.6%	4.5%
Return/surplus risk	1.01	1.34
Interest rate hedge ratio	75.0%	84.0%

Source: BlackRock, as of November 2023 based on BlackRock's Capital Market Assumptions (CMA) and *Aladdin*.

According to BlackRock, Portfolio 2 demonstrates how incorporating enhanced credit assets can help reduce surplus risk and incrementally enhance expected returns. The expected portfolio return for Portfolio 2 is higher while maintaining a lower expected surplus risk. Specifically, Portfolio 2 shows a Return/Surplus Risk ratio of 1.34, compared to 1.01 for Portfolio 1. This illustrates the advantage of integrating enhanced credit assets into the investment strategy.

[77] Portfolio 1 has specifically the average portfolio allocation of the top 200 U.S. Corporate defined benefit pension plans.

2. Additional Remarks on Asset Allocation and Practical Examples

In recent years, passive strategies have been employed by significantly more funds. Pension funds, replicating the index funds approach, have tried to replicate the performance of broad-based market indexes. This approach has seen a rise in its employment due to two main reasons. The first is that index funds, particularly in the recent years market roller coasters, have provided safe and predictable returns. The second reason is the cost efficiency offered by passive strategies. As this approach does not employ financial analysts to investigate asset prices and rarely incur in transaction costs from portfolio re-balances it charges low management fees. Strong-form market efficiency implies that active portfolio management is profitless so that its costs amount to wasted resources.

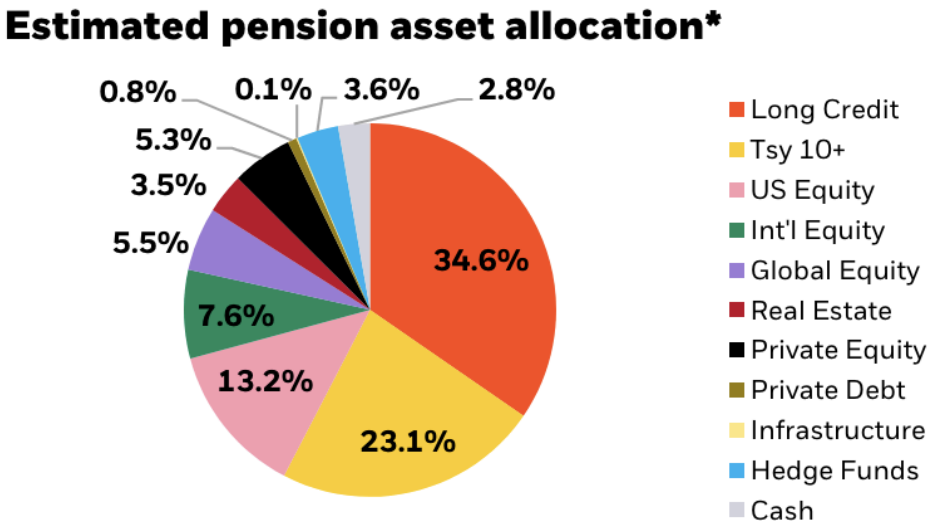
2.1. The example of American corporate pension plans: BlackRock's U.S. LDI Pension MarketWatch

What is the current state of asset allocation in American pension funds? After having examined the theory and principles guiding asset allocation, we will briefly review a practical example coming from U.S. largest corporate plans.

The overall market trend in the U.S. indicates that the 60/40 (Fixed Income/Equity) approach remains popular. However, variations can be observed due to the increasing allocation towards alternative investments.[78] According to a recent survey conducted by BlackRock[79] on the top 200 American corporate pension plans,[80] the average asset allocation is 57.7% in fixed income instruments, 26.3% in equity, and the remaining 16.1% in alternative investments and cash.

Graph 8: Estimated pension asset allocation of top U.S. corporate plans

[78] Of which we analyzed the advantages at the beginning of this chapter.
[79] *See* BlackRock, *U.S. LDI Pension MarketWatch,* April 2024. https://www.blackrock.com/institutions/en-us/literature/investor-education/blackrock-us-ldi-market-watch-publication.pdf
[80] As of 31/12/2023.



Source: BlackRock, U.S. LDI Pension MarketWatch, April 2024.

