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POLICY PAPER

A Portfolio Approach to Assessing an Auto-Enrolment Pension Scheme for Ireland

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Abstract: This paper investigates the feasibility of a national auto-enrolment pension scheme in Ireland. The design of an auto-enrolment scheme for Ireland is motivated by international experiences of auto-enrolment. Using a bootstrap approach to model historical returns for 24 hypothetical portfolios over a 40-year period, we investigate the probability of achieving a target pension income. The purpose of this empirical analysis is to determine what strategies and portfolio design will best achieve a projected target income replacement ratio for a typical member of a national auto-enrolment scheme. The simulated results indicate that a contribution rate of 8 per cent should, for the median outcome, be sufficient to generate a pension income close to 65 per cent of final salary. However, the State Contributory Pension plays an important and significant buffer for retirees, especially in the unlucky outcome when asset values have fallen just before retiring.

I INTRODUCTION

A key part of the International Labour Organization (ILO) Convention 102 relates to the protection and provision of old-age benefit for all citizens beyond the working life of a person. In a recent report from the OCED (2013), Ireland was found to be at the lower end of the pension spending scale and with over 90 per

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cent of defined benefit (DB) schemes in deficit and scheme wind-ups a regular occurrence (see Irish Association of Pension Funds (IAPF), 2013), a severe "pension gap" has emerged. The credit crisis has highlighted the vulnerability of the current pension and old-age benefit system in Ireland (D'Addio and Whitehouse, 2010). The OECD suggests that Ireland should look to voluntary private pension schemes as a way of tackling the pension gap. In particular, the OECD suggests mandating pensions on top of public plans as a means to do this. Their conclusion is that compulsion would be the less costly and most effective approach, while auto-enrolment is considered the second best approach.

It is difficult to determine the single best national system for pension provision due to variations in the objectives, e.g. poverty relief and risk-sharing, variations in constraints and differences in political processes (Barr, 2009). Over the years, many countries have undertaken considerable reforms of national pension structures, most notably Chile (Arenas de Mesa *et al*., 2008; Berstein *et al*., 2006), Sweden (Hedesstrom *et al*., 2004), Australia (Basu and Drew, 2010; Warren, 2010), New Zealand (O'Connell, 2009; MacDonald *et al*., 2012) and the UK (Clark and Knox-Hayes, 2009; Curry, 2008).

The scheme introduced in the UK was a national auto-enrolment pension scheme and, given the emphasis that has been placed on mandatory or quasi-mandatory pension provisioning in both the National Pensions Framework Review and the OECD Review, it seems clear that this issue has been placed firmly on the agenda in Ireland.

There are several academic works which have examined the concept of *default funds* and *optimal asset allocation* in the context of national mandatory or auto-enrolment pension schemes; however much of the literature on private pension provisioning in Ireland centres on behavioural elements. While the behavioural aspects are very relevant, it is intended that this paper will explore the investment considerations for an auto-enrolment scheme in an Irish context, an area that has been relatively unexplored to date.

Prior to the financial crisis, Irish pension schemes tended to rely on traditional investment techniques where the objective was simply to maximise return within an acceptable level of risk. A 2007 Survey by the IAPF showed that the industry was heavily weighted towards traditional asset classes, in particular equities. The fall in the value of Irish equities (and property related assets) during the credit crisis resulted in a significant switch post-crisis from asset classes such as equities and properties into bonds and cash. For example, the proportion of defined contribution (DC) funds invested in cash increased from 5.5 per cent in 2007 to 16.8 per cent in 2011.[1]

This paper investigates the feasibility of a national auto-enrolment pension scheme in Ireland, including the requirements for reform and the rationale behind the OECD and National Pensions Framework proposals on auto-enrolment, and the

[1] Irish Association of Pension Funds DC Survey (2011).

impact of the recent financial crisis on pension provision. We consider the various asset classes used in traditional pension fund portfolios and outline the various considerations for formulating investment strategies and portfolio design for pension funds (see, for example, Barr, 2009; Blake *et al*., 2001; Lucas, 2001; Lucas and Zeldes, 2006; Viceira, 2009). We present an analysis on Life Style strategies and how they compare with alternative strategies, while drawing on previous empirical analysis and research conducted in this area (see, for example, Bodie *et al*., 2009; Booth and Yakoubov, 2000; Ellement and Lucas, 2007).

The main focus of the empirical analysis is to bootstrap a series of returns for a number of hypothetical portfolios over a 40-year period. The purpose of this is to determine what strategies will best meet the target income replacement ratio for a typical member of a national auto-enrolment scheme. This analysis will provide valuable insights for the design and feasibility of a national auto-enrolment scheme for Ireland.

Section II provides a brief outline of the current pension system in Ireland, including the requirements for reform and the rationale behind the OECD and National Pensions Framework proposals on auto-enrolment. Section III examines the international experiences of auto-enrolment. Section IV outlines the various asset classes used in traditional pension fund portfolios and outlines the various considerations for formulating investment strategies for pension funds. Within this section, an in-depth analysis on Life Style strategies is given, including how they compare with alternative strategies. The data, methodology and empirical results are presented in Section V. A final section concludes.

II PENSION REFORM IN IRELAND

The Irish pension system is based on the Beveridgean system and is essentially a two-pillar system; Irish citizens pay Pay-Related Social Insurance which entitles them to receive the State Contributory Pension and other benefits at age 66 years and they can also avail of private pensions such as occupational pensions, a Personal Retirement Savings Account or a Personal Pension Plan in order to top up their benefits. This system is supplemented with means-tested benefits for those who have not contributed enough to qualify for the State Contributory Pension. Private pension coverage is generally voluntary, although in certain sectors such as the public service and semi-state sector, pension membership is compulsory.

To incentivise people to contribute to private pensions, tax relief applies to pension contributions subject to certain limits.[2] The contribution rate for the State

[2] Currently, Ireland offers an income tax relief against earnings from employment for pension contributions (including Additional Voluntary Contributions (AVCs)) to Occupational Pension Schemes, Personal Retirement Savings Accounts (PRSAs), Retirement Annuity Contracts (RACs) and certain overseas plans. Details available on all reliefs at www.revenue.ie.

Contributory Pension is based on a percentage of earnings (circa 4 per cent); however the benefits derived are the same regardless of the levels of contribution made.

In a comprehensive report in 2012 by TILDA (The Irish Longitudinal Study on Ageing), the Pensioner Support Ratio in Ireland is projected to decrease from 5.4 to 1 in 2010 to 2.3 to 1 in 2055. Although the Irish population will age later than European counterparts, the country faces a challenge of growing pension costs and it is anticipated that gross public pension expenditure will increase from 7.5 per cent of GDP in 2010 to 11.4 per cent of GDP in 2050.

In Ireland, private pension coverage has remained largely static since 2005 at circa 55 per cent of those in employment. In addition, there are certain sectors of industry which have very poor private pension coverage e.g. hotels, catering and retail. The National Pensions Policy Initiative set a target supplementary pension coverage ratio of 70 per cent of the workforce over the age of 30 and a target income replacement rate of 50 per cent of gross pre-retirement income.

2.1 Mandatory Pensions and Auto-enrolment

The 2010 National Pensions Framework envisaged a framework for radical and wide-scale reform of the Irish pension system. Under this framework, the Government committed to developing an auto-enrolment system for employees, with mandatory employer contributions and a matching State Contribution equal to 33 per cent tax relief. The scheme is designed to encourage a more equitable pension provision than the current system of marginal tax relief. Furthermore, another advantage of the scheme is that it is "quasi-mandatory" meaning that the opt-out mechanism allows people to temporarily take a break from saving for retirement when they need to do so. However, the scheme currently offers little in the way of the investment strategy for this auto-enrolment scheme – it is this aspect which we address in the paper.

Irish employees would be automatically enrolled into this pension scheme unless they are a member of their employer's scheme and that scheme provides higher contribution levels or is a defined benefit scheme. It was envisaged that the total employee contribution would be 4 per cent of earnings, and total contributions would therefore be 8 per cent, within a band of earnings. These contributions will be collected through the PRSI system.

While the National Pensions Framework originally implied that the total contribution rate for a national auto-enrolment scheme would be 8 per cent of salary, the recent OECD report suggests that this level of contribution will not be sufficient to meet the needs of participants in retirement and have recommended a total contribution of 15 per cent of salary.

III INTERNATIONAL EXPERIENCES OF PENSION REFORM

In the last few decades, pension reform has been on the top of most governments' agendas, with many countries already undertaking considerable reforms of pension coverage and provision. Most notably, reformers of national pension structures include Chile, Sweden, Australia, New Zealand and in 2012, the UK.

Since 1981, Chile has had a system of mandatory, funded and privately managed individual pension accounts for citizens. However, the Chilean government recognised that unless accompanied by a robust system of poverty relief, a system consisting exclusively of individual accounts would not be sufficient and in 2008, they introduced a non-contributory pension financed by taxation which would be payable to two-thirds of the population.

The Swedish system underwent considerable change in the 1990s and their system now consists of a funded system of individual accounts and a partially-funded guaranteed minimum level of pension. In terms of individual accounts, there is an extensive range of funds to choose from and a default fund for those who do not choose, the latter being the choice of most.

