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OPTIMAL RETIREMENT SAVINGS: A SOUTH AFRICAN PERSPECTIVE

by

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DECLARATION OF ORIGINALITY

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ABSTRACT

There is worldwide concern that people do not save enough towards retirement. To stimulate savings, tax incentives are a method employed by governments to encourage retirement savings. In this context, the asset allocation decisions that individuals make and the asset allocation restrictions that are imposed by regulators in an attempt to protect retirement savings, potentially impact the retirement ending wealth, which could be accumulated in the pre-retirement phase of an individual.

The objective of the study was to determine the impact of tax legislation, Regulation 28 of the Pension Funds Act (24/1956) and asset allocation choices on accumulated retirement ending wealth and what could be deemed appropriate for most individuals considering different time horizons.

Therefore, the aim of this study was two-fold: to determine whether pension fund legislation which limits the exposure to risky asset classes resulted in sub-optimal accumulated retirement ending wealth despite the associated tax savings; and to determine whether life cycle retirement funds, as opposed to different balanced retirement funds, were appropriate for most individuals.

The study did not find support for the notion that direct investment funds dominated high equity balanced retirement funds that complied with Regulation 28 as measured by first-order and almost stochastic dominance. Despite the higher asset allocation to equities that was possible with direct investments, this benefit was outweighed by the tax savings attributable to retirement funds. Additionally, the results of the study refuted the notion that a direct investment fund could be optimal over a long investment horizon. The implication of the finding was that an individual saving for retirement should, firstly, do so by taking full advantage of the tax savings that retirement funds offered. Hence retirement funds are an effective retirement saving tool despite the limitations on high-risk asset class allocations.

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The study found only limited support for the hypothesis that a theoretical retirement fund with a 100 per cent allocation to equities dominated a high equity balanced retirement fund that complied with Regulation 28 (particularly in the case of a 100 per cent local equity retirement fund compared with a Regulation 28 high equity balanced fund with no foreign equity exposure). Because the South African equity asset class was very volatile (annualised standard deviation of 19.8 per cent against 17.4 per cent for local against foreign equity in the data used in the study), a high exposure could lead to very low accumulated retirement ending wealth values; the intent of Regulation 28 was to protect the retirement savings of individuals against such adversity. Despite being perceived as very restrictive on the individual, the findings could not conclude that Regulation 28 restrictions on asset classes were inappropriate.

This study provided no support for the notion that a life cycle fund dominated a balanced fund with similar starting asset allocation from the perspective of accumulated retirement ending wealth. This raised the question whether life cycle funds, which are often included as default options for members of retirement funds, have a place. Hence they were likely not the optimal choice compared with a balanced fund counterpart with similar starting asset allocation. However, they could be attuned to the preferences of the individual (such as risk and personal preferences) rather than a rational objective assessment of one fund compared with another.

The study provided mixed support for whether a life cycle fund dominated a balanced fund with dissimilar starting asset allocations. This indicated that whether there was a place for a life cycle fund in any retirement fund default options, or whether it was optimal compared with an alternative balanced fund, strongly depended on the underlying asset allocations of the funds while the length of the glide path, the investment horizon as well as the risk and return characteristics of the investable universe could also influence the conclusion.

The study uniquely contributed to the retirement savings question with evidence that did not support the notion that Regulation 28 of the Pension Funds Act was necessarily inappropriate to serve the purpose of protecting retirement savings. The study also showed how the lower risk attribute of life cycle strategies impacted on accumulated retirement ending wealth, how it compared with balanced funds and which choice would be appropriate for most individuals. Because the life cycle industry is a fast-growing portion of the retirement fund market and becoming more popular as default options in retirement funds, the study contributed by contrasting life cycle funds with balanced funds and showed that the choice of which fund was optimal, was driven by the different characteristics of the funds such as investment horizon, starting and ending asset allocations as well as the length of the glide path.

Keywords: accumulated retirement ending wealth, life cycle funds, balanced funds, direct investments, retirement funds, Regulation 28, stochastic dominance, first-order stochastic dominance, almost stochastic dominance, retirement wealth, asset allocation decisions.

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LIST OF ABBREVIATIONS

ALBI	FTSE/JSE All Bond Index
ALSI	FTSE/JSE All Share Index
ASD	almost stochastic dominance
BA	bankers' acceptance
CIS	collective investment scheme
DB	defined benefit
DC	defined contribution
FSD	first-order stochastic dominance
GD	gentle descent
IRR	Internal rate of return
NCD	negotiable certificate of deposit
SD	steep descent
STeFi	Alexander Forbes Short-term Fixed Interest index
UK	United Kingdom
VAR	value at risk

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CHAPTER 1:
INTRODUCTION AND BACKGROUND

1.1 OVERVIEW

The adequacy of accumulated retirement wealth is a global dilemma. In a South African context, according to Jones (2011), only 6 per cent of South Africans save sufficiently for retirement while Old Mutual (in Kemp, 2005) puts this figure slightly higher at 10 per cent. From an American perspective, the National Institute on Retirement Savings (2013) estimates that, should one consider formal retirement savings of households only, which include 401(k) plans and individual retirement account balances, 92 per cent of American households will fall short of their retirement targets. When considering total wealth, 65 per cent of Americans will not meet their retirement goals. In the United Kingdom (UK), the Department for Work and Pensions (2012) estimates that, at the time of the research, 38 per cent of the UK's work force will not be adequately prepared for retirement.

Furthermore, Van Deventer (2012) warns against being too conservative in one's retirement investment choices and adds that the last five years before retirement is especially critical. Although equity markets offer greater returns than other asset classes, an individual is likely to experience a negative return during at least one of the five years prior to retirement. The author further adds that an individual has a long post-retirement period, which is normally at least 20 years, while, according to the latest annuitant mortality data of the Actuarial Society of South Africa, the average life expectancy of a 65-year-old South African with an annuity is 82 and 86 for males and females respectively (Jensen, 2015). This is important to consider because many people tend to move assets into lower risk asset classes while the required risk may be much higher to meet retirement obligations. A number of studies have focused on the implication of different asset allocation strategies on accumulated retirement ending wealth; that is wealth accumulated at the end of one's working career intended

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to sustain retirement (Basu, Byrne & Drew, 2011; Basu & Drew, 2009; Lewis, 2008b; Pfau, 2010).

Mechanisms can be put in place by government (monetary or fiscal policies) to encourage individuals to save more and protect retirement savings. In South Africa, this was achieved, among others, by providing tax relief for retirement funds and individuals that contribute to retirement funds. However, these products have certain caveats. Isaacs and Terblanche (2011) analysed whether the tax relief and associated benefits of retirement annuities, despite the concomitant stipulations, would be superior to a 100 per cent investment in the higher return equity asset class. They state that retirement annuities are indeed still superior to a 100 per cent direct investment strategy.

A number of retirement fund proposals and the implementation thereof are under discussion by the National Treasury of South Africa to reform the retirement environment and encourage savings (National Treasury of South Africa, 2004, 2015a, 2015b).

1.2 PROBLEM STATEMENT AND RATIONALE FOR THE STUDY

South Africans save too little towards retirement. People want to save in the most optimal and effective way considering the accumulated retirement ending wealth to be achieved and risk characteristics of retirement options. In addition, retirement fund regulations as well as tax treatment of retirement funds as opposed to direct investments influence the attractiveness and feasibility of the various asset allocation strategies and the choice between a retirement fund and direct investment. Asset allocation strategies in particular refer in particular to the choice between balanced funds and life cycle funds, which are both popular asset allocation strategies in the retirement fund environment.

The impact of limiting asset class exposure, whether by choice or due to regulations, on accumulated retirement ending wealth as well as an extensive comparison of

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retirement funds and direct investments in the South African market is not found in academic literature. Furthermore, evaluating choices with a risk-adjusted measure has not been carried out. Therefore, the problem that arises is a lack of evidence of how pension fund regulations and taxes influence accumulated retirement ending wealth as well as the appropriateness and efficacy of such regulations.

1.3 RESEARCH OBJECTIVES

The study aims to determine the impact of tax legislation, Regulation 28 of the Pension Funds Act (24/1956) and asset allocation choices on accumulated retirement ending wealth and what would be deemed appropriate for most individuals considering different time horizons.

The research objectives are as follows:

a. to determine whether the tax relief offered to retirement funds outweighs the benefit of higher allocation to high-risk asset classes in direct investments;
b. to determine the effectiveness of life cycle asset allocation strategies.

1.4 THESIS STATEMENT

The thesis statement is articulated as follows:

Regulation (retirement fund and taxation) and asset allocation decisions have a significant impact on accumulated retirement ending wealth and the appropriateness of different retirement savings choices.

1.5 RESEARCH QUESTIONS

The main research questions to be tested in this study are as follows:

Research Question 1:

Is a fund fully invested in equities optimal compared with a high equity balanced retirement fund with maximum equity allocation of 75 per cent?

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Research Question 2:

Are life cycle funds optimal when compared with balanced funds?

In testing the research questions, a better understanding of the tax and regulatory impact on retirement savings vehicle choices will be obtained. Additionally, the risk characteristics of the asset allocation strategies will provide further insight into retirement savings choices.

1.6 DELIMITATIONS AND LIMITATIONS

There are numerous decisions that individuals face in a retirement planning context; however, this study focuses in particular on retirement savings vehicle and asset allocation decisions. While the literature review also discusses the impact of the investment term and contribution rate, it is not the primary focus of the study. The literature draws from both South African and international resources; however, the empirical analysis of the study takes place in a South African context.

The study is limited to:

- the perspective of a South African resident;
- who is 25 years of age and intends to work till the age of 65;
- who is saving towards retirement;
- who is doing so by means of a direct investment or defined contribution retirement fund[1].

The latest recommendations regarding the retirement reform proposals of South Africa are dated October 2015 with any additional comments and changes after this date falling outside the scope of this study. The tax legislation applicable to individuals applied to the study refers to the tax year ending 28 February 2015.

The limitations of the study, including the modelling, are discussed in Chapter 3 (research method) and include the following:

[1] A defined contribution retirement fund (DC fund) refers to a retirement fund for which the retirement benefit received is not guaranteed.

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- The study considers only traditional asset classes, namely equity, fixed income and money market and hence excludes alternative asset classes such as property and hedge funds.
- A combination of retirement funds and direct investments to save towards retirement is not considered.
- Historical data is used in the modelling.
- The unique characteristics of individuals are excluded from the analysis.

1.7 ASSUMPTIONS

It is assumed that individuals will choose a portfolio based on a comparative analysis of one portfolio (or model) against another in terms of the first-order or almost stochastic dominance (FSD or ASD) decision-making tool. The asset allocation decision may be influenced by regulations and the risk characteristics of asset classes. Furthermore, each research question is applied to the following investment horizons:

- a 10-year investment horizon, which commences in 30 years,
- a 20-year investment horizon, which commences in 20 years,
- a 30-year investment horizon, which commences in 10 years and
- a 40-year investment horizon, which covers the full 40-year pre-retirement working years of an individual who starts working at 25 and intends to retire at 65.

1.8 IMPORTANCE AND BENEFITS OF THE STUDY

Research in South Africa on the impact of retirement regulation and asset class decisions is limited. Additionally, saving for retirement is a global challenge. A research contribution that focuses on how to protect retirement funds while facilitating sufficient accumulated retirement ending wealth is valued by the industry and individuals alike.

The study makes the following contributions to the existing literature: Firstly, it illustrates how asset allocation decisions impact accumulated retirement ending wealth, which many individuals are not mindful of. The study takes this further by exhibiting how the risk-reducing attributes of life cycle strategies compare with

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balanced funds and which choice would be appropriate for most individuals. Because the life cycle industry is a fast-growing portion of the market, this makes a significant contribution to understanding the asset allocation strategies.

1.9 SCOPE AND STRUCTURE OF THE RESEARCH

Chapter 1 provided a brief outline of the problem statement and motivation for the study followed by the research objectives, thesis statement and research questions. Subsequently, the delimitations, limitations and assumptions were discussed. The last section described the importance and benefits of the study.

Chapter 2 focuses on the literature review and commences with additional background to the research problem. It continues with a summary of the life cycle hypothesis, followed by an overview of the factors that impact accumulated retirement ending wealth, namely the investment term, contribution rate and asset allocation. Where applicable, retirement funds and direct investments, including regulatory restrictions and tax implications, are compared.

Chapter 3 presents the research design and method for the study including Monte Carlo simulation and bootstrapping. The next section describes the rationale for data used in the simulations, followed by a detailed discussion of the delimitations, limitations and assumptions of the study, which include the model-specific assumptions. The model-specific methodologies are presented next, followed by the descriptive and statistical techniques for analysis of the results. The decision-making criteria stochastic dominance is presented next, followed by the reliability, validity and ethical considerations. The chapter ends by presenting the research questions, hypotheses and sub-hypotheses.

Chapter 4 presents the descriptive statistics pertaining to the data used in the analysis as well as the results, analysis, findings and discussion applicable to Research Question 1: *Is a fund fully invested in equities optimal compared with a high equity balanced retirement fund with maximum equity allocation of 75 per cent?* The chapter commences by presenting the descriptive statistics of the historical data used in the

Monte Carlo simulations. The next section discusses the hypotheses, models and asset allocation strategies pertaining to Research Question 1. The descriptive statistics for the Monte Carlo simulations of each model follow, after which the empirical results and findings for the hypotheses are presented and discussed. The next section presents a discussion of the major findings pertaining to Research Question 1 followed by the conclusion.

Chapter 5 presents the descriptive statistics, results, analysis and findings applicable to Research Question 2: *Are life cycle funds optimal when compared with balanced funds?* The chapter commences by presenting the hypotheses, models and asset allocation strategies pertaining to Research Question 2. The descriptive statistics for the Monte Carlo simulations of each model follow, after which the empirical results and findings for the hypotheses are presented and discussed. The last section presents a discussion of the major findings pertaining to Research Question 2 followed by the conclusion.

Chapter 6 concludes by summarising the main findings of the study, highlighting the contributions and discussing areas for future research.

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CHAPTER 2:

FACTORS THAT IMPACT ACCUMULATED RETIREMENT ENDING WEALTH

2.1 INTRODUCTION

The asset allocation decision of an individual has a significant influence on the risk and return characteristics of any investment. Additionally, how an individual saves, for example, direct investments or retirement funds, influences whether one is saving in the most effective way or not. However, people tend to struggle with these decisions and tend to give their retirement less thought than they should. Retirement is perceived to be such a long time from today, which makes it difficult to visualise that "future self" and makes it challenging for people today to make the appropriate choices for their retirement savings. Although there are a number of factors that influence these decisions, the research focuses on the asset allocation decision and impact of regulations, which are the focus of the literature review that follows.

This chapter commences with additional background to the research problem. It continues with a summary of the life cycle hypothesis, followed by an overview of the factors that impact accumulated retirement ending wealth, namely the investment term, contribution rate and asset allocation. The asset allocation overview includes a discussion of particular asset allocation strategies including balanced funds and life cycle funds. Additionally, the characteristics of direct investments and retirement funds are presented incorporating and contrasting the pension fund and tax regulations applicable.

2.2 ADEQUACY OF RETIREMENT PROVISION

People do not save enough for retirement with a significant portion being insufficiently prepared for retirement. There are a number of ways in which individuals can be encouraged to save, and save more effectively, towards retirement. These range from changing people's behaviour regarding retirement savings, which are discussed in

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studies such as those of Thaler and Benartzi (2007b) and Mitchell and Utkus (2004), to providing a better understanding of asset allocation decisions and the impact on accumulated retirement ending wealth (Basu *et al.*, 2011; Byrne, Blake, Cairns & Dowd, 2006; Lewis, 2008c). Furthermore, most countries offer benefits such as tax relief to individuals when they use formal retirement funds[2] to save towards retirement (Thaler & Benartzi, 2007a).

This study focuses on the impact of asset allocation and retirement fund and tax regulations on accumulated retirement ending wealth and what investment vehicle considering these factors would be deemed optimal.

2.2.1 RETIREMENT VEHICLES

In the context of this research, *retirement funds* refer to any fund, specifically intended for individuals to save towards retirement, which falls within the scope of the Pension Funds Act (24/1956) of South Africa (hereafter referred to as the Pension Funds Act), which includes provident funds, pension funds and retirement annuities. The company or employer who provides a retirement fund is referred to as the plan sponsor (Mitchell & Utkus, 2004).

Whereas a *pension fund* and *provident fund* are linked to a particular employer, a *retirement annuity* is not, but it permits similar benefits to a pension fund, including the tax treatment. A provident fund is treated differently in terms of the Income Tax Act (58/1962) (hereafter referred to as the Income Tax Act), which is discussed in Section 2.4.2.1.2. Importantly, the proposed South African retirement reforms will result in similar tax treatment of retirement annuities, provident funds and pension funds, which are discussed where applicable. At the time of writing, October 2015, the implementation date of the retirement reforms is still uncertain, but current discussion documents indicate either full implementation on 1 March 2016 or a phased approach starting from 1 March 2016 (National Treasury of South Africa, 2015b).

[2] Because legislation is country specific and some discrepancies in the use and definition of terms exist, the research will use the South African legislative backdrop for consistency and clarity.

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An individual can also choose to save for retirement by investing directly in financial markets. By doing so, he or she would, on the one hand, give up some of the benefits offered by formal retirement funds but, on the other hand, would not be restricted by the regulatory requirements of retirement funds.

2.2.2 DEFINED BENEFIT AND DEFINED CONTRIBUTION FUNDS

Retirement funds can either be characterised as *defined benefit (DB)* or *defined contribution (DC)* funds. A DB retirement fund refers to a fund for which the retirement benefit received by an individual upon retirement is guaranteed, irrespective of how financial markets perform, and determined by a formula which usually considers an individual's ending salary and years of service (Bodie, Marcus & Merton, 1988). Regular contributions are made to the fund by the participant and in some cases, by the employer, but it is the plan sponsor's responsibility to make additional contributions if the financial assets in the fund are not sufficient to cover future liabilities, hence the plan sponsor bears the investment risk of the fund (Bodie *et al.*, 1988).

A DC fund refers to a retirement fund for which the retirement benefit received is not guaranteed. The benefit received by a participant upon retirement depends on the performance of financial markets. Regular contributions are made to the fund by the participant, and in some cases, by the employer (Bodie *et al.*, 1988). The individual bears the investment risk of the fund and a DC plan often shifts a significant number of decisions such as the asset mix as well as how much to invest from the plan sponsor to the participant as is the case in a member-directed plan (Thaler & Benartzi, 2007b). Because the interest in this research is particular to the decision individuals can make, the focus is on DC plans.

According to Graham (2012), DB plans have become unpopular. Boender (2005) offers supportive evidence from the US that for the period 1985 to 2002, DB plans decreased from 170 000 to 38 000 while DC plans increased from 462 000 to 702 000. In South Africa, DB plans have also fallen out of favour, with DC plans dominating in

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2010 with USD187 billion in assets compared with DB plans at only USD69 billion (KPMG., 2011).

The Pension Funds Act of South Africa makes provision for someone to make contributions to a DC or DB plan by means of a retirement annuity, pension fund or provident fund as defined in the Pension Funds Act.

2.2.3 ASSET ALLOCATION STRATEGIES

A DC plan can generally offer individuals three choices, which are not mutually exclusive in one DC plan, namely funds that invest in only one asset class, balanced or target risk funds and life cycle funds, also known as target date funds. *Balanced funds* or *target risk funds* are funds which maintain a constant asset mix resulting in the risk of the fund being consistent over time (Lewis, 2008c). Contrary to target risk funds, *life cycle funds* or *target date funds* are diversified funds that reduce the asset mix over the investment horizon from higher to lower risk asset classes as the individual approaches retirement based on the age and remaining investment horizon of the individual (Lewis, 2008c). The risk of the fund therefore changes and is tailored towards an expected retirement date. Due to the growth and popularity of life cycle funds (Lewis, 2008b), these funds are discussed extensively in Section 2.4.3.2.

To accumulate adequate retirement ending wealth, individuals must make appropriate choices during the pre-retirement phase in order to sustain smoothed consumption[3] over their life cycle and hence during retirement. The literature review focuses on the impact of the investment horizon, contribution rate, asset allocation decisions and regulatory influences on accumulated retirement wealth whether saving with a retirement fund or direct investment. In the light of these factors and the intent to smooth consumption over time, the following section starts by presenting the life cycle hypotheses, after which literature on each of the factors mentioned is presented.

[3] This is the practice of accumulating financial assets in one's working years to support retirement, consequently, smoothing consumption over different periods.

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2.3 THE LIFE CYCLE HYPOTHESIS

The life cycle hypothesis creates the context of the savings behaviour of individuals. The theory also influences the pre-retirement decisions that an individual makes, when to start saving, how much to save, the asset allocation of such savings and when to retire. These aspects are briefly described in the context of the life cycle hypothesis.

The life cycle hypothesis postulates that income and consumption of individuals do not necessarily coincide. Individuals accumulate financial assets in their working years to support retirement, consequently, smoothing consumption over different periods (Clark, Munnell & Orszag, 2006; Modigliani & Brumberg, 1954). Therefore, people have a hump-shaped age path of wealth holding with savings evident in the pre-retirement phase and dissavings in the post-retirement phase (Modigliani, 1986).

Retirement savings follow the same pattern: in the working years, individuals accumulate retirement wealth, which they then draw from during the post-retirement years. Accordingly, Mitchell and Utkus (2004) describe the following phases of the financial planning life cycle: the *accumulation phase* is usually prior to retirement and represents the stage in which the individual accrues retirement wealth. This is followed by the *transition* (a phase not discussed in the life cycle hypothesis) and *distribution phase*. During the transition phase, the focus shifts to align wealth in such a manner to facilitate the distribution phase when an individual starts using the accumulated retirement wealth. The focus of this research is the first two phases of the *financial planning life cycle* (accumulation and transition phase) of the individual as some might argue that life cycle funds encompass both the first and second phase (Mitchell & Utkus, 2004).

Modigliani and Brumberg (1954) argue that savings is a rational and voluntary action, not just a residual or consequence as was originally the view of the life cycle hypothesis. However, individuals have differing approaches and preferences regarding the future as well as risk and this influences how individuals allocate their financial wealth (Clark *et al.*, 2006). This point is important when comparing asset

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allocation decisions of individuals and will be highlighted in the discussion of asset allocation (Section 2.4.3).

The pre-retirement phase decisions of an individual should reflect the life cycle hypothesis thereby accumulating sufficient financial wealth to support retirement. The next section describes the impact of the investment horizon, contribution rates and asset allocation choices on accumulated retirement ending wealth.

2.4 PRE-RETIREMENT DECISIONS

Mitchell and Utkus (2004) argue that, should the life cycle hypothesis be true, individuals should exhibit some proven ability to assess their post-retirement financial needs, which will be reflected in their savings behaviour during the accumulation or pre-retirement phase. These decisions should be rational: "…a style of behaviour that is appropriate to the achievement of given goals, within the limits imposed by given conditions and constraints" (Simon, 1972:161). Individuals usually control how much is saved, their proposed retirement date and asset mix during the pre-retirement phase and can alter this to ensure sufficient accumulated retirement savings (Booth, 2004). The following sections explore how these decisions impact on accumulated retirement ending wealth.

2.4.1 INVESTMENT TERM

Byrne *et al.* (2006) argue that the shorter the investment horizon, the lower the replacement ratio that can be achieved. *Replacement ratio* is defined as initial real retirement income divided by the real salary immediately prior to retirement. The results from the study (Figure 2-1) show that an individual with a 10-year investment horizon can achieve a replacement ratio of between 0.10 and 0.12, while this increases to between 0.31 and 0.56 with a 40-year investment horizon.

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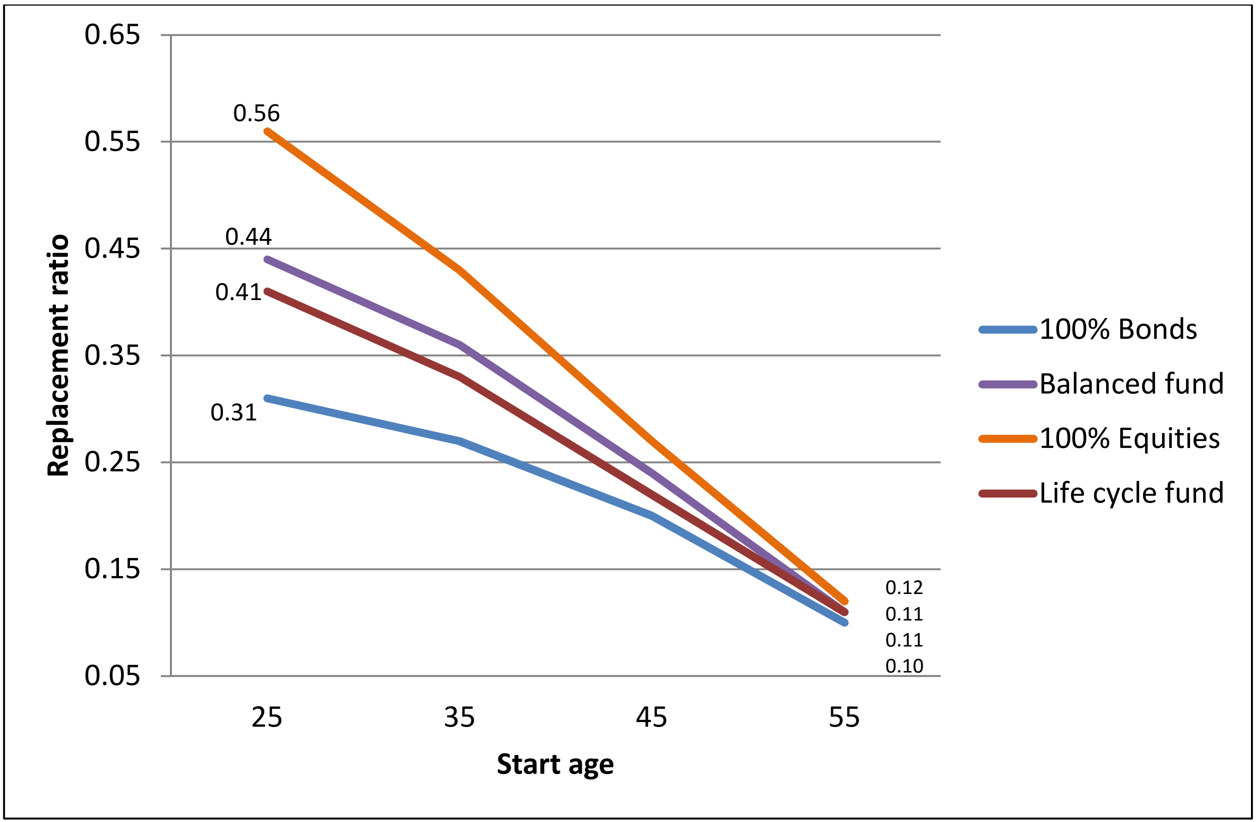
Figure 2-1: Mean replacement ratios at different ages



Source: Byrne *et al.* (2006)

Lewis (2008b) concurs with Byrne *et al.* (2006) that a longer investment term or pre-retirement phase is more favourable for the individual's retirement savings problem. Lewis (2008b) compares how an increase in the investment horizon from 30 to 40 and 45 years would impact three target date funds, namely an aggressive, moderate and conservative fund with the aggressive fund starting out and ending with a higher allocation to equities than the moderate and conservative fund. The conservative fund has the lowest beginning and ending equity allocation. The replacement ratio for the aggressive fund increases from a median replacement ratio of 0.38 to 0.48 and 0.57 for each subsequent investment horizon. The moderate fund increases from 0.36 to 0.44 and 0.50 while the replacement ratio increases from 0.33 to 0.40 and 0.44 for the conservative fund.

Spitzer and Singh (2001) evaluate the efficacy of a college savings programme which, similar to retirement funds, offers tax advantages but prescribes the asset allocation

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of the programme. Despite the research focusing on a different type of investment, the findings also support the notion that the longer the investment horizon or participation, the better the benefit achieved.

Despite the fact that the research of Ervin, Faulk and Smolira (2009) does not consider the retirement phase *per se*, it provides valuable insight into the impact and interactions of the pre-retirement phase decisions on the success of retirement withdrawals. Ervin *et al.* (2009) take the stance that the success or feasibility of sufficient retirement withdrawals is strongly influenced by the investment horizon. Similarly, Pfau (2010) concludes that the longer the pre-retirement phase and the longer the pre-retirement phase compared with the retirement phase specifically, the greater the chance of success. It would seem that the longer the investment horizon, the better the accumulation wealth achieved (Ervin *et al.*, 2009; Pfau, 2010).

The notion that one should start to save towards retirement as soon as possible is challenged by Hanna, Fan and Chang (1995), who argue that the future income pattern of the individual and his or her risk tolerance should determine the level of savings. All the previous studies mentioned were published later, assumed a constant growth rate in wages and did not consider the risk tolerance of the individual, challenging Hanna *et al.* (1995).

2.4.2 CONTRIBUTION RATE

As the life cycle hypothesis suggests, an individual saves today for future post-retirement consumption. An individual must therefore decide how much of his or her disposable income is saved today for this purpose. Intuitively, the more money one saves, the greater the accumulation of wealth should be.

Supporting evidence is provided by Lewis (2008b), who not only evaluates the impact of time on accumulated retirement ending wealth, but also the impact of contribution rates. The results support the notion that the higher the contribution rate, all other factors held constant, the greater the median accumulated retirement ending wealth and hence replacement ratio that can be achieved (see Figure 2-2). For the aggressive

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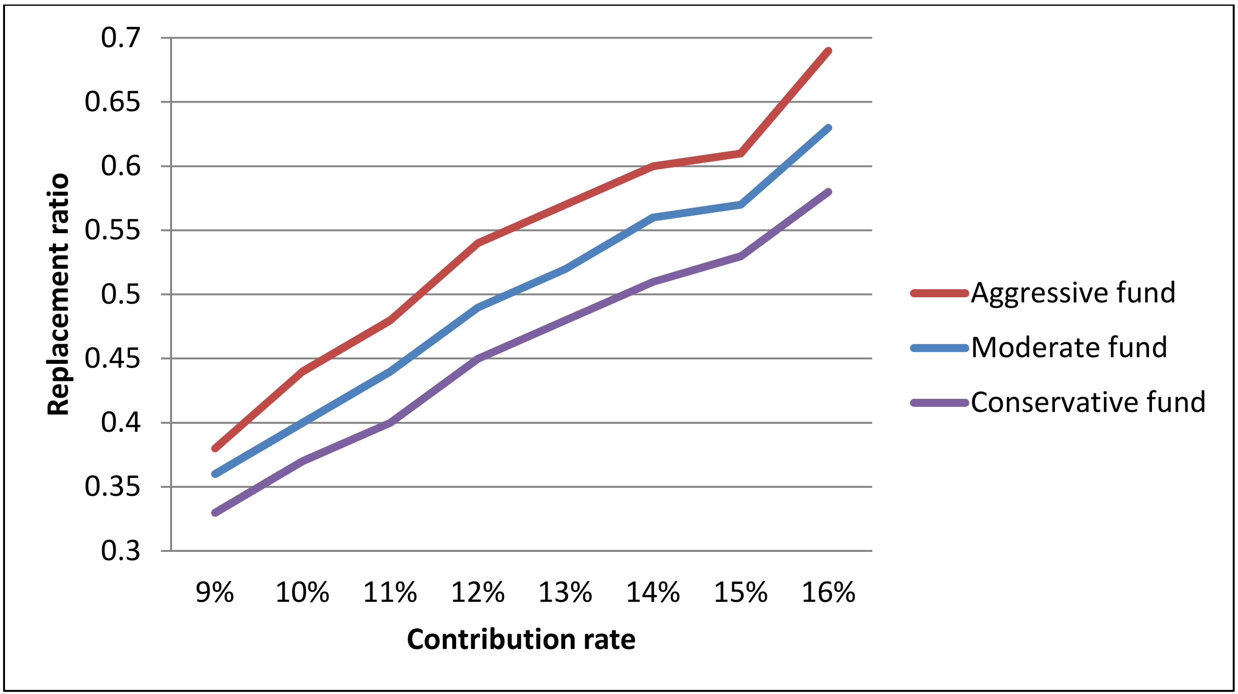
fund, the replacement ratio ranges from 0.38 to 0.69, the moderate fund from 0.36 to 0.63 and the conservative fund from 0.33 to 0.58. Additionally, the results support the notion that asset allocation matters. However, this is discussed in a later section (Section 2.4.3: ASSET ALLOCATION).

The research by Ervin *et al.* (2009) referred to earlier, and which is supported by Pfau's (2010) research, concurs that the higher the pre-retirement phase savings rate or contribution rate, the greater the chances of success to meet an adequate replacement ratio.

Figure 2-2: Median replacement ratio for different contribution rates



Source: Lewis (2008b)

However, Blake, Wright and Zhang (2011), in line with Hanna *et al.* (1995), state that an ideal funding strategy could result in a contribution rate that varies. In these circumstances, the contribution rate would be age-dependent and a function of the individual's willingness to accept risk, the magnitude of human capital and the goal to achieve constant consumption over the life cycle. Schleef and Eisinger (2007) advocate a strategy that invests the lowest contribution rate required (hence a variable

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rate) to achieve the retirement target as set by the individual as opposed to a constant *real* contribution, which they postulate has a much greater risk of not achieving the retirement target. Schleef and Eisinger (2007) state that the individual faces one of two risks: either a fluctuation in contribution rates or the risk of not having sufficient retirement ending wealth when maintaining constant contribution rates. However, Schleef and Eisinger (2007) caution that the performance of the portfolios depends heavily on the asset mix of the portfolio.

Byrne *et al.* (2006) allude to the interaction between delaying retirement and required contribution rates. Their study shows that should saving for retirement be delayed, it may result in an unrealistically high required contribution rate to ensure an adequate retirement (measured by the replacement ratio that can be achieved). They concede that such high contribution rates may be unattainable for low and medium earners.

Should an individual receive tax benefits for saving towards retirement, as is the case with retirement funds, one would expect the rational individual to take full advantage of these benefits (Attanasio, Banks & Wakefield, 2004). The following section discusses the tax implications of retirement funds and direct investment contributions from the perspective of a South African investor.

2.4.2.1 Tax implications

An individual can choose to save towards retirement by directly investing in financial markets or through retirement funds. Currently, the tax treatment of provident fund, pension fund and retirement annuity contributions is dissimilar. The National Treasury of South Africa (2013b) proposed retirement reforms to harmonise the tax treatment of retirement funds, which resulted in revisions to how contributions and retirement cash withdrawals were treated. The treatment of cash withdrawals at retirement is a consequence of how contributions are treated and is discussed in Section 2.4.2.1 b.

Following is a description of how contributions to direct investments are treated followed by the tax treatment of retirement fund contributions. The tax treatment of retirement fund contributions discusses the *status quo* of contributions and cash

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withdrawals, followed by the retirement reform proposals and an outline of what the future practice entails.

2.4.2.1.1 Direct investments

Contributions by an individual to a fund that does not fall within the scope of the Pension Funds Act are not tax deductible. Such contributions cannot be deducted from the taxable income of the individual and therefore, effectively, are after-tax contributions, which do not provide any tax benefits. However, the individual has full discretion regarding the asset allocation of such funds, which is not the case for retirement funds. This aspect is discussed in the section on asset allocation (Section 2.4.3).

2.4.2.1.2 Retirement funds

a. Contributions

According to the Income Tax Act the tax treatment of contributions to pension funds, provident funds and retirement annuities currently differs. Employer contributions to pension and provident funds are not taxed and employers could receive an annual tax deduction for employer contributions to a maximum of 20 per cent of the so-called 'approved remuneration' of each employee (KPMG., 2013).

Employee contributions to pension funds and retirement annuities are tax deductible in terms of Section 11(k) and 11(n) of the Income Tax Act (Stiglingh, Koekemoer, Van Schalkwyk, Wilcocks & De Swardt, 2013). However, the Income Tax Act places an upper limit on the amount that can be deducted for both pension fund and retirement annuity contributions. Any pension fund contribution is limited to a maximum of R1 750 or 7.5 per cent of the individual's retirement funding employment, capped at a maximum of actual contributions, while the deduction allowed for a retirement annuity is the maximum of R1 750 or R3 500 minus deductions allowed for the year for the pension fund contributions; or 15 per cent of income that falls within the definition of the Income Tax Act (Stiglingh *et al.*, 2013). In contrast, employee contributions to provident funds are not tax deductible (Stiglingh *et al.*, 2013) (Table 2-1).

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Consequently, withdrawals of cash amounts at retirement are also treated differently and discussed in the subsequent section.

Table 2-1: Allowable deduction of retirement fund contributions annually

	Pension fund	Provident fund	Retirement annuity
Employee contributions	Maximum of: • R1 750; or • 7.5% of income resulting from the "retirement funding employment" The deduction is capped at the value of actual contributions	No tax deduction	Maximum of: • R1 750; or • R3 500 minus deductions allowed for the year for pension fund contributions; or • 15% of income as defined for the purposes of the calculation
Employer contributions	• Not taxed in the hands of the employee • Approved employer deduction of 20 per cent of employee remuneration		Not applicable

Source: Stiglingh *et al.* (2013:337)

b. Retirement withdrawals and annuitisation

The tax treatment for retirement annuities, provident funds and pension funds differs regarding any lump sum withdrawals at retirement in terms of Section 1(c)(ii)(dd) and Section 1(b)(ii) of the Income Tax Act.

Both retirement annuities and pension funds allow an individual to only take one third of the retirement benefit in cash while the remaining two thirds must be annuitised. Section 1, Paragraph (c)(ii)(dd) of the Income Tax Act specifically states: "…that no more than one-third of the total value of the retirement interest may be commuted for a single payment and that the remainder must be paid in the form of an annuity (including a living annuity) except where two-thirds of the total value does not exceed R75 000". However, the annuitisation requirement does not apply to provident funds and therefore the full retirement benefit can be taken in cash.

However, the link between the tax treatment of the contributions and cash withdrawals does not only vest in the annuitisation requirement that differs but also in the impact of allowable deductions from any cash withdrawals (whether one third of the retirement

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benefit as is the case with pension funds and retirement annuities or the full amount as with a provident fund). The lump sum taxable amount is defined in Schedule 2, Paragraph 2(1)(a)(i) and 5 and include a number of allowable deductions.

Most importantly, any contributions to the retirement fund that were not previously allowed as a deduction against taxable income can be deducted from the taxable amount at retirement. As no member contributions to provident funds are currently (or were in the past) tax deductible, all contributions may be deducted in determining the taxable income at retirement, which is not the case with a pension fund or retirement annuity. In essence, the tax benefit of the member contribution to a provident fund is therefore delayed until retirement.

c. Retirement reform proposals

The proposed retirement fund reforms deal with a number of issues specific to the retirement industry in South Africa. One of the proposals deals with harmonising the tax treatment of all retirement funds, which will remedy the current inconsistent practices and inequitable treatment (National Treasury of South Africa, 2012a, 2013b).

Additionally, the reforms also aim to revise the cash withdrawal principles. The National Treasury of South Africa (2012c) has a particular concern over how the current lump sum or cash withdrawal benefits applicable to provident funds worsen inadequate retirement provision. Many provident fund members do not annuitise any of their retirement wealth taking the full retirement benefit in cash. Such members often deplete their assets very quickly, becoming reliant on the state or family (National Treasury of South Africa, 2012c).

As the tax treatment of contributions and lump sum benefits is linked, both aspects are dealt with in the reform proposals, which originally had a proposed implementation date of 1 March 2016 (National Treasury of South Africa, 2014b). The implementation date has recently (27 October 2015) been re-opened for discussion, which may result in delayed implementation or a phased approach being followed (National Treasury of South Africa, 2015b). The proposals are applicable to all new contributions to

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retirement funds while vested rights have been protected (National Treasury of South Africa, 2014a). The following aspects pertain specifically to the treatment of contributions (Table 2-2) (National Treasury of South Africa, 2013b):

- All retirement fund contributions will qualify for a tax deduction, unifying the tax treatment of retirement funds (therefore, no distinction will be required between a pension fund, provident fund or retirement annuity for the purposes of the research).
- Employer contributions to all retirement funds will become a fringe benefit in the hands of the employee.
- However, the above is complemented with an increase in the tax deduction that an individual receives for a retirement fund. The tax deduction is increased to 27.5 per cent of the maximum of remuneration and taxable income;
- A maximum tax deduction of R350 000 will be allowed in any one financial year.
- Unused deductions may be rolled over to be used in a subsequent financial year.

Additionally, the National Treasury of South Africa (2012c) also proposed to unify the treatment of the annuitisation requirements of provident funds to be similar to that of pension funds and retirement annuities as described in the previous section with an implementation date that coincides with the changes in the tax treatment of contributions. The proposed annuitisation requirements are consequently the guiding principles for this research.

d. Future tax treatment

Given the implementation date of 1 March 2016 regarding the retirement reform proposals on the tax treatment of retirement fund contributions and annuitisation requirements, Table 2-2 summarises the legislation before and after implementation of the retirement reform proposals as discussed in the previous sections.

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Table 2-2: Impact of retirement reform proposals

Employee contributions			
	Pension fund	**Provident fund**	**Retirement annuity**
Current treatment	Maximum of: • R1 750; or • 7.5% of income resulting from the "retirement funding employment" The deduction is capped at the value of actual contributions	No tax deduction	Maximum of: • R1 750; or • R3 500 minus deductions allowed for the year for pension fund contributions; or • 15% of income as defined for the purposes of the calculation
Effective 1 March 2016	• Employer contributions to all retirement funds are a fringe benefit in the hands of the employee. • The employee may deduct up to 27.5 per cent of the maximum of remuneration and taxable income. • The 27.5 per cent limit applies to aggregate contributions to retirement funds. • A maximum tax deduction of R350 000 will be allowed in any one financial year. • Unused deductions may be rolled over to be used in a subsequent financial year.		
At retirement treatment			
	Pension fund	**Provident fund**	**Retirement annuity**
Current treatment	Maximum of one third of retirement benefit may be taken in cash. Minimum of two thirds must be annuitised. Compulsory annuitisation applies to fund balances (i.e. after deduction of one third in cash) above R75 000.	Full retirement benefit may be taken in cash. No annuitisation requirement applies.	Maximum of one third of retirement benefit may be taken in cash. Minimum of two thirds must be annuitised. Compulsory annuitisation applies to fund balances (i.e. after deduction of one third in cash) above R75 000.
Effective 1 March 2016	Maximum of one third of retirement benefit may be taken in cash. Minimum of two thirds must be annuitised. Compulsory annuitisation applies to fund balances (i.e. after deduction of one third in cash) above R150 000. (above applies to provident funds net of vested rights)		

Source: National Treasury of South Africa (2012c, 2013b)

As these changes will take effect in the near future, a distinction between pension funds, retirement annuities and provident funds is not necessary. This being said, the recommended changes protect the vested rights of provident funds, meaning that individuals who made contributions, which were not tax deductible, to a provident fund in the past will still receive the tax benefit at retirement. Consequently, going forward, retirement funds can, for the purposes of the research, be used as a collective and one set of principles applied to any modelling in this study.

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2.4.3 ASSET ALLOCATION

The asset allocation decision has a significant influence on the overall performance of a portfolio. According to Brinson, Hood and Beebower (1986), 93.6 per cent of the variation of portfolio performance over time can be explained by the asset allocation.

Markowitz (1952) advise that by combining different assets, the return of a portfolio can be enhanced for each level of risk. Consequently, the most appropriate asset allocation for an individual is a function of the risk and return objective with consideration given to any constraints such as liquidity, time horizon, taxes, legal and regulatory issues and any other unique circumstances (Maginn, Tuttle, Pinto & McLeavey, 2007).

However, individuals struggle with choosing the most suitable asset allocation initially and adjusting it appropriately over the investment horizon as their objectives change (Madrian & Shea, 2001). Bodie and Treussard (2007) add that this may be caused by insufficient knowledge to choose rationally among options, finding the decision too time consuming or simply feeling an aversion to such a decision. Behavioural studies offer supporting evidence for the reasons why people struggle with the asset allocation decision, but falls outside the scope of this research (see Conlisk, 1996; Kahneman, 2003; Mitchell & Utkus, 2004; Simon, 1972). Suffice it to say, individuals do not always make good, rational asset allocation choices.

Consequently, this research focuses on creating a framework for the impact of different asset allocations and asset allocation strategies on accumulated retirement ending wealth and is not concerned with the uniqueness of the individual *per se*.

Much of the research regarding retirement wealth focuses on a comparison of the following asset allocation strategies on accumulated retirement ending wealth:

- funds consisting of only one asset class (equities, bonds or treasury bills);
- funds consisting of a combination of asset classes with the allocation unchanged over the investment horizon (balanced or target risk funds); or

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- funds consisting of a combination of asset classes with the allocation to equities reduced during the investment horizon (life cycle or target date funds).

The following section focuses on the characteristics of traditional asset classes and the impact of various asset allocation strategies on accumulated retirement ending wealth, after which regulatory matters that impact on asset allocations in the retirement savings environment will be discussed.

2.4.3.1 Asset class characteristics

Because this research is concerned with funds constructed from traditional asset classes, what follows particularly deals with the risk and return characteristics of equities, the fixed income asset class and money market asset class over various investment horizons.

Firstly, research by Dimson, Marsh and Staunton (2011) is presented, which provides insight into the return characteristics of asset classes in 19 countries. Characteristics of the South African market are presented next.

According to Dimson, Marsh and Staunton (2000), US equities outperformed both the fixed income and money market asset classes over the period 1900 to 2000 with equities achieving a nominal geometric return of 10.3 per cent, while fixed income and money market only delivered 4.7 and 4.3 per cent respectively. Equities were the highest risk asset class with an annualised standard deviation of 20 per cent, with the standard deviation for fixed income and money market at 8.1 and 2.8 per cent respectively.

Dimson *et al.* (2011) offer supporting evidence regarding the performance of asset class returns for 19 countries and three proxy indices for Europe, the world and the world ex-US for the period 1900 to 2010: equities offered the highest real return, followed by fixed income and, lastly, money market (irrespective of the country or index) (see Figure 2-3). The annualised real returns achieved for US equities, fixed income and money market over the longer historical period were 6.3, 1.8 and 1 per

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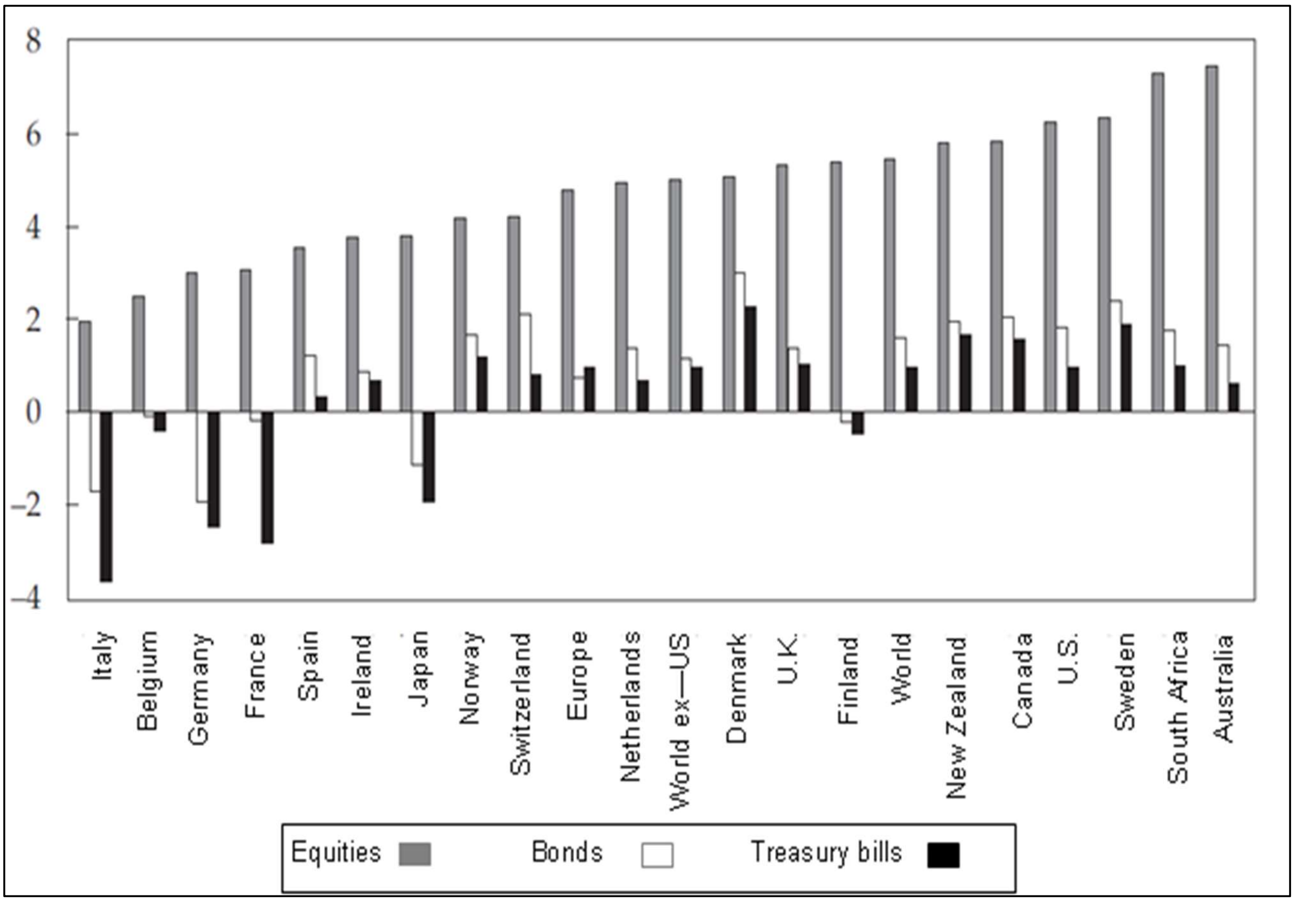
cent respectively. Dimson *et al.* (2011) add that, for all countries, equities are still the highest risk asset class followed by fixed income and money market.

Figure 2-3: Real annualised returns (1900-2010)



Source: Dimson *et al.* (2011)

Firer and McLeod (1999) and Firer and Staunton (2002) evaluate the risk and return characteristics of the South African equity, fixed income and money market asset classes over a long historical period. While Firer and McLeod (1999) used data from 1925 to 1998, Firer and Staunton (2002) used data from 1900 to 2001.

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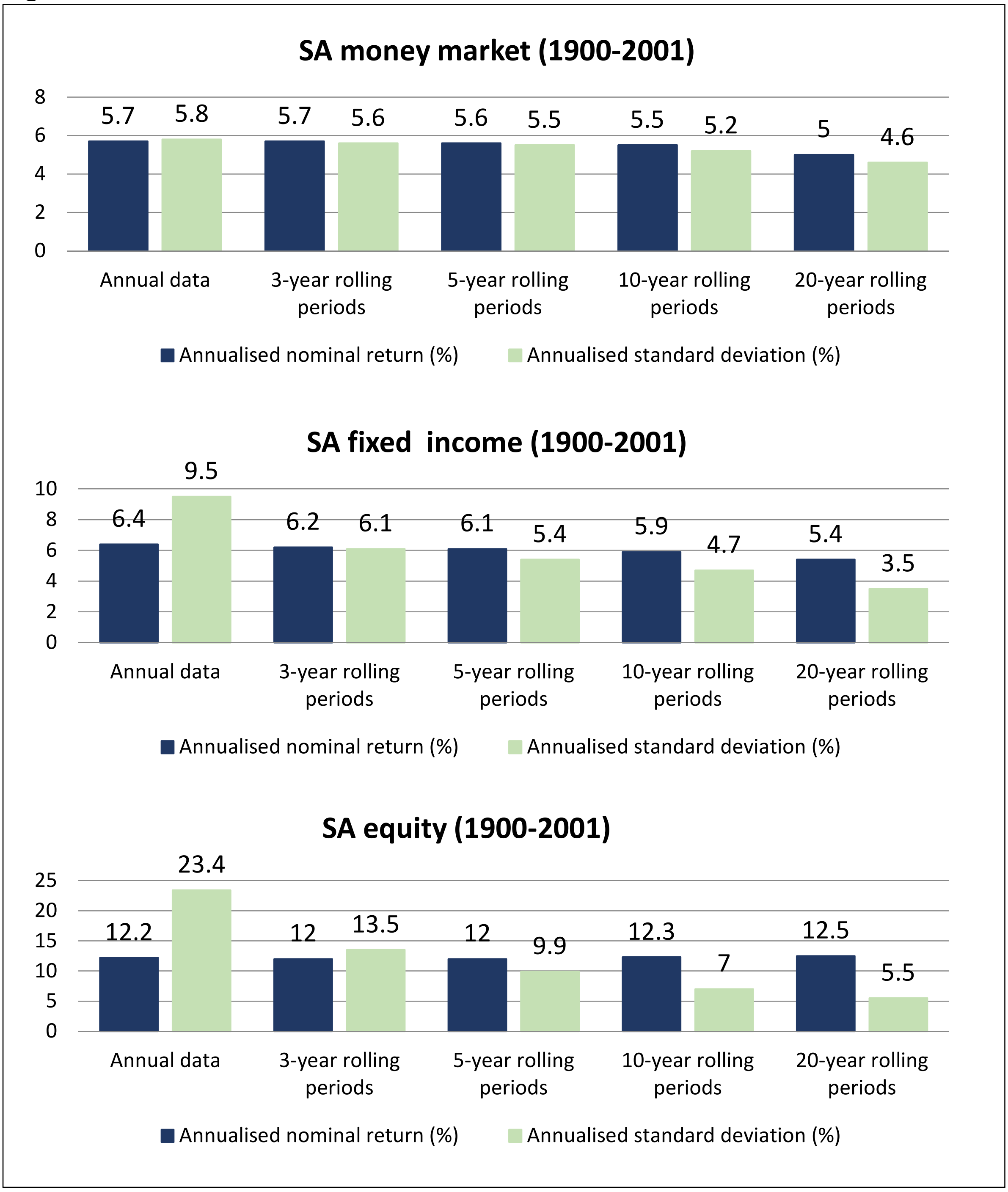
Figure 2-4: SA asset class returns



Source: Firer and Staunton (2002)

An important observation, for all three asset classes, is that it holds true that the longer the investment horizon, the lower the volatility (see Figure 2-4).

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Despite the different historical periods, both studies conclude that equity remains the higher risk-return asset class, followed by fixed income and money market. Equity outperforms notably with annualised returns of between 12 and 12.5 per cent depending on the investment horizon (annualised standard deviation of 5.5 to 23.4 per cent). The fixed income asset class is slightly less risky with lower return potential offering an annualised return of 5.4 to 6.4 per cent and standard deviation of 3.5 to 9.5 per cent. The annualised return for money market is between 5 and 5.7 per cent with an annualised standard deviation of between 4.6 and 5.8 per cent depending on the investment horizon.

The data presented in Figure 2-4 shows that the longer the rolling periods for which the annualised mean and standard deviation are shown, the lower the risk and return exhibited because the method of using longer rolling periods has a smoothing effect on the results. The annualised mean and standard deviation of the annual data for each asset class will be compared with the annualised mean and standard deviation of the historical data which is used in Chapter 4 of the study; as Shiller (2006) warns, historical risk and return is not necessarily a reflection of the future.

All the studies in this section suggest that should someone attempt to accumulate maximum wealth, the best strategy is to be fully invested in equities as this asset class provides the highest annualised return. However, this does not consider the risk of the asset class or risk tolerance of the individual.

As life cycle funds have grown significantly (Lewis, 2008c), the next section is dedicated to a discussion of this particular type of fund followed by research on how different asset allocation strategies perform in the pre-retirement phase.

2.4.3.2 Life cycle funds

Gains and Naismith (2012) describe *life cycle investing* as the process of moving assets from higher risk to lower risk asset classes as the individual advances towards retirement in an attempt to preserve retirement ending wealth (Basu *et al.*, 2011; Lewis, 2008b, 2008c; Spitzer & Singh, 2011). Life cycle funds adjust equity exposure

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to lower the risk of a portfolio, that is, offer downside protection (Branch & Qiu, 2011). Traditional life cycle finance suggests switching out of higher risk asset classes considering only the age and investment horizon of an individual while modern life cycle theory suggests that the switch should also consider other factors such as an individual's risk tolerance (Bodie & Treussard, 2007).

Gains and Naismith (2012) highlight the advantages and disadvantages of lifestyling (Table 2-3). Although lifestyling provides protection from capital losses that are more likely with greater allocation to high-risk asset classes, it may fail to exploit the opportunities of capital growth. However, lifestyling offers the individual peace of mind as he or she is not responsible for the asset allocation decision. It may nevertheless lead to complacency and apathy on the part of the individual as the responsibility of decision-making is taken out of his or her hands. Further weaknesses are that the fund assumes homogeneous participants in terms of age and risk profile with a similar retirement date. As the life cycle process is mechanical and related to age, market conditions are ignored. Gains and Naismith (2012) also caution that should lifestyling be incorporated over a long time period, it may decrease the potential overall returns achieved. Furthermore, it is not suited when phased retirement[4] is considered because the retirement date is not definitive or in circumstances where income drawdown as a post-retirement product is considered.

[4] This is an option available in the UK whereby the purchase of an annuity, which in most cases is compulsory for at least a portion of retirement wealth in a retirement fund, is not required to take place at retirement and can be deferred indefinitely (Gains & Naismith, 2012).

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Table 2-3: Advantages and disadvantages of lifestyling

Disadvantages	Advantages
Assumes that individuals of the same age have a similar risk profile	Provides downside protection from capital depreciation of high-risk asset classes as retirement approaches
Lifestyle choices assume a particular retirement date, which may not be feasible	If the option is chosen at the beginning, it reduces individual involvement as switching happens automatically
May fail to take advantage of capital growth delivered by higher risk asset classes such as equities	Appropriate for the lower risk profile that several individuals move towards as they grow older
Decision-making is not in the hands of the individual	
A long period over which lifestyling is incorporated may decrease possible overall returns	
As the process is specific in its structure, it ignores market conditions and timing.	
It is not suited when phased retirement is considered	
It is not suited if income drawdown is considered as post-retirement product	
Individual contentment, which leads to apathy	

Source: Gains and Naismith (2012:369-370)

Different glide paths[5] are used for life cycle funds. Some researchers reduce the allocation to equities linearly over the full investment horizon (Lewis, 2008b, 2008c; Pang & Warshawsky, 2011; Schleef & Eisinger, 2007), however, Branch and Qiu (2011) and Spitzer and Singh (2011) also model a life cycle fund that only starts to decrease equities 15 years into the original 40-year investment horizon. The results of the late descent life cycle fund modelled in the latter two studies, offer slightly worse downside protection, a somewhat better mean accumulated wealth but significantly higher upside potential showing how important the length of the glide path is.

Despite conceptual academic support for the modern life cycle theory, most life cycle retirement funds offered are traditional funds, reducing the asset allocation to risky assets based only on age (Spitzer & Singh, 2011). Mutual fund or pension fund life cycle funds have therefore become popular in the retirement fund offering because

[5] The glide path refers to the time period over which there is a switch to a different (usually less risky) asset allocation in a life cycle fund. It can take different forms although a linear glide path is commonly used in the literature.

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the individual does not have to make the asset allocation and switching decisions as the fund does so automatically – his or her only decision is choosing the appropriate life cycle fund given his or her expected retirement date (Basu *et al.*, 2011; Basu & Drew, 2009; Estrada, 2013; Lewis, 2008a, 2008b, 2008c; Spitzer & Singh, 2008, 2011). However, the downside of the homogeneous offering is that it cannot accommodate individual risk tolerance (Lewis, 2008c). Should an individual retain more discretion, as would be the case with direct investments, a unique glide path is possible.

To this end, Boscaljon (2011) describes the glide path period as a separate phase between the accumulation and retirement phase during which the focus shifts from specifically *maximising* wealth to *optimising* wealth and in some of his analysis, he considers the impact of human capital. Boscaljon (2011) adjusts only the level of equity exposure in a fund which is modelled as a factor of the individual risk tolerance; the more risk tolerant, the higher the allocation to equities at the onset of the pre-retirement phase. Importantly, the intent is consistently to have an equity exposure of 50 per cent at the beginning of the retirement phase (Boscaljon, 2011). The important contribution of the research is that the glide path phase should only commence once a critical wealth level has been reached, which is specific to the individual, and should not simply be based on age or remaining years until retirement (Boscaljon, 2011). Fullmer and Tzitzouris (2014) state that the challenge in choosing an appropriate glide path for a life cycle fund lies in balancing the trade-off between maximising accumulated wealth and limiting the risk of capital loss as retirement approaches. Although the findings of Boscaljon (2011) provide valuable insight into the glide path dilemma, the matter of human capital, unique risk tolerance and retirement targeting falls outside the scope of this study.

Table 2-4 summarises a number of studies found in the literature and the characteristics of the life cycle funds strategies modelled, including the choice of glide path.

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Table 2-4: Life cycle fund structures in the literature

Research	Starting equity allocation	Investment horizon (years)	Glide path	Equity target at retirement
Basu and Drew (2009) and Pfau (2011b)	100%	40	Gradual linear decline in last 20 years	0%
	100%	40	Gradual linear decline in last 15 years	0%
	100%	40	Gradual linear decline in last 10 years	0%
	100%	40	Gradual linear decline in last 5 years	0%
Basu *et al.* (2011)	100%	40	Gradual linear decline in last 10 years	0%
	100%	40	Gradual linear decline in last 20 years	0%
Branch and Qiu (2011)	90%	40	Gradual linear decline over 40 years	50%
	90%	40	Gradual linear decline over last 25 years	50%
Byrne *et al.* (2006)	100 minus age	Modelled for 10, 20, 30 and 40	Gradual decline based on 100 minus age	100 minus age
Estrada (2013)	100%	40	Gradual linear decline over full investment horizon	0%
	90%	40	Gradual linear decline over full investment horizon	10%
	80%	40	Gradual linear decline over full investment horizon	20%
	70%	40	Gradual linear decline over full investment horizon	30%
	60%	40	Gradual linear decline over full investment horizon	40%
Lewis (2008a, 2008b, 2008c)	100%	35	Gradual linear decline over full investment horizon	50%
	90%	35	Gradual linear decline over full investment horizon	40%
	80%	35	Gradual linear decline over full investment horizon	30%
Pfau (2010)	90/7/3*	40	Gradual linear decline over last 20 years	55/31.5/13.5*
	90/7/3*	40	Gradual linear decline over full investment period	52.5/33.25/14.25*
	85/10.5/4.5*	40	Gradual linear decline over last 20 years	30/49/21*
	90/7/3*	40	Gradual linear decline over full investment period	32.5/47.25/20.25*
Schleef and Eisinger (2007)	78%	30	Gradual linear decline over full investment horizon	60%
	85%	30	Gradual linear decline over full investment horizon	60%
	78%	30	Gradual linear decline over full investment horizon	40%
	85%	30	Gradual linear decline over full investment horizon	40%
Shiller (2006)	85%	44 (retirement age 65)	Gradual linear decline from age 29 to 60	15% at age 60 maintained till age 65
	70%	44 (retirement age 65)	Gradual linear decline from age 29 to 60	10% at age 60 maintained till age 65
	90%	44 (retirement age 65)	Gradual linear decline from age 29 to 60	40% at age 60 maintained till age 65
Spitzer and Singh (2011)	90%	40 years	Gradual linear decline in last 25 years	50%
	90%	40 years	Gradual linear decline over full investment horizon	50%
*Equity/fixed income/money market asset allocation percentage				

As is evident from Table 2-4, there is no consistency regarding the glide path followed, although the majority of academic studies follow a glide path over the full investment horizon.

2.4.3.3 Comparison of asset allocation strategies

As previously mentioned, an individual can choose to invest in only one asset class, create a balanced fund or invest in a life cycle strategy. In the context of the pre-retirement phase, whatever strategy an individual chooses should be appropriate in terms of risk while balancing the adequacy requirement of retirement savings. This section focuses on how different asset allocation strategies impact accumulated retirement wealth.

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In his research, Shiller (2006) considers three life cycle portfolios, namely a bond portfolio, a 50/50 bond-equity portfolio and a 100 per cent equity portfolio. The life cycle funds are as follows (Shiller, 2006):

- a baseline fund with 85 per cent in equities to age 29, when it drops linearly to 15 per cent by age 60;
- a conservative fund, which follows the same equity allocation pattern as the baseline portfolio but starts with an equity allocation of 70 per cent and ends with 10 per cent; and
- an aggressive fund, which again follows the same equity pattern but commences with 90 per cent equity and falls to 40 per cent equities.

The results show that the 100 per cent equity portfolio offered does not only result in the highest mean accumulated ending wealth but also the highest minimum value. On the other hand, the equity portfolio exhibits the largest range of possible outcomes. Of the life cycle funds, the aggressive fund seems to offer the better mean accumulated ending wealth (see Figure 2-5) (Shiller, 2006).

However, Shiller's (2006) research has certain shortcomings. He warns that future returns for the US asset classes may be lower than what the case was in the historical period covered (1871 to 2004). Additionally, the study is based on only 91 simulations representing 44-year rolling periods.

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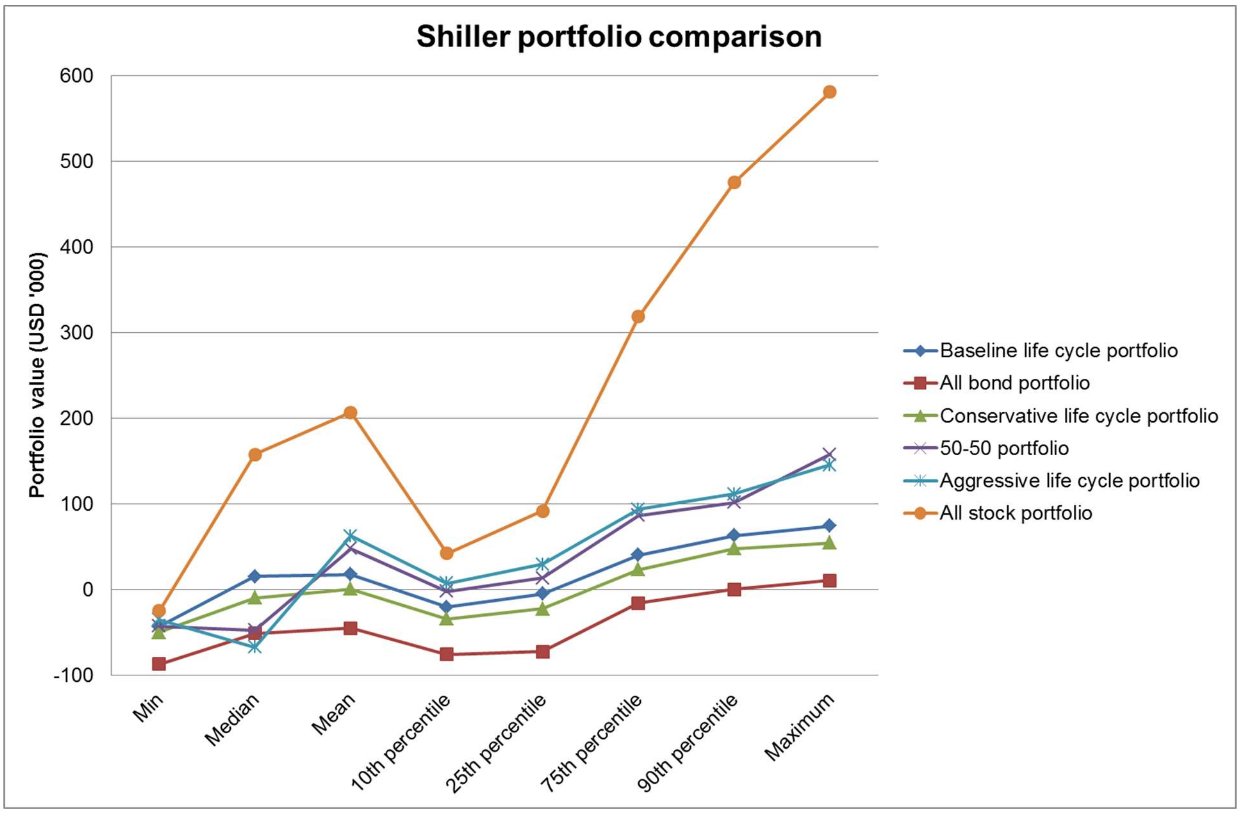
Figure 2-5: Shiller accumulated wealth outcomes



Source: Shiller (2006)

Ervin *et al.* (2009) take the stance that the success or feasibility of sufficient retirement withdrawals is strongly influenced by the asset allocation, investment horizon and savings rate during the pre-retirement phase. Similar to Lewis (2008b), Ervin *et al.* (2009) focus on replacement ratio. They evaluate what the success rate of various asset allocations, time horizons and savings rates are to achieve an income replacement ratio of 80 per cent. The results indicate that the savings rate would have to be increased for risk-averse individuals with lower equity exposure. The following valuable conclusions are drawn:

- The longer the pre-retirement phase, and the longer the pre-retirement phase compared with the retirement phase, the greater the chance of success.
- The higher the pre-retirement phase savings rate, the greater the chances of success.
- The higher the asset allocation to equities, the greater the chance of success.

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Booth (2004) uses a slightly different approach. His research focuses on choosing an asset allocation strategy that would result in a 70 per cent chance of reaching the required accumulated retirement wealth to sustain the individual through the retirement years. Booth (2004) argues that the terminal wealth will always increase with the allocation to equities, but beyond a certain point, the likelihood of meeting a specific target starts to decrease due to the changes in the distribution of terminal wealth. Furthermore, if an individual is primarily concerned with the shortfall risk of accumulated retirement wealth, more equities may be viewed as a lower risk choice as this asset class delivers higher returns and a greater chance of meeting retirement targets. *Shortfall risk* is defined as “the probability that accumulated savings at retirement fail to be sufficient to generate a minimally acceptable retirement income” (Lewis, 2008a:16). Additionally, because the asset allocation is a function of the investment horizon and age, the findings support the notion of an equity allocation of 100 minus one’s age (Booth, 2004). Booth’s (2004) research concludes that the investment horizon and age of the individual influence the asset allocation decision and terminal wealth.

Booth (2004) adds that the unpredictability of annual rates of return further influences the distribution of the accumulated retirement wealth. Similar to other studies, the distribution is skewed to the right and leptokurtic (Lewis, 2008c). Booth (2004) shows that as the volatility of returns increase, the distribution becomes even more skewed away from what is expected. Hence the greater the allocation to equities (the higher risk and return asset class), the more extreme the effect on the distribution (Booth, 2004).

Spitzer and Singh (2011) use bootstrap Monte Carlo simulations to model different asset allocation strategies and run 10 000 simulations of each strategy. This is more robust than the research of Shiller (2006), which used a 44-year investment horizon and was limited to 91 rolling return periods. The results reiterate that a 100 per cent equity portfolio results in the highest mean accumulated retirement wealth compared with any balanced or life cycle fund (Byrne *et al.*, 2006; Estrada, 2013). Intuitively, this is also the case when compared with a fixed income and money market fund.

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However, the distribution and range of the ending wealth simulations are much larger for equity than for any other portfolio (Spitzer & Singh, 2011).

Byrne *et al.* (2006) compare how a 100 per cent bond, 100 per cent equity, balanced fund (60 per cent equity, 40 per cent bonds) and a life cycle fund (100 per cent equity minus the individual's age over the investment horizon) impact accumulated retirement ending wealth. The equity portfolio consistently offers a higher mean replacement ratio irrespective of the investment horizon, followed by the life cycle fund. As expected, the bond fund with no equity exposure performs the worst. An important observation is that the shorter the investment horizon, the less profound the benefit of including equity in the portfolio.

In contrast, the results of Spitzer and Singh (2011) indicate that neither of the life cycle portfolios modelled outperformed a balanced portfolio with an allocation to equities of equal to or greater than 80 per cent and all the models exhibited right-skewness or were positively skewed (the mean exceeding the median) similar to the findings of Pfau (2010). It is important to note that Spitzer and Singh (2011) focus on achieving the highest mean ending wealth and do not consider the range of possible outcomes or the risk exhibited by each strategy.

However, it is important to highlight how the construction of the life cycle portfolios in Spitzer and Singh's (2011) research differ from that of Byrne *et al.* (2006). The two life cycle models simulated have the following structure: the first model has a 90 per cent allocation to equities, which decreased in the last 25 years to 50 per cent (late descent portfolio), while the second model has 90 per cent initially invested in equities, which falls linearly to 50 per cent over a 40-year period (early descent portfolio) with an investment horizon of 40 years for both portfolios (Spitzer & Singh, 2011). The mean accumulated retirement wealth of the two models is superior to balanced funds with an allocation lower or equal to 60 per cent. The early descent model also outperforms the 70 per cent equity portfolio while the late decent portfolio fails to do so (Spitzer & Singh, 2011). As discussed previously, this highlights that the beginning and ending

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equity allocations over the investment horizon along with how aggressive the glide path is, are important factors which determine the success of a life cycle strategy.

Similarly, Branch and Qiu (2011) compare various undiversified, balanced and life cycle funds based on the accumulated ending wealth as well as risk-adjusted measures, namely the Sharpe and Treynor ratios. The two life cycle strategies follow different glide paths; the gentle descent (GD) fund reduces equity from 90 per cent to 50 per cent over the full investment horizon while the steep descent (SD) fund only does so in the last 25 years. As would be expected, the higher the allocation to equities in a fund, the better the mean retirement wealth accumulation that can be achieved but also the greater the standard deviation.

Branch and Qiu (2011) used different methods to compare the strategies, which influenced how the life cycle strategies fared (Table 2-5). Generally, the strategies do not outperform funds with an allocation of 70 per cent or more to equities. However, the risk-adjusted returns indicate that the target strategies may be preferable on a risk-adjusted basis to all lower equity funds. The GD target date strategy generally outperforms funds with an equity allocation of less than 70 per cent while the SD target date strategy outperforms funds with an equity allocation of less than 80 per cent. However, the SD target date strategy is superior on a risk-adjusted basis when considering the Sharpe ratio (Branch & Qiu, 2011).

Pang and Warshawsky (2011) compare life cycle and balanced funds. The final wealth accumulations and distributions of all the life cycle models are greatly influenced by the initial asset allocation decision along with the assumptions of the glide path (when it commences, rate of change and intended retirement date asset mix). As the investment horizon of the models increase, the less profound the difference in mean retirement wealth accumulation is. Furthermore, Pang and Warshawsky (2011) state that exceptional economic catastrophes have a significant impact on the wealth accumulation of life cycle funds.