Of the 57.7% allocated to fixed income investments, the primary investment is in long credit (34.6%) and is represented[81] by the Bloomberg U.S. Long Credit Index. Quoting Bloomberg's website, its U.S. Long Credit Index includes "investment grade, US dollar-denominated, fixed-rate, taxable corporate and government-related bond markets" but also non-corporate component "that includes non-US agencies, sovereigns, supranationals and local authorities."[82]. The remaining fixed income is invested in classical U.S. 10-year treasury bills. It is interesting to note that alternative investments have indeed gained significant popularity, as the percentage invested in these assets has grown considerably in recent years. This shift in preference is further highlighted by the decrease in the percentage invested in equity from the traditional 60/40 approach. Today, top American pension plans allocate only 26.3% of their assets to equity. As discussed at the beginning of this chapter, there is a growing trend towards alternative investments. Funds now allocate up to 16.1% of their assets to alternative investments and cash - with cash accounting for less than 3%. The main components of these investments are private equity (5.3%), followed by hedge funds (3.6%) and real estate (3.5%).

[81] We assume that funds investments closely match the most popular index for this asset class, which is represented by the Bloomberg U.S. Long Credit Index.
[82] For a detailed description of the Bloomberg U.S. Long Credit Index *see* https://assets.bbhub.io/professional/sites/10/00152.pdf

According to BlackRock, inflation 2024 estimates "have come down significantly, but are still well above the Federal Reserve's 2% target.". Given these estimates, the Fed announced it would maintain the current policy rate but left the door open for potential future rate cuts. It dismissed the likelihood of further rate hikes, citing an already sufficiently restrictive monetary policy. These movements have been profoundly beneficial for funds as they have lowered the value of liabilities "thus raising their funding ratio.". Based on BlackRock estimates, the average funding ratio for the top 200 U.S. corporate pensions was approximately 104.0%. The funding ratio has been steadily increasing, passing from approximately 96% in December 2022. As seen in table 1, the growth of the funding ratio was fueled by a stronger decrease in the returns of liabilities compared to the assets.

Figure 3: Returns of corporate pension plans

Est. Return**	Apr 24	YTD
Assets	**-4.42%**	**-3.16%**
Fixed Income	*-5.37%*	*-7.54%*
Equity	*-3.48%*	*4.82%*
Alternatives/Cash	*-2.60%*	*-0.09%*
Liabilities	**-4.30%**	**-5.61%**
Funded Status	**-0.13%**	**2.59%**

Source: BlackRock estimates. All data as of market close at 30/04/2024. Returns are calculated by taking a weighted average of the asset allocation weights and the returns of the typical profile shared by top 200 U.S. corporate pension plans[83].

From April 2023 to April 2024, the estimated asset return decreased by 3.16%, while the liabilities return decreased by 5.61%. The overall decline in returns observed in the last year raised the funding ratio by 2,59%. It is also interesting to note that the return on fixed income assets fell by 7.54% over the year, further highlighting the potential benefits of private market

[83] No allowance has been made for active management or costs.

investments previously discussed. According to Elizabeth Perry, client portfolio manager at BlackRock, "the historically low credit spreads suggest limited potential for further tightening"[84] which impacts LDI strategies. LDI clients are encouraged to take a strategic view on interest rate hedging, considering the significant rise in rates and evaluating their overall hedge. Additionally, Perry argues that the flat and inverted yield curve emphasizes the importance of key-rate duration exposure.[85] The cuts that are expected by markets in 2025 necessitate that corporate pension plans maintain a strategic hedge to manage potential liability growth.

2.2. Growth of ETF Investment in Private Pension Funds

Following the increasing allocation of pension fund assets to private markets and enhanced credit classes, a significant trend has emerged: the growing use of Exchange-Traded Funds (ETFs) in private pension fund portfolios. This strategic incorporation of ETFs is reshaping asset allocation strategies by offering new avenues for diversification and enhancing liquidity management, marking a significant evolution in the asset allocation and risk management practices of private pension funds.

