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A REPORTING STANDARD FOR DEFINED CONTRIBUTION PENSION PLANS

Kees de Vaan
Daniele Fano
Herialt Mens
Giovanna Nicodano

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Kees de Vaan
Syntrus Achmea Vermogensbeheer

Daniele Fano
Tor Vergata University

Herialt Mens
Aegon Asset Management

Giovanna Nicodano
Collegio Carlo Alberto, University of Turin

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Abstract

We propose a method for projecting pension benefits, deriving from DC pension plans and other funded products, at retirement. Projections highlight how the current choice of asset allocation impacts on future potential retirement outcomes. The latter are compared with a money-back benchmark so as to clarify the trade-off between risk and return. After the initial projections, the pension plan revises its forecasts of retirement benefits on a yearly basis as a function of its own realized returns. Previous shorter-term projections are also compared to shorter-term ex-post performance. This simple method is a step towards an industry-reporting standard that responds to regulators' quest for helping investors monitor the risk of their future pension.

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1. Introduction

Defined contribution pension plans around the world report their performance in non-homogeneous ways to their members (Antolín and Harrison, 2012). A common feature they share is a focus on the returns obtained in the recent past. This practice does not necessarily convey information on longer-term returns, even if pension investment is for the long run. On the one hand, returns on certain assets may be close to unpredictable, in which case their past returns do not forecast future ones. On the other hand, projecting future outcomes given past performance is likely to exceed the household's ability, even if the pension fund invested in assets with predictable returns. There are very few instances of pension plans that report expectations of future returns. However, this does not convey to pension members information on the range of future pension benefits, and on how possible outcomes depend on alternative asset allocations and levels of contribution.

This paper proposes a method for projecting pension benefits in future years until retirement (given some contribution installments). Importantly, projections provide the plan member information about the trade-off between higher returns and higher risk taking. It then elaborates on how the pension fund may compare its recent realized performance to its previous short-term forecasts, and revise its projections of benefits at retirement as a function of its own actual returns.

Our proposal has three main features:
(a) pension forecasts refer to the retirement horizon of the plan member;
(b) both projections and ex-post realized performance are compared to an easy-to-grasp benchmark;
(c) yearly realized performance is assessed against the pension fund's previous yearly projections.

The first characteristic, "mark-to-retirement", stands in contrast with commonly used reporting methods. Drawing investors' attention towards longer-term goals may help improve their ability to allocate their savings. This longer-horizon perspective may indeed counter the investor's tendency to pour money into funds with high past returns at monthly or quarterly frequencies (Del Guercio and Tkac; 2002, Rakowski and Wang, 2009), and more generally to poorly time the market, which reduces their average returns (Friesen and Sapp, 2007). Moreover, this approach makes it possible to assess the consistency of goals with the assumed installment plan.

The second characteristic of our framework is represented by the benchmark against which pension fund performance is evaluated, i.e. a purchasing power equivalent, real terms money-back indicator. We depart from currently used benchmarks (Lehmann and Timmermann, 2008), which juxtapose realized fund returns to those of a portfolio with comparable risk exposure. Our benchmark is closer to the maturity-matched Inflation Indexed Bonds (IIB), that are almost riskless securities for a long-term investor with the same investment horizon as the bond maturity (see Bodie and Treussard, 2007). Projections against a riskless comparable allow plan members to appreciate the upside potential of risky assets, at the same time making them aware of their downside risk. Clearly, the benchmark we propose (the CPI) is easier to beat for the pension fund than a portfolio of inflation-linked bonds that usually provide a real return besides the indexation to inflation of the principal. Primarily, however, our benchmark is easier to project. Returns on

IIBs – which ought to be applied to contributions in order to mark-to-retirement the benchmark return – require reliable inflation-linked bond performance indices that are not currently available in each country, while the CPI index is one of the most established statistics.
Our proposal also requires the fund to contrast realized risk-return performance against its own previous projections. The more optimistic the ex ante projections, the worse the current performance will appear relative to expected outcomes. This feature disciplines pension fund managers when making initial projections, as plan members may leave the fund ex post if faced with blatant inconsistencies. We recommend that such an exercise be performed annually, although longer-term ex-post performance reports on a five- or ten- year basis would easily fit in our framework.
A key characteristic of our method is tying past performance and projected performance on a rolling base. In turn, this is simpler when the focus is on returns and financial wealth rather than pension income. Such focus is a shortcoming in countries, such as the Netherlands or Italy, where annuitization at retirement is respectively fully or partially compulsory. Conversion into annuities adds another relevant risk dimension, relating to the interest rate at retirement. We therefore illustrate information on this (augmented) risk-return trade-off with reference to prospective pension annuities, too.

This paper is a starting point towards the design of a reporting standard for pension plans and, more generally, for long-term financial investment plans. This reporting standard would complement the existing ones, GIPS, that allow for short-term performance comparisons (see GIPS, 2006), through its focus on longer-term financial investment assessments. With a similar angle, a recent paper by the Group of Thirty (2013) states that accounting methods that embed a short-term horizon are a potential impediment to long-term finance, and suggest a new approach called *target-date accounting.*

Viceira (2010) and (Bagliano, Fugazza and Nicodano, 2010) respectively suggest a method to inform on the trade-off between risk and return at retirement and a benchmark for the performance evaluation of pension funds. Our proposal departs from them in two main ways. First, it combines in an integrated framework both periodic performance evaluation and longer-term risk return projections. Secondly, it focuses on a benchmark that is easy to understand for plan beneficiaries.

Traditional performance evaluation scrutinizes managerial skills such as security selection and market timing that allow asset managers to systematically earn risk-adjusted returns above the market returns (Lehmann and Timmerman, 2008). Our example assumes away return predictability and security selection activities– thereby abstracting from abnormal returns. Here, performance evaluation investigates whether the strategic asset allocation, together with the chosen contribution path, allows managers to both return the purchasing power of contributions and reach a desired range of monthly pension payments.

The Chilean Pension Supervisor experiments, since 2012, with a simulator that provides stochastic projections of future pension benefits (see Antolin and Fuentes, 2012; and Berstein et al., 2013). Their focus is on re replacement rates at retirement, rather than on cumulated wealth as in our main proposal. They carefully model stochastic labour income as a function of personal characteristics. On the contrary, we expand on pension income sensitivity to interest rate risk when we shift from projected pension assets to projected income. Interestingly, the Chilean experiment reveals that pension members face difficulties understanding information related to pension risk - even when provided with simple words. This is why we resort to graphs that highlight the money-back benchmark, so as to convey the idea of both downside and upside potential.

The rest of the paper is organized as follows. Section 2 below describes our base proposal for a reporting framework, in real terms. Section 3 - 4 project a monthly pension equivalent instead of accumulated capital, which may help plan members to understand the reports better. Section 4 discusses alternative inflation and wage growth scenarios. Section 5 indicates possible extensions. Appendix A addresses the sensitivity of monthly pension projections to interest rate volatility. Appendix B explains how to report in current euro.

2. A Mark-to-Retirement Reporting Framework

Our reporting framework is composed of a limited number of figures and tables, along with a model to produce them.

Figure 1 below shows the type of asset allocation across time underlying the model.

Figure 2 reports the possible values of pension assets at retirement (time T) against an easy-to-grasp benchmark, at current purchasing power. This picture is prepared at the time the pension member joins the fund (time 0), under assumptions concerning the distribution of asset returns as specified below.

Figure 3 reports the possible values of pension assets and of the benchmark after one year (time 1), highlighting the realized value of pension assets. This picture allows the investor to compare the realized return against the pension fund's initial projections.

Figure 4 repeats the simulation of the distribution of pension assets at retirement, starting from their current (time 1) realized value[1]. Table I gathers all maintained assumptions. Tables II and III report some summary statistics concerning, respectively, time 0 and time 1 projections. The Figures 3 and 4, along with the corresponding Tables, will be updated every year. They can be interpreted as mark-to-market and mark-to-retirement, respectively.

Figure 5 shows wage payments in retirement, and the replacement rates**.** It represents the translation of the above mentioned pension assets at retirement in an annuity, conditional on the level of interest rates and given a set of standard actuarial assumptions.

The model is characterized by the following choices, as summarized in Table 1: the asset menu, which should coincide with the menu adopted by the pension fund; the return distribution; the asset allocation; the contribution profile; the benchmark; the treatment of transaction costs; real wage growth; and a set of parameters.

[1] As will become clear later, we are still using time 0 euro.

In our example, only “stocks” (high-risk assets) and “ten-years duration bonds” (low-risk assets) belong to the asset menu. We allow real and bond stock returns to be jointly log-normally distributed with known mean, variance and correlation, as is customary in the literature on long-term asset allocation. Both stock and bond returns are independently distributed in time.

We assume that the plan member contributes a monthly amount until retirement. Our benchmark capital is the sum of all contributions, capitalized at the expected inflation rate. In our example we assume that a 20- years- old worker contributes 100 € each month in the first year. With zero wage growth, benchmark capital at retirement is equal to 48,000 €.

We acknowledge the existence of both transaction costs of new contributions and a yearly fee levied on Assets Under Management (AUM). We do not compute them when projecting benchmark capital: in this respect, our benchmark is equivalent to a money-back equivalent sum in real terms. This benchmark will be compared with the value of accumulated assets net of costs. Thus, the pension fund beats the benchmark if its real return exceeds its costs.[2] Absent any cost, the minimum real pension fund return needed to meet the benchmark is equal to 0%. It becomes 0.43% to compensate yearly AUM fees equal to 0.4% (compounded quarterly) and transaction costs on new money, of 0.05%.[3]

The yearly mean real return on equities is equal to 5.5% with 18% volatility. It is assumed to be independently distributed in time. The real interest rate on constant maturity bonds is 2.5% with volatility 3%. The correlation between risky assets and bond returns is set to 0.1.

In the example shown in the first set of tables and graphs, the chosen asset allocation entails 20% in bonds and 80% in stocks, with quarterly rebalancing, as portrayed in Figure 1.

2.1 Projecting Future Pension Assets and the Risk-Return Trade- Off

This section addresses more specifically the information about the long-term risk return trade-off given to a new pension plan member, age 25, with T=40 years to retirement. Figure 2 reports projected pension assets from age 25 to age 65 over 2,000 possible scenarios that originate from a random drawing of stock and bond returns from their assumed joint distribution.

Our "money-back" benchmark, gross of fund costs, appears in red. Mean accumulated assets appear in black. This picture clearly conveys the upside potential of equity investing, together with its downside risk.