The fund choice for auto-enrolment schemes tends to vary significantly from country to country. For example, in Chile, investors may only choose from a selection of five funds. In contrast, under the Swedish mandatory system there were 776 funds for investors to choose from (Tapia and Yermo, 2007). The US Thrift Saver Scheme offers only ten funds, while in New Zealand there are approximately 24 providers, all of whom offer a choice of funds. However, too much choice may actually reduce actual choice exercised. For example, over 90 per cent in the Swedish system opted for the default fund, while only 40 per cent of members of the US Thrift Saver Scheme opted for the default fund.

The Kiwi-Saver scheme came into effect in New Zealand in 2007; members are automatically enrolled between the ages of 18 and 65 years if in employment but can choose to opt-out between day 14 and day 56 of their employment. In order to discourage opt-outs, the New Zealand government provided a NZ$1,000 tax-free "kick-start" to the individual's savings account (this was discontinued in May 2015). As well as minimum contributions from employers and employees, the government has a subvention.

NEST was launched in 2012 in the UK as a trust based occupational scheme aimed at low to moderate income workers and is subject to national and European legislation. It is essentially a personal accounts system and its key distinctive features are that it is simple and charges are kept to a minimum.

The Kiwi-Saver and NEST (UK) schemes differ in terms of design features; in the UK employers are responsible for ensuring employees enrolled in the scheme. The employee holds a personal account, and can choose for their contributions to be invested in a limited choice of funds. However, in line with expectations, most have opted for the default fund and therefore personal accounts essentially

constitute one large fund which is invested at arm's length by the investment managers chosen by NEST. In this context, competition will arise though contracts set up by NEST rather than by individual consumers making their own choices. Cost savings and simplicity were the main drivers behind the design of the UK model. In addition, the perception is that participants will not want to choose how to invest and do not have financial literacy to choose well.

The Kiwi-Saver Scheme, on the other hand, allows any provider to apply to provide the accounts to consumers once they comply with some predefined guidelines on the structure of the product. There are approximately 24 different providers, and of these, nine have been selected to provide default funds. The Kiwi Saver Scheme, therefore, appears to place more emphasis on providing opportunities for participants to exercise control over their investment choices and to choose a product which is appropriate to their circumstances.

IV INVESTMENT STRATEGIES FOR DEFAULT PORTFOLIOS

For the most part, pension funds rely primarily on four asset classes – equities, bonds, property and cash. Traditionally, equities have offered higher returns but are inherently riskier assets, as evidenced by the recent losses suffered by Irish pension schemes during the financial crisis due to their high allocation to equities. Alternative asset classes, such as commodities, are recently becoming increasingly attractive for pension investors. These assets have the possible diversification benefit of historically being less correlated with traditional assets.

4.1 Formulating Investment Strategy for Pension Schemes

There are three main considerations which are central to formulating the risk objective of an auto-enrolment scheme; the level of risk that future members should take, the level of returns needed to ensure their contributions grow to meet their retirement expectations, and the capacity to reduce the dispersion of outcomes that the investment approach generates, particularly closer to retirement age.

The standard approach for determining the asset allocation of any portfolio is mean-variance optimisation. Default funds of many DC pension schemes have very high equity weightings for long periods whereas DB schemes tend to have a more balanced investment approach with a greater mix of assets. Absolute Returns or Diversified Growth strategies which combine equities, bonds, cash and alternative investments are also increasingly popular. Tactical asset allocation is an alternative to strategic asset allocation and involves increasing investment when markets are attractive and reducing holdings in less attractive markets.

Another key decision for pension fund managers is whether the fund should be actively or passively managed. That decision depends on the strategic asset allocation and preferences in relation to risk (active management carries security

selection risk while passive management carries mainly benchmark risk). The cost is the other main factor as fees associated with active management are considerable.

Traditional life-styling generally involves switching from riskier assets such as equities to safer assets like bonds within five to ten years of retirement. Target-date funds are similar but instead of switching from units in a higher to lower risk fund, the switch generally occurs at the level of the fund that corresponds to the individual's expected retirement date. Target-date funds also are advantageous in that they focus members on the outcome and draw attention away from short-to medium-term volatility. The critical flaws of target-date funds are two-fold: first, a lower equity exposure does not necessarily mean lower risk and neither equity risk nor correlations between asset classes are consistent over time; and second, target-date fund providers confuse consumers by adopting differing investment approaches (Tretiakova and Yamada, 2011). Stochastic life-styling involves predicting the most probable investment outcome based on stochastic simulations which will define the target range of final pension pot values. When the value of savings enters a target range, money is switched into lower risk investments in order to minimise the risk of future losses.

4.2 Life-Styling Approach to Asset Allocation Strategies

A popular investment theory that is often used is the "life-cycle hypothesis". However, in their 2012 Pensions Outlook Report, the OECD cautions that such life-cycle investment strategies (including target-date funds) may need to be carefully regulated to ensure that workers are offered sufficient diversification and protection from market shocks in old age.

Life-cycle funds (or target-date funds) were approved in the US by the American Pension Protection Act of 2006 as a default option for DC plans. Broadly speaking, these funds reduce equity exposure as a predetermined retirement date approaches. There has been some concern about the asset allocation and performance of these funds in the US, as many of these funds have not rebalanced their allocation away from equities on the grounds that retirees continue to need a heavy equity allocation to offset the danger of outliving their savings. Booth and Chang (2011) examined the asset allocation and performance of target-date funds from January 2006 to May 2009 and found that target-date funds increased their common equity allocation and reduced cash reserves immediately before and during the 2008 financial crisis. Fund managers tried to maximise returns on short-dated funds close to their target date by retaining high allocations in equities and also a lack of dynamic rebalancing on the part of fund managers as they let their winners grow (in this sense they followed a momentum strategy, as is typical of many fund managers; see Carhart, 1997).

The key considerations that should be borne in mind in relation to the life-cycle model are that assumptions may not always be realistic as future labour income is not always risk free; however Viceira (2009) shows that future earnings have to be

extremely volatile before an individual moves to a more conservative investment policy. Second, labour supply can be flexible. Bodie *et al*. (1992) show that individuals can invest even larger proportions of their financial wealth in risky investments if labour supply is adjusted and Viceira (2009) suggests that individuals may also apply this approach where future earnings are not risk-free. Third, the correlation between labour income growth and stock returns are important. Viceira (2009) shows that a positive correlation between earnings and stock market returns leads to a significant reduction in the desired position in stocks and a high positive correlation can lead to young workers being less willing to hold stocks than older workers (see also Benzoni, 2002).

4.3 Comparing Investment Strategies

With regard to other types of managed funds, Pang *et al*. (2008) use simulation analysis to compare the investment performance of a balanced fund and a life-cycle fund using average asset allocations observed on the market. The results of this analysis show that the balanced fund is more likely to outperform the life-cycle fund; it also increases the risk to participants in the years immediately preceding retirement.

There appears to be a certain level of support for high allocations of equities versus life-style investment strategies in the construction of the default portfolio. Booth and Yakoubov (2000) use historical data returns to investigate the retirement income implications of five different investment strategies; one with a constant 70 per cent equity/20 per cent bonds/10 per cent cash mix, and four varying life-cycle strategies. The findings indicated that there is weak support for the superiority of life-cycle approaches and that an equity-based fund in the ten years preceding retirement stochastically dominates the cash and fixed income strategies because of higher expected return. Similarly, Blake *et al*. (2001) employs a stochastic simulation model to investigate various default fund asset allocation strategies and found that the overall distribution of potential outcomes is very wide and that a well-diversified, high equity strategy provides best overall outcome. While the life-cycle strategy avoids some of the worst potential outcomes, it significantly reduces the average level of pension provision. Hibbert and Mowbray (2002) conducted similar analysis and found that a 100 per cent equity strategy produces the highest expected value but with a wide range of potential outcomes. Life-cycle strategies significantly narrow the range of potential outcomes but at the expense of reduced expected value, particularly where life-cycle switch begins 15 years from retirement.

A further alternative to the life-styling strategy is the Safety First Strategy, which is already in use in a number of countries, and which aims to maximise the probability of achieving at least a minimum level of required retirement income. Assets are divided into a large portfolio of risk-free bonds and a smaller portfolio of risk bearing securities. Bodie *et al*. (2009) argue that that these minimum income

guarantees should be the default option in retirement investments because they reduce moral hazard in the provision of retirement products and therefore they incur lower marketing and distribution costs. They also create greater transparency for consumers and reduce the need for costly financial education, and they make consumers aware of the risk of stocks. The drawback of this approach, however, is that it requires inflation-linked bonds to lock in a protected inflation amount and these can be limited in supply (Broeders and Rijsbergen, 2010).

V EMPIRICAL ANALYSIS

We construct a number of 40-year pension portfolio styles/strategies comprising of different asset classes which are typical to traditional pension funds. Some portfolio asset allocations will remain fixed for the 40-year period and others will incorporate a life-styling strategy. The main objective is to simulate outcomes using a bootstrap resampling method for the next 40-year period based on historical returns and, in doing so, determine the likelihood of accruing an amount which will generate a target pension figure for a typical member of an Irish auto-enrolment scheme.

In recent times this approach has been used by similar other studies, such as MacDonald *et al.* (2012). In the case of New Zealand, MacDonald *et al.* (2012) found that when the contribution rate increased to 6 per cent, investors had a 40 per cent probability of attaining their retirement target. In the decumulation phase, the hypothetical investor, on average, replaces 60 per cent of their final gross earnings up to age 95 years.