ETFs have long been popular among retail investors, but they are now becoming integral to the strategies of institutional investors, including private pension funds. Historically, ETFs were primarily used for short-term tactical allocations. However, as Christopher Dunn, Vice President of Investment Management at Greenwich Associates, notes, there is now a strategic application of ETFs within institutional portfolios[86]. This shift means that ETFs are being held for longer periods and are becoming core components of pension funds' investment strategies. One notable example is the shift in equity allocations. Traditional core exposures, such as domestic equities, are increasingly being replaced by ETFs due to their liquidity and lower costs. The fixed-income segment also illustrates the expanding role of ETFs. David Kletz, Vice

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[84] *See* Perry, E., *Views from the LDI desk: Spring 2024 markets commentary*, BlackRock, May 2024. https://www.blackrock.com/institutions/en-us/insights/ldi-spring-2024-markets-commentary

[85] Key rate duration is a measure that estimates the expected changes in the value of a bond or portfolio of bonds following unparallel shifts in the yield curve. Given expected interest movements, an investor can use the key rate duration metric to figure out which bond maturities are likely to offer the most profitable investment returns which makes the metric useful to compare various prospective fixed-income investments. For a deeper analysis *see* CME Group, Case Study: Key Rate Duration Adjustment, (2017). Available at: https://www.cmegroup.com/education/articles-and-reports/case-study-key-rate-duration-adjustment.html and Kalotay, A., Buursma, J., The Key Rate Durations of Municipal Bonds, The Journal of Fixed Income, Fall 2019, 29(2) 61-64, DOI: 10.3905. Available at: https://www.pm-research.com/content/iijfixinc/29/2/61

[86] *See* Financial Post, "Institutional investors getting in on the ETF Act". Retrieved from https://business.financialpost.com/news/institutional-investors

President at Forstrong Global Asset Management Inc., highlights that bond ETFs provide instant diversification across numerous bonds, mitigating inherent risks. This feature has significantly contributed to the increased adoption of ETFs by institutional investors for longer-term strategic asset allocation, rather than just for short-term tasks.[87] Additionally, ETFs that follow ESG criteria allow private pension funds to align their investments with social causes while pursuing financial returns. For example, the Ontario Municipal Employees' Retirement System (OMERS) recently announced a $100 million investment in a Royal Bank of Canada fund focused on gender diversity in Canadian companies, reflecting their commitment to inclusion and diversity. In the context of market volatility and potential interest rate hikes, ETFs also offer active management capabilities. As Vlad Tasevski, Vice President at Purpose Investments Inc., explains, active ETFs enable managers to adjust duration exposure and manage interest rate risks more effectively over time.

2.3. Strategic versus Tactical Asset Allocation: The Vanguard Example

Building on our analysis of various investment methods and asset allocation approaches we now explore how these strategies compare in practice. Specifically, we will examine Vanguard's approach and the lessons we can learn from their example.

Vanguard, managing over $8.1 trillion[88], is a global leader in investment management, renowned for its low-cost index funds. Its influence on investment strategies, especially within pension funds, is significant, often setting the benchmark for stable, long-term growth. But what approach does Vanguard use, and what lessons can we take from their example?

Among the two asset allocation approaches, Vanguard's Target Retirement series emphasizes a strategic approach[89]. This preference arises because Tactical Asset Allocation (TAA) is notoriously difficult to execute consistently. Despite the advantages of professional investment managers, even the best analysts and sophisticated models are not enough. Vanguard

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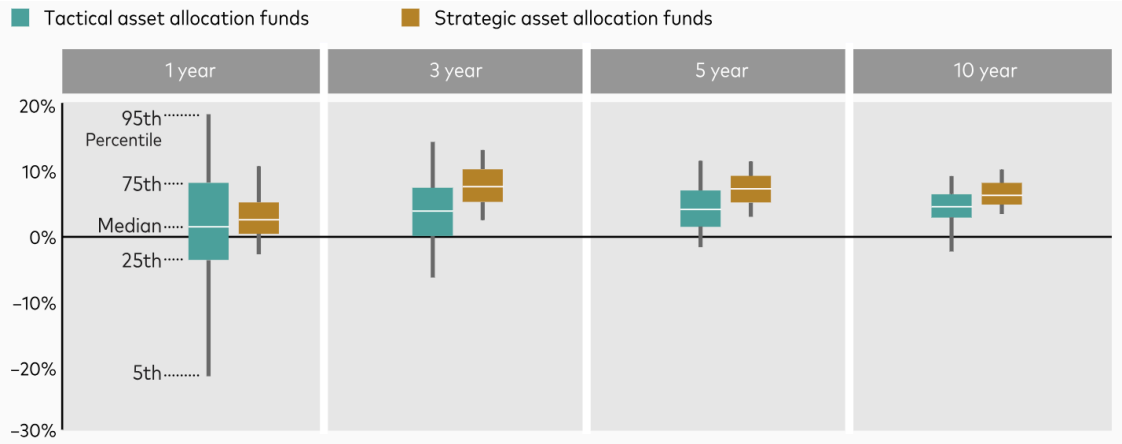
[87] *See* Wojakovski, N., "Turning to ETFs", *Pensions Age*. (2023).Retrieved from https://www.pensionsage.com/pa/turning-to-etfs.php