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Table 2-5: Fund comparison

GD target date strategy			
Method	**One-year bootstrapping**	**10-year bootstrapping**	**40-year rolling periods**
Mean accumulation wealth	Inferior to balanced funds with equity allocation of 70 per cent or more and SD target date fund.		
Sharpe ratio	Inferior only to funds with an equity allocation of 70 and 80 per cent and SD fund.	Inferior to funds with an equity allocation of 70 per cent or more and SD fund.	Inferior to funds with an equity allocation of 70 per cent or more and SD fund.
SD target date strategy			
Method	**One-year bootstrapping**	**10-year bootstrapping**	**40-year rolling periods**
Mean accumulation wealth	Inferior to funds with equity allocation of 80 per cent or more. Superior to GD target date fund.		
Sharpe ratio	Superior to all funds.	Inferior to funds with an equity allocation of 80 per cent or more.	Inferior to funds with an equity allocation of 90 per cent or more.

Source: Branch and Qiu (2011)

Similar to Byrne *et al.* (2006), the results in Pang and Warshawsky (2011) indicate that balanced funds tend to be riskier as evident in a wider range of retirement ending wealth values. However, the balanced funds offer similar mean accumulation wealth to life cycle funds in contrast to the findings of Byrne *et al.* (2006). Pang and Warshawsky (2011) deduce that this is the result of a higher asset base and income in later years with a higher allocation to equities compared with life cycle funds. Hence the lower income and accumulated assets in the early years, with the same asset mix as in later years, do not detract from the mean accumulation (Pang & Warshawsky, 2011).

Additionally, Byrne *et al.* (2006) also assess the interquartile value at risk (VAR) range for the replacement ratio (Figure 2-6). All the portfolios, irrespective of investment horizon, offer quite similar lower bounds (the 25th per centile figure) but show very different results for the 75th per centile. Focusing on savings from the age of 25, both the life cycle and balanced fund seem to offer a favourable risk-return profile with an

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interquartile range of 0.26 to 0.49 and 0.26 to 0.53 respectively, while offering a mean replacement ratio of 0.41 and 0.44 in turn. For equities, the 75th per centile and mean replacement ratio is much higher at 0.65 (25th per centile of 0.23) and 0.56.

Lewis (2008b) determines the efficacy of life cycle funds by focusing on the replacement ratio that can be achieved by different life cycle strategies. The so-called aggressive, moderate and conservative target date funds start out with 100, 90 and 80 per cent of the portfolio allocated to equities, which is linearly reduced to 50, 40 and 30 per cent respectively over the 35-year investment horizon. The median replacement ratio for each strategy is 0.38, 0.36 and 0.33 for the three target date strategies. However, the inter-quartile range of the replacement ratio for each portfolio offers valuable insights. For the aggressive portfolio, the range is 0.30 to 0.52, while the moderate portfolio is 0.29 to 0.46. As would be expected, the inter-quartile range for the lower risk conservative target date fund is 0.27 to 0.41. The results highlight the issue of how an individual views retirement wealth risk; if shortfall risk during retirement is perceived as being a greater risk, more aggressive strategies with higher allocations to equity might be preferable where the shortfall refers to accumulating less wealth than what was required at retirement.

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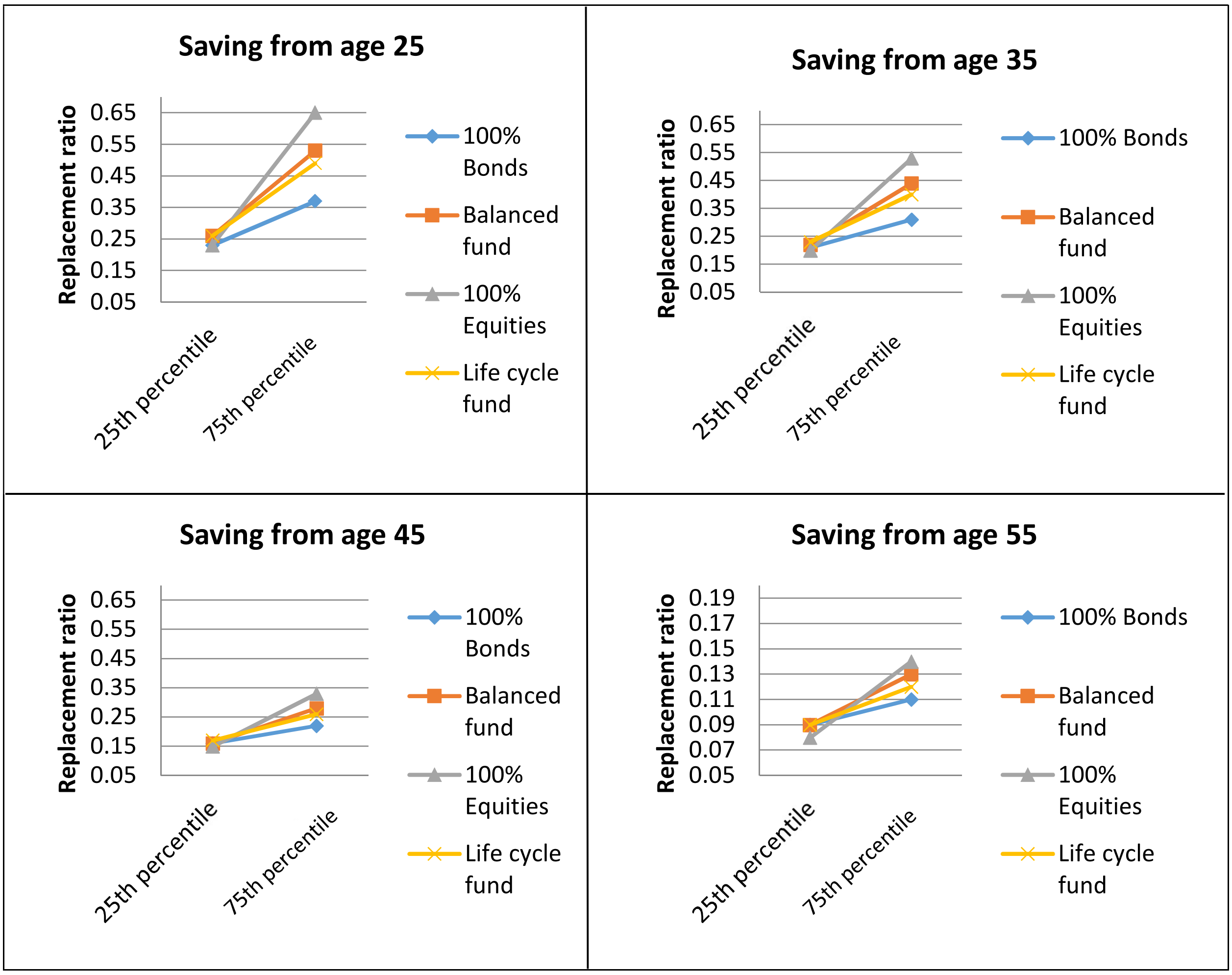
Figure 2-6: Interquartile VAR range



Source: Byrne *et al.* (2006)

Lewis (2008a) acknowledges that the intent of life cycle funds is to lower the likelihood of potential losses by decreasing the allocation to risky assets as retirement approaches. He determines the shortfall risk inherent in a variety of portfolio strategies. The three life cycle models proposed by Lewis (2008a) are similar to that of Lewis (2008b) and the results indicate that the aggressive portfolio results in the highest mean return of 7.2 per cent, with the moderate and conservative portfolios offering 6.7 and 6.3 per cent respectively (Lewis, 2008a).

Lewis (2008a) extends the analysis by determining the probability of shortfall at different income replacement ratios. The three portfolios exhibit a 34.7 per cent (aggressive), 43.8 per cent (moderate) and 58.6 per cent (conservative) probability of

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shortfall for an income replacement ratio of 0 to 0.5. Hence an individual who invests in the aggressive portfolio and pursues an income replacement ratio of 0.5 has a 34.7 per cent probability of shortfall or to put it another way, a 65.3 per cent chance of achieving the income replacement ratio objective. The results indicate that, if an individual views shortfall as the greatest risk, a higher allocation to low-risk asset classes may not be optimal despite the lower short-term volatility of the portfolio. Lewis (2008a) further indicates that an inverse relationship exists between the savings rate and probability of shortfall.

Lewis (2008c) compared balanced funds with life cycle funds with bootstrapping and Monte Carlo simulation (similar to Spitzer and Singh (2011) using similar life cycle strategies as in previous research. The aggressive portfolio exhibits the highest standard deviation and widest range of outcomes with the conservative portfolio exhibiting the lowest risk (standard deviation and range). Lewis (2008c) subsequently infers the average asset allocation to equity within each life cycle portfolio and simulates three comparable balanced funds. The results reveal the following: the average percentage of retirement salary which could be achieved by each of the resulting three portfolios is consistently higher for the balanced funds (Lewis, 2008c).

Lewis (2008c), similar to Spitzer and Singh (2011), finds that the distributions of results are not symmetrical. An additional observation is that although the skewness of the balanced and life cycle comparable funds is similar (and positively skewed), this is not the case for the kurtosis of the distribution of the proportion of final salary attainable for accumulated wealth. Although the kurtosis of the life cycle funds and balanced funds' distributions is positive, indicating a non-normal distribution which is leptokurtic, the kurtosis of the life cycle funds is consistently slightly higher than that of the comparable balanced funds (Field, 2013; Lewis, 2008c). Also noteworthy is that the minimum and maximum proportion of retirement wealth that could be obtained is higher for the balanced funds compared with the life cycle funds in Lewis (2008c). Although Basu *et al.* (2011) do not indicate the maximum and minimum accumulated retirement wealth for the balanced and life cycle strategies, they disclose the 75th per centile. The results of their study indicate that the 75th per centile is higher for the life

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cycle funds compared with that of the balanced funds indicating contrary results to that of Lewis (2008c).

Estrada (2013) states that comparisons and debates on the most optimal asset allocation strategy may be nestled in how risk is defined and that a unanimous definition is yet to be reached. Some may view a low-risk fund as a stable investment with little adverse shocks while an alternative view may be that the fund provides the highest mean accumulated ending wealth (Lewis, 2008c; Shiller, 2006). Should "risk" be interpreted as a greater range exhibited by the outcomes, the balanced funds would however be a riskier choice.

With this in mind, Estrada (2013:2) makes the following case for life cycle funds: "... the goal of these funds is not to maximize the accumulated savings at retirement but rather to balance risk and return". Watson Wyatt in Estrada (2013:2) adds that "… [a life cycle fund] seeks to reduce risk as the capacity of the member to take risk diminishes …". Basu and Drew (2009) have similar comments on the risk of life cycle funds, namely that the primary focus is to protect retirement wealth accumulation against adverse market conditions and especially so closer to retirement when the individual does not have time to recover from such losses.

The research of Schleef and Eisinger (2007), firstly, compares different life cycle strategies and the chances of meeting a retirement target. They, subsequently, also evaluate how changing the contribution level may improve an individual's chances of meeting the retirement target (which was discussed in Section 2.4.2 regarding contribution rates). Regarding the asset allocation question posed, the researchers conclude that strategies weighted towards equities still have a better chance of achieving the retirement target. The results indicate that for all the simulated portfolios (life cycle and balance funds) there is more than a 50 per cent chance of failing to meet the retirement target. Balanced funds with an asset allocation to equities of 70 per cent or more are superior to all other portfolios, including an aggressive life cycle portfolio, in achieving the retirement target; the 100 per cent equity portfolio has only a 39 per cent chance of not meeting the target (Schleef & Eisinger, 2007).

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Pfau (2010) also makes a strong case in support of life cycle funds by focusing on the risk-return trade-off between more aggressive balanced funds and the protection offered by life cycle funds. His research introduces a utility function that captures the risk aversion of the individual and how this may alter one's interpretation of which strategy is optimal. Without considering investor utility, the life cycle strategies modelled by Pfau (2010) slightly underperform the balanced fund strategies with a similar average equity exposure. Furthermore, the distributions of the life cycle and comparable balanced fund strategies exhibit similar patterns for most of the per centiles of the distribution. Considering risk aversion, the results of Pfau (2010) indicate that the life cycle strategies are indeed reasonable despite the lower mean expected wealth that can be achieved particularly for investors with a risk aversion of 3.5 to 4.5. A risk aversion of 0 indicates a risk-neutral individual, 1 represents an aggressive investor, 3 to 5 a moderate risk propensity and above 5, a very conservative investor.

Pfau (2010) therefore proposes that not only mean returns are important, but also the whole distribution of potential outcomes for each strategy. The research of Basu *et al.* (2011) deals with this matter and is presented shortly. Additionally, if risk is viewed slightly different, namely as the probability of meeting a particular retirement wealth, balanced funds with high equity allocations would be most appropriate (Pfau, 2010).

Similar to Boscaljon (2011) and Pfau (2010), Pfau (2011b) also considers the risk tolerance of the individual in evaluating the appropriateness of life cycle strategies. Pfau (2011b) acknowledges that should the goal be maximising mean accumulated retirement wealth, the best strategy is to be in equities near retirement. However, if an individual is rather concerned with minimising the risk of loss, a particular level of risk aversion may result in a lifecycle strategy providing more expected utility to an individual. Pfau (2011b) introduces a utility function that captures the risk tolerance of the individual and applies this not only to US data, but to a more extensive database covering 17 countries. The results indicate that the expected utility for life cycle strategies compared with contrarian strategies is quite different between the 17 countries and a generalisation cannot be made. However, it is clear that despite the

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criticism offered against life cycle funds (Basu & Drew, 2009), it may be optimal depending on the risk aversion of the individual. While the research of Pfau (2011b) considers the risk averseness of the individual, Basu *et al.* (2011) used a slightly different approach to compare optimal funds and did so at the hand of the inherent risk embedded in the cumulative distribution function of each fund (this is also the method that is applied to this study). The research of Basu *et al.* (2011) forms part of the literature review, while the method employed is discussed in the research method chapter.

Although contrarian life cycle strategies and dynamic life cycle strategies will not be modelled in this study, they provide valuable insights into potential alternative asset allocation strategies. Estrada (2013) contrasts the performance of life cycle funds with contrarian funds, similar to Basu and Drew (2009). The intent of the contrarian strategy is to take advantage of the higher returns offered by equity when the accumulated wealth is larger as is the case in later years closer to retirement. Hence a contrarian strategy entails in effect the mirror image of a life cycle portfolio, with a similar glide path, where the asset allocation of the contrarian portfolio to high-risk asset classes increases instead of decreases as the retirement date approaches (Basu & Drew, 2009).

The findings of Basu and Drew (2009) and Estrada (2013) indicate that the mean and retirement wealth accumulation of life cycle strategies are lower compared with that of contrarian strategies. Furthermore, contrarian strategies outperform life cycle portfolios on all the upside metrics considered in both studies and exhibit lower downside risk. In contrast, life cycle funds provide more certainty about the accumulated terminal wealth.

Similar to Booth (2004) and Lewis (2008c), Basu and Drew (2009) state that the mean is not the most likely outcome for any of the strategies because the terminal value distributions are not normally distributed. Above-average outcomes at the 75th per centile and 25th per centile concur with the superior nature of the contrarian strategies. Additionally, the results indicate that the greater the similarity in the life cycle and

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contrarian strategies, the greater the differences in results. Hence a contrarian strategy that moves from bonds and cash to equities in the first five years of the horizon and remains in equity thereafter for 30 years shows greater divergent results for the life cycle comparable portfolio (investing in equity for the first 30 years and then moving to bonds and cash in the last five years before retirement). In contrast, a strategy with a 20-year glide path and 20-year full investment in equity, with the equity allocation in the first 20 years for the life cycle portfolio as against the last 20 years for the contrarian portfolios, has less divergent results (Basu & Drew, 2009).

Additionally, Basu and Drew (2009) emphasise that if the goal is to maximise target wealth, the life cycle strategies significantly underperform compared with the contrarian strategies. However, contrarian strategies are unprotected from significant declines in markets. The results indicate that up to the 10th per centile, life cycle strategies are superior. However, from the 15th per centile of the distributions onwards, the contrarian strategies dominate (Basu & Drew, 2009).

A further valuable conclusion is drawn, namely that life cycle strategies that commence with a glide path early in the investment horizon are better at protecting downside risk. There also seems to be a diminishing risk reduction benefit for life cycle strategies that defer switching to more conservative asset classes (Basu & Drew, 2009).

Ambachtsheer (2009) criticises the approach Basu and Drew (2009) used to select the data. Basu and Drew (2009) used a random draw with replacement of one-year data points from the empirical distribution of asset class returns. This method inherently assumes that each year’s data is independent from the preceding return set. Ambachtsheer (2009) claims that an analysis reveals that the historical data points seem to show seven specific investment regimes all lasting 10 to 20 years, which refutes the appropriateness of bootstrapping one-year returns.

Basu *et al.* (2011) addressed the criticism of Ambachtsheer (2009) and introduced an innovative alternative to the traditional life cycle fund. Where a traditional life cycle fund switches out of higher risk asset classes based on the age and retirement target

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of the individual, the dynamic approach proposed considers the retirement target and the asset class returns achieved to date. Basu *et al.* (2011) contend that although the traditional life cycle strategy may be appropriate to protect the downside risk of the portfolio closer to retirement, it may fail to realise the retirement wealth target.

The dynamic strategy switches to lower risk asset classes on the condition that the retirement target may realistically be achieved based on the accumulated wealth at every stage of switching, therefore, considering the impact of past market performance and future return expectations. Switching to a lower risk asset class is only done if the accumulated retirement wealth is in excess of the present value of the required terminal wealth at that particular point in time, otherwise the allocation to higher return-higher risk asset classes is increased (Basu *et al.*, 2011).

The results of Basu *et al.* (2011) indicate that the dynamic life cycle strategies seem superior to traditional life cycle funds, irrespective of how long the glide path is. It also offers better downside protection and mean accumulated wealth compared with a balanced fund.

Irrespective of the method used in the various studies consulted, the outcome is unanimous that the highest mean retirement accumulated wealth is achieved when fully invested in equities. Additionally, it is undisputed that based on risk metrics such as range, distribution and standard deviation, a 100 per cent equity fund is also the highest risk asset class strategy.

Likewise, the higher the allocation to equities in a balanced fund, the better the mean wealth accumulation. The riskiness of the strategy as measured by range, distribution and standard deviation increases with the equity allocation.

In comparison, life cycle funds start with varying exposures to equity at the beginning of the pre-retirement phase and have diverse retirement equity targets for the beginning of the retirement phase. Additionally, the funds exhibit diverse periods over which the glide path is implemented. These factors make it difficult to generalise about

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the performance of these funds. However, the literature indicates that, generally, a balanced fund with an average asset allocation over the investment horizon, which is similar to that of a life cycle counterpart, offers a higher mean retirement accumulation and wider range, distribution and standard deviation (Lewis, 2008c). The latter finding was challenged by Pang and Warshawsky (2011), who acknowledged that balanced funds exhibited a wider range, distribution and standard deviation but indicated that, in their research, the mean accumulated ending wealth for balanced and life cycle funds was quite similar.

Importantly, some research pays particular attention to the shape of the distribution, value at risk, downside risk, shortfall risk or replacement ratio and upside potential of the strategies, which may prove to be important metrics when evaluating the appropriateness and choice of an asset allocation strategy (Lewis, 2008c). Most studies find the distributions of accumulated wealth to be non-symmetrical, leptokurtic and positively skewed. The optimal strategy for an individual may be influenced by the need for sufficient retirement wealth as opposed to capital protection closer to retirement (Basu & Drew, 2009; Estrada, 2013).

a. Summary

The asset allocation strategy that an individual chooses should strike a balance between the inherent risk of the strategy and the potential accumulated retirement ending wealth that can be achieved.

With regard to single asset portfolios, equity portfolios have the highest mean accumulation and exhibit the highest risk followed by the fixed income and money market asset class. Similarly, the more equities in the asset allocation of balanced funds, the higher the mean accumulation and risk exhibited.

For life cycle funds, the length of the glide path as well as the composition of the beginning and ending asset allocation will influence the mean accumulation and the risk of the strategy. The following factors, all others held constant, result in a higher mean accumulation and risk:

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- a short glide path;
- a starting asset allocation with a bias to equities; and
- an ending asset allocation with a bias to equities.

The drawback of comparing different asset allocation strategies based on the mean and standard deviation, which is the predominant risk measure, is as follows:

- both metrics are one dimensional; and
- the standard deviation assumes normally distributed outcomes, which is not the case for the problem at hand as the distribution of potential outcomes is positively skewed.

In evaluating different strategies, a more dynamic decision-making criteria tool, which has the ability to capture both elements, namely risk and ending wealth, would be preferred. This may challenge some of the traditional findings pertaining to life cycle funds as opposed to balanced funds.

Although the individual can make certain choices regarding asset allocation, regulatory requirements may also direct the asset allocation choices as is the case with South African retirement funds. This aspect is discussed in the following section.

2.4.3.4 Regulation 28 of the Pension Funds Act

Regulation 28 of the Pension Funds Act dictates maximum exposures that a retirement fund may have to particular investable asset classes and, in certain instances, the acceptable selections within a particular asset class (National Treasury of South Africa, 2011a). Prior to 1 July 2011, an individual could invest 100 per cent of his or her retirement fund in equities. Hence the updated regulations are an attempt to protect individuals against adverse market conditions by limiting concentrated holdings and high asset class exposures in retirement funds (National Treasury of South Africa, 2011b, 2011a).

In particular, the goal of the updated Regulation 28 is to "…ensure that the savings South Africans contribute towards their retirement is invested in a prudent manner that

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not only protects the retirement fund member, but is channelled in ways that achieve economic development and growth" (National Treasury of South Africa, 2011b:1).

Table 2-6 shows the primary asset class limits imposed by Regulation 28. Each maximum exposure to a particular asset class includes both the local and foreign exposure.

Table 2-6: Regulation 28 asset class limits

	Limits being the maximum percentage of aggregate fair value of total assets of fund
Categories of assets	**For all issuers/ entities**
CASH	100%
DEBT INSTRUMENTS INCLUDING ISLAMIC DEBT INSTRUMENTS	100% for debt instruments issued by or guaranteed by the Republic, otherwise 75%
EQUITIES	75%
IMMOVABLE PROPERTY	25%
COMMODITIES	10%
INVESTMENTS IN THE BUSINESS OF A PARTICIPATING EMPLOYER	5%
HEDGE FUNDS, PRIVATE EQUITY FUNDS AND ANY OTHER ASSET NOT REFERRED TO IN THIS SCHEDULE	15%

Source: National Treasury of South Africa (2011a)

A retirement fund may be fully invested (100 per cent) in the traditionally low-risk, low-return money market asset class (cash), while the fixed income asset class (or bonds) can be fully invested only in South African Government debt or South African Government guaranteed instruments. For other debt instruments such as corporate bonds, the maximum is 75 per cent of the portfolio allocation. The allocation to property is limited to a maximum of 25 per cent with alternative instruments such as hedge funds and private equity restricted to no more than 15 per cent. Importantly, the higher return, higher risk equity asset class is restricted to a maximum of 75 per cent of the overall asset allocation.

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The asset allocation decision of an individual who invests in a retirement fund must therefore abide by Regulation 28 while someone who invests directly in financial markets has freedom of choice. Additionally, a retirement fund would have to rebalance when any asset class breaches the limitations of Regulation 28.

Apart from Regulation 28, foreign exchange (forex) control limits imposed by the South African Reserve Bank influence the financial assets allocated overseas for both retirement funds and direct investments. The impact of foreign exchange control limits is discussed in a subsequent section (Section 2.4.3.6).

After the amendments to Regulation 28, the question arose whether retirement annuities, which are representative of all retirement funds in this study, are still an optimal choice due to the tax benefits (Sections 2.4.2 and 2.4.3.7) despite the limitation imposed on the allocation to equities. Isaacs and Terblanche (2011) explored this question. Although the analysis was not very robust and included some post-retirement decisions that are not considered in this study, the conclusions are worth mentioning as there is limited literature that discusses the matter. Isaacs and Terblanche (2011) conclude that retirement annuities with its associated tax benefits are still an effective retirement savings vehicle but acknowledge that over a very long investment horizon, a 100 per cent equity direct investment may outperform the retirement annuity. However, they caution that one of the challenges with a direct equity investment is the fact that an individual can access those funds at any time and make poor decisions in bear markets, such as liquidating and realising losses instead of waiting the market out, which could significantly deplete the accumulated retirement ending wealth and challenge the benefits derived from the 100 per cent equity direct investment.

The results of Isaacs and Terblanche (2011) do not provide strong evidence, but indicate that the higher the tax bracket of the individual, the more advantageous the benefits of a retirement annuity against a direct investment.

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2.4.3.5 ASISA categorisation based on asset allocation

Based on asset allocation, the Association of Savings and Investments South Africa (ASISA) provides a standard for the classification of collective investment schemes (CIS)[6] in South Africa. One of the goals of the classification standard is to assist individuals in their fund choices and comparisons of funds (ASISA, 2014). The classification makes, among others, provision for multi-asset funds (i.e. funds that invest in a range of asset classes). The multi-asset high, medium and low categories are of particular interest as all three categories have equity limits within the bounds of Regulation 28 of the Pension Funds Act and are described as follows (ASISA, 2014):

- Multi-asset high equity funds can invest a maximum of 75 per cent of assets in equities (including foreign equities) with a maximum investment in properties of 25 per cent (local and foreign).
- Multi-asset medium equity funds can invest a maximum of 60 per cent of assets in equities (including foreign equities) with a maximum investment in properties of 25 per cent (local and foreign).
- Multi-asset low equity funds can invest a maximum of 40 per cent of assets in equities (including foreign equities) with a maximum investment in properties of 25 per cent (local and foreign).

The different asset allocations indicate that the three categories range from a high risk-return category, medium risk-return category and low-risk-return category. In this study, the maximum equity allocations indicated by the ASISA classification for the high, medium and low equity strategies, will be used as guiding principles for the asset allocation strategies modelled.

2.4.3.6 Forex control limits

In line with Regulation 28 and the allowable foreign limits of the South African Reserve Bank, retirement funds are allowed to invest a maximum of 25 per cent of assets in foreign markets (National Treasury of South Africa, 2011b; South African Reserve

[6] CIS structures include, among others, unit trust (or mutual funds).

Bank, 2012). However, the Pension Funds Act makes provision for this limit to be increased should the South African Reserve Bank increase allowable foreign limits and a retirement fund apply to take advantage thereof (National Treasury of South Africa, 2011b). In addition, retirement funds may invest an additional five per cent in African markets (total 30 per cent) (South African Reserve Bank, 2012).

However, the regulation that applies to foreign investments of individuals is different; until 31 March 2015, an individual could invest a maximum of R4 million per calendar year in foreign markets (the limit has subsequently been increased to R10 million) (South African Reserve Bank, 2015). Additionally, exchange control regulation requires, for amounts in excess of R1 million, a tax clearance certificate (South African Reserve Bank, 2011). Direct investments are thus not restricted by a foreign asset allocation limit *per se* but instead by a rand amount that can be invested abroad annually.

The previous sections discussed the impact of the Pension Funds Act and foreign exchange control legislation on the asset allocation choices of an individual. The section that follows concentrates on the tax implications of the asset allocation decision for both retirement funds and direct investments and has particular bearing on the assumptions of this research.

2.4.3.7 Tax implications

The retirement reform proposals will impact how the returns of direct investments are taxed as well as the tax treatment of retirement funds. Both aspects are important to this research. This section is structured as follows: firstly, the current tax implications for direct investments and retirement funds are discussed, followed by an overview of the applicable retirement reform proposals and how this will impact the tax treatment going forward.

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2.4.3.7.1 Current tax implications

a. Retirement funds

According to the provisions of Section 10 (1)(d)(i) of the Income Tax Act, all retirement funds are exempt from taxes on the returns generated.

b. Direct investments

In contrast to retirement funds, the returns from direct investments, whether from interest, dividends or capital gains and losses, are taxed in the hands of the individual. Furthermore, different tax implications apply to the returns from local as opposed to foreign sources.

Firstly, interest earned by an individual from South African sources is taxed at the marginal income tax rate applicable to the individual in terms of Section 10(1)(i) of the Income Tax Act. For the 2015 financial year, the first R23 800 earned by an individual under the age of 65, from a source within South Africa, is exempt from taxes while the exemption amounts to R34 500 for individuals 65 years and older (South African Revenue Service, 2014a). Any amount over the threshold is included in taxable income and taxed at the applicable marginal income tax rate.

Dividend withholding taxes in terms of Sections 64E, EA and F of the Income Tax Act are applicable to all local dividends. The dividend tax rate is 15 per cent for the 2015 financial year (South African Revenue Service, 2014a). South African dividend withholding taxes do not apply to dividends from foreign sources.

Realised returns and losses that are capital in nature and from local or foreign sources are taxed as capital gains or losses and dealt with in the Eighth Schedule of the Income Tax Act (Mazars, 2014; Stiglingh *et al.*, 2013). Additionally, the tax legislation has certain technical and legal details particular to the type of instrument that results in a capital gain or loss such as direct share holdings and unit trusts[7]. In the case of equities, returns or losses due to the selling of the shares are either deemed to be

[7] A unit trust pools the money from different individuals together, which is then collectively invested (also known as a mutual fund).

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income or capital depending on the intent of the taxpayer, namely whether it is held as trading stock or as capital assets. With capital assets the intent is to hold the instrument for a longer period (South African Revenue Service, 2014b). With shares, individuals can either adopt the "first-in, first-out" method or the weighted average cost method when determining the cost base of the equities to be sold (South African Revenue Service, 2000). Capital gains tax is applied at a rate of 33.3 per cent of the realised gains, which is included in the taxable income of the individual. However, natural persons receive an exemption to the amount of R30 000 annually on any capital gains or losses and any previous net capital losses can be offset against future capital gains (but not taxable income) (Mazars, 2014). Although the technical differences as well as exceptions which exist in the tax legislation depending on the type of instrument are recognised, the basic principle regarding capital gains taxes and articulated as it applies to shares, is applied to this study to both the local and foreign equity asset classes.

Dividends from foreign sources received by a resident of South Africa are dealt with in Section 10(B) of the Income Tax Act. A ratio exemption applies, which is calculated as 25/40 of total foreign dividends gross of any foreign withholding taxes. Any amount after the ratio exemption is included in taxable income and taxed at the applicable marginal tax rate. Any foreign taxes paid on the dividend may be deducted from the local income tax liability (Stiglingh *et al.*, 2013). As is the case with capital gains tax, the legislation makes provision for certain unique circumstances, exemptions and technical details regarding foreign dividend taxes. However, for the purposes of the study, the application of the foreign dividend taxes methodology in its simplest form and articulated above is considered sufficient.

Interest income from foreign sources received by a South African is taxed at the marginal tax rate of the individual because there is no exemption in terms of Section 10 of the Income Tax Act (Stiglingh *et al.*, 2013).

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2.4.3.7.2 Retirement reform proposals

The retirement reform proposals aim to, among others, unify the tax treatment of pension funds, provident funds and retirement annuities and encourage savings among South Africans (National Treasury of South Africa, 2012a, 2013b). To this end, a number of retirement reforms, which have not yet been discussed, have particular bearing on this research. A description of the applicable retirement reforms is included followed by a summary of how these will impact taxes on direct investments and retirement funds going forward.

a. Non-retirement savings

The National Treasury of South Africa (2013b) will proceed with the development of a non-retirement savings vehicle that is exempt from all taxes, namely dividend, capital gains and interest taxes, in an attempt to encourage discretionary non-retirement savings and reduce the vulnerability of households (National Treasury of South Africa, 2012b). The maximum contributions that an individual can make are set at R30 000 per annum with a lifetime limit of R500 000 (both limits adjusted at inflation annually). Implementation was affected on 1 March 2015 (South African Revenue Service, 2015a).

As the intent of this initiative is primarily to encourage short-term savings and there is still some uncertainty regarding the details of qualifying investments, the non-retirement savings choice is disregarded in this study as a retirement investment opportunity. However, it is acknowledged that this may be a viable opportunity to consider in similar research going forward (National Treasury of South Africa, 2014c).

The non-retirement savings proposal impacts the exemption an individual receives for local interest income. The proposal indicates that the local interest exemptions of R23 800 and R34 500 will not be increased with inflation annually, effectively reducing the real value thereof over time (National Treasury of South Africa, 2014c). This provision has an impact on the effective tax an individual will pay on any interest earned from direct investments in interest-bearing instruments such as money market and the fixed income asset class, which is relevant to this research. Because this study

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does not model the inclusion of the non-retirement savings vehicle, the interest exemption of R23 800 is retained and adjusted for inflation.

b. Preservation

Although preservation of retirement savings pre-retirement is low in South Africa, interested parties that commented on the draft proposals agreed that extremes such as no access to retirement savings when leaving employment or full access was not practical or sensible (National Treasury of South Africa, 2013b). The retirement reform proposals pertaining to preservation (with an implementation date of 1 March 2016) include the following proposed suggestions to reduce pre-retirement leakage and are deemed relevant to this research (National Treasury of South Africa, 2013b, 2014b, 2015a):

- Vested rights on retirement fund balances on the implementation date, including the growth of such assets going forward, will be protected.
- Pension and provident funds must offer a default preservation option.
- Should individuals leave the employment of the employer, they will be required to deposit such funds in a preservation fund or move it to the pension fund of the new employer.
- Access to funds with no vested rights (i.e. post-implementation of the proposals) is allowed on the following basis: annual withdrawal limited to a maximum of the state old-age grant or 10 per cent of the initial value deposited with the preservation fund. Any unused withdrawals may be carried forward (National Treasury of South Africa, 2013a, 2013b).

2.4.3.7.3 Future tax treatment

While the retirement reform proposals have no impact on the tax-exempt status of retirement funds, the non-retirement savings proposal impacts any interest earned from a direct investment in interest-bearing asset classes because the interest exemption of R23 800 and R34 500 respectively will be phased out over time. Because the study does not model the inclusion of the non-retirement savings vehicle,

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the interest exemption of R23 800 is retained and adjusted for inflation. The rest of the tax treatment of direct investments will continue with the current practice.

2.5 CONCLUSION

Retirement savings adequacy is a worldwide challenge and therefore regulators, industry players and individuals have an interest in how the pre-retirement decisions impact accumulated retirement ending wealth.

Individuals should save enough during their working careers to support themselves during retirement (the life cycle hypothesis theory). Consequently, the choices people make during the pre-retirement phase will have a significant impact on how much wealth will be accumulated by their retirement date. These decisions include how long and how much they choose to save as well as how the wealth is invested. Research shows that the longer the investment horizon, the more retirement wealth will be accumulated. Similarly, the higher the contribution rate, the greater the accumulated retirement ending wealth.

The literature review further highlighted that individuals can choose to invest directly in financial markets or use retirement funds. While direct investments give an individual full discretion on how the funds are invested, retirement funds only allow discretion within the limits set out in the legislation. However, retirement funds offer certain tax advantages because the contributions to retirement funds are tax deductible.

How retirement savings are invested, i.e. which asset classes an individual chooses to invest in, has a significant influence on the accumulated retirement ending wealth. There is consensus in the literature that should the primary goal of an individual be to maximise accumulated retirement ending wealth, a 100 per cent allocation to equities is optimal. However, this may be too risky given the risk aversion of an individual, which supports a place for balanced funds and life cycle funds.

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Although the majority of the research supports the notion that the balanced funds provide the higher accumulated retirement ending wealth compared with life cycle funds, researchers acknowledge that the lower risk strategy of life cycle funds may still have a place for more risk-averse individuals. Additionally, the innovative dynamic life cycle strategies proposed, which shift the focus to obtaining the retirement target of an individual as opposed to focusing on the retirement date, provide an interesting alternative to managing retirement savings during the pre-retirement phase. The evidence indicates that this strategy may well be more optimal compared with the traditional life cycle and balanced fund strategies.

The asset allocation strategy may also be influenced by regulations. Regulation 28 of the Pension Funds Act dictates a maximum exposure to equities of 75 per cent, a maximum exposure to foreign markets (excluding Africa) of 25 per cent and a limit to Africa of 5 per cent for retirement funds. These limits are not applicable to direct investments. On the other hand, direct investment returns are taxable, while retirement funds are tax exempt.

The literature review also discussed future changes in the South African retirement space. As these changes are eminent and will result in a unified treatment of the different retirement funds in South Africa, the study incorporates the majority of these changes.

The current body of knowledge has not dealt with the impact of South African retirement fund legislation on asset allocation strategies and how this impacts on accumulated retirement ending wealth. Similarly, although studies regarding life cycle funds as opposed to balanced funds are found in the literature, they predominantly focus on the US. This study will contribute by dealing with the asset allocation decision from these two perspectives.

Research Question 1 focuses on the impact of legislation in South Africa on the asset allocation strategies of retirement funds and the alternative savings choice for individuals, namely direct investments while Research Question 2 focuses on a

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comparative analysis of traditional life cycle as opposed to balanced funds. Additionally, the decision-making criteria proposed in the following chapter to evaluate the research questions capture the risk and all potential outcomes of each strategy.

Research Question 1 therefore tests a number of hypotheses. Hypotheses 1A and 1B focus on funds that are fully invested *directly in equity markets,* as opposed to a high equity balanced retirement fund with only 75 per cent invested in local equities. The high equity balanced retirement fund is a meaningful choice for an individual because it represents the highest equity exposure possible within the asset class limits of the retirement fund legislation. Noteworthy, the funds fully invested directly in equity markets do not have the tax benefits that the retirement funds have. The null and alternative hypotheses for 1A and 1B follow in Chapter 3, Section 3.13.1.

Hypotheses 1C, 1D and 1E focus on a *theoretical retirement fund* that allocates 100 per cent of assets to equities as opposed to a high equity balanced retirement fund with only 75 per cent invested in equities. Although retirement fund legislation currently does not allow a 100 per cent allocation to equities, it did in the past and therefore individuals have questioned the sensibility of the current asset allocation limits. These hypotheses will provide a comparative analysis, which could settle the debate. The null and alternative hypotheses for 1C, 1D and 1 E follow in Chapter 3, Section 3.13.2.

For Research Question 2, two hypotheses will be tested. Hypothesis 2A focuses on life cycle funds as opposed to balanced funds that have similar starting asset allocations while Hypothesis 2B evaluates life cycle funds as opposed to balanced funds that have dissimilar starting asset allocations.

The research method chapter presented next provides the research method dealing with the research questions, hypotheses and models.

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CHAPTER 3:
RESEARCH METHOD

3.1 INTRODUCTION

The literature review conducted in Chapter 2 created a theoretical framework for the accumulation phase choices (investment horizon, contribution rate and asset class decisions) with an emphasis on the body of knowledge regarding different asset allocation strategies in addition to sketching the pension fund regulatory space, including tax implications. Chapter 3 presents the research questions and hypotheses followed by the research design and method for the study including Monte Carlo simulation and bootstrapping. The next section describes the data used in the simulations, followed by the delimitations, limitations and assumptions of the study, which include the model-specific assumptions. The descriptive and statistical techniques for analysis of the results follow, after which the model-specific methodologies are presented. A discussion of the decision-making criteria stochastic dominance follows, while the chapter concludes by discussing the reliability, validity and ethical considerations of the study.

The empirical part of the study investigates how the pre-retirement phase choices related to asset allocation and choice of vehicle (i.e. retirement fund as opposed to direct investment) impact accumulated retirement ending wealth. In particular, the interest of the study is, firstly, the impact of different asset allocation strategies and, secondly, the impact of regulations.

3.2 RESEARCH DESIGN AND METHOD

Table 3-1 illustrates the research design for the study primarily based on the framework presented by Saunders, Lewis and Thornhill (2009) followed by a discussion of and motivation for each element.

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Table 3-1: Research design

Philosophy	Positivism
Approach	Deductive
Time horizon	Cross-sectional
Method (Techniques and procedures)	Simulations Historical financial data

Source: *Adapted from Saunders et al. (2009)*

3.2.1 RESEARCH PHILOSOPHY AND APPROACH

The study follows a positivism approach, is deductive in nature and is independent of researcher subjectivity (Saunders *et al.*, 2009). Collis and Hussey (2003) further describe this approach based on the assumptions stated in Table 3-2.

Table 3-2: Positivism paradigm

Assumption	Question	Positivism (Quantitative)
Ontology	Nature of reality?	Objective and singular
Epistemological	Relationship between researcher and researched	Researcher is independent
Axiological	Role of values?	Unbiased and value-free
Rhetorical	Language of the research?	• Formal • Quantitative • Based on definitions • Impersonal
Methodological	Process of research?	• Deductive • Cause and effect • Static design • Context-free • Generalisations leading to prediction, explanation and understanding • Accurate and reliable through validity and reliability

Source: Collis and Hussey (2003:49)

The positivism research philosophy is characterised by researcher independence and objectivity. There is no researcher influence on the perception and definition of accumulated retirement ending wealth. Furthermore, it is impersonal and quantitative in nature because clearly defined quantitative models are used. The study is deductive focusing on cause and effect such as the impact of time horizon and asset allocation decisions on accumulated retirement ending wealth. Furthermore, the models are measured for reliability and validity to support the findings.

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3.2.2 RESEARCH STRATEGY AND TIME HORIZON

Positivism methodologies are classified by Collis and Hussey (2003) including cross-sectional studies which aim to gather information on specific variable(s) (such as accumulated retirement ending wealth in the case of this study).

Based on the approaches of Saunders *et al.* (2009) and Collis and Hussey (2003), the nature of the study indicates that a cross-sectional time horizon would be most appropriate because the dependent variable in question, namely accumulated retirement ending wealth, is determined by manipulating the independent variables to create a comparative framework for the impact of pre-retirement choices over similar time horizons. These choices include different asset allocations and direct investment as opposed to retirement fund models.

3.2.3 BROAD RESEARCH METHOD

The study uses Monte Carlo simulation and bootstrap with replacement while secondary historical financial market data from reputable data providers and peer-reviewed research studies are used for the simulations. Secondary data is preferred for the study as it is reliable, valid and easily obtainable. The practice of using secondary financial market data is similar to the majority of studies in the literature (Basu *et al.*, 2011; Basu & Drew, 2009; Booth, 2004; Pfau, 2010; Spitzer & Singh, 2008). Mouton (2012) further highlights modelling and simulation studies as appropriate for numerical data and that modelling and simulation studies exhibit a relatively high level of control.

Simulation allows generating an expected value and probability distribution of possible outcomes by running similar scenarios, which is appropriate for this research question (Hofstee, 2010; Little, 2013; Mouton, 2012). The ability of computer-generated simulations to produce a considerable number of outcomes with different paths allows for a much richer view of potential results (Little, 2013). Simulations, furthermore, encompass a wide range of techniques including, but not limited to, overlapping rolling period simulations, stochastic modelling or simulation and Monte Carlo simulation (Byrne *et al.*, 2006; Lewis, 2008b; Mouton, 2012; Pang & Warshawsky, 2011).

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Studies that use historical data as well as overlapping rolling historical periods to model the research question of accumulated retirement ending wealth are limited by the availability of sufficient historical data to create a credible number of scenarios from which to draw conclusions (see studies by Branch & Qiu, 2011; Shiller, 2006). Additionally, serial correlation is present in the data when using overlapping rolling periods, which limits the statistical techniques that can be used to describe and interpret the results.

Monte Carlo simulation does not have these constraints. A number of selected research studies dealing with the accumulation wealth question employ Monte Carlo simulation and bootstrapping with replacement (bootstrap resampling), as shown in Table 3-3.

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Table 3-3: Monte Carlo simulation and bootstrapping studies

Authors	Method employed	Number of simulations	Data
Basu and Drew (2009)	Monte Carlo simulation and bootstrapping with replacement	10 000	Annual nominal return data Period: 1900 to 2004 US data
Basu *et al.* (2011)	Monte Carlo simulation and bootstrapping with replacement	10 000	Annual nominal return data Period: 1900 to 2004 US data
Booth (2004)	1. Chance constraint programming model 2. Monte Carlo simulation and bootstrapping from normal distribution function with seed value of 5	1 000	Annual real return data Period: 1871 to 1997 US data
Branch and Qiu (2011)*	Monte Carlo simulation and bootstrapping with replacement†	100 000	Annual real return data Period: 1926 to 2008 US data
Ervin *et al.* (2009)	Monte Carlo simulation	10 000	Annual nominal return data Period: 1926 to 2008 US data
Lewis (2008a)	Monte Carlo simulation and bootstrapping with replacement	10 000	Monthly return data‡ Period: 1870 to Oct 2007 US data
Pfau (2010)	Monte Carlo simulation and bootstrapping with replacement	10 000	Annual nominal return data Period: 1900 to 2008 US data
Pfau (2011a)	Monte Carlo simulation and bootstrapping with replacement	10 000	Annual nominal return data Period: 1900 to 2004 US data
Shiller (2006)	Overlapping rolling period method	91 periods of 44 years	Annual real return data Period: 1871 to 2004 US data
Spitzer and Singh (2001)	Monte Carlo simulation and bootstrapping with replacement	1 000	Quarterly nominal return data Period: 1980 to 1999 US data
Spitzer and Singh (2008)	1. Monte Carlo simulation and bootstrapping with replacement 2. Overlapping rolling period method	10 000 49 periods of 30 years	Annual nominal return data Period: 1926 to 2003 US data
Spitzer and Singh (2011)	Monte Carlo simulation and bootstrapping with replacement	10 000	Annual nominal return data Period: 1926 to 2003 US data

* Study uses real return data as opposed to most others that use nominal return data.
† The bootstrapping method used assumes one-year, five-year and 10-year bootstrap periods with the latter maintaining possible multi-year serial correlations between data.
‡ Unclear whether historical returns are nominal or real.

3.2.3.1 Monte Carlo simulation and bootstrapping

"Monte Carlo analysis is a research strategy that incorporates randomness into the design, implementation, or evaluation of theoretical models" (Johnson, 2013:454). Therefore, the research employs random numbers and usually uses a computer program. With greater computer capabilities, the technique of Monte Carlo simulation

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has gained popularity in a number of fields, including finance. Ervin *et al.* (2009) offer support for Monte Carlo simulation because of the intrinsic statistical independence of the technique compared with other estimation models.

The advantage of large numbers ensures that the average of the simulations will approximate the true expected value (McLeish, 2005; Wang, 2012). Additionally, in cases where it is simpler to randomly generate values for a model, this may be preferred to determining the exact distribution of potential values (McLeish, 2005).

Because Monte Carlo simulation relies on random number generation in some or other way whether part of the design, implementation or evaluation of the theoretical model, the random number generation process or method employed is critical (Johnson, 2013). A number of random number generators exist but Johnson (2013) cautions that certain number generators may fall short if it repeats itself in a predictable pattern or if there are trends evident. Additionally, L'Ecuyer (in Johnson, 2013) adds that one should be wary of the random number generators of popular software packages such as Excel and Visual Basic. A superior number generator should choose values in an "equally likely" manner (Johnson, 2013). According to Johnson (2013), the MT19937 random number generator is superior to many other programs and has been adopted by software packages such as Matlab, SAS, R and many others. Because this study will be modelled in SAS, it uses the MT 19937 random number generator.

Bootstrapping with replacement is one method of random number generation. As applied in this study and others (see Table 3-3), bootstrapping with replacement follows a random draw with replacement from the empirical distribution of asset class returns. The historical return data for every asset class is randomly resampled with replacement to create asset class return vectors for each period (in the case of this study, each month) applicable to the investment horizon of a model (Basu *et al.*, 2011; Basu & Drew, 2009). This method allows a significant number of repetitions of the simulation.

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Because the resampling is done with replacement, a particular data point from the original data set can appear multiple times in a given bootstrap sample (Basu *et al.*, 2011). Additionally, accurate bootstrapping will require using asset class returns from the same time period (year or month as is the case in this study) to maintain the correlation between the different asset class returns (Branch & Qiu, 2011). Furthermore, it is assumed that the individual asset classes are independently distributed over time (Basu & Drew, 2009). In this study, serial correlation is not evident in the data and the asset classes modelled are independently distributed, therefore, bootstrapping with replacement of single variables will be employed.

However, alternative methods for bootstrapping with replacement of single variables do exist should any of the factors mentioned be a concern. In general, block bootstrap can be used where there is some form of dependency in data as described by Ambachtsheer (2009) and Chernick (2008). Depending on the nature of the data, this can take the form of moving block bootstrap, non-overlapping block bootstrap and generalised block bootstrap (Chernick, 2008). These methods are suggested when the data exhibits serial correlation because bootstrapping with replacement of single variables does not allow for this pattern to be captured. However, block bootstrapping reduces the number of historical data points available to construct a simulation.

3.2.3.2 Strengths

Simulation is easy to use and has a wide application (Redelinghuis, Julyan, Steyn & Benade, 1989). Wang (2012) adds that Monte Carlo simulation is easily applied to quantify financial models, allows for comparable computing and repetition, is flexible and can be used for complex models, which would not otherwise have been possible.

Bootstrap with replacement of single data points allows a researcher to circumvent the challenge of insufficient data and may result in a much wider range of future possibilities that can be captured by obtaining a large number of bootstrap samples from the observed historical data (Basu *et al.*, 2011).

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3.2.3.3 Weaknesses

However, simulation is not without its weaknesses; the complexity of the proposed models, the quality of the data used in the analysis and potential unexpected variables will impact the appropriateness and reliability of simulations as an acceptable research design (Hofstee, 2010; Mouton, 2012). No model is reality *per se* but a simplification which relies on assumptions (Hofstee, 2010; Mouton, 2012). Additionally, one must take care against any errors that may occur in the model construction (Hofstee, 2010; Wang, 2012).

Wang (2012) states that a large sample size is usually required and because model misspecification is a risk, he recommends theoretical justification for results wherever possible. Simulation does not provide an optimal solution but only the outcome of different scenarios. Redelinghuis *et al.* (1989) state that it may be challenging to create true real-life models within the confines of a simulation.

However, these weaknesses are mitigated in this study by the following:

- The proposed models are clearly specified, unambiguous and realistic.
- The models are developed in both Excel and SAS to compare and ensure that model misspecification does not occur.
- The underlying data is sound, appropriate and from reputable sources.

As Ambachtsheer (2009) cautions, should there be serial correlation evident in the historical data set, the method of bootstrapping with replacement of single variables could be questionable. He argues that should bear and bull market returns pool together, this method will greatly underestimate the risk of high equity strategies. Also, all the simulations are based on the same historical data set, which is not necessarily indicative of the future (Ambachtsheer, 2009). In mitigation of this potential weakness, a visual inspection of scatterplots of the historical total return data, which is used in the study, does not indicate that there is concerns regarding correlation present in the data set. The scatterplots are presented in Appendix B.

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Despite the weaknesses of simulation, the nature of the research question and the actions that will be taken to mitigate these weaknesses indicate that simulation is an appropriate design to compare different asset allocation strategies of retirement funds and direct investments over various investment horizons.

The following sections present the data that will be used in the study followed by the delimitations, limitations and assumptions including the model-specific assumptions.

3.3 DATA

3.3.1 SOUTH AFRICAN DATA

3.3.1.1 Data: 1925 to 2000

Secondary monthly nominal total return data for South African equity, fixed income and money market asset classes as well as inflation for the period 1925 to 1998 were used in a study by Firer and McLeod (1999) and extended by Firer to 2000. Thereafter, Firer and Staunton (2002) extended the database to include 1900 to 1924 and 2000 to 2001. In both studies, the researchers only reported annual total return data.

The monthly database for the period 1925 to 2000 was made available by Staunton for this study (Staunton, 2013). The study requires nominal returns and the splitting of total returns into capital and dividend or capital and interest returns to accurately reflect the tax implications where applicable.

The database is proposed for the study for the following reasons:

- It was constructed using an acceptable calculation methodology published in peer-reviewed journals (Firer & McLeod, 1999; Firer & Staunton, 2002);
- It covers a long historical period of South African data including longer dated periods when there were no indices to be representative of the South African equity, fixed income and money market asset classes as well as inflation.
- It allows for a significantly larger number of data points compared with a database that consists only of annual returns, which allows a greater number of simulations to be modelled with varied combinations of the underlying data.

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- Firer and McLeod (1999) constructed some of the historical data (especially the earlier years) from a variety of sources and theoretical models because asset class index proxies did not yet exist in the South African market for the longer historical periods. Additionally, academic literature was consulted to ensure accuracy and soundness of the methods and sources used to construct the longer historical data. For the later years when indices did become available, the researchers used the JSE All Share Index (equity), JSE All Bond Index (fixed income) and NCD rates (money market).

Although the data set is extensive and covers a long historical period, it has the following drawbacks:

- The longer historical data provided by Staunton (2013) and constructed by Firer and McLeod (1999) and Firer and Staunton (2002) does not provide monthly return data for some periods for the local fixed income asset class (January 1925 to April 1946); and
- From January 1980 to December 1985, the data set does not split the total fixed income asset class return into interest and capital.

Due to these limitations, the data set only proves useful for this study from January 1986 providing monthly return data, split between capital and dividend (for equities) or capital and interest returns (fixed income).

A longer historical data period is not necessarily superior or optimal; there have been significant structural changes in the South African economy over the longer historical period. Where other similar studies used annual data in combination with resampled bootstrapping, this study also uses bootstrap with replacement but uses monthly data. As previously mentioned, resampled bootstrapping is ideally suited in situations where limited data is available.

3.3.1.2 Data: 2001 to 2013

For the period 2001 to 2013, the historical monthly data set will be extended by applying the return calculation method used by Firer and Staunton (2002). The asset

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class price index and dividend or interest yield data is provided by I-Net BFA and Morningstar, both reputable providers of financial data. The proxies representing each of the local asset classes are presented in Table 3-4.

Table 3-4: Appropriate indices per asset class

Asset class	Index
Money market	Alexander Forbes Short-term Fixed Interest Index (STeFi)
Fixed income	FTSE/JSE All Bond Index (ALBI)
Equities	FTSE/JSE All Share Index (ALSI)

Regarding the money market asset class, the SteFi, index which was used to extend the data from 2001 to 2013, is different from what was used by Firer and McLeod (1999). Firer and McLeod (1999) settled on using NCDs as a proxy for the money market asset class as there were concerns regarding price distortions that, at the time, existed for Treasury bills and Banker's Acceptances[8]. Banker's Acceptances were generally used by banks as liquid assets but could not be used by pension funds and insurers for their prescribed asset requirements. Furthermore, there did not exist an index for the money market asset class as the SteFi index was only available from October 2000, which is outside the time frame of the original research done by Firer and McLeod (1999). However, the SteFi index is considered superior to the custom NCD index of Firer and McLeod (1999), because it is a better reflection of the current investable universe of money market instruments available to investors.

[8] "A tradable short-term debt instrument, primarily issued to finance the export, import, shipment and storage of goods" (van Zyl, Botha, Skerrit & Goodspeed, 2009:468).

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Table 3-5: STeFi index

	Alexander Forbes Short-term Fixed Interest index (STeFi)
Composition	Market capitalisation weighted composite index, which includes: Call Deposit Index on Absolute Overnight Call rate, 3-month NCD index, 6-month NCD index, 12-month NCD index
Available from	October 2000
Base Date	100 on 1 October 2000

Source: Alexander Forbes Asset Consulting and SAFEX. (n.d.)

3.3.2 FOREIGN DATA

The Firer and Staunton (2002) database does not include a foreign equity asset class. The MSCI World index is deemed to be a reliable, valid and appropriate diversified foreign equity index to represent the foreign equity asset class in this study. The index offers net return, gross return and price return indices (in US dollars). Data for the MSCI World index is available daily from December 1969. The MSCI (2014) distinguishes between the MSCI Gross Daily Total Return index and the Net Daily Total Return index as follows:

Gross daily total return

"This series approximates the maximum possible reinvestment of regular cash distributions (cash dividends or capital repayments). The amount reinvested is the cash distributed to individuals resident in the country of the company, but does not include tax credits" (MSCI, 2014:29).

Net daily total return

"This series approximates the minimum possible reinvestment of regular cash distributions. Provided that the regular capital repayment is not subject to withholding tax, the reinvestment in the Net Daily Total Return is free of withholding tax. Effective December 1, 2009, the regular cash dividend is reinvested after deduction of withholding tax by applying the maximum rate of the company's country of incorporation applicable to institutional investors. MSCI uses different withholding taxes depending if the indices are international or domestic:

- International indices: the maximum rate applicable to non-resident institutional investors who do not benefit from double taxation treaties.

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- Domestic indices: the maximum rate applicable to resident institutional investors" (MSCI, 2014:29).

It is accepted that the country of residence of an individual may influence which index would be most appropriate. The net daily total return approximates the minimum possible reinvestment, which could potentially understate the dividend component earned by an individual while the gross daily return may overstate it. However, the principle decision was made to use the gross daily total return.

The fact that price and total gross indices are available, allows for monthly returns to be decomposed into the price and dividend component, which, as previously mentioned, is important in this study. The method employed to determine the total monthly dividend return is as follows:

$$r_{dividend\,(USD)} = \frac{(1 + r_{total\ gross\,(USD)})}{(1 + r_{price\,(USD)})} - 1$$

(Equation 3-1)

With:

r = monthly return

r_{price} = monthly capital return

$r_{dividend}$ = monthly dividend return

$r_{total\ gross}$ = monthly total gross return

3.4 DELIMITATIONS

The modelling is limited to:

- the perspective of a South African resident;
- who is 25 years of age and intends to work till the age of 65;
- who is saving towards retirement; and
- who is doing so by means of a direct investment or DC retirement fund.

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Additionally:

- The latest recommendations regarding the retirement reform proposals of South Africa are dated October 2015 with any additional comments and changes after this date falling outside the scope of the study;
- the tax legislation applicable to individuals applied to this study refers to the tax year ending 28 February 2015; and
- unique characteristics of individuals and lump sum withdrawals prior to or at retirement are excluded from the analysis.

3.5 LIMITATIONS

The modelling has a number of limitations as follows:

- Any differences in cost between retirement funds and direct investments are not modelled as this is not the focus of the study. Additionally, there exist variations in the fees of different retirement funds as well as direct investments in financial markets. This makes it challenging to make an appropriate generalised assumption.
- A combination of retirement funds and direct investments to save towards retirement is not considered in the study. An individual can choose to save towards retirement by partially investing in a retirement fund and investing directly in financial markets. However, this becomes more focused on the individual's circumstances than a comparison of retirement funds and direct investments and falls outside the scope of the study.
- Active management suggests that portfolio managers can enhance portfolio returns by creating alpha. Direct investments and retirement funds can be actively or passively managed, therefore, for a generalised comparison of accumulated retirement ending wealth, passive proxies are used in the study.
- The implications of taxes at retirement are different as individuals can make a variety of financial decisions at retirement regarding accumulated retirement ending wealth based on what is most appropriate for their post-retirement needs. For this reason, a simplified approach is applied in that the focus is only on accumulated retirement ending wealth pre-retirement, that is, right before

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any retirement financial decisions are made that may trigger different tax implications (such as cash withdrawals).

- The study considers only traditional asset classes, namely equity, fixed income and money market hence excludes alternative asset classes such as property and hedge funds. Indices for non-traditional asset classes do not currently provide sufficient historical data to be included in the study. The index construction methodologies of particularly hedge funds tend to be problematic suffering from survivorship bias, among others.
- The study models foreign equity only and no other foreign asset classes (such as the fixed income or money market asset class). This results in a higher risk and higher return foreign exposure in the modelling. Inclusion of other foreign asset classes was considered irrelevant to the primary focus of the study, which in particular considers the maximum asset allocation allowed to equities in terms of the pension fund regulations.
- Additionally, the Africa allocation that is allowed under Regulation 28 of the Pension Funds Act is not modelled due to limited data available for the asset class.
- The study uses historical data spanning the period January 1986 to December 2013. It is acknowledged that historical returns are not necessarily reflective of future returns.
- The study does not model dynamic life cycle strategies.

3.6 ASSUMPTIONS

3.6.1 ASSUMPTIONS APPLICABLE TO ALL MODELS

- The study includes the retirement funds reform proposals (as they stand in October 2015), which unifies the treatment of retirement annuities, pension funds and provident funds while it does not incorporate the non-retirement savings account into the modelling as this is not intended for retirement savings (despite this product being described as part of the retirement fund reform proposals).

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- Where the interest exemption is applicable, the exemption of R23 800 increases annually at the rate of inflation of 4.5 per cent because the tax-free savings vehicle (non-retirement savings account) is not modelled (Section 2.4.3.7.2 a).
- Contrary to similar studies, the study uses monthly data and not annual data. This practice is possible because sufficient monthly return data is available. Additionally, monthly return data will more accurately reflect the impact of monthly contributions and returns earned on accumulated retirement ending wealth compared with what the case is when annual returns and contributions are modelled. Modelling monthly contributions is also a better reflection of reality as contributions to retirement savings are usually done monthly and not only once a year.
- The study also follows the practice of annually rebalancing of funds as was the practice in other studies (Basu & Drew, 2009; Lewis, 2008c; Pfau, 2011b; Schleef & Eisinger, 2007; Spitzer & Singh, 2011). In practice, the South African retirement fund legislation does allow some leeway regarding rebalancing; should an asset class limit be breached due to market movements, no more assets may be invested in the particular asset class and any breaches must be corrected within 12 months of the original occurrence (National Treasury of South Africa, 2011a). Therefore, annual rebalancing is in line with legislation.
- Salaries are increased at the inflation rate of 4.5 per cent, which reflects the midpoint of the inflation targeting range of 3 to 6 per cent for South Africa that was announced in February 2000 and impacts salary increases in the study (Van der Merwe, 2004). It is acknowledged that individuals may have unique income patterns that are different from this simplified assumption. For an individual starting to save 30, 20 and 10 years before retirement, the starting salaries indicated in Table 3-6 are increased linearly at the annual rate of inflation for 10, 20 and 30 years respectively to reflect the increase in wages. The salaries shown in Table 3-6 are based on the taxable income brackets for the tax year ending 28 February 2015 (South African Revenue Service, 2014a). For the 18 and 25 per cent tax bracket, the annual salary represents the upper bound of the tax bracket while it is the lower threshold for the 40 per cent tax

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bracket, because, in the latter case, the tax bracket represents the highest tax bracket for which there is no upper limit to the taxable income or a higher tax bracket beyond this.

Table 3-6: Annual starting salary

Starting salary	Depends on how far from retirement the individual is and which tax bracket is modelled. An individual starting to save 40 years before retirement is assumed to be earning the upper limit of the applicable tax bracket except in the case of the 40 per cent tax bracket, where it is the lower limit of the range as an individual can earn any amount greater than that with no change in the tax rate: • For an individual in the 18 per cent tax bracket, the starting salary is R174 550. • For an individual in the 25 per cent tax bracket, the starting salary is R272 700. • For an individual in the 40 per cent tax bracket, the starting salary is R673 101.

- Any tax brackets, exemptions and rebates are annually adjusted at the inflation rate of 4.5 per cent, which is similar to the assumption applied to salary increases and the practice employed by the regulator to adjust these variables upwards.
- Local dividend taxes are paid monthly reflecting the practice of dividend withholding taxes being deducted before dividends are paid to shareholders.
- All other income, dividend and capital gains taxes are calculated annually at the end of the calendar year and payable six months later. The latter is deemed appropriate as the tax season for submission of tax filings generally open only four months after the financial year and some individuals have as much as seven months to file their tax returns (South African Revenue Service, 2015b).
- It is assumed that contributions are constant at 15 per cent per month of the monthly income earned. The retirement reform proposals discussed (Chapter 2, Section 2.4.3.7.2) allow a 27.5 per cent deduction. However, the increase in the deductible contribution is primarily a result of employer contributions being taxed in the hands of the employee. There is currently no indication whether individuals in general will make use of the higher deduction and so the modelling remains at 15 per cent, which is the current limit.

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- Each research question is applied to the following investment horizons:
  - a 10-year investment horizon, which commences in 30 years,
  - a 20-year investment horizon, which commences in 20 years,
  - a 30-year investment horizon, which commences in 10 years and
  - a 40-year investment horizon, which covers the full 40-year pre-retirement working years of an individual.
- The tax brackets modelled are 18, 25 and 40 per cent. While 18 per cent is representative of the lowest tax bracket for the 2015 tax year, 40 per cent is the highest tax bracket (South African Revenue Service, 2014a). The 25 per cent tax bracket is representative of the average taxable income of tax payers for the 2012 and 2013 tax years (National Treasury of South Africa & South African Revenue Service, 2014; South African Revenue Service, 2011, 2012)
- Short selling is excluded.
- Transaction costs are ignored.
- The allocations to asset classes must be between 0 and 1, implying that portfolios cannot be leveraged.
- The sum of the asset allocation mix of a model must equal 1 (therefore be fully invested at all times).
- Individuals are assumed to stay in the workforce for the full investment horizon.
- It is assumed that no withdrawals take place during the pre-retirement phase.
- Where capital gains tax is applicable, the weighted average cost method is used to calculate capital gains (Section 2.4.3.7.1 b).
- The limitations on foreign investments by an individual in any particular tax year (Section 2.4.3.6) are acknowledged but not modelled.
- The life cycle funds are modelled as traditional life cycle funds, which reduces the allocation to risky asset as the retirement date nears. The glide paths modelled are funds that reduce the allocation to risky assets in the last five or 10 years before retirement.
- Historical data for the period January 1986 to December 2013 is used in the study. It is acknowledged that historical data is not necessarily reflective of future expected returns and that the data period and data set used may influence the results. If the more recent returns in the data set are indicative of

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future returns, it may suggest a lower return environment locally and internationally than what the mean returns for the data set from January 1986 to December 2013 indicate. However, extending the data set to include the lower returns experienced prior to 1986 is problematic because this period was characterised by a very different political and economic regime in South Africa.

3.6.2 MODEL-SPECIFIC ASSUMPTIONS

The proposed models to deal with each research question are based on a number of assumptions in terms of Table 3-7. The table indicates the underlying asset allocation strategy (i.e. type of fund), whether the strategy is modelled as a direct investment or retirement fund (type of vehicle), what the beginning asset allocation is, the ending asset allocation and glide path (only applicable to life cycle funds) as well as to which time horizons and tax brackets the model is applied. The models for each research question are discussed in detail in Section 3.8.

For example, Model 6 is a high equity balanced fund with 50 per cent allocation to local equities, 25 per cent allocation to foreign equities, and 15 and 10 per cent respectively allocated to the local fixed income and money market asset classes. Because the model is a balanced fund which does not change the asset allocation over the investment horizon, there is no alternative ending asset allocation or glide path period applicable. The model is applicable to all four investment horizons and all three tax brackets.

The glide paths shown in Table 3-7 are therefore subjective. However, it is consistently applied to the various models.

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Table 3-7: Asset allocation strategies modelled

						40-year investment horizon			30 year-investment horizon			20-year investment horizon			10-year investment horizon		
Model	Type of fund	Type of vehicle	Beginning asset allocation* (%)	Ending asset allocation* (%)	Glide path period (years)	18% tax bracket	25% tax bracket	40% tax bracket	18% tax bracket	25% tax bracket	40% tax bracket	18% tax bracket	25% tax bracket	40% tax bracket	18% tax bracket	25% tax bracket	40% tax bracket
RESEARCH QUESTION 1: IS 100% EQUITY FUNDS OPTIMAL COMPARED WITH A REGULATION 28 COMPLIANT RETIREMENT FUND WITH MAXIMUM EQUITY ALLOCATION OF 75%?																	
Model 1	Equity	Theoretical Retirement fund	100/0/0/0	100/0/0/0	N/A	X	X	X	X	X	X	X	X	X	X	X	X
Model 2	Equity	Direct investment	100/0/0/0	100/0/0/0	N/A	X	X	X	X	X	X	X	X	X	X	X	X
Model 3	Equity	Theoretical Retirement fund	75/25/0/0	75/25/0/0	N/A	X	X	X	X	X	X	X	X	X	X	X	X
Model 4	Equity	Direct investment	70/25/0/5	70/25/0/5	N/A	X	X	X	X	X	X	X	X	X	X	X	X
Model 5	Balanced - high equity (no foreign exposure)	Retirement fund	75/0/15/10	75/0/15/10	N/A	X	X	X	X	X	X	X	X	X	X	X	X
Model 6	Balanced - high equity (25% foreign equity exposure)	Retirement fund	50/25/15/10	50/25/15/10	N/A	X	X	X	X	X	X	X	X	X	X	X	X
RESEARCH QUESTION 2: ARE LIFE CYCLE FUNDS OPTIMAL WHEN COMPARED WITH BALANCED FUNDS?																	
Model 5	Balanced - high equity (no foreign exposure)	Retirement fund	75/0/15/10	75/0/15/10	N/A			X			X			X			X
Model 6	Balanced - high equity (25% foreign equity exposure)	Retirement fund	50/25/15/10	50/25/15/10	N/A			X			X			X			X
Model 7	Balanced - medium equity (25% foreign equity exposure)	Retirement fund	35/25/30/10	35/25/30/10	N/A			X			X			X			X
Model 8	Balanced - low equity (25% foreign equity exposure)	Retirement fund	15/25/50/10	15/25/50/10	N/A			X			X			X			X
Model 9	Life cycle	Retirement fund	75/0/15/10	0/0/0/100	Final 10 years			X			X			X			N/A†
Model 10	Life cycle	Retirement fund	75/0/15/10	0/0/0/100	Final 5 years			X			X			X			X
Model 11	Life cycle	Retirement fund	50/25/15/10	0/0/0/100	Final 10 years			X			X			X			N/A†
Model 12	Life cycle	Retirement fund	50/25/15/10	0/0/0/100	Final 5 years			X			X			X			X

* Asset allocation indicated as: local equity/foreign equity/local fixed income/local money market

† The study excludes models that follow a life cycle strategy over the full investment horizon. Therefore, for a 10 year investment horizon, Models 9 and 11 is not applicable.

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3.6.2.1 Research Question 1 models

Models 1 to 6 are compared to deal with Research Question 1.

Research Question 1: Is a fund fully invested in equities optimal compared with a high equity balanced retirement fund with maximum equity allocation of 75 per cent?

In terms of Table 3-7, Models 1 to 4 are 100 per cent equity funds, either with a diversification to foreign equity (Models 3 and 4) or fully invested in local equity (Models 1 and 2). Models 1 and 3 are hypothetical retirement funds invested in 100 per cent equities, an asset allocation strategy that is not allowed under Regulation 28 but is included here to illustrate the limitation of the regulation as it pertains to equities and what could be possible without such a limitation.

Models 5 and 6 are representative of the highest equity allocation strategy that is allowed for retirement funds under Regulation 28 with the full allowable 75 per cent allocation to equities in local equity markets (Model 5) and Model 6 is more diversified with 50 and 25 per cent of the equity exposure in local and foreign equities respectively.

The following is worth mentioning regarding the two direct investment fund models, namely Model 2 and Model 4:

- In the case of Model 2, the fund is fully invested in local equities and therefore never has to be rebalanced. For the duration of the investment horizon, the only tax implication is dividend tax and, as discussed in the research method chapter, dividend tax is deducted from any dividends earned before being paid to the individual (i.e. net of taxes). For these reasons, Model 2 does not require an allocation to money market to make provision for cash outflows for taxation.
- In contrast, the asset allocation of Model 4 consists of more than one asset class (local and foreign equity), which results in annual rebalancing to maintain the proposed asset allocation of the model. The rebalancing may result in a capital gain or loss while the dividends earned on the foreign asset class are taxed at the income tax rate of the individual (described in the research method chapter). Hence Model 4 maintains a 5 per cent allocation to money market to

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ensure available cash for any taxes payable as a consequence of rebalancing or income tax payable on foreign equity dividends.

3.6.2.2 Research Question 2 models

Models 5 to 12 are compared to deal with Research Question 2.

Research Question 2: Are life cycle funds optimal when compared with balanced funds?

Table 3-7 shows that Models 5 to 6 are representative of the highest equity allocation strategy that is allowed under Regulation 28 with the full allowable 75 per cent allocation to equities invested in local equity markets. Model 6 is more diversified with 50 and 25 per cent of the equity exposure invested in local and foreign equities respectively. These funds fall within the ASISA category of Regulation 28 multi-asset high equity funds.

Model 7 is representative of the ASISA category multi-asset medium equity funds with the allowable equity allocation of 60 per cent (and also Regulation 28-compliant) of which 25 per cent is invested in foreign equity. Model 8 represents a multi-asset low equity fund according to ASISA's classification with a maximum of 40 per cent invested in equities (including 25 per cent in foreign equities). (The ASISA classification was discussed in Chapter 2, Section 2.4.3.5).

Models 9 to 12 are life cycle funds, all starting with an asset allocation of 75 per cent to equities and ending fully invested in money market. While Models 9 and 10 are fully invested in local equities, Models 11 and 12 are diversified with a 50/25 split between local and foreign equities. Models 9 and 11 follow a glide path over a 10-year period, while Models 10 and 12 do so over five years. In all cases, a linear shift from equity and the fixed income asset class to the money market asset class is applied with the ending asset allocation 100 per cent invested in the money market asset class.

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3.7 MODELLING METHODOLOGY

3.7.1 GENERAL

Asset class return vectors for each month in the analysis period are obtained from resampled bootstrapping of the nominal return data.

The asset class return vectors are then combined with the asset allocation weights as specified by the particular model to generate the portfolio return and portfolio value at the end of the month. The portfolio is rebalanced at the end of every year back to the original asset allocation. Because retirement funds are exempt from taxes, the impact of taxes is specifically modelled for direct investments only (discussed in Chapter 2, Section 4.3.7.1 b).

Regarding the monthly foreign capital return, the USD monthly return is adjusted to reflect the historical currency impact. The ZAR/USD currency effect is calculated and forms part of the capital return component as follows:

$$r_{nominal\ capital\ ZAR} = (1 + r_{nominal\ capital\ USD}) \times (1 + r_{ZAR\ currency\ appreciation/depreciation}) - 1$$

(Equation 3-2)

With:

r = monthly return

For foreign dividends, the dividend yield of the foreign index is applied to the beginning of the month USD market value of foreign equity. The impact of the ZAR/USD currency on foreign dividends is not included in the dividend return *per se* because it is assumed in the modelling that the foreign dividend is received at the end of the month and converted to ZAR at the end of month ZAR/USD exchange rate. The ZAR dividend return earned in a month is calculated as follows:

$$Dividend_{ZAR} = (r_{nominal\ dividend\ USD}) \times (ZAR/USD_{end\ of\ month})$$

(Equation 3-3)

With:

r = monthly return

$Dividend$ = rand amount

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The researcher acknowledges that the chosen method to account for the currency impact on dividends and capital may lead to a slight over- or underestimation of the foreign equity capital and dividend returns. However, it is not considered to be material or fundamental to the results of the modelling.

For direct investments, local dividend tax is deducted monthly, while all other taxes (capital gains, income tax on interest and foreign dividends) are calculated annually at the end of each calendar year (12-month period) that falls within the investment horizon and paid six months later.

3.7.2 BALANCED RETIREMENT FUND MODELS

The following section describes the calculation method of the balanced retirement fund models. For illustrative purposes, it describes the hypothetical first 13 months of an investment horizon.

Month 1

- At the beginning of Month 1, the value of the fund is 0. There are no returns earned and only at the end of the month is a contribution made to the fund.