McDonald *et al*. (2012) measure retirement success in terms of multiples of final earnings of between five and eight times final salary (Basu and Drew (2010) also use eight). This translates to a 70 per cent income replacement benchmark as a reasonable target.[3] However, Ghilarducci (2010) suggests that middle and high income people need close to 95 per cent to 100 per cent of income to maintain living standards because more elderly are in debt and still paying mortgages while health care costs are increasing.

Most pension literature broadens optimal portfolio choice by examining other empirical variables such as contribution rates, time varying investment and dollar weighted returns and other market returns (MacDonald *et al*., 2012). Some use static assumptions, for example, Mitchell *et al*. (1998), while others such as Blake *et al*. (2001) allow for stochastic behaviour. However, it is difficult to source a single broadly accepted measure of retirement adequacy. We adopt a similar approach to MacDonald *et al*. (2012) and create 24 portfolios based on the asset allocations for other auto-enrolment schemes and typical asset allocation strategies

[3]Tretiakova and Yamada (2011) also use a target retirement capital of 70 per cent of income replacement.

referred to in previous literature, including life-styling strategies. Furthermore, we create stylised portfolios based on the default portfolios of specified national auto-enrolment schemes.

5.1 Methods and Investment Framework

To create a simulation model for the accumulated fund on retirement, it is necessary to create a profile for a hypothetical worker. We define the wage formation equation of this worker as:

$$S_t = S_0(1 + g)^{t-1} \tag{1}$$

where, S_0 is the initial salary, g is the nominal growth rate of wages, and t is the number of years elapsed since the start of employment. The nominal salary at retirement is denoted as S_T.

Given a contribution rate of s, the terminal value at time T of the pension is given by:

$$W_T = s \sum_{t=0}^{R-1} S_t(1 + r_t) \prod_{u=t+1}^{R-1} (1 + r_u) \tag{2}$$

where, R is the number of years before retirement, and r_t is the nominal rate of investment returned earned in year t.

For our empirical work we consider an average worker in Ireland and using the CSO Earnings data (Table NSA87) for 2013, the average (mean) worker aged 25-29 years old earned €26,963.56. We, therefore, set S_0 = €26,963.56. In terms of salary inflation (g), we apply a salary inflation of 3 per cent for forecasting pension accrual and therefore earnings inflation of 3 per cent per annum will be assumed for consistency. The working lifetime is assumed to be 40 years.[4]

The returns r_t are generated from the historical monthly returns for equity, bonds, property and cash for the period between 1971:1 and 2015:9. We use bootstrap resampling to generate monthly returns for the subsequent 40-year period. A number of hypothetical portfolios are created based on the strategic asset allocations of alternative schemes nationally and internationally – in particular, the Kiwi-Saver Scheme, the NEST Scheme in the UK, and the average asset allocation of Australian mandatory pension accounts. The list of portfolios constructed and their respective asset allocations is provided Table 1. We feel that this represents a reasonable spread of potential default funds in terms of style and strategy. From the bootstrapped return series, we generate a series of annual returns for each of the portfolios based on the asset allocations assigned.

[4] A 40-year period will be taken as indicative of the typical pensions saving period, in line with Irish societal norms.

Table 1: Hypothetical Portfolios Constructed

No	*Strategic Asset Allocation*	*Details*	*Total Equity Weighting*
1	World Equities (40%), US Equities (20%), Irish Equities (20%), UK Equities (20%),	Based on Booth and Yakabouv (Diversified Equity Portfolio)	100%
2	World Equities (25%), US Equity (15%), UK Equity (15%), Irish Equity (15%), Global Corporate Bonds (20%), Cash (10%)	Based on Booth and Yakabouv (Constant Balanced Portfolio)	70%
3	World Equities (20%), US Equity (13%), UK Equity (13%), Irish Equity (14%), Global Corporate Bonds (20%), Bonds (20%)	Based on Treitikova (Balanced Fund)	60%
4	World Equities (30%), Irish Equity (15%), Irish Property (8%), Global Corporate Bonds (20%), Bonds (17%), Cash (10%)	Kiwi-Saver Balanced Fund	45%
5	World Equities (12%), Irish Equity (6%), Property (4%), Global Corporate Bonds (29%), Bonds (27%), Cash (22%)	Kiwi-Saver Conservative Fund	18%
6	World Equities (12%), Irish Equity (6%), Property (3%), Global Corporate Bonds (26%), Bonds (14%), Cash (39%)	Kiwi-Saver Default Fund	18%
7	World Equities (43%), Irish Equity (24%), Property (10%), Global Corporate Bonds (7%), Bonds (5%), Cash (11%)	Kiwi-Saver Growth Fund	67%
8	Bonds (75%), Cash (25%)	NEST Pre-Retirement Fund	0%
9	World Equities (26%), Irish Equity (10%), Property (2%), Global Corporate Bonds (14%), Bonds (38%), Cash (10%)	NEST Foundation Fund	36%
10	World Equities (34%), Irish Equity (16%), Property (3%), Global Corporate Bonds (20%), Bonds (22%), Cash (5%)	NEST Growth Fund	50%
11	World Equities (26%), Irish Equity (31%), Property (11%), Global Corporate Bonds (8%), Bonds (14%), Cash (10%)	Average Australian Default Fund	57%
12	World Equities (45%), Irish Equity (19%), Irish Property (7%), Global Bonds (18%), UK Bonds (4%), Irish Cash (7%)	Average Irish Pension Fund Allocation (2000)	64%
13	World Equities (20%), US Equity (15%), UK Equity (15%), Irish Equity (16%), Property (10%), Global Corporate Bonds (13%), Bonds (6%), Cash (5%)	Average Irish Pension Fund Allocation (2007)	76%

Table 1: Hypothetical Portfolios Constructed (Contd.)

No	*Strategic Asset Allocation*	*Details*	*Total Equity Weighting*
14	World Equities (23%), UK Equity (10%), Irish Equity (20%), Global Corporate Bonds (20%), Property (4%), Bonds (6%), Cash (17%)	Average Irish Pension Fund Allocation (2011)	53%
15	Phase 1: World Equities (20%), US Equity (15%), UK Equity (15%), Irish Equity (16%), Property (10%), Global Corporate Bonds (13%), Bonds (6%), Cash (5%) Phase 2 at Year 34: Global Corporate Bonds (40%), Bonds (35%), Cash (25%)	Average Irish Pension Fund Allocation (2007) with Life Styling (7 years)	Phase 1: 76% Phase 2: 0%
16	Phase 1: World Equities (23%), UK Equity (10%), Irish Equity (20%), Global Corporate Bonds (20%), Property (4%), Bonds (6%), Cash (17%) Phase 2 at Year 36: Bonds (75%), Cash (25%)	Average Asset Allocation Irish PensionFunds (2011) with Life Styling (5years)	Phase 1: 53% Phase 2: 0%
17	Phase 1: World Equities (23%), UK Equity (10%), Irish Equity (20%), Global Corporate Bonds (20%), Property (4%), Bonds (6%), Cash (17%) Phase 2 at Year 31: World Equities (12%), UK Equity (5%), Irish Equity (10%), Global Corporate Bonds (37%), Property (4%), Bonds (15%), Cash (17%) Phase 3 at Year 36: Bonds (75%), Cash (25%)	Average Asset Allocation Irish PensionFunds (2011) with Phased Life Styling (10 and 5 years)	Phase 1: 53% Phase 2: 27% Phase 3: 0%
18	Phase 1: World Equities (26%), Irish Equity (31%), Property (11%), Global Corporate Bonds (8%), Bonds (14%), Cash (10%) Phase 2 at Year 33: Bonds (75%), Cash (25%) Phase 2 at Year 33: Bonds (75%), Cash (25%)	Average Australian Default Fund with Life Styling (8 Years)	Phase 1: 57% Phase 2: 0%
19	Phase 1: World Equities (34%), Irish Equity (16%), Property (3%), Global Corporate Bonds (20%), Bonds (22%), Cash (5%) Phase 2 at Year 34: Bonds (75%), Cash (25%)	NEST Growth Fund with Life Styling (7 years)	Phase 1: 50% Phase 2: 0%

Table 1: Hypothetical Portfolios Constructed (Contd.)