[88] As of 2022. See Wikipedia, The Vanguard Group. https://en.wikipedia.org/wiki/The_Vanguard_Group#cite_note-fast-facts-2:~:text=US%248.1%C2%A0 Trillion%

[89] *See* Vanguard, Tactical versus strategic asset allocation, (2022). https://institutional.vanguard.com/insights-and-research/perspective/tactical-vs-strategic-asset-allocation.html#:~:text=tactical%20allocation%20funds%20have%20generally%20posted%20lower%20median%20returns%20with%20greater%20return%20variation

highlights that TAA has historically produced "lower median returns with greater variability"[90] compared to Strategic Asset Allocation (SAA) (see Graph 9).

Graph 9: Distribution of annualized returns



Source: Vanguard calculations using data from Morningstar, Inc., as of December 31, 2021.

Quoting Vanguard, past results have shown that "TAA has consistently offered lower median returns with greater return variation" with respect to the results of the SAA funds. The primary challenge of TAA lies in its market-timing[91] necessities. The major issues concerning TAA are related to doubts on managers market-timing capabilities and more specifically the high costs brought by TAA and the impossibility to constantly predict the market. The analysis burden brought by TAA requires the work of several analysts, sophisticated computer models and other costly resources. To be profitable and add value, TAA must yield abnormal returns that surpass the high implementation costs and commissions of active management. Secondly, also considering that a TAA can add value in the short-run it is difficult to believe that it will do so consistently. Research has demonstrated that consistently forecasting market trends is nearly

[90] *See* Id.
[91] Market-timing refers to the act of moving investment money in or out of a financial market based on predictive methods.

impossible[92]. Vanguard's own study[93] estimated that missing the best 30 trading days in history could result in losing nearly half the potential returns (see Graph 10).

Graph 10: Annualized returns of U.S. stock market from 1928 through 2021

Source: Vanguard calculations, using data from Macrobond, Inc, as of December 31, 2021.[94]

Failed tactical moves can have long-lasting negative impacts. Furthermore, the best and worst trading days often occur in close proximity, complicating timing efforts. Research supports the dominance of SAA. Studies, including Vanguard's "Framework for Constructing Globally Diversified Portfolios" (2021), reveal that over 90% of a portfolio's return variability is attributable to its asset mix. Short-term tactical decisions, like market-timing and security selection, have minimal impact on long-term return variability.

Vanguard's adherence to SAA, as seen in its target retirement funds, aligns with the risk-averse nature and long-term horizons of pension funds. While some view this approach as

[92] *See* Brinson, G. PHood, L. R. and Beebower, G. L., Determinants of Portfolio Performance, *Financial Analysts Journal,* (1986). Available at https://www.jstor.org/stable/4478947. In this seminar research known as the *Brinson Study* the authors concluded that asset allocation accounts for over 90% of the variability in a portfolio's returns over time, with market timing and security selection having a minimal impact. This highlighted the importance of strategic asset allocation in long-term investment performance.
[93] *See* Vanguard, Framework for Constructing Globally Diversified Portfolios (2021). Available at https://corporate.vanguard.com/content/dam/corp/research/pdf/Vanguards-Framework-for-constructing-globally-diversified-portfolios-US-ISGCGP_062021_july12-update_Online.pdf
[94] *See* supra note 79.

passive, it consistently drives reliable long-term returns and financial stability. Vanguard's adherence to SAA, as seen in its target retirement funds, aligns with the risk-averse nature and long-term horizons of pension funds. The consistent and reliable performance of SAA proves its effectiveness in driving long-term financial stability. Moreover, the risk-averse nature of pension funds and their substantial asset levels support the use of SAA. TAA may offer short-term outperformance, but it is not compatible with the long-term horizon of pension funds. While some may view this approach as passive, it remains a reliable strategy for achieving long-term financial stability.