The statistics at the bottom (Table II) provide some quantitative information. The first column indicates the probability of not reaching the "money-back" benchmark (3.35%) after 40 years. This is the observed proportion of scenarios that end up with accumulated assets below benchmark. The maximum shortfall with respect to the benchmark is equal to € -23,299.75, while

[2] Pension funds often invest in mutual funds, which charge additional fees, instead of individual securities. These fees should not affect benchmark capital, either. We overlook transaction costs associated with quarterly rebalancing. Thus our simulations overstate pension fund return projections. Throughout the analysis, we do not consider distortions induced by taxation. We discuss other maintained assumptions in Section 4.

[3] Those figures complete our example, but a regulator may want to establish a cost benchmark.

the average of all scenarios ending below the money-back benchmark is € -6,772.41. The second column reveals that the average amount of accumulated assets is equal to € 177,597.05, while the minimum equals € 24,747.04. The last four rows report upper and lower percentile boundary figures: these provide an idea of the accumulated assets associated with highly probable outcomes on the upside as well as on the downside. For instance, the last two read like "there is a 15% probability that accumulated assets will end below € 76,519.86; and a 5% probability they will end below € 53,064.12".

2.2. Reporting Pension Performance One Year Later

Figure 3 allows the pension or investment plan member to assess the performance of her pension fund one year later. It highlights, with a blue mark, the actual ex-post accumulated assets against both the projected ones and the "money-back" benchmark in red. In the example, the gross-of-fees-and-transaction-costs realized return is equal to -30.4%, leaving her with € 1,000 instead of € 1,200. Thus, the blue mark appears below the money-back benchmark. This picture does not depart from the logic of mark-to-market pension assets; however, it allows the plan participant to acknowledge that the (negative) performance result was among the ones considered possible ex-ante.

In other words, a plan member should understand that there might be large transitory deviations from the benchmark even in the case of a DC-plan that exactly matches an inflation-indexed benchmark. The plan will eventually deliver the expected return over the entire period because it is matched. The next section describes mark-to-maturity, which allows us to cast performance evaluation in a long-horizon perspective.

2.3. Updating Future Pension Assets and the Risk-Return Trade-Off.

Figure 4 allows the investment plan member to understand the implications of realized performance in a retirement perspective by projecting her assets to age 65, given the actual performance realized during the first year and her initial asset allocation. Both the red and the black benchmark appear clearly in Figure 4.

Obviously, a below-mean performance after one year makes it less likely that the plan participant will reach the "money-back" benchmark (the probability increases to 3.80%, up from 3.35%, and the average shortfall increases from €5361 to €5446, as stated in Table III[4]). But mean accumulated assets are equal to € 179,392.88. Note that the mean accumulated assets have roughly remained the same as in the t=0 example. This indicates that a long time horizon allows for the possibility of offsetting initial adverse shocks, making it less sensible to deviate from a pre-determined investment policy. This holds true even in the (unreported) case of a loss of all initial contributions: the probability of ending below the benchmark increases to 4.3%, the average shortfall jumps as high as €8006 and average accumulated assets fall slightly to €175,075.

[4] Section 2 assumes that realized wage growth and realized inflation are both equal to 0%, in line with expectations. This is indeed the simplest case.

By comparison, consider a member that starts contributing two years from retirement. At the beginning she expects as cumulated assets equal to €2,522, against a benchmark capital of €2,400. The probability of ending below the benchmark is high (36%) with an average shortfall of €178. After all of the contributions are lost in the first year, the average accumulated assets fall to €1,228, well below the benchmark, the probability of not reaching the target jumps to 100% and the average shortfall is equal to €1172.

3. Reporting Monthly Pension Equivalent of Accumulated Asset.

Our previous framework reports the projected amount of accumulated and capitalized contributions at retirement. This does not clearly inform beneficiaries on consumption possibilities, which is a central demand of plan members. This information is better conveyed by the replacement rate -- i.e. the ratio of the annual pension annuity to wage.[5] But replacement ratios are less clearly associated with fund performance and their determination is not straightforward in a DC world. Our proposal, which aims at easing long-term performance evaluation, thus focuses primarily on the projected amount of contributions.

However, we do engage in the further step that consists of converting accumulated capital at retirement in a monthly pension pay. This exercise allows to highlight another relevant dimension of risk. The monthly pension pay will depend on the conversion rate between the capital at retirement and annuities, which in turn will be a function of a set of factors such as interest rates, mortality, transaction costs, fees, and so forth. In section 3.1. we also contrast the projected pension annuity/ drawdown profile with a desired pension payment, computed as a percentage of the current wage (i.e. a component of a replacement rate at retirement) [6]. This kind of reporting, based on further assumptions concerning the length of life after retirement, allows the pension member to assess the income/consumption possibilities, and their variability as a function of the interest rate that will prevail at retirement.

Appendix A1 takes an additional step, by explicitly modeling stochastic interest rates in order to show that particular kinds of asset allocation are able to contain the variability of consumption in response to interest rate shocks. Pension members who either must annuitize or choose to do so, may prefer a portfolio at retirement that is "conformable" with the annuities pay-out. Appendix A1 provides three reporting examples based on alternative asset allocations that differently immunize prospective annuities from interest rate volatility.

3.1.Communicating Monthly Pension Equivalent of Accumulated Assets

In this section we translate the results portrayed in Figure 2, which are expressed in terms of total accumulated assets, into annuities (i.e. into an equivalent monthly pay received after retirement). This kind of reporting best suits those systems that partially or fully annuitize DC pension

[5] Pension authorities use replacement ratios in order to communicate pension adequacy – for instance, in the Swedish "orange envelope". See also the Chilean pension simulator that projects DC pension benefits at retirement (Berstein et al, 2013).

[6] It is also possible to highlight an alternative "annuities benchmark". This is the conversion of the "real money-back" capital in an annuity, given an expected real interest rate and given the expected age of retirement. This benchmark is thus directly comparable with current wage.

benefits. Even for systems where annuities are not mandatory, this reporting method makes it possible to have a representation of the expected replacement rate of a DC plan in terms of current wages.

In the examples that follow we will assume a life expectancy of 20 years post-retirement.[7] Moreover, we allow for 10 possible levels of conversion rates at retirement, which we use to convert real accumulated capital into a monthly real annuity. Conversion rates depend essentially on life expectancy and real interest rates. In our examples, life expectancy is fixed; thus, the variability of conversion rates depends on possible alternative real interest rates. We therefore convert each of the 2,000 simulated levels of accumulated capital above, using alternative interest rates. We start with a 1% real interest rate, and we average the 2,000 possible pays to achieve a monthly average pay of € 816.40. And we repeat this exercise for the other possible interest rates.

Table IV shows all the results of the average monthly pension during retirement. It ranges from €816.40 when the interest rate is as low as 1%, to € 1,663.44 for a high level of the interest rate-clearly displaying the sensitivity of pension income to the rate. The columns of table IV show the average monthly pay. We now see that the average pension would not be sufficient to match the desired income in some interest rate environments. Unless another source of pension wage is present, a participant may therefore want to increase her contribution.

Communication can be further improved by highlighting the desired monthly pension as a percentage of the current wage. Figure 5 also displays the average "+ 1 standard deviation" and the average "- 1 standard deviation" pension, respectively labeled better and worse. The grey line in the figure shows the desired monthly pension per month, set at Euro € 875,00.[8] The graph now makes clear that only better return scenarios allow the investor participant to hit the desired replacement rate when interest rate is low. As in Figure 2, the black line indicates the real money-back benchmark, converted into monthly annuity payments, which rises with higher real interest rates. A conservative participant may even want to limit the projected gap between the two lines by raising monthly contributions during the accumulation phase.

A problem with these representations is that the pension fund, which is responsible for the reports we are addressing, may not be able to control the terms of annuity provision. A second difficulty is that inflation protected annuities, like the ones portrayed in Table IV and Figure 5, are very seldom marketed by insurance companies.

4. *Pension Fund Reporting, Inflation and Real Wage Growth.*

Sections 2 and 3 assume that realized wage growth and realized inflation are both equal to 0%, in line with expectations. This is the simplest possible case, but hides three issues.

First, realizations typically differ from expectations. Over time, such differences may become so large as to make projections no longer meaningful for the plan member. We suggest that such

[7] Users of this reporting scheme may refer to mortality tables (conditional on country, age, sex …) to get better estimates.

[8] In the Netherlands, the most common wage (modus) is about € 35,000 a year. If we take 30% of this wage (which roughly accounts for the Dutch second-pillar part of retirement pay) and divide by 12 we get € 875.00.

realizations be incorporated in the projection updates (as in Figure 4) every year. Appendix B provides an example with positive realized wage growth, where contributions increase with real wages. It also allows for positive realized inflation. In order to make the projected pension pay bear a clear link to current pay, it is better to change the base year every year – rather than leaving it unchanged at t=0.

Second, a pension plan may use alternative expected wage growth or inflation scenarios. An alternative inflation scenario is irrelevant as long as inflation is non-stochastic (see the example in section 4.1. below). On the contrary, positive wage growth scenarios imply growing contributions, which increase benchmark capital at retirement. Alternative wage growth scenarios can thus be used, but they should always be compared to the conservative default option of zero expected growth.

Last but not least, previous sections assume non-stochastic inflation – or, that inflation risk can be fully hedged at no cost. Such costs, when present, ought instead to be deducted from return projections. Moreover, projections understate the risk of asset allocations that are tilted towards imperfect inflation hedges such as long-term nominal bonds. Section 4.2 indicates the way to explicitly embed stochastic inflation into our reporting framework. We postpone until section 5.2 a discussion about stochastic wage growth.

4.1. Non-Stochastic Inflation

Assume that the expected inflation rate is equal to 2% (ECB benchmark). If the inflation rate is non-stochastic, then it is perfectly anticipated. It follows that nominal returns on assets are equal to 7.5% for stocks and 4.5% for bonds, respectively with no change in real returns, volatility and correlation. The yearly nominal return, ensuring that the value of pension assets will be equal to the benchmark at retirement, is equal to 2.44%. With these changes, the average, maximum and minimum returns on accumulated assets roughly coincide with the ones described above, without inflation.

4.2. Stochastic Inflation

Let us now assume that the inflation rate has non-zero volatility. This is going to increase (reduce) the expected real return on assets that are good (bad) inflation hedges, thus changing the range of possible outcomes at retirement in Figure 2. One way to account for this is to estimate a forecasting model where the distribution of asset returns is a function of the inflation rate, as in Campbell, Sunderam and Viceira (2013) or more simply in Briére et al. (2011) and Fugazza, Guidolin and Nicodano (2010). The reporting scheme should not otherwise be affected by stochastic inflation. Even if realized inflation differs from what had been expected, both ex post performance and revised projections are a function of real variables only. A higher-than-expected inflation will depress the realized real return on pension assets below the expected outcomes, if these assets are not good inflation hedges; and will require higher nominal contributions in order to keep projected contributions constant in real terms.

