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Target-driven investing: Optimal investment strategies in defined contribution pension plans under loss aversion

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ABSTRACT

Assuming the loss aversion framework of Tversky and Kahneman (1992), stochastic investment and labour income processes, and a path-dependent fund target, we show that the optimal investment strategy for defined contribution pension plan members is a target-driven 'threshold' strategy, whereby the equity allocation is increased if the accumulating fund is below target and is decreased if it is above. However, if the fund is sufficiently above target, the optimal investment strategy switches to 'portfolio insurance'. We show that the risk of failing to attain the target replacement ratio is significantly lower with target-driven strategies than with those associated with the maximisation of expected utility.

1. Introduction

The purpose of this paper is to determine the optimal dynamic investment strategies for defined contribution (DC) pension plans when plan members experience loss aversion.

The concept of 'loss aversion' was first proposed by Kahneman and Tversky (1979) within the framework of prospect theory (PT), the foundation stone of behavioural finance. The recent literature on behavioural finance has provided powerful evidence that the standard optimisation paradigm, expected utility maximisation within a framework of risk-averse economic agents, does not correspond well with how economic agents actually behave in real world risk situations.[1] Real world investors are prone, among other things, to overconfidence in their investment abilities, regret and, especially, loss aversion. They also tend to monitor the performance of their portfolios (particularly their long-term portfolios) 'too frequently'. As a result, they tend to become risk averse when winning and sell winning investments too quickly, and avoid cutting losses and even take extra risks when they have made losses.[2]

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[1] Kahneman and Tversky (1979) developed this theory to remedy the descriptive failures of subjective expected utility theories of decision making.
[2] See Mitchell and Utkus (2004) for a review of investment decision making in pension plans in a behavioural context.

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Loss aversion (LA) is defined in terms of gains and losses in wealth relative to a pre-defined reference or endowment point, rather than in terms of changes in the absolute level of total wealth, as with expected utility theory (EUT). Rabin and Thaler (2001) have argued that EUT is manifestly not a suitable explanation for most observed risk attitudes: 'we have also often been surprised by economists' reluctance to acknowledge the descriptive inadequacies of [the] theory'. They suggest that LA and the tendency to isolate each risky choice and analyse it separately should replace EUT as the foremost descriptive theory of risk attitudes.

Given the behavioural traits exhibited by many investors, it is important to investigate the consequences of using a PT utility function to determine the optimal investment strategy in a DC plan and to compare the results with those implied by the traditional expected utility model.

In a DC plan, members contribute part of their income each year to building a pension fund for retirement.[3] The accumulated fund is then used to buy a life annuity to provide a pension income after retirement. Members are assumed to have a target replacement ratio[4] at retirement age 65. This translates into a target pension fund at retirement which will depend, in part, on their longevity prospects during retirement. Members are assumed to be loss averse with respect to the target retirement pension fund and to a series of annual interim target fund levels prior to retirement. The interim targets reflect the discounted value of the final target retirement fund level and, for convenience, we will treat the interim targets as being age-related.[5] Members are also assumed to have an investment strategy (i.e., make asset allocation decisions) which aims to maximise the expected total discounted value of PT utility over the period until retirement. To do this, we use a two-asset, dynamic-programming-based numerical solution method with stochastic labour income and both borrowing and short selling constraints.

Within this proposed framework, it will be shown that the optimal dynamic asset allocation strategy is consistent with a target-driven strategy known as 'threshold', 'funded status' or 'return banking', an example of which was discussed in Blake et al. (2001). With this strategy, the weight in risky assets such as equities is increased if the accumulating fund is below the relevant interim target and is decreased if the fund is above target. This is because, under loss aversion, the member is risk seeking in the domain of losses and risk averse in the domain of gains. Close to each target (whether above or below), the plan member has the lowest equity weighting (for that target) in order to minimise the risk of a significant loss relative to the target. However, if the fund is sufficiently above the target, there is a discrete change in the investment strategy and the equity weighting is increased (subject to the member's degree of risk aversion in the domain of gains), since the risk of the fund falling below the target is now considered to be acceptably low. This strategy of increasing the equity weight as the fund value continues to rise above the target is consistent with the investment strategy known as 'portfolio insurance' and its role in portfolio choice under loss aversion has been noted by other researchers (e.g., Berkelaar et al., 2004; Gomes, 2005).

If the target-driven strategy is successful in the sense that the series of interim targets has been met, the overall equity weight will tend to fall with age, since the fund is in line to meet the final target fund level at retirement. Although this is similar to what happens in conventional (deterministic) 'lifestyle' strategies,[6] the target-driven strategy considered here is very different. In particular, whilst conventional lifestyle strategies typically involve switching mechanically from 100% equities only in the last 5–10 years before retirement and often end up holding 100% of the fund in bond-type assets at retirement, the optimal strategy under loss aversion involves a much more gradual reduction in the equity holding if the fund remains close to the sequence of targets. If, however, the fund is either well below or well above a particular target, even one near to the retirement date, the optimal equity holding will be high for reasons given in the previous paragraph. We also show that under loss aversion, the risk of failing to attain the desired replacement ratio at retirement is significantly lower with target-driven strategies than those arising out of a traditional risk aversion framework aimed at maximising a power utility function on retirement.

We assume that the PT utility function is defined as follows (see Tversky and Kahneman, 1992):

$$U(F) = \begin{cases} (F-f)^{\nu_1}/\nu_1 & \text{if } F \geq f \\ -\lambda((f-F)^{\nu_2}/\nu_2) & \text{if } F < f \end{cases} \tag{1}$$

where F is the actual value of the pension fund when the plan member is a given age, f is the pre-defined target value of the pension fund at the same age, ν_1 and ν_2 are the curvature parameters for gains and losses, respectively, and λ is the loss aversion ratio.

As shown in Fig. 1, the two key properties of the PT utility function are: the PT utility function is 'S'-shaped (i.e., convex below the reference point and concave above it) when $0 < \nu_1 < 1$ and $0 < \nu_2 < 1$, implying that individuals are risk seeking in the domain of losses and risk averse in the domain of gains (this contrasts with the concave shape in standard utility functions, where individuals are assumed to be risk averse for all levels of wealth and have diminishing marginal utility of wealth); and the PT utility function is steeper below the reference point than above when $\lambda > 1$, implying that individuals are λ times more sensitive to a unit loss than to a corresponding unit gain.

Conventional lifestyle investment strategies are currently widely used by many such pension plans as the default investment option. However, as will be shown below, there can be substantial uncertainty over the size of the fund at

[3] Typically, the employer also makes a contribution. If so, we count the total contribution into the plan.
[4] The replacement ratio is defined as the ratio of pension income immediately after retirement to labour income immediately before retirement.
[5] However, they could equally be treated as time-related (in the sense of years, rather than age, from final target).
[6] Also known as 'lifecycle' or 'age-phasing' strategies (Samuelson, 1989).