3. Remarks on fund risk management

3.1. Improvements to Fund's Risk Management

Following our examination of various risk measures such as VaR and tracking error volatility, it is important to understand that the sophisticated risk management practices detailed in this thesis are still not the common standard across all private pension funds. There is significant variability in risk management sophistication. While some large funds dedicate considerable resources to internal trading, risk analysis, and managing external fund managers, smaller funds in less developed private fund sectors, such as Italy, lack robust risk management practices. This deficiency poses significant risks for their members.

A good pension fund manager/trustee must not only have an excellent knowledge of the fund — such as its liability cash flow profile and the average member's age — but also possess a deep knowledge of finance. When funds' managers are not well informed, they could choose incorrect SAAs, either too risky or too conservative, posing significant threats to the fund's safety. The role of the asset manager should be to offer a complementary opinion, not to make the primary decisions; the final say should always rest with the fund managers. Many medium-sized and some larger funds who have limited staff and resources, often excessively rely on consultants for risk analysis and for defining their asset allocation. This reliance is partly due to the corporate governance structure of pension funds, where trustees or benefits committees often have limited investment expertise. Consultants, however, may be reluctant to propose substantial changes in Asset-Liability Management (ALM) strategies or portfolio compositions that deviate from previous advice or industry consensus. This conservatism can

lead to herding behavior and slow the adoption of innovative risk management practices.Let's recall that one key difference between pension funds and other financial institutions like banks and insurance companies is the absence of a capital buffer on the balance sheet dedicated to the risk coverage. Pension fund boards must aim to keep risks within critical levels without a formal capital requirement to cover these risks. For this reason, internal risk management in pension funds should be even more rigorous and conservative to ensure strengthened and adequate coverage despite the lack of explicit capital reserves.

Another risk arises directly from the nature of the mandates given by pension funds to asset managers. Pension funds delegate the financial management of their assets to an external entity — the asset manager. The mandate is usually given for a relatively short term[95] compared to the investment horizon of the members, which easily exceeds thirty years for younger participants. How can one evaluate a manager's performance in the short term when their investment strategies should be long-term oriented? For example, a manager who invested a significant portion of resources in the equity markets for younger members would inevitably be exposed to the higher volatility of these markets. How can we distinguish, in the short term, whether a particularly favorable or unfavorable result is due to the manager or simply market movements? To compensate for early underperformance, a manager might take on higher risks in the latter half of the mandate, potentially compromising the ideal risk profile as the mandate nears its end. This issue can be addressed by defining an appropriate benchmark for each reference market. However, benchmarks highlight a potentially dangerous risk for pension funds: the potential misalignment between the manager's objectives and the fund's objectives. If the management produces unsatisfactory results in the initial part of the mandate, the manager might face the risk of being replaced due to poor performance. For example, if the manager underperforms the benchmark in the first half of the mandate, he might take on higher risks in the latter half of the mandate to make up for the shortfall, knowing that simply matching the benchmark in the second period wouldn't be enough to retain their position. Such a scenario would potentially compromise the fund's ideal risk profile as the mandate nears its end.[96]

[95] This characteristic varies significantly by country. In Italy, mandates are typically given for very short terms (2 to 3 years), whereas in more developed countries like the U.K. and the U.S., they are granted for much longer periods.
[96] *See* Corvino and Saita (2001), "La definizione della strategia di investimento nei fondi pensione", *Il risparmio previdenziale e la sua gestione*, p.237, ISBN 88-86110-16-2.

Understanding these dynamics allows us to better appreciate the complexities and challenges in improving risk management practices across the pension fund industry. Having informed and prepared managers and trustees to oversee and monitor the asset managers' results is crucial for managing and eliminating these risks. By fostering a culture of informed decision-making and effective oversight, pension funds can better navigate the intricate landscape of risk management.

