1 Introduction

Retirement systems are designed to provide pensions to individuals who have, in principle, stopped working because they have reached a certain age, after which it is regarded as "normal" to retire from the labor market. How to finance pensions for current retirees, how to secure benefits for workers who plan to retire in several decades and what conditions a person should fulfill to claim their pension are matters of debate with numerous economic, political and social implications. This Element focuses on a question that is often overlooked in general public discussions: how to efficiently invest retirement savings so that they produce replacement income when needed – that is, in the retirement period. This is different from the approach that begins with a quest for the "retirement number," which is the amount that an individual should accumulate in order to retire, and continues with the design of a savings and investment plan such that the pension pot can grow to that size. In this approach, the setup of the investment strategy ends up being disconnected from the income-generation objective and boils down to generic considerations on the risk and return properties of financial assets. A central idea in this Element is that there should be as much consistency as possible between the accumulation and the decumulation phases. Put differently, the investment strategy in accumulation should be organized around the objective to generate replacement income, following the principles of *goal-based investing*, which are themselves rooted in the first principles of finance theory.

So, this Element is about good investment practices for retirement. Though the subject is of general interest, it is not targeted to a general audience because it does not convey simple messages such as "product A should be preferred to a product B to be on track for retirement." In fact, the "improved" products for which it makes a case, which would better be called "investment solutions" because they take into account individuals' goals and constraints, do not exist in the catalogs of asset managers, so it is impossible to orient customers to them. The objective of this Element is to foster interest in the investment industry for the launch of new forms of retirement investment solutions that better serve the goal of generating replacement income than existing products with a retirement label.

Once genuine *solutions* to the needs of retirees and future retirees are available, the next step will be to encourage individuals to choose them as opposed to adopting default investment solutions or fashionable products without questioning their adequacy for retirement preparation. In other words, individuals should be in a position to make educated investment choices because this decision is theirs alone, just like the decision of how much to save on their own to complement state- and employer-provided pensions. But in order to play such

an active role in their saving and investment decisions, individuals need at least a minimal bank of knowledge on the properties of financial assets and allocation methods. To address financial education challenges is beyond the scope of this Element, but the last section provides suggestions for what remains a task to be accomplished. The message is, after all, simple: it is well known that a balanced diet and regular physical exercise are recommended to maintain good physical condition, so it makes intuitive sense that regular contributions and investment decisions consistent with one's objectives are recommended to reach these objectives.

This Element is organized as follows. Section 2 provides a broad picture of the organization of retirement systems and reviews the demographic and economic challenges that they present, which make it increasingly important for individuals to set up savings and investment strategies to supplement their retirement income. Section 3 studies the problem of decumulation, which consists in finding a way to convert accrued savings into a stable income stream that lasts for a sufficient amount of time. It concludes with the introduction of *retirement bonds*, which play an important role in this Element and are defined as securities that provide fixed or cost-of-living-adjusted income for an individual's expected lifetime. Section 4 goes through a detailed presentation of these bonds, showing, in particular, how their price can be used to evaluate the purchasing power of savings in terms of replacement income, thus providing a series of helpful metrics to individuals who want to know if they are on track for retirement. Section 5 turns to investment strategies for the accumulation phase, which is the life cycle stage in which a person saves money for retirement, and it describes new forms of balanced funds and target date funds in which retirement bonds are used as building blocks. Section 6 introduces a more sophisticated class of investment strategies, designed to secure minimum levels of replacement income in retirement while keeping the upside potential needed to reach higher levels in favorable market scenarios. Section 7 offers concluding remarks and discusses the implications of adopting a goal-based investment approach in retirement planning. Appendices contain technical details and mathematical derivations.