5. Discussion

Our framework provides an example of a reporting standard based on relatively straightforward calculation rules that can be performed by pension plans and understood by plan members.

While the reporting standard should be based on common scenarios and layouts to ease comparisons, the underlying framework lends itself to other uses. It can accommodate alternative communication frameworks (future pension assets or monthly pension equivalent) and inflation and growth scenarios. It is also possible to simulate the consequences of competing choices by the plan member, thus contributing to financial education. For instance, a worker may ask to have her exposure to the stock market reduced after negative performance, such as the one portrayed in Figure 3. This framework can produce new projections associated with a more defensive asset allocation, revealing that lower risk entails lower upside potential.

Sections 5.1-5.4 discuss our choices against alternatives that imply substantial departures from the current simple settings.

5.1. An alternative benchmark

The purchasing power of a future pension is what matters to a prospective retiree. Along these lines, Bodie and Treussard (2007) assume that contributions are invested in a maturity matched inflation-indexed bond *at time 0*, whose principal value is indexed to the CPI and pays, additionally, a coupon. This way, it is possible to get rid of all (but insolvency) risks. They also suggest using IIB as a performance benchmark.

We could adopt the same approach.[9] We opt instead for a benchmark with zero real return, which is compared with a net-of-fee return on pension assets under management. The rationale behind this proposal is the following. First, a CPI benchmark is easy to understand and communicate. Second, this benchmark has the desirable property of being achievable in normal circumstances of positive real interest rates, at least where there is a market for IIB, and also given that equities have historically provided positive real returns over longer periods.[10] Third, attaining the CPI benchmark, while possible, is not straightforward. Markets for inflation-linked bonds are absent in some countries. Even where they exist, there may be discontinuity in the coverage of the yield curve, so that inflation cannot be hedged at all horizons without bearing some market risk[11]. Furthermore, covering inflation plus management costs remains a challenge in itself, especially when the time-to-retirement is short.

The solution we propose here, besides being driven by a search for simplicity, may be able to satisfy the various parties involved: the investors, who would receive a standardized representation of retirement capital in real terms; the industry, which may be willing to adopt this

[9] In our framework, some real interest rate risk would still be present because contributions are invested throughout the life cycle (not just at t=0), and the rate on IIB that prevails in the future is unknown.

[10] On the contrary, efficient benchmarks (with no transaction costs and no fees) on average beat the performance of net-of-fee asset managers by definition, thus generating misunderstandings with investors. Inefficient benchmarks such as stock indexes may be hard to beat in practice because of regulatory restrictions that prevent managers from investing outside the benchmark asset menu.

[11] A similar observation motivates the investigation by Martellini and Milhau (2013).

reporting standard because it is offered an attainable benchmark; and the regulators, because this is consistent with investor protection principles.

5.2. A life-cycle approach

There are several ways in which the model could benefit from life-cycle research. On the one hand, it may help design the contribution path. In our model, contributions grow together with the realized wage growth. However, a welfare-enhancing contribution profile connects contributions to the plan member's income and family composition, in such a way that contributions constrain less the consumption of young families and weigh more on older and richer families. [12]

Life-cycle research also recognizes that an investor's total wealth, and the risk she bears is derived not only from financial returns but from labor income as well. In certain countries, labor income gives rise to pension wealth in the form of first-pillar entitlements. Ideally, then, Figures 2, 3 and 4 ought to portray the possible values of *total* accumulated assets, which may include also first-pillar entitlements. To the extent that such financial and labor incomes are not perfectly correlated, bad (good) financial shocks are compensated by good (bad) labor income shocks. This reasoning implies that the variability of total accumulated assets is likely to be smaller than that of pension fund assets only. Our proposal sidesteps this approach, in order to focus more closely on rolling performance assessment which requires focusing on the financial wealth generated by the pension plan.[13]

5.3. Return predictability and rebalancing of contributions

Our assumption of independent returns over time has several implications. On the one hand, it implies that future returns cannot be predicted on the basis of past realized returns, or past realized inflation, and so forth. Moreover, our assumption implies that there is no gain from active portfolio management. Finally, the annualized conditional variance of returns is independent of the investor's horizon.

There is, however, a large literature on return predictability, which shows that lagged returns, the inflation rate, the dividend-price ratio, the term premium and the default premium can explain current equity, real estate, bond and especially T-bill returns in in-sample experiments. Predictability impacts on optimal portfolio management, creating a difference between long-term and short-term management. Indeed, if returns on equities (bonds) are mean reverting (averting), then the equity (bond) annualized volatility over a long horizon is lower (higher) than the annualized volatility over a short horizon. An optimal long-run portfolio entails a higher

[12] Research on optimal life-cycle investments (among others see Benzoni *et al*., 2007; Bodie *et al*. (1992, 2009); Campbell *et al*., 2001; Cocco *et al*., 2005; and Koijen *et al*, 2010 and Bagliano *et al*., 2014) provides the logical background for consumption-smoothing contribution paths that are able to improve on the investor's welfare.

[13] However, the performance evaluation for pension plans may also be based on their ability to smooth consumption during retirement years (see Bagliano et al., 2010).

(lower) equity (bond) share than a short-term one does (Campbell and Viceira, 2005; Fugazza, Guidolin and Nicodano, 2007). However, there is no consensus, yet, as to whether these patterns are useful for improving future portfolio performance relative to simpler strategies (Goyal and Welch, 2008; Fugazza, Guidolin and Nicodano, 2014; Turner, 2014), or whether it is necessary to resort to more elaborate prediction models. This is why we stick to the simplest return representation which can, however, be changed without prejudice to the rest of the proposal.

Our projections also keep the yearly contribution insensitive to realized returns. The projections could instead allow for increases in contributions after lower than-expected returns[14]. In this case, this feature should be incorporated also when building the *ex ante* accumulated assets projections. This dynamic "contribution rebalancing" strategy would yield better outcomes if portfolio returns were negatively correlated over time at the yearly frequency.

5.4. Parameter uncertainty and forecast reliability

Our framework assumes that forecasts of outcome ranges are reliable because the distribution of asset returns is known. On the contrary, the parameters (mean, variance, etc) of the assumed distribution are usually estimated from the data with errors. The latter affect comparatively more riskier than safer assets, and compound over time reducing the precision of long-term forecasts of riskier assets. In turn, this implies that long term risk-averse investors are less attracted by riskier assets relative to short-term investors because of this added uncertainty (see Barberis, 2000; Fugazza, Guidolin and Nicodano, 2009). Our reporting framework omits the modeling of such estimation error, thus implicitly understating the risk of riskier assets the more so, the longer the horizon. More generally, we do not provide any hint as to the reliability of the forecast.

5.5. Outsourcing return forecasts used in projections?

Projections rely on the distribution of returns on several asset classes. In our proposal, these are chosen by each pension fund on the grounds that each could have views on asset prospects that motivate their proposed asset allocation. At the same time, incentives to boost returns in order to attract new members should be mitigated by the knowledge that disappointed members are likelier to leave the fund ex post. This mitigation may not work if managers have short horizons and there are short-term performance fees. In such a case the industry association may provide return forecasts to all pension funds. This also preserves comparability of performance across pension funds.

6. Concluding comments

DC pension funds currently project expected benefits at retirement in a very limited set of countries, using either no risk scenario or a very limited number of scenarios –but for the case of Chile. Our reporting framework projects the distribution of outcomes at retirement associated with a large number of scenarios, thus making the plan member aware of both the upside

[14] Besides, during periods of dramatic declines in equities prices, participants may not be willing to increase contributions fearing for the continuation of their jobs.

potential and the downside risk. This is in line with the desire of supervisory authorities, which are not only aware of the importance of projections, but also stress the need to convey to plan members the level of uncertainty surrounding expected benefits (OECD, 2010b; Rinaldi, and Giacomel, 2008).

Another concern of the authorities has to do with the conflict of interest between fund members and pension providers, exacerbated by the poor understanding of the impact of cost and fees (Rinaldi and Giacomel, 2008). We address this problem as follows. First, we propose associating projections with the asset allocation chosen by the plan member, so as to make her aware of the higher risks associated with larger equity investments. Second, the plan member is able to assess ex-post pension fund performance against the latter previous projections, so as to curb the incentives to overstate future returns and pension benefits. Third, the return on the money-back-benchmark is cost-free, thus implicitly putting an upper bound on charges. Thus the plan member can grasp the additional costs and downside risks of alternatives to the "money-back" benchmark at retirement. At the same time, this reporting framework has advantages for the industry as well, especially in terms of fair comparability with the benchmark and simple and effective communication. Indeed, the plan member also understands the costs of lower risk strategies in terms of foregone upside potential. Secondly, reports do not emphasize poor ex-post pension plan performance until the real return, net of costs, falls below zero. Finally, a longer-term assessment may mitigate the pension member's reaction to poor short-term performance, which often results in withdrawals in bear markets.

A final concern of regulators has to do with the actual framing of reports so as to ensure they are understood by plan members (OECD, 2010b). While this proposal does not address this issue in detail, we wish to stress that we limit the amount of information, knowing that too much information is equivalent to none. Indeed, we envisage the regular distribution of only two figures and tables with explanatory notes to all members. A website should contain information on assumptions, on the chosen asset allocation as well as disclaimers. More work on this aspect is postponed to future drafts.

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Table I

The Assumptions Underlying Projections

The table reports assumptions concerning the parameters listed in the first column. Percentage returns and growth rates are annualized. The real returns on equity and bonds are assumed to be jointly log-normally distributed, and IID over time.

	Mean	**Standard Deviation**
Inflation Rate (π)	0	
Real Returns on 10-year Duration Govt. Bonds	2.5	3.0
Real Equity Returns	5.5	18
Bond-Equity Return Correlation	0.1	//
Inter-temporal Return Correlation	0	//
Yearly Real Wage Growth Rate (w)	0	0
Monthly Contribution	100	
Percentage Transaction Costs on New Contributions	0.5	
Percentage Yearly Fee on Assets Under Management	0.4	
Rebalancing Costs	0	
Tax rates	0	

Figure 1

Asset allocation

This figure explains to the worker the chosen asset allocation and how it evolves during life. In this example, the allocation entails 20% in bonds and 80% in stocks, with quarterly rebalancing.