Month 2

- At the beginning of the second month, the fund value is equal to the contribution made at the end of the previous month. The contribution is invested in each asset class according to the asset allocation strategy. The returns earned for each asset class are based on the beginning of month investment to the particular asset class. At the end of the month, the contribution for Month 2 is paid to the fund. The end of month fund value consists of the assets invested in each asset class, the capital, interest and dividend returns as well as the additional contribution that was made at the end of Month 2. (Note: Capital returns can result in the asset allocation of the fund at the end of a particular period, or month, being inconsistent with the asset allocation specified for the model.)

Month 3

- At the beginning of Month 3, the interest and dividends earned in Month 2, along with the additional contribution made at the end of the previous month, are

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invested according to the asset allocation strategy and the capital, dividend and interest returns calculated. At the end of Month 3, the contribution for the month is paid to the fund. The end of month fund value consists of the assets invested in each asset class, the capital, interest and dividend returns as well as the additional contribution that was made at the end of Month 3.

Month 4 to 12

- The process described for Months 2 and 3 is repeated.

Month 13 (start of a new year)

- At the beginning of Month 13, the fund is rebalanced (due to annual rebalancing). This implies that the fund value at the end of Month 12 is allocated to each asset class according to the asset allocation strategy of the model. Capital, dividend and interest returns are calculated for the month. At the end of Month 13, the contribution for the month is paid to the fund. The end of month fund value consists of the assets invested in each asset class, the capital, interest and dividend returns as well as the additional contribution that was made at the end of Month 13.

The method is described mathematically in Appendix A. The following section describes, in short, the adjustment made in the calculation method of the life cycle retirement fund model.

3.7.3 LIFE CYCLE RETIREMENT FUND MODELS

The life cycle retirement fund models follow the same method as the balanced fund model except for the following:

- Where a life cycle glide path is implemented, the asset allocation is rebalanced at the beginning of the year (Month 13, 25, etc.) to the proposed asset allocation applicable to that year and calculated based on the following assumptions:
    - the number of years that the glide path is applicable to;
    - the target asset allocation at retirement; and
    - the assumption of linearly adjusting asset allocations over the glide path period.

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For example, a life cycle fund that originally started with an asset allocation of 50/25/15/10 (local equity/foreign equity/local fixed income/local money market) and follows a two-year glide path will be rebalanced at the beginning of the second last investment year to 40/17.5/32.5/10 and at the beginning of the last investment year to 30/10/50/10.

3.7.4 DIRECT INVESTMENT FUND MODELS

The direct investment fund models are fundamentally built on the same principles as the balanced retirement fund models except for the impact of taxes, which is not applicable to retirement funds.

Taxes are calculated annually at the end of a 12-month period and paid six months later (at the beginning of the month). Any taxes due are paid from the money market asset class and any additional contributions made during the particular month.

Taxes have the following impact on the direct investment fund models:

- Contributions

  As there are no tax deductions for contributions to direct investment portfolios, contributions are done with after-tax money. For example, an individual in the 18 per cent tax bracket who contributes R500 to a retirement fund will only contribute R500 x (1-0.18) = R410 to a direct investment fund if the net outflow to the individual must be similar.
- Local dividend income

  Local dividend income is taxed at 15 per cent and paid to the individual net of taxes. In the modelling, all dividends received are modelled to be net of dividend taxes.
- Local interest and foreign dividend income taxed at the individual's tax rate
  - Local interest income

  The first R23 800 local interest earned per annum is exempt from taxes. All interest income earned above the exemption is taxed at the individual's tax rate. The interest exemption is modelled to increase annually at the rate of inflation of 4.5 per cent.

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- Foreign dividend income

An exemption also applies to foreign dividend income: the first 62.5 per cent of foreign dividend income is exempt from taxes. Any amount over and above the exemption is taxed at the tax rate of the individual.

- Capital gains tax

The net profit or loss from rebalancing the portfolio after every 12 months is calculated based on the weighted average cost method for the local fixed income, local equity and foreign equity asset classes (the appropriateness of the weighted average cost method was discussed in Chapter 2, Section 2.4.3.7.1 b). Any net capital gains are taxed as follows: an exemption of R30 000 applies, after which a capital gains tax of 33.33 per cent is applied and included in the taxable income of the individual, taxed at the individual's tax rate. As an example, the capital gain for a year is R100 000 for an individual in the 18 per cent tax bracket. The first R30 000 is tax exempt with the remaining R70 000 taxed: R70 000 x 33.33% x 18% = R4 199.58 taxes payable.

Although the legislation allows for any capital losses in a particular year to be rolled forward and applied to a later financial year's capital gains, it is not modelled in this study. Furthermore, the assumption is that the capital gains tax exemption of R30 000 increases every year at the rate of inflation of 4.5 per cent.

3.8 ANALYSIS OF SIMULATED FINDINGS

3.8.1 MONTE CARLO SIMULATION RESULTS

The simulation trial of each model is iterated 10 000 times resulting in 10 000 accumulated retirement ending wealth values.

3.8.1.1 Accumulated retirement ending wealth

The accumulated retirement ending wealth represents the nominal wealth of one iteration for a particular model, investment horizon and tax bracket.

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3.8.1.2 Implied annualised return

The implied annualised return of the mean accumulated retirement ending wealth for each model is determined in addition to the rand value as the measure is often used when comparing investment options. The implied monthly return of the mean accumulated retirement ending wealth value is calculated as the internal rate of return (IRR) of assuming an initial investment of zero, payments equal to the contributions made each month during the applicable investment horizon and future value equal to the mean accumulated retirement ending wealth of the particular model. The monthly return is annualised as follows:

Annualised return = $(1+ \text{monthly return})^{12} - 1$ (Equation 3-4)

3.8.2 DESCRIPTIVE AND COMPARATIVE STATISTICS

Descriptive analysis reports on what is observed while *comparative analysis* involves a comparison of observations between different groups or, as is the case in this study, different accumulated retirement ending wealth models (Johnson & Harris, 2002). Histograms, cumulative distribution plots and scatterplots of each model will be presented. Each model will further be described based on measures of central tendency, measures of dispersion and the shape of the distribution.

3.8.2.1 Measures of central tendency

Measures of central tendency indicate "where the center of a frequency distribution lies" (Field, 2013:21). These measures include the median and mean. The *median* represents the "middle score when scores [data] are ranked in order of magnitude" (Field, 2013:22), while the *mean* is the average of all scores or, as would be the case in this study, average return for a particular asset class proxy (Field, 2013). Both the geometric and arithmetic means will be presented.

3.8.2.2 Measures of dispersion

Measures of dispersion attempt to quantify the spread of scores or data (Field, 2013). A number of measures will be used to describe the spread of each asset class proxy, namely range, interquartile range, variance and standard deviation.

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The range subtracts the minimum score or value from the maximum and is therefore greatly affected by outliers. Additional informational value is provided by the interquartile range, that is the middle 50 per cent of scores or outcomes (Field, 2013).

The standard deviation can be used as a measure of dispersion. The lower the standard deviation, the closer the data are to the mean and *vice versa* (Field, 2013). However, the literature states that historical financial data is not normally distributed and in such circumstances, the range and per centiles may be a better indication of risk.

3.8.2.3 Shape of distribution

Should the mean be greater than the median, it indicates that the distribution is positively skewed or exhibit right-skewness with more scores clustered at the lower end of the distribution, while a mean lower than the median indicates a negatively skewed distribution or left-skewness (Field, 2013; Pfau, 2010). While a symmetrical distribution exhibits a skewness of 0, a positive (negative) value for skewness indicates right-skewness (left-skewness) of the distribution (Field, 2013).

“Kurtosis measures the degree to which scores cluster in the tails of a frequency distribution” (Field, 2013:878). A positive (negative) value of kurtosis indicates that a distribution is pointy (flat) and exhibits heavy (light) tails and is called leptokurtic (platykurtic). A normal distribution should exhibit a kurtosis of 0 (Field, 2013).

3.9 DECISION-MAKING CRITERIA: STOCHASTIC DOMINANCE

The decision-making criteria used in the study to assess each research question and subsequent hypothesis are first-order and almost stochastic dominance.

Stochastic dominance (SD) is the most general approach to decision-making under uncertain circumstances (Levy, 2009). Additionally, SD can be employed irrespective of whether the distributions of the choices under consideration are normally distributed

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(Basu *et al.*, 2011; Levy, 2009). First-degree stochastic dominance (FSD) assumes that the utility function of the decision-maker $U(x)$ increases with x, $U'(x)>0$. Therefore, the decision-maker prefers more of x rather than less (Graves & Ringuest, 2009).

Assuming two portfolios, namely A and B, an individual would prefer Portfolio A over B under FSD if:

$F_B(x) \geq F_A(x)$ (Equation 3-5)

For all values of x

With:

$F_B(x)$ = Cumulative probability distribution of B

$F_A(x)$ = Cumulative probability distribution of A

That implies that A will dominate B if the cumulative probability distribution of B is always below or to the right of that of A (Graves & Ringuest, 2009). Additionally, if the cumulative distribution function of a model is steeper relative to another, the strategy is generally considered to result in less volatile outcomes (Basu *et al.*, 2011).

As previously stated, FSD of A over B only exists if $F_B(x) \geq F_A(x)$. ASD relaxes this strict assumption because it does not require that the cumulative probability distribution of B always has to be below that of A to dominate by ASD. However, the relaxation of this assumption is conditional: the area of violation (i.e. the area where the cumulative probability distribution of B is above that of A) must be very small compared with the total area of the two distributions (Basu *et al.*, 2011; Levy, 2009, 2012).

Graves and Ringuest (2009) state that often "…ordinary stochastic dominance yields results inconsistent with common sense preferences of most decision makers". Developed by Leshno and Levy (2002), the ASD decision-making criteria indicates what would be the optimal decision for *most* decision-makers, not *all* decision-makers (Graves & Ringuest, 2009; Levy, 2012).

Consequently, Basu *et al.* (2011) used the principle of SD, in particular *almost stochastic dominance (ASD)*, to compare different asset allocation strategies and indicate which strategy would be preferred by most individuals. Basu *et al*. (2011) used

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the cumulative distribution function of the accumulated retirement ending wealth for their analysis.

Where there is no clear indication of FSD, Basu *et al.* (2011) apply a conservative rule that if ε, the area of violation, is between 0 and 0.01, one can accept dominance by ASD. Levy, Leshno and Leibovitch (in Basu *et al.*, 2011) conducted an experiment with undergraduate and graduate students as well as mutual fund managers and estimated the value of ε to be 5.9 per cent. Setting a low threshold of 0.01 as suggested by Basu *et al.* (2011) makes it highly unlikely that an error regarding dominance by ASD is probable.

The range over which FSD is violated is defined as s_1 with:

$$s_1(F,G) = \{t : G(t) < F(t)\}$$ (Equation 3-6)

The ratio between the area of FSD violation and the total area (or range of possible outcomes, *s*) between the cumulative distributions is defined as ε_1 with:

$$\varepsilon_1 = \frac{\int_{s_1} \left(F(t) - G\ (t)\right)dt}{\int_s |F(t) - G(t)|dt}$$

(Equation 3-7)

The illustration in Figure 3-1 graphically depicts FSD. In the illustration, the cumulative distribution function of Fund A2 is constantly below or to the right of that of Fund A1. As the cumulative distribution functions of the two models never cross, Fund A2 dominates Fund A1 by FSD.

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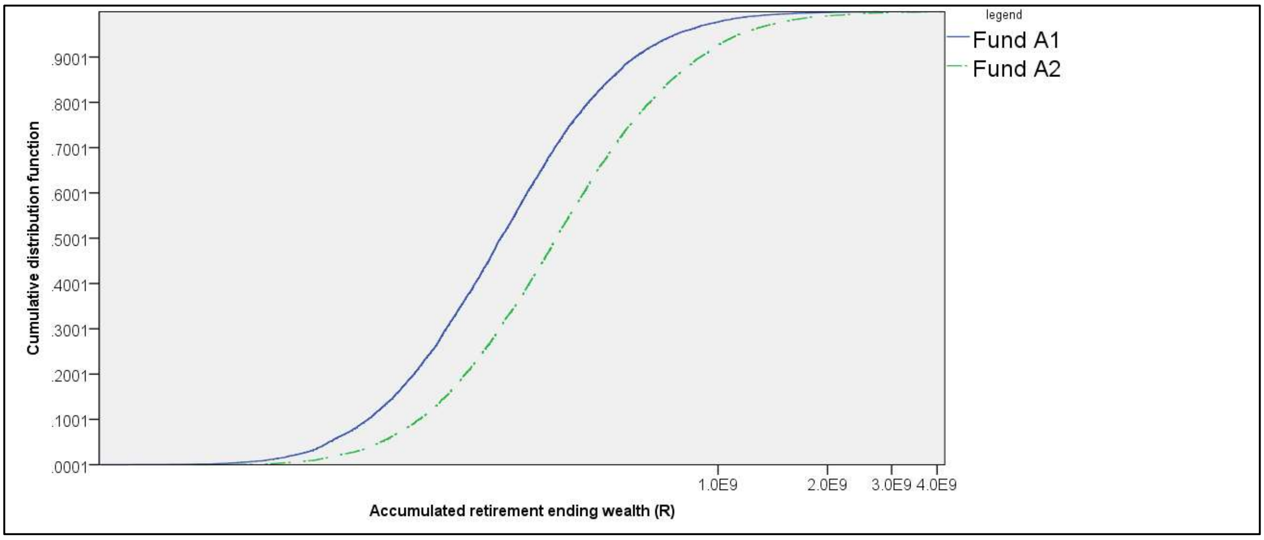
Figure 3-1: Illustration of first-order stochastic dominance



Contrast Figure 3-1 with Figure 3-2 where the cumulative distribution graphs of the funds cross. In Figure 3-2, the cumulative distribution graphs cross at Point X (a cumulative probability of approximately 0.12). For any cumulative probability below 0.12, Fund B1 offers a higher accumulated retirement ending wealth compared with Fund B2, while the opposite is true for any cumulative probability value above 0.12. Hence Fund B1 is optimal below 0.12, while Fund B2 is optimal above 0.12. As a fund does not dominate the other by FSD because the cumulative distribution functions cross, dominance of one fund over the other will be so if dominance by ASD exists. Because Area A where Fund B2 is optimal is smaller than Area B, it indicates that overall, Fund B1 seems optimal. If Area A as a fraction of Area B is below the threshold value of 0.01 (the area of SD violation as opposed to the area of non-SD violation), which is the case in this instance, Fund B1 dominates Fund B2 by ASD.

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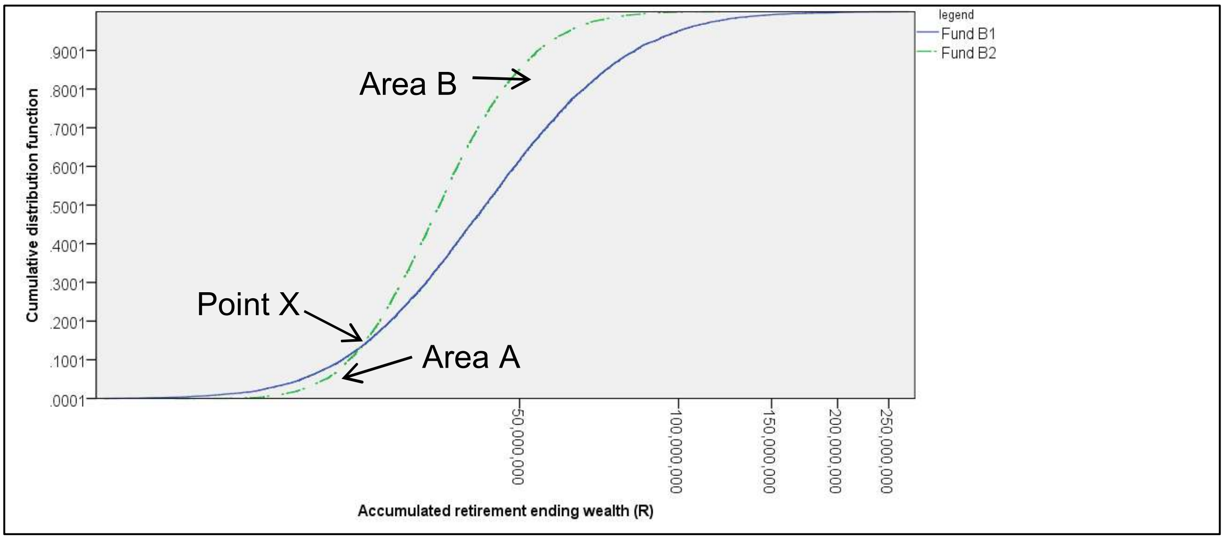
Figure 3-2: Illustration of almost stochastic dominance



Leshno and Levy (2002) highlight the benefits of ASD. Firstly, ASD allows options to be ranked, which would not otherwise have been the case. Furthermore, ASD eliminates options that would be deemed to be mediocre by most from the efficient set. Lastly, ASD highlights the relationship between investment horizon and the riskiness of the asset allocation decision (i.e. how much of a portfolio is invested in high-risk equities) because, all other factors held constant, ASD does not remain static when either the investment horizon or asset allocation changes. The lower the risk of the strategy, the steeper the cumulative distribution function of that strategy will be.

The research of Schleef and Eisinger (2007) as well as that of Basu *et al.* (2011) dealt with the retirement target of an individual and how this unique need of an individual could influence what the individual would deem to be the most appropriate fund in his or her particular circumstances. To illustrate, in Figure 3-3, an individual who has a retirement target to the left of Point X, will prefer Fund 2C, because Fund 2C has a higher probability of meeting the retirement target. Should an individual have a retirement target of R6.25 million, there is approximately a 95 per cent chance that Fund 1C will deliver on the target while there is a 99 per cent chance that Fund 2C will.

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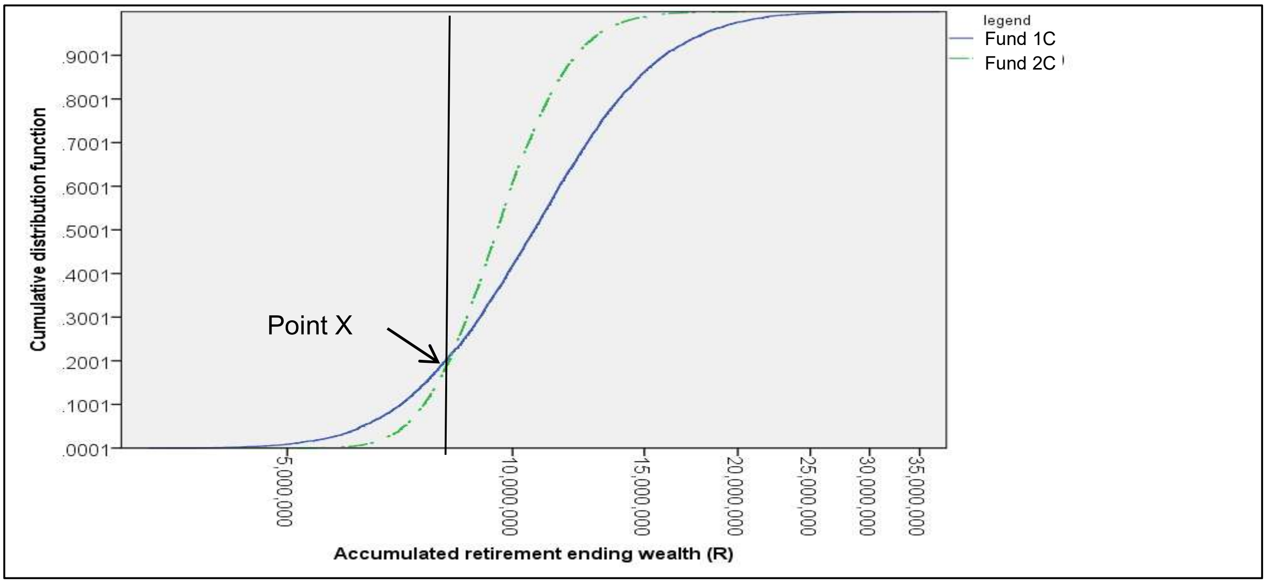
Figure 3-3: Illustration of almost stochastic dominance and target retirement wealth



In this study, the cumulative distribution function of the accumulated retirement ending wealth will be used to test for FSD or ASD. Although target retirement wealth can be used to compare different funds, it shifts the focus from the different fund strategies *per se* to the unique needs of the individual. The study's focus is on a comparative analysis of the different strategies, not the likelihood of meeting a particular target. Additionally, a similar decision rule to that of Basu *et al.* (2011) will be applied: should the area of violation be $0 \leq \varepsilon_1 \leq 0.1$, dominance by ASD can be accepted. Furthermore, the smaller ε_1, the stronger the dominance (Levy, 2012).

The FSD and ASD decision-making criteria captures both risk and ending wealth as part of the method as the retirement ending wealth values and the slopes of the cumulative distribution functions, influence the area of SD violation versus the total area encompassed by the cumulative distribution functions. The riskiness of a strategy is evident in the how steep the slope of the cumulative distribution function is: the steeper the slope, the less risky the strategy. If two funds have similar risk characteristics, the total area encompassed by the cumulative distribution functions will be much less compared to a fund with a very low risk (and therefore steep cumulative distribution function) and a fund with a very high risk (and therefore flatter cumulative distribution function with lower and higher minimum and maximum retirement ending wealth values).

3.10 RELIABILITY

"Reliability refers to the extent to which your data collection techniques or analysis procedures will yield consistent findings" (Saunders *et al.*, 2009:156).

The historical data used in the study is reliable because the monthly data provided by Staunton (Staunton, 2013), used in the research by Firer and Staunton (2002), was verified and compared with other publications where the annual data was used. For any of the later years, the indices used to extend the historical data period are reputable indices constructed by FTSE/JSE, MSCI and Alexander Forbes, all reputable companies with sound index construction methodologies. Because INet BFA and Morningstar are industry leaders providing financial data, the index data was sourced from them.

Regarding the Monte Carlo simulations and bootstrap with resampling technique, SAS is an industry-accepted statistical package and, as Little (2013) states, use a reputable and acceptable bootstrap program. Furthermore, preliminary testing of the SAS modelling of the simulations will be simultaneously built in Excel and one simulation tested (static data) to ensure that no modelling misspecification is evident in the SAS programming.

3.11 VALIDITY

External validity questions whether the so-called causal relationship identified in a study holds true in general (Cooper & Schindler, 1998:387). The validity of the study depends on whether the assumptions used in the study are a true reflection of reality as well as whether the models are correctly specified. Both these aspects as well as the limitations thereof have been clearly specified and great care will be taken with the modelling to ensure that model misspecification is not present.

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3.12 ETHICAL CONSIDERATIONS

Ethical approval was given by the Ethics Committee of the Faculty of Economic and Management Sciences. All engagement with the data was done responsibly and any calculation methods applied objectively and consistently. The secondary data used for the study is with the permission of Staunton, INet BFA and Morningstar.

3.13 RESEARCH QUESTIONS AND HYPOTHESES

The following section shows the research questions and introduces the hypotheses applicable to Research Question 1 and 2.

3.13.1 RESEARCH QUESTION 1

Research Question 1 focuses on whether a fund fully invested in equities is optimal to a high equity balance retirement fund. While Hypotheses 1A and 1B consider direct investments as opposed to high equity balanced retirement funds, Hypotheses 1C, 1D and 1E consider theoretical retirement funds which invest 100 per cent of assets in equities as opposed to high equity balanced retirement funds. The theoretical retirement funds are not possible due to the current limits in Regulation 28 of the Pension Funds Act but were possible before.

Regarding Hypothesis 1B, the direct investment fund model has an exposure to equities of 95 per cent and not 100 per cent. This is due to the fact that rebalancing of the asset allocation between local and foreign equities is required to maintain a static asset allocation in the model which, in this case, triggers tax implications and cash outflows, which requires a cash holding in the portfolio. This aspect is comprehensively discussed in this chapter. The hypotheses also make reference to the appropriate models to test each hypothesis. Similarly, the models are described in detail in the current chapter (Section 3.6.2 and 3.7).

Research Question 1: *Is a fund fully invested in equities optimal compared with a high equity balanced retirement fund with maximum equity allocation of 75 per cent?*

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Hypothesis 1A(10, 20, 30, 40 years)

H_0: A 100 per cent local equity direct investment fund (Model 2) does not dominate a high equity balanced retirement fund with 75 per cent local equity (Model 5) by first-order stochastic dominance (FSD) or almost stochastic dominance (ASD).

H_a: A 100 per cent local equity direct investment fund (Model 2) dominates a high equity balanced retirement fund with 75 per cent local equity (Model 5) by first-order stochastic dominance (FSD) or almost stochastic dominance (ASD).

Hypothesis 1B(10, 20, 30, 40 years)

H_0: A 95 per cent equity direct investment fund with a 70/25 per cent local/foreign equity split (Model 4) does not dominate a high equity balanced retirement fund with a 50/25 per cent local/foreign equity split (Model 6) by first-order stochastic dominance (FSD) or almost stochastic dominance (ASD).

H_a: A 95 per cent equity direct investment fund with a 70/25 per cent local/foreign equity split (Model 4) dominates a high equity balanced retirement fund with a 50/25 per cent local/foreign equity split (Model 6) by first-order stochastic dominance (FSD) or almost stochastic dominance (ASD).

Hypothesis 1C(10, 20, 30, 40 years)

H_0: A theoretical 100 per cent local equity retirement fund (Model 1) does not dominate a high equity balanced retirement fund with a maximum 75 per cent local equity allocation (Model 5) by first-order stochastic dominance (FSD) or almost stochastic dominance (ASD) over the 10-, 20-, 30- or 40-year investment horizon.

H_a: A theoretical 100 per cent local equity retirement fund (Model 1) dominates a high equity balanced retirement fund with a maximum 75 per cent local equity allocation (Model 5) by first-order stochastic dominance (FSD) or almost stochastic dominance (ASD) over the 10-, 20-, 30- or 40-year investment horizon.

Hypothesis 1D(10, 20, 30, 40 years)

H_0: A theoretical 100 per cent equity retirement fund with a 70/25 per cent local/foreign equity allocation split (Model 3) does not dominate a high equity balanced retirement fund with a 50/25 per cent local/foreign equity allocation split (Model 6) by first-order stochastic dominance (FSD) or almost stochastic dominance (ASD) over the 10-, 20-, 30- or 40-year investment horizon.

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H_a: A 100 per cent equity retirement fund with a 70/25 per cent local/foreign equity allocation split (Model 3) dominates a high equity balanced retirement fund with a 50/25 per cent local/foreign equity allocation split (Model 6) by first-order stochastic dominance (FSD) or almost stochastic dominance (ASD) over the 10-, 20-, 30- or 40-year investment horizon.

Hypothesis 1E$_{(10, 20, 30, 40 \text{ years})}$

H_0: A theoretical 100 per cent equity retirement fund with a 100 per cent local equity allocation (Model 1) does not dominate a high equity balanced retirement fund with a 50/25 per cent local/foreign equity allocation split (Model 6) by first-order stochastic dominance (FSD) or almost stochastic dominance (ASD) over the 10-, 20-, 30- or 40-year investment horizon.

H_a: A theoretical 100 per cent equity retirement fund with a 100 per cent local equity allocation (Model 1) dominates a high equity balanced retirement fund with a 50/25 per cent local/foreign equity allocation split (Model 6) by first-order stochastic dominance (FSD) or almost stochastic dominance (ASD) over the 10-, 20-, 30- and 40-year investment horizon.

3.13.2 RESEARCH QUESTION 2

Research Question 2 focuses on whether life cycle funds are optimal to balanced funds. While Hypothesis 2A focuses on a life cycle and balanced funds with a similar starting asset allocation, Hypothesis 2B focuses on life cycle and balanced funds with dissimilar starting asset allocations.

The hypotheses also make reference to the appropriate models to test each hypothesis. The models are described in detail in the current chapter.

Research Question 2: *Are life cycle funds optimal when compared with balanced funds?*

Table 3-8 to shows the sub-hypotheses pertaining to life cycle funds as opposed to balanced funds with similar starting asset allocations.

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Table 3-8: Hypothesis 2A pertaining to Research Question 2: life cycle funds against balanced funds with similar starting asset allocations

Research Question 2 *Are life cycle funds optimal when compared with balanced funds?*
Sub-hypothesis 2A
Life cycle funds against balanced funds – similar starting asset allocation
Hypothesis 2A $H_0^{10,20,30,40\ years}$: Life cycle funds do not dominate balanced funds by first-order stochastic dominance (FSD) or almost stochastic dominance (ASD) when the funds have similar starting asset allocations. $H_a^{10,20,30,40\ years}$: Life cycle funds dominate balanced funds by first-order stochastic dominance (FSD) or almost stochastic dominance (ASD) when the funds have similar starting asset allocations.
Sub-hypothesis 2A$_{9,5}$ $H_0^{20,30,40\ years}$: Life cycle fund Model 9 does not dominate balanced fund Model 5 by almost stochastic dominance (ASD) or first-order stochastic dominance (FSD) when the funds have similar starting asset allocations. $H_a^{20,30,40\ years}$: Life cycle fund Model 9 dominates balanced fund Model 5 by almost stochastic dominance (ASD) or first-order stochastic dominance (FSD) when the funds have similar starting asset allocations. **Sub-hypothesis 2A$_{10,5}$** $H_0^{10,20,30,40\ years}$: Life cycle fund Model 10 does not dominate balanced fund Model 5 by almost stochastic dominance (ASD) or first-order stochastic dominance (FSD) when the funds have similar starting asset allocations. $H_a^{10,20,30,40\ years}$: Life cycle fund Model 10 dominates balanced fund Model 5 by almost stochastic dominance (ASD) or first-order stochastic dominance (FSD) when the funds have similar starting asset allocations. **Sub-hypothesis 2A$_{11,6}$** $H_0^{20,30,40\ years}$: Life cycle fund Model 11 does not dominate balanced fund Model 6 by almost stochastic dominance (ASD) or first-order stochastic dominance (FSD) when the funds have similar starting asset allocations. $H_a^{20,30,40\ years}$: Life cycle fund Model 11 dominates balanced fund Model 6 by almost stochastic dominance (ASD) or first-order stochastic dominance (FSD) when the funds have similar starting asset allocations. **Sub-hypothesis 2A$_{12,6}$** $H_0^{10,20,30,40\ years}$: Life cycle fund Model 12 does not dominate balanced fund Model 6 by almost stochastic dominance (ASD) or first-order stochastic dominance (FSD) when the funds have similar starting asset allocations. $H_a^{10,20,30,40\ years}$: Life cycle fund Model 12 dominates balanced fund Model 6 by almost stochastic dominance (ASD) or first-order stochastic dominance (FSD) when the funds have similar starting asset allocations.

Tables 3-9 and 3-10 show the sub-hypotheses pertaining to life cycle funds as opposed to balanced funds with dissimilar starting asset allocations.

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Table 3-9: Hypothesis 2B pertaining to Research Question 2: life cycle funds against balanced funds with dissimilar starting asset allocations, Models 9 and 10

Research Question 2 *Are life cycle funds optimal when compared with balanced funds?*
Sub-hypothesis 2B: Models 9 and 10
Life cycle funds versus balanced funds – dissimilar starting asset allocation
Hypothesis 2B $H_0^{10,20,30,40\ years}$: Life cycle funds do not dominate balanced funds by almost stochastic dominance (ASD) or first-order stochastic dominance (FSD) when the funds have different starting asset allocations. $H_a^{10,20,30,40\ years}$: Life cycle funds dominate balanced funds by almost stochastic dominance (ASD) or first-order stochastic dominance (FSD) when the funds have different starting asset allocations.
Sub-hypothesis 2B $_{9,6}$ $H_0^{20,30,40\ years}$: Life cycle fund Model 9 does not dominate balanced fund Model 6 by almost stochastic dominance (ASD) or first-order stochastic dominance (FSD) when the funds have different starting asset allocations. $H_a^{20,30,40\ years}$: Life cycle fund Model 9 dominates balanced fund Model 6 by almost stochastic dominance (ASD) or first-order stochastic dominance (FSD) when the funds have different starting asset allocations. **Sub-hypothesis 2B $_{9,7}$** $H_0^{20,30,40\ years}$: Life cycle fund Model 9 does not dominate balanced fund Model 7 by almost stochastic dominance (ASD) or first-order stochastic dominance (FSD) when the funds have different starting asset allocations. $H_a^{20,30,40\ years}$: Life cycle fund Model 9 dominates balanced fund Model 7 by almost stochastic dominance (ASD) or first-order stochastic dominance (FSD) when the funds have different starting asset allocations. **Sub-hypothesis 2B $_{9,8}$** $H_0^{20,30,40\ years}$: Life cycle fund Model 9 does not dominate balanced fund Model 8 by almost stochastic dominance (ASD) or first-order stochastic dominance (FSD) when the funds have different starting asset allocations. $H_a^{20,30,40\ years}$: Life cycle fund Model 9 dominates balanced fund Model 8 by almost stochastic dominance (ASD) or first-order stochastic dominance (FSD) when the funds have different starting asset allocations. **Sub-hypothesis 2B $_{10,6}$** $H_0^{10,20,30,40\ years}$: Life cycle fund Model 10 does not dominate balanced fund Model 6 by almost stochastic dominance (ASD) or first-order stochastic dominance (FSD) when the funds have different starting asset allocations. $H_a^{10,20,30,40\ years}$: Life cycle fund Model 10 dominates balanced fund Model 6 by almost stochastic dominance (ASD) or first-order stochastic dominance (FSD) when the funds have different starting asset allocations. **Sub-hypothesis 2B $_{10,7}$** $H_0^{10,20,30,40\ years}$: Life cycle fund Model 10 does not dominate balanced fund Model 7 by almost stochastic dominance (ASD) or first-order stochastic dominance (FSD) when the funds have different starting asset allocations. $H_a^{10,20,30,40\ years}$: Life cycle fund Model 10 dominates balanced fund Model 7 by almost stochastic dominance (ASD) or first-order stochastic dominance (FSD) when the funds have different starting asset allocations. **Sub-hypothesis 2B $_{10,8}$** $H_0^{10,20,30,40\ years}$: Life cycle fund Model 10 does not dominate balanced fund Model 8 by almost stochastic dominance (ASD) or first-order stochastic dominance (FSD) when the funds have different starting asset allocations. $H_a^{10,20,30,40\ years}$: Life cycle fund Model 10 dominates balanced fund Model 8 by almost stochastic dominance (ASD) or first-order stochastic dominance (FSD) when the funds have different starting asset allocations.

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Table 3-10: Hypothesis 2B pertaining to Research Question 2: life cycle funds against balanced funds with dissimilar starting asset allocations, Models 11 and 12

Research Question 2

Are life cycle funds optimal when compared with balanced funds?

Sub-hypothesis 2B: Models 11 and 12

Life cycle funds versus balanced funds – dissimilar starting asset allocation

Hypothesis 2B

$H_0^{10,20,30,40\ years}$: Life cycle funds do not dominate balanced funds by almost stochastic dominance (ASD) or first-order stochastic dominance (FSD) when the funds have different starting asset allocations.

$H_a^{10,20,30,40\ years}$: Life cycle funds dominate balanced funds by almost stochastic dominance (ASD) or first-order stochastic dominance (FSD) when the funds have different starting asset allocations.

Sub-hypothesis 2B $_{11,\ 5}$

$H_0^{20,30,40\ years}$: Life cycle fund Model 11 does not dominate balanced fund Model 5 by almost stochastic dominance (ASD) or first-order stochastic dominance (FSD) when the funds have different starting asset allocations.

$H_a^{20,30,40\ years}$: Life cycle fund Model 11 dominates balanced fund Model 5 by almost stochastic dominance (ASD) or first-order stochastic dominance (FSD) when the funds have different starting asset allocations.

Sub-hypothesis 2B $_{11,\ 7}$

$H_0^{20,30,40\ years}$: Life cycle fund Model 11 does not dominate balanced fund Model 7 by almost stochastic dominance (ASD) or first-order stochastic dominance (FSD) when the funds have different starting asset allocations.

$H_a^{20,30,40\ years}$: Life cycle fund Model 11 dominates balanced fund Model 7 by almost stochastic dominance (ASD) or first-order stochastic dominance (FSD) when the funds have different starting asset allocations.

Sub-hypothesis 2B $_{11,\ 8}$

$H_0^{20,30,40\ years}$: Life cycle fund Model 11 does not dominate balanced fund Model 8 by almost stochastic dominance (ASD) or first-order stochastic dominance (FSD) when the funds have different starting asset allocations.

$H_a^{20,30,40\ years}$: Life cycle fund Model 11 dominates balanced fund Model 8 by almost stochastic dominance (ASD) or first-order stochastic dominance (FSD) when the funds have different starting asset allocations.

Sub-hypothesis 2B $_{12,\ 5}$

$H_0^{10,20,30,40\ years}$: Life cycle fund Model 12 does not dominate balanced fund Model 5 by almost stochastic dominance (ASD) or first-order stochastic dominance (FSD) when the funds have different starting asset allocations.

$H_a^{10,20,30,40\ years}$: Life cycle fund Model 12 dominates balanced fund Model 5 by almost stochastic dominance (ASD) or first-order stochastic dominance (FSD) when the funds have different starting asset allocations.

Sub-hypothesis 2B $_{12,\ 7}$

$H_0^{10,20,30,40\ years}$: Life cycle fund Model 12 does not dominate balanced fund Model 7 by almost stochastic dominance (ASD) or first-order stochastic dominance (FSD) when the funds have different starting asset allocations.

$H_a^{10,20,30,40\ years}$: Life cycle fund Model 12 dominates balanced fund Model 7 by almost stochastic dominance (ASD) or first-order stochastic dominance (FSD) when the funds have different starting asset allocations.

Sub-hypothesis 2B $_{12,\ 8}$

$H_0^{10,20,30,40\ years}$: Life cycle fund Model 12 does not dominate balanced fund Model 8 by almost stochastic dominance (ASD) or first-order stochastic dominance (FSD) when the funds have different starting asset allocations.

$H_a^{10,20,30,40\ years}$: Life cycle fund Model 12 dominates balanced fund Model 8 by almost stochastic dominance (ASD) or first-order stochastic dominance (FSD) when the funds have different starting asset allocations.

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3.14 CONCLUSION

The chapter presented the research design and methods applicable to the study. It created a background to the applicable philosophy and approach followed in the design, namely positivism and quantitative in nature, which uses cross-sectional data.

The broad research method employed is simulations and in particular Monte Carlo simulation with resampled bootstrapping with replacement. The method offers certain advantages such as the fact that it can be used where limited data is available. However, it is not without its weaknesses such as the risk of model misspecification. This is mitigated by clearly specified, unambiguous and realistic models. The models are also developed in both Excel and SAS to compare and ensure that model misspecification does not occur. The data used in the Monte Carlo simulation is also sound, appropriate and from reputable sources.

A description of the data that will be used in the analysis was presented, followed by the delimitations, limitations and assumptions of the study. A short description of the outputs from the Monte Carlo simulations was offered, namely accumulated retirement ending wealth and the annualised return. A total of 10 000 iterations of the accumulated retirement ending wealth will be done for each model resulting in a range of possible outcomes. The descriptive statistics reported will include measures of central tendency (mean accumulated retirement ending wealth), measures of dispersion (range and standard deviation) and the shape of the distribution of outcomes (kurtosis and skewness).

This was followed by an outline of the modelling methodology and the decision criteria of almost stochastic dominance. The chapter dealt with reliability and validity. The study is deemed reliable with reputable software (SAS) used for the Monte Carlo simulations, data from reliable data sources used in the study and mitigating measures used to ensure reliability of the SAS programming. The study is valid with realistic and clearly defined limitations and assumptions. This was followed with a discussion of the ethical considerations pertinent to the study. The chapter closed by presenting the research questions and hypotheses.

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CHAPTER 4:

RESEARCH QUESTION 1: ANALYSIS AND DISCUSSION

4.1 INTRODUCTION

The previous chapter described the research method that is used in the study, which includes Monte Carlo simulation and bootstrapping as well as the proposed models (i.e. the asset allocation strategies modelled) and the decision-making criteria applied to the study.

This chapter presents the results, findings and discussion pertaining to Research Question 1: *Is a fund fully invested in equities optimal compared with a high equity balanced retirement fund with maximum equity allocation of 75 per cent?*

The chapter commences with presenting the descriptive statistics of the historical data used in the Monte Carlo simulations. Thereafter, the hypotheses, models and asset allocation strategies pertaining to Research Question 1 are presented. The descriptive statistics for the models follow, whereafter the empirical results, findings and discussion for the hypotheses relating to the research question are presented.

4.2 DESCRIPTIVE STATISTICS OF HISTORICAL DATA

The data used in the study and described in the subsequent sections is for the period January 1986 to December 2013; hence 336 historical monthly data points for each asset class for the following reasons:

- From January 1986, the local fixed income data decomposes the total return into interest and capital gains (which is not the case for earlier years) and this is consistently the case to December 2000 for all three asset classes.
- The additional data from 2001 to 2013 constructed for this study also provides monthly dividend or interest and capital returns for the respective asset classes. The foreign equity asset class historical monthly data that was compiled for the study is also available for both dividends and capital gains.

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The descriptive statistics presented include an analysis of annual and monthly total nominal return data as well as separate analysis for dividend and interest monthly nominal return data and monthly nominal capital return data for each asset class proxy.

4.2.1 ANNUALISED RETURN DATA

Table 4-1 indicates the annualised return data for the underlying data set of each asset class in ZAR. Hence the foreign equity asset class data presents both the currency return and total index return. Although the nominal total foreign equity return is not used in the modelling *per se*, it is important for a comparison between the different asset classes. It is evident, from the table, that local equity is the higher risk and higher return asset class with an annualised geometric mean return of 17.1 per cent and standard deviation of 19.8 per cent against local fixed income and money market at a return of 14.9 and 12 per cent respectively and annualised standard deviation of 8.4 and 1.2 per cent.

Table 4-1: Descriptive statistics of nominal total annualised returns of local and foreign asset classes (1986 to 2013)

	Foreign equity (in ZAR)	Local equity (in ZAR)	Local fixed income (in ZAR)	Local money market (in ZAR)
Annualised geometric mean	14.2%	17.1 %	14.9%	12.0%
Annualised arithmetic mean	15.9%	19.4%	15.3%	12.0%
Annualised standard deviation	17.4%	19.8%	8.4%	1.2%

Source: Provided by Staunton (2013) and calculated from Morningstar

The foreign equity asset class underperformed both local equity and fixed income in rand terms with a geometric return of 14.2 per cent against 17.1 per cent and 14.9 per cent. The local equity asset class is more volatile than the foreign equity asset class with a standard deviation of 19.8 per cent against 17.4 per cent. The data for the annualised arithmetic mean return offers contradictory information based on this metric with local equity offering the highest return (19.4 per cent), followed by foreign equity (15.9 per cent), local fixed income (15.3 per cent) and local money market (1.2 per cent).

Contrasting the annualised return and standard deviation of the historical data used in the study for the period January 1986 to December 2013 with the Firer and Staunton (2002) study presented in Chapter 2, Section 2.4.3.1 reveals that equities are in both instances the higher risk and return asset class, followed by fixed income and money market thereafter. The annual data presented by Firer and Staunton (2002) reveals that equities have an annualised nominal mean return of 12.2 per cent as opposed to an annualised geometric mean return of 17.1 per cent for the historical data in the study. The annualised standard deviation for equities is higher at 23.4 per cent against 19.8 per cent.

The fixed income asset class is slightly less risky with lower return potential offering an annualised return of 6.4 per cent against 15.3 per cent and standard deviation of 9.5 against 8.4 per cent (the data of Firer and Staunton (2002) is compared with the historical data for the study). Finally, the annualised return for the money market asset class is 5.7 against 12 per cent with an annualised standard deviation of 5.8 against 1.2 per cent (for each metric, the latter value shows what is evident in the historical data). The comparison illustrates that the historical data is not necessarily reflective of what can be expected in future. Additionally, the time period which is used in the study will also influence the results. The historical data used in the study (January 1986 to December 2013) is shorter than that of Firer and Staunton (2002) but seem to include a greater number of higher return data points creating an upward bias compared with the data of Firer and Staunton (2002).

4.2.2 MONTHLY RETURN DATA

The following section describes the monthly return data of each asset class as well as the ZAR/USD exchange rate. Apart from the tables presented in these sections, Appendix A includes more comprehensive tables and figures.

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Table 4-2: Descriptive statistics of nominal total monthly returns of local and foreign asset classes (1986-2013)

	Foreign equity (in ZAR)*	Local equity (in ZAR)	Local fixed income (in ZAR)	Local money market (in ZAR)
Median	1.2134%	1.8358%	1.2584%	0.8960%
Arithmetic mean	1.2338%	1.4911%	1.1917%	0.9476%
Geometric mean	1.1090%	1.3243%	1.1623%	0.9470%
Minimum return	-19.5938%	-29.7057%	-14.4574%	0.3860%
Maximum return	18.9578%	17.7647%	11.4067%	1.7940%
Standard deviation	5.0161%	5.7182%	2.4317%	0.3428%
Observations	336	336	336	336

* For comparison, the returns are reported in ZAR. However, in the modelling, the USD return and applicable ZAR/USD exchange rate are used (as per the applicable vector) because the cash impact on foreign dividend and capital returns is slightly different (see Chapter 3, Section 7).

Source: Provided by Staunton (2013) and calculated from Morningstar

Table 4-2 shows the monthly nominal return data for the foreign and local asset classes. Similar to the annualised data, local equity is the higher risk and return asset class compared with local fixed income and money market.

The following sections describe the monthly return data that is used in the modelling and Monte Carlo simulations.

4.2.2.1 Local equity asset class

As shown in Table 4-3, capital return is the greatest contributor to the overall return of the asset class and much more volatile than the dividend component. The geometric mean for the nominal total return was 1.3243 per cent with the capital return at 1.0694 per cent and dividend return at 0.2522 per cent. Dividend returns also tend to be much more stable than capital returns (standard deviation of 0.0633 against 5.7032 per cent respectively).

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Table 4-3: Descriptive statistics of local equity asset class monthly returns (1986-2013)

	Local equity nominal total return	Local equity nominal capital return	Local equity nominal dividend return
Median	1.8358%	1.5565%	0.2347%
Arithmetic mean	1.4911%	1.2357%	0.2523%
Geometric mean	1.3243%	1.0694%	0.2522%
Minimum return	-29.7057%	-29.8701%	0.1667%
Maximum return	17.7647%	17.5072%	0.4458%
Standard deviation	5.7182%	5.7032%	0.0633%
Observations	336	336	336

Source: Provided by Staunton (2013) and calculated from Morningstar

4.2.2.2 Local fixed income asset class

The monthly total, capital and interest return data for local fixed income is presented in Table 4-4. The geometric mean for the total return was 1.1623 per cent with the capital return 0.1495 per cent and interest return 1.0113 per cent. However, the interest returns tend to be much more stable than capital returns (standard deviation of 0.2006 against 2.3879 per cent respectively).

Table 4-4: Descriptive statistics of local fixed income asset class monthly returns (1986-2013)

	Fixed income nominal total return	Fixed income nominal capital return	Fixed income nominal interest return
Median	1.2584%	0.2430%	1.0652%
Arithmetic mean	1.1917%	0.1782%	1.0115%
Geometric mean	1.1623%	0.1495%	1.0113%
Minimum	-14.4574%	-15.5458%	0.6582%
Maximum	11.4067%	9.9328%	1.3480%
Standard deviation	2.4317%	2.3879%	0.2006%
Observations	336	336	336

Source: Provided by Staunton (2013) and calculated from Morningstar

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4.2.2.3 Local money market asset class

Money market is the lowest risk and return asset class with a geometric mean monthly return of 0.9470 per cent and standard deviation of 0.3428 per cent as shown in Table 4-5.

Table 4-5: Descriptive statistics of local money market asset class monthly returns (1986-2013)

	Money market nominal total return
Median	0.8960%
Arithmetic mean	0.9476%
Geometric mean	0.9470%
Minimum	0.3860%
Maximum	1.7940%
Standard deviation	0.3428%
Observations	336

Source: Provided by Staunton (2013) and calculated from Morningstar

4.2.2.4 Foreign equity asset class and ZAR/USD exchange rate

Table 4-6 shows the foreign equity nominal capital return (in ZAR) and foreign equity nominal dividend return (USD and ZAR) descriptive statistics. As described in Chapter 3, Section 7, the foreign equity capital return used in the modelling includes the currency effect and is, therefore, the foreign equity nominal capital return in South African rand. The applicable monthly foreign equity dividend return in USD is applied to the market value of the foreign equity asset class (in USD) and converted to South African rand at the ZAR/USD exchange rate at the end of the month based on the bootstrapping data for each vector. Hence the currency impact on the different components of the foreign equity asset class is incorporated similar to how the returns would be translated to South African rand; the capital return considers the change in the ZAR/USD exchange rate from the beginning of the month to the end of the month while the dividend return is converted to South African rand at the end of the month as if that is when the dividends are paid and received.

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Table 4-6: Descriptive statistics of foreign asset class monthly returns (1986-2013)

	Foreign equity nominal capital return (ZAR)	Foreign equity nominal dividend return (ZAR)	Foreign equity nominal dividend return (USD)
Median	0.9857%	0.0512%	0.1802%
Arithmetic mean	0.5309%	0.0585%	0.1875%
Geometric mean	0.4281%	0.0585%	0.1875%
Minimum	-19.1493%	-0.0685%	0.0603%
Maximum	11.4254%	0.4049%	0.5343%
Standard deviation	4.4988%	0.0731%	0.0732%
Observations	336	336	336

Source: Calculated from Morningstar

During the historical period from 1986 to 2013, the arithmetic mean exchange rate was 5.6264 (ZAR/USD) with a maximum and minimum of 11.9904 and 1.9313 (ZAR/USD) respectively.

The next section starts by detailing the research question and main hypotheses as well as the models used in the Monte Carlo simulation. The descriptive statistics for the models follow, whereafter the empirical results, findings and discussion for the hypotheses are presented. The last section presents a summary of the findings and discussion pertaining to Research Question 1.

4.3 RESEARCH QUESTION 1: FUNDS FULLY INVESTED IN EQUITIES AGAINST REGULATION 28 BALANCED FUNDS

The models applicable to test Research Question 1 are shown in Table 4-7 and discussed thereafter along with the five hypotheses which are used to test the research question.

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Table 4-7: Models for Research Question 1

Model	Type of fund	Retirement fund or Direct investment fund	Asset allocation (%)*	Glide path period (years)
Model 1	Equity	Theoretical retirement fund	100/0/0/0	N/A
Model 2	Equity	Direct investment	100/0/0/0	N/A
Model 3	Equity	Theoretical retirement fund	75/25/0/0	N/A
Model 4	Equity	Direct investment	70/25/0/5	N/A
Model 5	Balanced - High equity (no foreign exposure)	Retirement fund	75/0/15/10	N/A
Model 6	Balanced - High equity (25% foreign equity exposure)	Retirement fund	50/25/15/10	N/A

*Local equity/foreign equity/local fixed income/local money market

A reminder regarding the two direct investment fund models, namely Model 2 and Model 4 (discussed in the research method chapter) is as follows:

- In the case of Model 2, the fund is fully invested in local equities and therefore never has to be rebalanced. For the duration of the investment horizon, the only tax implication is dividend tax and, as discussed in the research method chapter, dividend tax is deducted from any dividends earned before being paid to the individual (i.e. net of taxes). For these reasons, Model 2 does not require an allocation to money market to make provision for cash outflows for taxation.
- In contrast, the asset allocation of Model 4 consists of more than one asset class, which results in annual rebalancing to maintain the proposed asset allocation of the model. The rebalancing may result in a capital gain or loss while the dividends earned on the foreign asset class are taxed at the income tax rate of the individual (described in the research method chapter). Hence Model 4 maintains a 5 per cent allocation to money market to ensure available cash for any taxes payable as a consequence of rebalancing or income tax payable on foreign equity dividends.

Research Question 1 postulates whether a fund fully invested in equities (100 per cent invested in local equities or with a 70/25 split between local and foreign equities respectively) is optimal when compared with a high equity balanced retirement fund

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with the maximum equity allocation of 75 per cent. The research question is tested by means of five hypotheses (and particular sub-hypotheses):

- Hypothesis 1A focuses on a model that invests 100 per cent of assets *directly in local equity markets* (Model 2) compared with a high equity balanced retirement fund with only 75 per cent invested in local equities (Model 5).
- Hypothesis 1B focuses on a model that invests 95 per cent of assets *directly in local and foreign equity markets* (Model 4) compared with a high equity balanced retirement fund with only 75 per cent invested in equities, split between 50 per cent against 25 per cent local and foreign equities (Model 6).
- Hypothesis 1C focuses on a *theoretical retirement fund* that allocates 100 per cent of assets to local equities (Model 1) compared with a high equity balanced retirement fund with only 75 per cent invested in local equities (Model 5).
- Hypothesis 1D focuses on a *theoretical retirement fund* that allocates 100 per cent of assets to equities split 75/25 between local and foreign equities (Model 3) compared with a high equity balanced retirement fund with only 75 per cent invested in equities split between local and foreign equities 50/25 (Model 6).
- Hypothesis 1E focuses on a *theoretical retirement fund* that allocates 100 per cent of assets to equities with no foreign exposure (Model 1) compared with a high equity balanced retirement fund with only 75 per cent invested in equities of which 25 per cent is allocated to foreign equities (Model 6).

Additionally, the analysis focuses on retirement funds and direct investments for individuals that fall within the 18, 25 and 40 per cent tax brackets, which determine the annual starting salary modelled. This is important to note for Hypotheses 1A and 1B as the direct investment models have significant tax burdens ranging from a lower contribution amount to taxes payable on interest, dividend and capital returns as discussed in Chapters 2 and 3 respectively. In the case of Hypotheses 1C to 1E, the applicable tax bracket is only important regarding the annual starting salary that is used in the models for each investment horizon and individual because the comparative models in each hypothesis are all retirement fund models.

As discussed in the research method chapter, the annual starting salary for an individual within the 40 per cent tax bracket and an expected retirement date in 40

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years (i.e. an investment horizon of 40 years) is R673 101. A 30-year investment horizon assumes that an individual does not participate in saving for retirement for another 10 years and only then starts saving (i.e. 30-year investment horizon). During this period of non-participation, an individual's salary is assumed to grow annually at inflation. Hence the annual starting salary for someone with a 30-year investment horizon is R1 045 305 (see Table 4-8).

Table 4-8: Annual starting salary

Investment horizon	10 years	20 years	30 years	40 years
Starting salary* 40% tax bracket	R2 520 977	R1 623 327	R1 045 305	R673 101
Starting salary* 25% tax bracket	R1 021 348	R657 674	R423 495	R272 700
Starting salary* 18% tax bracket	R653 745	R420 965	R271 071	R174 550

** Starting annual salary adjusted at rate of inflation of 4.5 per cent per annum*

The following section proceeds by providing a summary of the descriptive statistics of the Monte Carlo simulation results of the models, whereafter the results, findings and discussion for each hypothesis are presented.

4.4 DESCRIPTIVE STATISTICS

The following section only provides a short summary of the more relevant descriptive statistics pertaining to accumulated retirement ending wealth while Appendix C (Tables C 1 to C 12) includes comprehensive tables for the 10-, 20-, 30- and 40-year investment horizons and each tax bracket for the models applicable to Research Question 1. The descriptive statistics distinguish between the models that have no foreign equity exposure (Models 1, 2 and 5) and those that do have foreign equity exposure (Models 3, 4 and 6). Appendix D presents histograms of the Monte Carlo simulated results for the models applicable to each investment horizon.

4.4.1 ARITHMETIC MEAN

Figures 4-1 to 4-3 show the 10-, 20-, 30- and 40-year mean accumulated retirement ending wealth for each of the tax brackets. In the graph, the dark green portion of each bar shows the mean accumulated retirement ending wealth achieved for a 10-year investment horizon. The additional accumulated retirement ending wealth, which

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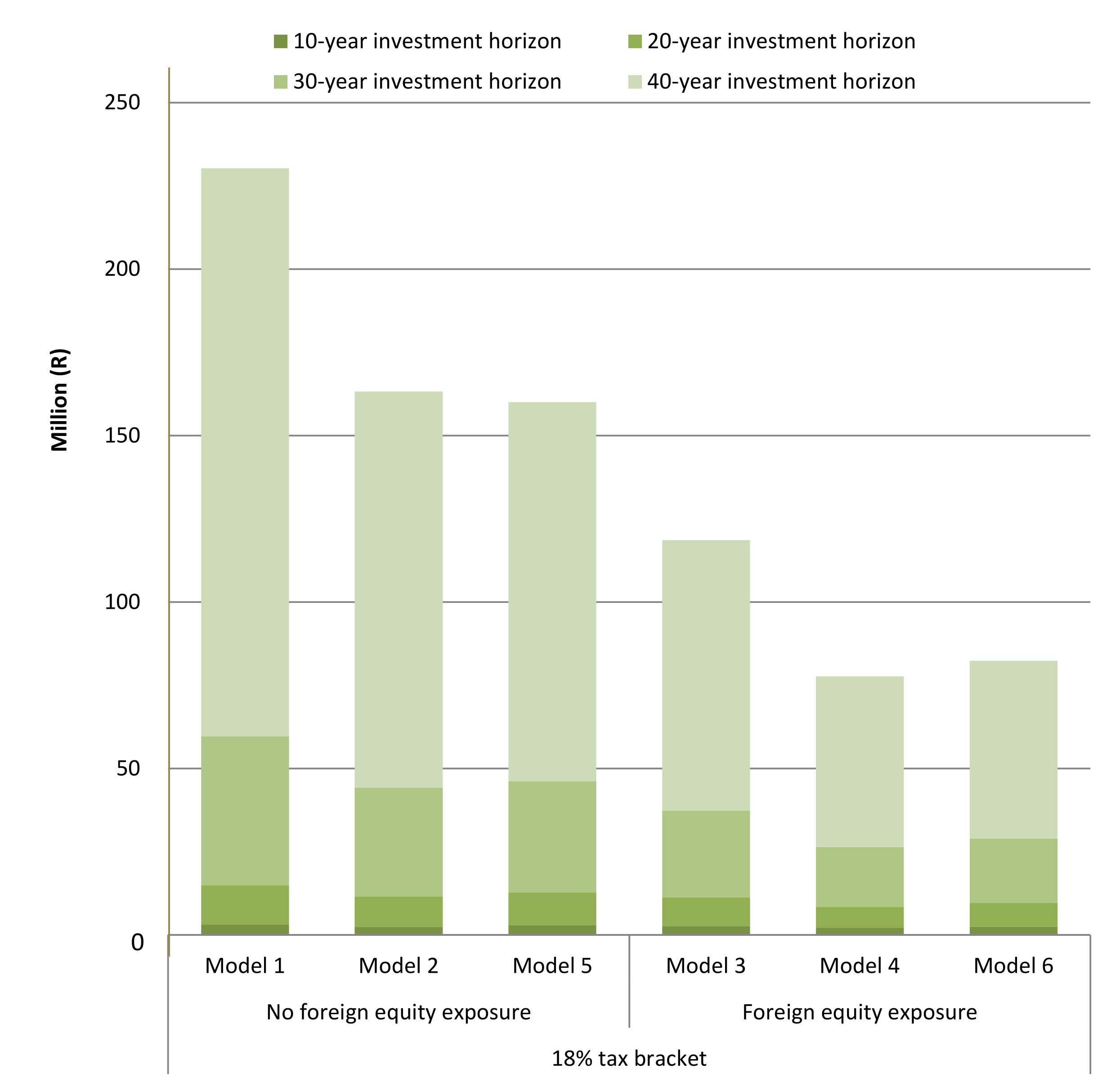
results from extending the investment horizon to 20 years, is shown as a lighter green section on the graph. The rand value of the mean accumulated retirement ending wealth values for each model and investment horizon is shown below the graph.

Regarding the models with no foreign equity exposure, Model 1 is ranked first with the highest accumulated retirement ending wealth followed by Model 5 and, lastly, Model 2 in third position except for the 18 per cent tax bracket, 10- and 40-year investment horizons. In these instances, Model 2 is ranked in second place followed by Model 5.

For the models with foreign equity exposure, the following is true for all tax brackets and investment horizons: Model 3 is ranked the highest, followed by Model 6 and, lastly, Model 4. Additionally, the difference in the mean accumulated retirement ending wealth between the direct investment model (Model 4) and the retirement fund models (Models 3 and 6) becomes proportionally larger, the longer the investment horizon.

Figure 4-1: Arithmetic mean results: 18 per cent tax bracket (R)



	No foreign equity exposure			Foreign equity exposure		
	Model 1 (theoretical 100% equity retirement fund)	Model 2 (100% equity direct investment)	Model 5 (high equity balanced retirement fund)	Model 3 (theoretical 100% equity retirement fund)	Model 4 (95% equity direct investment)	Model 6 (high equity balanced retirement fund)
10 years	3 110 796	2 482 952	2 907 212	2 745 345	2 165 284	2 563 993
20 years	14 903 811	11 483 752	12 765 384	11 237 777	8 428 837	9 627 822
30 years	59 715 638	44 191 068	46 223 692	37 414 805	26 387 737	28 999 931
40 years	230 302 965	163 247 755	160 002 533	118 621 075	77 650 165	82 400 315

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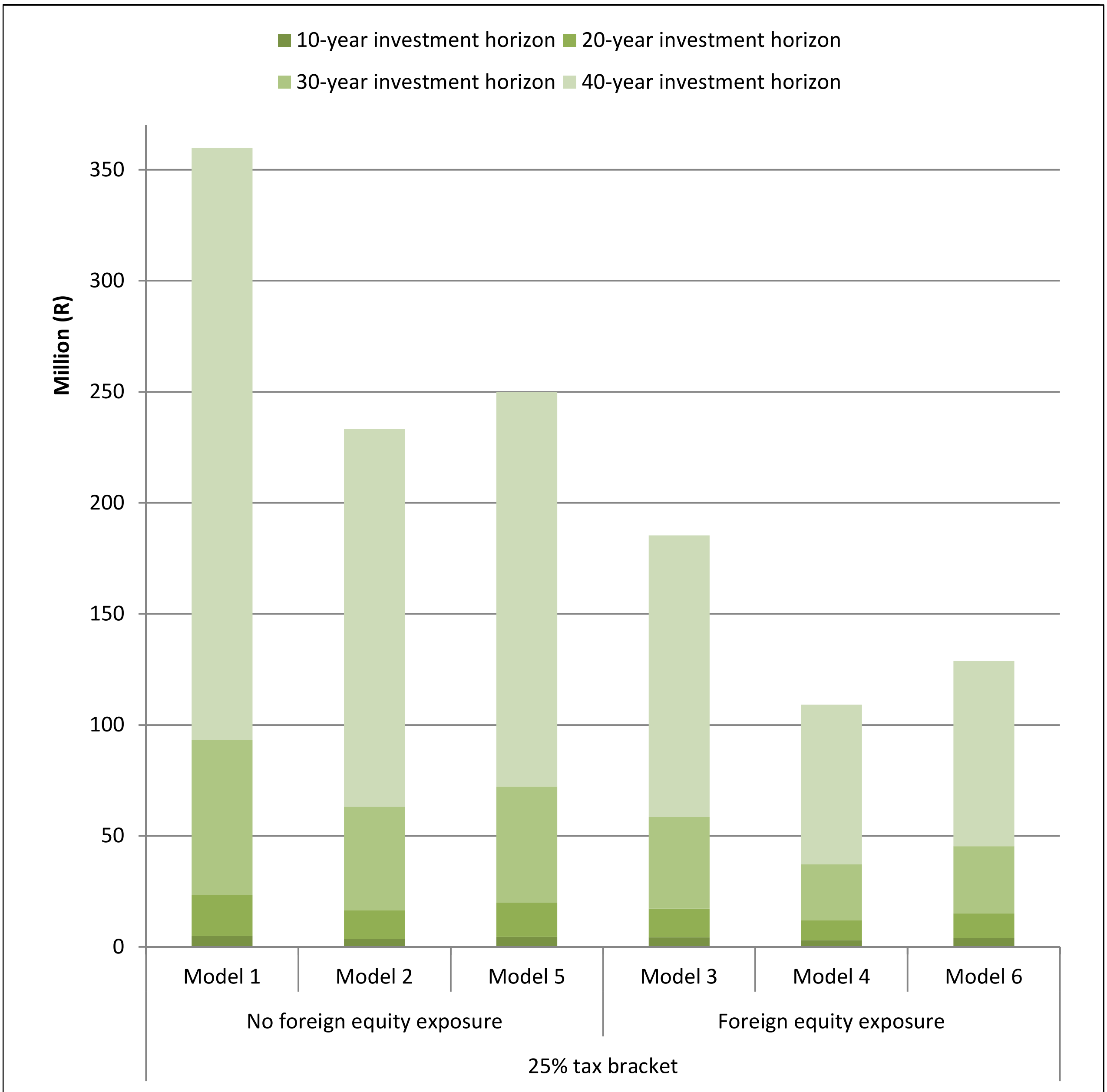
Figure 4-2: Arithmetic mean results: 25 per cent tax bracket (R)



	No foreign equity exposure			Foreign equity exposure		
	Model 1 (theoretical 100% equity retirement fund)	Model 2 (100% equity direct investment)	Model 5 (high equity balanced retirement fund)	Model 3 (theoretical 100% equity retirement fund)	Model 4 (95% equity direct investment)	Model 6 (high equity balanced retirement fund)
10 years	4 860 007	3 547 980	4 541 948	4 289 062	3 091 689	4 005 735
20 years	23 284 237	16 409 521	19 943 371	14 874 182	12 015 046	13 722 098
30 years	93 293 912	63 146 189	72 215 406	58 453 256	37 416 184	45 306 676
40 years	359 803 028	233 270 550	249 972 448	185 322 070	109 149 622	128 734 264

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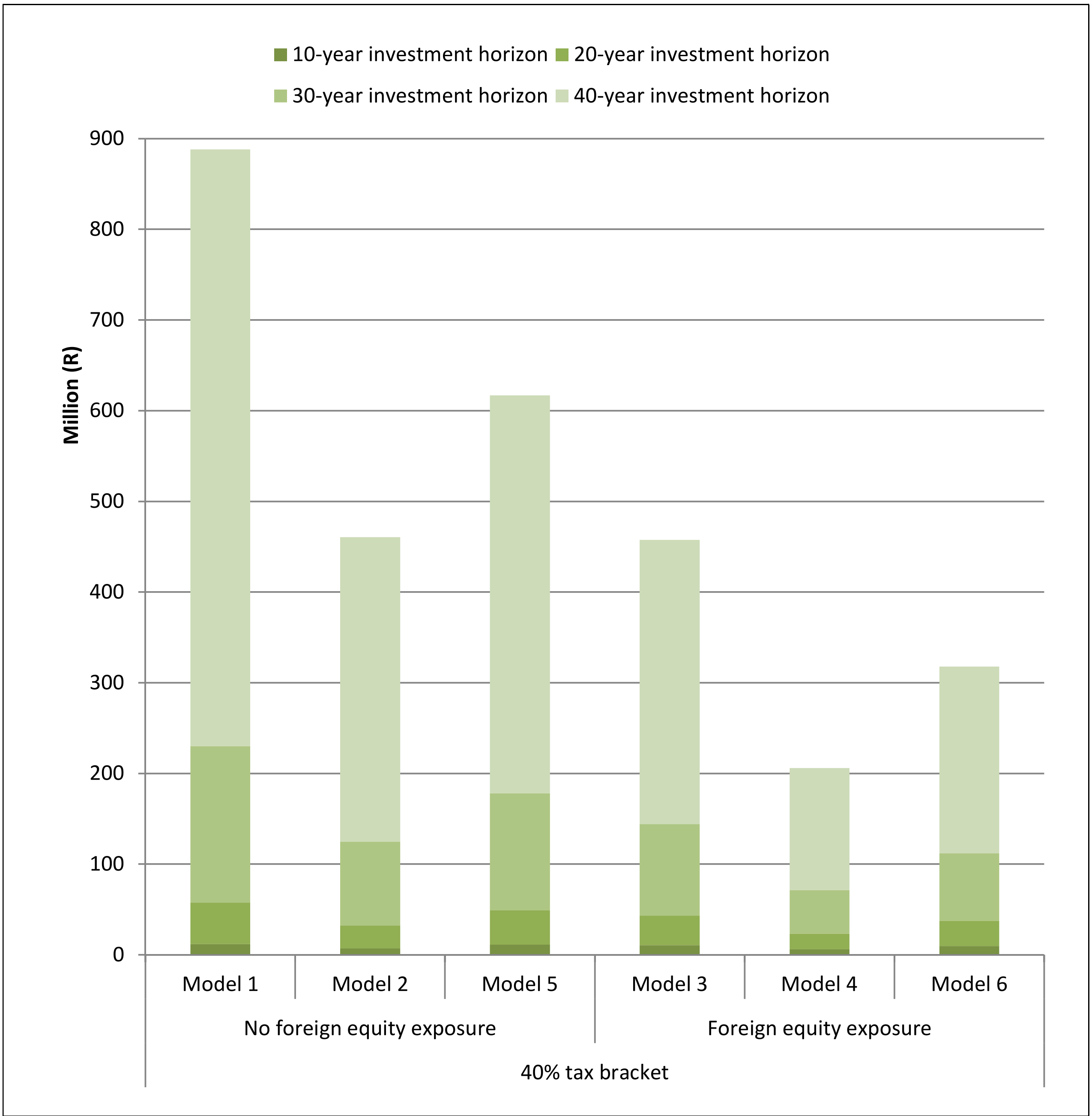
Figure 4-3: Arithmetic mean results: 40 per cent tax bracket (R)



	No foreign equity exposure			Foreign equity exposure		
	Model 1 (theoretical 100% equity retirement fund)	Model 2 (100% equity direct investment)	Model 5 (high equity balanced retirement fund)	Model 3 (theoretical 100% equity retirement fund)	Model 4 (95% equity direct investment)	Model 6 (high equity balanced retirement fund)
10 years	11 995 978	7 005 938	11 210 817	10 586 624	6 090 880	9 887 293
20 years	57 472 137	32 402 702	49 225 929	43 335 165	23 550 839	37 126 846
30 years	230 275 664	124 690 070	178 247 972	144 279 109	72 140 072	111 829 643
40 years	888 059 994	460 622 340	617 002 951	457 427 467	206 053 457	317 752 029

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As expected, the source of the return (i.e. asset allocation) and investment horizon have a significant influence on the mean accumulated retirement ending wealth achieved. The following section discusses the observations regarding the distribution of the accumulated retirement ending wealth.

4.4.2 ACCUMULATED RETIREMENT ENDING WEALTH DISTRIBUTION

The results for all the models and all investment horizons indicate that the median is lower than the mean, which indicates that the frequency distributions of all the models are positively skewed. This is confirmed by a visual inspection of the histograms (presented in Appendix D) and the results for skewness of the various models (individual results in Appendix C). As would be expected, the longer the investment horizon and more persistent the exposure of a model to the local equity asset class, the greater the skewness exhibited by the distribution of accumulated retirement ending wealth.

Similar to the results of Lewis (2008c), all the models' frequency distributions are leptokurtic with positive kurtosis. The longer the investment horizon, the greater the value of kurtosis, that is, the more peaked the distribution of accumulated retirement ending wealth. The following observations hold true irrespective of the tax bracket or investment horizon: the kurtosis of Model 1 is consistently the highest irrespective of the tax bracket or investment horizon, followed by that of Models 2 and 3. Models 4 and 5 follow with Model 6 exhibiting the lowest kurtosis value.

Generally, the greater the exposure to the higher risk and return local equity asset class, the more volatility the model exhibits with higher standard deviation and variance.

Similarly, the greater and more persistent the exposure to the higher risk and return local equity asset class, the greater the range exhibited.

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4.5 RESULTS AND FINDINGS

Chapter 3 discussed the research method and in particular the decision-making criteria which are applied and for which the results and findings are reported and discussed in this section. The salient points are reiterated here before the results and findings of each hypothesis are presented.

FSD exists for one model relative to another if the cumulative distribution function of that model always remains below or to the right of the other and no area of SD violation therefore exists and the ε value is 0. For ASD to exist for one model relative to another, the area of stochastic dominance (SD) violation should be between 0 and 0.01. Furthermore, if the cumulative distribution function of the model is steeper than that of another, the strategy is generally considered to result in less volatile outcomes (Basu *et al.*, 2011). The results and findings for each of the hypotheses, which include all tax brackets and investment horizons, are presented in the sections that follow.

4.5.1 DIRECT INVESTMENTS AGAINST REGULATION 28 RETIREMENT BALANCED FUND

4.5.1.1 Hypothesis 1A[9]

The models applicable to Hypothesis 1A are as follows:

Model	Type of fund	Retirement fund or Direct investment fund	Ending asset allocation* (%)	Glide path period (years)
Model 2	Equity	Direct investment	100/0/0/0	N/A
Model 5	Balanced - High equity (no foreign exposure)	Retirement fund	75/0/15/10	N/A
*Local equity/foreign equity/local fixed income/local money market				

[9] Based on a comment by an examiner, an addendum was added to the thesis which address the pre- and post-retirement tax implications of the models versus the results reported here, which only considers the pre-retirement tax implications of the models.

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The hypothesis was articulated as:

H_0: A 100 per cent local equity direct investment fund (Model 2) does not dominate a high equity balanced retirement fund with 75 per cent local equity (Model 5) by first-order stochastic dominance (FSD) or almost stochastic dominance (ASD).

H_a: A 100 per cent local equity direct investment fund (Model 2) dominates a high equity balanced retirement fund with 75 per cent local equity (Model 5) by first-order stochastic dominance (FSD) or almost stochastic dominance (ASD).

4.5.1.1.1 Results

Figure 4-4 presents the cumulative distribution functions for Model 2 (direct investment fund) and Model 5 (high equity balanced retirement fund) for an 18 per cent tax bracket individual and a 10-year investment horizon (it is repeated, along with the other cumulative distribution graphs for the 25 and 40 per cent tax brackets and all investment horizons in Appendix E, Section E1 with Figure E 1 to Figure E 3 showing the results for the 10-year investment horizon, Figure E 4 to E 6 for the 20-year investment horizon, E 7 to E 9 for the 30-year investment horizon and Figure E 10 to E 12 for the 40-year investment horizon).

To illustrate, Figure 4-4 shows the cumulative distribution functions for Model 2 (direct investment fund model) and Model 5 (high equity balanced retirement fund model) for the 18 per cent tax bracket and 10-year investment horizon.