No	*Strategic Asset Allocation*	*Details*	*Total Equity Weighting*
20	Phase 1: World Equities (34%), Irish Equity (16%), Property (3%), Global Corporate Bonds (20%), Bonds (22%), Cash (5%) Phase 2 at Year 29: World Equities (22%), Irish Equity (10%), Property (3%), Global Corporate Bonds (25%), Bonds (25%), Cash (15%) Phase 3 at Year 35: Bonds (75%), Cash (25%)	NEST Growth Fund with Phased Life Styling (12 years and 6 years)	Phase 1: 50% Phase 2: 32% Phase 2: 0%
21	Phase 1: World Equities (43%), Irish Equity (24%), Property (10%), Global Corporate Bonds (7%), Bonds (5%), Cash (11%) Phase 2 at Year 31: Global Corporate Bonds (40%), Bonds (35%), Cash (25%)	Kiwi-Saver Growth Fund with Life Styling (10 years)	Phase 1: 67% Phase 2: 0%
22	Phase 1: World Equities (43%), Irish Equity (24%), Property (10%), Global Corporate Bonds (7%), Bonds (5%), Cash (11%) Phase 2 at Year 36: Global Corporate Bonds (40%), Bonds (35%), Cash (25%)	Kiwi-Saver Growth Fund with Life Styling (5 years)	Phase 1: 67% Phase 2: 0%
23	Phase 1: World Equities (43%), Irish Equity (24%), Property (10%), Global Corporate Bonds (7%), Bonds (5%), Cash (11%) Phase 2 at Year 26: World Equities (22%), Irish Equity (12%), Property (7%), Global Corporate Bonds (24%), Bonds (20%), Cash (15%) Phase 3 at Year 34: Global Corporate Bonds (40%), Bonds (35%), Cash (25%)	Kiwi-Saver Growth Fund with Phased Life Styling (at 15 years and 7 years)	Phase 1: 67% Phase 2: 36% Phase 3: 0%
24	Phase 1: World Equities (40%), US Equity (20%), Irish Equity (20%), UK Equities (20%) Phase 2 at Year 21: World Equities (35%), US Equity (15%), Irish Equity (15%), UK Equities (15%), Global Corporate Bonds (15%), Bonds (5%) Phase 3 at Year 31: World Equities (30%), US Equity (10%), Irish Equity (10%), UK Equities (10%), Global Corporate Bonds (20%), Bonds (10%), Cash (10%)	Basu and Drew Reducing Equity (20 years and 10 years)	Phase 1: 100% Phase 2: 80% Phase 3: 60%

Portfolios have also been constructed which also best represent the strategic asset allocations of Irish pension funds in 2000, 2007 and 2011. Others represent asset allocations specified in previously referenced literature. Finally, ten portfolios which incorporate the phased transition to less risky assets (life-style strategy) are constructed. This process is generally carried out between five and ten years to retirement. The IAPF Defined Contribution Survey 2011 confirms that the preferred default strategy for Irish DC schemes is the life-style strategy. Eighty per cent of schemes de-risked over a five- to 12-year period while 20 per cent of funds de-risked over a 15-year period or upward.

We consider an annual contribution rate (s) of 8 per cent and also 15 per cent per annum over the 40-year period, with the latter rate suggested by the OECD. The bootstrapping simulation produces varying time series of returns r_t. Contributions are assumed to be invested at year end and the accumulated fund at year end is reinvested at the subsequent rate, see Equation (2). For the purpose of analysis we ignore taxes (including stamp duty) and charges (bid-ask spread and other management expenses and charges). In the case of charges these can be significant, with the management and expense ratio usually in the range of between 1-2 per cent per annum. As the fees, charges and taxes vary across funds/portfolios and individuals, we concentrate on gross performance. Therefore, the findings provide a low watermark for achievement of an adequate pension, our results will overstate the performance (especially in the case of high equity-based funds) if we took into consideration such charges (and also potential taxes).

To determine the adequacy of the pension fund at retirement, annuity rates at retirement for the hypothetical worker will be used to determine the pension that can be purchased at retirement. The annuity factor has varied considerably in the last few years (with the large falls in baseline interest rates), ranging from 36.5:1 (or an annuity rate of 2.74 per cent) to 20.8:1 (or 4.8 per cent), with an average of 26.0:1 (or 3.84 per cent). We use the average annuity factor of 26.0:1, and this factor includes pension increases at a rate of 3 per cent per annum. Therefore, the annual pension from the annuity is equal to

$$w = W_T k \tag{3}$$

where, k is the annuity rate.

The State Contributory Pension will also be added to the annual pension amount w and the sum will be compared with earnings on retirement to determine whether the target replacement rate has been met. The future value of the State Contributory Pension is given by

$$C_t = C_0(1 + h)^{t-1} \tag{4}$$

where, C_0 is the initial level of State Contributory Pension, h is the nominal growth rate of this pension. The nominal State Contributory Pension is denoted as C_T. For our purposes of calculating the future value of the State Contributory Pension, h is

taken to be an indexation rate of 2 per cent, in line with anticipated CPI increases (Actuarial Review of the Social Insurance Fund).[5] The 2013 State Contributory Pension of €11,975.60 is used as the initial pension level C_0, with C_T then equal to €25,924.12 at retirement. Therefore, the annual pension at retirement is given by

$$P_T = w + C_T \tag{5}$$

We consider if P_T is sufficient to meet the target replacement rate. The replacement rate will be 65 per cent of pre-retirement salary (S_T) as this reflects the level of income in 2013 associated with the Living Wage threshold (we also report a 50 per cent and 75 per cent pre-retirement earnings, the latter is the OECD recommendation).

5.2 Data and Summary Statistics

The data are representative of the four main asset classes which pension funds predominantly invest in i.e. equities, bonds, cash and property. The analysis will focus on hypothetical portfolios which contain varying combinations of Irish and global asset allocations. Given the lack of breadth in the Irish equity and bond market, the historical returns for World, US and UK equity markets, as well as global corporate bonds, will also feature in the simulations.

Tables 2-4 provide a breakdown of the asset allocations of some of the default portfolios in UK, Australia and New Zealand, respectively, of auto-enrolment or mandatory schemes. The mix of asset allocation is similar to what we consider in our analysis.

Table 2: Average Benchmark Asset Allocations for Top Ten Kiwi-Saver Schemes

KiwiSaver Fund Type	*NZ Cash h%*	*NZ Bonds %*	*NZ Property %*	*NZ Equities %*	*Inter-national Bonds %*	*Inter - national Equities %*
Default	39	14	3	6	26	12
Conservative	22	27	4	6	29	12
Balanced	10	17	8	15	19	30
Growth	11	5	10	24	7	43

Source: MacDonald *et al*. (2012).

The historical return data are monthly for the period 1971:1 through to 2015:9 and from *Datastream*. All assets are denominated in a common (Irish Pound/Euro) currency. Total return indices of ISEQ Overall is used for Irish equity, and the MSCI total return indexes are used for the World, US and UK. Ten-year government bond

[5] Department of Social Protection, 2010.

Table 3: Average Benchmark Allocations for NEST Target-Date Funds

NEST FundType	*UK Cash %*	*UK Bonds %*	*UK Property %*	*UK Equities %*	*International Bonds %*	*International Equities %*
Pre-Retirement	24.8	75.2				
Foundation Phase 2055	9.5	38.0	1.9	10.6	13.8	26.3
Growth Phase 2040	5.4	22.2	2.6	15.8	19.7	34.1

Source: nestpensions.org.uk.

Table 4: Average Benchmark Allocations for Australian Superannuation Default Funds

Sector	*AZ Cash %*	*AZ Bonds %*	*AZ Property %*	*AZ Equities %*	*International Bonds %*	*International Equities %*	*Other Assets %*
Corporate	6	13	9	32	7	25	8
Industry	6	5	12	31	7	23	17
Public Sector	9	9	9	28	5	26	15
Retail	14	20	7	25	6	21	7

Source: IOPS Working Paper on Effective Pension Supervision, No 18.

yields are used for returns on Irish bonds and the three-month interbank rate is used for Irish cash. The corporate bond variable is the Citi Group Broad Investment Grade (USBIG) total return index and the property variable is the total return in the share TR Property Investment Trust plc. These latter two variables are chosen as they reflect a long data history and are also most closely associated with the returns from these asset categories for an Irish investor.

Summary statistics of returns for each of the asset classes for the period 1971:1 to 2015:9 are given in Table 5. A key characteristic of the data is that all return series are non-normal, with large differences between mean and median returns in the case of equity and property returns. In general, equity have the highest median returns but also exhibit high variability (in terms of standard deviation). Another feature is that there is some serial dependence in the case of Irish equity but more significant in the case of Irish Cash and Bonds, with the AR(1) coefficient[6] at 0.95 and 0.99, respectively.

[6] The AR(1) coefficient is the estimated ρ in the regression $r_t = \alpha + \rho r_{t-1} + \varepsilon_t$, where r_t is the rate of return in an asset (or portfolio) and ε_t is the residual. ρ measures first-order correlation present in the return series.

Table 5: Summary Statistics of Monthly Asset Returns

	Mean Returns	*Medium Returns*	*Standard Deviation*	*Skewness*	*Kurtosis*	*JB*	*AR(1)*
World	0.88	1.47	5.01	–0.76*	2.28*	167.8*	0.03
US	0.91	1.14	5.53	–0.68*	2.46*	176.2*	0.00
UK	0.92	1.34	6.01	0.08	6.36*	904.6*	0.08***
Ireland	0.69	0.89	6.06	–0.57*	3.12*	246.3*	0.22*
Corporate	0.74	0.73	3.26	0.15	0.59**	7.7***	0.05
Bonds	0.73	0.72	0.36	0.33*	–0.92*	28.6*	0.99*
Cash	0.63	0.54	0.45	0.75*	1.34*	90.7*	0.95*
Property	1.06	1.27	7.57	–0.14	5.73*	736.6*	0.07

Notes: The table represents statistics of monthly returns for the sample period 1971:1 to 2015:9. All data are from *Datastream*. All assets are denominated in a common (Irish Pound/Euro) currency. World, US, and UK are the MSCI total return indexes of the respective countries stocks market. Ireland is the total return of ISEQ Overall index. The Corporate bond variable is the Citi Group Broad Investment Grade (USBIG) total return index. 10-year government bond yields are used for returns on Irish Bonds and the 3-month interbank rate is used for Irish Cash. The Property variable is the total return in the share TR Property Investment Trust plc. JB is the Jarque-Bera test for normality. AR(1) test for first order serial correlation in the assets return series. * denotes significance at the 1 per cent level, ** at the 5 per cent level and *** at the 10 per cent level.