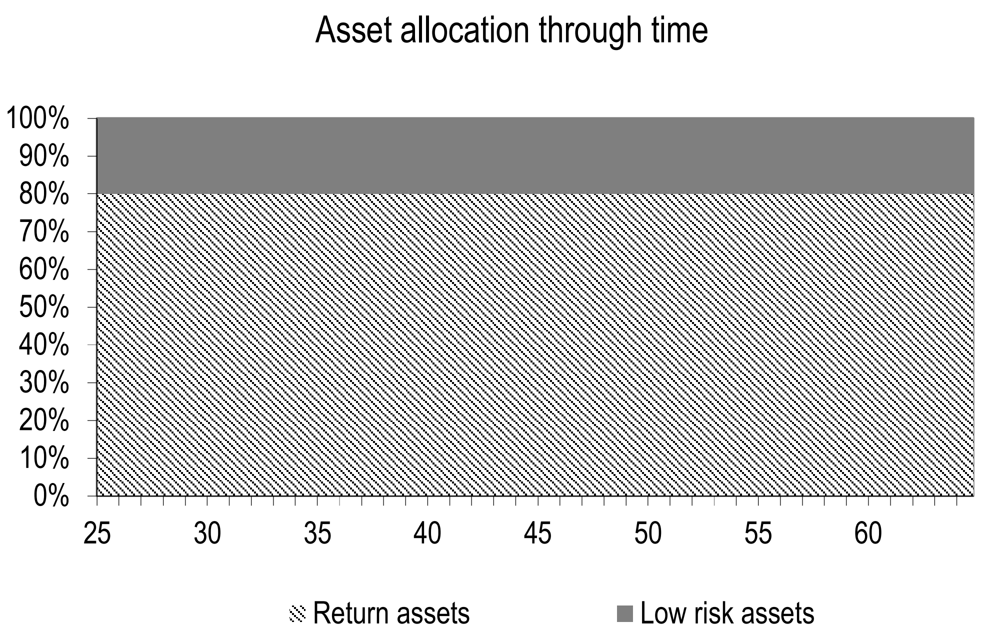


Figure 2

Projected pension assets at age 25

This is the figure the worker sees when joining the pension fund at age 25. It reports projected pension assets from age 25 to age 65, when yearly contributions equal € 1,200. The benchmark "your money-back", which corresponds to a zero real rate of return, appears in black. Mean accumulated assets appear in white. The asset allocation entails 20% in bonds and 80% in stocks, with quarterly rebalancing.

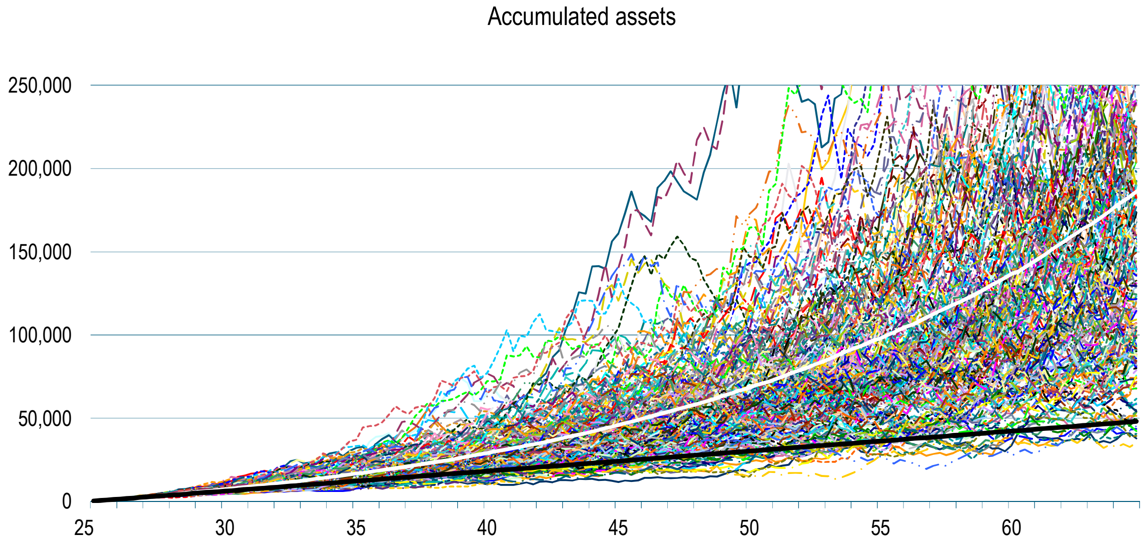


Table II
Key projected outcomes at 25

The first column reports statistics relating to shortfall risk. The first row indicates the probability of not reaching the "money-back" benchmark after 40 years. The second, fourth and fifth rows indicate the average, maximum and minimum euro shortfall with respect to the benchmark. The second column shows the average, maximum and minimum accumulated assets. The last four rows indicate upper and lower percentile boundary figures for accumulated assets.

	Risk of not reaching benchmark after accumulation phase	Amount of assets after accumulation phase (40 years)
Probability	3.35%	
Average	**-6,772.41**	**177,597.05**
st.dev	*5,361.47*	*137,020.73*
Maximum	-23,299.75	1,735,955.07
Minimum	-72.97	24,747.04
5 % distr. upper bound		409,432.80
1 5% distr. upper bound		273,318.78
15% distr. lower bound		76,519.86
5% distr. lower bound		53,064.12

Figure 3
Realized and projected pension assets at age 26

This figure allows the worker to assess the yearly performance of her pension fund at age 26. It highlights with a white square mark, the actual ex-post accumulated assets against projected ones. In the picture both the white and black benchmarks are highlighted.

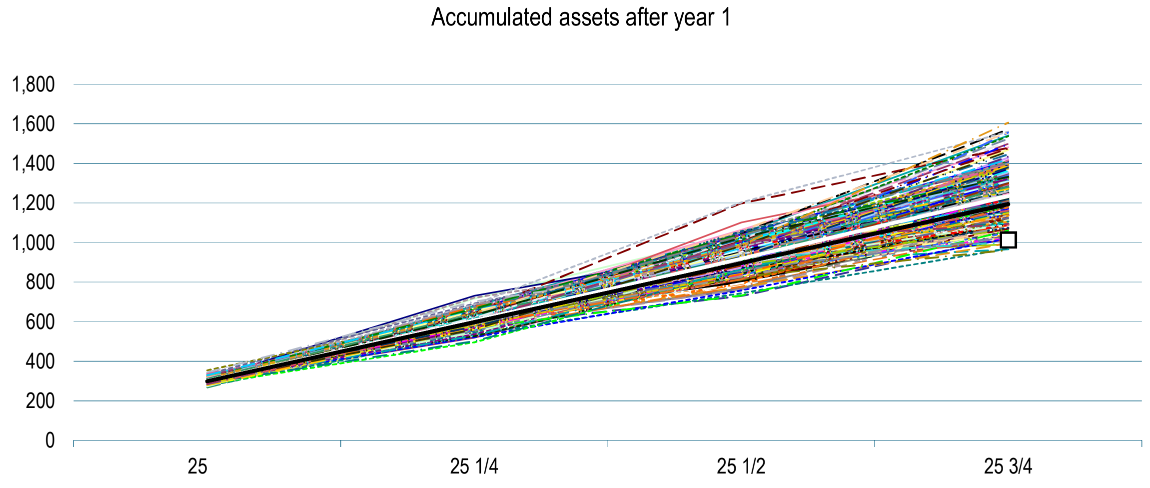


Figure 4

Projected retirement assets at age 26

This figure allows a 26-year-old worker to project her assets to age 65, conditional on one-year actual performance. Both the black and the white benchmark appear clearly.

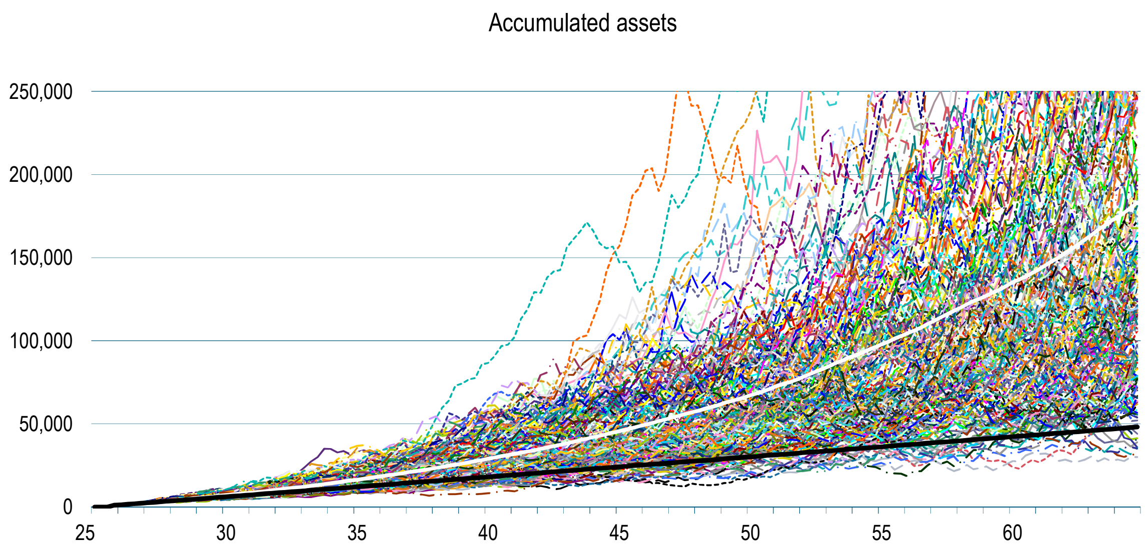


Table III

Key projected outcomes at 26.

The first column reports statistics relating to shortfall risk one year later. The first row indicates the probability of not reaching the "money-back" benchmark after 39 years. The second, fourth and fifth rows indicate the average, maximum and minimum euro shortfall with respect to the benchmark. The second column shows the average, maximum and minimum accumulated assets. The last four rows indicate upper and lower percentile boundary figures for accumulated assets.