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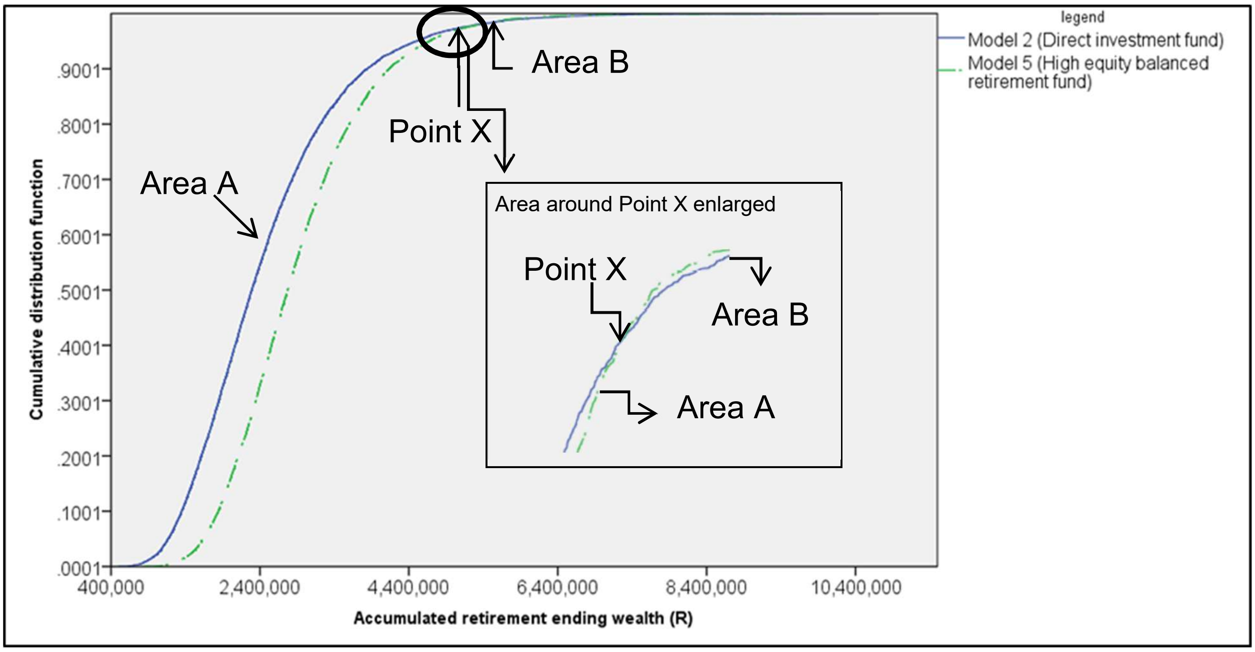
Figure 4-4: Cumulative distribution functions of accumulated retirement ending wealth for Model 2 against Model 5 (10-year investment horizon, 18% tax bracket)



Source: SPSS output

The first observation is that the cumulative distribution functions of the two models cross (it is not visible on the graph as it is at an area where the two cumulative distribution functions are very close to each other), violating the strict FSD principle that one model should consistently be below or to the right of the other to dominate by FSD. This is at a cumulative probability of approximately 0.9819 and an accumulated retirement ending wealth value of approximately R5.4 million. However, there is still a chance that one of the models may dominate the other by ASD. For any accumulated retirement ending wealth value of below approximately R5.4 million where the cumulative distribution functions cross, the cumulative distribution function of Model 5 is below or to the right of Model 2 with the area shown on the figure as Area A, enclosed by the cumulative distribution functions. For this section, Model 5 is the optimal choice compared with Model 2 as Model 5 has a greater accumulated retirement wealth for each cumulative probability value. The opposite is true to the right of an accumulated retirement ending wealth of approximately R5.4 million with the area enclosed by the cumulative distribution functions as Area B (in Figure 4-4, the section around Point X was enlarged to make a section of Area B visible).

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In terms of Chapter 3, Section 3.10, the ε value to test for ASD of one model against another is calculated as the area of SD violation divided by non-SD violation. For testing Hypothesis 1A, the ε values for Model 2 against Model 5 would be calculated as Area A divided by Area B. Because Area A is significantly larger than Area B, the resulting ε value is much higher than the threshold value of 0.01. On the other hand, to test for ASD of Model 5 over Model 2, the ε value would be calculated as Area B divided by Area A, which is the inverse of the ε value for Model 2 over Model 5. Using the latter method, one has to be cognisant of the sensitivity of the values due to rounding.

Because Area A is much greater than the area where Model 2 is optimal, the cumulative distribution functions indicate that Model 5 is likely to dominate Model 2 by ASD if the ε value is between 0 and 0.01 and that Model 2 is unlikely to dominate Model 5 (the latter comparison being consistent with what is required to test the null hypothesis). This is confirmed by the ε values for Model 2 against Model 5, which are significantly higher than the threshold value of 0.01 for all sub-hypotheses or show “No value” (Table 4-9). To provide additional insights, the table also indicates the instances where Model 5 dominates Model 2 (with the symbol “***”): for the 10-year investment horizon, Model 5 dominates Model 2 by ASD for all tax brackets. Model 5 also dominates Model 2 by FSD in the case of a 20- and 30-year investment horizon and 40 per cent tax bracket.

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Table 4-9: ASD results of Model 2 against Model 5

Area of SD violation relative to non-violation (ε)** Direct investment fund model – Model 2 (100/0/0/0, equity fund) AGAINST Balanced fund model - Model 5 (75/0/15/10, retirement fund)			
Tax bracket/Time horizon	18% tax bracket	25% tax bracket	40% tax bracket
10 years	113.6364***	2500.0000***	No value***
20 years	6.2073	29.7619	17 972.6815***
30 years	1.7730	5.3135	1111.1111***
40 years	1.2436	2.0589	23.2019

†FSD
¥ Value of zero shown due to rounding, does not exhibit FSD in the truest form.
** Almost stochastic dominance exists for threshold value of 0 < ε < 0.01.
*** Model 5 dominates Model 2 by FSD if ε value shows "No value" or ASD in all other cases.

A comparison of the cumulative distribution graphs for all investment horizons and tax brackets as well as the ε values shown in Table 4-9 lead to the following findings (Figures E 1 to E 12 in Appendix E):

- In all instances, the null hypothesis cannot be rejected because the ε values are greater than the threshold value of 0.01.
- The longer the investment horizon, the narrower the gap between the cumulative distribution functions where Model 5 is optimal (Area A). This indicates that, although Model 5 is optimal for the lower accumulated retirement ending wealth values, the advantage becomes less so as the investment horizon increases, while the opposite is true for the area to the right of the point where the cumulative distribution functions cross (Area B). This implies that Model 2 is optimal to the right of the point where the cumulative distributions cross and that this benefit is greater as the investment horizon increases. This holds true irrespective of the tax bracket applicable. Hence the longer the investment horizon, the lower the area of SD violation relative to non-violation when testing for dominance of Model 2 over Model 5 and the more likely that Model 2 could dominate Model 5. However, in this study, the ε values to test for dominance of Model 2 over Model 5 never meet the threshold requirement of being below 0.01 in any of the investment horizons.

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- The higher the tax bracket, the wider the area enclosed by the cumulative distribution functions of Models 2 and 5 to the left of Point X (Area A) where the cumulative distribution functions cross (in the case of the 40 per cent tax bracket, the models never cross and Model 5 is dominated by FSD). This is true irrespective of the investment horizon compared and supported by the ε values for ASD shown in Table 4-9. Hence the higher the tax bracket, the higher the area of SD violation relative to non-violation, all other factors held constant, when testing for dominance of Model 2 over Model 5. However, in this study, the ε values to test for dominance of Model 2 over Model 5 never meet the threshold requirement irrespective of the tax bracket.

4.5.1.1.2 Summary

Table 4-10 shows a summary of the findings pertaining to Hypothesis 1A. The results indicate that for all sub-hypotheses, Model 2 (the direct equity fund with a 100 per cent allocation to local equities) fails to dominate Model 5 (the Regulation 28 balanced fund with a 75 per cent allocation to local equities) by FSD or ASD and therefore fails to reject the null hypothesis.

Table 4-10: Summary of findings – Hypothesis 1A

Hypothesis 1A H_0: A 100 per cent local equity direct investment fund does not dominate a high equity balanced retirement fund (75 per cent local equity) by first-order stochastic dominance (FSD) or almost stochastic dominance (ASD). H_a: A 100 per cent local equity direct investment fund dominates a high equity balanced retirement fund (75 per cent local equity) by first-order stochastic dominance (FSD) or almost stochastic dominance (ASD).				
Time horizon/ Tax bracket	**10 years**	**20 years**	**30 years**	**40 years**
18 per cent	**Sub-hypothesis 1A$^{10\ years}$** Fails to reject the null hypothesis	**Sub-hypothesis 1A$^{20\ years}$** Fails to reject the null hypothesis	**Sub-hypothesis 1A$^{30\ years}$** Fails to reject the null hypothesis	**Sub-hypothesis 1A$^{40\ years}$** Fails to reject the null hypothesis
25 per cent	**Sub-hypothesis 1A$^{10\ years}$** Fails to reject the null hypothesis	**Sub-hypothesis 1A$^{20\ years}$** Fails to reject the null hypothesis	**Sub-hypothesis 1A$^{30\ years}$** Fails to reject the null hypothesis	**Sub-hypothesis 1A$^{40\ years}$** Fails to reject the null hypothesis
40 per cent	**Sub-hypothesis 1A$^{10\ years}$** Fails to reject the null hypothesis	**Sub-hypothesis 1A$^{20\ years}$** Fails to reject the null hypothesis	**Sub-hypothesis 1A$^{30\ years}$** Fails to reject the null hypothesis	**Sub-hypothesis 1A$^{40\ years}$** Fails to reject the null hypothesis

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4.5.1.1.3 Key findings

The results for Hypothesis 1A lead to the following key findings:

- Model 2 (direct investment fund model which has a 100 per cent local equity allocation) fails to dominate Model 5 (high equity balanced retirement fund with a 75 per cent local equity allocation) by FSD or ASD.
- All other factors held constant, the longer the investment horizon, the more likely Model 2 is to dominate Model 5 by FSD or ASD. However, in this study, the ε values to test for dominance of Model 2 over Model 5 never meet the threshold requirement of being below 0.01 in any of the investment horizons.
- All other factors held constant, the higher the tax bracket, the less likely Model 2 is to dominate Model 5 by FSD or ASD. However, in this study, the ε values to test for dominance of Model 2 over Model 5 never meet the threshold requirement irrespective of the tax bracket.
- However, in certain instances, Model 5 dominates Model 2 by FSD or ASD.

The next section presents the results, analysis and key findings of Hypothesis 1B.

4.5.1.2 Hypothesis 1B[10]

The models applicable to Hypothesis 1B are as follows:

Model	Type of fund	Retirement fund or Direct investment fund	Asset allocation* (%)	Glide path period (years)
Model 4	Equity	Direct investment	70/25/0/5	N/A
Model 6	Balanced - High equity (25% foreign equity exposure)	Retirement fund	50/25/15/10	N/A
*Local equity/foreign equity/local fixed income/local money market				

[10] Based on a comment by an examiner, an addendum was added to the thesis which address the pre- and post-retirement tax implications of the models versus the results reported here, which only considers the pre-retirement tax implications of the models.

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The hypothesis was articulated as follows:

H_0: A 95 per cent equity direct investment fund with a 70/25 per cent local/foreign equity split (Model 4) does not dominate a high equity balanced retirement fund with a 50/25 per cent local/foreign equity split (Model 6) by first-order stochastic dominance (FSD) or almost stochastic dominance (ASD).

H_a: A 95 per cent equity direct investment fund with a 70/25 per cent local/foreign equity split (Model 4) dominates a high equity balanced retirement fund with a 50/25 per cent local/foreign equity split (Model 6) by first-order stochastic dominance (FSD) or almost stochastic dominance (ASD).

4.5.1.2.1 Results

Figure 4-5 presents the cumulative distribution functions for Model 4 (direct investment model) and Model 6 (high equity balanced retirement fund) for an 18 per cent tax bracket individual with a 10-year investment horizon (repeated, along with the other cumulative distribution graphs for the 25 and 40 per cent tax brackets as well as 10-, 20-, 30- and 40-year investment horizons in Appendix E. Figure E 13 to Figure E 15 and E 16 to E 18 show the results for the 10- and 20-year investment horizon with Figures E 19 to E 21 and E 22 to E 24 the results for the 30- and 40-year investment horizons).

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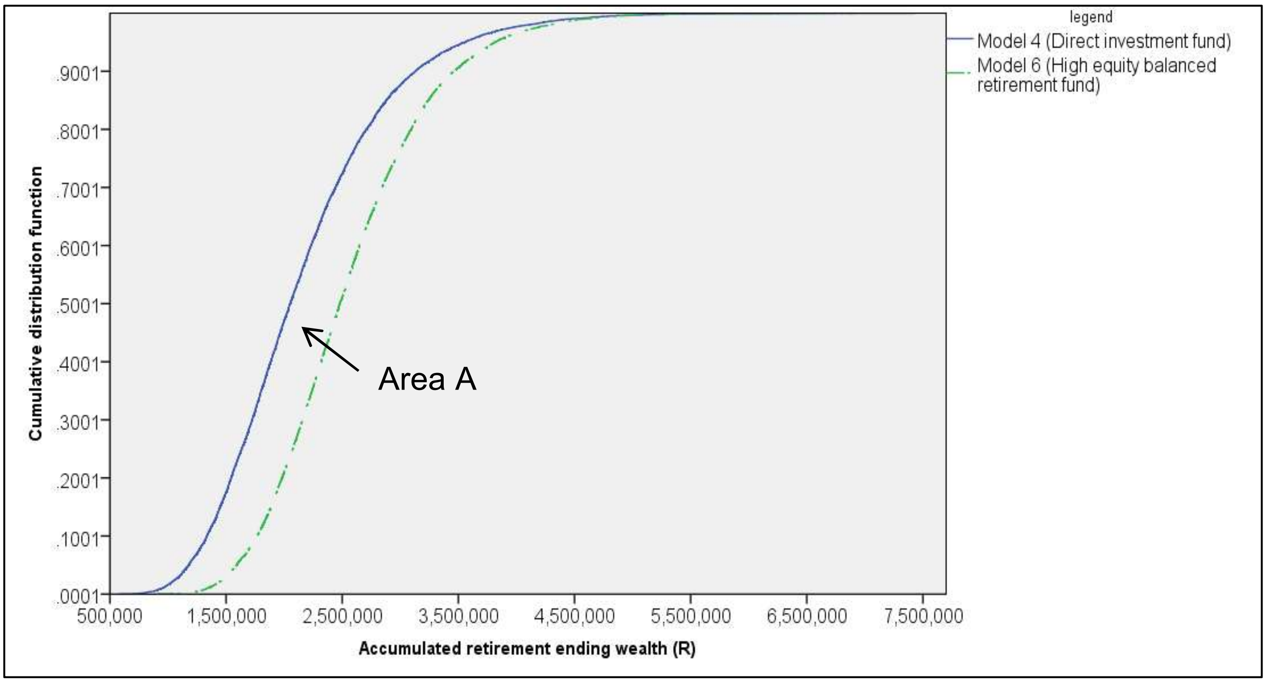
Figure 4-5: Cumulative distribution functions of accumulated retirement ending wealth for Model 4 against Model 6 (10-year investment horizon, 18% tax bracket)



Source: SPSS output

In Figure 4-5, the cumulative distribution functions of Model 4 and Model 6 cross, violating the strict FSD principle. This is at a cumulative probability of approximately 0.9977 and an accumulated retirement ending wealth value of R5.2 million (it is not visible on the graphs because it is on an area where the two cumulative distribution functions are very close to each other). For any accumulated retirement ending wealth value of below approximately R5.2 million where the cumulative distribution functions cross, the cumulative distribution function of Model 6 is below or to the right of Model 4 with the area shown on the figure as Area A, enclosed by the cumulative distribution functions. For this section, Model 6 is optimal compared with Model 4 while the opposite is true to the right of an accumulated retirement ending wealth of approximately R5.2 million.

Because Area A, which is the stochastic dominance area for Model 6, is much greater than the area where Model 4 is optimal, the cumulative distribution functions indicate that Model 6 is likely to dominate Model 4 by ASD if the ε value is between 0 and 0.01 and that Model 4 is unlikely to dominate Model 6 (the latter being consistent with what is required to test the null hypothesis). This is confirmed by the ε values for Model 4

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against Model 6, which are significantly higher than the threshold value of 0.01 for all sub-hypothesis (Table 4-11). This results in a failure to reject the null hypothesis in any of the cases.

Table 4-11: ASD results of Model 4 against Model 6

Area of SD violation relative to non-violation (ε)** Direct investment fund model – Model 4 (70/25/0/5, equity fund) VERSUS Balanced fund model - Model 6 (50/25/15/10, retirement fund)			
Tax bracket/Time horizon	18% tax bracket	25% tax bracket	40% tax bracket
10 years	1 000.0000***	No value***	No value***
20 years	21.0849	289.7379	No value***
30 years	5.0630	28.4849	No value***
40 years	2.3359	11.0988	2 000.0000***

†FSD
¥ Value of zero shown due to rounding, does not exhibit FSD in the truest form.
** Almost stochastic dominance exists for threshold value of $0 < \varepsilon < 0.01$.
*** Model 6 dominates Model 4 by FSD if ε value shows "No value" or ASD in all other cases.

The table also indicates the instances where Model 6 dominates Model 4 (with the symbol "***"): for the 10-year investment horizon, Model 6 dominates Model 4 by ASD for the 18 per cent tax bracket and by FSD for the 25 and 40 per cent tax bracket. For the 40 per cent tax bracket, Model 6 also dominates Model 4 by FSD for the 20- and 30-year investment horizons and ASD for the 40-year investment horizon.

A comparison of the cumulative distribution graphs for all investment horizons and tax brackets as well as the ε values shown in Table 4-11 leads to the following findings (Figures E 13 to E 24 in Appendix E):

- In all instances, the null hypothesis cannot be rejected because the ε values are greater than the threshold value of 0.01.
- All other factors held constant, the longer the investment horizon, the more likely Model 4 is to dominate Model 6 by FSD or ASD. However, in this study, the ε values to test for dominance of Model 4 over Model 6 never meet the threshold requirement of being below 0.01 in any of the investment horizons.

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- All other factors held constant, the higher the tax bracket, the less likely Model 4 is to dominate Model 6 by FSD or ASD. However, in this study, the ε values to test for dominance of Model 4 over Model 6 never meet the threshold requirement irrespective of the tax bracket.

4.5.1.2.2 Summary

Table 4-12 shows a summary of the findings pertaining to Hypothesis 1B. The results indicate that for all sub-hypotheses, Model 4 (direct equity fund with a 95 per cent allocation to equities, including 25 per cent foreign equity exposure) fails to dominate Model 6 (high equity balanced retirement fund with a 75 per cent allocation to equities, including 25 per cent foreign equity exposure) by FSD or ASD and therefore fails to reject the null hypothesis.

Table 4-12: Summary of findings – Hypothesis 1B

Hypothesis 1B
H_0: A 100 per cent equity direct investment fund (75/25 per cent local/foreign equity split) fails to dominate a high equity balanced retirement fund (50/25 per cent local/foreign equity split) by first-order stochastic dominance (FSD) or almost stochastic dominance (ASD).

H_a: A 100 per cent equity direct investment fund (75/25 per cent local/foreign equity split) dominates a high equity balanced retirement fund (50/25 per cent local/foreign equity split) by first-order stochastic dominance (FSD) or almost stochastic dominance (ASD).

Time horizon/ Tax bracket	10 years	20 years	30 years	40 years
18 per cent	**Sub-hypothesis $1B^{10\ years}$** Fails to reject the null hypothesis	**Sub-hypothesis $1B^{20\ years}$** Fails to reject the null hypothesis	**Sub-hypothesis $1B^{30\ years}$** Fails to reject the null hypothesis	**Sub-hypothesis $1B^{40\ years}$** Fails to reject the null hypothesis
25 per cent	**Sub-hypothesis $1B^{10\ years}$** Fails to reject the null hypothesis	**Sub-hypothesis $1B^{20\ years}$** Fails to reject the null hypothesis	**Sub-hypothesis $1B^{30\ years}$** Fails to reject the null hypothesis	**Sub-hypothesis $1B^{40\ years}$** Fails to reject the null hypothesis
40 per cent	**Sub-hypothesis $1B^{10\ years}$** Fails to reject the null hypothesis	**Sub-hypothesis $1B^{20\ years}$** Fails to reject the null hypothesis	**Sub-hypothesis $1B^{30\ years}$** Fails to reject the null hypothesis	**Sub-hypothesis $1B^{40\ years}$** Fails to reject the null hypothesis

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4.5.1.2.3 Key findings

The results for Hypothesis 1B lead to the following key findings:

- Model 4 (direct investment fund model, which has a 95 per cent equity allocation of which 25 per cent is in foreign equities) fails to dominate Model 6 (high equity balanced retirement fund with a 75 per cent local and 25 per cent foreign equity allocation) by FSD or ASD.
- All other factors held constant, the longer the investment horizon, the more likely Model 4 is to dominate Model 6 by FSD or ASD. However, in this study, the ε values to test for dominance of Model 4 over Model 6 never meet the threshold requirement of being below 0.01 in any of the investment horizons.
- All other factors held constant, the higher the tax bracket, the less likely Model 4 is to dominate Model 6 by FSD or ASD. However, in this study, the ε values to test for dominance of Model 4 over Model 6 never meet the threshold requirement irrespective of the tax bracket.
- However, in certain instances, Model 6 dominates Model 4 by FSD or ASD.

The next section presents the results, analysis and key findings of Hypotheses 1C to 1 E, which relate to hypothetical retirement funds invested 100 per cent in equities compared with high equity balanced retirement funds which are Regulation 28 compliant.

4.5.2 100 PER CENT EQUITY RETIREMENT FUND AGAINST REGULATION 28 RETIREMENT BALANCED FUND

For each hypothesis in this section, the two models compared are both retirement fund models. In these circumstances, there are no unique tax treatments between the different models. This results in similar ε values for a particular investment horizon, irrespective of the tax bracket. This is expected because, in the case of the retirement fund models, the only implication of different tax brackets is the relatively higher salary earned as the tax bracket increases, which results in a relatively larger contribution in the modelling.

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The section commences by presenting the results, analysis and key findings pertaining to Hypothesis 1C.

4.5.2.1 Hypothesis 1C

The models applicable to Hypothesis 1C are as follows:

Model	Type of fund	Retirement fund or Direct investment fund	Asset allocation* (%)	Glide path period (years)
Model 1	Equity	Theoretical retirement fund	100/0/0/0	N/A
Model 5	Balanced - High equity (no foreign exposure)	Retirement fund	75/0/15/10	N/A
*Local equity/foreign equity/local fixed income/local money market				

The hypothesis was articulated as follows:

H_0: A theoretical 100 per cent local equity retirement fund (Model 1) does not dominate a high equity balanced retirement fund with a maximum 75 per cent local equity allocation (Model 5) by first-order stochastic dominance (FSD) or almost stochastic dominance (ASD) over the 10-, 20-, 30- or 40-year investment horizon.

H_a: A theoretical 100 per cent local equity retirement fund (Model 1) dominates a high equity balanced retirement fund with a maximum 75 per cent local equity allocation (Model 5) by first-order stochastic dominance (FSD) or almost stochastic dominance (ASD) over the 10-, 20-, 30- or 40-year investment horizon.

4.5.2.1.1 Results

Figure 4-6 presents the cumulative distribution functions for Model 1 (theoretical 100 per cent equity retirement fund model) and Model 5 (high equity balanced retirement fund model) for an 18 per cent tax bracket individual and a 10-year investment horizon (it is repeated, along with the other cumulative distribution graphs for the 25 and 40 per cent tax brackets and 10-, 20-, 30- and 40-year investment horizons in Appendix E, Figures E 25 to E 27 and E 28 to E 30 for the 10- and 20-year investment horizons and Figures E 29 to E 31 and E 32 to E 34 for the 30- and 40-year investment horizons).

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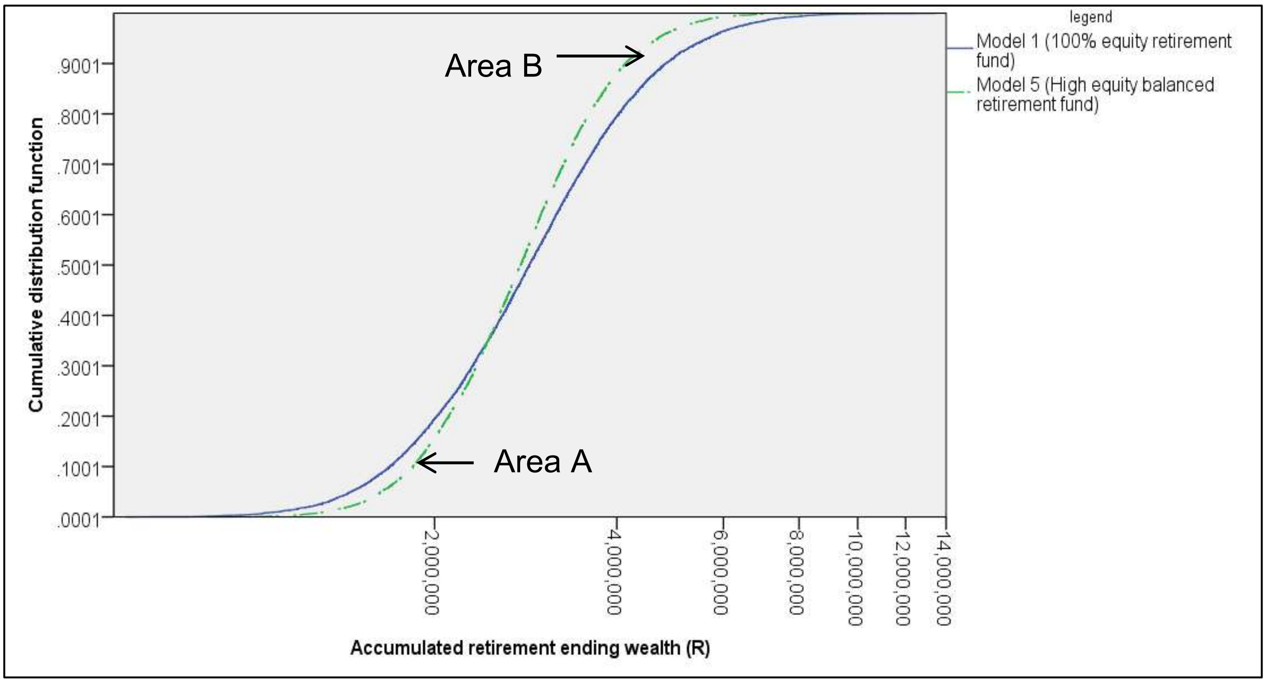
The first observation from Figure 4-6 is that the cumulative distribution functions of the two models cross, violating the strict FSD principle. This is at a cumulative probability of approximately 0.3458 and an accumulated retirement ending wealth value of R2.4 million. For any accumulated retirement ending wealth value of below approximately R2.4 million where the cumulative distribution functions cross, the cumulative distribution function of Model 5 is below or to the right of Model 1 with the area shown on the figure as Area A, enclosed by the cumulative distribution functions. For this section, Model 5 is optimal while the opposite is true to the right of an accumulated retirement ending wealth of approximately R2.4 million.

Figure 4-6: Cumulative distribution functions of accumulated retirement ending wealth for Model 1 against Model 5 (10-year investment horizon, 18% tax bracket)



Source: SPSS output

Because Area B, which is the stochastic dominance area for Model 1, is greater than the area where Model 5 is optimal (Area A), the cumulative distribution functions indicate that Model 1 is likely to dominate Model 5 by ASD if the ε value is between 0 and 0.01. However, the ε values for Model 1 against Model 5 are consistently above

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the threshold value of 0.01 for all sub-hypotheses (Table 4-13). This results in a failure to reject the null hypothesis of each sub-hypothesis and therefore Hypothesis 1C.

Table 4-13: ASD results of Model 1 against Model 5

Area of SD violation relative to non-violation (ε)** Direct investment fund model – Model 1 (100/0/0/0, equity fund) AGAINST Theoretical retirement fund model - Model 5 (75/0/15/10, retirement fund)	
Tax bracket/Time horizon	**18%, 25% and 40% tax bracket**
10 years	0.1563
20 years	0.0667
30 years	0.0320
40 years	0.0168

†FSD
¥ Value of zero shown due to rounding, does not exhibit FSD in the truest form.
** Almost stochastic dominance exists for threshold value of 0 < ε < 0.01.

The FSD and ASD results (Table 4-13) lead to the following conclusion, namely that for no sub-hypothesis does Model 1 (theoretical 100 per cent equity retirement fund model) dominate Model 5 (high equity balanced retirement fund) because the ε values are consistently above the threshold value of 0.01 irrespective of the tax bracket or investment horizon.

A comparison of the cumulate distribution graphs for all investment horizons and tax brackets as well as the ε values shown in Table 4-13 leads to the following additional finding (Figures E 25 to E 36 in Appendix E):

- In all instances, the null hypothesis cannot be rejected as the ε values are greater than the threshold value of 0.01.
- All other factors held constant, the longer the investment horizon, the more likely Model 1 is to dominate Model 5 by FSD or ASD. However, in this study, the ε values to test for dominance of Model 1 over Model 5 never meet the threshold requirement of being below 0.01 in any of the investment horizons.

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4.5.2.1.2 Summary

Table 4-14 shows a summary of the findings pertaining to Hypothesis 1C. The results indicate that in all of the cases, the cumulative distribution functions of the theoretical retirement fund model with a 100 per cent allocation to local equities (Model 1) are, mostly, below or to the right of that of the high equity balanced retirement fund model with a 75 per cent allocation to local equities (Model 5). However, Model 1 fails to dominate Model 5 in any of the cases because the ε values are above the threshold value of 0.01.

Table 4-14: Summary of findings – Hypothesis 1C

Hypothesis 1C

H_0: A 100 per cent local equity retirement fund does not dominate a high equity balanced retirement fund (maximum 75 per cent local equity allocation) by first-order stochastic dominance (FSD) or almost stochastic dominance (ASD) over the 10-, 20-, 30- or 40-year investment horizon.

H_a: A 100 per cent local equity retirement fund dominates a high equity balanced retirement fund (maximum 75 per cent local equity allocation) by first-order stochastic dominance (FSD) or almost stochastic dominance (ASD) over the 10-, 20-, 30- or 40-year investment horizon.

Time horizon/ Tax bracket	10 years	20 years	30 years	40 years
18 per cent	**Sub-hypothesis $1C^{10\ years}$** Fails to reject the null hypothesis	**Sub-hypothesis $1C^{20\ years}$** Fails to reject the null hypothesis	**Sub-hypothesis $1C^{30\ years}$** Fails to reject the null hypothesis	**Sub-hypothesis $1C^{40\ years}$** Fails to reject the null hypothesis
25 per cent	**Sub-hypothesis $1C^{10\ years}$** Fails to reject the null hypothesis	**Sub-hypothesis $1C^{20\ years}$** Fails to reject the null hypothesis	**Sub-hypothesis $1C^{30\ years}$** Fails to reject the null hypothesis	**Sub-hypothesis $1C^{40\ years}$** Fails to reject the null hypothesis
40 per cent	**Sub-hypothesis $1C^{10\ years}$** Fails to reject the null hypothesis	**Sub-hypothesis $1C^{20\ years}$** Fails to reject the null hypothesis	**Sub-hypothesis $1C^{30\ years}$** Fails to reject the null hypothesis	**Sub-hypothesis $1C^{40\ years}$** Fails to reject the null hypothesis

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4.5.2.1.3 Key findings

The results for Hypothesis 1C lead to the following key findings:

- Model 1 (theoretical retirement fund model, which has a 100 per cent local equity allocation) is unsuccessful in dominating Model 5 (high equity balanced retirement fund model with a 75 per cent local equity allocation).
- Irrespective of the tax bracket, the longer the investment horizon, the more likely Model 1 is to dominate Model 5 by FSD or ASD. However, in this study, the ε values to test for dominance of Model 1 over Model 5 never meet the threshold requirement of being below 0.01 in any of the investment horizons.
- Hence the longer the investment horizon, the lower the area of SD violation relative to non-violation, all other factors held constant.

The next section presents the results, analysis and key findings of Hypothesis 1D.

4.5.2.2 Hypothesis 1D

The models applicable to Hypothesis 1D are as follows:

Model	Type of fund	Retirement fund or Direct investment fund	Asset allocation* (%)	Glide path period (years)
Model 3	Equity	Theoretical retirement fund	75/25/0/0	N/A
Model 6	Balanced - High equity (25% foreign equity exposure)	Retirement fund	50/25/15/10	N/A
*Local equity/foreign equity/local fixed income/local money market				

The hypothesis was articulated as follows:

H_0: A theoretical 100 per cent equity retirement fund with a 75/25 per cent local/foreign equity allocation split (Model 3) does not dominate a high equity balanced retirement fund with a 50/25 per cent local/foreign equity allocation split (Model 6) by first-order stochastic dominance (FSD) or almost stochastic dominance (ASD) over the 10-, 20-, 30- or 40-year investment horizon.

H_a: A theoretical 100 per cent equity retirement fund with a 75/25 per cent local/foreign equity allocation split (Model 3) dominates a high equity balanced retirement fund with

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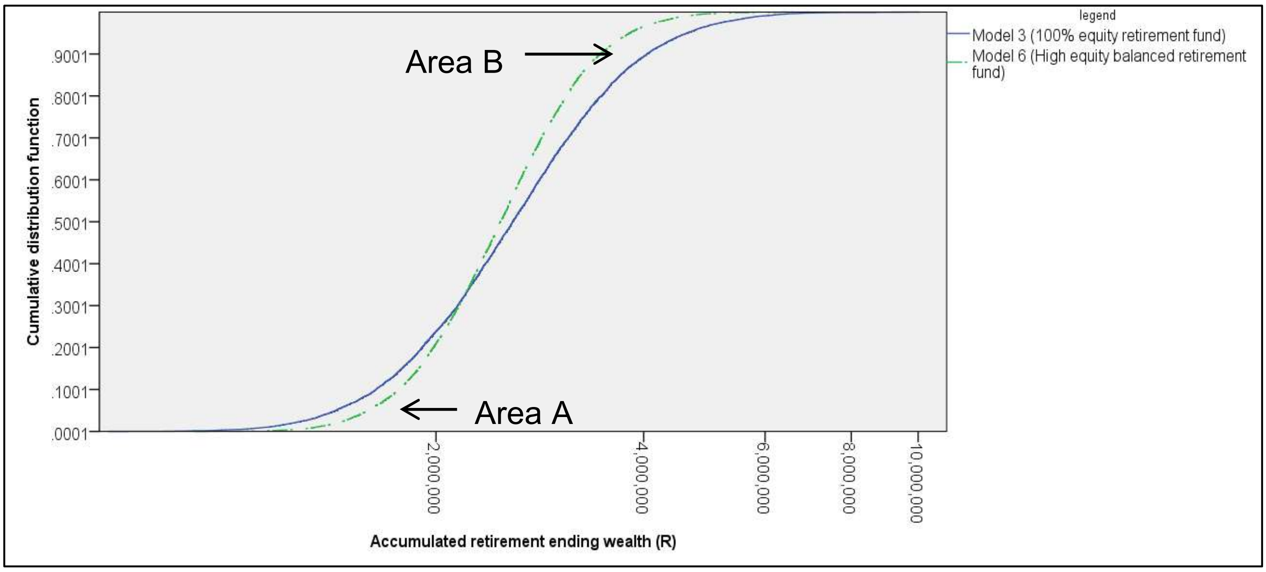
a 50/25 per cent local/foreign equity allocation split (Model 6) by first-order stochastic dominance (FSD) or almost stochastic dominance (ASD) over the 10-, 20-, 30- or 40-year investment horizon.

4.5.2.2.1 Results

Figure 4-7 presents the cumulative distribution functions for Model 3 (theoretical 100 per cent equity retirement fund model) and Model 6 (high equity balanced retirement fund model) for an 18 per cent tax bracket individual and 10-year investment horizon (it is repeated, along with the other cumulative distribution graphs for the 25 and 40 per cent tax brackets and 10-, 20-, 30- and 40-year investment horizons in Appendix E, Figures E 37 to E 39 and Figures E 40 to E 42 for the 10- and 20-year investment horizons and Figures E 43 to E 45 and Figures E 46 to E 48 for the 30- and 40-year investment horizons).

Figure 4-7: Cumulative distribution functions of accumulated retirement ending wealth for Model 6 against Model 3 (10-year investment horizon, 18% tax bracket)



Source: SPSS output

As shown in Figure 4-7, the cumulative distribution functions of the two models cross, violating the strict FSD principle. The models cross at a cumulative probability of approximately 0.3193 and an accumulated retirement ending wealth value of R2.2 million. For any accumulated retirement ending wealth value of below approximately

R2.2 million, the cumulative distribution function of Model 6 is below or to the right of Model 3 with the area shown on the figure as Area A, enclosed by the cumulative distribution functions. For this section, Model 6 is optimal while the opposite is true to the right of an accumulated retirement ending wealth of approximately R2.2 million.

Because Area B, which is the stochastic dominance area for Model 3, is greater than the area where Model 6 is optimal (Area A), the cumulative distribution functions indicate that Model 3 is likely to dominate Model 6 by ASD if the ε value is between 0 and 0.01. However, the ε values for Model 3 against Model 6 are consistently above the threshold value of 0.01 for all sub-hypotheses (Table 4-15). This results in a failure to reject the null hypothesis of each sub-hypothesis and therefore Hypothesis 1D.

Table 4-15: ASD results of Model 3 against Model 6

Area of SD violation relative to non-violation (ε)** Theoretical retirement fund model – Model 3 (75/25/0/0, equity fund) AGAINST Retirement fund model - Model 6 (50/25/15/10, retirement fund)	
Tax bracket/Time horizon	**18%, 25% and 40% tax bracket**
10 years	0.1465
20 years	0.0608
30 years	0.0288
40 years	0.0150

†FSD
¥ Value of zero shown due to rounding, does not exhibit FSD in the truest form.
** Almost stochastic dominance exists for threshold value of 0 < ε < 0.01.

The ASD results (Table 4-15) lead to the following conclusion, namely for no sub-hypothesis does Model 3 (theoretical 100 per cent equity retirement fund model) dominate Model 6 (high equity balanced retirement fund) by FSD or ASD because the ε values are consistently above the threshold value of 0.01 irrespective of the tax bracket or investment horizon.

Additionally, a comparison of the cumulative distribution graphs for all investment horizons and tax brackets as well as the ε values shown in Table 4-15 leads to the following additional finding (Figures E 37 to E 48 in Appendix E):

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- In all instances, the null hypothesis cannot be rejected because the ε values are greater than the threshold value of 0.01.
- All other factors held constant, the longer the investment horizon, the more likely Model 3 is to dominate Model 6 by FSD or ASD. However, in this study, the ε values to test for dominance of Model 3 over Model 6 never meet the threshold requirement of being below 0.01 in any of the investment horizons.

4.5.2.2.2 Summary

Table 4-16 shows a summary of the findings pertaining to Hypothesis 1D. The results indicate that in all cases, the cumulative distribution functions of Model 3 (theoretical retirement fund model with a 100 per cent allocation to equities split between local and foreign equities) are, mostly, below or to the right of that of Model 6 (high equity balanced retirement fund model with a 50/25 per cent allocation to local/foreign equities). However, Model 3 consistently fails to dominate Model 6 by FSD or ASD in any of the cases because the ε values are above the threshold value of 0.01.

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Table 4-16: Summary of findings – Hypothesis 1D

Hypothesis 1D

H_0: A 100 per cent equity retirement fund (75/25 per cent local/foreign equity allocation split) dominates a high equity balanced retirement fund (50/25 per cent local/foreign equity allocation split) by first-order stochastic dominance (FSD) or almost stochastic dominance (ASD) over the 10-, 20-, 30- or 40-year investment horizon.

H_a: A 100 per cent equity retirement fund (75/25 per cent local/foreign equity allocation split) dominates a high equity balanced retirement fund (50/25 per cent local/foreign equity allocation split) by first-order stochastic dominance (FSD) or almost stochastic dominance (ASD) over the 10-, 20-, 30- or 40-year investment horizon.

Time horizon/ Tax bracket	10 years	20 years	30 years	40 years
18 per cent	**Sub-hypothesis $1D^{10\ years}$** Fails to reject the null hypothesis	**Sub-hypothesis $1D^{20\ years}$** Fails to reject the null hypothesis	**Sub-hypothesis $1D^{30\ years}$** Fails to reject the null hypothesis	**Sub-hypothesis $1D^{40\ years}$** Fails to reject the null hypothesis
25 per cent	**Sub-hypothesis $1D^{10\ years}$** Fails to reject the null hypothesis	**Sub-hypothesis $1D^{20\ years}$** Fails to reject the null hypothesis	**Sub-hypothesis $1D^{30\ years}$** Fails to reject the null hypothesis	**Sub-hypothesis $1D^{40\ years}$** Fails to reject the null hypothesis
40 per cent	**Sub-hypothesis $1D^{10\ years}$** Fails to reject the null hypothesis	**Sub-hypothesis $1D^{20\ years}$** Fails to reject the null hypothesis	**Sub-hypothesis $1D^{30\ years}$** Fails to reject the null hypothesis	**Sub-hypothesis $1D^{40\ years}$** Fails to reject the null hypothesis

4.5.2.2.3 Key findings

The key findings are as follows:

- Model 3 (theoretical retirement fund model, which has a 75/25 per cent, local/foreign, equity allocation) does not dominate Model 6 (the high equity balanced retirement fund model with a 50/25 per cent split between local and foreign equities) in any of the cases.
- Irrespective of the tax bracket, the longer the investment horizon, the more likely Model 3 is to dominate Model 6 by FSD or ASD. However, in this study, the ε values to test for dominance of Model 3 over Model 6 never meet the threshold requirement of being below 0.01 in any of the investment horizons. Hence the longer the investment horizon, the lower the area of SD violation relative to non-violation, all other factors held constant.

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4.5.2.3 Hypothesis 1E

The models applicable to Hypothesis 1E are as follows:

Model	Type of fund	Retirement fund or Direct investment fund	Asset allocation* (%)	Glide path period (years)
Model 1	Equity	Theoretical retirement fund	100/0/0/0	N/A
Model 6	Balanced - High equity (25% foreign equity exposure)	Retirement fund	50/25/15/10	N/A
*Local equity/foreign equity/local fixed income/local money market				

The hypothesis was articulated as follows:

H_0: A theoretical 100 per cent equity retirement fund with a 100 per cent local equity allocation (Model 1) does not dominate a high equity balanced retirement fund with a 50/25 per cent local/foreign equity allocation split (Model 6) by first-order stochastic dominance (FSD) or almost stochastic dominance (ASD) over the 10-, 20-, 30- or 40-year investment horizon.

H_a: A theoretical 100 per cent equity retirement fund with a 100 per cent local equity allocation (Model 1) dominates a high equity balanced retirement fund with a 50/25 per cent local/foreign equity allocation split (Model 6) by first-order stochastic dominance (FSD) or almost stochastic dominance (ASD) over the 10-, 20-, 30- and 40-year investment horizon.

4.5.2.3.1 Results

Figure 4-8 presents the cumulative distribution functions for Model 1 (theoretical 100 per cent local equity retirement fund model) and Model 6 (high equity balanced retirement fund model) for an 18 per cent tax bracket individual and 10-year investment horizon (it is repeated, along with the other cumulative distribution graphs for the 25 and 40 per cent tax brackets and 10-, 20-, 30- and 40-year investment horizons in Appendix E with Figures E 49 to E 51 and E 52 to E 54 for the 10- and 20-year investment horizons and Figures E 55 to E 57 and E 58 to E 60 for the 30- and 40-year investment horizons).

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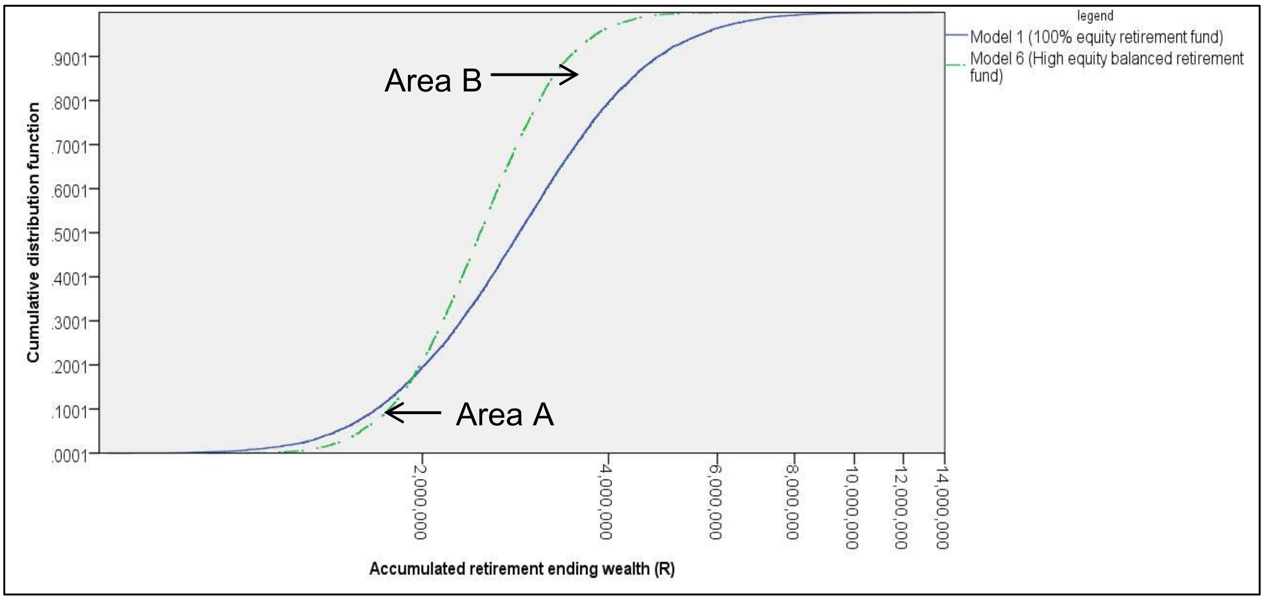
Figure 4-8: Cumulative distribution functions of accumulated retirement ending wealth for Model 1 against Model 6 (10-year investment horizon, 18% tax bracket)



Source: SPSS output

As shown in Figure 4-4, the cumulative distribution functions of the two models cross, violating the strict FSD. The models cross at a cumulative probability of approximately 0.1723 and an accumulated retirement ending wealth value of R1.9 million. For any accumulated retirement ending wealth value of below approximately R1.9 million, the cumulative distribution function of Model 6 (high equity balanced retirement fund model) is below or to the right of that of Model 1 (theoretical 100 per cent equity retirement fund model) with the area shown on the figure as Area A, enclosed by the cumulative distribution functions. For this section, Model 6 is optimal, while the opposite is true to the right of an accumulated retirement ending wealth of approximately R1.9 million.

Because Area B, which is the stochastic dominance area for Model 1, is greater than the area where Model 6 is optimal (Area A), the cumulative distribution functions indicate that Model 1 is likely to dominate Model 6 by ASD if the ε value is between 0 and 0.01. However, the ε values for Model 1 against Model 6 are below the threshold value of 0.01 for all investment horizons other than the 10-year investment horizon,

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which leads to rejecting the null hypotheses for the 20-, 30- and 40-year investment horizons (Table 4-17).

Table 4-17: ASD results of Model 1 against Model 6

Area of SD violation relative to non-violation (ε)** Theoretical retirement fund model – Model 1 (100/0/0/0, equity fund) AGAINST Retirement fund model - Model 6 (50/25/15/10, retirement fund)	
Tax bracket/Time horizon	**18%, 25% and 40% tax bracket**
10 years	0.0317
20 years	0.0056*
30 years	0.0012*
40 years	0.0003*

†FSD
¥ Value of zero shown due to rounding, does not exhibit FSD in the truest form.
** Almost stochastic dominance exists for threshold value of 0 < ε < 0.01.

The ASD results lead to the following conclusions:

- For all sub-hypotheses pertaining to the 20-, 30- and 40-year investment horizons, Model 1 (theoretical 100 per cent equity retirement fund model) dominates Model 6 (high equity balanced retirement fund) by ASD because the ε values are consistently below the threshold value of 0.01 irrespective of the tax bracket or investment horizon.

A comparison of the cumulative distribution graphs for all investment horizons and tax brackets as well as the ε values shown in Table 4-17 leads to the following additional finding (Figure E 49 to E 60 in Appendix E):

- All other factors held constant, the longer the investment horizon, the more likely Model 1 is to dominate Model 6.

4.5.2.3.2 Summary

Table 4-18 shows a summary of the findings pertaining to Hypothesis 1E. The results indicate that for the 20-, 30- and 40-year investment horizons, Model 1 dominates Model 6 by ASD. As mentioned, the tax bracket has no bearing on the results.

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Table 4-18: Summary of findings – Hypothesis 1E

Hypothesis 1E				
H_0: A 100 per cent equity retirement fund (100 per cent local equity allocation) dominates a high equity balanced retirement fund (50/25 per cent local/foreign equity allocation split) by first-order stochastic dominance (FSD) or almost stochastic dominance (ASD). H_a: A 100 per cent equity retirement fund (100 per cent local equity allocation) dominates a high equity balanced retirement fund (50/25 per cent local/foreign equity allocation split) by first-order stochastic dominance (FSD) or almost stochastic dominance (ASD).				
Time horizon/ Tax bracket	**10 years**	**20 years**	**30 years**	**40 years**
18 per cent	**Sub-hypothesis $1E^{10\ years}$** Fails to reject the null hypothesis	**Sub-hypothesis $1E^{20\ years}$** Rejects the null hypothesis	**Sub-hypothesis $1E^{30\ years}$** Rejects the null hypothesis	**Sub-hypothesis $1E^{40\ years}$** Rejects the null hypothesis
25 per cent	**Sub-hypothesis $1E^{10\ years}$** Fails to reject the null hypothesis	**Sub-hypothesis $1E^{20\ years}$** Rejects the null hypothesis	**Sub-hypothesis $1E^{30\ years}$** Rejects the null hypothesis	**Sub-hypothesis $1E^{40\ years}$** Rejects the null hypothesis
40 per cent	**Sub-hypothesis $1E^{10\ years}$** Fails to reject the null hypothesis	**Sub-hypothesis $1E^{20\ years}$** Rejects the null hypothesis	**Sub-hypothesis $1E^{30\ years}$** Rejects the null hypothesis	**Sub-hypothesis $1E^{40\ years}$** Rejects the null hypothesis

4.5.2.3.3 Key findings

The key findings are as follows:

- Model 1 (theoretical retirement fund model, which has a 100 per cent allocation to local equities) dominates Model 6 (high equity balanced retirement fund model with a 70/25 per cent split between local and foreign equities) for all tax brackets in the case of the 20-, 30- and 40-year investment horizons hence rejecting the null hypotheses in these particular cases. For the 10-year investment horizon, the results fail to reject the null-hypotheses.
- All other factors held constant, the longer the investment horizon, the more likely Model 1 is to dominate Model 6. Hence the longer the investment horizon, the lower the area of SD violation relative to non-violation, all other factors held constant.

- Comparing the findings of Hypotheses 1C, 1D and 1E, it is evident that the composition or asset allocation of the two models compared will have a significant influence on the likelihood of one fund against the other to be dominant.

4.6 DISCUSSION: KEY FINDINGS

4.6.1 DIRECT INVESTMENT FUNDS AGAINST HIGH EQUITY BALANCED RETIREMENT FUNDS

4.6.1.1 Finding 1: HYPOTHESES 1A AND 1B: direct investment against a high equity balanced retirement fund (foreign and no foreign exposure)

It was postulated that the benefit from a higher allocation to equities, which is possible through a direct investment model, may outweigh the negative effect of taxes applicable to direct investments. The study also considers that Regulation 28 of the Pension Funds Act may not be appropriate for most individuals because it can reduce the accumulated retirement ending wealth on the upside for an insignificant proportion of downside protection, which these individuals may wish to exploit by rather investing directly in financial markets.

The findings indicate that, irrespective of the inclusion of a 25 per cent allocation to foreign equities, the paired comparisons show that the direct investment fund models fail to dominate the high equity balanced retirement fund models by FSD or ASD.

Similarly, the research by Isaacs and Terblanche (2011) does not provide evidence that direct investment funds are optimal compared with retirement annuities (i.e. retirement funds in the context of this study). However, the article by Isaacs and Terblanche (2011) lacks statistical robustness, which the FSD and ASD results in this study provide.

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In this study and for both Hypotheses 1A and 1B, the ε values to test for FSD or ASD of the direct investment funds over the retirement funds are much higher than the threshold value of 0.01. It was considered prudent to use a conservative threshold value of 0.01 similar to what was employed by Basu *et al.* (2011), which would make it highly unlikely that an incorrect finding with regard to dominance of one fund over another could result. Even if a threshold value of 0.059, which was mentioned in Basu *et al.* (2011), was applied to this study, it would make no difference to the findings and still result in failing to reject the null hypothesis.

The major factors that contributed to a failure to reject the null hypothesis are the tax savings attributable to retirement funds, which include taxes on any income and capital returns as well as the tax saving credited to the tax deductibility of any contributions with the latter being the most significant. Additionally, the higher the tax bracket of the individual, the greater the benefit that is derived.

To illustrate, should an individual have a 40-year investment horizon, the starting annual salaries for an individual within the 18, 25 and 40 per cent tax brackets and the resultant contributions in the first year to a direct investment and retirement fund as well as the difference, are contrasted in Table 4-19.

Table 4-19: Comparative annual contributions

Investment horizon	Starting annual salary	Retirement fund contribution	Direct investment fund contribution	Difference
40% tax bracket	R673 101	R100 965	R60 579	R40 386
25% tax bracket	R272 700	R40 905	R30 679	R10 226
18% tax bracket	R174 550	26 183	R21 470	R4 713

Over time, the capital committed to the direct investment fund or, to put it another way, the assets contributed, are much less than what is the case for a retirement fund. Furthermore, the higher the tax bracket, the less attractive it becomes to invest in a direct investment fund versus a high equity balanced retirement fund, which has a significant impact on the FSD and ASD results presented for Hypotheses 1A and 1B.

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To illustrate, in Tables 4-9 and 4-11, which show the ASD and FSD results for Hypotheses 1A and 1B, there are a number of instances for the 40 per cent tax bracket where there is no area in the cumulative distribution function graphs where the direct investment fund is optimal compared with the high equity balanced fund model when testing for dominance of the direct investment fund model over the high equity balanced retirement fund model (indicated by “No value” shown in the tables with results).

In these instances, there is no chance that the direct investment fund model can dominate the high equity balanced fund model by FSD or ASD as the cumulative distribution function of the direct investment fund model is consistently above or to the left of the high equity balanced fund model.

In the findings by Isaacs and Terblanche (2011), the researchers allude to the possibility that, for longer investment horizons, the tax benefits from retirement annuities (i.e. retirement funds in the context of this study) may not be sufficient to outweigh the greater equity exposure possible with direct investments. However, this was not statistically tested. The findings in this study support the notion that the longer the investment horizon, the less profound the impact of the retirement fund tax benefits and the more significant the benefits of an additional 25 per cent allocation to equities for the direct investments. However, these combined factors do not lead to the direct investment fund models dominating the high equity balanced fund models by the strict criteria of ε values below 0.01. Hence the study suggests that this is in actual fact not the case; despite a longer investment horizon, the direct investment fund models still fail to dominate the retirement fund models by FSD or ASD, which is an important finding.

As none of the direct investment fund models dominate the high equity balanced funds by FSD or ASD, the contrary was briefly explored for completeness. These results indicate that, in some instances, the high equity balanced retirement fund models may be the most optimal choice for most individuals because the high equity balanced fund dominates the direct investment fund models by FSD or ASD. These results indicate that the high equity balanced retirement fund is more likely to dominate the direct

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investment fund model by FSD or ASD over a short time horizon of 10 years or a high tax bracket of 40 per cent. At a higher threshold value of 0.059, there would have been more instances where the high equity balanced funds dominate the direct investment fund models by FSD or ASD.

4.6.1.2 Finding 2: Impact of investment horizon

The longer the investment horizon, the lower the ε values to test for ASD of the direct investment fund models over the high equity balanced retirement fund models. However, in all cases, the ε values remain higher than the threshold value of 0.01, which makes it unlikely that, during a typical pre-retirement phase, the former models will dominate a high equity balanced retirement fund model by FSD or ASD.

4.6.1.3 Finding 3: Impact of tax bracket

The higher the tax bracket, the higher the ε values to test for ASD of the direct investment fund models over the high equity balanced retirement fund models (irrespective of the time horizon). This indicates that the higher the tax bracket of the individual, the more detrimental the negative tax implications (taxes on returns and the lower contribution amount) of the direct investment fund models are to the accumulated retirement ending wealth. The results indicate that especially individuals within the highest tax bracket of 40 per cent will not derive sufficient return enhancement from the additional 25 per cent allocation to equities that is possible through a direct investment fund model to compensate for the tax implications of these funds.

4.6.1.4 Finding 4: Impact of asset allocation

If different models are compared based on the mean accumulated retirement ending wealth, it is intuitive that the fund with the highest allocation to asset classes that are characterised by a higher risk and return, will offer the highest mean accumulated retirement ending wealth. However, one cannot generalise when applying the stochastic dominance decision criteria. It is not necessarily the case that a fund with a higher allocation to risky assets will automatically dominate a fund with a lower

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allocation to such assets. One fund will only dominate another, if the area of SD violation divided by non-SD violation is less than 0.01.

Furthermore, two specific pairs of direct investment funds versus high equity balanced retirement funds were tested in this study. Hence, the results and findings are particular to these cases. Other combinations may lead to different results (i.e. lower equity allocations in the direct investment fund and high equity balanced retirement funds).

Lastly, as shown earlier in the chapter (Section 4.2), the South African equity asset class is more volatile than that of the US. Hence it is acknowledged that, consistent with what can be expected, a longer investment horizon and/or greater allocation to the local equity asset class results in a higher mean accumulated retirement ending wealth and, importantly, also a cumulative distribution function that leads to significantly lower (and higher) accumulated retirement ending wealth values. However, the FSD and ASD decision-making criteria are more robust in evaluating two pairs of models as it considers the whole cumulative distribution function. Where a fund with a higher allocation to equities will always result in a higher mean accumulated retirement ending wealth, this does not imply that it will also dominate another with a lower exposure to equity by FSD or ASD. Additionally, the cumulative distribution function slope is flatter for funds with a higher equity allocation, which supports the notion that these models are generally considered to result in more volatile outcomes (Basu *et al.*, 2011). In particular, the extent of the foreign versus local equity allocation may lead to slightly different results should pairs with different asset allocation from what was modelled in this study be used.

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4.6.2 100 PER CENT EQUITY RETIREMENT FUNDS AGAINST HIGH EQUITY BALANCED RETIREMENT FUNDS

4.6.2.1 Finding 5: HYPOTHESES 1C, 1D AND 1E: 100 per cent equity retirement fund against a high equity balanced retirement fund (foreign and no foreign exposure)

It was postulated that Regulation 28 of the Pension Funds Act, although intended to provide downside protection of retirement wealth, significantly reduces the accumulated retirement ending wealth that can be achieved through a 100 per cent allocation to equities and that the aforementioned benefit is not sufficient to give up the upside potential of a 100 per cent allocation to equities. Additionally, one must note that a regulation such as Regulation 28 is aimed at *most* individuals, which made the ASD criteria sensible to employ in this context. To test this, a theoretical retirement fund with a 100 per cent allocation to equities was compared with a Regulation 28-compliant balanced fund with the maximum allowed equity allocation of 75 per cent.

With regard to Hypotheses 1C to 1E, the findings indicate that the theoretical retirement fund models invested 100 per cent in equities are mostly unsuccessful in dominating the high equity balanced retirement fund models by FSD or ASD.

Regarding Hypothesis 1C, for a theoretical retirement fund 100 per cent invested in local equities against a high equity balanced retirement fund with the maximum allowable allocation invested in local equities (75 per cent) and the remainder in the fixed income asset class and money market (15 and 10 per cent respectively), the 100 per cent local equity retirement fund always fails to dominate the high equity balanced fund by FSD or ASD irrespective of the investment horizon.

The same is true for Hypothesis 1D, regarding a theoretical retirement fund 100 per cent invested in equities split 50/25 between local and foreign equities against a high equity balanced retirement fund with the maximum allowable allocation invested in equities (50/25 per cent split between local and foreign) and the remainder in the fixed income asset class and money market (15 and 10 per cent respectively), with the 100

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per cent equity retirement fund failing to dominate the high equity balanced fund by FSD or ASD irrespective of the investment horizon.

It is worth mentioning that the ε values pertaining to the 40-year investment horizon of Hypotheses 1C and 1D come very close to the threshold value of 0.01 at 0.0168 and 0.0150 respectively.

In the case of Hypothesis 1E, for a theoretical retirement fund 100 per cent invested in local equities against a high equity balanced retirement fund with the maximum allowable allocation invested in equities (50/25 per cent split between local and foreign) and the remainder in the fixed income asset class and money market (15 and 10 per cent respectively), the 100 per cent equity retirement fund dominates the high equity balanced fund by ASD for the 20-, 30- and 40-year investment horizons.

With Hypotheses 1C and 1D, the two paired funds have a similar asset allocation to the foreign equity asset class (no allocation in the case of Hypothesis 1C and a 25 per cent allocation in the case of Hypothesis 1D). However, the difference in the asset allocations was not significant enough to result in FSD and ASD dominance of the theoretical retirement fund with 100 per cent in equities over the high equity balanced retirement fund. In contrast, Hypothesis 1E compares a theoretical 100 per cent local equity retirement fund model (no foreign equity exposure) against a high equity balanced fund model with a 50/25 local against foreign equity allocation split. Only in this instance are there sub-hypotheses where the null hypothesis is rejected. This shows the impact of only one fund suffering from an allocation to the lower risk and return foreign equity asset class.

The intent of Regulation 28 is to "…ensure that the savings South Africans contribute towards their retirement is invested in a prudent manner that not only protects the retirement fund member, but is channelled in ways that achieve economic development and growth" (National Treasury of South Africa, 2011b:1). The majority of the results of the study do not provide convincing evidence that Regulation 28 fails in its aim because the theoretical retirement fund fully invested in equities mostly fails to dominate the high equity balanced retirement fund. However, the findings indicate

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that a theoretical retirement fund with a 100 per cent allocation to equities might dominate the high equity balanced retirement fund depending on how different the asset allocation of the theoretical 100 per cent retirement fund compared with high equity balanced fund is.

While the results do not offer strong support for a theoretical 100 per cent equity fund dominating the high equity balanced retirement fund, this finding does not imply that the opposite is true, namely that a Regulation 28-compliant high equity balanced fund is optimal for *most* individuals (based on the ASD criteria). To test the latter would require an analysis of the ε values to test for dominance of the high equity balanced retirement funds against the theoretical 100 per cent equity retirement funds at the threshold value of 0.01. In the study, these ε values are the inverse of the values reported for hypotheses 1C, 1D and 1E. At the threshold value of 0.01, the results provide no support for the notion that high equity balanced retirement funds dominate the theoretical 100 per cent equity retirement funds.

Additionally, the longer the investment horizon, the more likely that a retirement fund fully invested in equities (irrespective of whether local or a combination of local and foreign) will dominate a high equity balanced retirement fund model (irrespective of the pair tested). Importantly, in this study, the ε values to test for dominance in the case of Hypotheses 1C and 1D never met the threshold requirement of being below 0.01 in any of the investment horizons.

As mentioned before for Hypotheses 1C to 1D, the ε values to test for FSD or ASD are higher than the threshold value of 0.01. It is worth noting that if the more liberal threshold value of 0.059, which was mentioned in Basu *et al.* (2011), was applied to this study, it would impact the findings; the results would lead to rejecting the null hypothesis in the case of the 30- and 40-year investment horizons. If the more liberal threshold value of 0.059 was applied to Hypothesis 1E, the ε values to test for FSD or ASD would impact the findings pertaining to the 10-year investment horizon; the results would lead to rejecting the null hypothesis for all the investment horizons and not only the 20-, 30- and 40-year investment horizons.

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4.6.2.2 Finding 6: Impact of asset class characteristics

The risk and return characteristics of the local and foreign equity asset classes invested in play an important role in whether the retirement fund invested 100 per cent in equities is likely to dominate the high equity balanced fund with only a 75 per cent allocation to equities. As mentioned before, only in the case of Hypothesis 1E and for the 20-, 30- and 40-year investment horizons could the null hypothesis be rejected, which indicates the impact of the asset class characteristics.

As shown earlier in the chapter (Section 4.2), the South African equity asset class is much more volatile than that of the US. A longer investment horizon and/or greater allocation to the local equity asset class results in a cumulative distribution function that leads to significantly lower (and higher) accumulated retirement ending wealth values. Additionally, the cumulative distribution function is flatter, indicating that these models are generally considered to result in more volatile outcomes (Basu *et al.*, 2011). Hence, in the case of Hypothesis 1E, the 100 per cent local equity retirement fund was the highest risk and return fund (Model 1), while the high equity balanced retirement fund with a 25 per cent allocation to foreign equities (Model 6) was the lowest risk and return balanced retirement fund and it is only for some of these particular cases that the 100 per cent equity retirement fund could dominate the high equity balanced retirement fund.

4.6.2.3 Finding 7: Impact of investment horizon

The longer the investment horizon, the lower the ε values to test for ASD of the 100 per cent equity retirement fund models over the high equity balanced retirement fund models. However, in all cases, the ε values are still higher than the threshold value of 0.01 except for the sub-hypotheses pertaining to Hypothesis 1E for the 20-, 30- and 40-year investment horizons.

At a higher threshold of 5.9 per cent as mentioned by Basu *et al.* (2011), dominance by ASD of theoretical retirement funds with a 100 per cent allocation to equities over a high equity balanced retirement fund, however, becomes possible, generally for the 30- and 40-year investment horizons.

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4.7 CONCLUSION

In this chapter, the results and findings pertaining to Research Question 1, Hypotheses 1A to 1E were presented and discussed.

With regard to Hypotheses 1A and 1B, the results and findings consistently lead to a failure to reject the null hypothesis for all sub-hypotheses. That is, there is no evidence that a direct investment fund model with 100 or 95 per cent allocated to equities dominates a high equity balanced retirement fund model with a maximum 75 per cent allocation to equities by FSD or ASD. The major factors that contributed to a failure to reject the null hypothesis was the tax savings attributable to retirement funds, which include taxes on any income and capital returns as well as the tax saving credited to the tax deductibility of any contributions with the latter being the most significant.

Additionally, the findings pertaining to Hypotheses 1A and 1B provide statistical evidence that even for an investment horizon as long as 40 years, the direct investment fund models still fail to dominate the retirement fund models by FSD or ASD, which is an important finding.

Regarding Hypotheses 1C and 1D, a theoretical retirement fund with 100 per cent allocated to equities fails to dominate a high equity balanced retirement fund with the maximum 75 per cent allocated to equities by FSD or ASD. The results lead to a failure to reject the null hypothesis. With regard to Hypothesis 1E, a theoretical retirement fund 100 per cent invested in local equities compared with a high equity balanced retirement fund with the maximum allowable allocation invested in equities (50/25 per cent split between local and foreign) and the remainder in the fixed income asset class and money market (15 and 10 per cent respectively), the 100 per cent equity retirement fund dominates the high equity balanced fund by ASD for the 20-, 30- and 40-year investment horizons.

The majority of the results regarding Research Question 1 do not provide convincing evidence that Regulation 28 fails in its aim because the theoretical retirement fund fully invested in equities mostly fails to dominate the high equity balanced retirement fund. However, the findings support the greater likelihood that a theoretical retirement fund with a 100 per cent allocation to equities can dominate the high equity balanced retirement fund because the investment horizon increases as the area of SD violation to non-violation becomes lower.

Additionally, the findings indicate that the investment horizon, tax bracket as well as asset class allocation are important factors that impact dominance of one fund over another.

In Chapter 5, the results, findings and discussion pertaining to Research Question 2 are presented.

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CHAPTER 5:

RESEARCH QUESTION 2: ANALYSIS AND DISCUSSION

5.1 INTRODUCTION

The previous chapter presented the results, analysis and discussion pertaining to Research Question 1: *Is a fund fully invested in equities optimal compared with a Regulation 28-compliant retirement fund with maximum equity allocation of 75 per cent?* The following chapter presents the descriptive statistics, analysis, findings and discussion applicable to Research Question 2: *Are life cycle funds optimal compared with balanced funds?*

The chapter commences by detailing the hypotheses, models and asset allocation strategies pertaining to Research Question 2. The descriptive statistics for the models follow, whereafter the empirical results, findings and discussion for the hypotheses are presented.

5.2 RESEARCH QUESTION 2: LIFE CYCLE AGAINST BALANCED FUNDS

The models applicable to test Research Question 2 are shown in Table 5-1 and discussed thereafter along with the two hypotheses which are used to test the research question.

Research Question 2 enquires whether a life cycle fund compared with a balanced fund is optimal for most individuals. The research question is tested by means of two hypotheses (and particular sub-hypotheses):

- Hypothesis 2A focuses on life cycle funds as opposed to balanced funds that have similar starting asset allocations; and
- Hypothesis 2B focuses on life cycle funds as opposed to balanced funds that have dissimilar starting asset allocations.

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Table 5-1: Models for Research Question 2

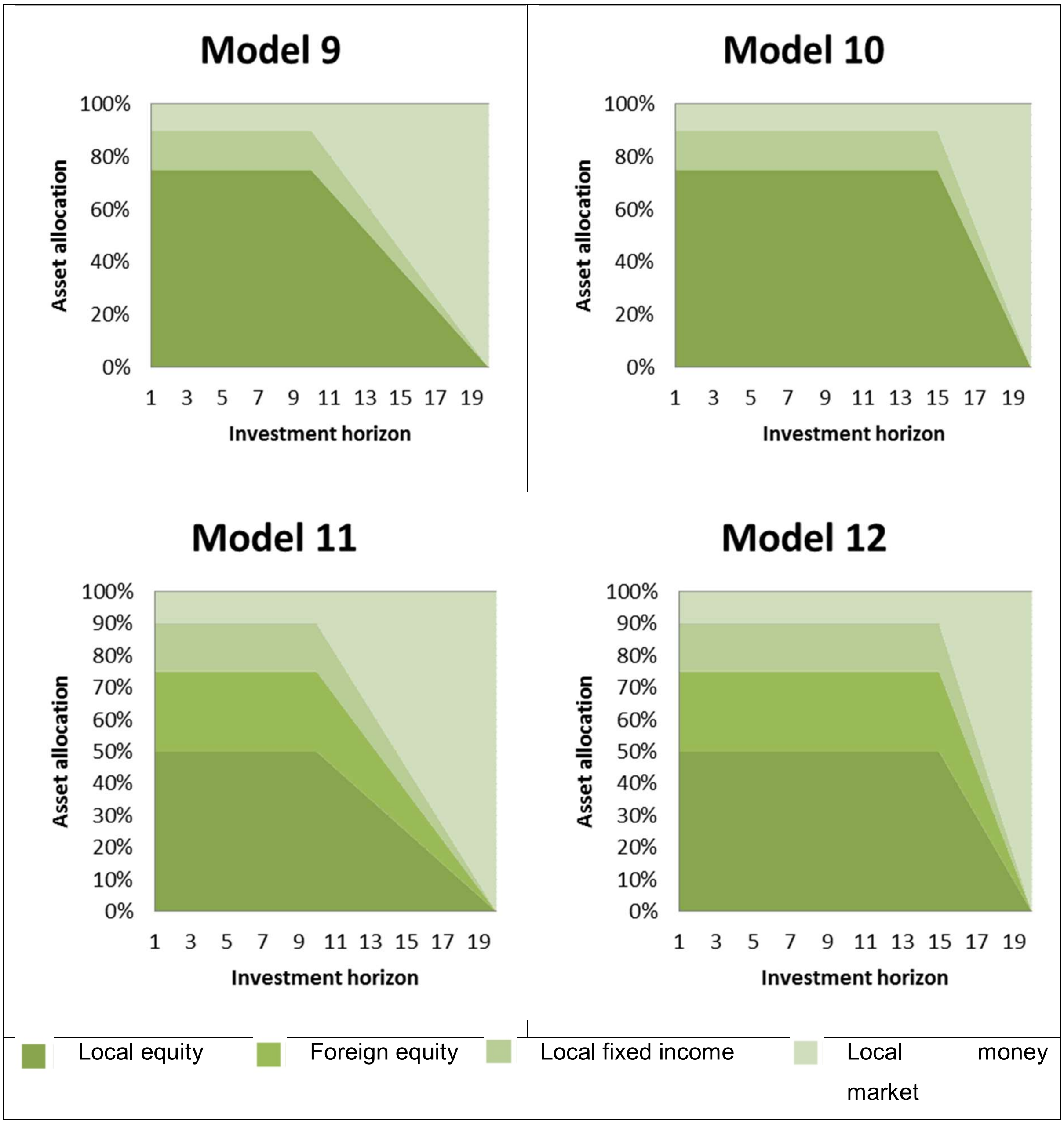
Model	Type of fund	Beginning asset allocation* (%)	Ending asset allocation* (%)	Glide path period (years)
5	Balanced high equity (no foreign exposure)	75/0/15/10	75/0/15/10	N/A
6	Balanced high equity (25% foreign equity exposure)	50/25/15/10	50/25/15/10	N/A
7	Balanced medium equity (25% foreign equity exposure)	35/25/30/10	35/25/30/10	N/A
8	Balanced low equity (25% foreign equity exposure)	15/25/50/10	15/25/50/10	N/A
9	Life cycle	75/0/15/10	0/0/0/100	Final 10 years
10	Life cycle	75/0/15/10	0/0/0/100	Final 5 years
11	Life cycle	50/25/15/10	0/0/0/100	Final 10 years
12	Life cycle	50/25/15/10	0/0/0/100	Final 5 years

*Local equity/foreign equity/local fixed income/local money market

The analysis was limited in scope to retirement funds (i.e. did not include direct investments in the analysis) to evaluate the balanced and retirement funds without the unique factors (such as taxes) that are applicable to direct investments.

Figure 5-1 graphically depicts the asset allocation strategy of each life cycle model (Models 9 to 12) over a 20-year investment horizon. For a 10-year investment horizon, the static allocation period is reduced by 10 years and for any investment horizon longer than 20 years, the static asset allocation is extended to cover that period.

Figure 5-1: Asset allocation strategies of Models 9 to 12 (20-year investment horizon)



As an example, for a 30-year investment horizon, Model 9 follows a static asset allocation of 75 per cent local equities, no foreign equities, 15 per cent local fixed income and 10 per cent local money market until only 10 years of the investment horizon remains. For the 10 years leading up to retirement, the glide path is followed with the asset allocations linearly changing to an at retirement asset allocation of 100 per cent money market as shown in Figure 5-1.