Table 6 reports the summary statistics of the 24 sample pension portfolios (as reported in Table 1). Higher weighted equity based portfolios exhibit higher average returns but also higher levels of variability (as measured by the standard deviation). Moreover, the difference between the mean and medium returns for many portfolios suggests that the distributions of returns are highly skewed. This is confirmed by the significant non-normality evidence from the Jarque-Bera test statistic. All portfolios report a significant level of negative skewness and positive kurtosis (except for Portfolio #8) – this indicates a greater chance of extremely negative outcomes. It is exactly this feature of return distribution that is undesirable, in particular for investors in pension funds as they run the risk of their final pension pot being reduced by one of these extreme negative outcomes. It is for this reason that we consider a bootstrap approach rather than an alternative simulation approach as it preserves the underlying distribution.

As well as significant non-normality there is also evidence of significant serial correlation in portfolio returns. The presence of an AR(1) component in all portfolios (albeit some at low levels) suggests that a block bootstrap approach is appropriate in simulating the returns.

The problem that serial dependence causes when using simple bootstrap is that the simulated series are unlikely to exhibit this serial dependence characteristic. In this way the simple bootstrap fails to capture an important characteristic of the data.

Table 6: Summary Statistics of Portfolio Monthly Asset Returns

Portfolio Number	*Mean Returns*	*Medium Returns*	*Standard Deviation*	*Skewness*	*Kurtosis*	*JB*	*AR(1)*
1	0.85	1.27	4.36	–0.89*	3.43*	334.9*	0.18*
2	0.81	1.26	3.60	–0.86*	2.49*	163.1*	0.14*
3	0.80	1.16	3.13	–0.83*	2.35*	148.1*	0.15*
4	0.77	1.03	2.74	–0.81*	2.54*	162.4*	0.21*
5	0.71	0.69	1.65	–0.24**	0.84*	16.7*	0.17*
6	0.68	0.67	1.55	–0.22***	0.81*	15.0*	0.18*
7	0.80	1.15	3.58	–1.03*	3.42*	284.0*	0.24*
8	0.63	0.54	0.36	0.77*	–0.27	44.0*	0.99*
9	0.73	0.93	2.01	–0.72*	1.94*	103.6*	0.19*
10	0.76	1.04	2.76	–0.76*	2.07*	117.9*	0.20*
11	0.77	1.11	3.21	–1.04*	3.46*	290.6*	0.30*
12	0.81	1.23	3.52	–0.88*	2.66*	180.5*	0.20*
13	0.85	1.28	3.68	–1.08*	3.90*	354.5*	0.19*
14	0.76	1.06	2.85	–0.87*	2.56*	170.6*	0.24*
15	0.81	0.86	3.27	–1.09*	5.14*	622.9*	0.20*
16	0.79	1.06	2.76	–0.87*	2.77*	213.7*	0.24*
17	0.76	0.60	2.48	–0.80*	3.71*	327.4*	0.26*
18	0.82	0.52	2.67	–1.07*	5.71*	743.3*	0.31*
19	0.74	0.56	2.43	–0.75*	3.17*	245.1*	0.21*
20	0.73	0.56	2.40	–0.70*	3.17*	240.1*	0.22*
21	0.83	0.69	2.98	–1.07*	5.63*	726.0*	0.26*
22	0.75	0.92	3.35	–1.06*	4.29*	458.8*	0.26*
23	0.81	0.75	2.88	–0.97*	6.00*	795.4*	0.26*
24	0.88	1.23	3.94	–0.98*	4.54*	488.6*	0.16*

Notes: The table represents statistics of monthly returns for the sample period 1971:1 to 2015:9. All data are from *Datastream*. All assets are denominated in a common (Irish Pound/Euro) currency. Portfolios are defined in Table 5 and a summary of the individual asset class returns are given in Table 4. JB is the Jarque-Bera test for normality. AR(1) test for first order serial correlation in the assets return series. * denotes significance at the 1 per cent level, ** at the 5 per cent level and *** at the 10 per cent level.

A further problem with the simple bootstrap approach is that it can fail to replicate the correlation in the data (see Sanfilippo, 2003). This is of particular importance for portfolio simulations as variance-covariance between assets is crucial in generating the variance of the data.

An alternative approach is to block bootstrap as this preserves the correlation structure given that it replicates the correlation by resampling blocks of data. It also preserves the serial correlation if the underlying portfolio exhibits serial correlation (see, for example, Bird *et al*., 1990; and Annaert *et al*., 2009). We consider both the simple and the block bootstrap approach in simulating the returns from investing 8 per cent and 15 per cent salary contributions annually into alternative portfolios. In this feature we differ from MacDonald *et al.* (2012) who only consider a simple bootstrap approach.

From Equation (1), S_0 is set at €26,963.56 in 2013 in accordance with earnings data obtained from the CSO (for the average (mean) worker aged 25-29 years old) and g = 3 per cent. Therefore, S_T = €85,394.32. Based on contribution rates (s) of 8 per cent and 15 per cent, we use the bootstrap method with 500,000 iterations to simulate final account balances at the end of the 40-year period. We report the median (average) total returns, and returns at the 5th and 95th percentile to represent unlucky and lucky outcomes/periods, respectively. In the decumulation phase, the final account balances are divided by the relevant annuity factor to determine the annual pension that can be purchased on behalf of the hypothetical retiree. The State Contributory Pension of €11,975.60 is also increased by 2 per cent per year (this is equal to €25,924.12 at retirement), added to the annual pension amount from the annuity and the total is compared with the target of 65 per cent of final salary.

5.3 Empirical Results and Analysis

For completeness we initially take a simple bootstrap approach and simulate 500,000 of each of the 24 portfolios. Table 7 reports the results from this simple bootstrap approach. In general, we report the results of the median, 5th and 95th percentiles from the simulations. The average annual returns range from 10.49 per cent (for Portfolio #1) and 7.58 per cent (for Portfolio #8). In the case of an 8 per cent contribution rate, this translates to a median pension pot of €1,186,890 (for Portfolio #1) and €775,154 (for Portfolio #8). The annuity income from such pension pots when added to the State Contributory Pension of €25,924.12 (at retirement) achieves 129 per cent of the target annual pension income (as measured as 65 per cent of average earnings) in the case of Portfolio #1 and exactly 100 per cent of the target in the case of Portfolio #8. Interestingly all of the portfolios in the median outcomes generate returns sufficient to more than achieve the target of 65 per cent of average earnings at retirement, with an 8 per cent contribution rate.

The extreme movements in equity markets could give rise to an outcome when one retires at a time just when equity markets have suffered an extreme fall (bear market) as in the case of the recent credit crisis. For this reason Table 7 also reports

Table 7: Statistics from Simple Bootstrapping of Portfolio and Annual Target Returns of 65 per cent of Average Earnings (The Living Wage Case) – Monthly Data

No.	*Return*	*Std Dev*	*AR(1)*	*Contrib Rate %*	*Bottom 5%*	*% of Target*	*Median*	*% of Target*	*Top 5%*	*% of Target*
1	10.49	2.56	–0.00	8	388,218	74	1,186,890	129	3,733,281	305
	[6.23, 14.64]		[–0.08, 0.07]	15	727,672	97	2,224,713	201	7,014,001	532
2	9.77	1.97	–0.00	8	475,171	80	1,150,146	126	2,839,896	243
	[6.49, 12.99]		[–0.08, 0.07]	15	890,488	108	2,155,496	196	5,322,749	415
3	9.58	1.71	–0.00	8	529,377	83	1,140,346	126	2,486,523	219
	[6.74, 12.37]		[–0.08, 0.07]	15	995,143	116	2,137,708	195	4,650,790	368
4	9.28	1.50	–0.00	8	557,632	85	1,086,073	122	2,136,685	195
	[6.79, 11.72]		[–0.08, 0.07]	15	1,044,427	119	2,037,901	188	4,009,034	324
5	8.48	0.90	–0.00	8	632,548	90	939,814	112	1,401,602	144
	[6.99, 9.97]		[–0.08, 0.07]	15	1,188,136	129	1,763,296	169	2,631,494	229
6	8.22	0.85	–0.00	8	611,473	89	883,122	108	1,282,221	135
	[6.82, 9.60]		[–0.08, 0.07]	15	1,145,394	126	1,656,779	161	2,409,296	213
7	9.64	1.96	–0.00	8	464,381	79	1,116,742	124	2,728,556	235
	[6.38, 12.83]		[–0.08, 0.07]	15	869,964	107	2,089,376	191	5,089,801	399
8	7.58	0.20	–0.00	8	712,074	96	775,154	100	845,800	105
	[7.25, 7.91]		[–0.08, 0.07]	15	1,335,030	139	1,453,239	147	1,585,853	156
9	8.77	1.10	–0.00	8	610,993	89	993,642	115	1,619,168	159
	[6.94, 10.56]		[–0.08, 0.07]	15	1,147,758	126	1,863,025	176	3,039,383	257
10	9.17	1.51	–0.00	8	540,150	84	1,054,377	120	2,082,016	191
	[6.67, 11.62]		[–0.08, 0.07]	15	1,012,679	117	1,979,466	184	3,898,449	316
11	9.21	1.75	–0.00	8	471,003	79	1,031,790	118	2,283,988	205
	[6.30, 12.05]		[–0.08, 0.07]	15	884,509	108	1,934,536	181	4,272,788	342

Table 7: Statistics from Simple Bootstrapping of Portfolio and Annual Target Returns of 65 per cent of Average Earnings (The Living Wage Case) – Monthly Data (Contd.)