	Risk of not reaching benchmark after accumulation phase	Amount of assets after accumulation phase (39 years)
Probability	3.80%	
Average	**-7,886.28**	**179,392.88**
st.dev	5,546.26	144,923.19
Maximum	-23,820.32	2,274,260.18
Minimum	-111.64	24,221.01
5 % distr. upper bound		425,976.47
1 5% distr. upper bound		279,918.53
15% distr. lower bound		74,447.81
5% distr. lower bound		51,211.86

Table IV

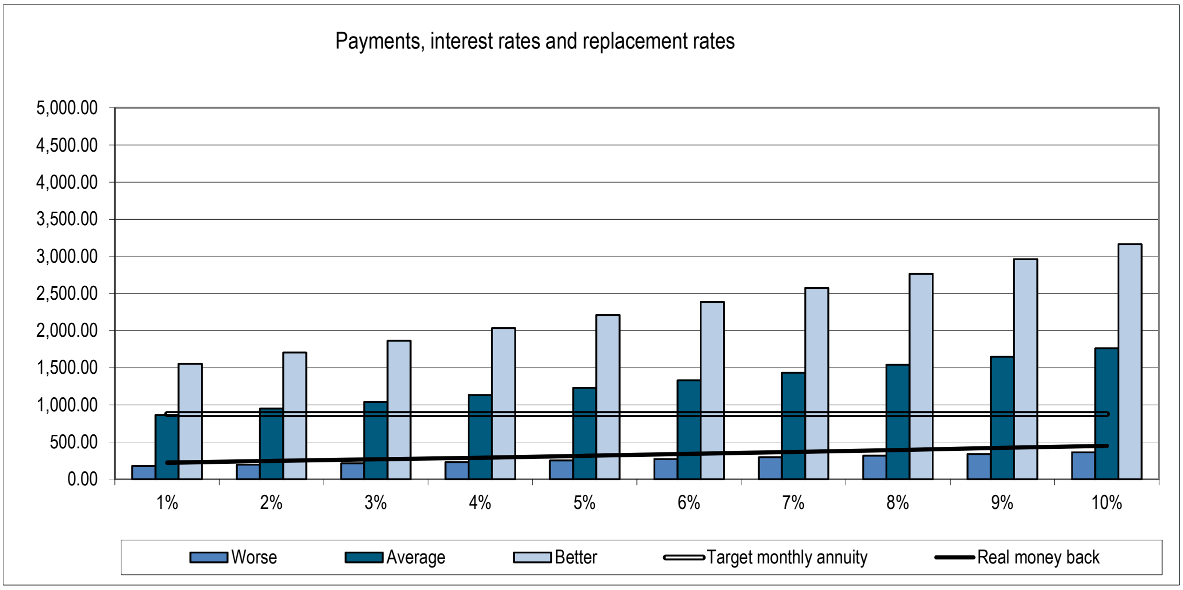
The table IV shows all the results of the average monthly pension during retirement. The columns show the average monthly pay.

Monthly pension equivalent of accumulated capital at retirement.									
This table reports the level of the real interest rate at retirement in the first row, and the associated average monthly pension pay in the second row.									
1%	2%	3%	4%	5%	6%	7%	8%	9%	10%
816.40	**896.91**	**981.35**	**1,069.52**	**1,161.19**	**1,256.13**	**1,354.08**	**1,454.79**	**1,557.99**	**1,663.44**

Figure 5

Simulated and desired pension payments, deterministic interest rates and money-back benchmark.

This figure reports the level of the real interest rate at retirement on the horizontal axis, and the monthly pension on the vertical one. The grey line indicates desired monthly pension, the darkest bars the average monthly pension, the darker and lighter bars a worse and better outcomes (respectively corresponding to the average minus/plus one standard deviation). In line with Figure 2, the black line indicates the real money-back benchmark, converted into monthly annuity payments, which rises with higher real interest rates. The grey line in the figure below shows the desired monthly pension per month, set at Euro € 875,00.



Appendix A

A.1. Stochastic interest rates.

In Figure 5 we assumes ten exogenous interest rate levels. Of course, interest rates are not equally likely. Moreover, one should also account for the impact of realized interest rates on bond values. When these features are built in the model, projections reveal the effects of alternative asset allocations on pension payment sensitivity to the interest rate. Below we show the effects of a , one which gradually invests in long-term bonds over the accumulation phase,

Figure A1

Projected pension assets at age 25 with stochastic interest rate

This figure is the counterpart of Figure 2, when the interest rate is simulated instead of the bond return. It reports projected pension assets from age 25 to age 65, when yearly contributions equal € 1,200. The money-back benchmark appears in black. Mean accumulated assets appear in white. The asset allocation entails 20% in bonds and 80% in stocks, with quarterly rebalancing.

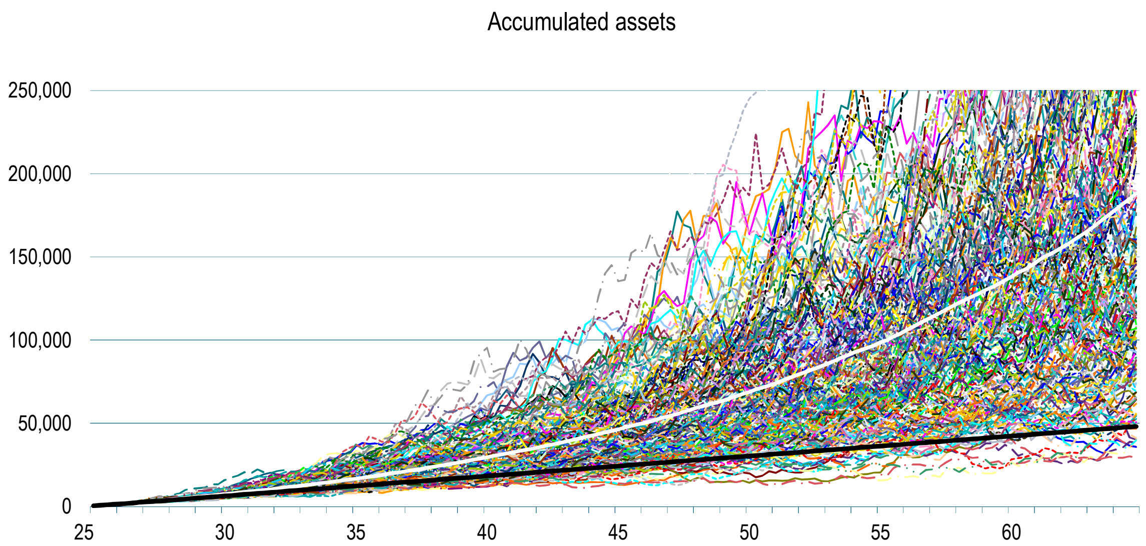


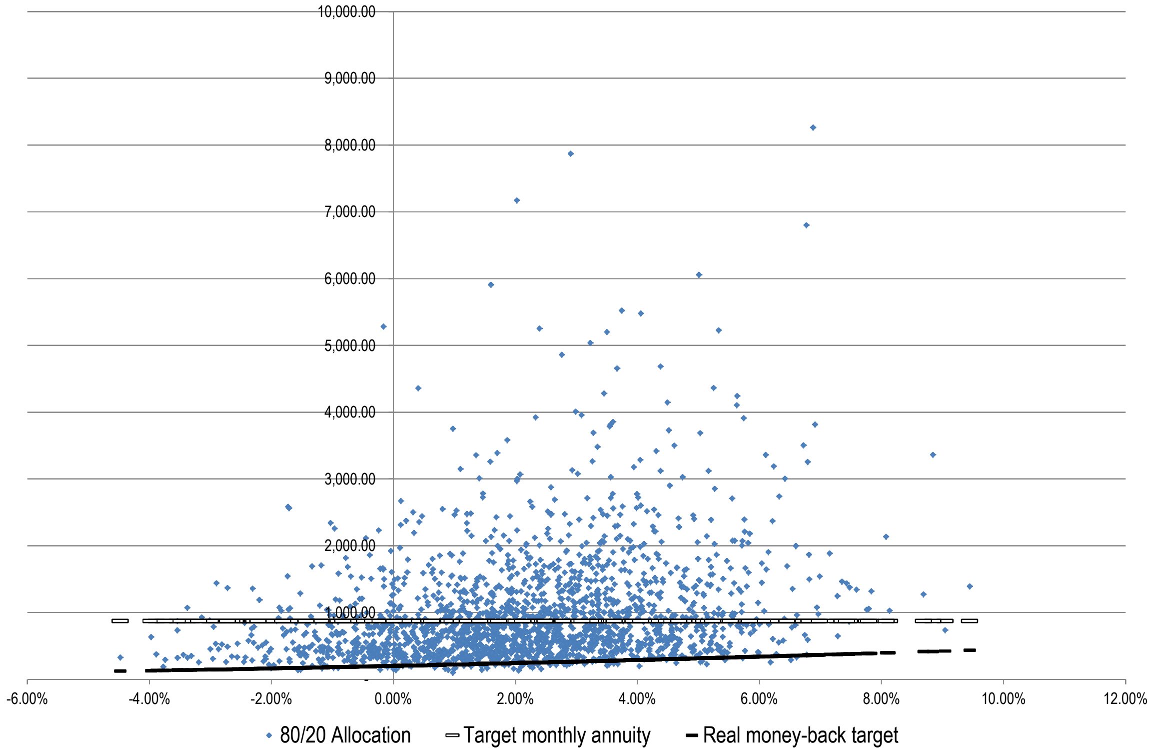
Table A1
Key projected outcomes at age 25 with stochastic interest rate

This table is the counterpart of Table II, when the interest rate is simulated instead of the bond return. The first column reports statistics relating to shortfall risk. The first row indicates the probability of not reaching the "money-back" benchmark after 40 years. The second, fourth and fifth rows indicate the average, maximum and minimum euro shortfall with respect to the benchmark. The second column shows the average, maximum and minimum accumulated assets. The last four rows indicate upper and lower percentile boundary figures for accumulated assets.

	Risk of not reaching benchmark after accumulation phase	Amount of assets after accumulation phase (40 years)
Probability	3.35%	
Average	**-7,212.73**	**181,531.67**
st.dev	5,261.22	133,676.06
Maximum	-23,432.69	1,524,056.49
Minimum	-58.02	24,614.10
5 % distr. upper bound		430,144.39
1 5% distr. upper bound		287,072.19
15% distr. lower bound		77,008.42
5% distr. lower bound		52,425.33

Figure A2
Simulated and desired pension payments, stochastic interest rates and money-back benchmark.

This figure is the counterpart of Figure 5, when the interest rate is simulated instead of the bond return. It shows the level of the real interest rate at retirement on the horizontal axis, and the monthly pension on the vertical one. The grey line indicates desired monthly pension, the dots the simulated monthly pension payments. The black line indicates the real money-back annuity benchmark. The asset allocation entails 20% in bonds and 80% in stocks, with quarterly rebalancing.



In other terms, the pension provider may want to immunize prospective annuities from interest rates shocks, by "locking in" the portfolio prospective capitals needed for annuity payments. This can be done with bonds of similar maturity as annuity payments. But before getting into effective examples of immunization, we would like to analyze the impact of interest rate volatility.