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Additionally, the analysis was limited to an individual that falls within the 40 per cent tax bracket. Although the latter is not important regarding tax implications *per se*, it is relevant with regard to the starting salary that is used for each investment horizon. As discussed in the research method chapter, the starting salary for an individual within the 40 per cent tax bracket and an expected retirement date in 40 years (i.e. and investment horizon of 40 years) is R673,101. A 30-year investment horizon assumes that an individual does not participate in saving for retirement for another 10 years and only then starts saving (i.e. 30-year investment horizon). During this period of non-participation, an individual's salary is assumed to grow annually at inflation. Hence the starting salary for someone with a 30-year investment horizon is R1 045 305 (see Table 5-2).

Table 5-2: Annual starting salary

Investment horizon	10 years	20 years	30 years	40 years
Starting salary*	R2 520 977	R1 623 327	R1 045 305	R673 101

** Starting salary adjusted at rate of inflation of 4.5 per cent per annum*

The following section proceeds by providing a summary of the descriptive statistics of the Monte Carlo simulation results of the models, whereafter the analysis and findings for each hypothesis are presented.

5.3 DESCRIPTIVE STATISTICS

The following section only provides a short summary of the more relevant descriptive statistics pertaining to accumulated retirement ending wealth, while Appendix F (Tables F 1 to F 4) includes comprehensive tables regarding the descriptive statistics of accumulated retirement ending wealth for the 10-, 20-, 30- and 40-year investment horizons for each of the models applicable to Research Question 2.

Appendix G shows histograms of the Monte Carlo simulated results for the models applicable to each investment horizon. As previously discussed, the models that were simulated for the 10-year investment horizon excludes Models 9 and 11, because the life cycle glide path presented by these models is similar to the investment horizon.

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Consequently, the models referred to for the 10 year-investment horizon includes Models 5 to 8, 10 and 12 only.

5.3.1 ARITHMETIC MEAN

Table 5-3 shows the rankings of the arithmetic mean accumulated retirement ending wealth for each investment horizon. In each case, the model that provides the highest mean accumulated retirement ending wealth is ranked first with the lowest accumulated retirement wealth ranked as eighth (or sixth in the case of the 10-year investment horizon).

For the 10-year investment horizon, the rankings of the funds place Model 5 (high equity balanced fund with 75 per cent local equity exposure) in first position, followed by Model 6 (high equity balanced fund with 75 per cent equity exposure split as 50/25 local versus foreign equity). Model 10 (life cycle fund with only local equity exposure) is ranked third, followed by the medium and low equity balanced funds (Models 7 and 8) and, lastly, Model 12 (life cycle fund with local and foreign equity exposure).

For the 20-year investment horizon, Model 5 remains in first position, followed by Models 10 and 9 (life cycle funds with only local equity exposure). Model 6 is in fourth position, followed by the balanced medium equity fund (Model 7). Model 12 (life cycle fund) is ranked sixth followed by Model 11 (life cycle fund with foreign equity exposure and short glide path). The balanced low equity fund, Model 8, is ranked last in eighth position.

The rankings of accumulated retirement ending wealth are similar for the 30- and 40-year investment horizons: Model 5 is ranked first followed by Models 10 and 9 with Model 6 in fourth position. Model 12 is ranked in fifth position, followed by the medium equity balanced fund, Model 7 in sixth position, Model 11 in seventh position and lastly (similar to the 20-year investment horizon), the balanced low equity fund, Model 8, is ranked last.

The next section presents the descriptive statistics pertaining to the distribution of the accumulated retirement ending wealth simulations.

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Table 5-3: Rankings of models from highest to lowest mean accumulated retirement ending wealth and annualised return

Model	Type of fund	Beginning asset allocation* (%)	Ending asset allocation* (%)	Glide path period (years)	Investment horizon			
					10 years	20 years	30 years	40 years
5	Balanced high equity (no foreign exposure)	75/0/15/10	75/0/15/10	N/A	1 R11 210 817	1 R49 225 929	1 R178 247 972	1 R617 002 951
6	Balanced high equity (25% foreign equity exposure)	50/25/15/10	50/25/15/10	N/A	2 R9 887 293	4 R37 126 846	4 R111 829 643	4 R317 752 702
7	Balanced medium equity (25% foreign equity exposure)	35/25/30/10	35/25/30/10	N/A	4 R9 576 759	5 R34 558 395	6 R99 363 153	6 R268 381 004
8	Balanced low equity (25% foreign equity exposure)	15/25/30/10	15/25/30/10	N/A	5 R9 173 077	8 R31 389 683	8 R84 815 063	8 R214 031 807
9	Life cycle	75/0/15/10	0/0/0/100	Final 10 years	N/A	3 R37 564 882	3 R134 589 420	3 R463 396 038
10	Life cycle	75/0/15/10	0/0/0/100	Final 5 years	3 R9 754 067	2 R42 187 047	2 R152 693 842	2 R527 552 000
11	Life cycle	50/25/15/10	0/0/0/100	Final 10 years	N/A	7 R31 558 285	7 R94 559 145	7 R267 206 159
12	Life cycle	50/25/15/10	0/0/0/100	Final 5 years	6 R9 105 526	6 R33 810 852	5 R101 945 633	5 R288 886 306

*Local equity/foreign equity/local fixed income/local money market

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5.3.2 ACCUMULATED RETIREMENT ENDING WEALTH DISTRIBUTION

The results for all the models and investment horizons indicate that the median is lower than the mean, which shows that the frequency distributions of all the models are positively skewed. This is confirmed by a visual inspection of the histograms (presented in Appendix G) and the results for skewness of the various models (individual results in Appendix F). As would be expected, the longer the investment horizon and more persistent the exposure of a model to the local equity asset class, the greater the skewness exhibited by the distribution of accumulated retirement ending wealth.

Similar to the results of Lewis (2008c), all the models' frequency distributions are leptokurtic with positive kurtosis. The longer the investment horizon, the greater the value of kurtosis, that is, the more peaked the distribution of accumulated retirement ending wealth. The kurtosis of the life cycle funds are consistently lower than that of its comparable balanced funds (Models 9 and 10 versus Model 5 and Models 11 and 12 versus Model 6).

Generally, the greater the exposure to the higher risk and return local equity asset class, the more volatility the model exhibits with higher standard deviation and variance.

Similarly, the greater and more persistent the exposure to the higher risk and return local equity asset class, the greater the range exhibited.

5.4 RESULTS AND FINDINGS

The results and findings for all the investment horizons are included in the relevant sections that follow with Hypothesis 2A presented in 5.4.1 and Hypothesis 2B in Section 5.4.2.

Additionally, although the results for FSD and ASD are based on a paired comparison of a particular balanced fund and life cycle fund, the figures in Appendix H show, for

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each investment horizon, the cumulative distribution functions of a particular balanced fund and all the life cycle funds for which the paired FSD and ASD results are calculated to limit the number of cumulative distribution figures in the appendix.

5.4.1 HYPOTHESIS 2A

The models applicable to Hypothesis 2A are as follows:

Model	Type of fund	Beginning asset allocation* (%)	Ending asset allocation* (%)	Glide path period (years)
5	Balanced high equity (no foreign exposure)	75/0/15/10	75/0/15/10	N/A
6	Balanced high equity (25% foreign equity exposure)	50/25/15/10	50/25/15/10	N/A
9	Life cycle	75/0/15/10	0/0/0/100	Final 10 years
10	Life cycle	75/0/15/10	0/0/0/100	Final 5 years
11	Life cycle	50/25/15/10	0/0/0/100	Final 10 years
12	Life cycle	50/25/15/10	0/0/0/100	Final 5 years
*Local equity/foreign equity/local fixed income/local money market				

The hypothesis was articulated as follows:

H_0: Life cycle funds do not dominate balanced funds by first-order stochastic dominance (FSD) or almost stochastic dominance (ASD) when the funds have similar starting asset allocations.

H_a: Life cycle funds dominate balanced funds by first-order stochastic dominance (FSD) or almost stochastic dominance (ASD) when the funds have similar starting asset allocations.

5.4.1.1 RESULTS

Figure 5-2 presents the cumulative distribution functions for Models 5 (high equity balanced fund) and 10 (life cycle fund with five-year glide path) for the 10-year investment horizon, which will be used for illustrative purposes shortly (it is repeated, along with the other cumulative distribution graphs for the 10-, 20-, 30- and 40-year investment horizons in Appendix H with Figures H 1 to H 3 for the 10-year investment

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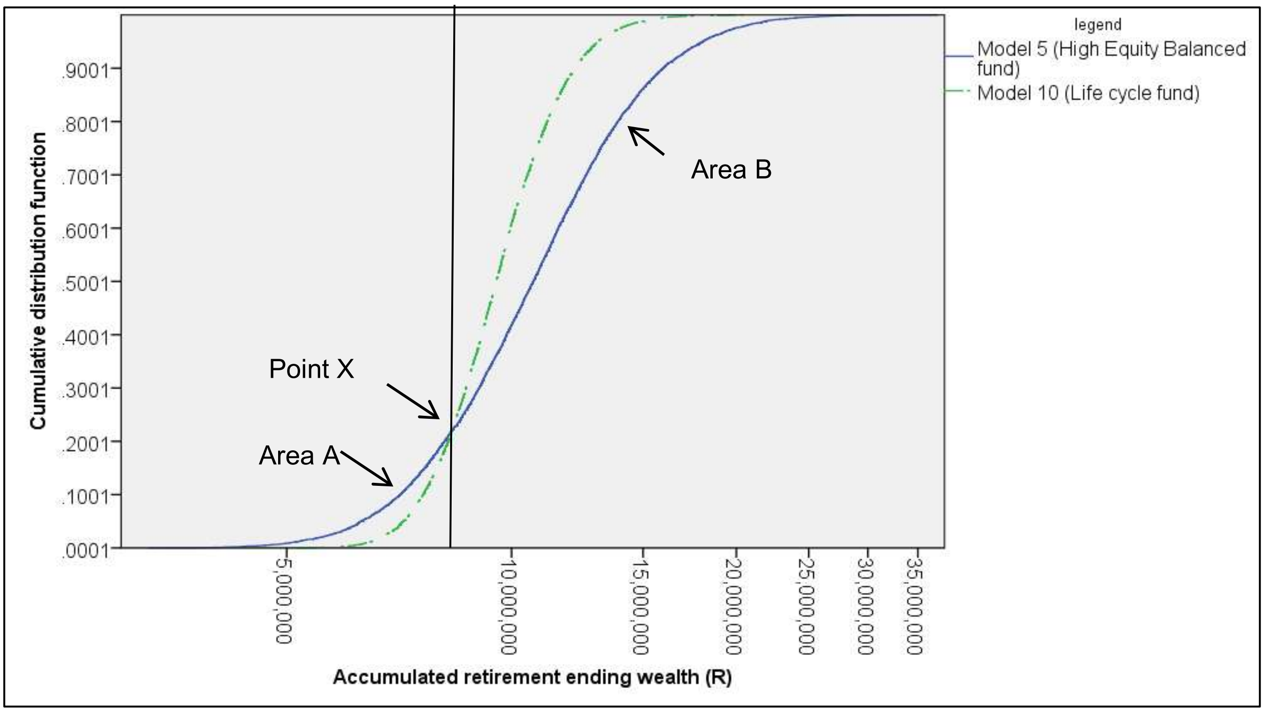
horizon, Figures H 4 to H 6 and H 7 to H 9 for the 20- and 30-year investment horizons and Figures H 10 to H 12 for the 40-year investment horizon).

To illustrate, Figure 5-2 shows the cumulative distribution functions for Models 5 (balanced high equity fund with no foreign exposure) and 10 (life cycle fund with 75 per cent local equity allocation) for the 10-year investment horizon. Both models start with an asset allocation of 75/0/15/10 invested in local equities, foreign equities, the fixed income and money market asset classes respectively.

Figure 5-2: Cumulative distribution functions of accumulated retirement ending wealth for Model 10 against Model 5 (10-year investment horizon)



Source: SPSS output

In Figure 5-2, the cumulative distribution functions of the two models cross at Point X, violating the strict FSD principle. This is at approximately a cumulative probability of 0.219 and accumulated retirement ending wealth of R8.3 million. For the small section to the left of Point X, the cumulative distribution function of Model 10 (life cycle fund) is below that of Model 5 (comparative balanced fund) and so Model 10 seems optimal compared with Model 5, while the opposite is true to the right of Point X. Except for the small section to the left of Point X, Model 5 has a higher chance of achieving any

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particular accumulated retirement ending wealth compared with Model 10 (the section to the right of Point X).

Because the area to the right of Point X, where Model 5 is optimal, is much greater than the area where Model 10 (life cycle fund) is optimal, the cumulative distribution functions indicate that Model 5 (high equity balanced fund) is more likely to dominate Model 10 by ASD if the ε value is between 0 and 0.01

Table 5-4 shows the ε values for Models 9, 10, 11 and 12 (all life cycle funds) against the applicable balanced fund models. For all sub-hypotheses, the ε values to test for ASD are higher than the threshold value of 0.01, which results in a failure to reject the null hypothesis in any of the cases. The table also indicates the instances where the balanced funds dominate the life cycle funds by FSD or ASD with the symbol "***".

Table 5-4: ASD results of life cycle funds against balanced funds – similar starting asset allocation (10-, 20-, 30- and 40-year investment horizons)#

Model	Balanced fund model	Beginning asset allocation* (%)	Glide path period (years)	Area of SD violation relative to non-violation (ε)** Life cycle fund model			
				Model 9 (75/0/15/10, 10-year glide path)	Model 10 (75/0/15/10, 5-year glide path)	Model 11 (50/25/15/10, 10-year glide path)	Model 12 (50/25/15/10, 5-year glide path)
5	Balanced high equity (no foreign exposure)	75/0/15/10	N/A	N/A to 10 years	12.9534 (10 years)		
				49.2611 (20 years)	63.2911 (20 years)		
				217.3913*** (30 years)	277.7778*** (30 years)		
				1 111.1111*** (40 years)	1 666.6667*** (40 years)		
6	Balanced high equity (25% foreign equity exposure)	50/25/15/10	N/A			N/A to 10 years	6.0864 (10 years)
						14.8810 (20 years)	17.8571 (20 years)
						35.3357 (30 years)	44.4444 (30 years)
						97.0874 (40 years)	128.2051*** (40 years)

*Local equity/foreign equity/local fixed income/local money market.
** Almost stochastic dominance exists for threshold value of 0 < ε < 0.01.
# Investment horizon is shown in brackets.
*** The balanced fund model dominates the life cycle fund model by FSD if ε value shows "No value" or ASD in all other cases.

A comparison of the cumulative distribution graphs for all investment horizons as well as the ε values shown in Table 5-4 leads to the following findings (Figures H 1 to H 12 in Appendix H):

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- The longer the investment horizon, the narrower the gap between the cumulative distribution functions to the left of Point X where the life cycle funds are optimal. This indicates that although the life cycle fund models are still optimal to the left of Point X, the advantage becomes less so as the investment horizon increases. The opposite is also true: to the right of Point X, the gap between the cumulative distribution functions of a life cycle fund and balanced fund model pair widens as one moves to higher accumulated retirement ending wealth values although it does start to diminish gradually. This implies that the balanced fund model is optimal to the right of Point X and the advantage becomes more significant as the investment horizon increases, hence the lower the area of SD violation relative to non-violation, all other factors held constant.
- The long glide path of Models 9 and 11 is an important factor in the inability of the life cycle fund models to dominate the balanced fund models. Although the longer glide path provides greater downside risk protection, due to the cumulative nature of the accumulated retirement ending wealth problem, the upside potential is, however, significantly limited. The results indicate that the longer the glide path, the lower the area of SD violation relative to non-violation, all other factors held constant.

5.4.1.2 SUMMARY

Table 5-5 shows a summary of the findings pertaining to Hypothesis 2A. The results indicate that for all sub-hypotheses, the life cycle funds fail to dominate the balanced funds with a similar starting asset allocation by FSD or ASD thereby failing to reject the null hypothesis.

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Table 5-5: Summary of findings – Hypothesis 2A

Hypothesis 2A

$H_0^{10,20,30,40\ years}$: There is no evidence that life cycle funds dominate balanced funds by almost stochastic dominance (ASD) or first-order stochastic dominance (FSD) when the funds have similar starting asset allocations.

$H_a^{10,20,30,40\ years}$: There is evidence that life cycle funds dominate balanced funds by almost stochastic dominance (ASD) or first-order stochastic dominance (FSD) when the funds have similar starting asset allocations.

Time horizon/ Model comparison	10 years	20 years	30 years	40 years
Model 9 against Model 5	N/A to 10 years	**Sub-hypothesis $2A_{9,5}^{20\ years}$** Fails to reject the null hypothesis	**Sub-hypothesis $2A_{9,5}^{30\ years}$** Fails to reject the null hypothesis	**Sub-hypothesis $2A_{9,5}^{40\ years}$** Fails to reject the null hypothesis
Model 10 against Model 5	**Sub-hypothesis $2A_{10,5}^{10\ years}$** Fails to reject the null hypothesis	**Sub-hypothesis $2A_{10,5}^{20\ years}$** Fails to reject the null hypothesis	**Sub-hypothesis $2A_{10,5}^{30\ years}$** Fails to reject the null hypothesis	**Sub-hypothesis $2A_{10,5}^{40\ years}$** Fails to reject the null hypothesis
Model 11 against Model 6	N/A to 10 years	**Sub-hypothesis $2A_{11,6}^{20\ years}$** Fails to reject the null hypothesis	**Sub-hypothesis $2A_{11,6}^{30\ years}$** Fails to reject the null hypothesis	**Sub-hypothesis $2A_{11,6}^{40\ years}$** Fails to reject the null hypothesis
Model 12 against Model 6	**Sub-hypothesis $2A_{12,6}^{10\ years}$** Fails to reject the null hypothesis	**Sub-hypothesis $2A_{12,6}^{20\ years}$** Fails to reject the null hypothesis	**Sub-hypothesis $2A_{12,6}^{30\ years}$** Fails to reject the null hypothesis	**Sub-hypothesis $2A_{12,6}^{40\ years}$** Fails to reject the null hypothesis

5.4.1.3 KEY FINDINGS

The results for Hypothesis 2A lead to the following key findings:

- A life cycle fund with a similar starting asset allocation to a balanced fund fails to dominate the balanced fund by FSD or ASD.
- The shorter the investment horizon, the more likely it is that a life cycle fund will dominate a balanced fund by FSD or ASD. However, in this study, the ε values to test for dominance of life cycle funds over balanced funds never meet the threshold requirement of being below 0.01 in any of the investment horizons.
- The longer the glide path, the lower the area of SD violation relative to non-violation. Hence the more likely that a life cycle fund will dominate a balanced fund by FSD or ASD. However, in this study, the ε values to test for dominance

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of life cycle funds over balanced funds never meet the threshold requirement of being below 0.01 irrelevant of the glide path. This was consistently so for all applicable investment horizons.

- The risk and return characteristics of the asset classes invested in play an important role in whether a life cycle fund is likely to dominate a balanced fund with similar starting asset allocation by FSD or ASD.
- Based on the results, it would seem that the length of the glide path, investment horizon as well as the extent of foreign equity exposure are determining factors for whether a particular life cycle fund will dominate a balanced fund with a similar starting asset allocation.
- In some instances, the contrary is evident, namely a balanced fund may dominate a life cycle fund by FSD or ASD.

The key findings pertaining to Hypothesis 2A will be reiterated and discussed after the results, analysis and key findings of Hypothesis 2B have been presented in the following section.

5.4.2 HYPOTHESIS 2B

The models applicable to Hypothesis 2B are as follows:

Model	Type of fund	Beginning asset allocation* (%)	Ending asset allocation* (%)	Glide path period (years)
5	Balanced high equity (no foreign exposure)	75/0/15/10	75/0/15/10	N/A
6	Balanced high equity (25% foreign equity exposure)	50/25/15/10	50/25/15/10	N/A
7	Balanced medium equity (25% foreign equity exposure)	35/25/30/10	35/25/30/10	N/A
8	Balanced low equity (25% foreign equity exposure)	15/25/50/10	15/25/50/10	N/A
9	Life cycle	75/0/15/10	0/0/0/100	Final 10 years
10	Life cycle	75/0/15/10	0/0/0/100	Final 5 years
11	Life cycle	50/25/15/10	0/0/0/100	Final 10 years
12	Life cycle	50/25/15/10	0/0/0/100	Final 5 years

*Local equity/foreign equity/local fixed income/local money market

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The hypothesis was articulated as follows:

$H_0^{10,20,30,40 \text{ years}}$: Life cycle funds do not dominate balanced funds by almost stochastic dominance (ASD) or first-order stochastic dominance (FSD) when the funds have different starting asset allocations.

$H_a^{10,20,30,40 \text{ years}}$: Life cycle funds dominate balanced funds by almost stochastic dominance (ASD) or first-order stochastic dominance (FSD) when the funds have different starting asset allocations.

Hypothesis 2B focused on life cycle funds and balanced funds which commence with dissimilar starting asset allocations. While the starting asset allocation remains constant in the balanced fund, the life cycle fund reduces the asset allocation with a linear glide path over the glide path period to be fully invested in the local money market asset class by the retirement date.

Importantly, balanced fund Models 6, 7 and 8 have different starting asset allocations with Model 6 the highest risk asset allocation strategy and Model 8 the lowest risk asset allocation strategy. Model 10 represents a life cycle fund that has a glide path of five years and start out with an asset allocation to the higher risk local equity asset class of 75 per cent versus Model 6 with a 50/25 per cent split between local and foreign equity.

5.4.2.1 RESULTS

Figure 5-3 presents the cumulative distribution functions for life cycle fund Model 10 compared with balanced fund Models 6, 7 and 8 for the 10-year investment horizon (it is repeated, along with the other cumulative distribution graphs for the 10-, 20-, 30- and 40-year investment horizons in Appendix H). Figure 5-3 will shortly be discussed in detail for illustrative purposes.

To illustrate, in Figure 5-3, the cumulative distribution function of Model 10 crosses over the cumulative distribution functions of all the balanced fund models except for Model 8 (this latter case is discussed shortly). In the figure, the cumulative distribution functions of Model 10 cross those of Models 6 and 7 at Points X and Y respectively,

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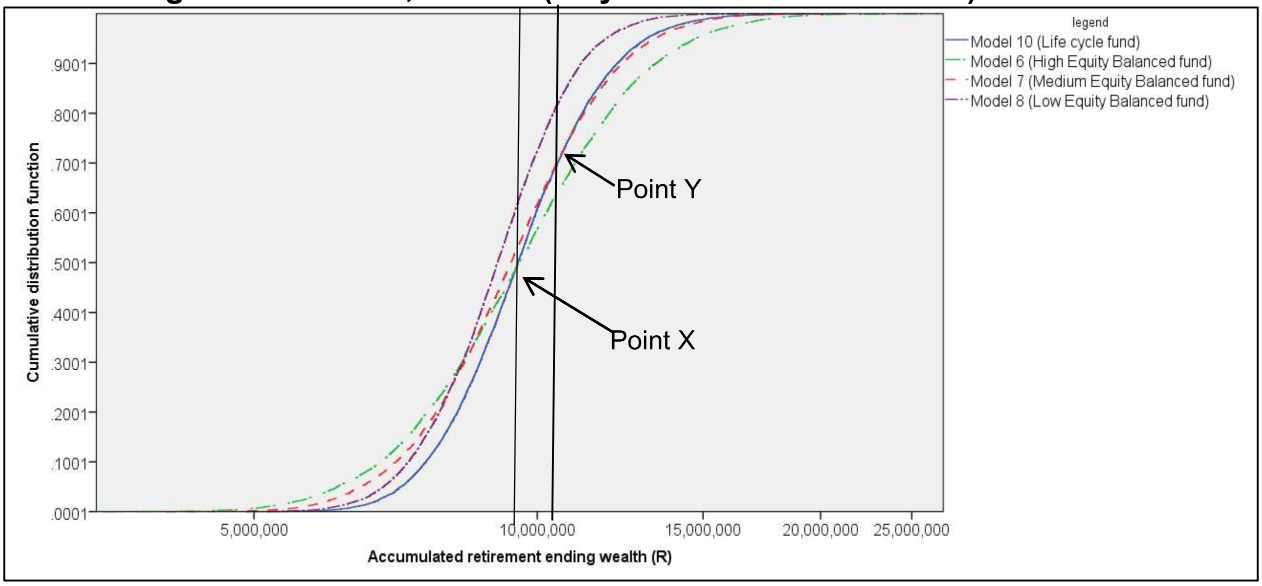
violating the strict FSD principle hence it will not be possible for Models 6, 7 and 10 to dominate each other by FSD. Points X and Y are at a cumulative probability and accumulated retirement ending wealth of 0.48 and R9.5 million and 0.73 and R10.7 million.

Figure 5-3: Cumulative distribution of accumulated retirement ending wealth for Model 10 against Models 6, 7 and 8 (10-year investment horizon)



Source: SPSS output

However, it is still possible for Model 10 to dominate Models 6 and 7, or for Models 6 and 7 to dominate Model 10 by ASD if the ε values were to be below the threshold value of 0.01. This is explored, firstly, before returning to the comparative results of Model 8 against Model 10.

The area to the left of Points X and Y enclosed by the cumulative distribution functions of Models 10 and 6 and Models 10 and 7 respectively, and indicate that to the left of these points, Model 10 is optimal. To the right of Points X and Y, the balanced fund models, namely Models 6 and 7, are optimal when compared with Model 10, because the balanced fund models have a greater accumulated retirement ending wealth for each cumulative probability value.

Returning to the observations regarding Model 10 against Model 8, the cumulative distribution function of Model 10 is consistently below or to the right of Model 8. In this instance, there is no violation of the strict FSD criteria and Model 10 dominates Model

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8 by FSD. These results indicate that Model 10 is appropriate for most individuals should they have to choose between Models 10 and 8.

Table 5-6: ASD results of life cycle funds against balanced funds – dissimilar starting asset allocation (10-, 20-, 30- and 40-year investment horizons)#

Model	Balanced fund model	Beginning asset allocation* (%)	Glide path period (years)	Area of SD violation relative to non-violation (ε)** Balanced fund model			
				Model 5 (75/0/15/10)	Model 6 (50/25/15/10)	Model 7 (35/25/30/10)	Model 8 (15/25/50/10)
9	Life cycle	75/0/15/10	Final 10 years		N/A to 10 years	N/A to 10 years	N/A to 10 years
					0.7142 (20 years)	0.0000†* (20 years)	0.0000†* (20 years)
					0.0000†* (30 years)	0.0000†* (30 years)	0.0002* (30 years)
					0.0000†* (40 years)	0.0000†* (40 years)	0.0001* (40 years)
10	Life cycle	75/0/15/10	Final 5 years		0.6544 (10 years)	0.1791 (10 years)	0.0000†* (10 years)
					0.0000†* (20 years)	0.0000†* (20 years)	0.0018* (20 years)
					0.0000†* (30 years)	0.0000†* (30 years)	0.0008* (30 years)
					0.0000†* (40 years)	0.0000†* (40 years)	0.0002* (40 years)
11	Life cycle	50/25/15/10	Final 10 years	N/A to 10 years		N/A to 10 years	N/A to 10 years
				137.3061*** (20 years)		17.4697 (20 years)	0.2392 (20 years)
				3 333.3333*** (30 years)		123.4568*** (30 years)	0.0346 (30 years)
				37 064.4922*** (40 years)		1.1936 (40 years)	0.0208 (40 years)
12	Life cycle	50/25/15/10	Final 5 years	23.4742 (10 years)		6.4309 (10 years)	2.8531 (10 years)
				384.6154*** (20 years)		56.8182 (20 years)	0.0682 (20 years)
				33 783.7838*** (30 years)		0.2103 (30 years)	0.0349 (30 years)
				99 009.9009*** (40 years)		0.0644 (40 years)	0.0191 (40 years)

* Local equity/foreign equity/local fixed income/local money market.
# Investment horizon shown in brackets.
†FSD
** Almost stochastic dominance exists for threshold value of $0 < \varepsilon < 0.01$.
*** The balanced fund model dominates the life cycle fund model by FSD if ε value shows "No value" or ASD in all other cases.

Table 5-6 shows the ε values to test for dominance of the life cycle funds over the balanced funds. The table also indicates the instances where balanced funds dominate life cycle funds by FSD or ASD with the symbol "***". A comparison of the cumulative distribution graphs for all investment horizons as well as the ε values shown in Table 5-6 leads to the following findings (Figures H 1 to H 12 in Appendix H):

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- Model 9

Model 9 successfully dominates all the balanced fund models which have a dissimilar starting asset allocation (Models 6, 7 and 8) by ASD except for Model 9 against Model 6 for the 20-year investment horizon. This indicates that, excluding the one exception mentioned, the lower risk and return characteristics of the balanced funds significantly change the cumulative distribution functions of the balanced funds to such an extent that the life cycle fund (Model 9) successfully dominates the balanced funds by ASD.

- Model 10

Model 10 successfully dominates all the balanced fund models which have a dissimilar starting asset allocation (Models 6, 7 and 8) except for Model 10 against Models 6 and 7 for the 10-year investment horizon. The ε values for Model 10 against Models 6 and 7 indicate that, except for the 10-year investment horizon, the ε values are below the threshold value of 0.01, in actual fact, there is no SD violation area, resulting in Model 10 dominating Models 6 and 7 by FSD. Additionally, Model 10 also dominates Model 8 by FSD for the 10-year investment horizon and by ASD for the 20-, 30- and 40-year investment horizon. This indicates that, excluding the two exceptions mentioned, the lower risk and return characteristics of the balanced funds significantly change the cumulative distribution functions of the balanced fund models to such an extent that the life cycle fund successfully dominates the balanced funds by ASD.

- Model 11

Model 11 does not dominate any of the balanced fund models by FSD or ASD for any of the investment horizons (Models 5, 7 and 8). The results indicate that, for the 30- and 40-year investment horizon, the ε values to test for dominance of Model 11 over Model 8 remain above the threshold value of 0.01. However, they are at least lower than the other ε values pertaining to Model 11. Rather, there are instances where the opposite is true, namely the balanced funds dominate the life cycle fund by FSD or ASD (Model 5 dominating Model 11 for the 20-, 30- and 40-year investment horizons and Model 6 dominating Model 11 for the 30-year investment horizon).

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- Model 12

As the ASD results indicate, Model 12 also fails to dominate any of the balanced funds by FSD or ASD. The only result that is close to the threshold value of 0.01 to test for dominance of Model 12 over Model 8, is for the 40-year investment horizon. In fact, balanced fund Model 5 dominates life cycle fund Model 12 for the 20-, 30- and 40-year investment horizons.

The key findings are as follows:

- Generally, the longer the investment horizon, the more likely a life cycle fund may dominate a balanced fund with a dissimilar asset allocation by FSD or ASD.
- The nature of the different starting asset allocations of a life cycle fund compared with a balanced fund is an important characteristic which influences whether a particular fund could dominate the other by FSD or ASD.
- The risk and return characteristics of the asset classes invested in play an important role in whether a particular fund is likely to dominate another.

5.4.2.2 SUMMARY

The results pertaining to the sub-hypotheses of Hypothesis 2B lead to the following findings as summarised and presented in Table 5-7 and Table 5-8:

- In most cases pertaining to the sub-hypotheses with reference to Models 9 and 10, the results lead to rejection of the null hypothesis.
- In all cases pertaining to the sub-hypotheses with reference to Models 11 and 12, the results lead to a failure to reject the null hypothesis.

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Table 5-7: Summary of findings – Hypothesis 2B, Models 9 and 10

Hypothesis 2B
$H_0^{10,20,30,40\ years}$: There is no evidence that life cycle funds dominate balanced funds by almost stochastic dominance (ASD) or first-order stochastic dominance (FSD) when the funds have different starting asset allocations.
$H_a^{10,20,30,40\ years}$: There is evidence that life cycle funds dominate balanced funds by almost stochastic dominance (ASD) or first-order stochastic dominance (FSD) when the funds have different starting asset allocations.

Time horizon/Model comparison	10 years	20 years	30 years	40 years
Model 9 against Model 6	N/A to 10 years	**Sub-hypothesis 2B** $_{9,6}^{20\ years}$ Fails to reject the null hypothesis	**Sub-hypothesis 2B** $_{9,6}^{30\ years}$ Rejects the null hypothesis	**Sub-hypothesis 2B** $_{9,6}^{40\ years}$ Rejects the null hypothesis
Model 9 against Model 7	N/A to 10 years	**Sub-hypothesis 2B** $_{9,7}^{20\ years}$ Rejects the null hypothesis	**Sub-hypothesis 2B** $_{9,7}^{30\ years}$ Rejects the null hypothesis	**Sub-hypothesis 2B** $_{9,7}^{40\ years}$ Rejects the null hypothesis
Model 9 against Model 8	N/A to 10 years	**Sub-hypothesis 2B** $_{9,8}^{20\ years}$ Rejects the null hypothesis	**Sub-hypothesis 2B** $_{9,8}^{30\ years}$ Rejects the null hypothesis	**Sub-hypothesis 2B** $_{9,8}^{40\ years}$ Rejects the null hypothesis
Model 10 against Model 6	**Sub-hypothesis 2B** $_{10,6}^{10\ years}$ Fails to reject the null hypothesis	**Sub-hypothesis 2B** $_{10,6}^{20\ years}$ Rejects the null hypothesis	**Sub-hypothesis 2B** $_{10,6}^{30\ years}$ Rejects the null hypothesis	**Sub-hypothesis 2B** $_{10,6}^{40\ years}$ Rejects the null hypothesis
Model 10 against Model 7	**Sub-hypothesis 2B** $_{10,7}^{10\ years}$ Fails to reject the null hypothesis	**Sub-hypothesis 2B** $_{10,7}^{20\ years}$ Rejects the null hypothesis	**Sub-hypothesis 2B** $_{10,7}^{30\ years}$ Rejects the null hypothesis	**Sub-hypothesis 2B** $_{10,7}^{40\ years}$ Rejects the null hypothesis
Model 10 against Model 8	**Sub-hypothesis 2B** $_{10,8}^{10\ years}$ Rejects the null hypothesis	**Sub-hypothesis 2B** $_{10,8}^{20\ years}$ Rejects the null hypothesis	**Sub-hypothesis 2B** $_{10,8}^{30\ years}$ Rejects the null hypothesis	**Sub-hypothesis 2B** $_{10,8}^{40\ years}$ Rejects the null hypothesis

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Table 5-8: Summary of findings – Hypothesis 2B, Models 11 and 12

Hypothesis 2B
$H_0^{10,20,30,40\ years}$: There is no evidence that life cycle funds dominate balanced funds by almost stochastic dominance (ASD) or first-order stochastic dominance (FSD) when the funds have different starting asset allocations.
$H_a^{10,20,30,40\ years}$: There is evidence that life cycle funds dominate balanced funds by almost stochastic dominance (ASD) or first-order stochastic dominance (FSD) when the funds have different starting asset allocations.

Time horizon/Model comparison	10 years	20 years	30 years	40 years
Model 11 versus Model 5	N/A to 10 years	**Sub-hypothesis 2B $_{11, 5}^{20\ years}$** Fails to reject the null hypothesis	**Sub-hypothesis 2B $_{11, 5}^{30\ years}$** Fails to reject the null hypothesis	**Sub-hypothesis 2B $_{11, 5}^{40\ years}$** Fails to reject the null hypothesis
Model 11 against Model 7	N/A to 10 years	**Sub-hypothesis 2B $_{11, 7}^{20\ years}$** Fails to reject the null hypothesis	**Sub-hypothesis 2B $_{11, 7}^{30\ years}$** Fails to reject the null hypothesis	**Sub-hypothesis 2B $_{11, 7}^{40\ years}$** Fails to reject the null hypothesis
Model 11 against Model 8	N/A to 10 years	**Sub-hypothesis 2B $_{11, 8}^{20\ years}$** Fails to reject the null hypothesis	**Sub-hypothesis 2B $_{11, 8}^{30\ years}$** Fails to reject the null hypothesis	**Sub-hyp4thesis 2B $_{11, 8}^{20\ years}$** Fails to reject the null hypothesis
Model 12 against Model 5	**Sub-hypothesis 2B $_{12, 5}^{10\ years}$** Fails to reject the null hypothesis	**Sub-hypothesis 2B $_{12, 5}^{20\ years}$** Fails to reject the null hypothesis	**Sub-hypothesis 2B $_{12, 5}^{30\ years}$** Fails to reject the null hypothesis	**Sub-hypothesis 2B $_{12, 5}^{40\ years}$** Fails to reject the null hypothesis
Model 12 against Model 7	**Sub-hypothesis 2B $_{12, 7}^{10\ years}$** Fails to reject the null hypothesis	**Sub-hypothesis 2B $_{12, 7}^{20\ years}$** Fails to reject the null hypothesis	**Sub-hypothesis 2B $_{12, 7}^{30\ years}$** Fails to reject the null hypothesis	**Sub-hypothesis 2B $_{12, 7}^{40\ years}$** Fails to reject the null hypothesis
Model 12 against Model 8	**Sub-hypothesis 2B $_{12, 8}^{10\ years}$** Fails to reject the null hypothesis	**Sub-hypothesis 2B $_{12, 8}^{20\ years}$** Fails to reject the null hypothesis	**Sub-hypothesis 2B $_{12, 8}^{30\ years}$** Fails to reject the null hypothesis	**Sub-hypothesis 2B $_{12, 8}^{40\ years}$** Fails to reject the null hypothesis

5.4.2.3 KEY FINDINGS

The key findings are as follows:

- In most cases pertaining to the sub-hypotheses of Models 9 and 10, the results lead to rejecting the null hypothesis, while, in the case of Models 11 and 12, the life cycle funds with foreign equity exposure, the results lead to a failure to reject the null hypothesis.
- The investment horizon has an impact on the likelihood of a life cycle fund dominating a balanced fund. However, there is no consistent pattern evident whether there is a positive relationship between the investment horizon and likelihood of a life cycle fund dominating a balanced fund.

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- Generally, the shorter the glide path of the life cycle fund, the lower the area of SD violation relative to non-violation for the comparison of the life cycle fund with the balanced fund. However, the difference in the starting asset allocations of the funds plays a role.
- The risk and return characteristics of the asset classes invested in play an important role in whether a particular fund is likely to dominate another.
- The nature of the different starting asset allocations of a comparison of a life cycle fund with a balanced fund is an important characteristic which influences whether a particular fund could dominate the other by FSD or ASD.
- In some instances, the balanced funds dominate the life cycle funds by ASD.

The following section brings together the key findings from Hypotheses 2A and 2B.

5.5 DISCUSSION

The findings of the study concur that life cycle funds with a similar starting asset allocation to a comparable balanced fund do not perform as well as the balanced funds based on the accumulated retirement ending wealth achieved (Estrada, 2013; Lewis, 2008b, 2008c; Shiller, 2006; Spitzer & Singh, 2011). Similar generalisations cannot be drawn from the Basu *et al.* (2011) study because the researchers did not construct balanced funds and life cycle funds with similar starting asset allocations.

As mentioned before, ASD and FSD studies in the literature that focus on the accumulated retirement ending wealth question are limited except for that of Basu *et al.* (2011). Academic literature regarding the question of South African data is also not found in the current body of knowledge. Hence Basu *et al.* (2011) present the most comparable research to relate the findings of this study despite its shortcomings.

5.5.1 ASD AND SOUTH AFRICAN HISTORICAL DATA

The intention of life cycle funds, by its nature, is to provide protection from capital losses close to the retirement date of an individual (Gains & Naismith, 2012). A life cycle fund therefore exposes the individual to less risk as retirement approaches when the allocation to higher risk asset classes is reduced in favour of lower risk asset

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classes. However, the natural consequence is that it also amplifies the impact of the lower return characteristics of lower risk asset classes.

The mean accumulated retirement ending wealth of a life cycle fund with a similar starting asset allocation to a balanced fund is lower and this is well documented as discussed in the literature review (see Basu *et al.*, 2011; Estrada, 2013; Lewis, 2008b, 2008c; Shiller, 2006; Spitzer & Singh, 2011). However, Branch and Qiu (2011) highlight that this is conditional: it depends on the similarity of the starting asset allocation of the balanced fund against the life cycle fund, how long the glide path of the life cycle fund is as well as how aggressive the shift from higher risk and return asset classes to lower risk and return asset classes is during the glide path period.

A drawback of evaluating different asset allocation strategies or funds based on the mean accumulated retirement ending wealth is that it remains a one-dimensional metric. Similarly, measures such as Sharpe and Treynor that capture risk, do not capture the positive skewness (or right skewness) generally present in financial data or the Monte Carlo simulation results used in this study.

Another drawback in the current body of knowledge is the bias of primarily using US data (Basu *et al.*, 2011; Estrada, 2013; Lewis, 2008b, 2008c; Shiller, 2006; Spitzer & Singh, 2011). In the literature review, the research of Dimson *et al.* (2011) shows that South African markets are much more volatile than other developed markets such as that of the US. An analysis of the historical data used in this study and presented in the research method chapter, reiterated that this is the case. Although this intuitively and correctly leads to the conclusion that a 100 per cent US equity fund will be less volatile than a 100 per cent South African equity fund, there is no body of knowledge in the literature that gives any indication how this phenomenon affects a comparison of balanced funds and life cycle funds in a South African context.

Additionally, the application of ASD and FSD principles by Basu *et al.* (2011) to compare different retirement asset allocation strategies, which was employed in this study, was a new application in the context of the accumulated retirement wealth question. As discussed in the research method chapter, applying the ASD and FSD

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criteria to an accumulated retirement ending wealth scenario where Monte Carlo simulations lead to a number of possible outcomes, not only captures the range of possible outcomes but also the risk propensities as is evident from the cumulative distribution function.

5.5.1.1 FINDING 1: DOMINANCE OF LIFE CYCLE FUNDS OVER BALANCED FUNDS, SIMILAR STARTING ASSET ALLOCATION

Irrespective of the time horizon and glide path, the life cycle funds fail to dominate their balanced fund counterparts, which indicate that for each sub-hypothesis, the life cycle fund is not appropriate for most individuals. For all sub-hypotheses, the cumulative distribution functions of the life cycle funds are, for the most part, above or to the left of the balanced funds and the ε values fail to be below the threshold value of 0.01. Even a more liberal threshold value of 0.059 as alluded to by Basu *et al.* (2011) would make no difference to the findings. Although not relevant to the hypotheses, there are some instances where the opposite is true, namely the balanced funds dominate the life cycle funds by FSD or ASD (in this study, it is predominantly the case for longer investment horizons of 30 and 40 years).

Although the research of Basu *et al.* (2011) did not consider paired comparison between balanced and life cycle fund models with similar starting asset allocations, it noted that life cycle funds were unlikely to dominate funds with higher and more persistent equity allocations based on the dominance decision-making criteria. However, and importantly so, this does not consider the unique characteristics that people may have such as a particular retirement target which may change the individual preference of one fund over the other.

However, in such instances, the decision-making criteria would not be based on ASD but rather on the likelihood of achieving a particular retirement target. In such instances, the individual would not be concerned with the entire cumulative distribution function but only with the cumulative distribution function below the retirement target which could change which model or fund would be appropriate for the individual. When

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comparing life cycle funds with balanced funds that have similar starting asset allocations, it is likely that due to the lower risk characteristics of life cycle funds, the life cycle fund could be appropriate for an individual if they have a very low retirement target. However, if the retirement target becomes quite high and meeting the target is more important than the overall risk of the fund chosen, a balanced fund could be chosen. Importantly however, is the fact that reaching the retirement target, becomes the primary driving force. The research of Schleef and Eisinger (2007) as well as that of Basu *et al.* (2011) dealt with the retirement target of an individual and how this unique need of an individual could influence what the individual would deem to be the most appropriate fund in his or her particular circumstances.

However, the almost stochastic dominance decision-making criteria, which considers the total cumulative distribution function and not a retirement target, is conclusive that when comparing balanced funds and life cycle funds with a similar starting asset allocation, the life cycle funds fail to dominate the balanced funds and an individual would therefore be indifferent between investing in a life cycle or balanced fund. It is important to acknowledge that the risk and return characteristics of the asset classes invested in play an important role in whether a balanced fund or life cycle fund is likely to dominate the other. In this study, the impact of including some exposure to the lower risk and return foreign equity asset class instead of a greater allocation to local equities (which have a higher risk and return than foreign equities) influenced the results. Hence the results are very sensitive not only to the asset classes invested in but also to the historical data used, what the assumed local asset classes are and the risk and return characteristics of the asset classes used in the study.

5.5.1.2 FINDING 2: IMPACT OF INVESTMENT HORIZON

In the case of life cycle funds compared with balanced funds with similar starting asset allocations, the shorter the investment horizon, the lower the ε values to test for dominance. However, the ε values are still higher than the threshold value of 0.01, which makes dominance by a life cycle fund model over a balanced fund model very unlikely. On the contrary, there are a few instances where the balanced fund models dominate the life cycle fund models by ASD. This can be attributed to the fact that the cumulative effect of the higher returns of equity asset classes in the balanced funds

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over the shorter investment horizons is not sufficient to provide a great enough benefit against the lower risk characteristics of the life cycle funds that offer downside protection but not the benefit. The balanced funds' more persistent allocation to equity becomes an advantage for the longer investment horizons.

With regard to life cycle funds and balanced funds with dissimilar starting asset allocations, the results are inconsistent and dominance depends, among others, on how the starting asset allocations of the two funds compared are different.

Of the studies consulted in the literature review, the majority focused on only one investment horizon, which was generally 40 years or more (Basu *et al.*, 2011; Estrada, 2013; Lewis, 2008b, 2008c; Pfau, 2010; Shiller, 2006). In contrast, Schleef and Eisinger (2007) as well as Lewis (2008b, 2008c) modelled their portfolios over 30 and 35 years respectively but did not apply the ASD decision-making criteria in their analysis. This study provides sound statistical findings on the impact of the investment horizon on accumulated retirement ending wealth and the choice of two funds.

5.5.1.3 FINDING 3: IMPACT OF GLIDE PATH

A glide path for a life cycle fund seems to play a significant role in the inability of life cycle funds to dominate the balanced funds when they have similar starting asset allocations. The longer the glide path, the greater the downside risk protection provided by a life cycle fund. However, due to the cumulative nature of the accumulated retirement ending wealth problem, the upside potential is significantly capped, which has a noticeable impact, especially for the longer investment horizons.

Additionally, in their research, Basu *et al.* (2011) constructed two life cycle funds, one with a 10-year glide path and the other with a 20-year glide path (in both instances, the funds had a 40-year investment horizon). Both strategies commence with a 100 per cent equity allocation, which was linearly shifted to bonds during the applicable glide path period. The comparative balanced fund to test for ASD was a balanced fund, which allocated 60 per cent to equities, 30 per cent to bonds and 10 per cent to cash. Although different from the comparative analysis pertaining to Hypothesis 2A in this study (i.e. balanced fund and life cycle fund with similar starting asset allocation), the

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findings provide informational value regarding the impact of the length of the glide path.

The results in Basu *et al.* (2011) show that the shorter the glide path, the lower the area of SD violation relative to non-violation. In this study, the findings pertaining to life cycle and balanced funds with similar asset allocations indicate that the longer the glide path, the lower the area of SD violation relative to non-violation. Hence the more likely that a life cycle fund will dominate a balanced fund by FSD or ASD.

5.5.1.4 FINDING 4: IMPACT OF ASSET CLASS CHARACTERISTICS

- The risk and return characteristics of the asset classes invested in play an important role in whether a balanced fund or life cycle fund is likely to dominate the other. While the balanced fund represented by Model 6, which has a foreign equity allocation, could not dominate the life cycle fund models with a similar starting asset allocation by FSD or ASD, this was not the case for the life cycle versus balanced pairs that had no allocation to foreign equity and also similar starting asset allocations. The impact of the asset class characteristics was even more obvious with regard to the findings pertaining to Hypothesis 2B where the extent of foreign equity exposure in the models had a significant impact on whether a life cycle fund could dominate the other by FSD or ASD. It is acknowledged that the results are very sensitive not only to the asset classes invested in but also to the historical data used, what the assumed local asset classes are and the risk and return characteristics of the asset classes used in the study.

None of the current works of literature demonstrate this finding as strongly as this particular study. While studies indicate that a more persistent and greater allocation to higher return and risk asset classes leads to a higher accumulated retirement ending wealth (Basu *et al.*, 2011; Basu & Drew, 2009; Estrada, 2013; Lewis, 2008a, 2008b, 2008c; Spitzer & Singh, 2008, 2011), only Basu *et al.* (2011) apply the stochastic dominance method. Furthermore, the South African equity asset class is much more

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volatile than that of the US as was shown in Dimson *et al.* (2011) and the historical data used in this study.

This finding also indicate that stochastic dominance results for comparative studies regarding life cycle funds as opposed to balanced funds are most likely to yield very different results depending on the historical data used, what the assumed local asset classes are and the risk and return characteristics of those asset classes.

5.5.1.5 FINDING 5: DOMINANCE OF LIFE CYCLE FUNDS OVER BALANCED FUNDS, DISSIMILAR STARTING ASSET ALLOCATIONS

The findings indicate that a generalisation regarding dominance of balanced funds and life cycle funds with dissimilar asset allocation strategies is not possible. In this study, however, life cycle fund Models 9 and 10, which have no foreign equity exposure, dominate by ASD or FSD in a large number of instances, while life cycle fund Models 11 and 12, which have some foreign equity exposure, in all instances fail to dominate the balanced funds.

However, the findings seem to indicate that the results are very sensitive to the following characteristics of the models:

- **Starting asset allocation:** All other factors held constant, the greater the exposure of a life cycle fund to the higher risk and return equity asset classes compared with the balanced fund, the more likely the life cycle fund could dominate by FSD or ASD.
- **The length of the glide path (life cycle fund):** Generalisations with regard to the impact of the glide path are not meaningful as the results are mixed. One observation is that the impact on dominance by ASD or FSD may be a combined interaction between the glide path and investment horizon.
- **The investment horizon:** The results are mixed, which do not make generalisations meaningful. However, it seems that there is an interaction between the starting asset allocations of the balanced and life cycle funds, ending asset allocation of the life cycle fund, glide path and investment horizon.

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- **Risk and return characteristics of asset classes:** The risk and return characteristics of the asset classes invested in play an important role in whether a balanced fund or life cycle fund is likely to dominate the other. In this study, the impact of including some exposure to the lower risk and return foreign equity asset class instead of a greater allocation to local equities (which have a higher risk and return than foreign equities) influenced the results. Hence the results are very sensitive not only to the asset classes invested in but also to the historical data used, what the assumed local asset classes are and the risk and return characteristics of the asset classes used in the study.

5.6 CONCLUSION

In this chapter, the findings regarding Research Question 2 were presented and discussed.

Regarding Hypothesis 2A, which questioned whether life cycle funds dominated balanced funds with similar starting asset allocations by FSD or ASD, the findings led to a failure to reject the null hypothesis; the results indicated that life cycle funds did not dominate balanced funds by FSD or ASD when the funds had similar starting asset allocations.

The findings pertaining to Hypothesis 2B, which compared life cycle funds and balanced funds with dissimilar starting asset allocations, indicated that, in the case of the life cycle fund models with no foreign equity allocation (Models 9 and 10), the null hypothesis was rejected for most sub-hypotheses because the life cycle funds dominated the balanced funds by FSD or ASD. In the case of the life cycle fund models with foreign equity exposure (Models 11 and 12), the null hypothesis was not rejected for any of the sub-hypotheses because the life cycle funds did not dominate the balanced funds by FSD or ASD.

The findings led to a number of important key findings: life cycle funds with similar starting asset allocations to balanced funds did not dominate the latter by FSD or ASD, with the investment horizon, glide path followed and characteristics of the asset

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classes used in the analysis having an important impact on whether a life cycle fund could dominate a balanced fund.

Regarding balanced funds and life cycle funds with different starting asset allocations, the results reiterated the fact that dominance of the life cycle funds of balanced funds depended on the starting asset allocations, extent to which the starting asset allocation of the life cycle fund and balanced fund differed, the length of the glide path (in the case of life cycle funds), the investment horizon and the risk and return characteristics of the asset classes used in the analysis.

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CHAPTER 6:
CONCLUSION

6.1 INTRODUCTION

Chapters 4 and 5 detailed the hypotheses, models and asset allocation strategies pertaining to Research Question 1: *Is a fund fully invested in equities optimal compared with a high equity balanced retirement fund with maximum equity allocation of 75 per cent?* and Research Question 2: *Are life cycle funds optimal compared with balanced funds?* The descriptive statistics for the models followed, after which the empirical results, findings and discussion of the hypotheses were presented.

This chapter presents a summary of the thesis as well as the main findings. The chapter concludes with a summary of the contributions of the study and highlights areas for future research.

6.2 SUMMARY OF KEY FINDINGS

6.2.1 LITERATURE REVIEW

The aim of the study was to determine the impact of tax legislation, Regulation 28 of the Pension Funds Act (24/1956) and asset allocation choices on accumulated retirement ending wealth and what would be deemed appropriate for most individuals considering different time horizons.

The objectives were as follows:

- to determine whether the tax relief offered to retirement funds outweigh the benefit of a higher allocation to high-risk asset classes in direct investments; and
- to determine the effectiveness of life cycle asset allocation strategies.

The key findings in the literature review showed that local equities were the highest risk and return asset class, followed by the local fixed income and money market asset

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classes. Local equities also exhibited higher returns (at a greater risk) compared with the foreign equity asset class.

The literature review paid particular attention to balanced funds and life cycle funds, two popular retirement savings options, and highlighted the fact that while balanced funds maintained a static asset allocation, traditional life cycle funds reduced the asset allocation to risky assets as retirement approached with the intent to protect capital. The literature supported the fact that, although life cycle funds were successful to limit downside risk, the mean accumulated retirement ending wealth derived from a life cycle fund was lower than that of a comparable balanced fund and might not be appropriate for some individuals. As expected, the higher and more persistent the asset allocation to equities, the greater the mean accumulated retirement ending wealth. However, comparing different asset allocation strategies on a risk-adjusted basis was limited.

Hence the study by Basu *et al.* (2011), which applied the decision-making criteria of stochastic dominance, was deemed valuable. In the study, the researchers determined whether one fund dominated another by first-order stochastic dominance (FSD) or almost stochastic dominance (ASD). The study considered balanced funds, traditional life cycle funds and dynamic life cycle funds. Although the research did not consider a comparative analysis of traditional life cycle funds against balanced funds, the findings indicated that the dynamic life cycle funds were optimal to traditional balanced funds.

The literature review further contrasted direct investments with retirement funds in terms of the regulatory framework of South Africa. Retirement funds in South Africa have certain tax advantages such as tax deductible contributions and all returns earned within a retirement fund being tax exempt. However, the pension fund legislation prescribes limits to the asset allocation of which the maximum of 75 per cent allowed to equities is of particular interest in this study (before 1 July 2011 one could invest 100 per cent of assets in equities). In contrast, direct investment funds have no limits on the asset allocation of any particular asset class but do not offer the same tax benefits as retirement funds. An analysis of the changes to the maximum

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equity limit within retirement funds as well as a comparative analysis of retirement funds and direct investments would be meaningful.

The decision-making criteria used in the study to assess each research question and subsequent hypothesis were first-order and almost stochastic dominance. First-order stochastic dominance state that if the cumulative probability function of a fund (Fund A) is always below or to the right of another (Fund B), Fund A dominates Fund B by FSD. Almost stochastic dominance relaxes the strict assumption of first-order stochastic dominance that the cumulative probability function of one fund should always be below or to the right of the other. Where the cumulative probability functions of two funds cross, a conservative rule was applied that if ε, the area of violation, was between 0 and 0.01, one could accept dominance by ASD.

6.2.2 RESEARCH QUESTION 1

Research Question 1 was articulated as follows:

Is a fund fully invested in equities optimal compared with a high equity balanced retirement fund with maximum equity allocation of 75 per cent?

The research question considered hypotheses which dealt with:

- a direct investment fund fully invested in equities against a high equity balanced retirement fund; and
- a theoretical retirement fund fully invested in equities against a high equity balanced retirement fund.

6.2.2.1 Direct investment funds against high equity balanced retirement funds

The findings showed that direct investment funds fully invested in equities did not dominate a high equity balanced retirement fund which was Regulation 28 compliant.

The findings did not support that the impact of the additional 25 per cent allocation to the higher risk and return equity asset class, which was possible with a direct investment, outweighed the tax benefits associated with retirement funds to such an

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extent that direct investment funds dominated retirement funds by FSD or ASD (this held true irrespective of the investment horizon and tax bracket of the individual).

Despite the regulatory limits on the equity allocation within a retirement fund, the associated tax benefits, in particular the tax deductibility of the contributions, are valuable attributes which seem to outweigh the no asset class limit feature of the direct investment fund models.

The longer the investment horizon, the more likely that a direct investment may dominate a retirement fund by FSD or ASD. However, in all cases, the test for dominance remained higher than the threshold value of 0.01, which makes it unlikely, during a typical pre-retirement phase, that direct investments will dominate a high equity balanced retirement fund model by FSD or ASD.

6.2.2.2 Theoretical 100 per cent equity retirement funds against high equity balanced retirement funds

The results did not offer conclusive support that a theoretical retirement fund fully invested in equities was optimal (measured by ASD and FSD) as opposed to a high equity balanced retirement fund.

It was postulated that Regulation 28 of the Pension Funds Act, although intended to provide downside protection of retirement wealth, reduced the accumulated retirement ending wealth that could be achieved through a theoretical retirement fund fully invested in equities and that the downside protection was not sufficient to give up the upside potential of a 100 per cent allocation to equities.

The intent of Regulation 28 is to "…ensure that the savings South Africans contribute towards their retirement is invested in a prudent manner that … protects the retirement fund member…." (National Treasury of South Africa, 2011b:1). The majority of the results of the study did not provide convincing evidence that the previous Regulation 28, which allowed a 100 per cent allocation to equities, was superior to the current Regulation 28 guidance because the theoretical retirement fund fully invested in

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equities mostly failed to dominate the high equity balanced retirement fund. This was the case regardless of the investment horizon modelled.

However, the findings supported the fact that the longer the investment horizon, the greater the likelihood that a theoretical retirement fund fully invested in equities could dominate the high equity balanced retirement fund. In this study, although the area of SD violation to non-violation decreased as the investment horizon became longer, the majority of results still met the strict ASD criteria.

- Cases that did not meet the strict ASD criteria:
  - Theoretical retirement fund fully invested in local equities as opposed to Regulation 28 high equity balanced fund with only local equity exposure;
  - Theoretical retirement fund fully invested in equities as opposed to Regulation 28 high equity balanced fund, both funds with a 25 per cent foreign equity exposure.

- Cases that met the strict ASD criteria for the 20-, 30- and 40-year investment horizon:
  - Theoretical retirement fund fully invested in local equities as opposed to Regulation 28 high equity balanced fund with a 25 per cent foreign equity exposure.

The risk and return characteristics of the local and foreign equity asset classes invested in played an important role in whether the retirement fund fully invested in equities was likely to dominate the high equity balanced fund with only a 75 per cent allocation to equities. This finding was evident in the comparison of the results of the three hypotheses related to a theoretical retirement fund. In the majority of cases, the retirement fund fully invested in equities failed to dominate the Regulation 28-compliant balanced fund by ASD or FSD except where the theoretical retirement fund had no foreign equities and the Regulation 28 high equity balanced fund had a 25 per cent allocation to foreign equities. The latter comparative analysis led to the theoretical retirement fund fully invested in equities dominating the Regulation 28 high equity retirement fund by ASD for the 20-, 30- and 40-year investment horizon. Therefore, it

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is important not to generalise too much regarding theoretical retirement funds fully invested in equities as opposed to Regulation 28 high equity balanced funds without taking cognisance of the impact of the comparative asset allocation.

If the theoretical 100 per cent retirement did not dominate the Regulation 28 high equity balanced fund, such a finding did not imply that the opposite was true, namely that the Regulation 28 high equity balanced fund was optimal for *most* individuals (based on the ASD criteria). To test such a hypothesis required testing for FSD or ASD of the Regulation 28 high equity balanced fund against the theoretical retirement fund fully invested in equities and whether the ε values meet the strict FSD and ASD criteria. However, the results provide no support for the notion that high equity balanced retirement funds dominate the theoretical 100 per cent equity retirement funds.

6.2.3 RESEARCH QUESTION 2

Research Question 2 was articulated as follows:

Are life cycle funds optimal for most investors when compared with balanced funds?

The research question considered hypotheses that dealt with the following:

- Life cycle funds against balanced funds with similar starting asset allocations; and
- Life cycle funds against balanced funds with dissimilar starting asset allocations.

The intention of life cycle funds, by its nature, is to provide protection from capital losses close to the retirement date of an individual. Therefore, a life cycle fund reduces the asset allocation to higher risk asset classes in favour of lower risk asset classes as retirement approaches. However, the natural consequence is that it also amplifies the impact of the lower return characteristics of lower risk asset classes.

Irrespective of the time horizon and glide path, the life cycle funds failed to dominate their balanced fund counterparts with a similar starting asset allocation, which indicated that for each sub-hypothesis, the life cycle fund was not appropriate for most

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individuals. Although not relevant to the hypotheses, there were some instances where the opposite was true, namely that the balanced funds dominated the life cycle funds by FSD or ASD (in this study, it was predominantly the case for longer investment horizons of 30 and 40 years. However, given the interaction between starting and ending asset allocation and the length of the glide path of life cycle funds, one should caution against generalisations).

In the case of life cycle funds as opposed to balanced funds with similar starting asset allocations, the shorter the investment horizon, the lower the ε values to test for dominance and the more likely that a life cycle fund will dominate a balanced fund. However, in all cases, it was much higher than the threshold value, which made dominance by a life cycle fund model over a balanced fund model very unlikely. Furthermore, the longer the glide path, the lower the area of SD violation relative to non-violation. Hence the more likely that a life cycle fund will dominate a balanced fund by FSD or ASD.

With regard to life cycle funds and balanced funds with dissimilar starting asset allocations, the results were inconsistent and dominance depended, among others, on how the starting asset allocations of the two funds compared were different. However, generally, life cycle fund Models 9 and 10, which had no foreign equity exposure, dominated by ASD or FSD in a large number of instances while life cycle fund Models 11 and 12, which had some foreign equity exposure, in all instances failed to dominate the balanced funds.

The findings indicated that a generalisation regarding dominance of balanced funds and life cycle funds with dissimilar asset allocation strategies was not possible. However, the findings seemed to indicate that the results were very sensitive to the following characteristics of the models:

- **Starting asset allocation:** All other factors held constant, the greater the exposure of a life cycle fund to the higher risk and return equity asset classes as opposed to the balanced fund, the more likely the life cycle fund could dominate by FSD or ASD.

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- **The length of the glide path (life cycle fund):** Generalisations with regard to the impact of the glide path were not meaningful as the results were mixed. One observation was that the impact on dominance by ASD or FSD might be a combined interaction between the glide path and investment horizon.
- **The investment horizon:** The results were mixed, which did not make generalisations meaningful. However, it seemed that there was an interaction between the starting asset allocations of the balanced and life cycle funds, ending asset allocation of the life cycle fund, glide path and investment horizon.
- **Risk and return characteristics of asset classes:** The risk and return characteristics of the asset classes invested in play an important role in whether a balanced fund or life cycle fund is likely to dominate the other. In this study, the impact of including some exposure to the lower risk and return foreign equity asset class instead of a greater allocation to local equities (having a higher risk and return than foreign equities) influenced the results. Hence the results were very sensitive not only to the asset classes invested in but also to the historical data used, what the assumed local asset classes were and the risk and return characteristics of the asset classes used in the study.

6.3 CONCLUSIONS

The aim of the study was to determine the impact of tax legislation, Regulation 28 of the Pension Funds Act (24/1956) and asset allocation choices on accumulated retirement ending wealth and what would be deemed appropriate for most individuals considering different time horizons.

Regarding Research Question 1, the study failed to find support for the hypothesis that direct investment funds dominated high equity balanced retirement funds that complied with Regulation 28. Despite the higher asset allocation to equities that was possible with direct investments, this benefit was outweighed by the tax savings attributable to retirement funds. Additionally, the results of the study refuted the notion that a direct investment fund could be optimal over a longer investment horizon (in the case of this study, the longest investment horizon considered was 40 years).

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The findings did not contain sufficient evidence that an individual should, to circumvent the Regulation 28 asset allocation limit, save for retirement by means of a direct investment where an equity allocation greater than 75 per cent was possible. The findings were also conclusive that it did not matter in which tax bracket an individual was as this made no difference to the findings. On the other hand, the findings did not provide conclusive evidence that the opposite was true, namely that a high equity balanced retirement fund was optimal to a direct investment. Importantly, the area of SD violation to non-violation was much less in this instance than for the hypothesis that was tested.

The study only found limited support for the hypothesis that a theoretical retirement fund with a 100 per cent allocation to equities dominated a high equity balanced retirement fund that complied with Regulation 28 (particularly in the case of a 100 per cent local equity retirement fund compared with a Regulation 28 high equity balanced fund with no foreign equity exposure). Because the South African equity asset class was very volatile (annualised standard deviation of 19.8 per cent against 17.4 per cent for local against foreign equity in the data used in the study), a high exposure could lead to very low accumulated retirement ending wealth values and the intent of Regulation 28 was to protect the retirement savings of individuals against such adversity. Despite being perceived as very restrictive on the individual and unpopular with some individuals and industry participants, the findings did not conclude that Regulation 28 restrictions on asset classes were inappropriate.

Regarding Research Question 2, the study found no support for a life cycle fund dominating a balanced fund with similar starting asset allocation. This raised the question whether life cycle funds, which are often included as default options for members of retirement funds, did have a place. Hence they were likely not the optimal choice for most individuals compared with a balanced fund counterpart with similar starting asset allocation. However, they could be attuned to the preferences of the individual (such as individual risk aversion and personal preferences) rather than a rational objective assessment of one fund against another.

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The study found mixed support for a life cycle fund dominating a balanced fund with dissimilar starting asset allocations. This indicated that whether there was a place for a life cycle fund in any retirement fund default options or whether it was optimal compared with an alternative balanced fund strongly depended on the underlying asset allocations of the funds while the length of the glide path, the investment horizon as well as the risk and return characteristics of the investable universe could also contribute.

6.4 SUMMARY OF CONTRIBUTIONS

Saving for retirement is a South African and global challenge; however, research in South Africa on the impact of retirement regulation and asset class decisions is limited. In addition, a research contribution that focuses on how to protect retirement funds while facilitating sufficient accumulated retirement ending wealth is valued by the industry and individuals alike. The results of this study have widespread implications for individuals, policy-makers, financial advisors as well as pension and retirement fund trustees, investment committees and sponsors. The study provides a valuable contribution to the literature regarding asset allocation and retirement fund choices by extending the current body of knowledge, which is predominantly US-centric, to a developing market such as South Africa.

From a South African perspective, this appears to be the first study of its nature that applied the stochastic dominance decision-making criteria, taking cognisance of the inherent risk and return of choices to evaluate different retirement options to a savings problem.

The study refuted the notion that a direct investment fund was a better choice than a retirement fund, should one have a long investment horizon. The study also provided a more insightful view to the life cycle fund question by applying an alternative statistical technique to evaluate this particular asset allocation strategy.

Additionally, the study considered whether particularly Regulation 28 applicable to retirement funds was debilitating to retirement savings and whether the regulator failed to create legislation that was appropriate for the majority of the population. The

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findings (based on a strict criteria of ε values lower than 0.01) did not provide adequate evidence that the alternatives to a Regulation 28-compliant high equity retirement fund, namely a direct investment or theoretical retirement fund fully invested in equities, were optimal and therefore did not provide sufficient evidence that Regulation 28 of the Pension Funds Act failed to serve the purpose of protecting retirement savings. The findings provided insufficient evidence that reducing the allowable allocation to equities to only 75 per cent given the higher risk nature of South African equity markets compared with US equity or other developed markets, for that matter, was improper. Also, the regulator provided decent tax incentives to motivate retirement savings by means of Regulation 28-complaint retirement funds rather than direct investments. Additionally, the study provided clear guidance and confirmation that the investment horizon was a determining factor when evaluating what would be an optimal retirement savings choice because the ε values to test for stochastic dominance did not stay constant with changes in the investment horizon.

The study took this further by exhibiting how the risk-reducing attributes of life cycle strategies impacted the accumulated retirement ending wealth compared with balanced funds and which choice would be appropriate for most individuals. Because life cycle funds is a fast-growing portion of the retirement fund market and becoming more popular as default options in retirement funds, this study contributes by statistically contrasting life cycle funds with balanced funds and by showing that the choice of which fund is optimal is driven by the different characteristics of the funds such as investment horizon, starting and ending asset allocations as well as the length of the glide path.

6.5 RECOMMENDATIONS

There was not sufficient evidence to criticise the asset allocation limits of Regulation 28 and contend that it was inappropriate to protect the retirement savings of individuals in South Africa.

When confronted with the decision to commit retirement savings to a direct investment rather than a retirement fund, this thesis did not support a clear directive that capital should rather be invested in a direct investment fund. Although a direct investment

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fund could take greater exposure in equities, retirement funds offer attractive tax savings, hence individuals should take full advantage of the tax benefits of retirement funds and rather choose to invest in them than in direct investments for retirement purposes.

With regard to life cycle funds, retirement fund trustees, investment committees and sponsors must take great care regarding the default funds that are offered to individuals and, while considering that some individuals may have very specific needs, be careful to create choices that are sub-optimal. In this study, life cycle funds were shown, in many instances, to fail to represent a better choice for most individuals. Additionally, investor education on the characteristics of different investment choices as well as the implications on accumulated retirement ending wealth will be beneficial in facilitating individual decision-making.

6.6 AREAS FOR FUTURE RESEARCH

A contribution to the current body of knowledge regarding dynamic life cycle funds compared with traditional life cycle and balanced funds (original study by Basu *et al.*, 2011) would be meaningful. Limited research has been conducted in this area and very little on South African markets. If this was indeed the case, the vehicle warrants greater scrutiny should it result in superior accumulated retirement ending wealth and provide better downside protection.

Furthermore, income could be modelled to exhibit the humped-shaped growth that Hanna *et al.* (1995) mention, which is often exhibited during an individual's pre-retirement (or accumulation) phase, to create a more realistic framework. Additionally, the impact of an individual leaving the workforce for a period during the pre-retirement phase, which is a reality for many individuals due to child rearing, illness or other life choices, could be explored, which consequently, could lead to varying the contribution rate of retirement savings similar to what was done by Schleef and Eisinger (2007). This will provide better insight into the impact of the pre-retirement decision on accumulated retirement ending wealth.

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In contrast to the studies of Lewis (2008b, 2008c), Pang and Warshawsky (2011) and Schleef and Eisinger (2007), this study followed a similar approach to the work of Basu *et al.* (2011), Branch and Qiu (2011) and Spitzer and Singh (2011), in which the glide path of traditional life cycle funds was not implemented over the full investment horizon, which could be an area for future research. It will contribute to the international body of knowledge regarding life cycle funds but provide a perspective based on the asset class characteristics of the South African market, which could be a proxy for emerging markets to be contrasted with the results of developed markets.

Importantly, using expected return data instead of historical data for similar research questions may provide a future perspective if the model can capture future drivers of expected returns, be it structural market changes, economic indicators, the impact of behaviour on financial markets or extreme events. As with any data set used, the reliability and validity of the expected returns and methods used to construct the data set must be sound.