No.	*Return*	*Std Dev*	*AR(1)*	*Contrib Rate %*	*Bottom 5%*	*% of Target*	*Median*	*% of Target*	*Top 5%*	*% of Target*
12	9.68	1.92	–0.00	8	476,266	80	1,132,578	125	2,728,484	235
	[6.49, 12.82]		[–0.08, 0.07]	15	896,975	109	2,128,803	194	5,121,773	401
13	10.17	2.01	–0.00	8	505,022	82	1,264,742	134	3,195,504	268
	[6.82, 13.43]		[–0.08, 0.07]	15	951,530	113	2,375,312	211	5,985,268	461
14	9.08	1.56	–0.00	8	511,867	82	1,024,657	118	2,066,803	190
	[6.49, 11.62]		[–0.08, 0.07]	15	959,990	113	1,918,487	179	3,882,887	315
15	9.80	1.85	–0.00	8	528,321	83	1,144,093	126	2,560,031	224
	[6.70, 12.80]		[–0.08, 0.08]	15	994,962	116	2,144,241	195	4,795,797	378
16	8.89	1.48	–0.00	8	532,612	84	974,044	114	1,814,221	172
	[6.43, 11.29]		[–0.08, 0.08]	15	999,210	116	1,823,918	173	3,406,460	282
17	8.85	1.42	–0.00	8	551,381	85	967,555	114	1,747,708	168
	[6.50, 11.16]		[–0.08, 0.08]	15	1,032,649	118	1,813,874	172	3,275,559	273
18	8.89	1.57	–0.00	8	513,991	82	952,256	113	1,825,078	173
	[6.27, 11.43]		[–0.08, 0.08]	15	966,015	114	1,785,046	170	3,426,098	284
19	8.90	1.37	–0.00	8	565,012	86	977,450	114	1,733,990	167
	[6.62, 11.13]		[–0.08, 0.08]	15	1,059,681	120	1,833,883	174	3,245,697	271
20	8.88	1.34	–0.00	8	578,391	87	974,307	114	1,687,229	163
	[6.65, 11.06]		[–0.08, 0.08]	15	1,085,202	122	1,825,320	173	3,166,526	266
21	9.23	1.74	–0.00	8	514,411	82	1,011,449	117	2,083,840	191
	[6.34, 12.05]		[–0.08, 0.08]	15	963,659	113	1,898,413	178	3,924,416	318
22	9.43	1.85	–0.00	8	487,435	80	1,061,464	120	2,382,709	212
	[6.35, 12.44]		[–0.08, 0.08]	15	913,828	110	1,989,628	184	4,467,913	356

Table 7: Statistics from Simple Bootstrapping of Portfolio and Annual Target Returns of 65 per cent of Average Earnings (The Living Wage Case) – Monthly Data (Contd.)

No.	*Return*	*Std Dev*	*AR(1)*	*Contrib Rate %*	*Bottom 5%*	*% of Target*	*Median*	*% of Target*	*Top 5%*	*% of Target*
23	9.22	1.67	–0.00	8	543,432	84	1,020,695	117	2,018,748	186
	[6.43, 11.94]		[–0.08, 0.08]	15	1,018,650	117	1,913,419	179	3,777,678	308
24	10.16	2.29	–0.00	8	469,276	79	1,193,206	129	3,225,440	270
	[6.35, 13.87]		[–0.08, 0.08]	15	880,100	108	2,236,935	201	6,072,593	467

Notes: The results are from the bootstrapping of 500,000 resampling. The mean annualised average return is reported along with the 5 per cent and 95 per cent confidence intervals (in square brackets). Also reported is the standard deviation (Std Dev) and AR(1) component with 5 per cent and 95 per cent confidence intervals (in square brackets). The Contrib Rate refers to annual contribution rates of 8 per cent and 15 per cent per annum, applied over the 40-year period. The Target is 65 per cent of average earnings at retirement (which coincides to the Living Wage Case). The Median case is the outcome from the 500,000 bootstrapped simulations and the Bottom 5 per cent and Top 5 per cent reflect the 5-percentile and 95-percentile outcomes from the bootstrapped simulations. The per cent of Target is generated from adding the State Contributory Pension (equal to €25,942.12 at retirement) to the annual pension amount from the annuity and the total is compared with the target of 65 per cent of final salary after 40 years working.

the 5th percentile as this represents an unlucky case (albeit that, on average, one in 20 of us will find ourselves in this position or an even worse position). We also report the lucky case of retiring after a bull run in the equity market and report the 95th percentile.

In the unlucky case, it is Portfolio #8 that gives the highest return of 7.25 per cent and Portfolio #1 giving the lowest return of 6.23 per cent. This represents a reversal of fortunes for the two extreme portfolios from the median case. With this level of return, none of the portfolios generate a sufficient pension pot to achieve the 65 per cent target income replacement at retirement when the contribution rate is 8 per cent. It is not so much a matter of what fund strategy to adopt but rather a higher contribution is needed to achieve the 65 per cent target income. When we move to a contribution rate of 15 per cent, most of the funds just achieve the target income replacement. In fact only one portfolio (Portfolio #1) fails to achieve the target replacement income.

The fact that the simple bootstrap fails to capture the serial correlation (Table 7 reports no significant AR(1) component in any of the bootstrapped portfolio returns), the simulated returns might be overstated, especially in the presence of non-normality. Table 8 reports the same analysis as that for Table 7 except we take a block bootstrap approach. A block length of 36 months (or three years) is chosen for the simulation. This length is sufficient to generate a similar AR(1) component in the bootstrap returns as those reported from the actual data (in Table 6).

In general, the block bootstrap simulation generates a more negative skewed returns distribution, results in lower returns on average and also lower returns at the bottom of the distribution (the unlucky case), with higher returns at the top of the distribution (the lucky case). The two extreme portfolios are still Portfolios #1 and #8, with an average annual return of 9.92 per cent and 7.43 per cent, respectively. In the case of an 8 per cent contribution rate, Portfolio #1 generates a median pension pot of €901,163 and only €739,476 is generated in the case of Portfolio #8. When added to the State Contributory Pension, there is little difference between the alternative portfolios in achieving the target of 65 per cent of average earnings at retirement, with an 8 per cent contribution rate. Portfolio #1 achieves 109 per cent of the target, whereas Portfolio #8 gets to 98 per cent of the target.

In the unlucky case, retirees only manage to achieve between 60 per cent and 81 per cent of the target income. The more equity weighted Portfolios (for example #1, 2, 13, 14, and 24) perform poorest. Even with a contribution rate of 15 per cent, these heavy equity-weighted portfolios do not generate an income equal to the target of 65 per cent of average earnings at retirement. This outcome is not very supportive of the OECD report that suggests a total contribution of 15 per cent of salary. What matters most in the unlucky case is the State Contributory Pension element of the retiree's income and not whether they have contributed 8 per cent or 15 per cent of their income over their working life. The results also point to support a low level of equity (no more than 60 per cent) in the portfolio or alternatively a life-style

Table 8: Statistics from Block Bootstrapping of Portfolio and Target Returns of 65 per cent of Average Earnings (The Living Wage Case) – Monthly Data with Block Bootstrapping

No.	*Return*	*Std Dev*	*AR(1)*	*Contrib Rate %*	*Bottom 5%*	*% of Target*	*Median*	*% of Target*	*Top 5%*	*% of Target*
1	9.92	3.37	0.15	8	189,940	60	901,163	109	4,172,595	335
	[4.08, 15.16]		[0.09, 0.21]	15	358,061	71	1,686,409	163	7,824,475	588
2	9.23	2.68	0.14	8	274,168	66	928,981	111	3,169,585	266
	[4.67, 13.48]		[0.07, 0.21]	15	513,114	82	1,742,822	167	5,913,422	456
3	9.10	2.40	0.15	8	319,934	69	950,523	112	2,815,043	241
	[5.02, 12.92]		[0.08, 0.21]	15	598,758	88	1,782,020	170	5,277,932	412
4	8.80	2.21	0.21	8	330,360	70	898,422	109	2,426,589	215
	[5.03, 12.32]		[0.14, 0.27]	15	617,505	89	1,682,856	163	4,563,046	362
5	8.05	1.54	0.15	8	446,636	78	825,225	104	1,670,199	162
	[5.61, 10.69]		[0.08, 0.23]	15	837,475	105	1,545,682	154	3,144,414	264
6	7.81	1.53	0.17	8	428,238	76	781,289	101	1,571,638	155
	[5.41, 10.42]		[0.09, 0.24]	15	802,447	102	1,461,250	148	2,942,443	250
7	9.15	2.85	0.24	8	219,606	62	849,464	105	3,179,612	267
	[4.21, 13.59]		[0.18, 0.30]	15	416,112	75	1,606,018	158	5,987,936	461
8	7.43	1.02	0.96	8	500,558	81	739,476	98	1,183,748	129
	[5.86, 9.21]		[0.93, 0.97]	15	939,293	112	1,385,562	143	2,216,963	200
9	8.39	1.77	0.18	8	403,825	75	873,988	107	1,933,754	180
	[5.44, 11.28]		[0.12, 0.24]	15	759,626	99	1,638,574	160	3,617,258	297
10	8.72	2.23	0.19	8	324,381	69	884,805	108	2,402,740	213
	[4.96, 12.27]		[0.13, 0.25]	15	610,830	89	1,657,731	161	4,512,431	359
11	8.83	2.70	0.30	8	224,068	62	819,883	103	2,788,962	240
	[4.12, 12.97]		[0.23, 0.35]	15	419,369	76	1,542,027	153	5,214,969	407
12	9.15	2.71	0.20	8	252,235	64	882,012	108	3,058,466	258
	[4.50, 13.41]		[0.13, 0.25]	15	475,242	80	1,655,882	161	5,724,425	443