3.2. The growing involvement of Governments and Public Authorities in Fund Practices

In addition to the internal challenges faced by pension funds, regulations imposed by governments and supranational authorities also play a critical role in shaping their risk management practices. Governments have become increasingly more aware of the funding challenges pension funds face from aging populations. For this reason, governments are very closely following the fund's financial decisions. Public authorities enforcement significantly influences funds' investment strategies and risk management practices. The growing involvement of a number of authorities such as the IOPS and the more frequent amendment of state regulations, such as the American Employee Retirement Income Security Act of 1974 (ERISA), indicates that public enforcement is increasingly focused on governance and risk management issues. Overall, global financial supervisors are moving towards a risk-based approach. This can be recognized as a structured process aimed at identifying potential critical risks that funds may face. Through a focused review by the supervisor, assessing both the pension fund's management of the risks and the pension fund's financial vulnerability to the risks[97].

As outlined by the IOPS Toolkit for Risk-based Supervision, pension funds are now responsible for implementing a risk-based supervision (RBS) approach. By enforcing the implementation of an RBS approach, supervising authorities will be able to identify the institutions posing the major threats and simply direct its resources towards them. This approach will not oblige pension funds to follow specific management guidelines dictated by the supervising authority, but will simply impose on them the obligation to remain within certain

[97] As it happens with banks. An example of this type of exercise for banks is the Federal Reserve's Comprehensive Capital Analysis and Review (CCAR). The CCAR is an annual exercise conducted by the Federal Reserve to assess whether the largest bank holding companies operating in the United States have sufficient capital to continue operations throughout times of economic and financial stress.

financial limits deemed as safe. Fund managers will retain the freedom to make all decisions and be responsible for them as authorities will only “verify” the financial data.

Among the rules enforced by supervising authorities, the main focus concerns tax regulations and regulatory choices regarding asset allocation and investments.

3.2.1. Taxation

Taxation rules, as set by governments, are powerful tools in enforcing risk management processes in pension funds. In most developed countries, taxation rules primarily focus on the funding ratio, yet the impact of taxation on the strength of pension funds appears to be mixed. Taxation and other rules can create disincentives or prohibitions to annual contributions or the withdrawal of surplus assets, thereby further discouraging precautionary overfunding and thus raising risks. In many cases, tax rules on pension contributions effectively set upper bounds for funding decisions. For example, in the U.S., contributions that increase the funding ratio beyond the fully-funded status are not tax-deductible.". On the other hand, lower bounds tax policies and penalties also aim to prevent large funding deficiencies, such as through the imposition of a tax of 100 percent of the deficiency in case of failure to correct it.

3.2.2. Regulation

As for taxation, regulation shapes the investment choices of pension funds, thus influencing its risk profile. To date, most regulations were based on simple provisions such as ensuring that assets were segregated and that specific minimum levels were respected. In the past regulations never actively forced managers to implement (or avoid implementing) predetermined strategies. More recently, pension supervisors have started to implement more stringent measures, limiting certain investments or asset holdings thus influencing fund’s investment behavior. In this sense, managers are now facing more stringent regulations concerning the diversification of their investments. Supervising authorities have more recently tightened the restrictions on the asset classes indirectly pushing funds to invest in investments considered to be safe, such as the domestic treasury bonds.

However, it is important to recognize that, although the implementation of these regulations originates from the fundamental principle of ensuring greater security for plan members, they could have the opposite effect. Financial literature recognizes diversification as

one of the most effective tools (if not the most) for eliminating or reducing investment risk. Indeed, there is evidence that such international diversification not only provides benefits from risk diversification, but may also provide higher returns on capital.[98] By limiting diversification opportunities, such as imposing quotas on domestic investments, supervising authorities might unintentionally worsen the situation rather than improve it. This underscores the importance of continuing regulatory efforts to eliminate domestic investment restrictions.[99] While some countries still impose upper limits on investments in foreign securities, regulatory constraints on pension fund allocations rarely pose a significant barrier to investments today.[100] Another type of regulatory approach concerns the VaR. Similar to banks, pension fund asset managers must maintain their portfolio VaR in between predetermined levels - as outlined by the Basel Regulations.

Overall, the evolving regulatory landscape highlights the importance of robust risk management practices to ensure the financial health and stability of pension funds.