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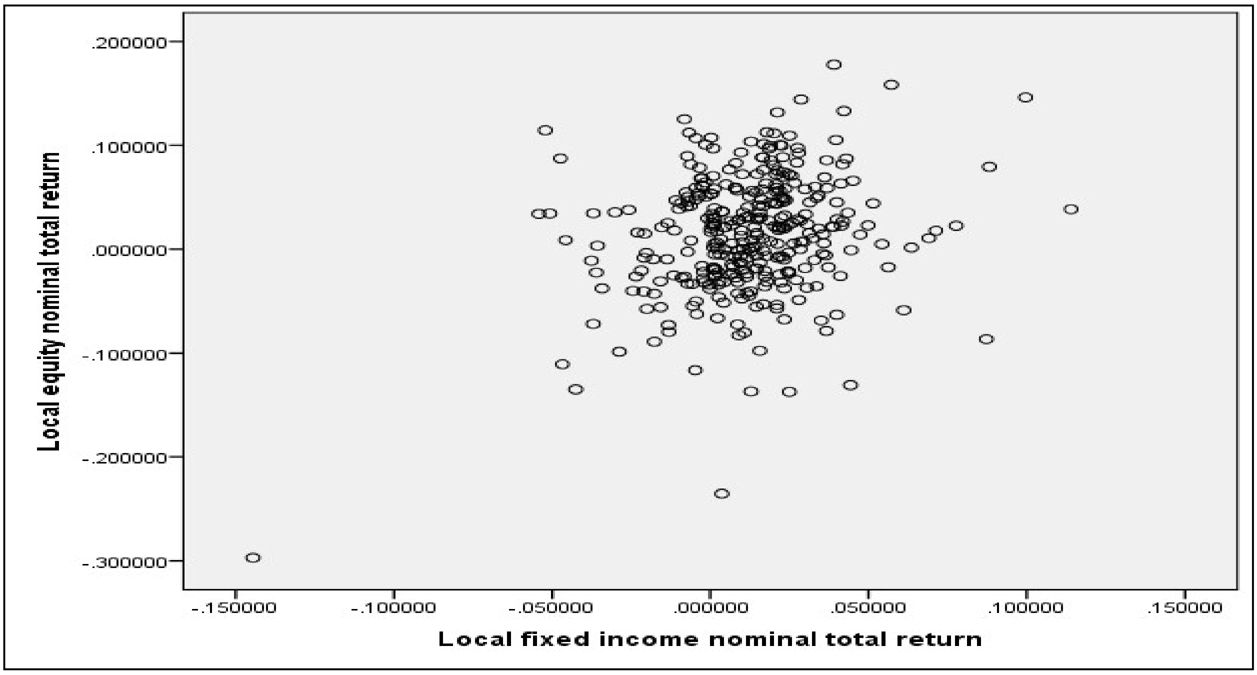
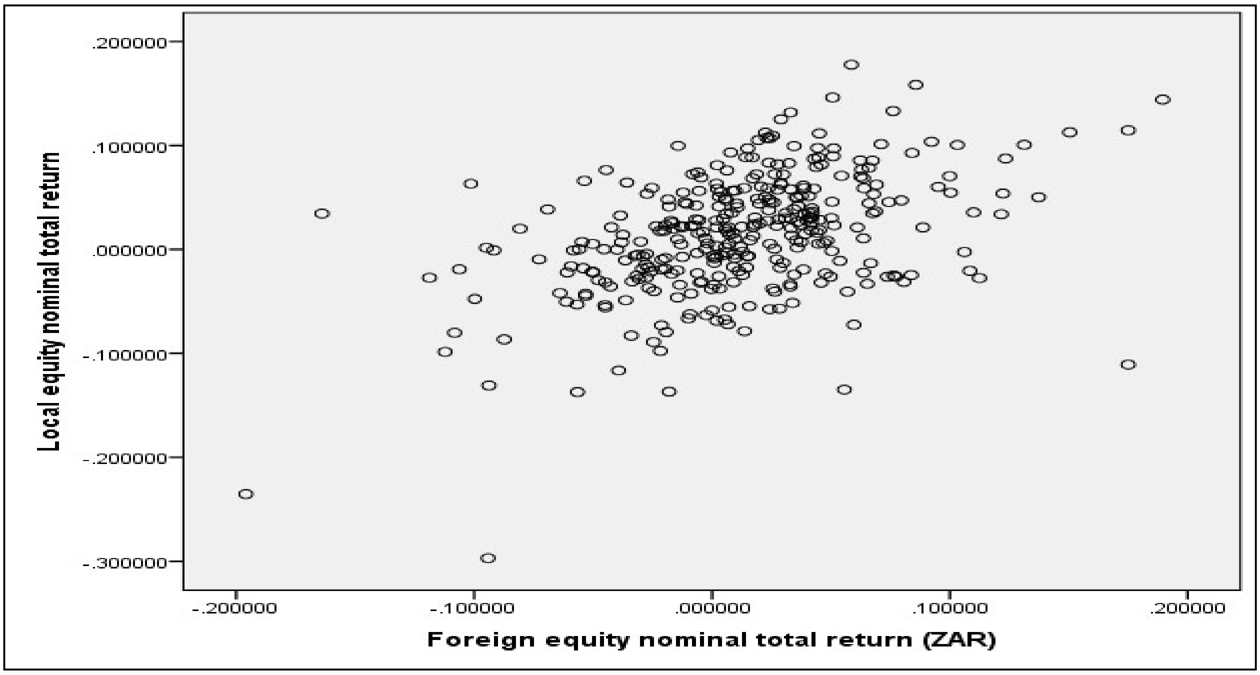
APPENDIX A: DESCRIPTIVE STATISTICS OF HISTORICAL DATA

Figure A1: Scatterplot of local equity nominal total return against local fixed income nominal total return



Source: SPSS output

Figure A2: Scatterplot of local equity nominal total return against foreign equity nominal total return



Source: SPSS output

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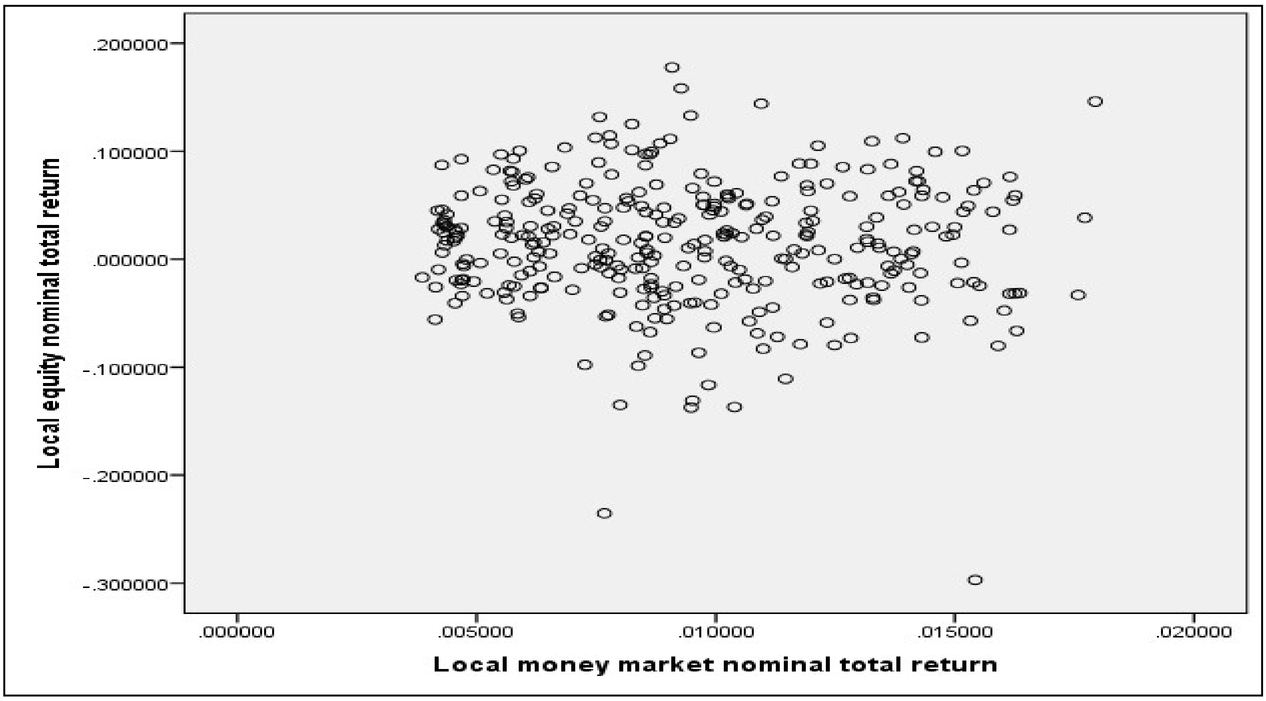
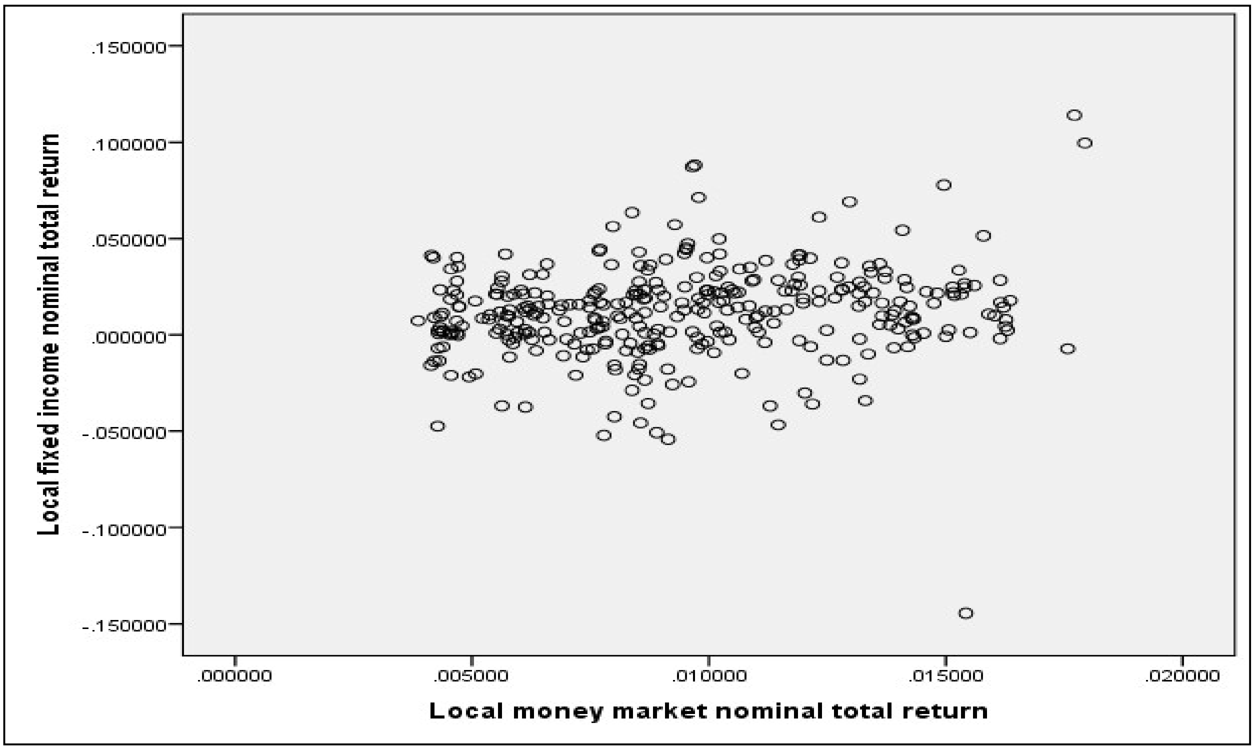
Figure A3: Scatterplot of local equity nominal total return against local money market nominal total return



Source: SPSS output

Figure A4: Scatterplot of local fixed income nominal total return against local money market nominal total return



Source: SPSS output

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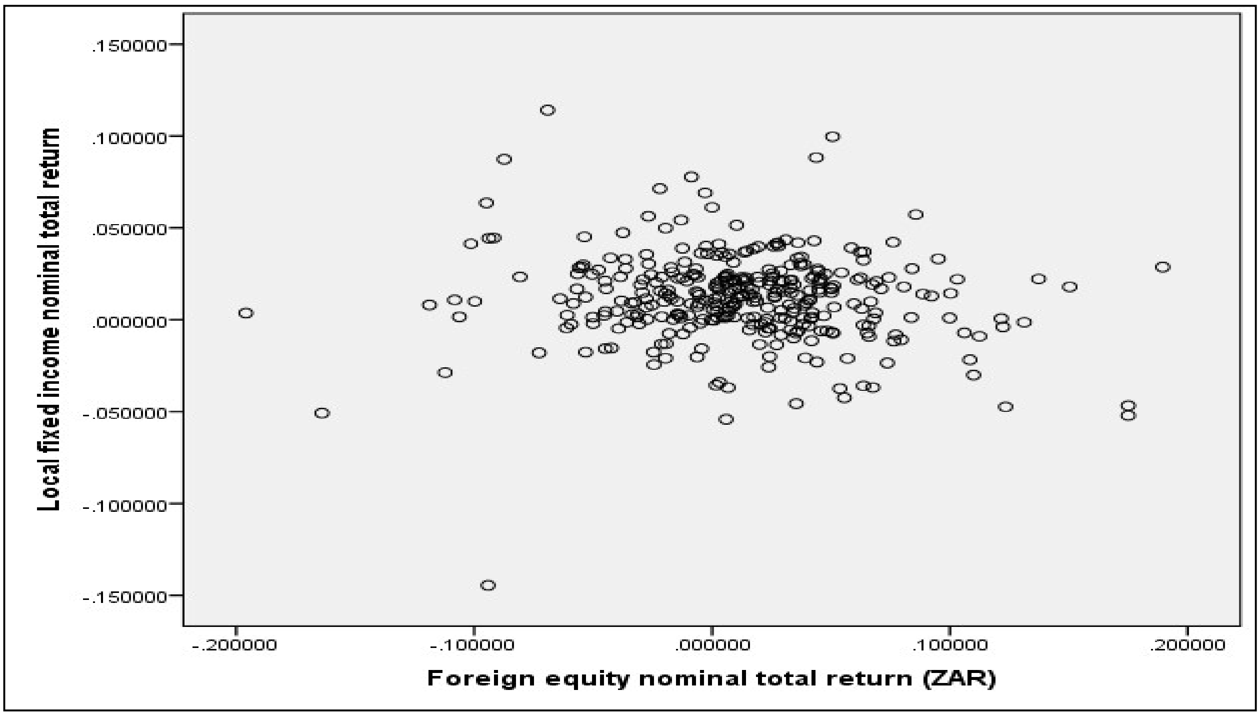
Figure A5: Scatterplot of local fixed income nominal total return against foreign equity nominal total return



Source: SPSS output

Table A1: Descriptive statistics nominal total monthly returns of local and foreign asset classes (1986-2013)

	Foreign equity (in ZAR)	Local equity (in ZAR)	Local fixed income (in ZAR)	Local money market (in ZAR)
Median	1.2134%	1.8358%	1.2584%	0.8960%
Arithmetic mean	1.2338%	1.4911%	1.1917%	0.9476%
Geometric mean	1.1090%	1.3243%	1.1623%	0.9470%
Minimum return	-19.5938%	-29.7057%	-14.4574%	0.3860%
Maximum return	18.9578%	17.7647%	11.4067%	1.7940%
Range	0.385516	0.474705	0.258641	0.01408
Interquartile range	0.057452	0.0722501	0.0230214	0.005448
Standard deviation	5.0161%	17.7647%	2.4317%	0.3428%
Variance	0.3000%	0.3000%	0.1000%	0.0000%
Kurtosis	1.863	3.182	6.412	-0.813
Skewness	-0.070	-0.735	-0.476	0.324
Observations	336	336	336	336

Source: Provided by Staunton (2013) and calculated from Morningstar

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Table A2: Descriptive statistics of local equity asset class monthly returns (1986-2013)

	Local equity nominal total return	Local equity nominal capital return	Local equity nominal dividend return
Median	1.8358%	1.5565%	0.2347%
Arithmetic mean	1.4911%	1.2357%	0.2523%
Geometric mean	1.3243%	1.0694%	0.2522%
Minimum return	-29.7057%	-29.8701%	0.1667%
Maximum return	17.7647%	17.5072%	0.4458%
Range	0.47471	0.47377	0.00279
Interquartile range	0.07225	0.07101	0.00084
Standard deviation	17.7647%	17.5072%	0.4458%
Variance	0.3000%	0.3000%	0.0000%
Kurtosis	3.182	3.189	0.323
Skewness	-0.735	-0.743	1.029
Observations	336	336	336

Source: Provided by Staunton (2013) and calculated from Morningstar

Table A3: Descriptive statistics of local fixed income asset class monthly returns (1986-2013)

	Fixed income nominal total return	Fixed income nominal capital return	Fixed income nominal interest return
Median	1.2584%	0.2430%	1.0652%
Arithmetic mean	1.1917%	0.1782%	1.0115%
Geometric mean	1.1623%	0.1495%	1.0113%
Minimum	-14.4574%	-15.5458%	0.6582%
Maximum	11.4067%	9.9328%	1.3480%
Range	0.25864	0.25479	0.00690
Interquartile range	0.02302	0.02342	0.00379
Standard deviation	2.4317%	2.3879%	0.2006%
Variance	0.1000%	0.1000%	0.0000%
Kurtosis	6.412	6.834	-1.413
Skewness	-0.476	-0.569	-0.215
Observations	336	336	336

Source: Provided by Staunton (2013) and calculated from Morningstar

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Table A4: Descriptive statistics of local money market asset class monthly returns (1986-2013)

	Money market nominal total return
Median	0.8960%
Arithmetic mean	0.9476%
Geometric mean	0.9470%
Minimum	0.3860%
Maximum	1.7940%
Range	0.01408
Interquartile range	0.00545
Standard deviation	0.3428%
Variance	0.0000%
Kurtosis	-0.813
Skewness	0.324
Observations	336

Source: Provided by Staunton (2013) and calculated from Morningstar

Table A5: Descriptive statistics of foreign asset class monthly returns (1986-2013)

	Foreign equity nominal capital return (ZAR)	Foreign equity nominal dividend return (ZAR)	Foreign equity nominal dividend return (USD)
Median	0.9857%	0.0512%	0.1816%
Arithmetic mean	0.5309%	0.0585%	0.1875%
Geometric mean	0.4281%	0.0585%	0.1875%
Minimum	-19.1493%	-0.0685%	0.0603%
Maximum	11.4254%	0.4049%	0.5343%
Range	0.305747	0.004734	0.00474
Interquartile range	0.053126	0.000782	0.000783
Standard deviation	4.4988%	0.0731%	0.0732%
Variance	0.2000%	0.0000%	0.0000%
Kurtosis	1.668	4.493	4.493
Skewness	-0.68	1.564	1.564
Observations	336	336	336

Source: Calculated from Morningstar

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APPENDIX B: MODELLING

$aw_{ending} = (1+r_{e(c)}) \times (v_{beginning(e)} + a_e \times cc_{previous\_month}) + (1+r_{f(c)}) \times (v_{beginning(f)} + a_f \times cc_{previous\_month}) + (1+r_{fe(c)}) \times (v_{beginning(fe)ZAR} + a_{fe} \times cc_{previous\_month}) + v_{interest\ and\ dividends\ (month)} + c_{month}$

(Equation A-1)

With:

$v_{interest\ and\ dividends\ (month)}$ = interest and dividend cash flow earned in a month

Calculated as:

$v_{interest\ and\ dividends\ (month)} = r_{e(d)} \times (v_{beginning(e)} + a_e \times cc_{month-1}) + r_{f(i)} \times (v_{beginning(f)} + a_f \times cc_{month-1}) + r_{m(i)} \times (v_{beginning(m)} + a_m \times cc_{month-1}) + r_{fe(d)} \times e_{ending\ (ZAR/USD)} \times (v_{beginning(fe)ZAR} + a_{fe} \times cc_{month-1}) \div e_{beginning(ZAR/USD)})$

(Equation A-2)

$cc_{month-1}$ = contribution received and cash flow from interest and dividends end of previous month

Calculated as:

$cc_{month-1} = c_{month-1} + v_{interest\ and\ dividends\ (month-1)}$

(Equation A-3)

And:

Capital returns

$r_{e(c)}$= monthly nominal capital return on local equity

$r_{f(c)}$= monthly nominal capital return on local bonds

$r_{fe(c)}$= monthly nominal capital return on foreign equity (in ZAR)

Dividend and interest returns

$r_{e(d)}$= monthly nominal dividend return on local equity

$r_{f(i)}$= monthly nominal interest return on local bonds

$r_{m(i)}$= monthly nominal interest return on local money market

$r_{fe(d)}$= monthly nominal dividend return on foreign equity (in USD)

Asset allocation parameters

a_e= asset allocation to local equity per model specifications

a_f= asset allocation to local fixed income per model specifications

a_m= asset allocation to local money market per model specifications

a_{fe}= asset allocation to foreign equity (in ZAR) per model specifications

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ZAR/USD exchange rate

$e_{beginning(ZAR/USD)}$= beginning of month exchange rate (ZAR/USD)

$e_{ending(ZAR/USD)}$= end of month exchange rate (ZAR/USD)

Accumulated retirement ending wealth monthly

$aw_{beginning}$ = accumulated wealth of retirement fund at the beginning of the month

aw_{ending} = accumulated wealth of retirement fund at the end of the month

Portfolio value of asset class

$v_{beginning(e)}$ = value of local equity at the beginning of the month

$v_{beginning(f)}$ = value of local fixed income at the beginning of the month

$v_{beginning(m)}$ = value of local money market at the beginning of the month

$v_{beginning(fe)ZAR}$ = value of foreign equity (in ZAR) at the beginning of the month

$v_{beginning(fe)USD}$ = value of foreign equity (in USD) at the beginning of the month

Contribution

$c_{month-1}$ = contribution at the end of the previous month

c_{month} = contribution at the end of the current month

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APPENDIX C: DESCRIPTIVE STATISTICS OF ACCUMULATED RETIREMENT ENDING WEALTH

Table C1: Descriptive statistics of Research Question 1 models: accumulated retirement ending wealth (R) – 10-year investment horizon, 18% tax bracket

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Annualised return implied by arithmetic mean	19.47%	18.94%	17.00%	16.22%	18.13%	15.63%
Arithmetic mean	3 110 796	2 482 952	2 745 345	2 165 284	2 907 212	2 563 993
Median	2 866 674	2 289 100	2 582 508	2 051 287	2 772 636	2 477 964
Minimum	617 892	498 713	669 604	573 333	847 740	894 935
Maximum	13 468 186	10 713 202	10 048 207	7 432 770	9 667 107	6 923 454
25th per centile	2 175 444	1 737 750	2 029 776	1 634 841	2 234 148	2 074 008
75th per centile	3 754 885	2 998 588	3 273 771	2 563 584	3 410 154	2 963 307
Range	12 850 295	10 214 489	9 378 603	6 859 437	8 819 367	6 028 519
Interquartile range	1 582 441	1 260 837	1 243 995	928 742	1 176 006	889 299
Standard deviation	1 331 495	1 058 151	1 004 573	743 330	948 827	689 414
Variance	1.773E+12	1.120E+12	1.009E+12	5.525E+11	9.003E+11	4.753E+11
Skewness	1.367	1.363	1.157	1.086	1.037	0.840
Kurtosis	3.444	3.431	2.504	2.219	2.036	1.378

Source: SAS and SPSS output

Table C2: Descriptive statistics of Research Question 1 models: accumulated retirement ending wealth (R) – 10-year investment horizon, 25% tax bracket

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Annualised return implied by arithmetic mean	19.47%	18.94%	17.00%	16.21%	18.13%	15.63%
Arithmetic mean	4 860 007	3 547 980	4 289 062	3 091 689	4 541 948	4 005 735
Median	4 478 615	3 270 978	4 034 661	2 928 778	4 331 698	3 871 331
Minimum	965 334	712 629	1 046 125	818 672	1 324 427	1 398 160
Maximum	21 041 393	15 308 480	15 698 348	10 613 416	15 102 954	10 816 535
25th per centile	3 394 017	2 483 134	3 171 125	2 334 356	3 490 417	3 240 230
75th per centile	5 866 270	4 284 790	5 114 623	3 660 703	5 327 695	4 629 584
Range	20 076 058	14 595 850	14 652 223	9 794 743	13 778 527	9 418 375
Interquartile range	2 472 253	1 801 656	1 943 498	1 326 347	1 837 278	1 389 354
Standard deviation	2 080 199	1 512 030	1 569 447	1 061 429	1 482 355	1 077 075
Variance	4.327E+12	2.286E+12	2.463E+12	1.127E+12	2.197E+12	1.160E+12
Skewness	1.367	1.363	1.157	1.086	1.037	0.840
Kurtosis	3.444	3.431	2.504	2.220	2.036	1.378

Source: SAS and SPSS output

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Table C3: Descriptive statistics of Research Question 1 models: accumulated retirement ending wealth (R) – 10-year investment horizon, 40% tax bracket

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Annualised return implied by arithmetic mean	19.47%	18.94%	17.00%	16.17%	18.13%	15.63%
Arithmetic mean	11 995 978	7 005 938	10 586 624	6 094 880	11 210 817	9 887 293
Median	11 054 494	6 458 962	9 958 690	5 773 129	10 691 861	9 555 545
Minimum	2 382 719	1 407 177	2 582 134	1 614 104	3 269 061	3 451 057
Maximum	51 936 134	30 228 542	38 747 983	20 902 934	37 278 380	26 698 281
25th per centile	8 377 397	4 903 264	7 827 237	4 601 194	8 615 342	7 997 809
75th per centile	14 479 621	8 460 862	12 624 343	7 217 826	13 150 266	11 427 129
Range	49 553 415	28 821 364	36 165 848	19 288 831	34 009 319	23 247 224
Interquartile range	6 102 224	3 557 598	4 797 105	2 616 632	4 534 924	3 429 321
Standard deviation	5 134 523	2 985 695	3 873 342	2 092 579	3 654 823	2 658 526
Variance	2.636E+13	8.914E+12	1.501E+13	4.379E+12	1.339E+13	7.068E+12
Skewness	1.367	1.363	1.157	1.085	1.037	0.840
Kurtosis	3.444	3.431	2.504	2.216	2.036	1.378

Source: SAS and SPSS output

Table C4: Descriptive statistics of Research Question 1 models: accumulated retirement ending wealth (R) - 20-year investment horizon, 18% tax bracket

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Annualised return implied by arithmetic mean	19.43%	18.90%	17.00%	16.22%	18.10%	15.64%
Arithmetic mean	14 903 811	11 483 752	11 237 777	8 428 837	12 765 384	9 627 822
Median	11 962 595	9 254 875	9 520 690	7 277 438	11 174 170	8 873 262
Minimum	1 378 469	1 087 054	1 397 357	1 198 705	2 114 919	2 123 456
Maximum	127 360 474	97 862 885	82 027 836	55 629 986	70 730 976	43 924 510
25th per centile	7 779 744	6 025 882	6 566 540	5 143 300	7 999 011	6 666 497
75th per centile	18 601 884	14 338 888	13 950 602	10 420 347	15 725 878	11 654 743
Range	125 982 006	96 775 831	80 630 480	54 431 280	68 616 057	41 801 054
Interquartile range	10 822 141	8 313 006	7 384 063	5 277 046	7 726 867	4 988 246
Standard deviation	10 959 156	8 388 777	6 882 951	4 794 221	6 919 617	4 202 630
Variance	1.201E+14	7.037E+13	1.738E+13	2.298E+13	4.788E+13	1.766E+13
Skewness	2.511	2.503	2.065	1.914	1.819	1.443
Kurtosis	10.606	10.551	7.354	6.341	5.678	3.651

Source: SAS and SPSS output

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Table C5: Descriptive statistics of Research Question 1 models: accumulated retirement ending wealth (R) – 20-year investment horizon, 25% tax bracket

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Annualised return implied by arithmetic mean	19.43%	18.90%	16.89%	16.19%	18.09%	15.64%
Arithmetic mean	23 284 237	16 409 521	17 346 005	12 015 046	19 943 371	15 041 554
Median	18 694 485	13 224 604	14 874 182	10 379 301	17 457 416	13 722 098
Minimum	2 153 583	1 553 327	2 183 092	1 709 593	3 304 140	3 317 478
Maximum	198 975 384	139 839 579	128 152 163	79 013 607	110 503 068	68 623 302
25th per centile	12 154 301	8 610 587	10 258 911	7 335 434	12 496 862	10 415 074
75th per centile	29 061 741	20 489 321	21 795 039	14 853 655	24 568 553	18 208 216
Range	196 821 801	138 286 252	125 969 071	77 304 014	107 198 928	65 305 825
Interquartile range	16 907 440	11 878 734	11 536 128	7 518 221	12 071 692	7 793 141
Standard deviation	17 121 500	11 987 007	10 753 240	6 823 242	10 810 524	6 565 772
Variance	2.931E+14	1.437E+14	1.156E+14	4.656E+13	1.169E+14	4.311E+13
Skewness	2.511	2.503	2.065	1.907	1.819	1.443
Kurtosis	10.606	10.551	7.354	6.288	5.678	3.651

Source: SAS and SPSS output

Table C6: Descriptive statistics of Research Question 1 models: accumulated retirement ending wealth (R) – 20-year investment horizon, 40% tax bracket

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Annualised return implied by arithmetic mean	19.43%	18.90%	17.00%	16.13%	18.10%	15.64%
Arithmetic mean	57 472 137	32 402 702	43 335 165	23 550 839	49 225 929	37 126 846
Median	46 143 321	26 113 675	36 713 723	20 394 619	43 089 881	33 870 050
Minimum	5 315 657	3 067 244	5 388 493	3 361 989	8 155 560	8 188 481
Maximum	491 127 995	276 131 171	316 316 087	153 337 199	272 753 088	169 381 881
25th per centile	30 000 280	17 002 707	25 321 918	14 420 846	30 845 818	25 707 373
75th per centile	71 732 664	40 458 790	53 796 371	29 119 350	60 642 197	44 943 069
Range	485 812 338	273 063 927	310 927 594	149 975 211	264 597 528	161 193 400
Interquartile range	41 732 384	23 456 084	28 474 454	14 698 504	29 796 378	19 235 696
Standard deviation	42 260 744	23 669 881	26 542 063	13 284 774	26 683 455	16 206 198
Variance	1.786E+15	5.603E+14	7.045E+14	1.765E+14	7.120E+14	2.626E+14
Skewness	2.511	2.503	2.065	1.884	1.819	1.443
Kurtosis	10.606	10.551	7.354	6.155	5.678	3.651

Source: SAS and SPSS output

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Table C7: Descriptive statistics of Research Question 1 models: accumulated retirement ending wealth (R) – 30-year investment horizon, 18% tax bracket

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Annualised return implied by arithmetic mean	19.43%	18.89%	16.98%	16.18%	18.09%	15.63%
Arithmetic mean	59 715 638	44 191 068	37 414 805	26 387 737	46 223 692	28 999 931
Median	41 362 917	30 739 551	28 641 959	20 937 329	37 214 930	25 083 094
Minimum	2 593 194	1 983 006	2 311 629	1 962 021	4 365 111	3 823 861
Maximum	771 485 282	564 630 260	408 680 072	253 705 575	345 781 405	183 262 321
25th per centile	23 457 715	17 489 083	17 436 038	13 161 386	23 928 194	17 448 783
75th per centile	71 606 378	53 022 092	45 929 767	32 480 403	57 060 653	35 637 899
Range	768 892 088	562 647 254	406 368 442	251 743 554	341 416 294	179 438 459
Interquartile range	48 148 663	35 533 010	28 493 729	19 319 018	33 132 459	18 189 117
Standard deviation	63 660 427	46 777 215	32 304 509	20 822 638	34 767 778	17 161 644
Variance	4.053E+15	2.188E+15	1.044E+15	4.336E+14	1.209E+15	2.945E+14
Skewness	3.904	3.888	3.144	2.851	2.633	2.044
Kurtosis	24.607	24.411	16.590	13.782	11.537	7.226

Source: SAS and SPSS output

Table C8: Descriptive statistics of Research Question 1 models: accumulated retirement ending wealth (R) – 30-year investment horizon, 25% tax bracket

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Annualised return implied by arithmetic mean	19.43%	18.89%	16.98%	16.14%	18.09%	15.63%
Arithmetic mean	93 293 912	63 146 189	58 453 256	37 416 184	72 215 406	45 306 676
Median	64 621 403	43 924 836	44 747 414	29 770 428	58 140 992	39 187 390
Minimum	4 051 354	2 833 588	3 611 465	2 795 477	6 819 625	5 974 029
Maximum	1 205 293 666	806 820 249	638 482 047	357 620 036	540 215 279	286 311 249
25th per centile	36 648 056	24 990 772	27 240 372	18 725 166	37 383 086	27 260 283
75th per centile	111 870 849	75 765 153	71 756 206	46 048 776	89 146 022	55 677 192
Range	1 201 242 312	803 986 661	634 870 582	354 824 559	533 395 654	280 337 219
Interquartile range	75 222 793	50 774 381	44 515 834	27 323 610	51 762 936	28 416 909
Standard deviation	99 456 868	66 841 625	50 469 426	29 381 298	54 317 800	26 811 685
Variance	9.892E+15	4.468E+15	2.547E+15	8.633E+14	2.950E+15	7.189E+14
Skewness	3.904	3.888	3.144	2.837	2.633	2.044
Kurtosis	24.607	24.411	16.590	13.664	11.537	7.226

Source: SAS and SPSS output

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Table C9: Descriptive statistics of Research Question 1 models: accumulated retirement ending wealth (R) – 30-year investment horizon, 40% tax bracket

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Annualised return implied by arithmetic mean	19.43%	18.89%	16.98%	16.01%	18.09%	15.63%
Arithmetic mean	230 275 664	124 690 070	144 279 109	72 140 072	178 247 972	111 829 643
Median	159 503 834	86 735 099	110 449 228	57 595 757	143 508 353	96 725 520
Minimum	9 999 884	5 595 275	8 914 114	5 485 822	16 832 756	14 745 588
Maximum	2 975 004 417	1 593 167 788	1 575 953 615	682 927 048	1 333 403 541	706 696 843
25th per centile	90 457 729	49 347 414	67 236 914	36 519 067	92 271 990	67 286 060
75th per centile	276 128 781	149 607 798	177 114 538	88 730 392	220 037 503	137 427 000
Range	2 965 004 533	1 587 572 513	1 567 039 501	677 441 225	1 316 570 785	691 951 256
Interquartile range	185 671 052	100 260 383	109 877 624	52 311 325	127 765 513	70 140 940
Standard deviation	245 487 576	131 987 172	124 572 766	56 013 535	134 071 637	66 178 794
Variance	6.026E+16	1.742E+16	1.552E+16	3.138E+15	1.798E+16	4.380E+15
Skewness	3.904	3.888	3.144	2.817	2.633	2.044
Kurtosis	24.607	24.411	16.590	13.497	11.537	7.226

Source: SAS and SPSS output

Table C10: Descriptive statistics of Research Question 1 models: accumulated retirement ending wealth (R) – 40-year investment horizon, 18% tax bracket

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Annualised return implied by arithmetic mean	19.43%	18.90%	16.99%	16.15%	18.09%	15.63%
Arithmetic mean	230 302 965	163 247 755	118 621 075	77 650 165	160 002 533	82 400 315
Median	131 050 566	93 304 803	78 054 173	54 210 401	114 545 467	65 453 342
Minimum	2 911 328	2 216 434	2 960 881	2 534 815	5 222 723	5 220 625
Maximum	5 179 022 029	3 666 255 167	2 056 049 101	1 149 025 979	1 862 491 373	718 765 364
25th per centile	66 681 662	47 872 360	43 290 388	31 245 344	67 488 747	42 215 324
75th per centile	263 802 113	187 513 048	141 160 108	93 724 128	195 493 291	101 689 589
Range	5 176 110 701	3 662 038 733	2 053 088 220	1 146 491 164	1 857 268 650	713 544 739
Interquartile range	197 120 451	139 640 688	97 869 720	62 478 784	128 004 545	59 474 265
Standard deviation	329 045 393	231 687 690	136 265 449	80 463 572	156 100 520	62 890 904
Variance	1.083E+17	5.368E+16	1.857E+16	6.474E+15	2.437E+16	3.955E+15
Skewness	5.363	5.342	4.350	3.907	3.455	2.719
Kurtosis	45.903	45.648	31.674	25.926	19.717	12.762

Source: SAS and SPSS output

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Table C11: Descriptive statistics of Research Question 1 models: accumulated retirement ending wealth (R) – 40-year investment horizon, 25% tax bracket

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Annualised return implied by arithmetic mean	19.43%	18.90%	16.99%	16.09%	18.09%	15.63%
Arithmetic mean	359 803 028	233 270 550	185 322 070	109 149 622	249 972 448	128 734 264
Median	204 740 700	133 326 567	121 944 274	76 389 658	178 954 734	102 257 956
Minimum	4 548 376	3 167 141	4 625 794	3 609 985	8 159 477	8 156 198
Maximum	8 091 201 989	5 235 985 133	3 212 171 813	1 602 473 137	2 909 775 981	1 122 929 331
25th per centile	104 176 965	68 406 526	67 632 705	44 093 517	105 437 876	65 953 130
75th per centile	412 138 850	267 944 095	220 534 869	131 686 945	305 419 768	158 869 956
Range	8,086 653 613	5 232 817 992	3 207 546 019	1 598 863 152	2 901 616 504	1 114 773 133
Interquartile range	307 961 885	199 537 569	152 902 163	87 593 427	199 981 893	92 916 826
Standard deviation	514 068 626	331 066 818	212 887 928	112 474 037	243 876 321	98 254 653
Variance	2.643E+17	1.096E+17	4.532E+16	1.265E+16	5.948E+16	9.654E+15
Skewness	5.363	5.342	4.350	3.889	3.455	2.719
Kurtosis	45.903	45.648	31.674	25.694	19.717	12.762

Source: SAS and SPSS output

Table C12: Descriptive statistics of Research Question 1 models: accumulated retirement ending wealth (R) – 40-year investment horizon, 40% tax bracket

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Annualised return implied by arithmetic mean	19.43%	18.90%	16.99%	17.27%	18.09%	15.63%
Arithmetic mean	888 095 994	460 622 340	457 427 467	206 053 457	617 002 951	317 752 702
Median	505 358 159	263 270 248	300 993 080	144 950 925	441 711 075	252 401 660
Minimum	11 226 683	6 253 923	11 417 773	7 077 513	20 139 905	20 131 812
Maximum	19 971 383 022	10 339 117 944	7 928 551 740	2 987 761 816	7 182 152 997	2 771 708 308
25th per centile	257 138 317	135 077 378	166 936 713	84 357 211	260 250 603	162 791 045
75th per centile	1 017 275 658	529 089 661	544 342 650	248 689 600	753 862 675	392 136 144
Range	19 960 156 339	10 332 864 021	7 917 133 967	2 980 684 303	7 162 013 092	2 751 576 497
Interquartile range	760 137 341	394 012 283	377 405 937	164 332 389	493 612 072	229 345 099
Standard deviation	1 268 867 277	653 733 499	525 467 831	210 057 763	601 955 980	242 520 370
Variance	1.610E+18	4.274E+17	2.761E+17	4.412E+16	3.624E+17	5.882E+16
Skewness	5.363	5.342	4.350	3.857	3.455	2.719
Kurtosis	45.903	45.648	31.674	25.313	19.717	12.762

Source: SAS and SPSS output

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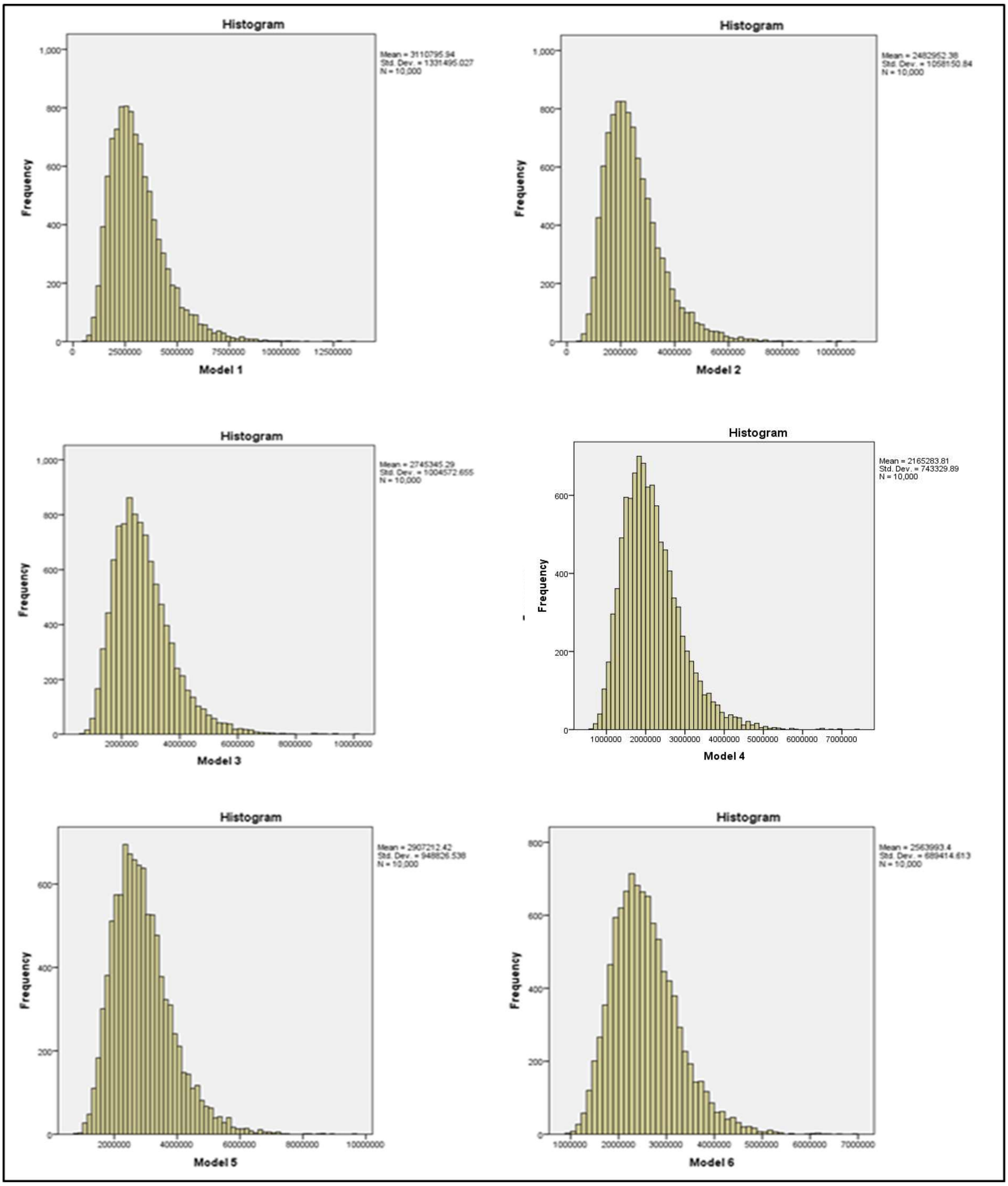
APPENDIX D: HISTOGRAMS OF ACCUMULATED RETIREMENT ENDING WEALTH

Figure D1: Histograms of accumulated retirement ending wealth for Models 1 to 6 – 10-year investment horizon, 18% tax bracket



Source: SPSS output

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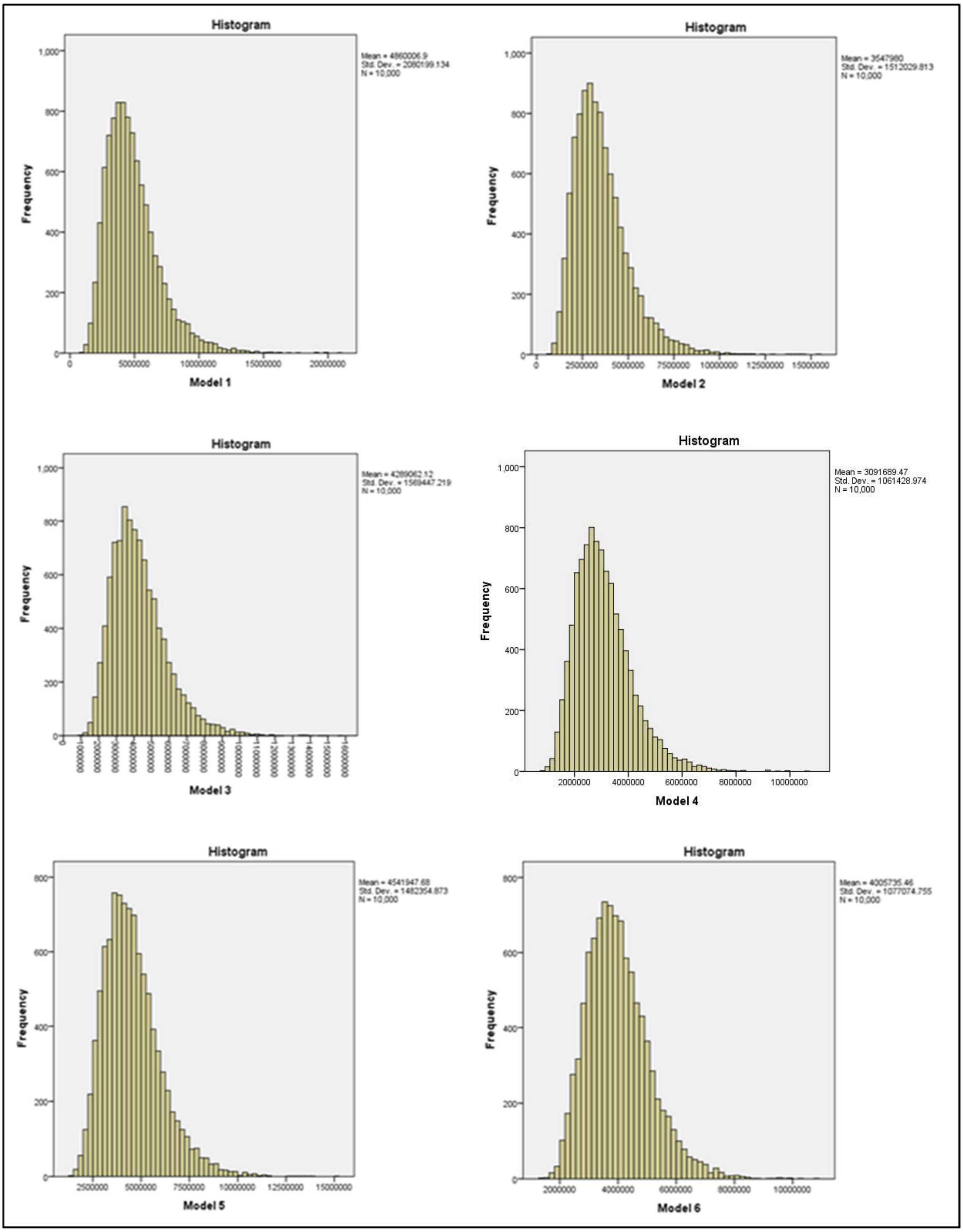
Figure D2: Histograms of accumulated retirement ending wealth for Models 1 to 6 – 10-year investment



Source: SPSS output

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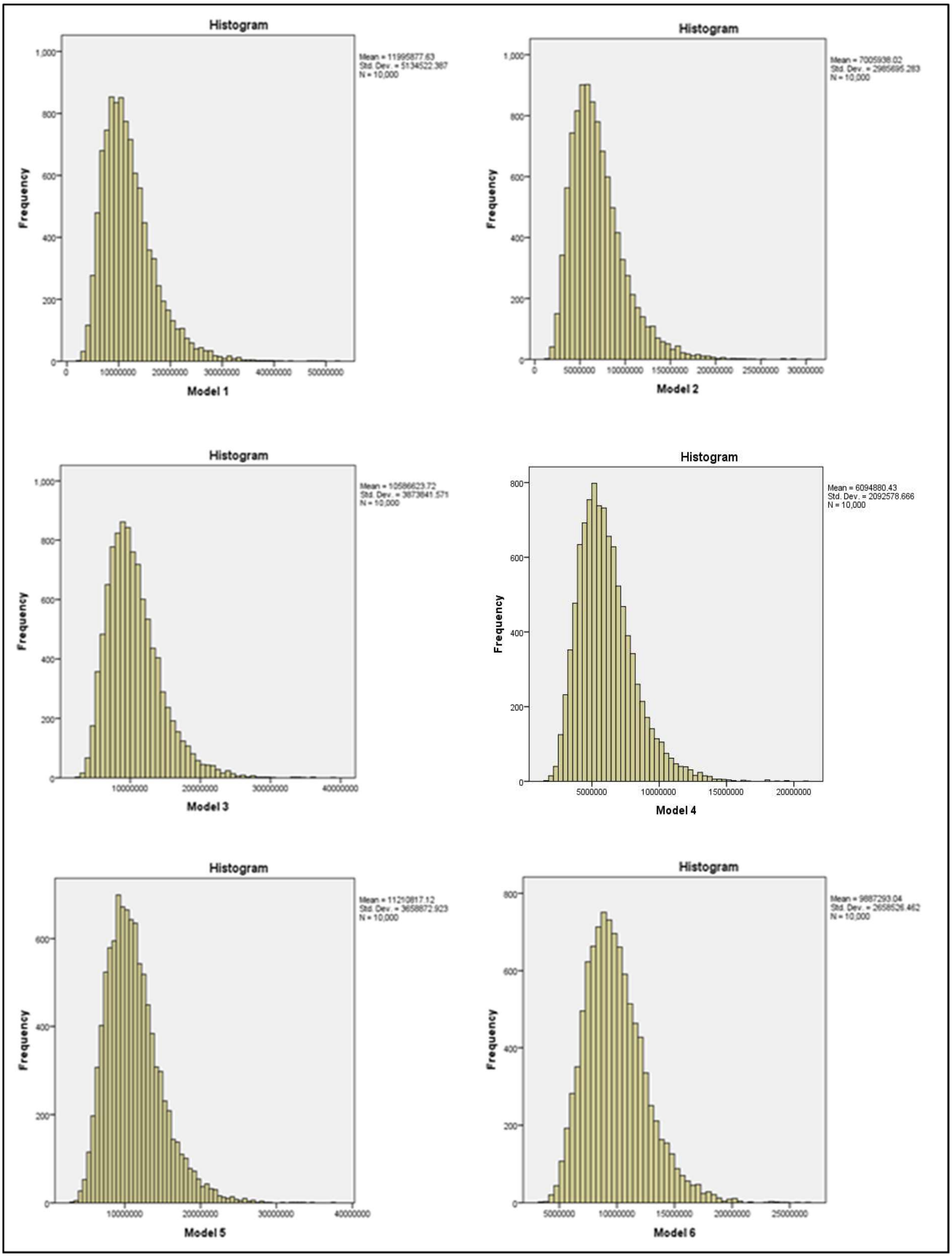
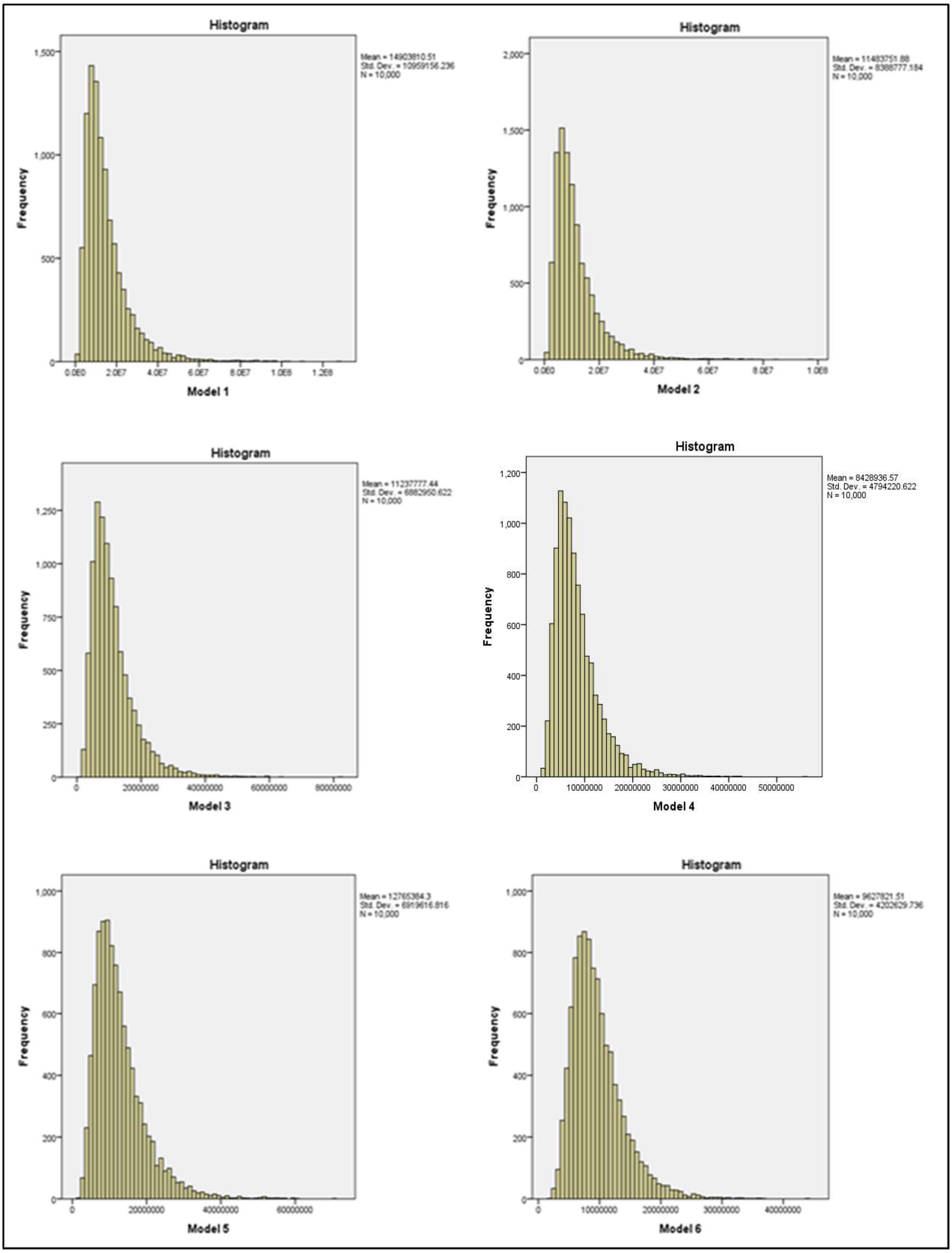
Figure D3: Histograms of accumulated retirement ending wealth for Models 1 to 6 – 10-year investment horizon, 40% tax bracket



Source: SPSS output

Figure D4: Histograms of accumulated retirement ending wealth for Models 1 to 6 – 20-year investment horizon, 18% tax bracket



Source: SPSS output

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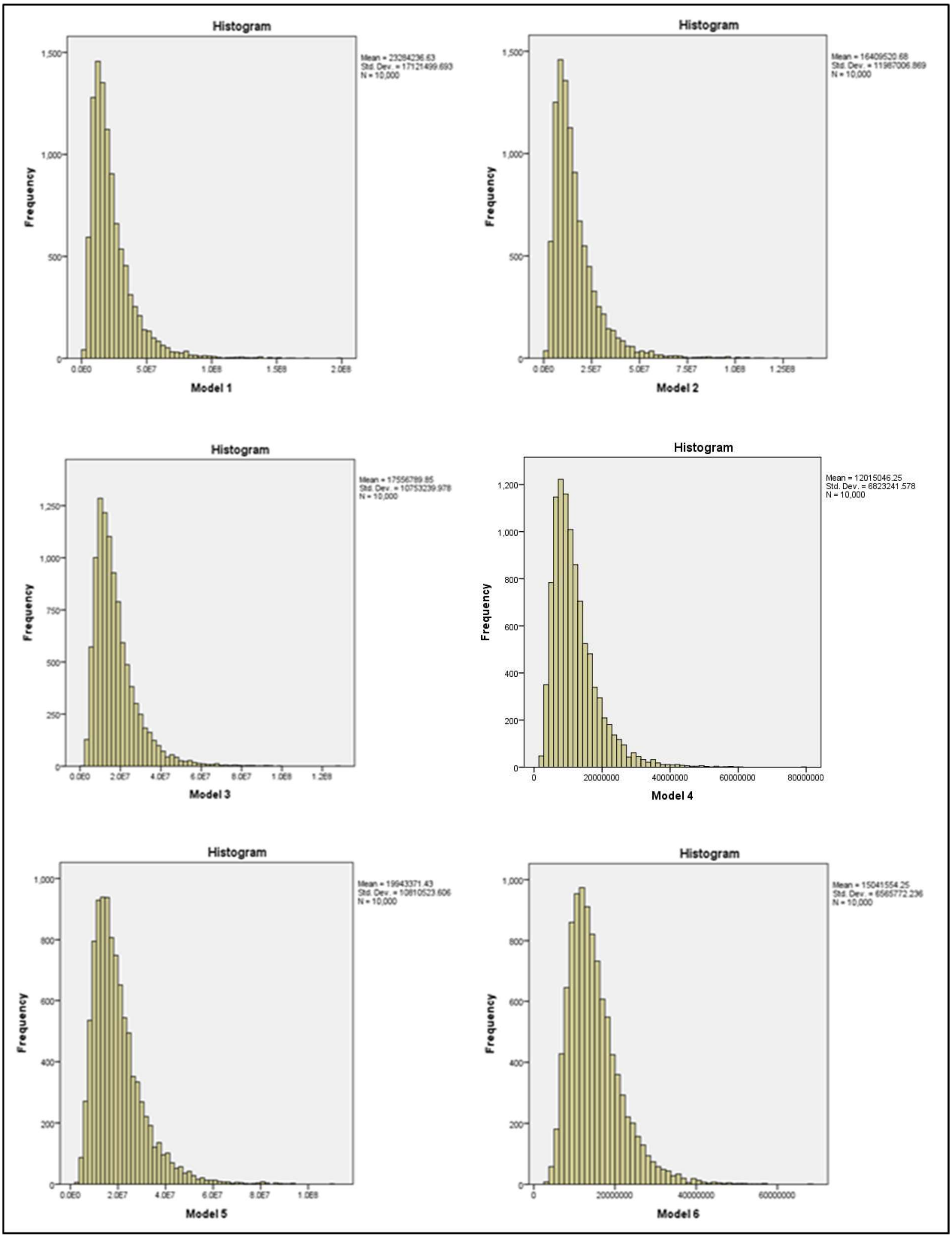
Figure D5: Histograms of accumulated retirement ending wealth for Models 1 to 6 – 20-year investment horizon, 25% tax bracket



Source: SPSS output

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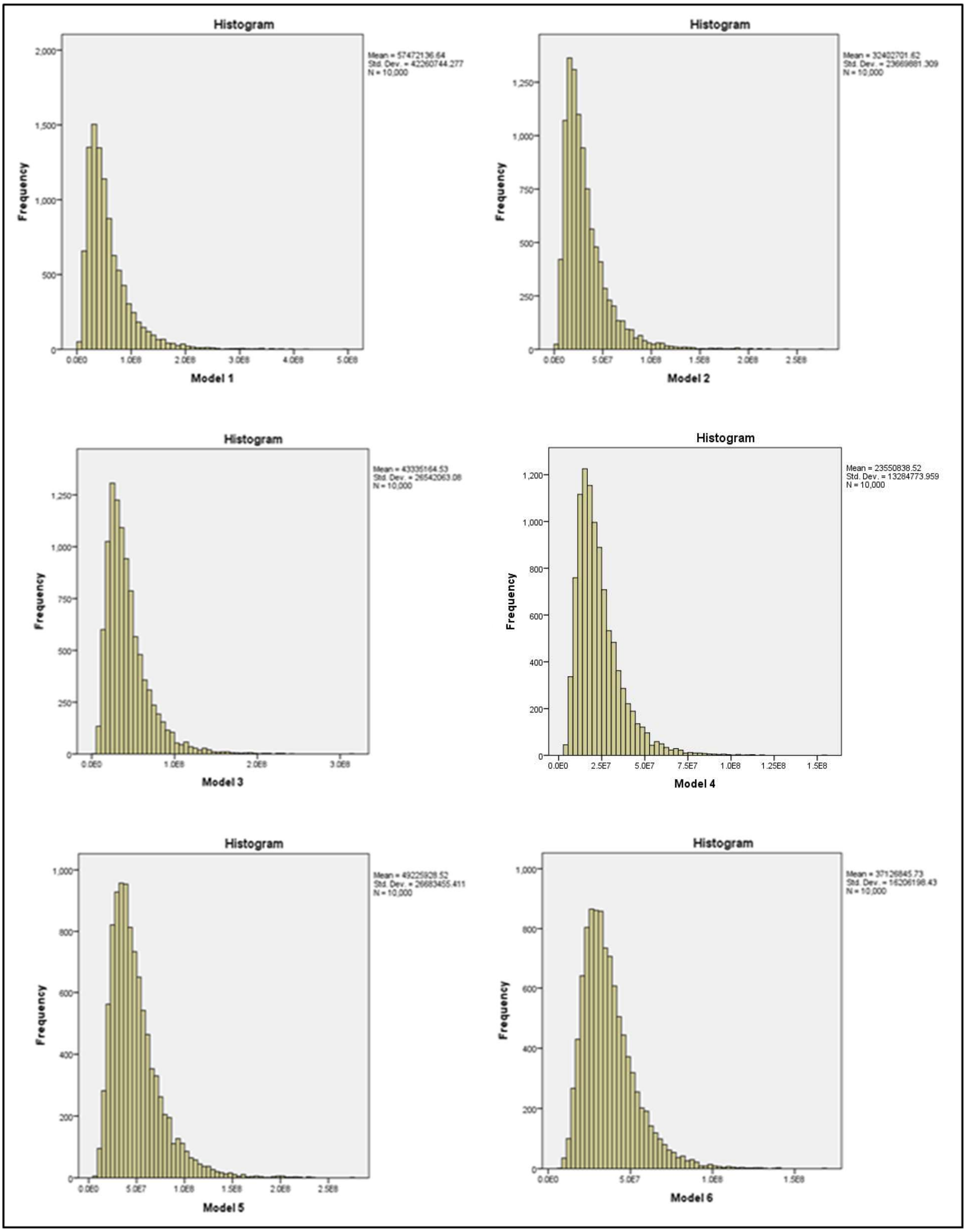
Figure D6: Histograms of accumulated retirement ending wealth for Models 1 to 6 – 20-year investment horizon, 40% tax bracket



Source: SPSS output

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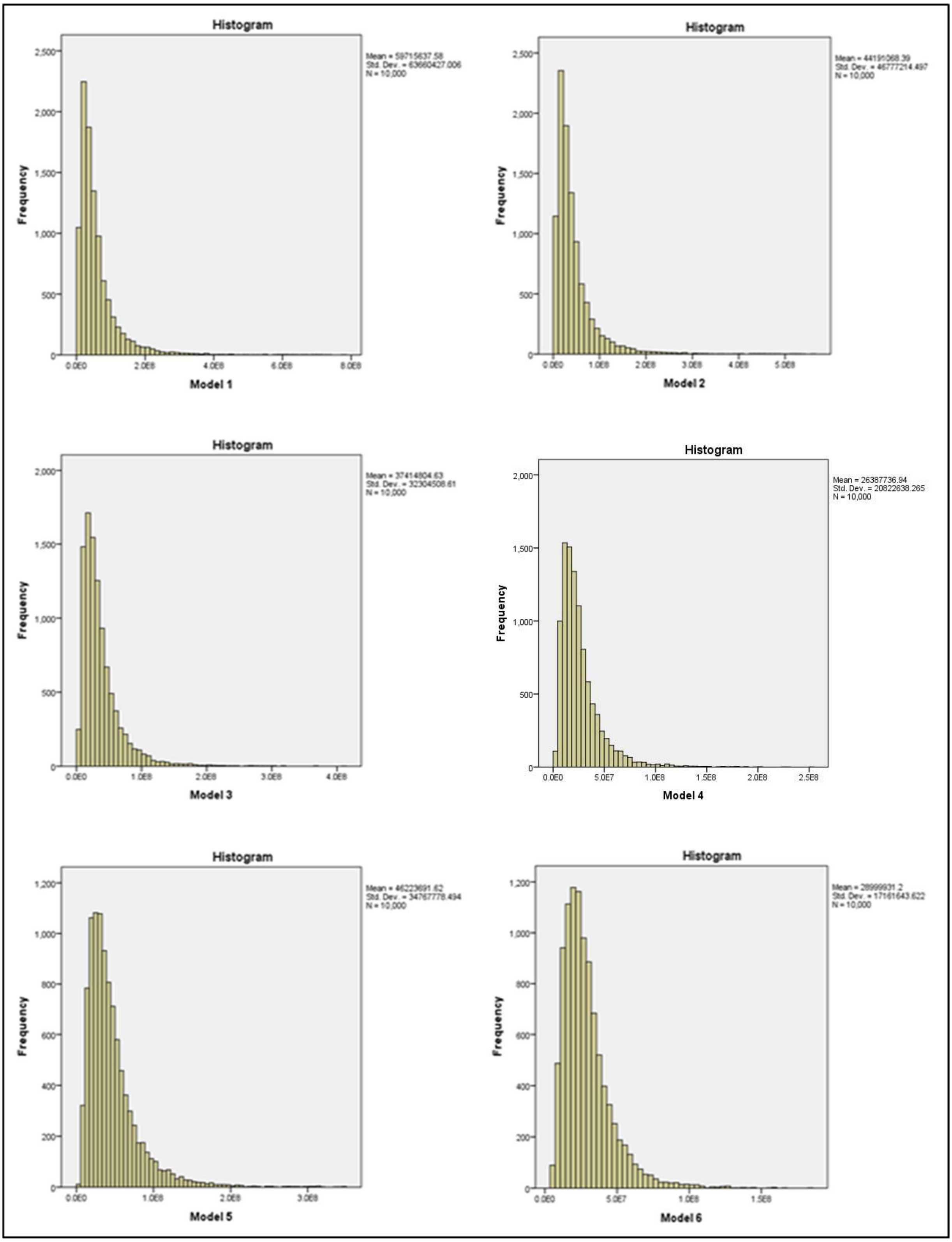
Figure D7: Histograms of accumulated retirement ending wealth for Models 1 to 6 – 30-year investment horizon, 18% tax bracket



Source: SPSS output

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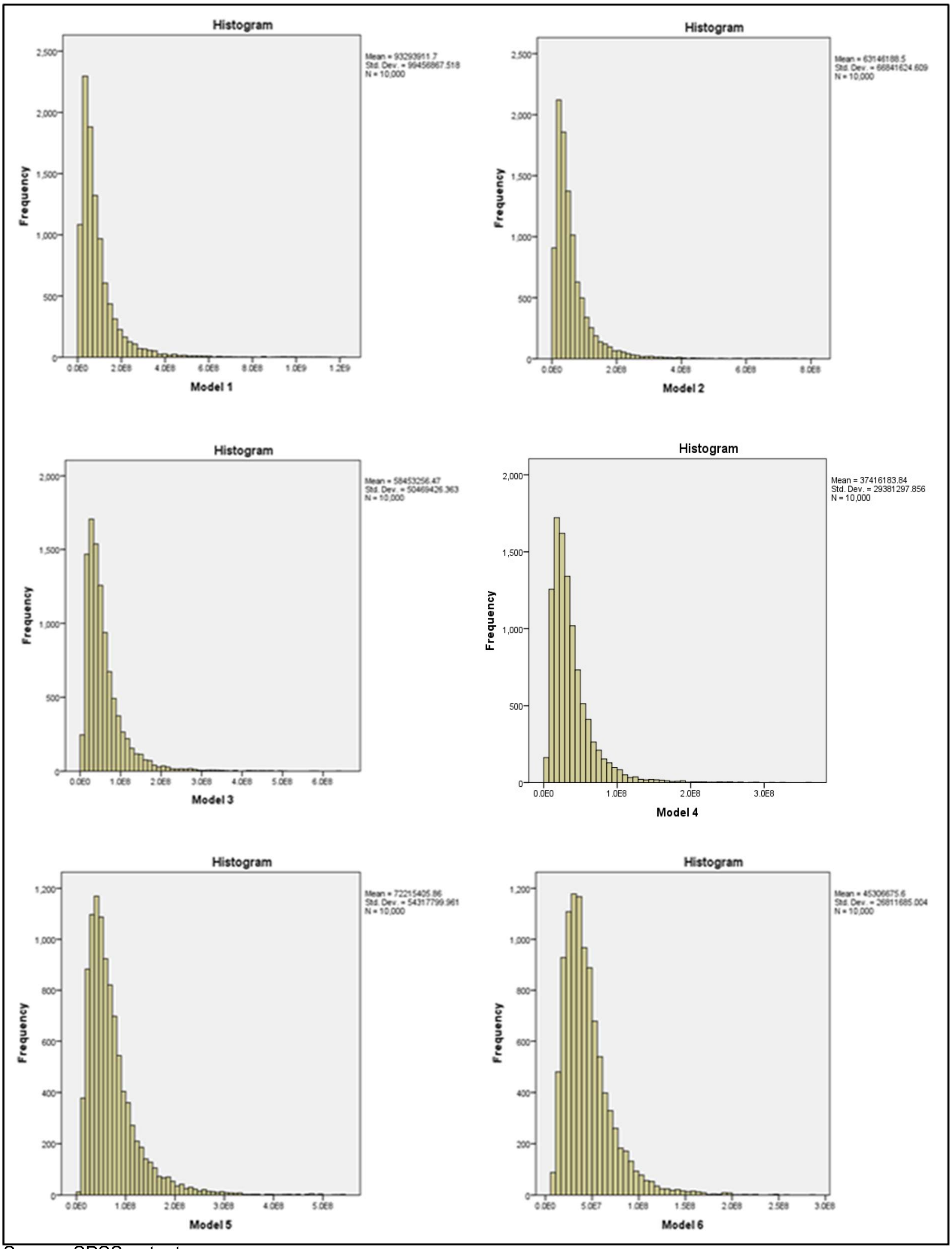
Figure D8: Histograms of accumulated retirement ending wealth for Models 1 to 6 – 30-year investment horizon, 25% tax bracket



Source: SPSS output

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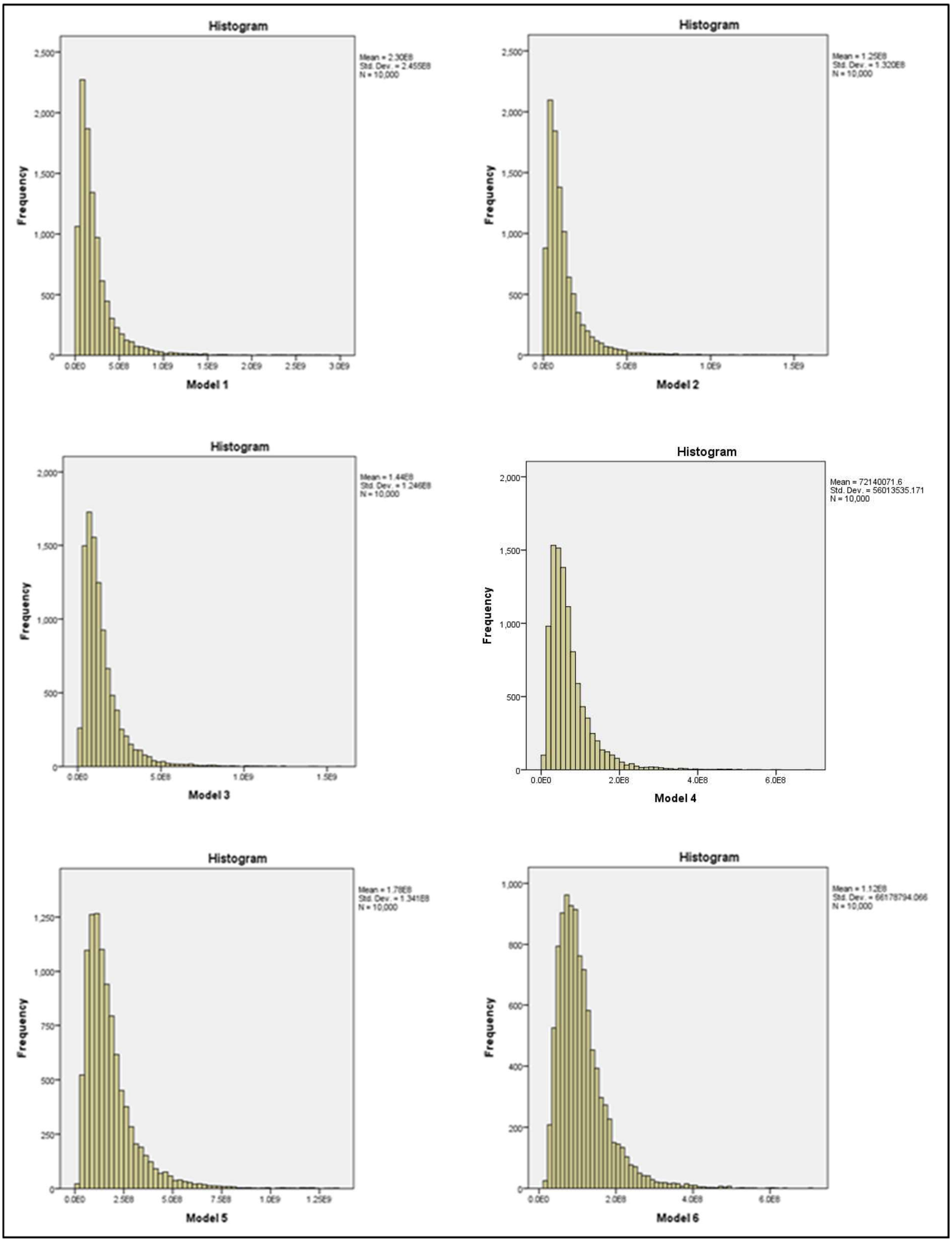
Figure D9: Histograms of accumulated retirement ending wealth for Models 1 to 6 – 30-year investment horizon, 40% tax bracket



Source: SPSS output

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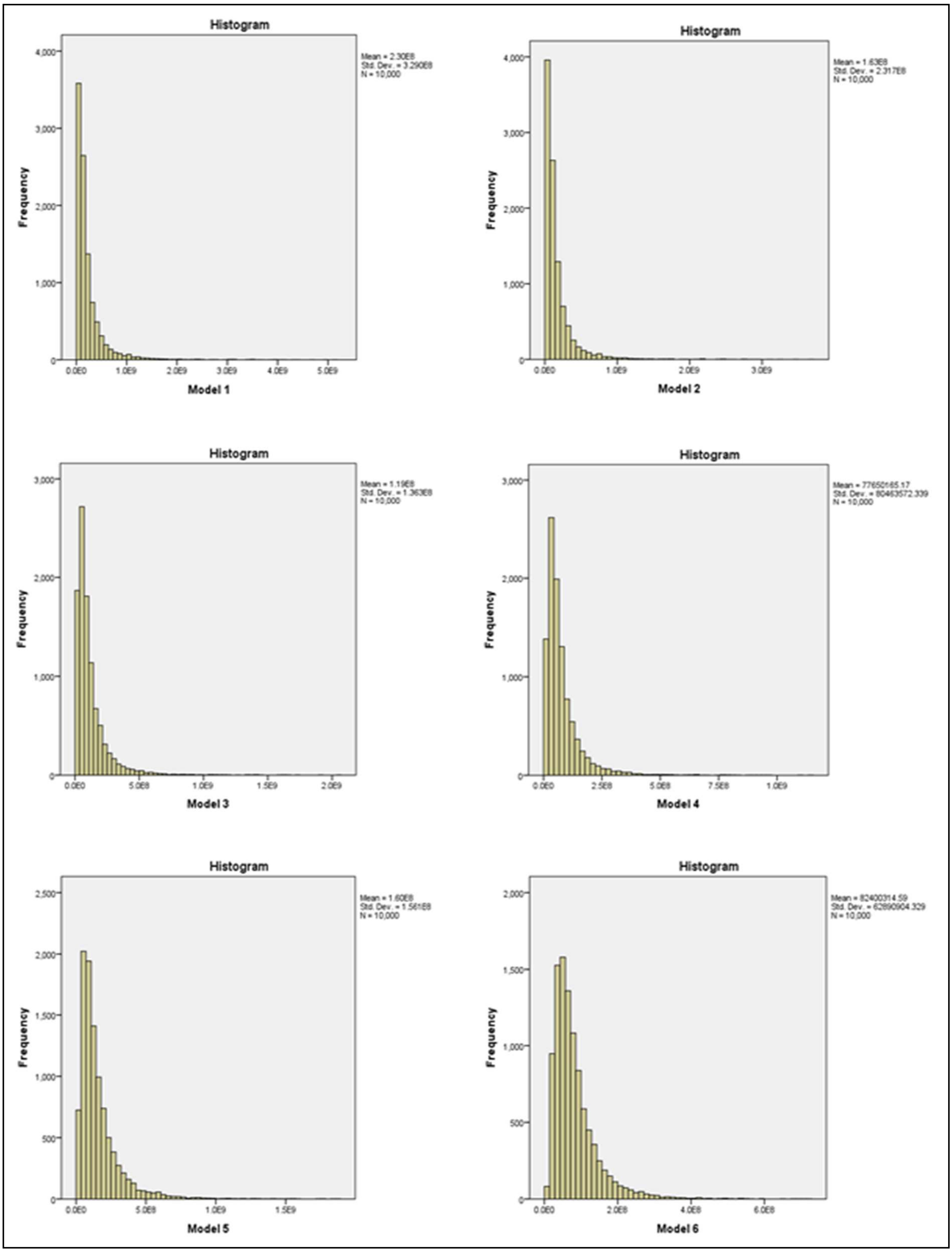
Figure D10: Histograms of accumulated retirement ending wealth for Models 1 to 6 – 40-year investment horizon, 18% tax bracket