2 Why Retirement Investing Matters

The merits and the drawbacks of different investment choices in the context of retirement saving are not the most popular topics in general discussions around retirement; often, these subjects are confined to debates among finance practitioners and researchers. However, investment decisions have a considerable impact on the outcome of a strategy in terms of replacement income because financial assets have very different abilities to generate stable and sufficiently

large replacement income. These decisions would be irrelevant if public retirement systems and defined-benefit pension plans alone were able to support the lifestyle desired by individuals. Unfortunately, this is not the case, for a set of demographic and economic reasons that we survey in this section, and this makes it necessary for individuals to supplement their retirement income by relying on their own saving and investment decisions.

2.1 Organization of Retirement Systems

Retirement systems are organized in three pillars, each of which provides income to retired individuals. A fourth is sometimes added to include nonfinancial assets like home ownership and informal sources of income like family support. This classification is standard and was introduced by the World Bank (Holzmann and Hinz, 2005), but the Organisation for Economic Co-operation and Development (OECD) uses a different taxonomy organized around three "tiers" – the first two of which are mandatory and the third is voluntary.

2.1.1 First Pillar: Mandatory and Publicly Managed Pension Schemes

The first pillar aims to provide a universal core of pension coverage to address basic consumption needs in retirement. Social Security systems that exist in most developed countries take on this task, as part of their broader objective to reduce poverty by providing income to the elderly as well as to special needs individuals, widows, orphans and so forth. This basic pension system is mandatory, publicly managed and usually pay-as-you-go, meaning that benefits are paid by payroll taxes levied from workers and employers, plus debt if needed: thus, the first pillar is redistributive in nature. A "zero pillar" is sometimes added to the classification to encompass noncontributory schemes, which pay a minimum pension to the most economically disadvantaged elderly without a contribution condition.

Basic pension schemes generally have a defined-benefit flavor in that benefits are neither expressed as functions of the contributions made during the working period nor as functions of the performance of an underlying investment, which simply does not exist in the case of unfunded systems. Instead, they are linked in various ways to an individual's past wages and to the length of the period during which contributions have been paid. A minimum contribution period and/or a minimum age is generally required to claim pension rights, and those who do not fulfill these conditions are either not eligible or receive reduced benefits. In France, individuals must be at least 62 to be eligible and have contributed for 172 quarters to have a full-rate pension. In the United

States, credits accrue every year, depending on earnings, with a maximum of 4 credits per year, and an individual needs at least 40 credits or 10 years. In the United Kingdom, the new State Pension rules impose a minimum qualifying period of 10 years.[1] Adjustments can be applied to take into account specific situations like disabilities, unemployment periods, childcare and arduous work.

To top up the benefits received from basic schemes and improve replacement rates, some countries have set up additional pension schemes with mandatory enrollment. This was the case in the UK with the State Earnings-Related Pension Scheme until 2002 and the Additional State Pension after 2002, until they were replaced by the new State Pension in 2016. In France, the Agirc-Arrco and the RAFP (*Retraite Additionnelle de la Fonction Publique*) provide additional benefits, respectively, for private-sector workers and for civil servants. Both are examples of point-based systems, so they have a more defined-contribution nature than the aforementioned systems. In such schemes, workers earn points by making mandatory contributions, possibly supplemented by employers, and points are stored in individual accounts until they are converted into benefits equal to the number of points multiplied by the value of a single point. RAFP is a funded system, in which pensions are backed by invested assets.

2.1.2 Second Pillar: Occupational Pension Plans with Mandatory Enrollment

The second pillar consists of public or private occupational pension schemes that require mandatory enrollment from workers. The size of these plans greatly varies across countries, depending on whether employer-sponsored plans existed before Social Security (Moore, 2011). In 2016, assets in private pension plans amounted to only 9.8% of gross domestic product (GDP) in France, where this pillar is not widely developed, versus 134.9% in the US, and they reached a maximum across OECD countries of 209% in Denmark (OECD, 2017).[2]

In the US and the UK, the traditional form of private pension plans is represented by defined-benefit (DB) pension plans. In these arrangements, the calculation of benefits is based on an employee's earnings and career length. These plans are thus exposed to the risk of underfunding in case their invested assets do not generate sufficient returns for the promised benefits to be

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[1] These rules applied at the time this Element was written (in 2019), and simplified versions of the actual rules are provided herein. Usually, not all cohorts are subject to the same rules because Social Security reforms are progressively enforced and impact more younger workers than their elders.