Table 8: Statistics from Block Bootstrapping of Portfolio and Target Returns of 65 per cent of Average Earnings (The Living Wage Case) – Monthly Data with Block Bootstrapping (Contd.)

No.	*Return*	*Std Dev*	*AR(1)*	*Contrib Rate %*	*Bottom 5%*	*% of Target*	*Median*	*% of Target*	*Top 5%*	*% of Target*
13	9.59	2.74	0.19	8	266,962	65	978,348	114	3,461,018	286
	[4.86, 13.89]		[0.11, 0.25]	15	501,071	81	1,833,630	174	6,501,901	497
14	8.66	2.34	0.24	8	292,939	67	854,322	106	2,435,611	215
	[4.65, 12.36]		[0.17, 0.30]	15	548,372	85	1,603,400	158	4,573,182	363
15	9.27	2.56	0.18	8	314,167	68	924,636	111	2,840,570	243
	[4.86, 13.29]		[0.11, 0.25]	15	588,078	87	1,729,509	166	5,320,889	415
16	8.52	2.24	0.24		326,643	69	833,188	104	2,151,546	196
	[4.69, 12.05]		[0.16, 0.31]	15	611,878	89	1,566,307	155	4,044,730	327
17	8.48	2.15	0.23	8	354,232	71	834,686	104	2,060,216	189
	[4.82, 11.89]		[0.16, 0.30]	15	664,024	93	1,567,657	155	3,876,907	315
18	8.58	2.45	0.30	8	392,550	74	808,762	103	2,224,510	201
	[4.28, 12.34]		[0.22, 0.36]	15	545,803	84	1,512,169	151	4,179,773	336
19	8.52	2.07	0.20	8	368,094	72	850,755	106	2,043,284	188
	[5.00, 11.81]		[0.12, 0.26]	15	692,508	95	1,595,780	157	3,841,316	312
20	8.47	2.03	0.19	8	384,997	73	848,195	105	1,993,970	185
	[5.05, 11.72]		[0.12, 0.26]	15	723,406	97	1,591,274	157	3,734,442	305
21	8.81	2.56	0.24	8	302,697	68	828,928	104	2,456,919	217
	[4.36, 12.79]		[0.16, 0.30]	15	566,260	86	1,559,695	155	4,598,487	365
22	8.98	2.70	0.24	8	259,028	65	838,008	105	2,762,470	238
	[4.29, 13.17]		[0.17, 0.30]	15	486,140	80	1,576,102	156	5,193,592	406
23	8.79	2.47	0.23	8	332,512	70	845,337	105	2,359,004	210
	[4.53, 12.64]		[0.16, 0.29]	15	625,409	90	1,582,588	156	4,409,043	352
24	9.61	3.03	0.14	8	272,712	66	941,011	112	3,568,485	294
	[4.37, 14.35]		[0.07, 0.20]	15	511,278	82	1,766,638	169	6,709,989	511

Notes: The results are from the block bootstrapping of 500,000 resampling. A block length of 36 months (3 years) is chosen for the simulation. The data is simulated at a monthly frequency. See Table 7 for description of columns.

portfolio (as in the case of Portfolios #15–23, all of which have a zero equity weight in the final years of the life of the portfolio).

The role that the State Contributory Pension plays in the overall pension for the retiree is significant and makes up on average 44 per cent of the income of the retiree (assuming an 8 per cent contribution). In the unlucky case (bottom 5 per cent) this contribution increases to 68 per cent on average. In this sense the State Contributory Pension is a very important and significant buffer for those retiring, especially in the unlucky case (retiring just after a significant fall in asset values).

Many studies have used a target of 50 per cent of average salary (albeit most of these studies, for example MacDonald *et al*. (2012), do not include any State Contributory Pension in the retiree's overall pension). For this reason we also show the overall findings for this 50 per cent target as well as a 75 per cent target. The results reported in Table 9 show that at the target of 50 per cent, all portfolios in the most likely outcome (the Median case) achieve significantly more than the required target, with an 8 per cent contribution rate. However, in the unlucky outcome (the Bottom 5 per cent case) only the low-equity weighted portfolios achieve the 50 per cent of average salary target and it requires a higher contribution rate and/or a life-style portfolio to achieve the target. At the 15 per cent contribution rate, all of the portfolios (apart from Portfolios #1 and #11) achieve the target.

In the case of a high target of 75 per cent of average salary, the contribution rate would have to be slightly higher than 8 per cent for the target to be achieved in the most likely outcome (the Median case), as most portfolios get to within 90 per cent of the target. However, a contribution rate of 15 per cent would not even be sufficient in the unlucky outcome (the Bottom 5 per cent case). This latter case, the best performing Portfolio #8 (a bonds and cash portfolio) only achieves 97 per cent of the target when the target is 75 per cent of average salary.

A potential option for the Irish government is to wind down or remove the State Contributory (or Old Age) Pension as the auto-enrolment scheme gets rolled out. However, as Table 10 reports, in the absence of the State Contributory Pension, an 8 per cent contribution would on average only generate between 51-68 per cent (on average 59 per cent) of the target of 65 per cent of average earnings at retirement (as little as one-third of average earnings at retirement). The contribution would need to be closer to 15 per cent as this generates on average 111 per cent of the target of 65 per cent of average earnings. In the unlucky case the numbers are even more stark, even a contribution of 15 per cent only achieves 42 per cent (on average) of the target of 65 per cent of average earnings at retirement (therefore, representing only a pension of just over a quarter of the average earnings at retirement).

The simulated results are clearer dependent on a number of assumptions surrounding the hypothetical worker/retiree, absence of a management fee (or taxes such as stamp duty) and the use of the current annuity rate. We have considered how robust the results are to these assumptions. To conserve space we only report on these qualitatively here but details are available on request from the authors.

Table 9: Statistics from Block Bootstrapping of Portfolio and Target Returns – Monthly Data with Block Bootstrapping: Target Cases of 75 per cent and 50 per cent of Average Earnings

		Target is 75% of Average Salary			*Target is 50% of Average Salary*		
No.	*Contrib Rate %*	*% of Target for Bottom 5%*	*% of Target for Median*	*% of Target for Top 5%*	*% of Target for Bottom 5%*	*% of Target for Median*	*% of Target for Top 5%*
1	8	52	95	291	78	142	436
	15	62	142	510	93	212	764
2	8	57	96	231	85	144	346
	15	71	145	395	107	217	593
3	8	60	97	209	89	146	314
	15	76	147	357	115	221	535
4	8	60	94	186	90	142	279
	15	78	141	314	116	212	471
5	8	67	90	141	101	135	211
	15	91	133	229	136	200	344
6	8	66	87	135	99	131	202
	15	89	128	217	133	192	325
7	8	54	91	231	80	137	347
	15	65	137	399	98	205	599
8	8	70	85	111	106	127	167
	15	97	124	173	145	185	260
9	8	65	93	156	97	139	235
	15	86	139	257	129	208	386
10	8	60	94	185	90	140	277
	15	77	140	311	16	210	467
11	8	54	90	208	81	134	312
	15	66	133	353	98	199	530
12	8	56	93	224	83	140	336
	15	69	140	384	103	210	576
13	8	56	99	248	85	149	372
	15	71	150	430	106	226	645
14	8	58	92	187	87	138	280
	15	73	137	315	110	205	472
15	8	59	96	211	89	144	316
	15	76	144	360	114	216	539
16	8	60	90	169	90	136	254
	15	77	134	283	116	202	424
17	8	62	91	164	93	136	246
	15	80	134	273	120	202	409
18	8	64	89	174	96	133	261
	15	73	131	291	110	197	437

Table 9: Statistics from Block Bootstrapping of Portfolio and Target Returns – Monthly Data with Block Bootstrapping: Target Cases of 75 per cent and 50 per cent of Average Earnings (Contd.)