Source: SPSS output

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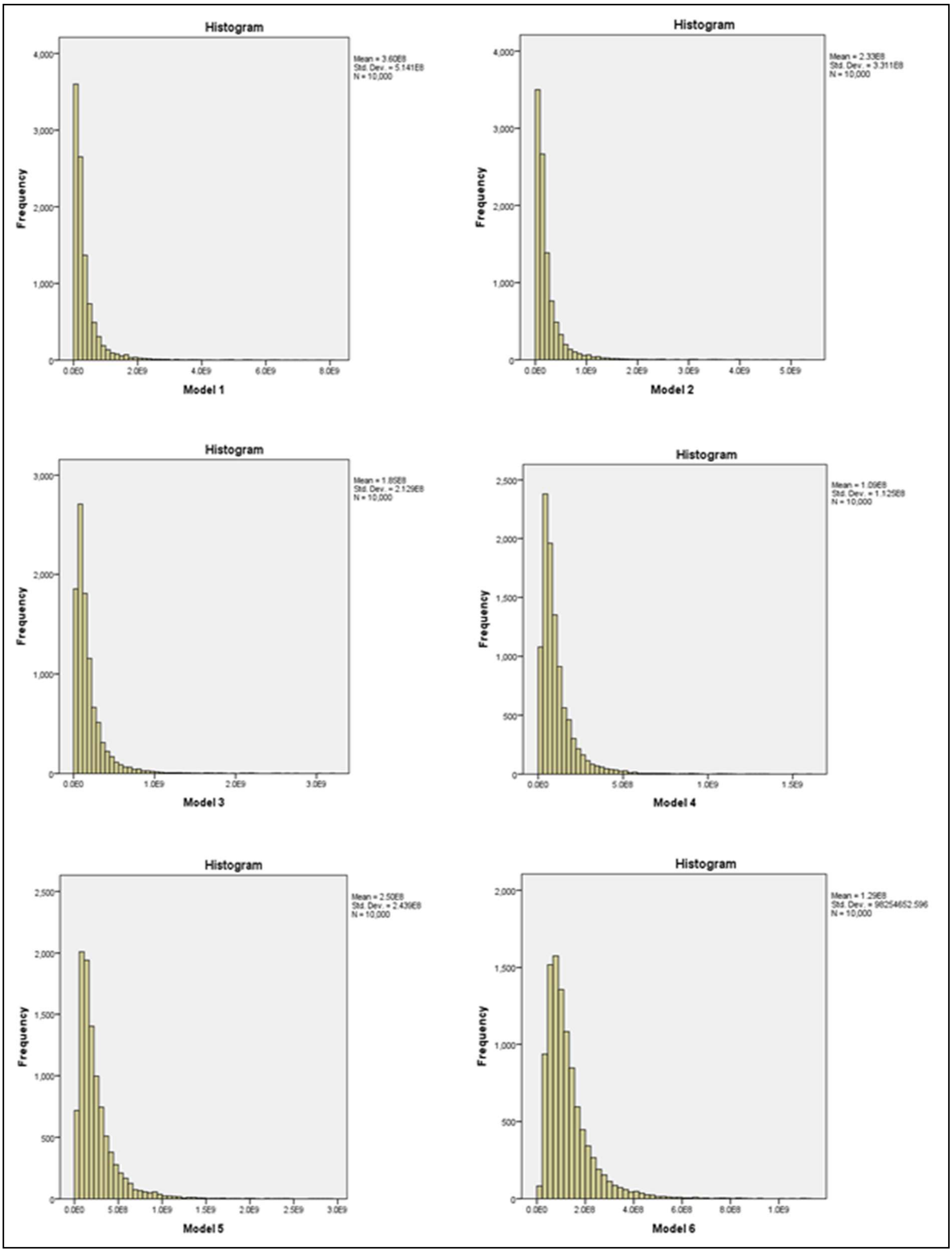
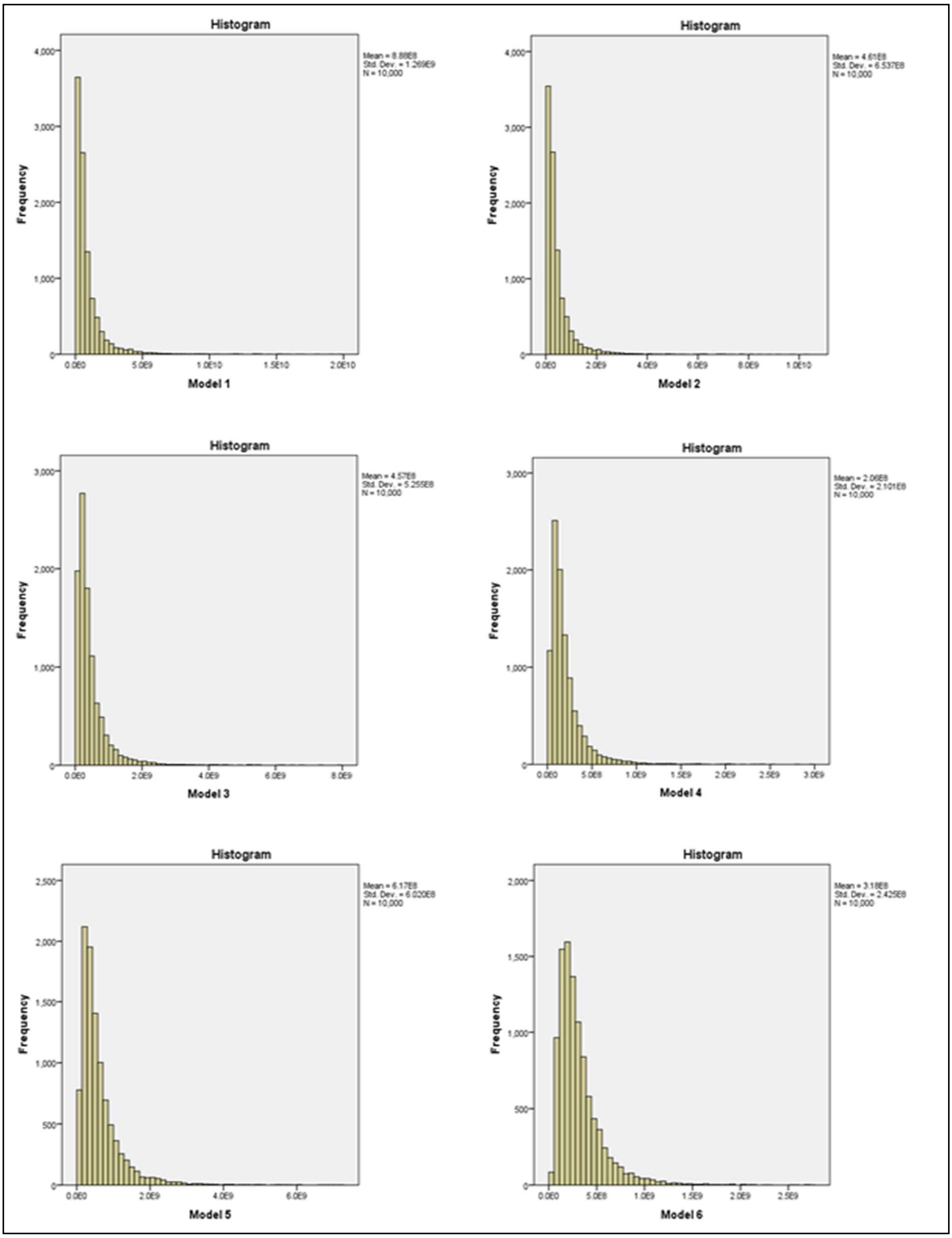
Figure D11: Histograms of accumulated retirement ending wealth for Models 1 to 6 – 40-year investment horizon, 25% tax bracket



Source: SPSS output

Figure D12: Histograms of accumulated retirement ending wealth for Models 1 to 6 – 40-year investment horizon, 40% tax bracket



Source: SPSS output

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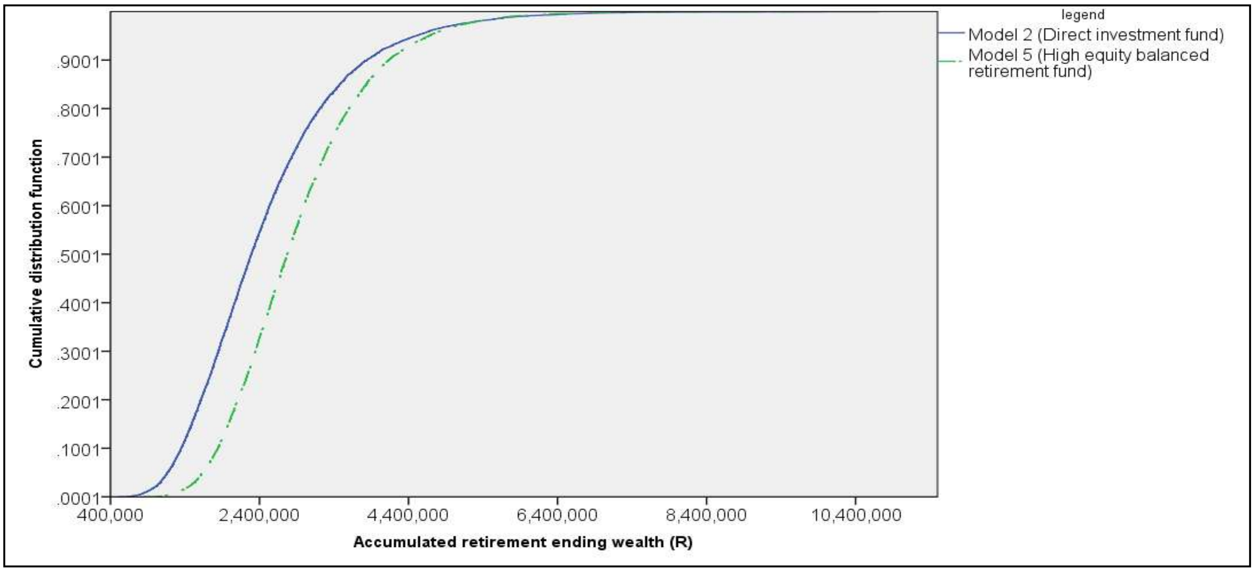
APPENDIX E: CUMULATIVE DISTRIBUTION FUNCTIONS HYPOTHESES 1A TO 1E

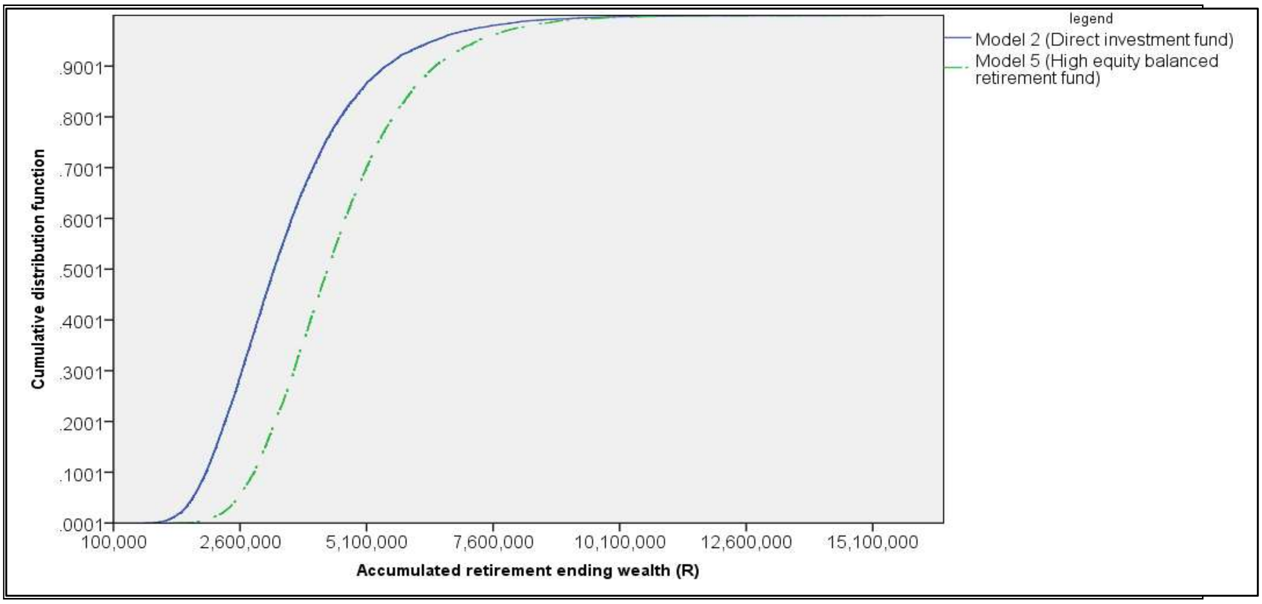
E1. HYPOTHESIS 1A

Figure E1: Cumulative distribution of accumulated retirement ending wealth for Model 2 against Model 5 (10-year investment horizon, 18% tax bracket)



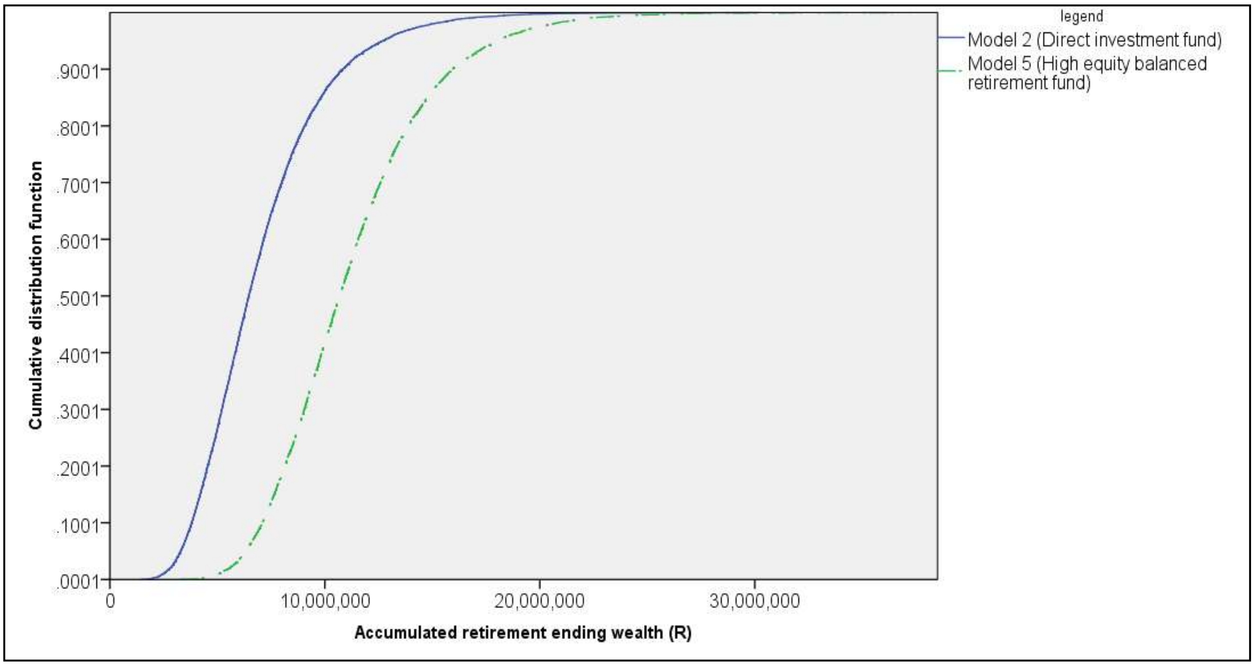
Source: SPSS output

Figure E2: Cumulative distribution of accumulated retirement ending wealth for Model 2 against Model 5 (10-year investment horizon, 25% tax bracket)



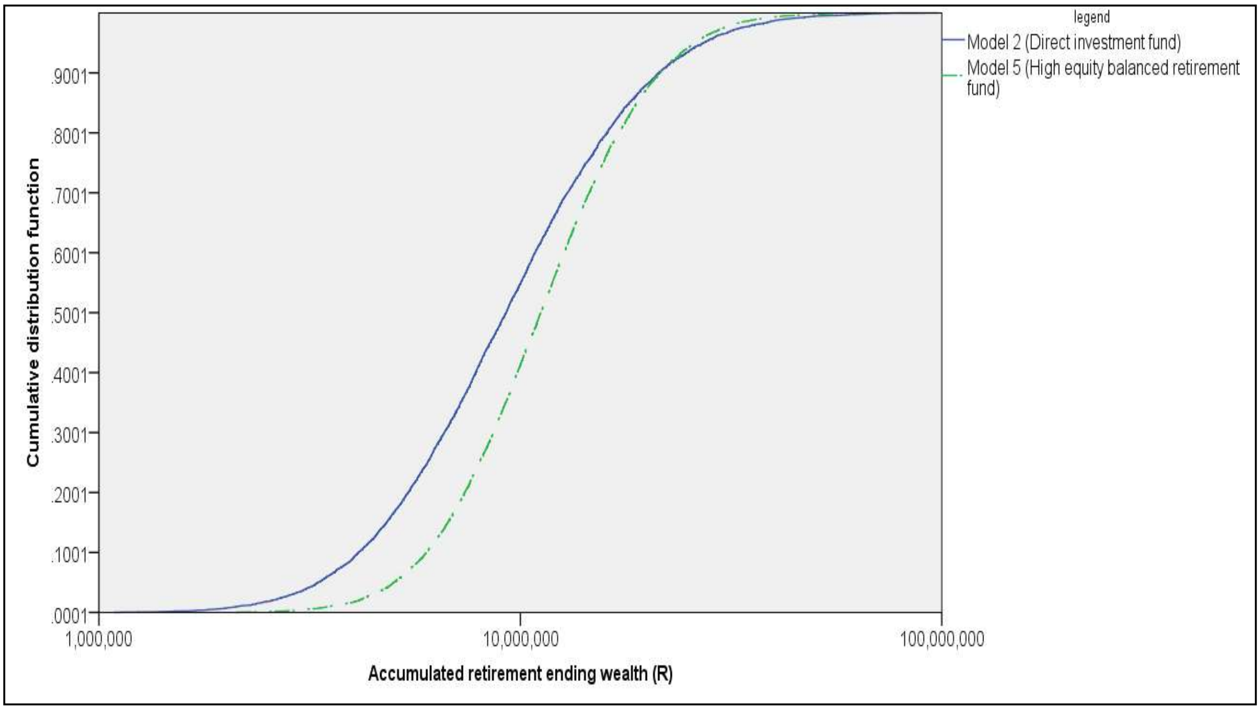
Source: SPSS output

Figure E3: Cumulative distribution of accumulated retirement ending wealth for Model 2 against Model 5 (10-year investment horizon, 40% tax bracket)



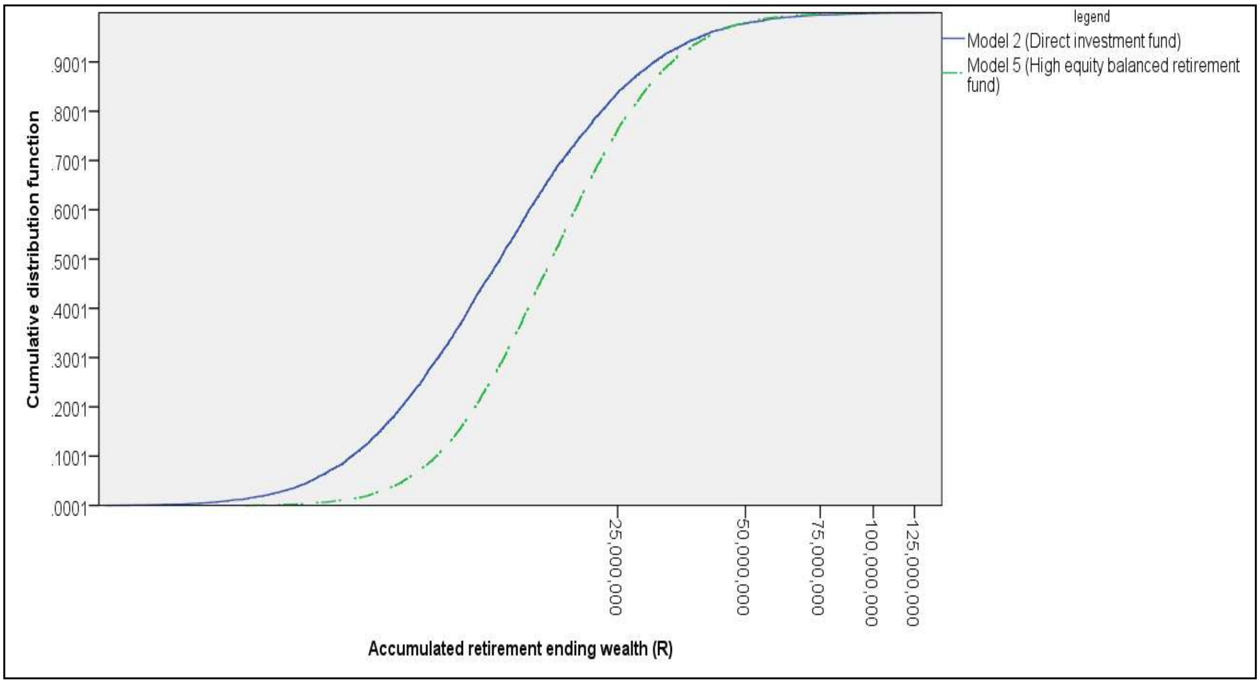
Source: SPSS output

Figure E4: Cumulative distribution of accumulated retirement ending wealth for Model 2 against Model 5 (20-year investment horizon, 18% tax bracket)



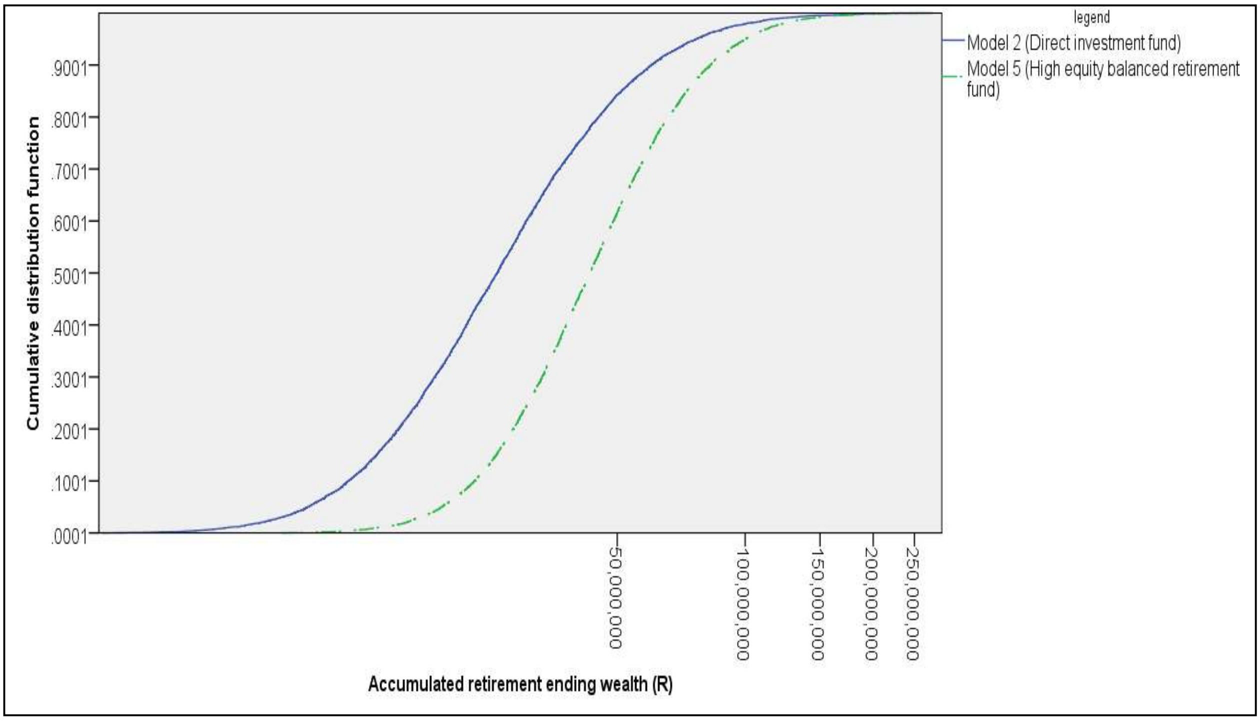
Source: SPSS output

Figure E5: Cumulative distribution of accumulated retirement ending wealth for Model 2 against Model 5 (20-year investment horizon, 25% tax bracket)



Source: SPSS output

Figure E6: Cumulative distribution of accumulated retirement ending wealth for Model 2 against Model 5 (20-year investment horizon, 40% tax bracket)



Source: SPSS output

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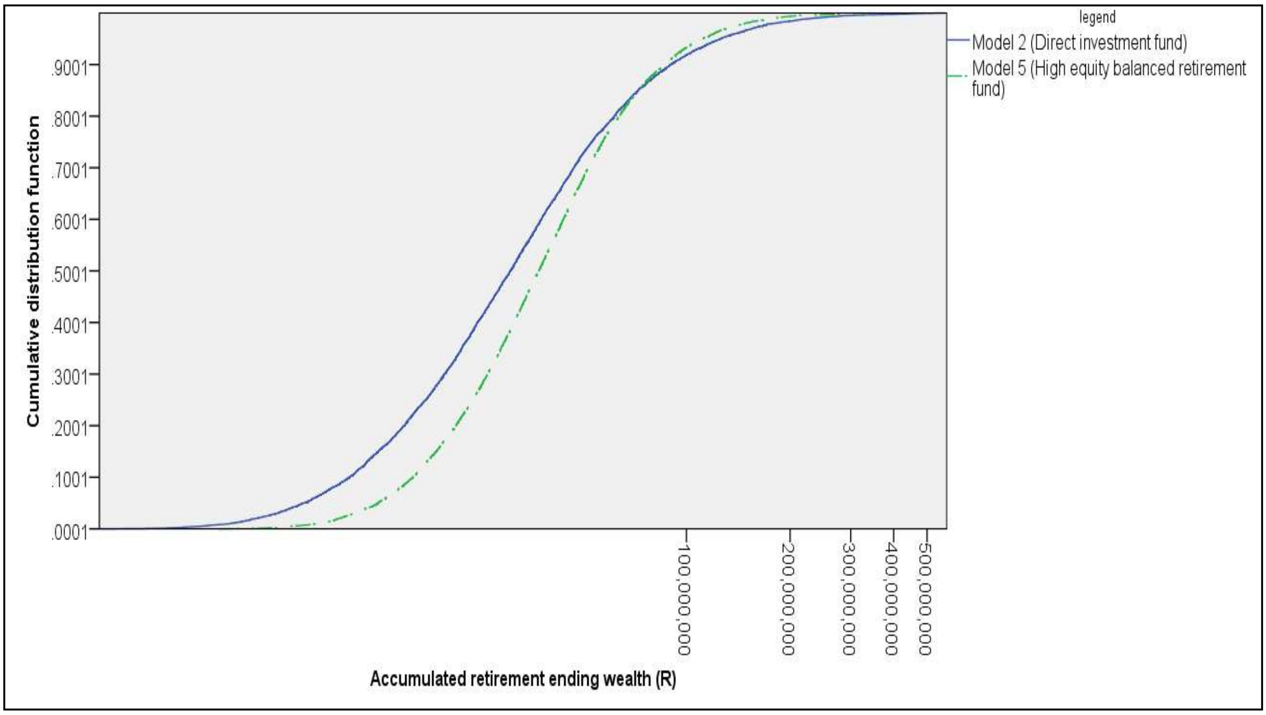
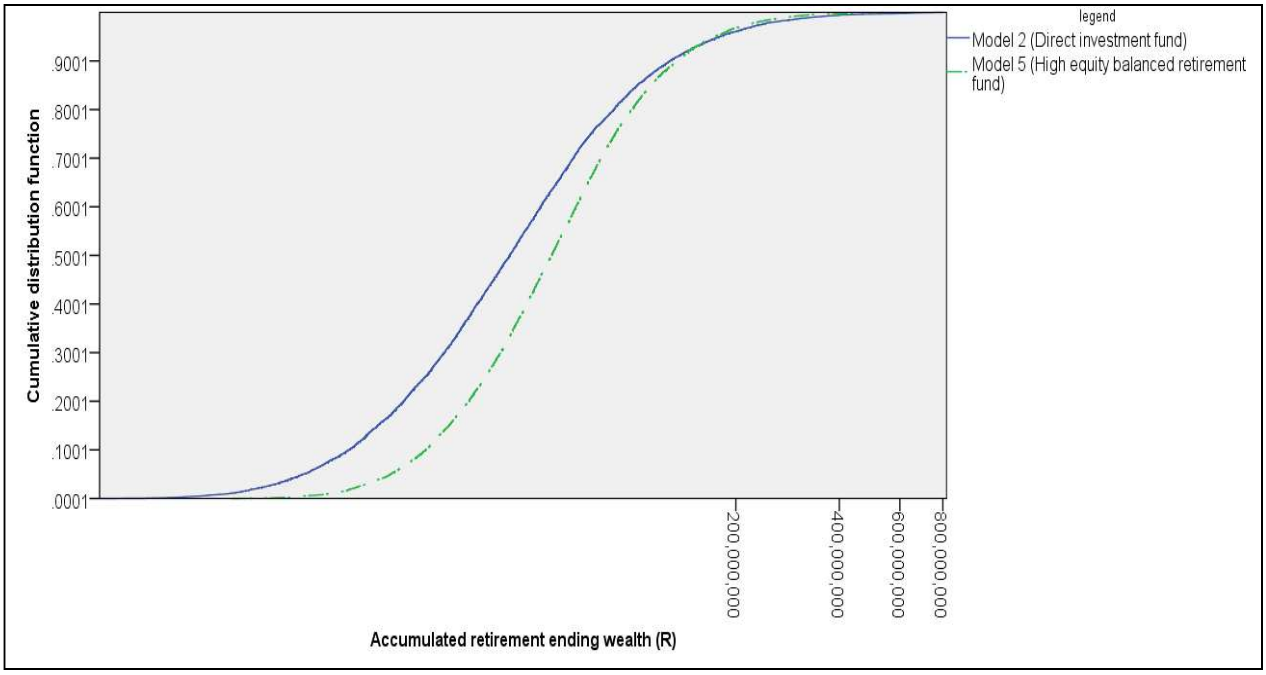
Figure E7: Cumulative distribution of accumulated retirement ending wealth for Model 2 against Model 5 (30-year investment horizon, 18% tax bracket)



Source: SPSS output

Figure E8: Cumulative distribution of accumulated retirement ending wealth for Model 2 against Model 5 (30-year investment horizon, 25% tax bracket)



Source: SPSS output

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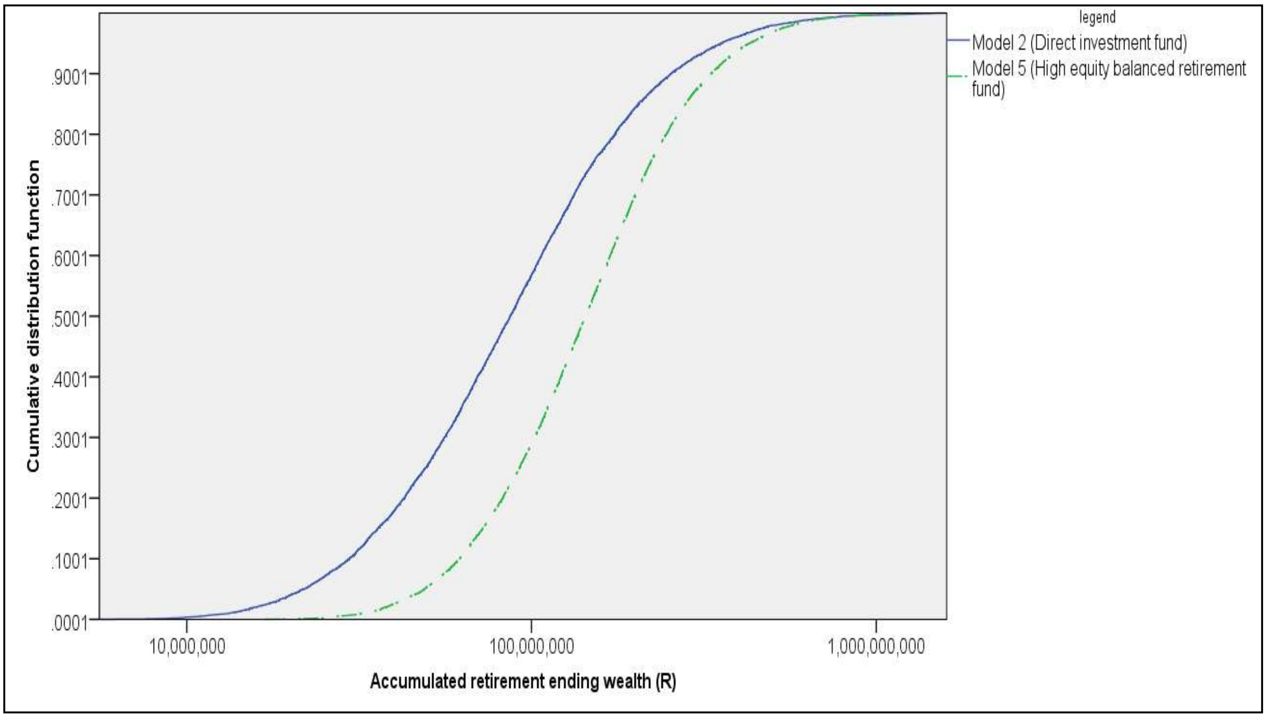
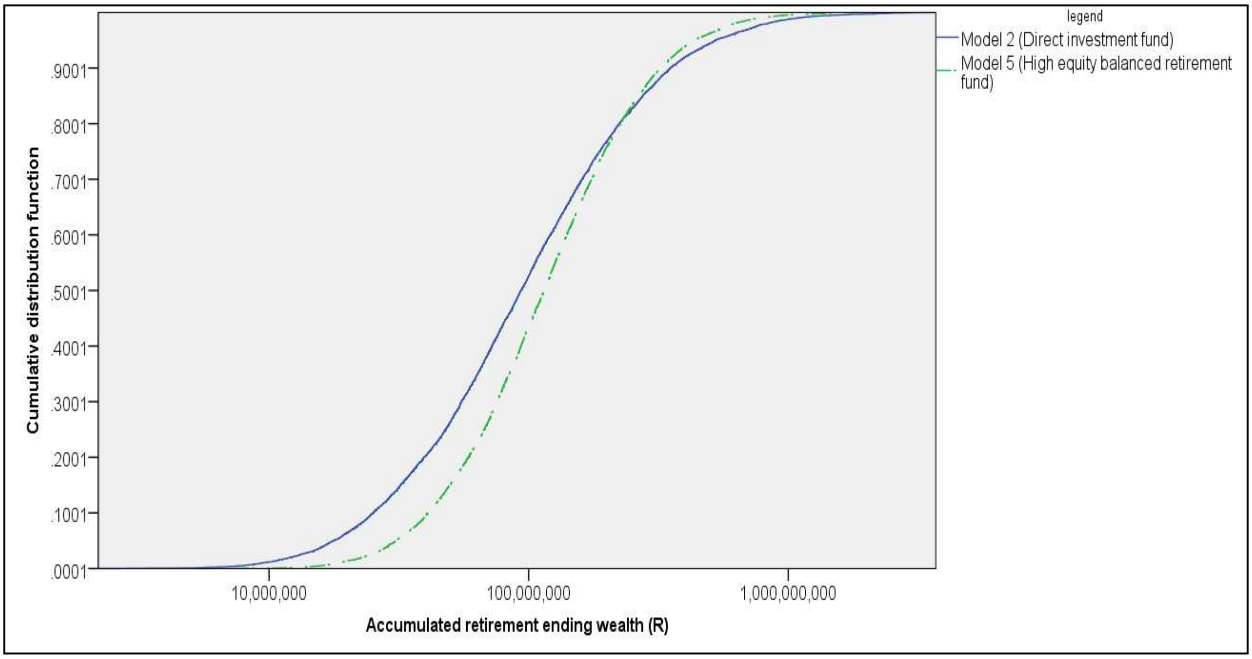
Figure E9: Cumulative distribution of accumulated retirement ending wealth for Model 2 against Model 5 (30-year investment horizon, 40% tax bracket)



Source: SPSS output

Figure E10: Cumulative distribution of accumulated retirement ending wealth for Model 2 against Model 5 (40-year investment horizon, 18% tax bracket)



Source: SPSS output

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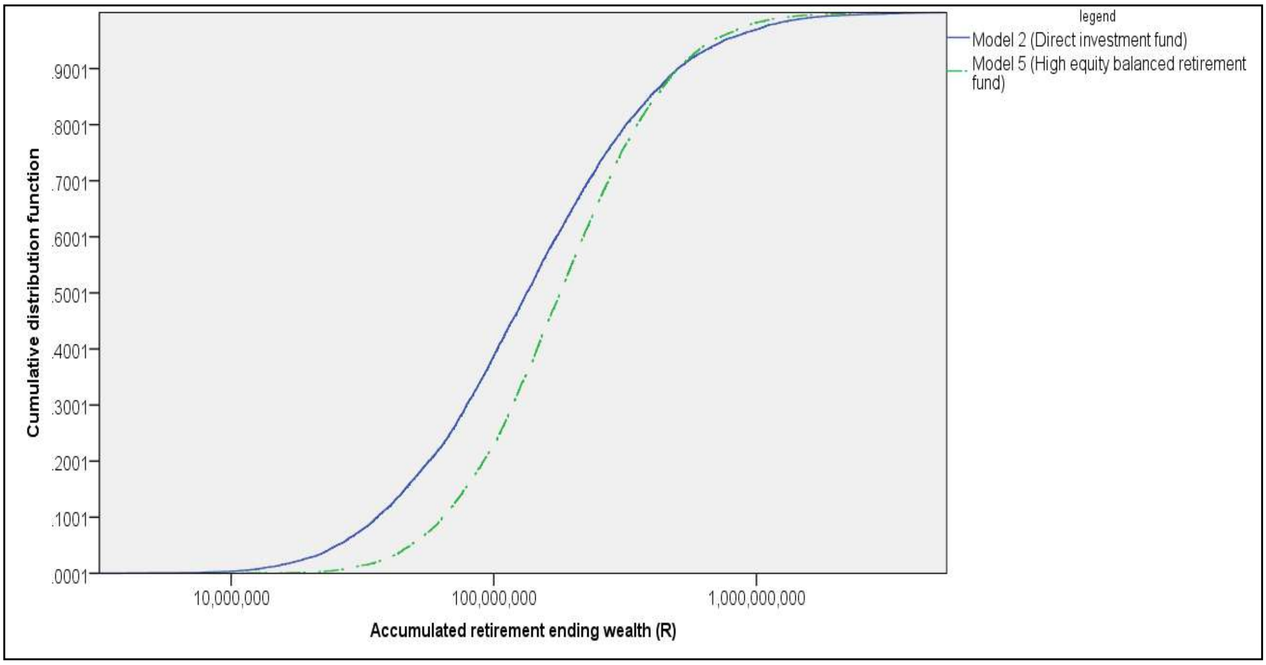
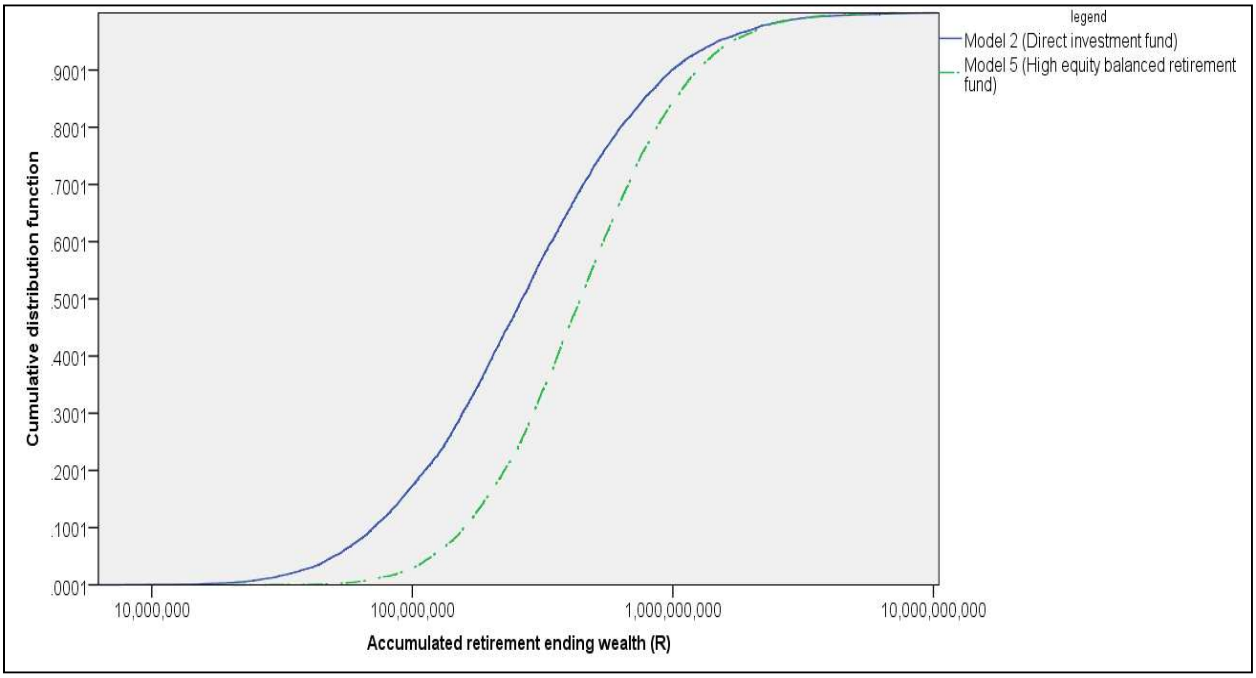
Figure E11: Cumulative distribution of accumulated retirement ending wealth for Model 2 against Model 5 (40-year investment horizon, 25% tax bracket)



Source: SPSS output

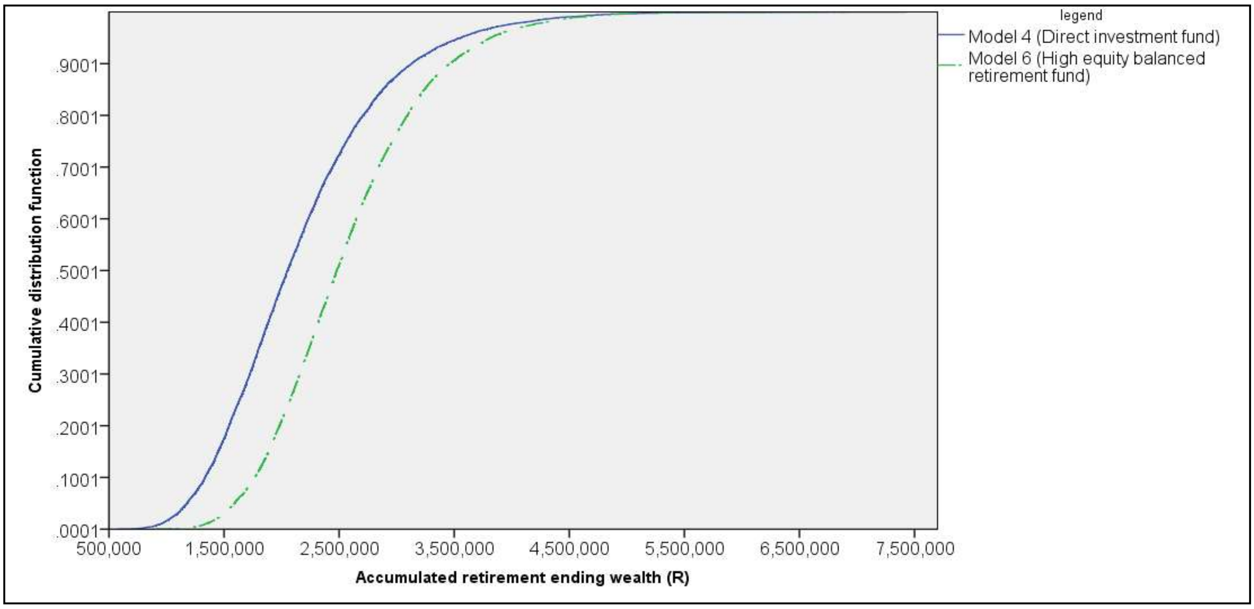
Figure E12: Cumulative distribution of accumulated retirement ending wealth for Model 2 against Model 5 (40-year investment horizon, 40% tax bracket)



Source: SPSS output

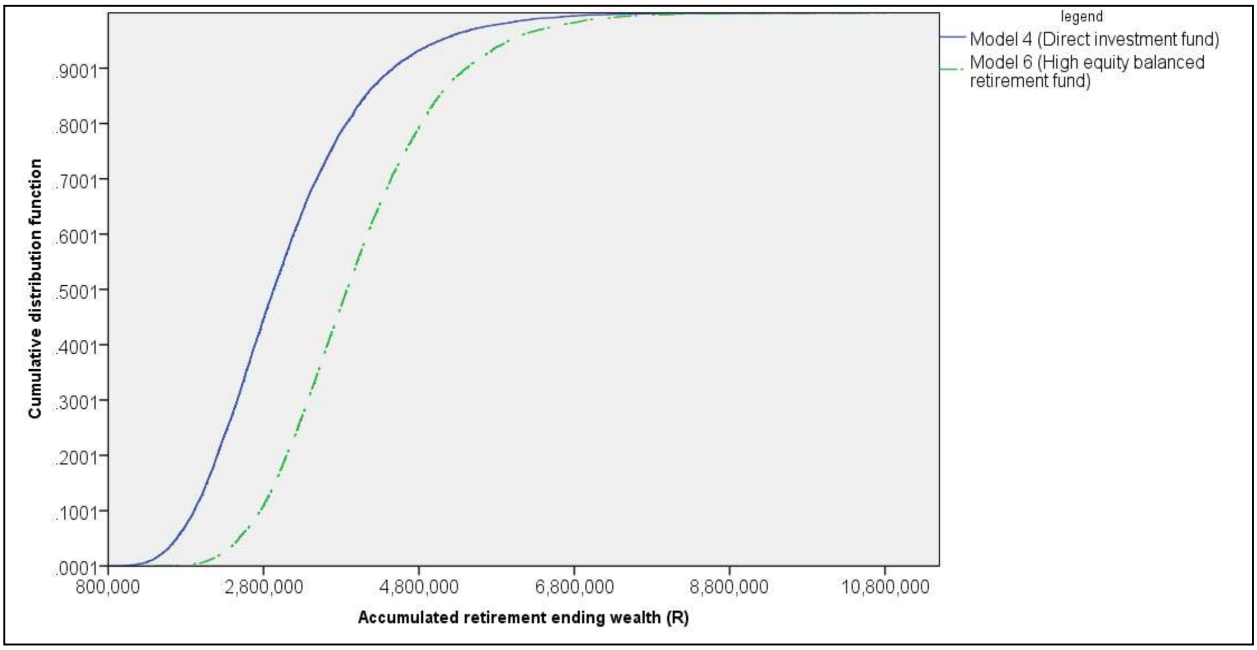
E2. HYPOTHESIS 1B

Figure E13: Cumulative distribution of accumulated retirement ending wealth for Model 4 against Model 6 (10-year investment horizon, 18% tax bracket)



Source: SPSS output

Figure E14: Cumulative distribution of accumulated retirement ending wealth for Model 4 against Model 6 (10-year investment horizon, 25% tax bracket)



Source: SPSS output

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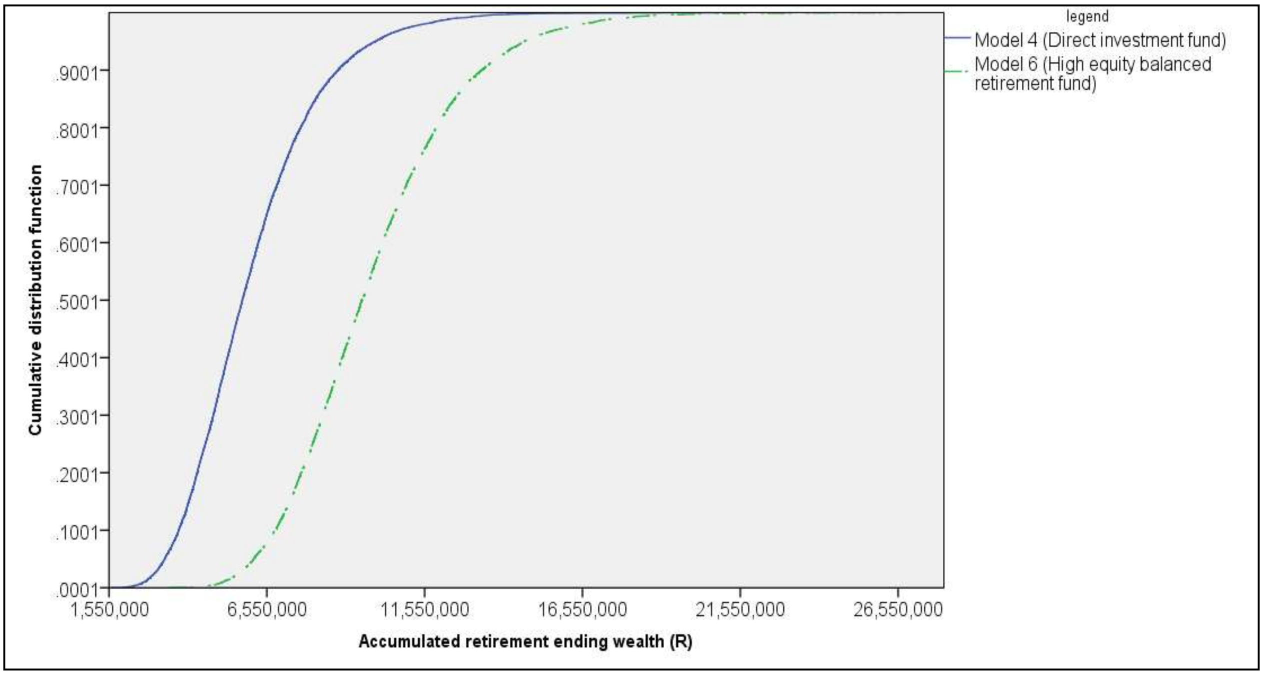
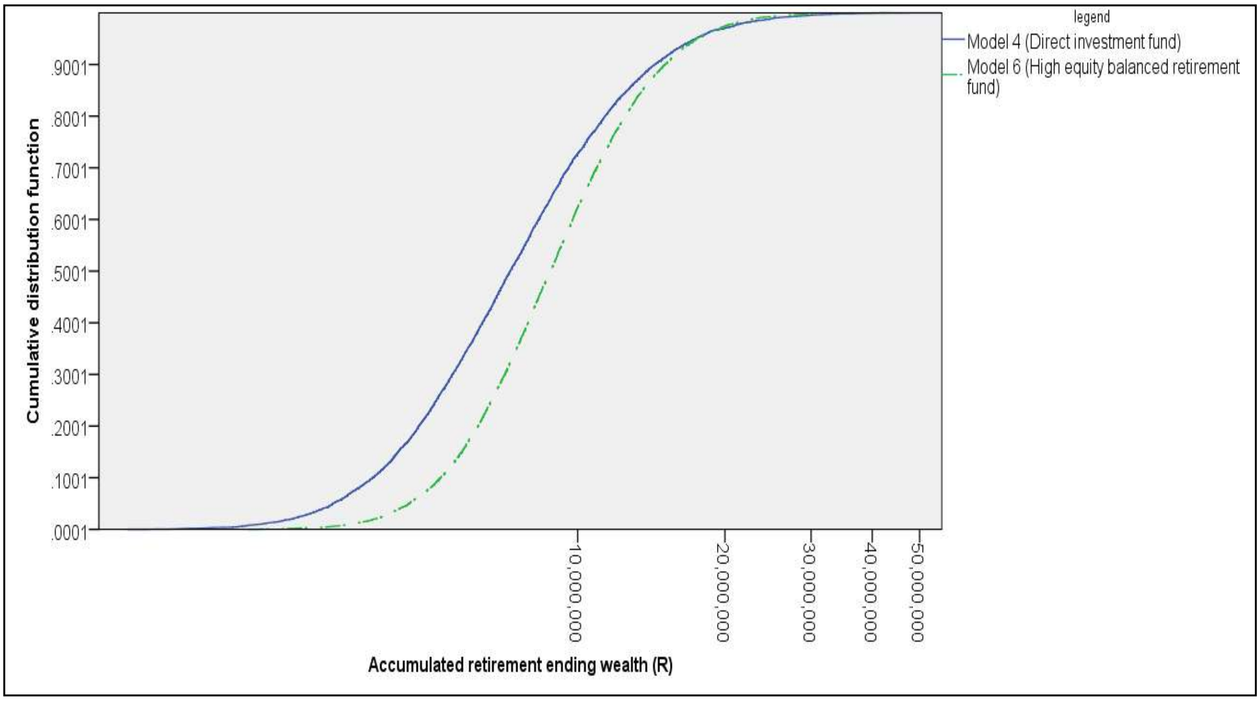
Figure E15: Cumulative distribution of accumulated retirement ending wealth for Model 4 against Model 6 (10-year investment horizon, 40% tax bracket)



Source: SPSS output

Figure E16: Cumulative distribution of accumulated retirement ending wealth for Model 4 against Model 6 (20-year investment horizon, 18% tax bracket)



Source: SPSS output

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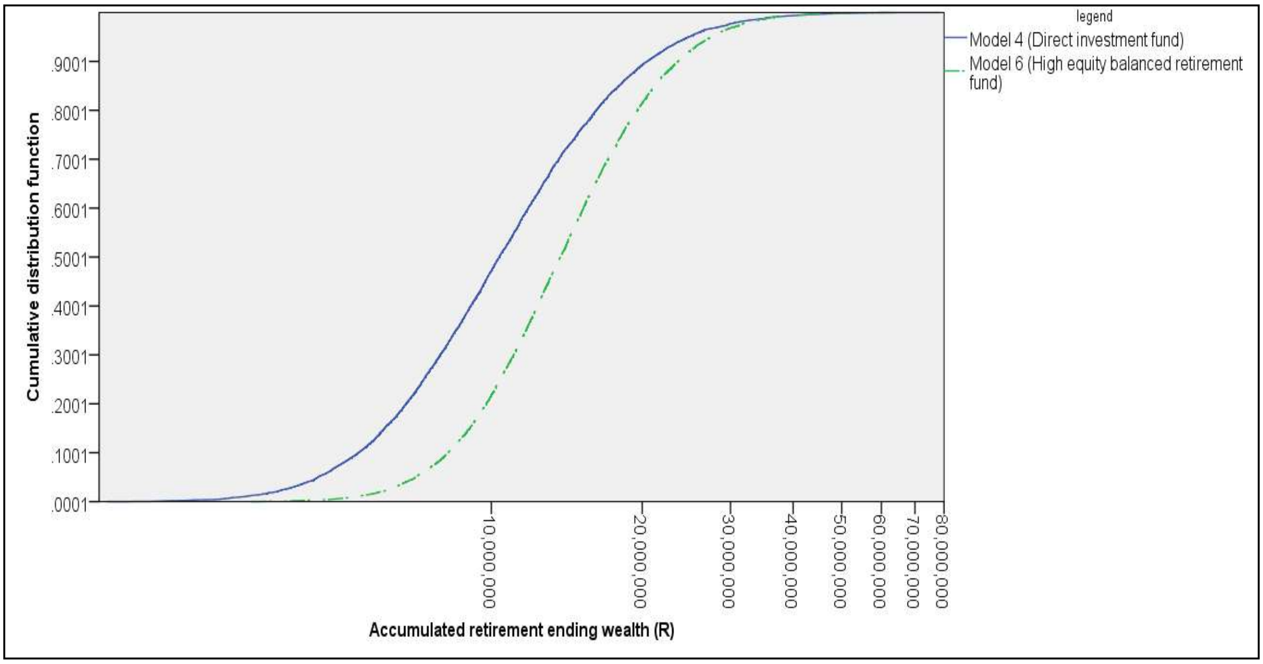
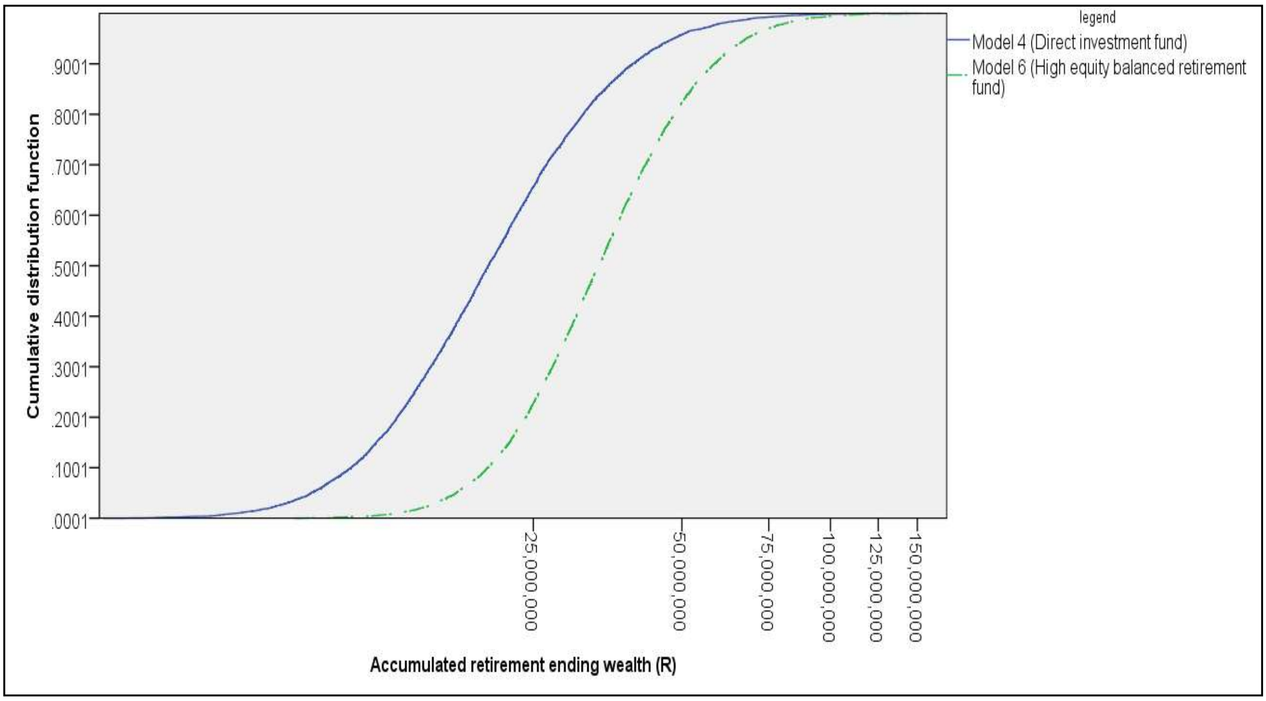
Figure E17: Cumulative distribution of accumulated retirement ending wealth for Model 4 against Model 6 (20-year investment horizon, 25% tax bracket)



Source: SPSS output

Figure E18: Cumulative distribution of accumulated retirement ending wealth for Model 4 against Model 6 (20-year investment horizon, 40% tax bracket)



Source: SPSS output

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Figure E19: Cumulative distribution of accumulated retirement ending wealth for Model 4 against Model 6 (30-year investment horizon, 18% tax bracket)

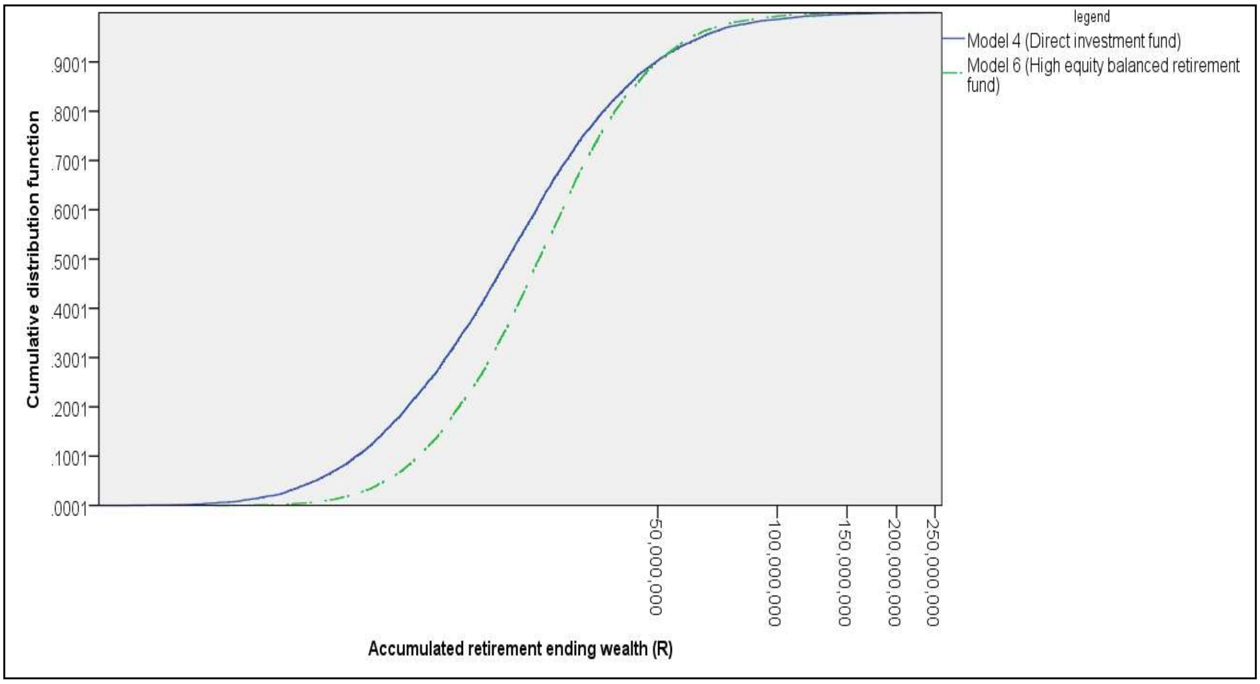

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Figure E20: Cumulative distribution of accumulated retirement ending wealth for Model 4 against Model 6 (30-year investment horizon, 25% tax bracket)

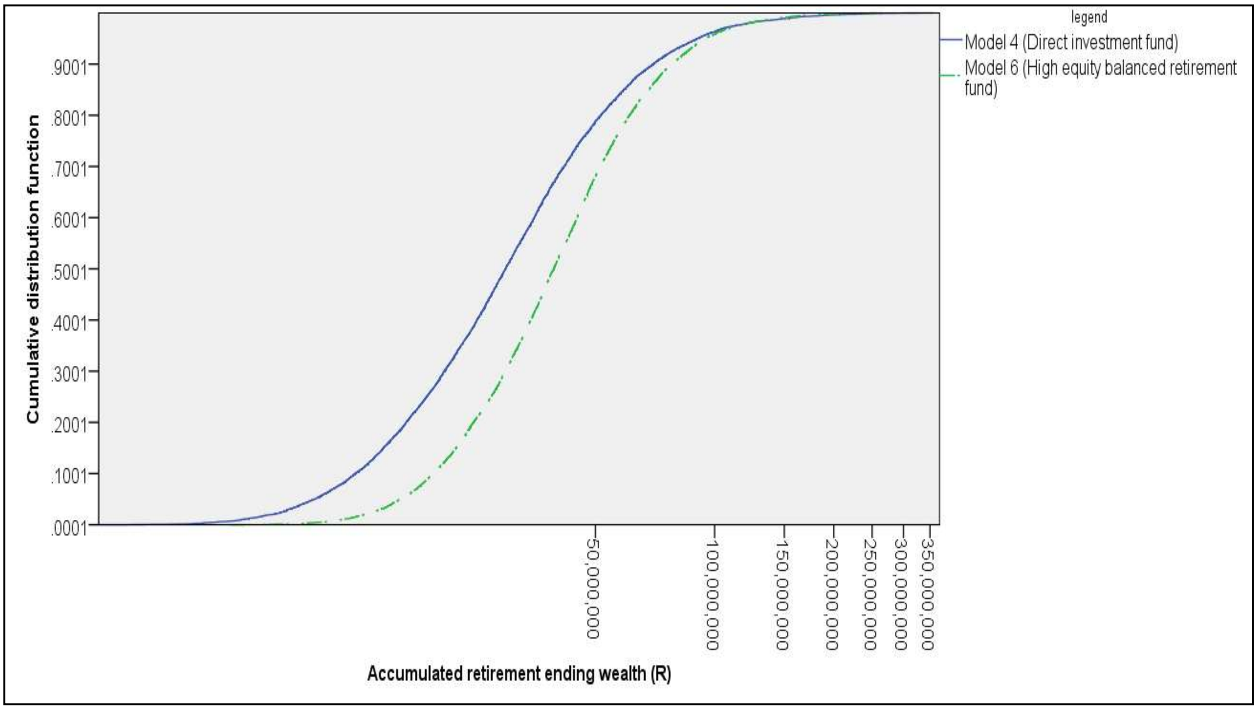

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Figure E21: Cumulative distribution of accumulated retirement ending wealth for Model 4 against Model 6 (30-year investment horizon, 40% tax bracket)

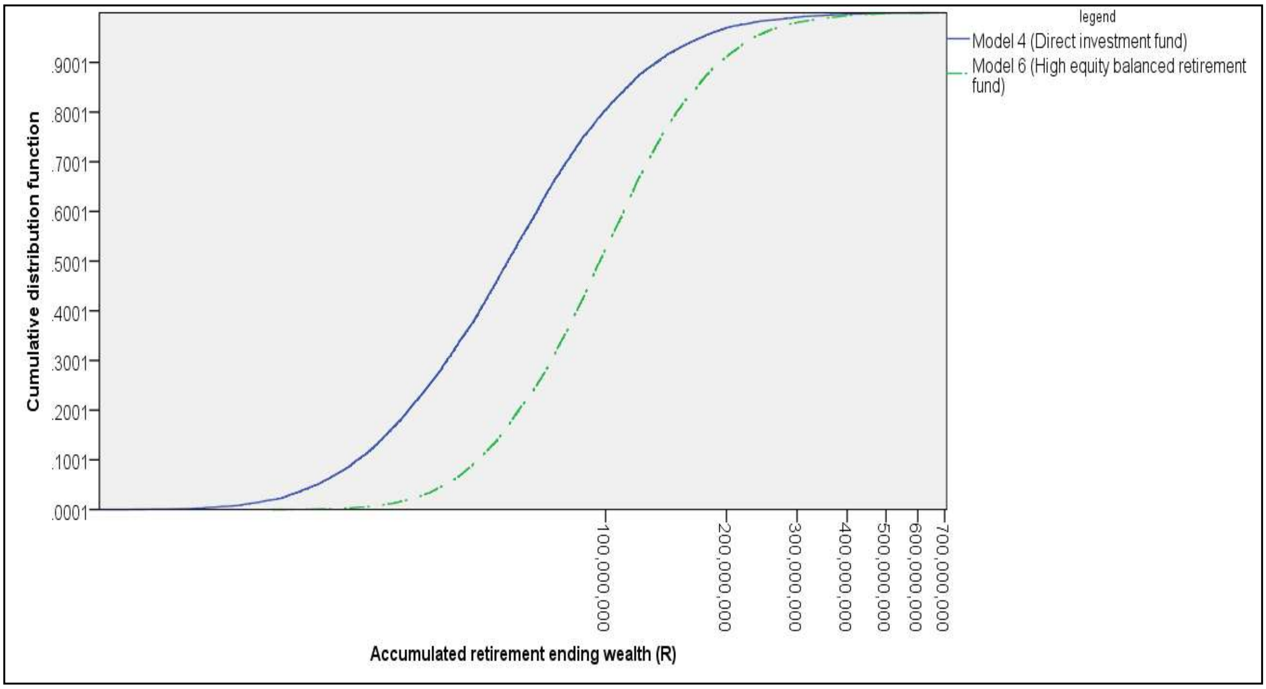

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Figure E22: Cumulative distribution of accumulated retirement ending wealth for Model 4 against Model 6 (40-year investment horizon, 18% tax bracket)

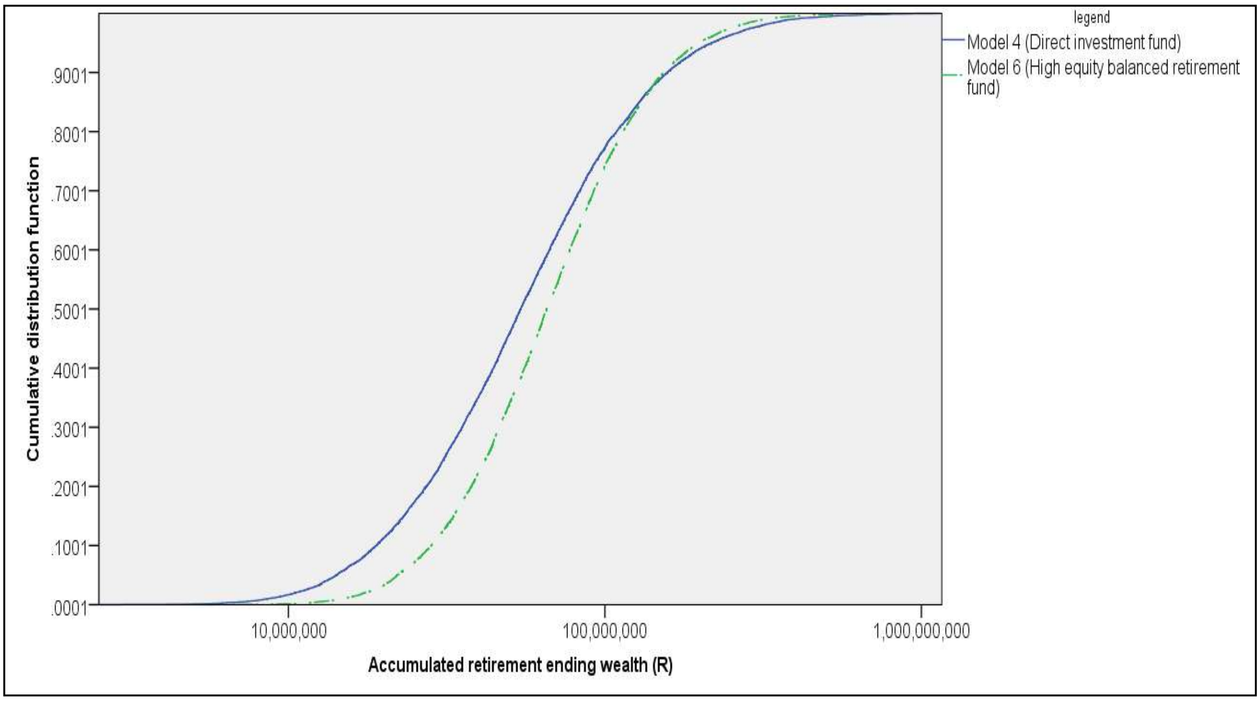

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Figure E23: Cumulative distribution of accumulated retirement ending wealth for Model 4 against Model 6 (40-year investment horizon, 25% tax bracket)

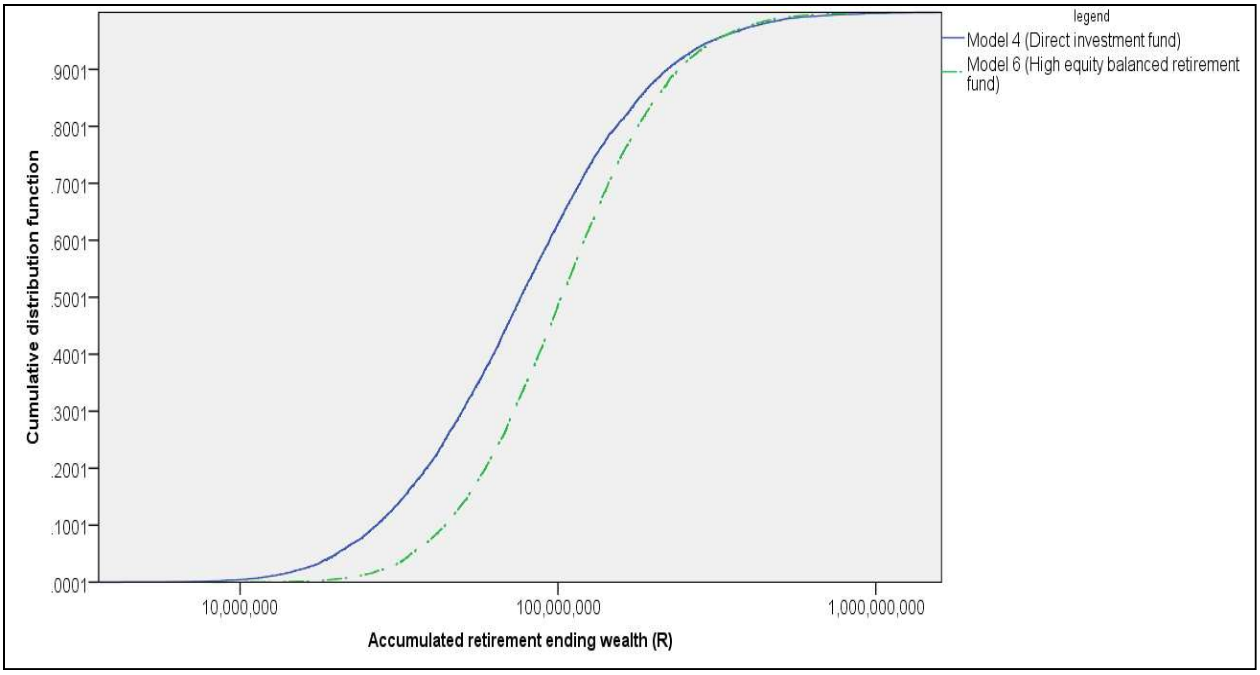

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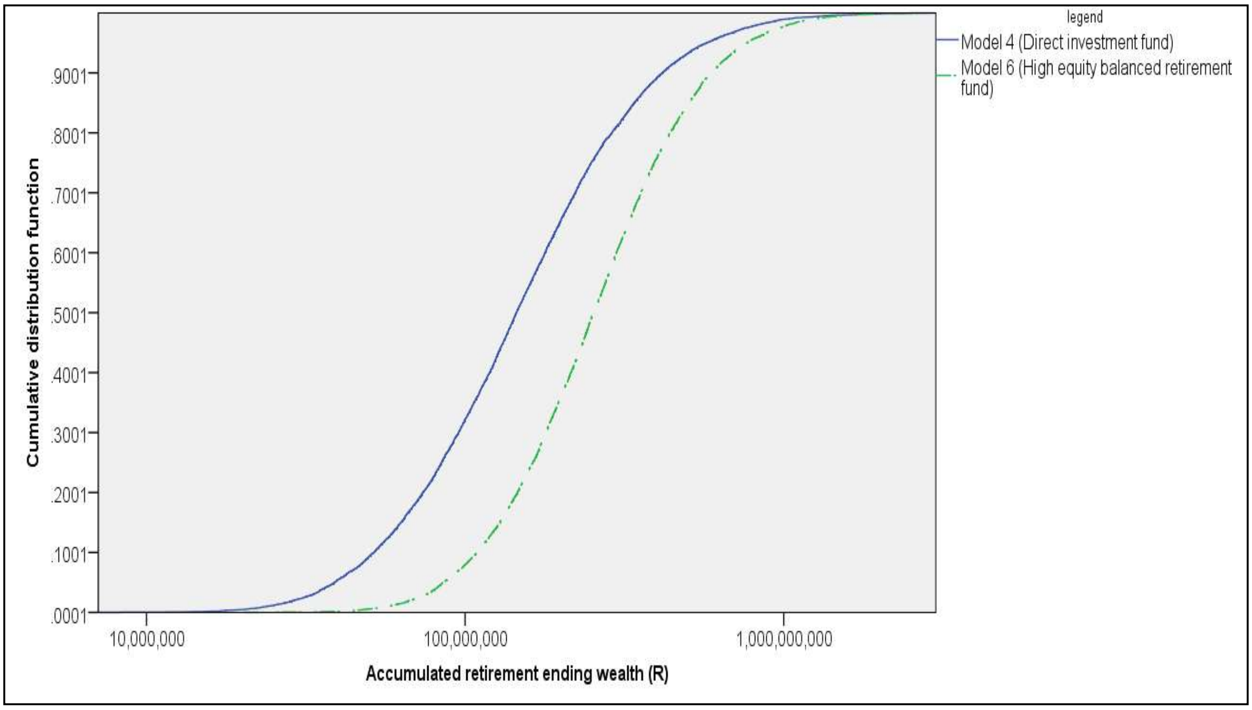
Figure E24: Cumulative distribution of accumulated retirement ending wealth for Model 4 against Model 6 (40-year investment horizon, 40% tax bracket)