[2] Source: OECD, http://dx.doi.org/10.1787/888933634686.

delivered. Clearly, underfunding is ultimately a risk for pensioners,[3] so some countries have set up insurance systems to secure the payment of benefits, like the Pension Benefit Guaranty Corporation (PBGC), which was created in the US by the Employee Retirement Income Security Act of 1974, and the Pension Protection Fund, which was created in the UK by the Pensions Act 2004. Before calling on a guarantee fund, underfunding risk can be reduced in the first place by the use of appropriate asset-liability management techniques, including the construction of *liability-hedging portfolios*, which ensure that assets match liabilities. This practice is fully consistent with OECD recommendations for private pension regulation:

> The investment policy should establish clear investment objectives for the pension fund consistent with its retirement income objective and specific attributes. . . . The investment objective should also be consistent with the characteristics of the liabilities of the pension fund where applicable.[4]

> A sound investment risk management process that supports the achievement of the investment objectives should be established. It should measure and seek to appropriately control portfolio risk and to manage the assets and eventual liabilities in a coherent and integrated manner.[5]

DB plans still account for large shares of invested assets in these countries, with respectively 82% and 40%, according to the 2016 figures of Willis Tower Watson (2017, p. 7). But the OECD (2016b, p. 24–27) reports that the number of participants has grown faster in DC versus DB plans since the turn of the millennium – an observation that can be repeated for all countries in which both types of plans are widespread. In the US, the number of members in occupational DB plans grew from 61,686,000 in 2000 to 72,577,000 in 2012 – hence a growth by 12% – while the number of those in occupational DC plans grew from 61,686,000 to 95,379,000 over the same period, representing an increase by almost 55%. The UK even saw a decrease in the number of members in DB plans between 2010 and 2015 – from 11,999,000 to 10,973,000 – which stands in sharp contrast to an increase from 2,360,000 to 6,931,000 in DC schemes.[6]

In DC plans, benefits depend on the contributions made by the employee (and possibly the employer) and the performance of invested assets, so that participants are more directly exposed to the consequences of poor returns. In these schemes, it is participants who bear the risk of insufficient contributions, while in DB plans, the employer has to make up for deficits.

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[3] See the failure of the Studebaker-Packard Corporation in 2003 (Wooten, 2001).
[4] OECD (2016a), Guideline 4.6, p. 34.
[5] OECD (2016a), Guideline 4.9, p. 35.
[6] Source: OECD, http://dx.doi.org/10.1787/888933426787.

2.1.3 Third Pillar: Voluntary Saving Schemes

The third pillar includes voluntary pension arrangements that individuals set up to supplement the income they receive from mandatory sources. It encompasses a variety of financial products, not all of which are explicitly intended for retirement saving, like balanced funds and life insurance. By convention, nonfinancial assets are excluded from this list, so the World Bank framework defines a "fourth pillar" that includes home ownership and reverse mortgage.

Many of the DC pension arrangements that are progressively taking over traditional DB plans with mandatory enrollment belong to this pillar. In the US, a large number of these new DC plans are 401(k) plans, named after the section of the Internal Revenue Code of 1986 that defined them, and participation in these plans is optional, although employees are automatically enrolled and must explicitly opt out if they do not want to participate. Other examples of collective voluntary pension arrangements include the French PERCO (*Plan Épargne pour la Retraite Collectif*), created in 2006, and the Dutch collective DC (CDC) schemes. CDCs have been created as an attempt to mix the best of both worlds. In CDC plans, the employer's contributions are fixed and assets brought by members are pooled in a fund rather than being invested in individual accounts, so that the risk of poor returns is divided between contributors.