To this end, we repeat the exercise we performed in the main body of the paper, simulating the real interest rate on five-year duration bonds rather than the return on bonds. The interest rate distribution is assumed to be lognormal with constant mean of 2.2% and volatility of 1%. The correlation between equity returns and interest rates is assumed to be low in absolute value and negative (-0.1). Figure A1 and Table A1 are a fairly close replication of Figure 2 and Table II, based on interest rate instead of bond total return simulation. Figure A2 portrays instead the simulated pension wage scenarios against realized interest rates. Now we see that higher interest rate scenarios are less likely than intermediate ones, and cases of negative real rates appear. In comparison to Figure 5, it reveals that most scenarios end up below benchmark even at intermediate rates of 4%-5%, and that some high average payments in Figure 5 may actually be associated with outliers.

Importantly, the simulation of interest rates makes it possible to investigate whether alternative asset allocations better hedge interest rate risk at retirement, while still beating the benchmark. For instance, we may wonder whether an equity glide path, which progressively substitutes constant duration bonds to stocks, is a better hedge against interest rate variation.
Figure A3 portrays the glide path. Figure A4 shows that the glide path substantially reduces very high and very low outcomes for accumulated assets, which is mirrored in a reduction in both shortfall probability and average accumulated assets. The following Figure A5 highlights that the glide path does not really help in shrinking interest rate sensitivity of pension income.

To complete our investigation, we experiment with a20% equity, 80% five-year duration bonds allocation. Asset projections (see Figure A6) now reveal that shortfall risk is eliminated together with the upside potential. The impact on monthly pension payment is dramatic. Interest rate risk is hedged quite well, as the sensitivity of the monthly pension payment is very low. However the level of the pension payment is almost always below the desired pension payment. Thus, a clear trade-off emerges between reduced exposure to interest rates and upside potential.

The choice of asset allocation depends on the choice of pension associates and provider. However, our reporting framework allows us to choose a "conformable" accumulation solution as a function of the nature of decumulation (fully annuitized, partly annuitized, based on capital drawdowns) and the life expectancy at retirement. Plan members that are forced to 100% annuitization will be more inclined to favor hedging of interest rate risk rather than trying to beat the benchmark.

FigureA3

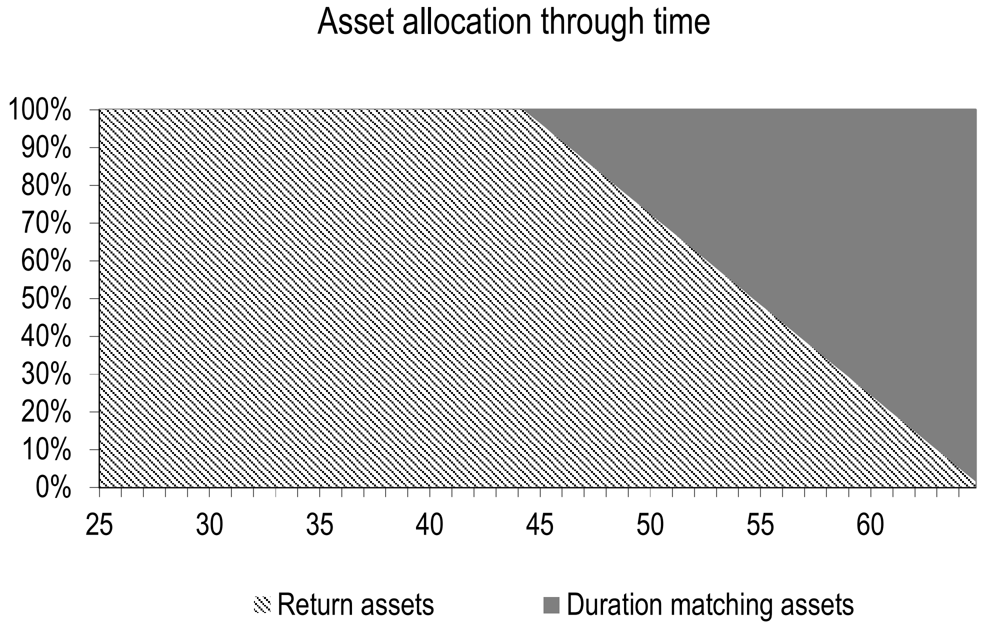


Figure A4

Projected pension assets at age 25

This figure is the counterpart of Figure A1, when the asset allocation entails a gradual reduction of the equity share from age 45 onwards, as represented in Figure A3. It reports projected pension assets from age 25 to age 65, when yearly contributions equal € 1,200. The money-back benchmark appears in black. Mean accumulated assets appear in white.

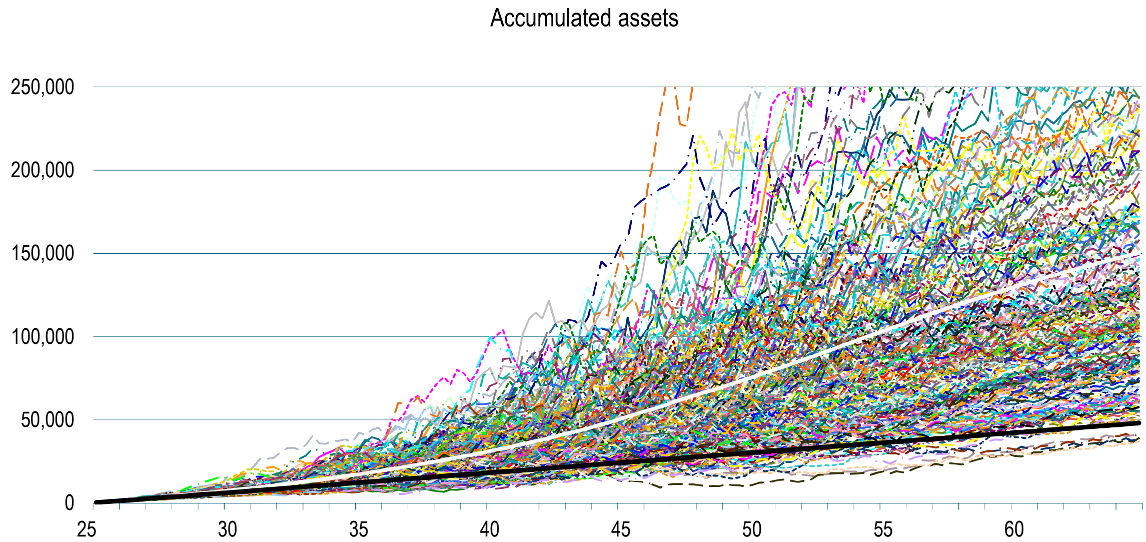


Table A2
Key projected outcomes at age 25

This table is the counterpart of Table A1, when the asset allocation entails a glide path, as indicated in Figure A3.

	Risk of not reaching benchmark after accumulation phase	Amount of assets after accumulation phase (40 years)
Probability	1.75%	
Average	**-5,190.38**	**146,581.34**
st.dev	3,679.39	97,302.15
Maximum	-16,320.79	1,217,730.29
Minimum	-702.63	31,726.00
5 % distr. upper bound		327,911.80
15% distr. upper bound		212,211.74
15% distr. lower bound		74,520.50
5% distr. lower bound		59,545.56

A.2. Conformable portfolios

This section provides other examples of portfolios that immunize, in varying degrees, the participant from interest rate volatility in the accumulation phase. The pension member, with the help of these projections, can choose the portfolio that best fits her needs of immunizing prospective annuities from interest rate volatility.

A.2.1. 100% matching annuities with bonds immunization in the accumulation phase

In this first example, contributions are invested in zero coupon bonds or swaps of decreasing maturity so as to provide 100% matching– as indicated in Figure A5. In Figure A6, the black line indicates the money-back (€ 48,000 in this case) benchmark. The dots form an almost flat line, indicating that the interest rate sensitivity of the monthly pension payment is minimal. It is apparent that the dots are always below the money-back benchmark in black. Thus, the benchmark appears unattainable with this asset allocation, since there are no equities and therefore no benefit from the equity risk premium. This is equally evident in Table A3, which reports statistics concerning accumulated assets at retirement. The probability of not reaching the benchmark is 1.

Figure A5


Asset allocation through time
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
25
30
35
40
45
50
55
60
Return assets
Zero coupon 10y
Zero coupon 15y
Zero coupon 20y
Zero coupon 25y
Zero coupon 30y
Zero coupon 35y
Zero coupon 40y

Figure A6
Simulated and desired pension payments, stochastic interest rates and money-back benchmark.

This figure is the counterpart of Figure A2, with stochastic interest rate, when the asset allocation entails 100% maturity matching, as indicated in Figure A5.

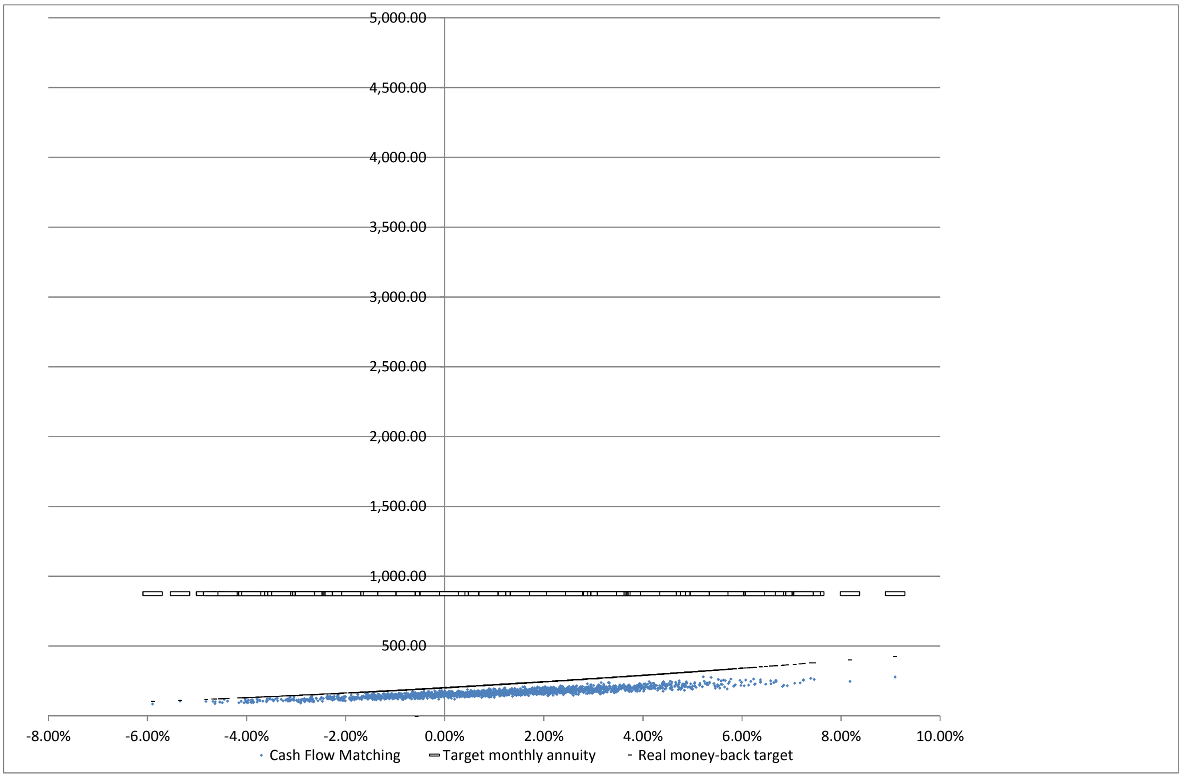


Table A3
Key projected outcomes at age 25

This table is the counterpart of Table A1, when the asset allocation entails 100% maturity matching, as indicated in Figure A5.