V) Conclusion

In this thesis we have analyzed the strategic risk management of pension funds and explored their strategic asset allocation. We have understood that, as populations age and the need for secure retirement income grows, private pension funds play a major role in the global financial system. Their investment strategies and asset allocation decisions can not only shape macroeconomic trends but also potentially trigger global crises. We analyzed the licensing and creation process as well as the distinctions between different types of funds. We defined the two main types of pension fund structures, Defined Benefit and Defined Contribution, and looked at the differences between open and closed funds. Understanding the global picture allowed us to set the foundation for our analysis, as each fund's own characteristics and specificities dictates the risk tolerance and the overall management strategy.

[98] As we have seen with enhanced credit strategies.
[99] *See* Deutsche Bank Research, 2003, "Aging, the German Rate of Return and Global Capital Markets".
[100] In the past, Japanese restrictions on allocations both to equities and to foreign securities acted as a strong constraint on pension fund allocation strategies, but these were abolished in 1997.

We analyzed the five stages of the risk management process in a fund: context definition; identification; analysis and measurement; evaluation and treatment; review and communication. Our exploration of risk management practices highlighted that, once good practices and systems to monitor are implemented, the second challenge consists in determining which quantitative methods are most suitable for measuring risks. We classified risk measures into three main categories and described the strengths and weaknesses of the most used risk measures: duration and modified duration, beta, volatility (standard deviation of returns), value at risk (VaR), and tracking error volatility (TEV). Lastly, we conducted a qualitative assessment of the main risks faced by pension funds by dividing them into macro-categories, presenting the main sub-risks within each category, and ranking them according to a frequency/severity approach.

We then moved to understand what most influences the risk profile of a pension fund: its investment strategy. We analyzed the main features of the strategy that has guided pension fund investments for the last two decades, the liability-driven investing (LDI) strategy. This approach aims to minimize surplus volatility by constructing a portfolio of assets that generate returns closely aligned with the fluctuations in the plan's liabilities. We conducted a literature review of the main asset allocation strategies adopted by pension funds. We analyzed dynamic strategies such as Buy-and-Hold, Constant-Mix, Constant-Proportion Portfolio Insurance (CPPI), and Option-Based Portfolio Insurance (OBPI). We remarked that there is no better overall strategy. Each strategy offers distinct advantages and disadvantages, and their effectiveness varies depending on the market conditions and the specific needs of the pension fund.

Lastly, we explored recent trends in private pension fund investment choices and risk management practices. We observed that a secular shift towards private markets has taken place. Due to the low rates offered by traditional asset classes, private markets have become an appealing option for pension funds. They can provide higher returns and enhance diversification, making them an interesting asset class. To provide a practical example, we studied BlackRock’s enhanced credit classes. We understood why BlackRock believes that such investments, integrated with an LDI approach, can provide diversification, yield enhancement, and effective risk management, making it beneficial for private pension fund asset allocation. To conclude our practical analysis, we reported the investment strategies used by U.S. top 200 corporate plans and noted the growing share of alternatives and private market investments. Another trend we observed concerned the rise of ETF investments, which have now become integral to the

strategies of institutional investors such as pension funds. Particularly insightful was our case study of Vanguard, one of the world's largest investment management companies. Vanguard's emphasis on Strategic Asset Allocation (SAA) over Tactical Asset Allocation (TAA) provided a valuable lesson in the importance of long-term, disciplined investment strategies. Vanguard's approach demonstrated how SAA can deliver more consistent and reliable returns, aligning with the long-term horizons and risk-averse nature of pension funds. After observing improvements in fund risk practices, we examined the growing involvement of governments and public authorities in regulating and guiding pension fund operations. The shift towards risk-based supervision and the adoption of frameworks such as the IOPS Toolkit highlight the ongoing need for enhancement in governance and risk management practices.

In conclusion, the evolving landscape of private pension funds requires a delicate balance between achieving high returns and managing risks effectively. As these funds continue to grow in size and influence, their role in ensuring financial stability for retirees becomes ever more critical. By adopting best practices in risk management, leveraging strategic asset allocation, and embracing innovative investment strategies, private pension funds can navigate the complexities of the financial markets and secure the futures of their beneficiaries. The insights gained from industry leaders like Vanguard and BlackRock provide valuable blueprints for achieving these goals.

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