In voluntary saving schemes, individuals are responsible for deciding how much they want to contribute and how they want to invest their savings, so saving practices reflect their attitude toward personal finance decisions. As a result, retirement saving is a privileged field for studies in behavioral economics. One of the well-known features of individual behavior is procrastination, which is the tendency to postpone the decision to reduce current consumption to finance future consumption. This behavior is also present in microeconomic theories based on individual optimization, where the degree of preference for the present and the propensity to substitute consumption over time are captured through ad hoc parameters. To create incentives for individuals to save on their own, regulation usually provides some form of tax advantage to saving in dedicated vehicles. There are three main categories of tax advantages, which occur at the three stages of the life of a retirement saving plan: the first applies to contributions, the second to growth in capital and the third to withdrawals.

The advantage can present as a deduction of contributions from taxable income, up to a certain limit, like in US 401(k) plans and traditional Individual Retirement Accounts (IRAs), and in the French PERP (*Plan Épargne Retraite Populaire*) for private-sector workers and Préfon for civil servants. In this system, taxes are deferred until income is distributed in retirement, so this provision is an advantage if individuals are taxed at lower rates in retirement

than during their working life, which is the case if they have less income in retirement and the tax system is progressive. Moreover, if the annual replacement income is greater than the annual contribution because the investments generated sufficient performance, the after-tax retirement income is greater than the after-tax contribution. This is an attractive feature for individuals if they roughly obey the permanent income hypothesis and elect the saving strategy that maximizes their income over the life cycle.

Tax advantage can also present upon withdrawals. In US Roth IRAs, created by the Taxpayer Relief Act of 1997, there is no advantage to contributions but distributed income is tax-free, provided withdrawals are made in a certain way that makes them *qualified*. Individual Savings Accounts (ISAs) in the UK have similar covenants, but they can be used for more general purposes than retirement saving. In France, the owner of a life insurance contract can convert it to lifetime income, but only a fraction of this income is taxed.

Finally, an advantage common to 401(k) plans, IRAs and ISAs is that dividends and interest earned and reinvested in the plans, as well as capital gains, incur no additional taxes. In France, capital income and gains in life insurance contracts are taxed when funds are withdrawn, but a tax rebate applies, depending on the contract's age.

In general, individuals can choose to utilize a variety of financial products to invest their savings. In France, the owners of life insurance contracts prize capital-guaranteed funds: the traditional ones (*fonds en euros*) are invested in sovereign bonds, but products implementing a dynamic allocation between bonds and other more risky assets like equities have emerged as a response to persistently low interest rates that do not even compensate investors for inflation. Aside from capital-guaranteed products, subscribers can save money in more risky mutual funds, invested, for instance, in equities, bonds and real estate, with no capital guarantee but higher *expected* returns.

Another extremely popular class of products is that of target date funds in the US. These funds, which are described in detail in Section 5.1, mix equities and bonds and let the equity allocation gradually decrease as they approach their target date. They have the status of a "Qualified Default Investment Alternative" via the Pension Protection Act of 2006; this means that by enrolling participants in such a fund, an employer is not responsible for losses. As a result, they are a default option in most 401(k) plans, and being a default choice, many workers stick to it.

In addition to mutual funds, which are asset management products, there exist insurance products, managed by insurers and broadly referred to as *annuities*. These are described in Section 3.2. By subscribing an annuity contract, an individual converts capital into lifetime income. In the simplest contracts, income is constant and depends on the interest rate conditions prevailing at the

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contract's writing date and the expected longevity of the individual, but products called *variable annuities* have blurred the line between insurance contracts and defined-contribution arrangements by linking income to the performance of an underlying fund.