	Risk of not reaching target after acc. Phase	Amount of assets after accumulation phase (40 years)
Probability	100.00%	
Average	**-12,322.52**	**35,724.27**
st.dev	*3,072.01*	*3,072.01*
Maximum	-20,366.60	47,892.44
Minimum	-154.35	27,680.19
5 % distr. upper bound		41,074.68
15% distr. upper bound		38,913.79
15% distr. lower bound		32,540.92
5% distr. lower bound		30,889.37

A.2.2. Constant 20% equity exposure and bonds immunization during accumulation.

In this second example, 20% of the portfolio is invested in equities, so as to take advantage of the risk premium, while the rest provides immunization from interest rate volatility (see Figure A7). Figure A8 shows that expected pension payments are now more sensitive to the interest rate, but it is more likely that the money-back benchmark is attained thanks to partial equity exposure.

Figure A7

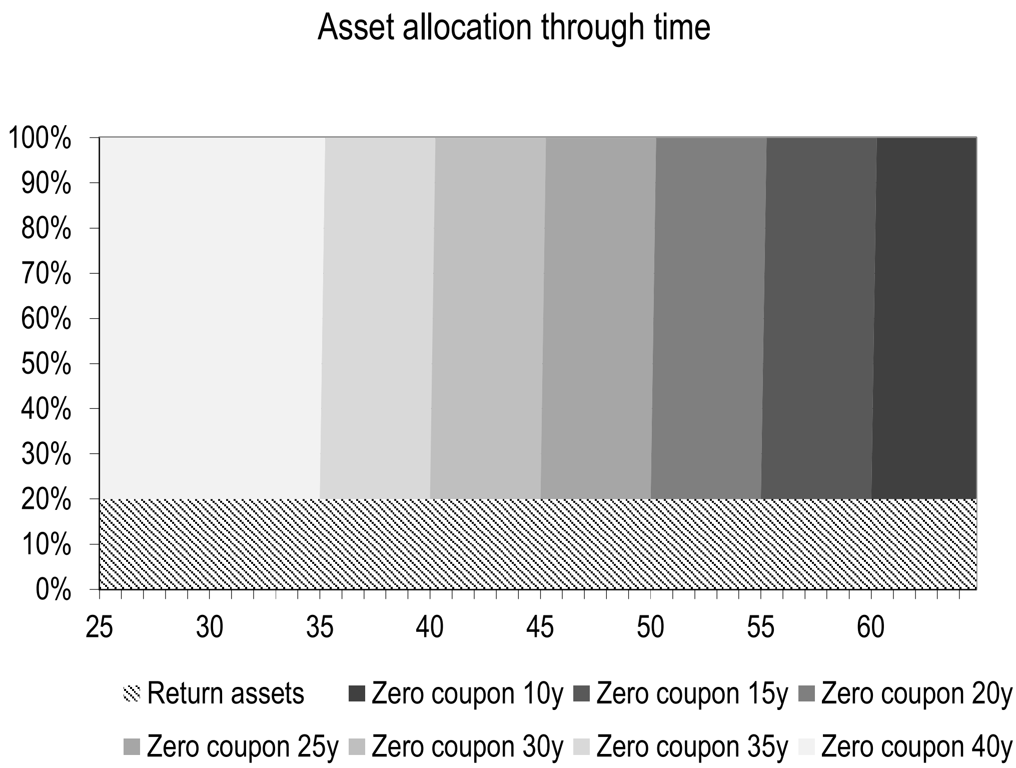
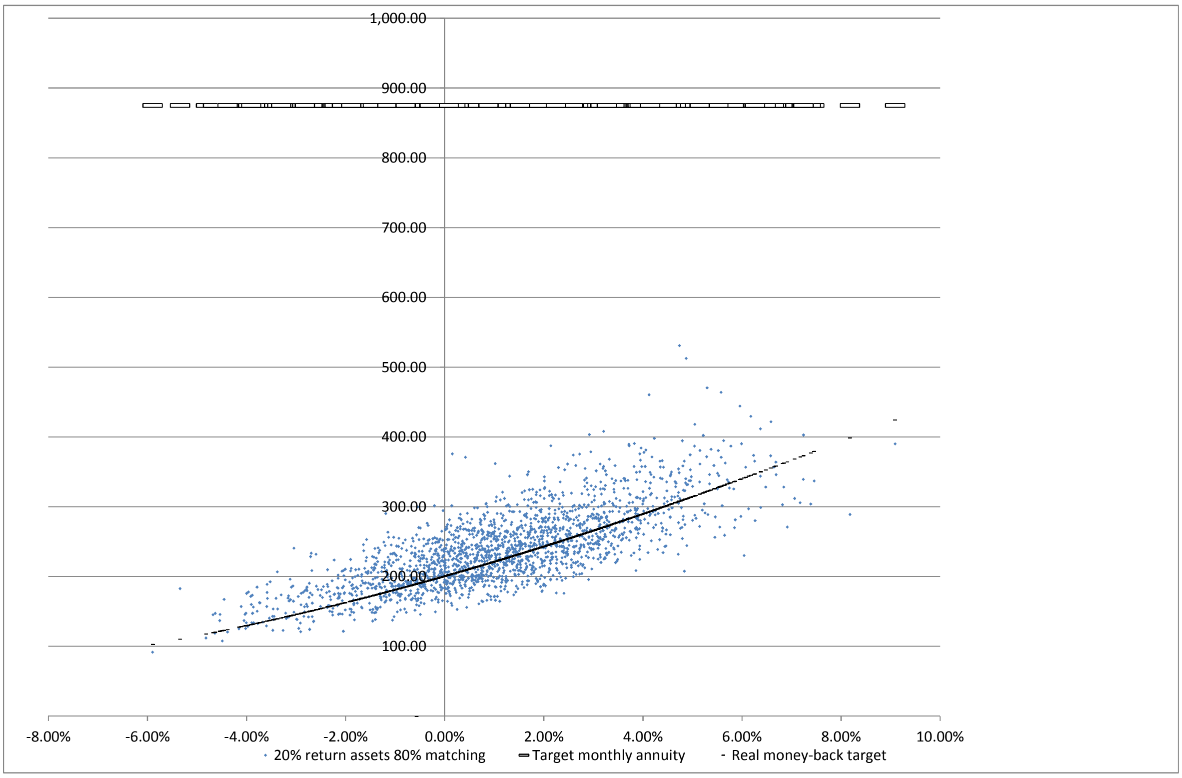


Figure A8

Simulated and desired pension payments, stochastic interest rates and money-back benchmark.

This figure is the counterpart of Figure A6 when the asset allocation is the one depicted in Figure A7. Note the different scale on the vertical axis.



A.2.3.Dynamic optimization with equities and bonds immunization during accumulation

In this last example the exposure to equities is much higher and portfolio immunization with respect to expected annuities starts later, at age 45. The equity risk premium allows the participant to have higher expected returns but of course implies a broader risk cone. An alternative representation of Figure A10 below, which echoes Figure 5, is given in Figure A11.

Figure A9 Dynamic glide path

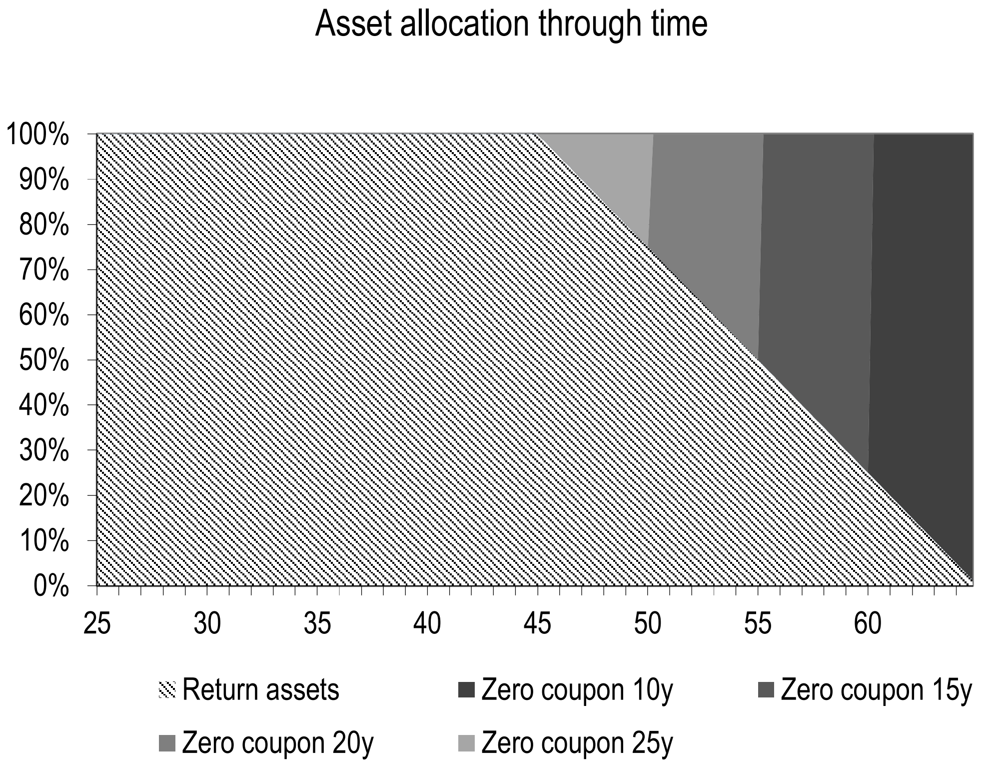


Figure A10

Simulated and desired pension payments, stochastic interest rates and money-back benchmark.
This figure is the counterpart of Figure A6 when the asset allocation is the glide path depicted in Figure A9.