		Target is 75% of Average Salary			*Target is 50% of Average Salary*		
No.	*Contrib Rate %*	*% of Target for Bottom 5%*	*% of Target for Median*	*% of Target for Top 5%*	*% of Target for Bottom 5%*	*% of Target for Median*	*% of Target for Top 5%*
19	8	63	91	163	94	137	244
	15	82	136	271	123	204	406
20	8	64	91	160	95	137	240
	15	84	136	264	126	204	397
21	8	59	90	188	88	135	282
	15	74	134	316	112	201	474
22	8	56	91	206	84	136	309
	15	70	135	352	104	202	528
23	8	60	91	182	91	137	273
	15	78	135	305	117	203	457
24	8	57	97	254	85	145	382
	15	71	146	443	107	220	664

Notes: The results are from the block bootstrapping of 500,000 resampling. A block length of 36 months (3 years) is chosen for the simulation. The data is simulated at a monthly frequency. See Table 7 for description of columns.

If we consider a higher (lower) starting salary, the results show that a higher (lower) contribution rate is required to meet the target income replacement at retirement. This is not surprising given the inclusions of the State Contributory Pension (which is not income dependent). If we allow for a management fee/expense/tax of say 1 per cent per annum on the value of the fund (which would be fairly common) then there is a significant reduction in the final pension pot and available income from the annuity . For example, in the case of a contribution rate of 8 per cent, Portfolio #1 generates a median pension pot of only €698,337 with a 1 per cent management fee as opposed to €901,163 when there is no fee. When added to the State Contributory Pension, Portfolio #1 now only achieves 95 per cent of the target, whereas with no management fee it was 109 per cent. With the introduction of a management fee, a higher contribution rate is required to meet the target income replacement at retirement.

Ideally, the annuity rates should be part of the block bootstrapping simulation (as the annuity rate is time dependent and linked to the simulated outcomes) but there are insufficient historical annuity rates available to give full consideration to a time series of annuity rates. From the data we have, the annuity factor has varied from 36.5:1 (or an annuity rate of 2.74 per cent) to 20.8:1 (or 4.8 per cent). In our tables we chose the average of 26.0:1 (or 3.84 per cent). When we consider a rate

Table 10: Statistics from Block Bootstrapping of Portfolio and Target Returns – Monthly Data with Block Bootstrapping: Target Cases of 75 per cent, 65 per cent and 50 per cent of Average Earnings, with no State Contributory Pension

		Target is 75% of Average Salary			*Target is 65% of Average Salary*			*Target is 50% of Average Salary*		
No	*Contrib Rate %*	*% of Target for Bottom5%*	*% of Target for Median*	*% of Target for Top5%*	*% of Target for Bottom5%*	*% of Target for Median*	*% of Target for Top5%*	*% of Target for Bottom5%*	*% of Target for Median*	*% of Target for Top5%*
1	8	11	54	250	13	62	289	17	81	375
	15	21	101	469	25	117	541	32	152	704
2	8	16	56	190	19	64	219	25	84	285
	15	31	104	355	35	121	409	46	157	532
3	8	19	57	169	22	66	195	29	85	253
	15	36	107	316	41	123	365	54	160	475
4	8	20	54	145	23	62	168	30	81	218
	15	37	101	274	43	116	316	56	151	410
5	8	27	49	100	31	57	116	40	74	150
	15	50	93	189	58	107	218	75	139	283
6	8	26	47	94	30	54	109	39	70	141
	15	48	88	176	56	101	204	72	131	265
7	8	13	51	191	15	59	220	20	76	286
	15	25	96	359	29	111	414	37	144	539
8	8	30	44	71	35	51	82	45	67	106
	15	56	83	133	65	96	153	84	125	199
9	8	24	52	116	28	60	134	36	79	174
	15	46	98	217	53	113	250	68	147	325
10	8	19	53	144	22	61	166	29	80	216
	15	37	99	271	42	115	312	55	149	406
11	8	13	49	167	16	57	193	20	74	251
	15	25	92	313	29	107	361	38	139	469
12	8	15	53	183	17	61	212	23	79	275
	15	28	99	343	33	115	396	43	149	515

Table 10: Statistics from Block Bootstrapping of Portfolio and Target Returns – Monthly Data with Block Bootstrapping: Target Cases of 75 per cent, 65 per cent and 50 per cent of Average Earnings, with no State Contributory Pension (Contd.)

		Target is 75% of Average Salary			*Target is 65% of Average Salary*			*Target is 50% of Average Salary*		
No	*Contrib Rate %*	*% of Target for Bottom 5%*	*% of Target for Median*	*% of Target for Top5%*	*% of Target for Bottom 5%*	*% of Target for Median*	*% of Target for Top 5%*	*% of Target for Bottom 5%*	*% of Target for Median*	*% of Target for Top 5%*
13	8	16	59	208	18	68	239	24	88	311
	15	30	110	390	35	127	450	45	165	585
14	8	18	51	146	20	59	168	26	77	219
	15	33	96	274	38	111	316	49	144	411
15	8	19	55	170	22	64	197	28	83	255
	15	35	104	319	41	120	368	53	156	479
16	8	20	50	129	23	58	149	29	75	194
	15	37	94	243	42	108	280	55	141	364
17	8	21	50	124	25	58	143	32	75	185
	15	40	94	232	46	108	268	60	141	349
18	8	24	48	133	27	56	154	35	73	200
	15	33	91	251	38	105	289	49	136	376
19	8	22	51	123	25	59	141	33	77	184
	15	42	96	230	48	110	266	62	144	345
20	8	23	51	120	27	59	138	35	76	179
	15	43	95	224	50	110	258	65	143	336
21	8	18	50	147	21	57	170	27	75	221
	15	34	94	276	39	108	318	51	140	414
22	8	16	50	166	18	58	191	23	75	248
	15	29	94	311	34	109	359	44	142	467
23	8	20	51	141	23	58	163	30	76	212
	15	37	95	264	43	109	305	56	142	397
24	8	16	56	214	19	65	247	25	85	321
	15	31	106	402	35	122	464	46	159	603

Notes: The results are from the block bootstrapping of 500,000 resampling. A block length of 36 months (3 years) is chosen for the simulation. The data are simulated at a monthly frequency. See Table 7 for description of columns.

of $k = 2.74$ per cent, in the median case, none of the portfolios achieve a 65 per cent target income replacement at retirement with a contribution rate of 8 per cent. The average portfolio allows the retiree to achieve 58 per cent of final salary. However, for $k = 4.8$ per cent, all portfolios achieve the 65 per cent target with a contribution rate of 8 per cent, with the average portfolio allowing the retiree to achieve 79 per cent of final salary.

VI CONCLUSION

Traditional pension investment strategies in Ireland are found to be inadequate to meet the target replacement ratios and have been for a number of years. Anecdotal and statistical evidence on the losses incurred by Irish pension funds in recent years suggests that a new approach to strategic asset allocation which considers both the final outcome and risk may be required.

With regard to the contribution rates which should apply, it seems clear that an 8 per cent contribution rate may not be sufficient in the case of an unlucky retirement point, irrespective of the choice of fund style/strategy. At the median outcome, the target replacement is just short of 100 per cent for nearly all the portfolios. Therefore, a contribution of over 8 per cent (but less than 15 per cent) seems more likely to achieve the desired results. Of course, the results may vary depending on the target group and salary levels. While this analysis assumes that the typical investor will be earning an average level of income, it is quite possible that the target group may broaden, particularly given that many private sector defined benefit schemes are now in the process of winding up. In particular, future research should also look at different cohorts of workers (especially those in low income).

In the most likely outcome (the Median case), we find that the high equity portfolios generate superior results to life-style strategies and fixed income heavy weighted strategies. This result is similar to Blake *et al*. (2001) and Basu and Drew (2010) who found that 100 per cent equity allocations provided superior result to life-style strategies. However, our results also show this performance is reversed in the unlucky outcome (the Bottom 5 per cent case). Moreover, the results show that the State Contributory Pension plays an important and significant buffer for retirees, especially in the unlucky outcome (Bottom 5 per cent case) when asset values have fallen just before those retiring.

If the Irish government was thinking of phasing out the State Contributory (or Old Age) Pension and using the auto-enrolment pension scheme as the sole source of pension income, then a contribution rate of near 15 per cent would (in the Median case) be required to achieve the target of 65 per cent of average earnings at retirement. However, even a contribution of 15 per cent would, in the unlucky case, only achieve 42 per cent of the living wage target – representing a retirement

income of just 27 per cent of the average earnings at retirement. A scheme could be designed to ensure that the retiree would receive the median outcome irrespective of the performance of the pension, as the portfolio performance in lucky times would be used to compensate for the unlucky times. This would require either an insurance type scheme or a national wealth fund scheme that workers contribute to – in both cases the retiree only receives a percentage of final salary irrespective of the performance of the funds/assets.

The empirical analysis has examined a number of portfolios with varying degrees of risk, many of which have been successful in meeting the target income replacement rate. This will be useful in selecting a default portfolio which best matches the likely target group's low risk appetite while still generating an adequate income on retirement. The analysis also provides some support for the practice of life-styling in order to reduce risk immediately prior to retirement and the empirical analysis provides evidence of how successful life-cycling strategies can be in also generating the target replacement income level on retirement.

Furthermore, there is much that can be learned from other national auto-enrolment schemes in terms of the design of the default fund. The portfolios which were based on the traditional asset allocations of the Kiwi-Saver Scheme, NEST and Australian pension funds were slightly more successful than Irish funds in meeting the target income replacement rate, at least in the median case.

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