2.2 Demographic and Financial Challenges

2.2.1 Demographic Context

Social Security systems hinge upon a balance between the contributions paid by workers and their employers and the benefits to retirees that they finance. But their sustainability is compromised by the general long-term trend toward population aging. The OECD estimates that in its member countries, the number of individuals aged 65 and over per 100 individuals aged between 20 and 64, a range that corresponds to working ages, rose from 19.5 in 1975 to 27.9 in 2015, and is expected to grow to 53.2 by 2050. In Japan and Korea, the ratio would even grow to 75.3% and 78.8%, respectively.[7]

An important component of this trend is the increasing life expectancy, an evolution that has been observed over the past 50 years and is expected to continue throughout the next century, as illustrated in Figure 1. By taking the difference between this value and the average effective age of labor-market exit, it is possible to estimate the average time spent in retirement – that is, the average length of the period during which an individual needs replacement income. Across OECD countries, the average retirement age in 2016 is 63.6 for women and 65.1 for men, and the two groups can expect to live, respectively,
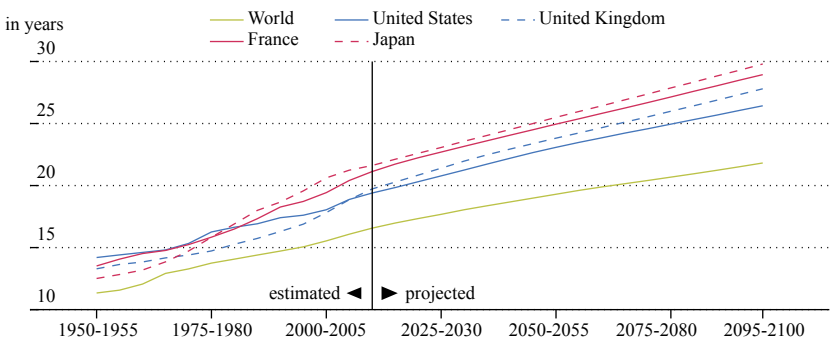

Figure 1 Estimated and projected life expectancy at age 65; data as of 2015.
Source: UNO, "Life Expectancy at Exact Age for Both Sexes,"
https://population.un.org/wpp/Download/Standard/Mortality. Figures are estimates from 1950 through 2015, and projections are from 2016 through 2100.

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[7] Source: OECD, http://dx.doi.org/10.1787/888933634306.

for some 22.5 and 18.0 years when they retire. The expected time in retirement peaks for France, at 27.6 years for women and 23.6 years for men.[8]

2.2.2 Underfunding Issues in DB Plans

Underfunding is a major risk for DB plans and was a motivation to pass minimum funding requirements through law. In the US, the failure of the Studebaker-Packard pension plan was even a triggering event for the passing of the ERISA, as recalled by Wooten (2001): when the corporation closed its automobile facility in South Bend, Indiana, in 1963, the pension plan did not have enough assets to pay the promised pensions, so many workers received reduced pensions or even nothing. In 1974, the ERISA expressed the first minimum funding rules, and the Pension Protection Act of 2006 introduced tighter rules, stating that DB plans must in principle be fully funded: "Except as provided in subsection (i)(1) with respect to plans in at-risk status, the funding target of a plan for a plan year is the present value of all benefits accrued or earned under the plan as of the beginning of the plan year."[9]

The ERISA also introduced new principles for the valuation of liabilities: in particular, interest rates used in the discounting of liabilities were required to be consistent with the rates of Treasury bonds, as opposed to being fixed, arbitrary values.[10] This practice gives a better sense of the size of commitments, but it creates volatility in the actuarial value of liabilities, defined as the sum of discounted cash flows, as reflected in the sponsor companies' income statements and/or balance sheets. In addition, the historically low interest rates that have prevailed since the 2008 downturn inflate this value and depress funding ratios.