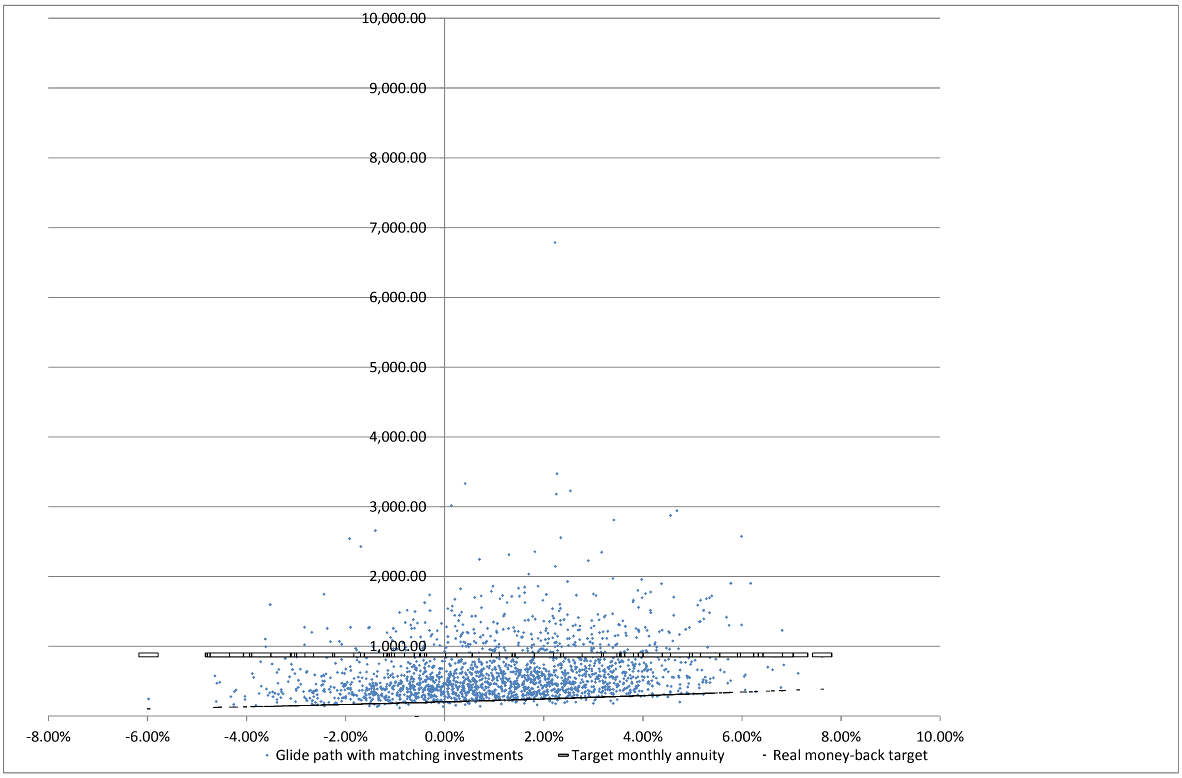
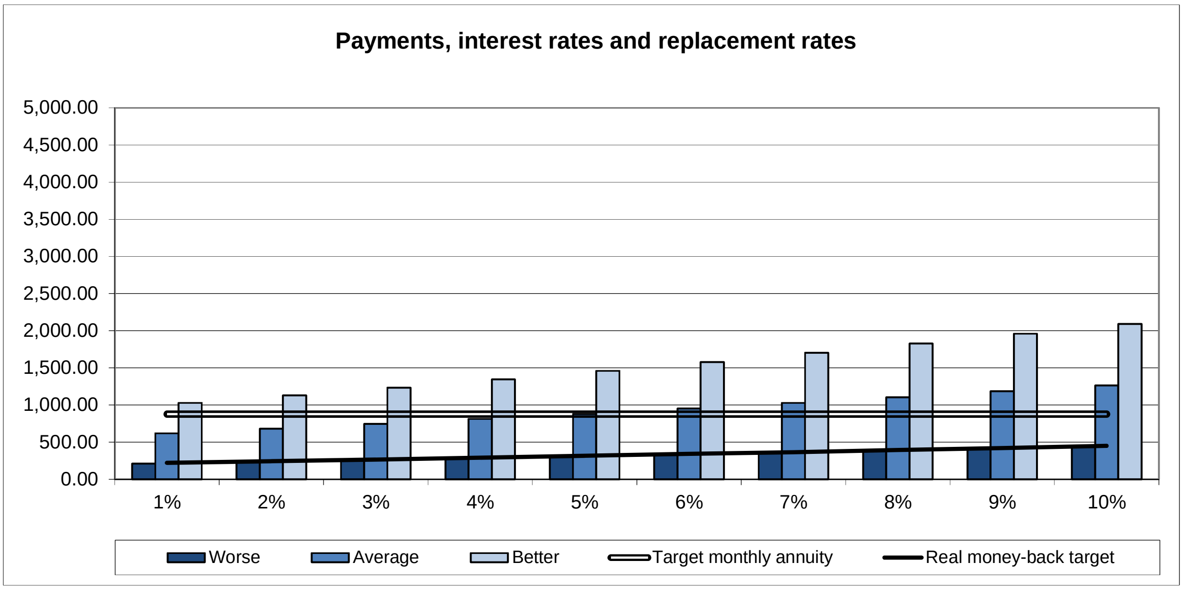


Figure A11

Simulated and desired pension payments, stochastic interest rates and money-back benchmark

This figure is the counterpart of Figure 5, when the real interest rate is stochastic. The real interest rate at retirement is on the horizontal axis, and the monthly pension on the vertical one. The asset allocation is the glide path depicted in Figure A9.



Appendix B
Communicating Projections and Performance Results in Current Euros

The hypothesis of zero real wage growth is not a necessary component of our model.[15] We now assume a 2% real wage growth forecast for the next 40 years, which sets the money-back benchmark at € 73,023.75.

Table B1

Contribution per month per person *invested*	100.00
Percentage Real Wage growth per year	2.00%
Investment horizon	40 year
Benchmark capital, in t=0 Euro	73,023.75
Pay-out time annuity	20 year
Real Return low-risk assets	2.5%
Real Risk low-risk assets	3.0%
Real Return high-return assets	5.5%
Risk high-return assets	18.0%
Correlation	10%
Asset allocation low-risk assets	20%
Asset allocation high-return assets	80%
Start capital (t=0)	0.00

Of course the model can also be run with alternative hypotheses. What matters is to (a) keep the same scenario as in the previous year, when evaluating ex post performance (b), revising the inputs for the new projections, on the basis of realized inflation and wage growth. [10] We use a negative real wage growth case in the next section, where we address the issue of the effect of inflation on "re-basing" the projections from one year to the next.

B.1. Rebasing projections year after year and the effect of inflation

Reports expressed in terms of constant purchasing power may no longer bear a correspondence with current purchasing power of plan members after some years, in inflationary scenarios. This

[15] The industry association that promotes the reporting standard among its members may choose the institution providing the inflation and wage forecasts, as well as the ex post figures, to all pension funds. A personalized pension simulator, such as the Chilean one, may also deliver individual wage forecast along the lines of Cocco et al. (2005).

section explains how to change the base year so as to report in current euro, accounting for non-neutral inflation effects.

Suppose CPI inflation, between t=0 and t=1, equaled 3.0%. That means that our original benchmark capital should be raised to € 73,023.75 x 1.03 = € 75,214.46 in order to keep the real benchmark constant. If inflation had been anticipated so that nominal returns were 3% higher than the real one; and if wage inflation had also been equal to 3%, due to indexation, then contributions as a share of nominal wage will also increase to 103. Thus there would only be nominal changes.

Realized inflation affects instead *real* projected outcomes if returns and incomes do not grow proportionally with inflation, i.e., when contracts are not perfectly indexed and/or inflation is unexpected.[16]

For instance, assume nominal wage growth is only 2% instead of 3% between t=0 and t=1. This implies that real contributions (rebased in year 1) will now be equal to 102.00 per month, unless the plan member decides to save a higher share of his real income. So the new set of inputs for the projections, with base year t=1, are the ones in the table below.

Table B2

The table reports the values of the parameters listed in the first column, expressed in t=1 Euro. Figures that differ from the ones in Table B1 are in bold. Percentage returns and growth rates are annualized. The real returns on equity and bonds are assumed to be jointly log-normally distributed, and IID over time.

Contribution per month per person *invested*	**102.00**
Percentage Real Wage growth per year (expected)	2.00%
Investment horizon	39 year
Benchmark capital, in t=1 Euro with no erosion in year 0 Benchmark capital in t=1 given erosion in year 0	**75,214.47** **73,009.79**.
Pay-out time annuity	20 year
Real Return low-risk assets	2.5%
Real Risk low-risk assets	3.0%
Real Return high-return assets	5.5%
Risk high-return assets	18.0%
Correlation	10%
Asset allocation low-risk assets	20%
Asset allocation high-return assets	80%
Start capital (t=1)	**1,195.00**

With the inputs stated above, projected accumulated assets at retirement as a result of contributions, wage growth and investment horizon are equal to € 73,009.79. Therefore the higher benchmark capital of €75,214.47 (0.1703%) requires a higher return on investments. This adds to the gross return on investment needed to compensate for yearly AUM fees and

[16] This is the case also if the tax system, which relies on nominal income, is progressive. For the sake of simplicity, we set the tax rate to zero.

transaction costs, which become 0.599% from 0.43%. In other words, inflation has reduced the real value of contributions, and this also raises the risk of not reaching this benchmark, as displayed in Table B3 below.

Table B3

	Risk of not reaching benchmark after accumulation phase	Amount of assets after accumulation phase (39 years)
Probability	3.60%	
Average	**-13,986.61**	**249,033.30**
st.dev	10,755.33	185,924.08
Maximum	-41,852.74	2,214,411.14
Minimum	-156.64	34,841.41
5 % distr. upper bound		596,440.68
15% distr. upper bound		373,717.35
15% distr. lower bound		110,889.78
5% distr. lower bound		82,086.59

Notice that the plan member may want to consider raising her monthly contributions in order to increase the chance of reaching her desired pension wage. If she increases, at t=1, her monthly contribution to 120, benchmark capital becomes 85,682.99.

Table B4

	Risk of not reaching benchmark after accumulation phase	Amount of assets after accumulation phase (39 years)
Probability	3.65%	
Average	**-14,675.33**	**284,369.41**
st.dev	11,727.50	193,188.74
Maximum	-41,270.85	1,854,148.70
Minimum	-68.90	46,122.94
5 % distr. upper bound		661,641.84
15% distr. upper bound		439,363.17
15% distr. lower bound		129,111.85
5% distr. lower bound		92,575.40

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