Stricter funding requirements and changes in accounting standards have created a less flexible environment for DB plans, which helps explain the shift toward DC plans. In several countries, accumulated assets are insufficient to cover liabilities, and the deficit is sometimes severe. In 2016, the average funding ratio was 61.0% in Iceland, 67.5% in the US, 88.7% in the UK and 95.0% in Canada.[11]

2.2.3 Inadequate Replacement Income

Inadequacy risk is the risk of insufficient replacement income to maintain one's lifestyle in retirement. Individuals have no control over the benefits provided by Social Security systems and employer-sponsored DB plans, but as far as the third pillar is concerned, they are responsible for making saving and

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[8] Source: OECD, http://dx.doi.org/10.1787/888933634401.
[9] Pension Protection Act of 2006, Public Law 109-280, Sec. 102, §(d)(1), p. 791.
[10] ERISA of 1974, Sec. 303, §(2)(B) and §(2)(C).
[11] Source: OECD, http://dx.doi.org/10.1787/888933634819.

investment decisions, so that inadequate income can be the result of two factors: insufficient savings and/or poor returns on investments.

As noted by the OECD (2016b), this risk is exacerbated by the fact that contributions tend to be lower in DC than in DB arrangements. Typical contribution rates are greater than 20% of wages in public or private DB schemes (e.g. 21.3% in France and 20.9% in the Netherlands in 2014, according to OECD [2015]) and are substantially lower in DC schemes (e.g. 9.5% in Australia). Inadequacy risk materializes in the pension replacement rate, defined as the ratio of benefits from mandatory public and private arrangements to labor income. This rate is generally decreasing in terms of income level, reflecting the redistributive nature of many systems, and it ranges from 42.4% to 59.9% in the US, from
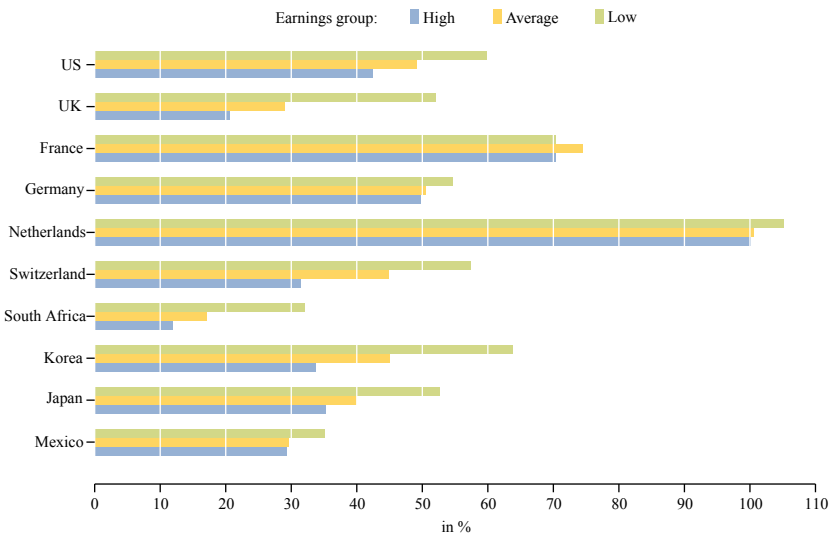

Figure 2 Net replacement rates from mandatory pension schemes, both public and private, as of 2016.
Notes: Figures are reproduced from Table 4.11 in OECD (2017) and are as of 2016.[12] The net replacement rate is the ratio of pension benefits in retirement to labor earnings for an individual earning 0.5 times the average worker earnings or less ("low earners"), between 0.5 and 1.5 times the average ("average earners") and more than 1.5 times the average ("high earners"). A detailed methodology, with assumptions on inflation, earnings growth rate, rate of return on assets in funded pension schemes, loading factor for annuities, discount rates, longevity and tax rates, is presented in pages 98–99 of the OECD report. In the US, UK, Germany, South Africa and Japan, a large fraction of the population is covered by voluntary private pension arrangements, so the total replacement rate, which aggregates mandatory and voluntary sources, is higher than the one shown in this diagram.

[12] **Source:** OECD, http://dx.doi.org/10.1787/888933634059.