Source: SPSS output

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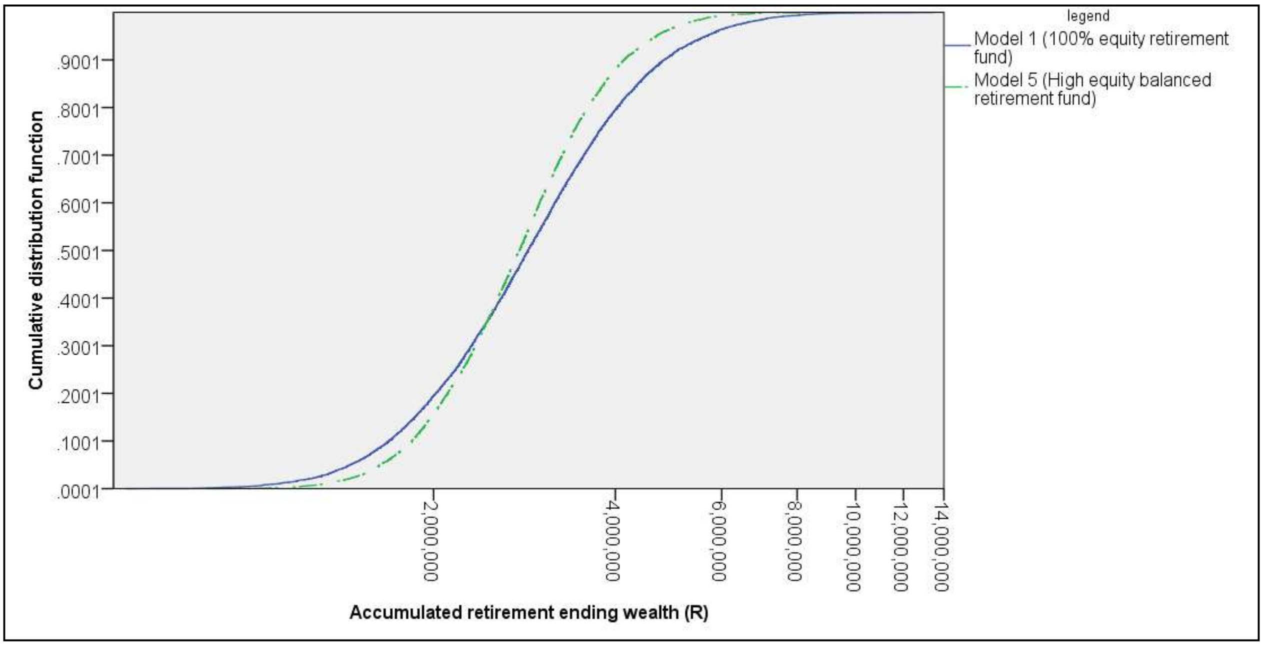
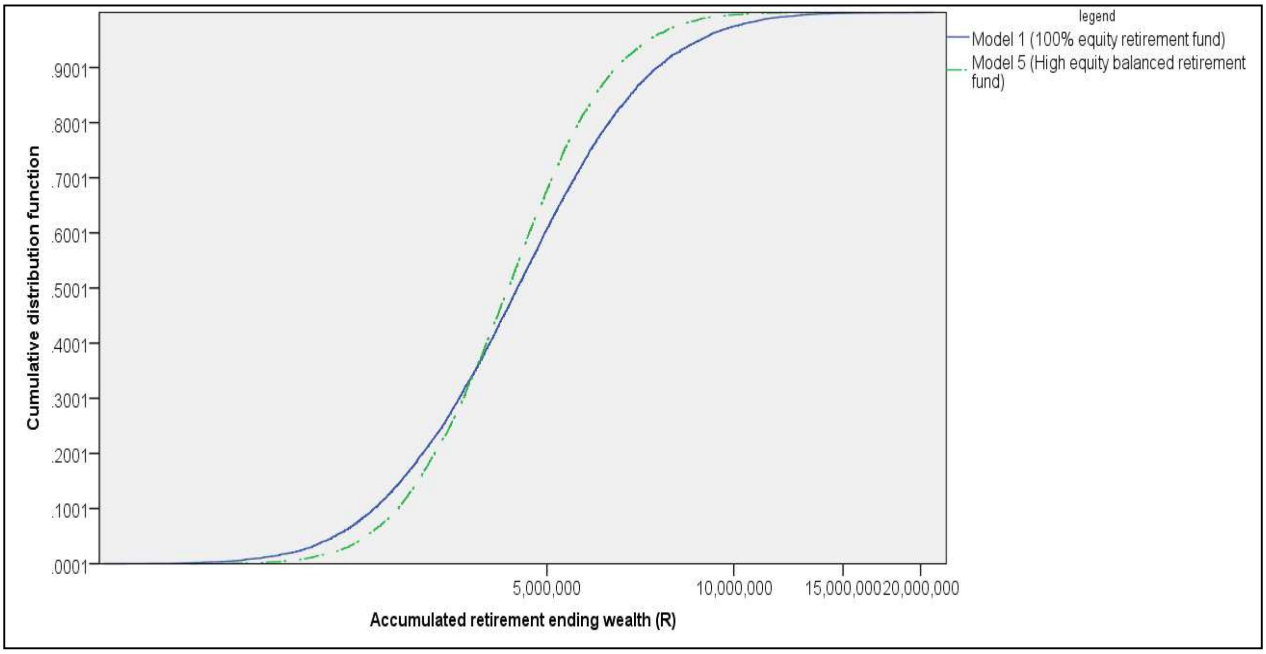
E3. HYPOTHESIS 1C

Figure E25: Cumulative distribution of accumulated retirement ending wealth for Model 1 against Model 5 (10-year investment horizon, 18% tax bracket)



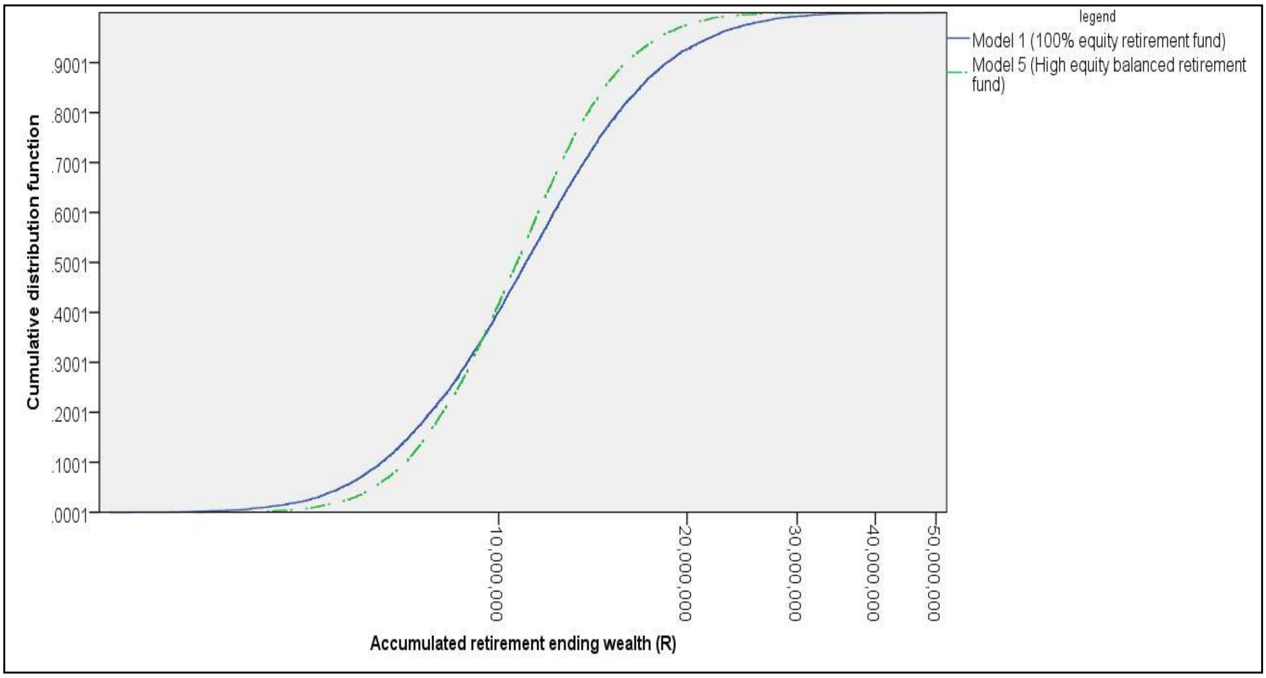
Source: SPSS output

Figure E26: Cumulative distribution of accumulated retirement ending wealth for Model 1 against Model 5 (10-year investment horizon, 25% tax bracket)



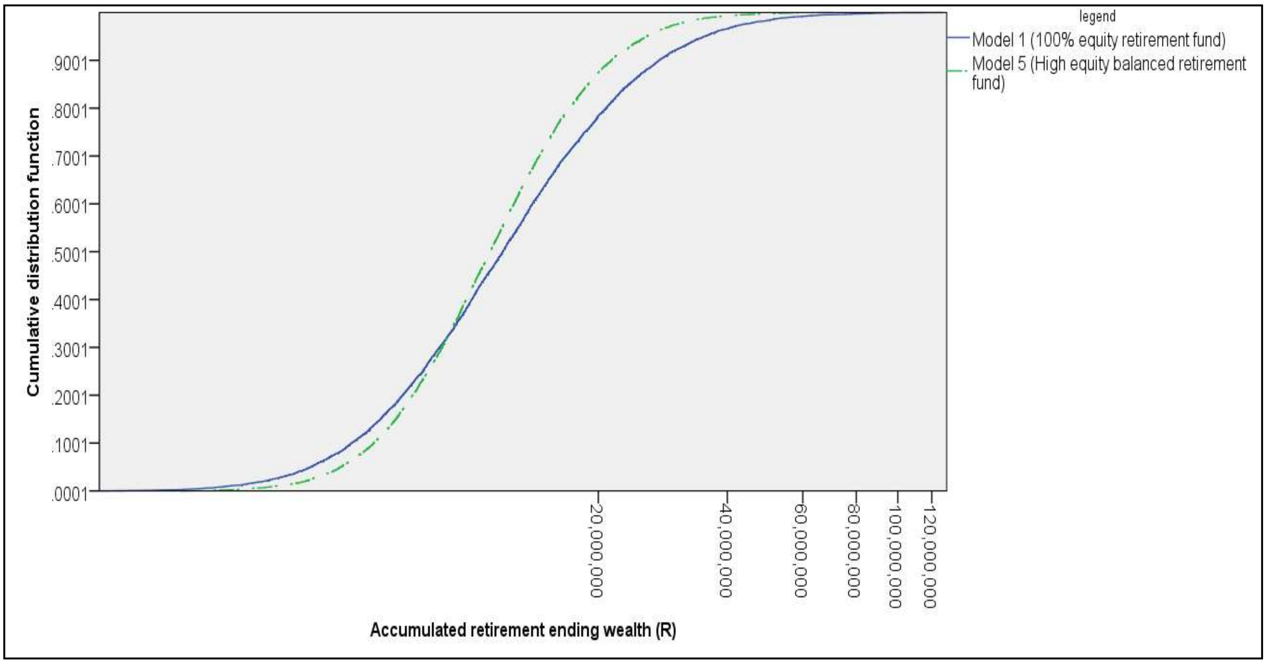
Source: SPSS output

Figure E27: Cumulative distribution of accumulated retirement ending wealth for Model 1 against Model 5 (10-year investment horizon, 40% tax bracket)



Source: SPSS output

Figure E28: Cumulative distribution of accumulated retirement ending wealth for Model 1 against Model 5 (20-year investment horizon, 18% tax bracket)



Source: SPSS output

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Figure E29: Cumulative distribution of accumulated retirement ending wealth for Model 1 against Model 5 (20-year investment horizon, 25% tax bracket)

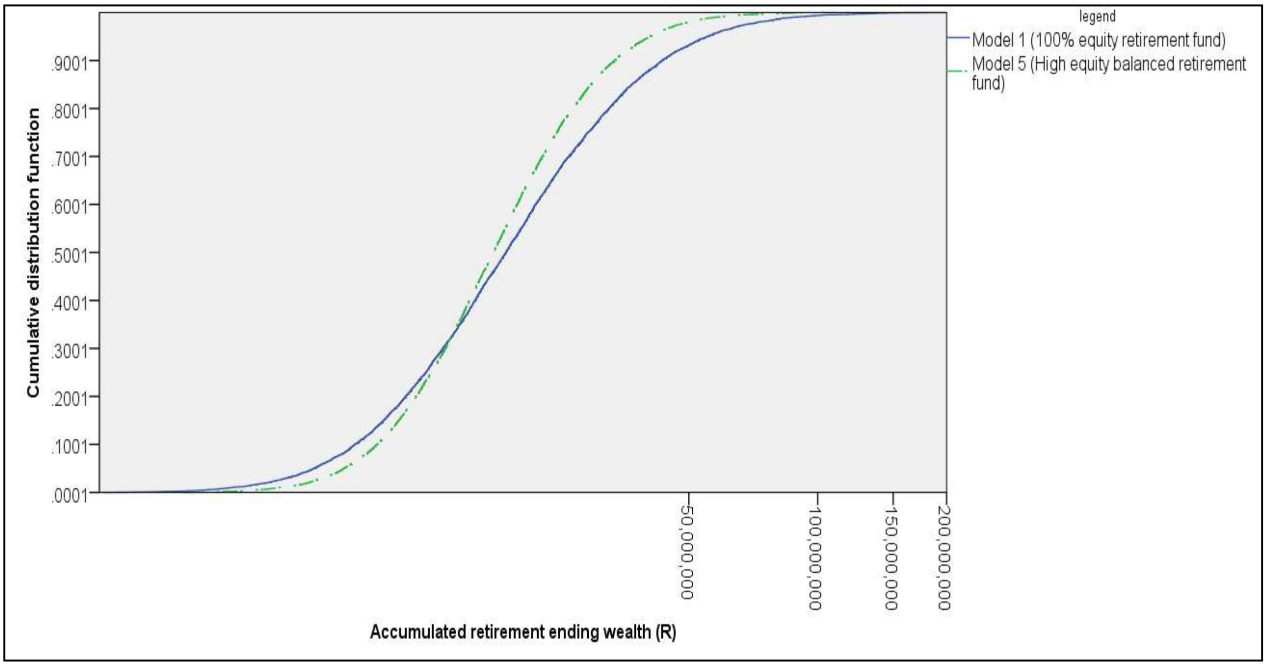

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Figure E30: Cumulative distribution of accumulated retirement ending wealth for Model 1 against Model 5 (20-year investment horizon, 40% tax bracket)

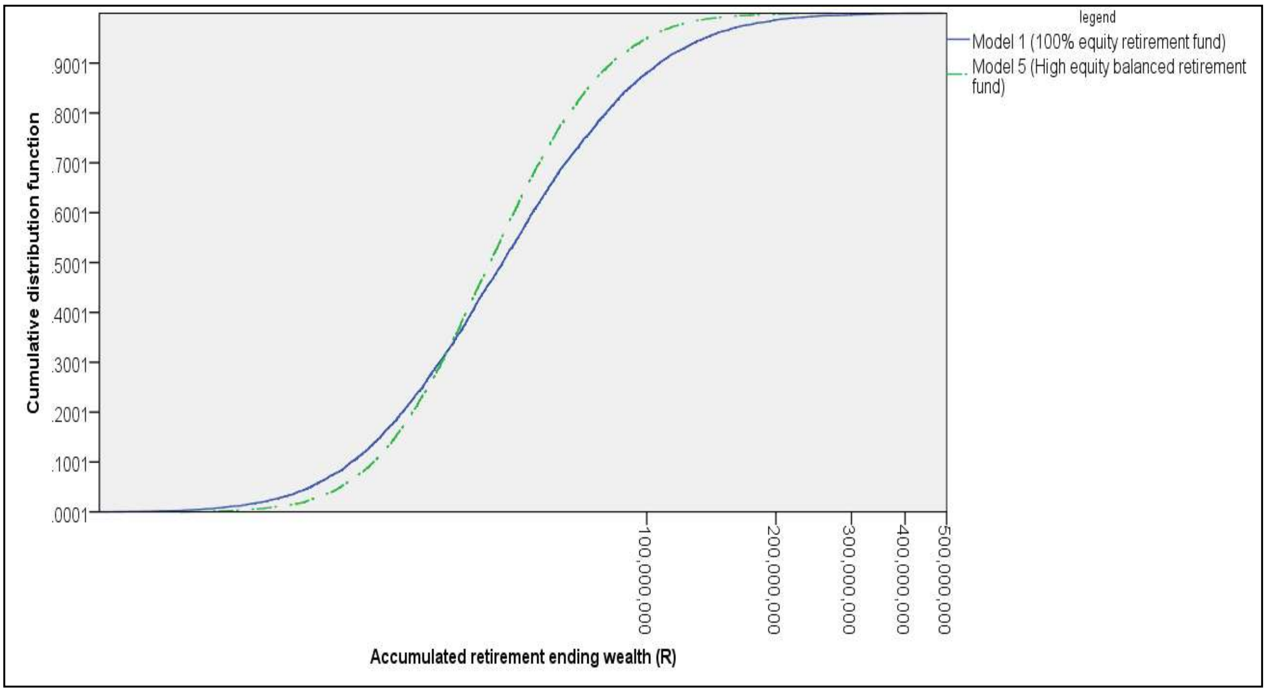

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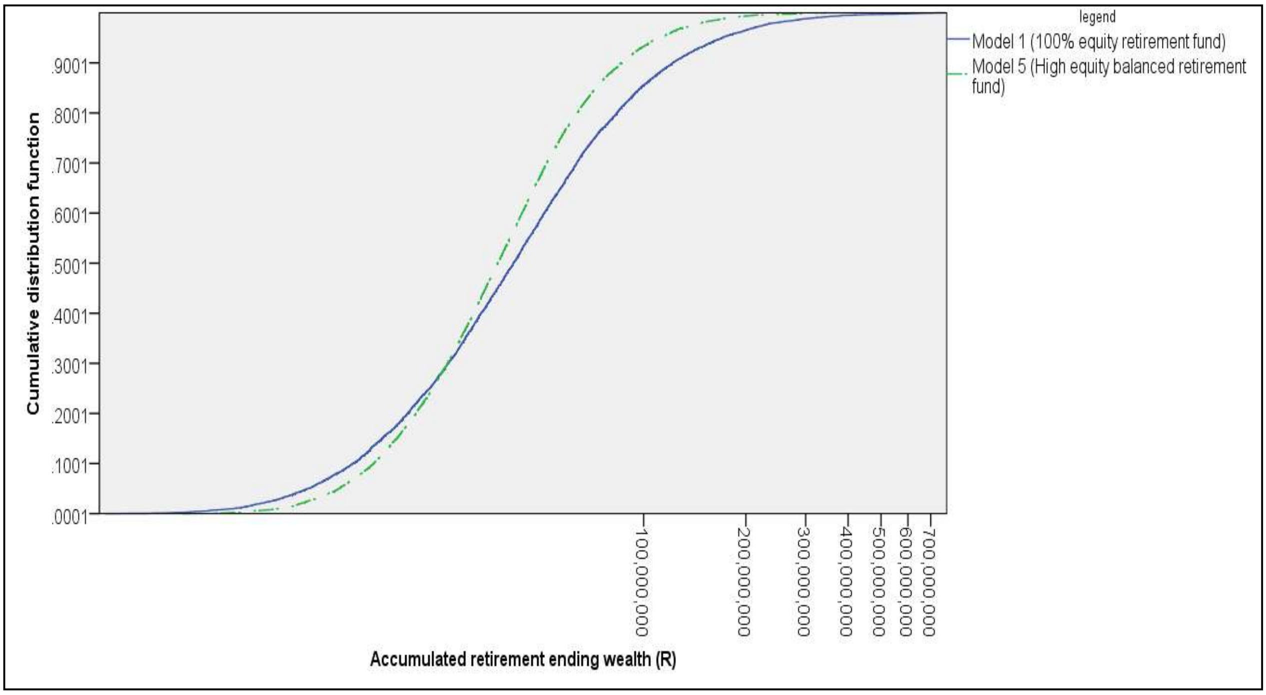
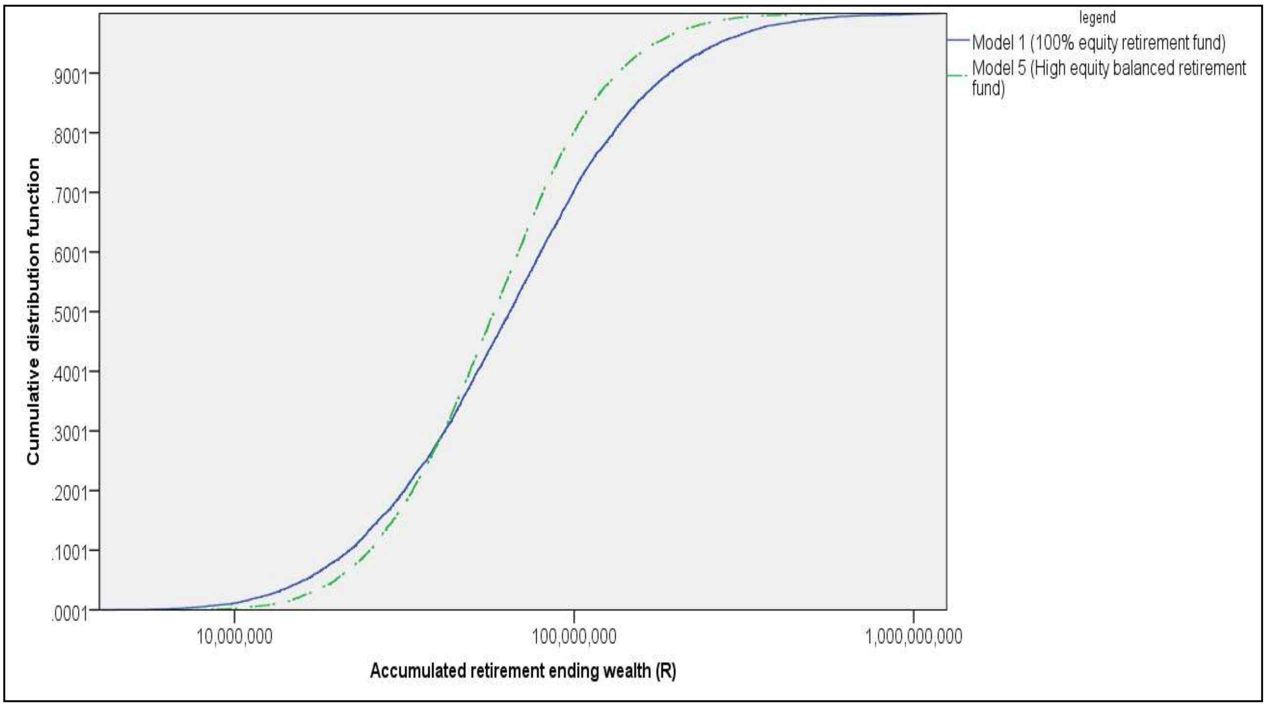
Figure E31: Cumulative distribution of accumulated retirement ending wealth for Model 1 against Model 5 (30-year investment horizon, 18% tax bracket)



Source: SPSS output

Figure E32: Cumulative distribution of accumulated retirement ending wealth for Model 1 against Model 5 (30-year investment horizon, 25% tax bracket)



Source: SPSS output

Figure E33: Cumulative distribution of accumulated retirement ending wealth for Model 1 against Model 5 (30-year investment horizon, 40% tax bracket)

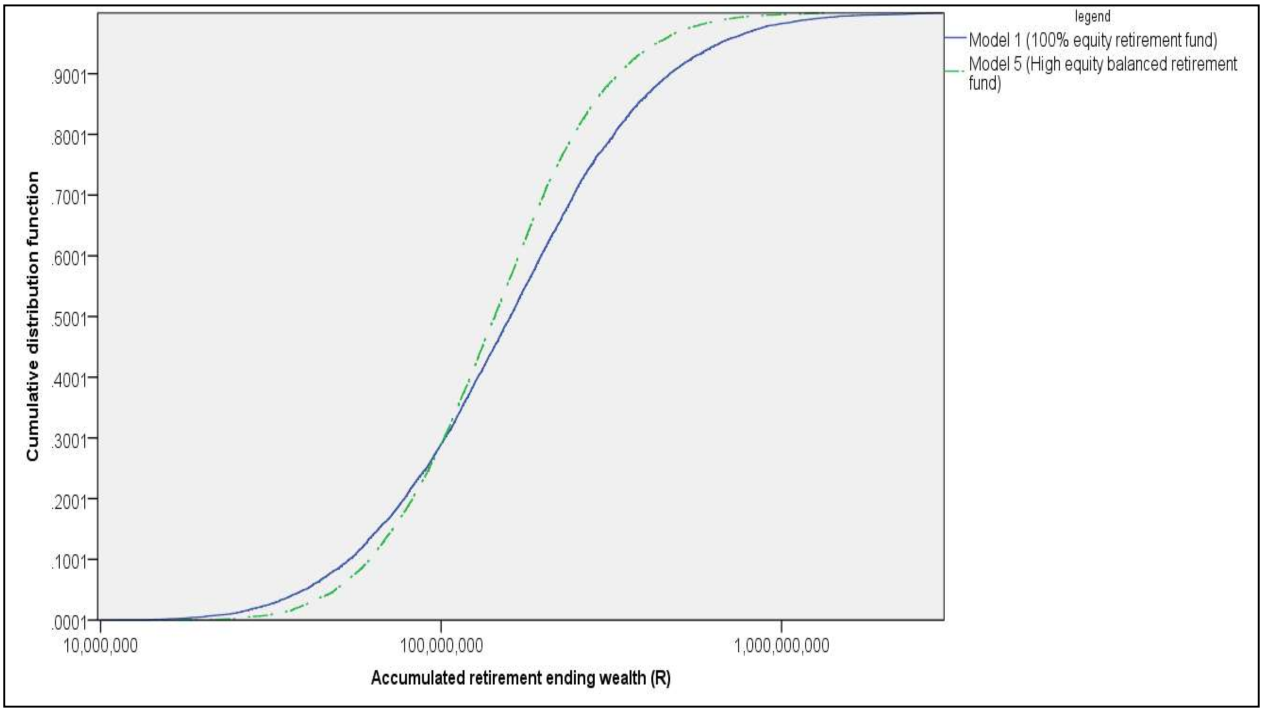


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Figure E34: Cumulative distribution of accumulated retirement ending wealth for Model 1 against Model 5 (40-year investment horizon, 18% tax bracket)

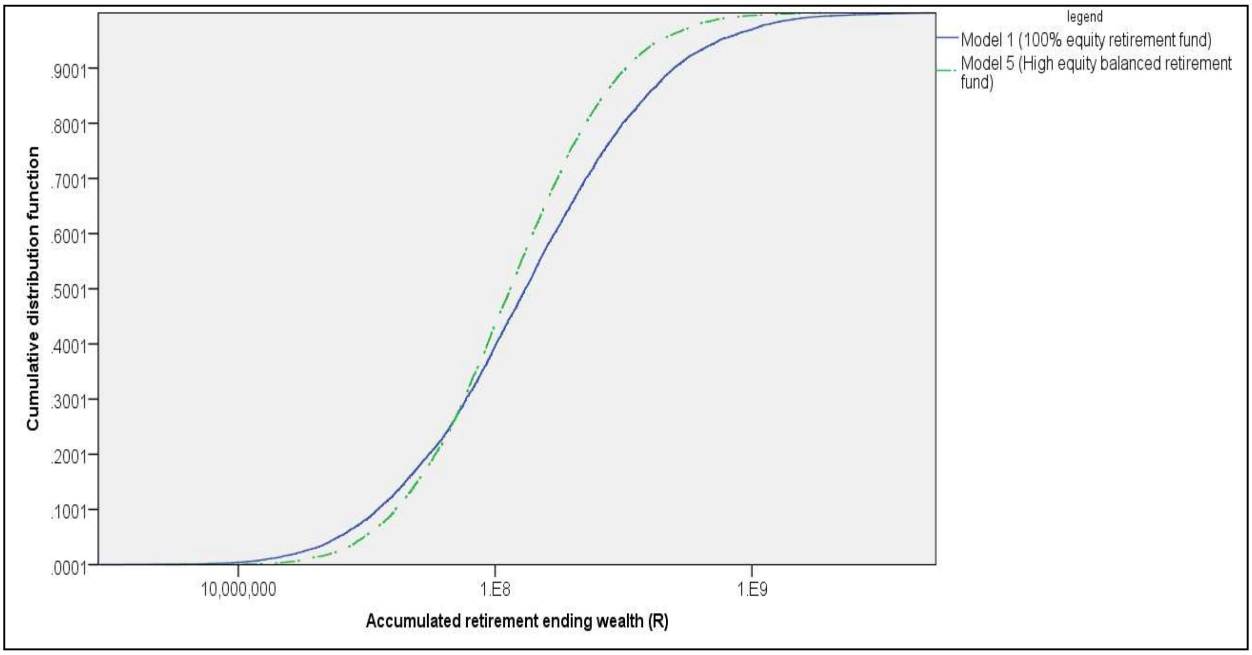

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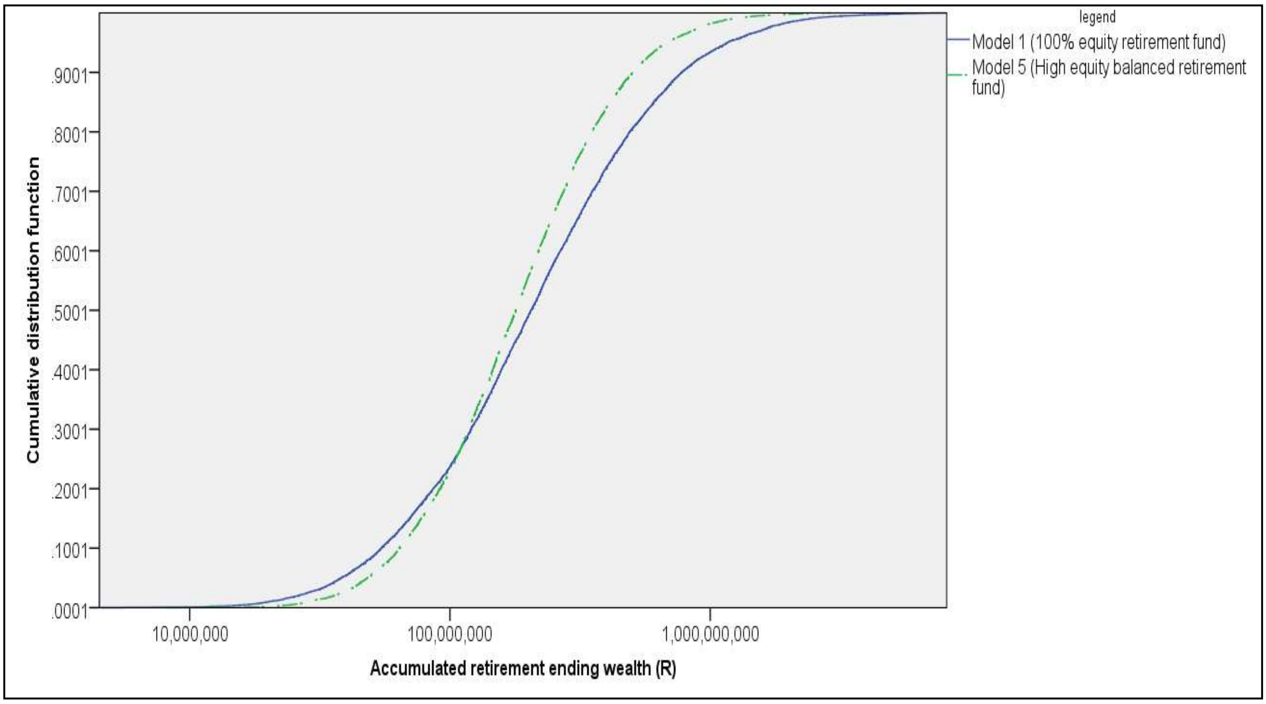
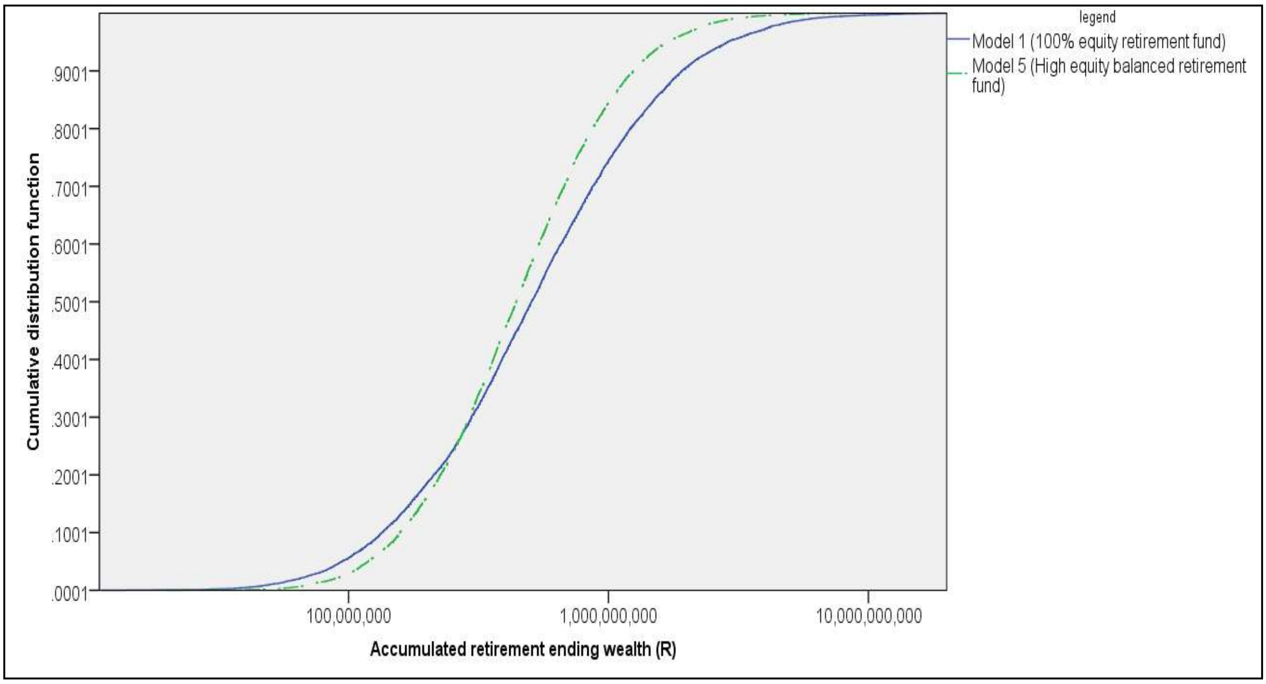
Figure E35: Cumulative distribution of accumulated retirement ending wealth for Model 1 against Model 5 (40-year investment horizon, 25% tax bracket)



Source: SPSS output

Figure E36: Cumulative distribution of accumulated retirement ending wealth for Model 1 against Model 5 (40-year investment horizon, 40% tax bracket)



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E4. HYPOTHESIS 1D

Figure E37: Cumulative distribution of accumulated retirement ending wealth for Model 3 against Model 6 (10-year investment horizon, 18% tax bracket)

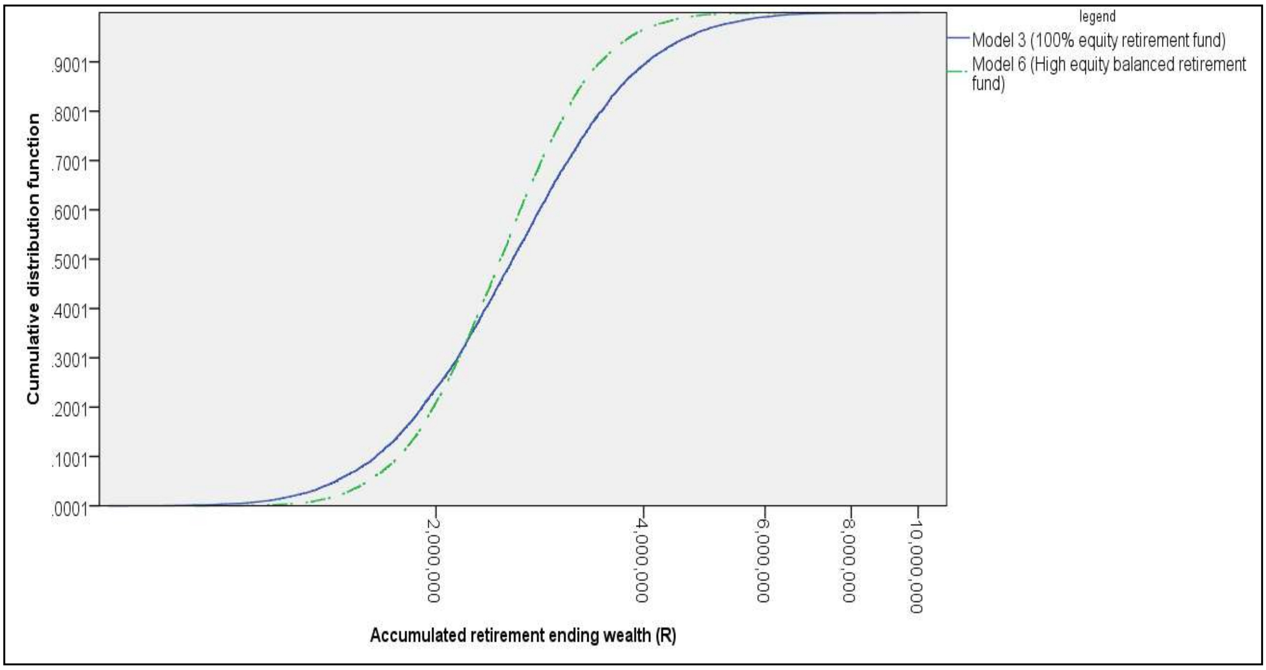

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Figure E38: Cumulative distribution of accumulated retirement ending wealth for Model 3 against Model 6 (10-year investment horizon, 25% tax bracket)

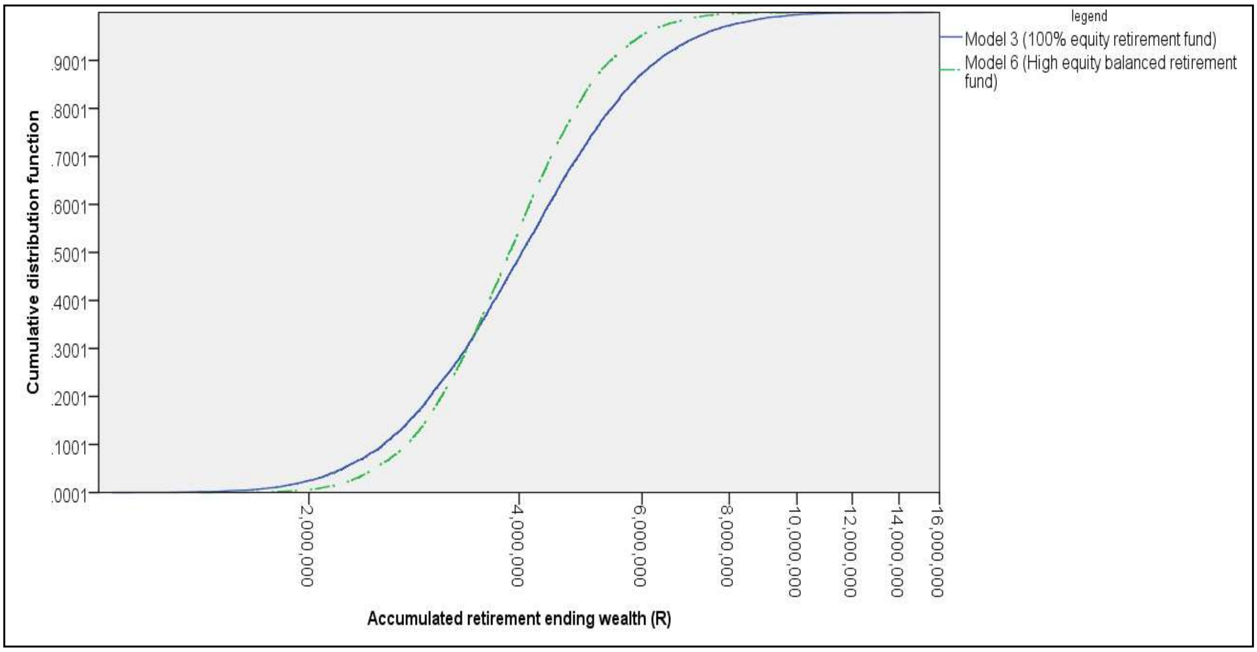

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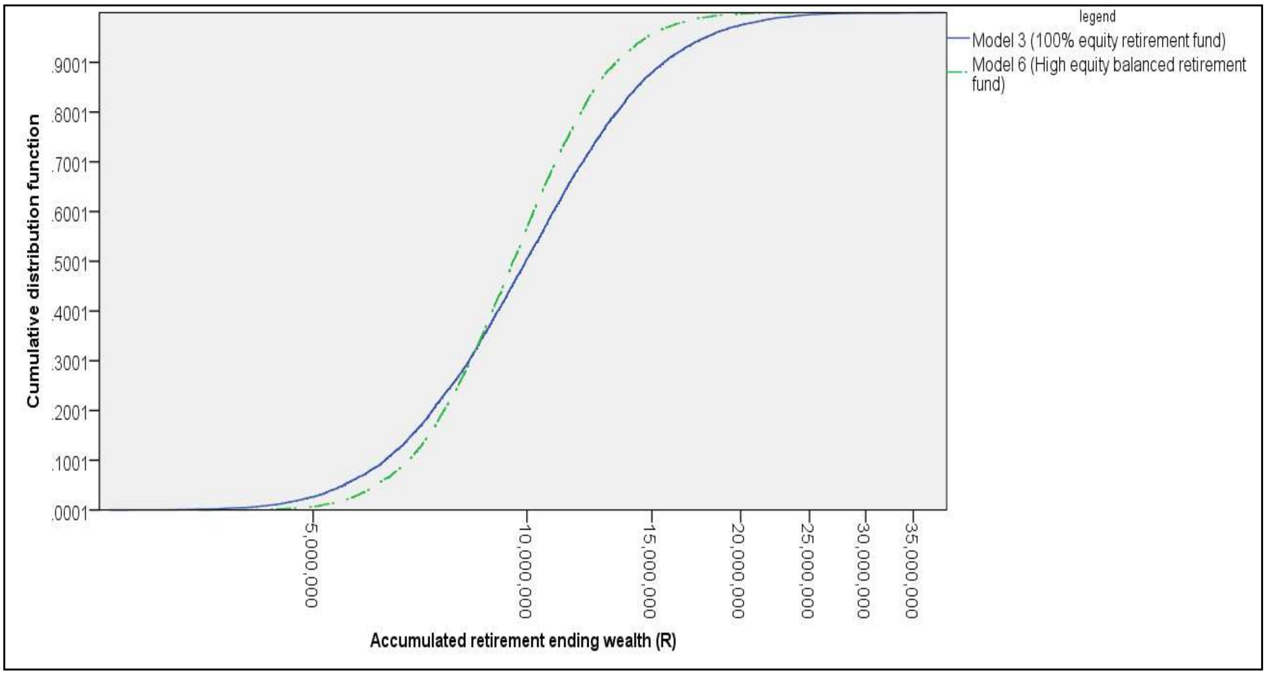
Figure E39: Cumulative distribution of accumulated retirement ending wealth for Model 3 against Model 6 (10-year investment horizon, 40% tax bracket)



Source: SPSS output

Figure E40: Cumulative distribution of accumulated retirement ending wealth for Model 3 against Model 6 (20-year investment horizon, 18% tax bracket)

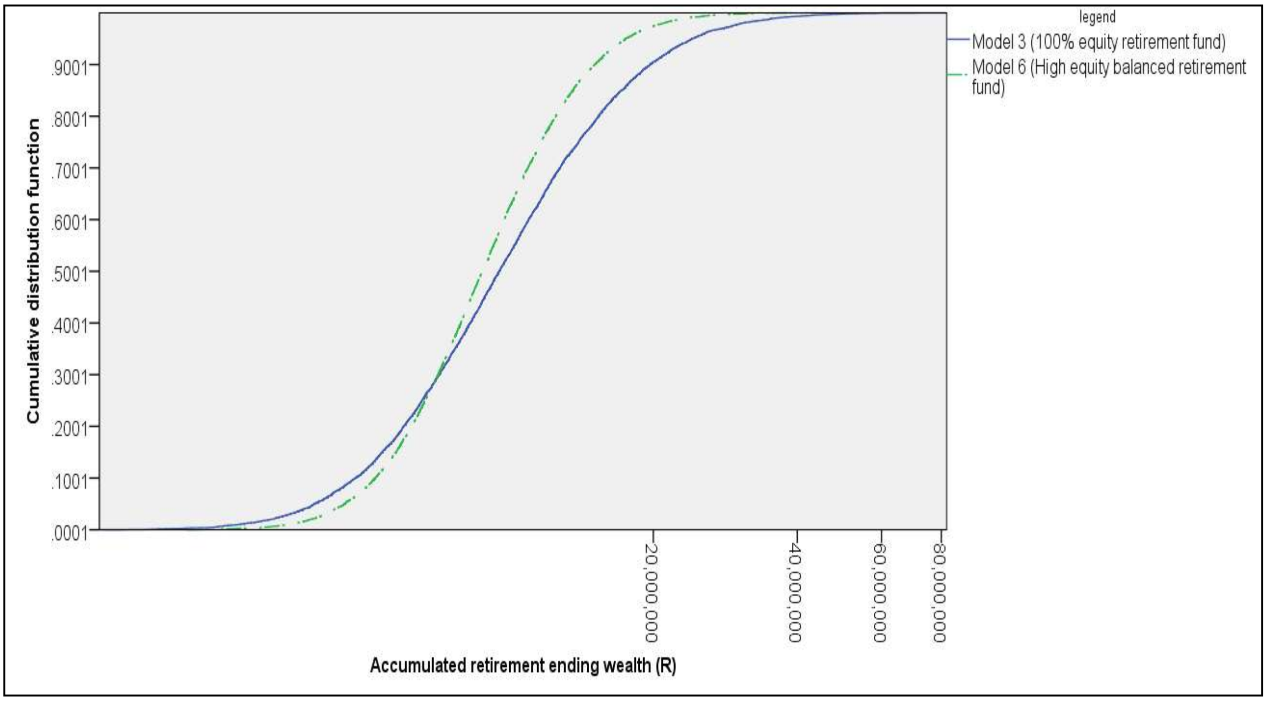


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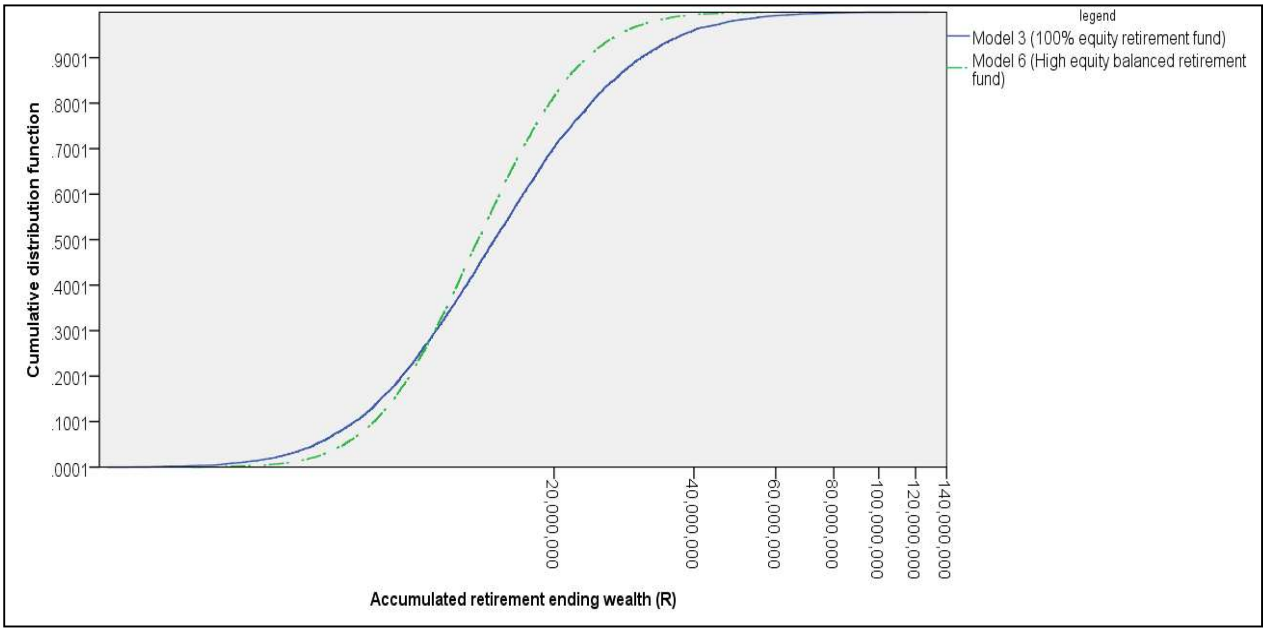
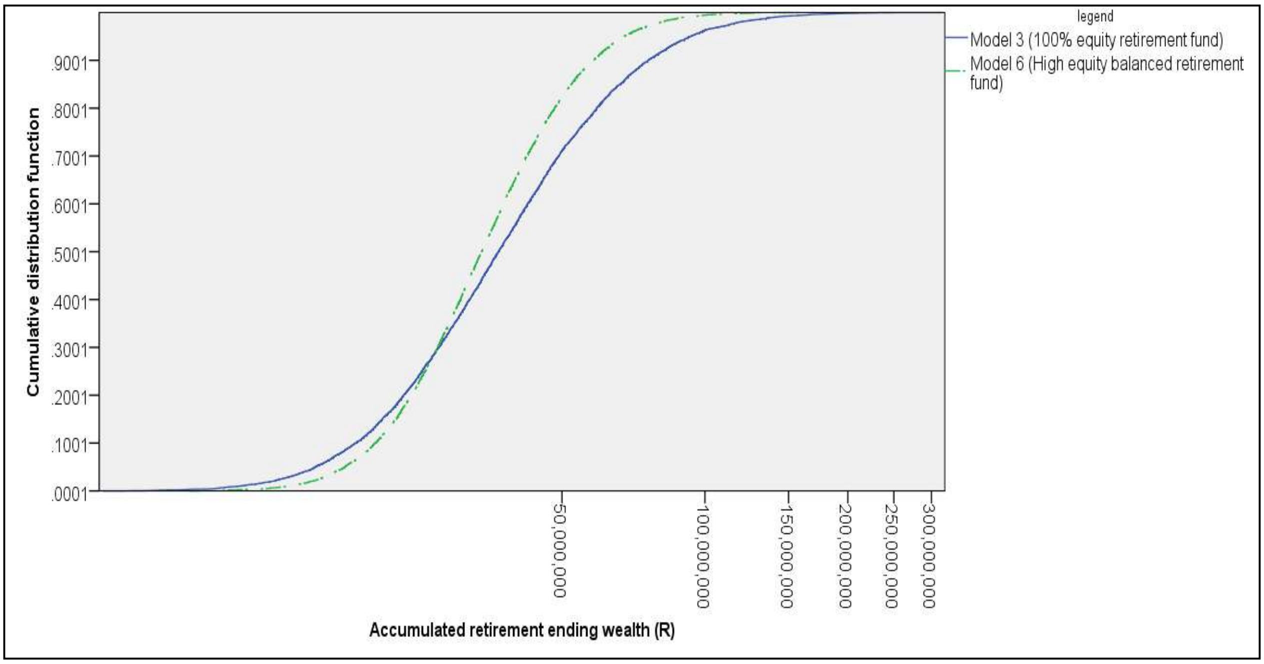
Figure E41: Cumulative distribution of accumulated retirement ending wealth for Model 3 against Model 6 (20-year investment horizon, 25% tax bracket)



Source: SPSS output

Figure E42: Cumulative distribution of accumulated retirement ending wealth for Model 3 against Model 6 (20-year investment horizon, 40% tax bracket)



Source: SPSS output

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Figure E43: Cumulative distribution of accumulated retirement ending wealth for Model 3 against Model 6 (30-year investment horizon, 18% tax bracket)

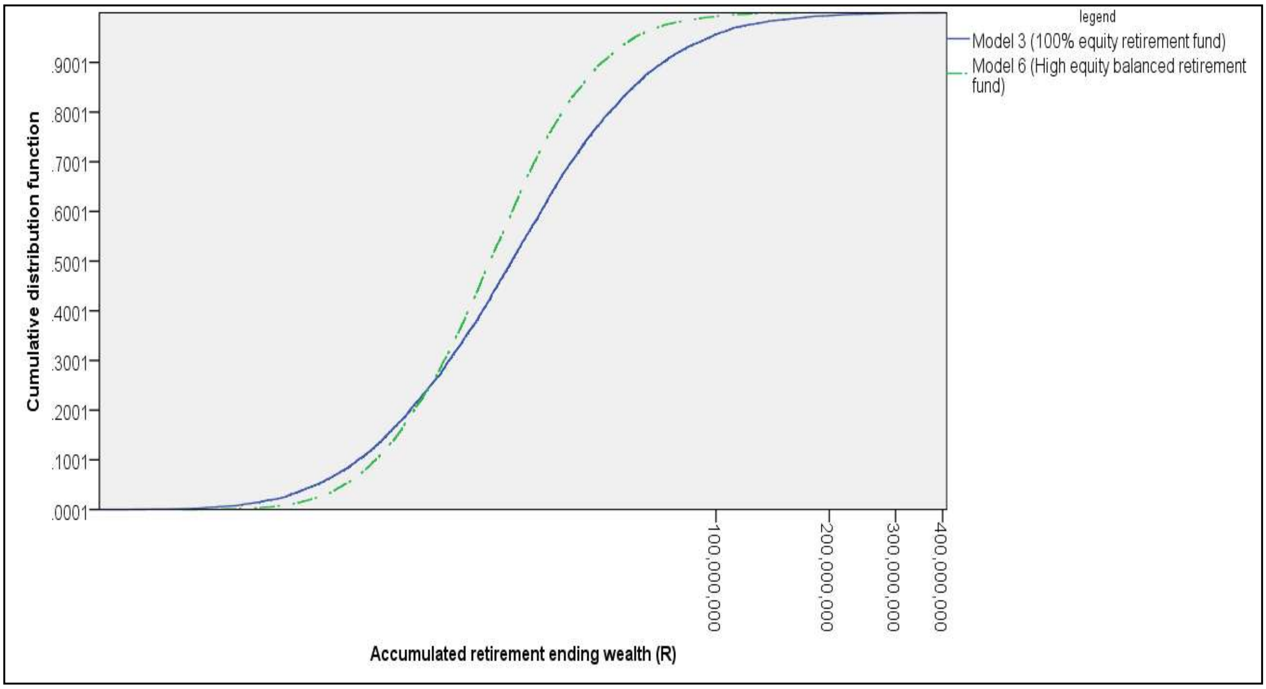

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Figure E44: Cumulative distribution of accumulated retirement ending wealth for Model 3 against Model 6 (30-year investment horizon, 25% tax bracket)

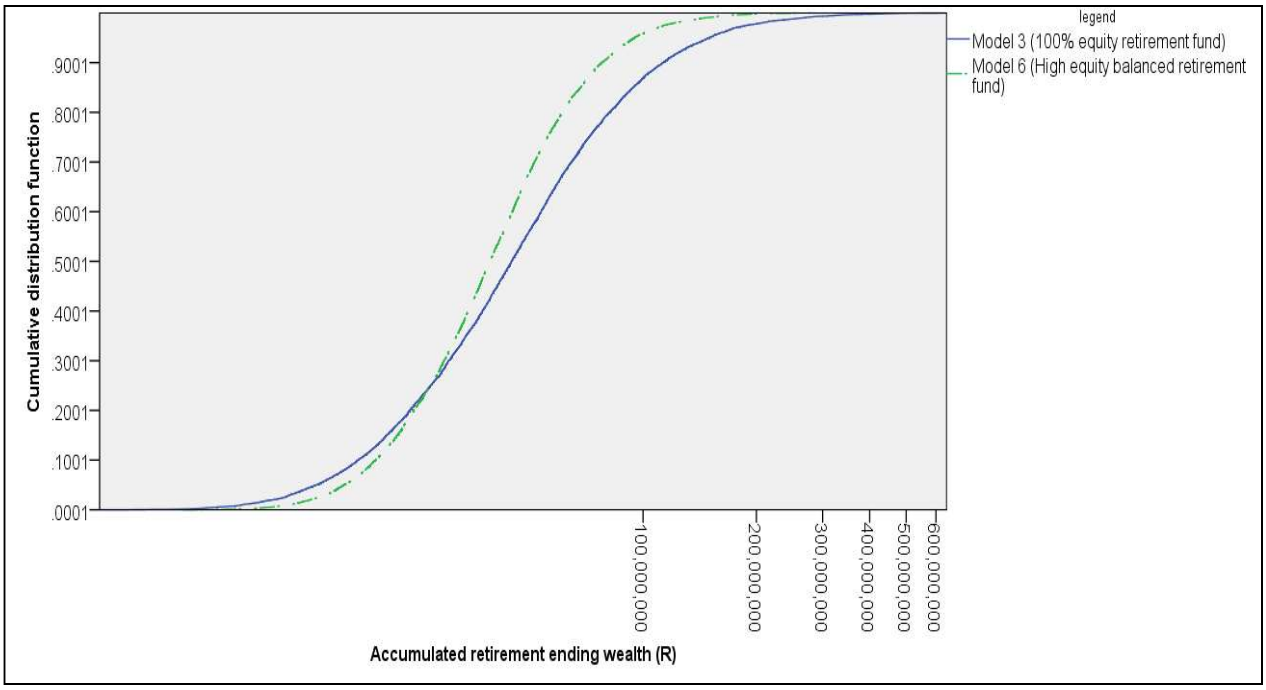

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Figure E45: Cumulative distribution of accumulated retirement ending wealth for Model 3 against Model 6 (30-year investment horizon, 40% tax bracket)

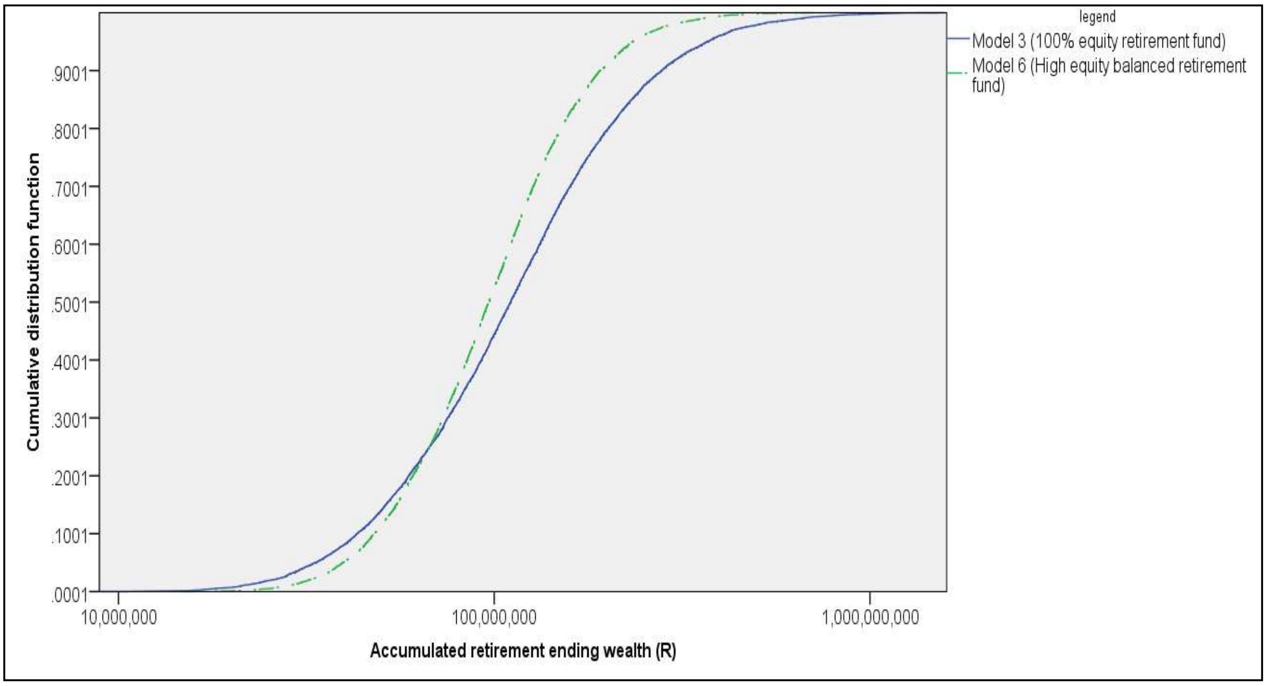

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Figure E46: Cumulative distribution of accumulated retirement ending wealth for Model 3 against Model 6 (40-year investment horizon, 18% tax bracket)

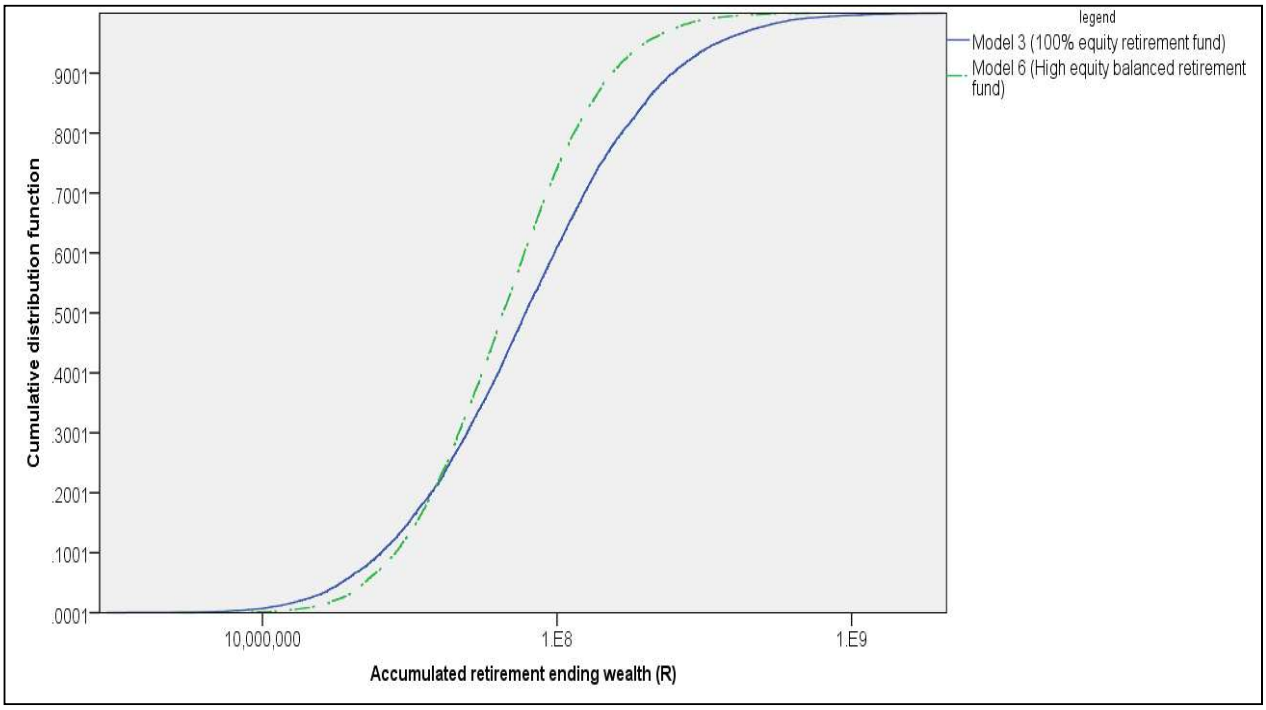

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Figure E47: Cumulative distribution of accumulated retirement ending wealth for Model 3 against Model 6 (40-year investment horizon, 25% tax bracket)

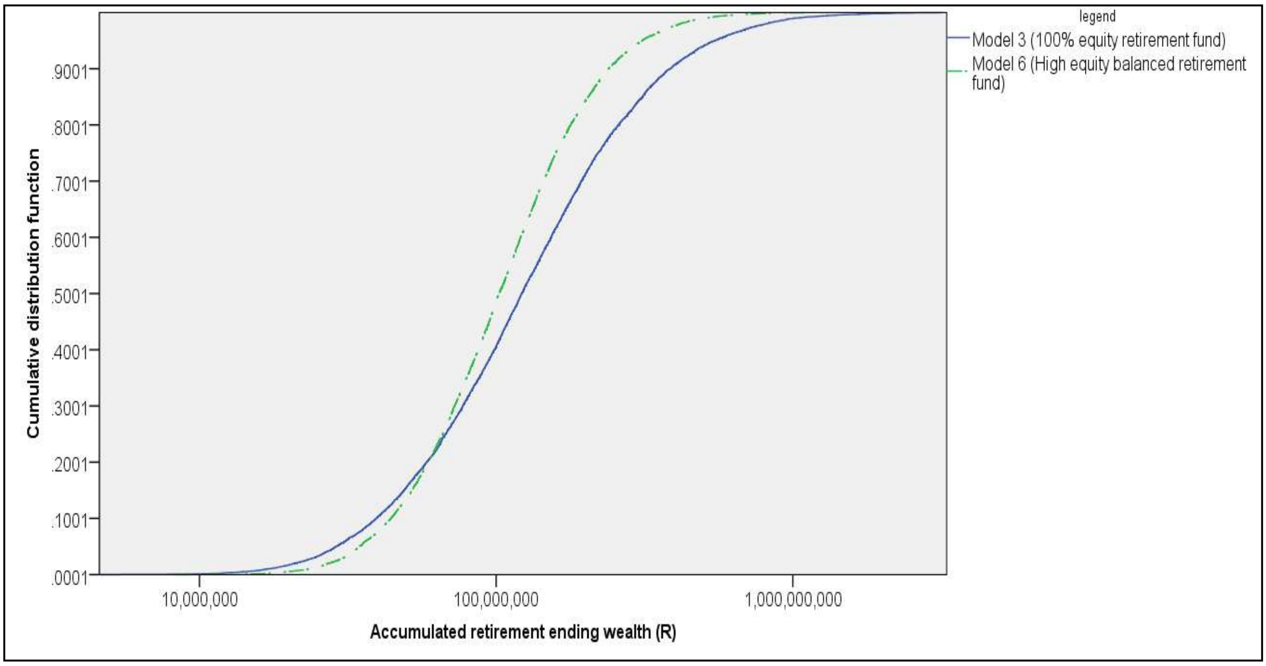

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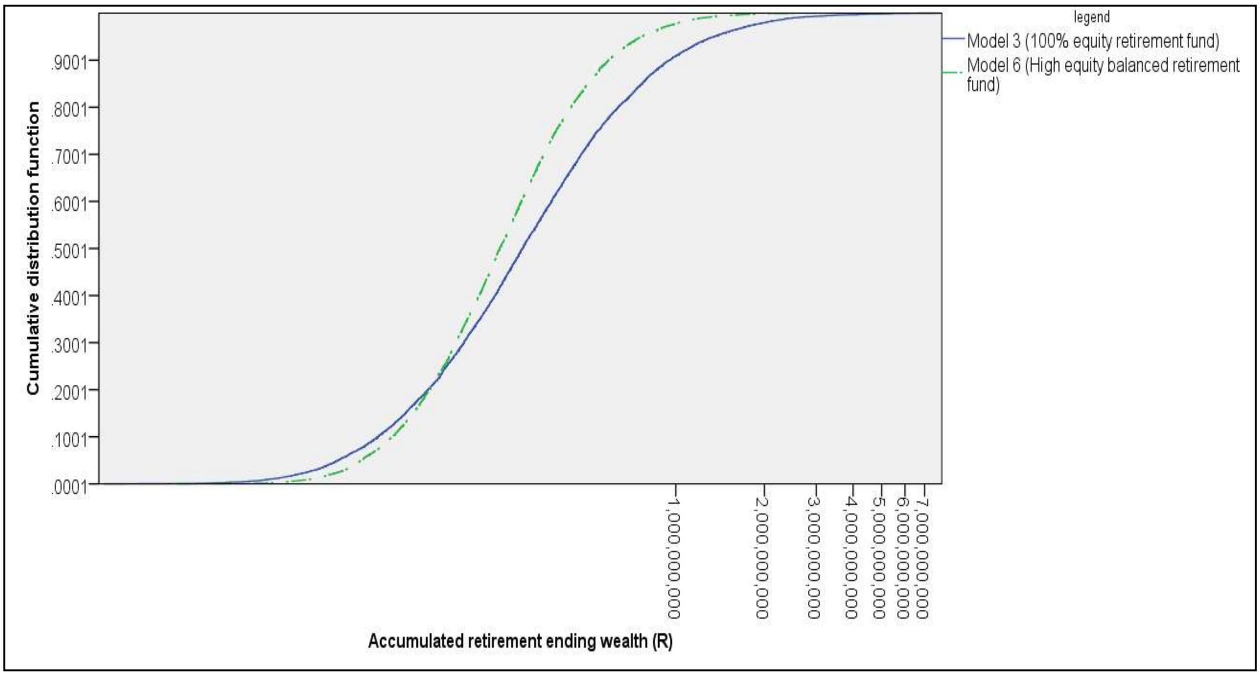
Figure E48: Cumulative distribution of accumulated retirement ending wealth for Model 3 against Model 6 (40-year investment horizon, 40% tax bracket)



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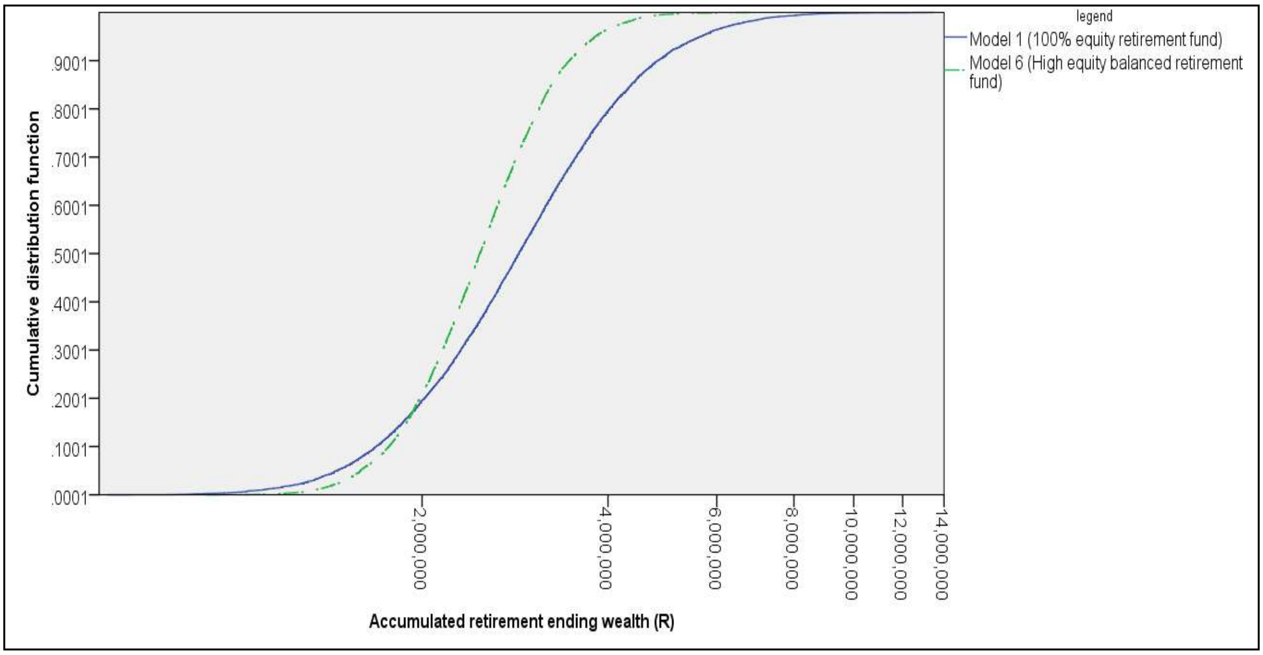
E5. HYPOTHESIS 1E

Figure E49: Cumulative distribution of accumulated retirement ending wealth for Model 1 against Model 6 (10-year investment horizon, 18% tax bracket)



Source: SPSS output

Figure E50: Cumulative distribution of accumulated retirement ending wealth for Model 1 against Model 6 (10-year investment horizon, 25% tax bracket)

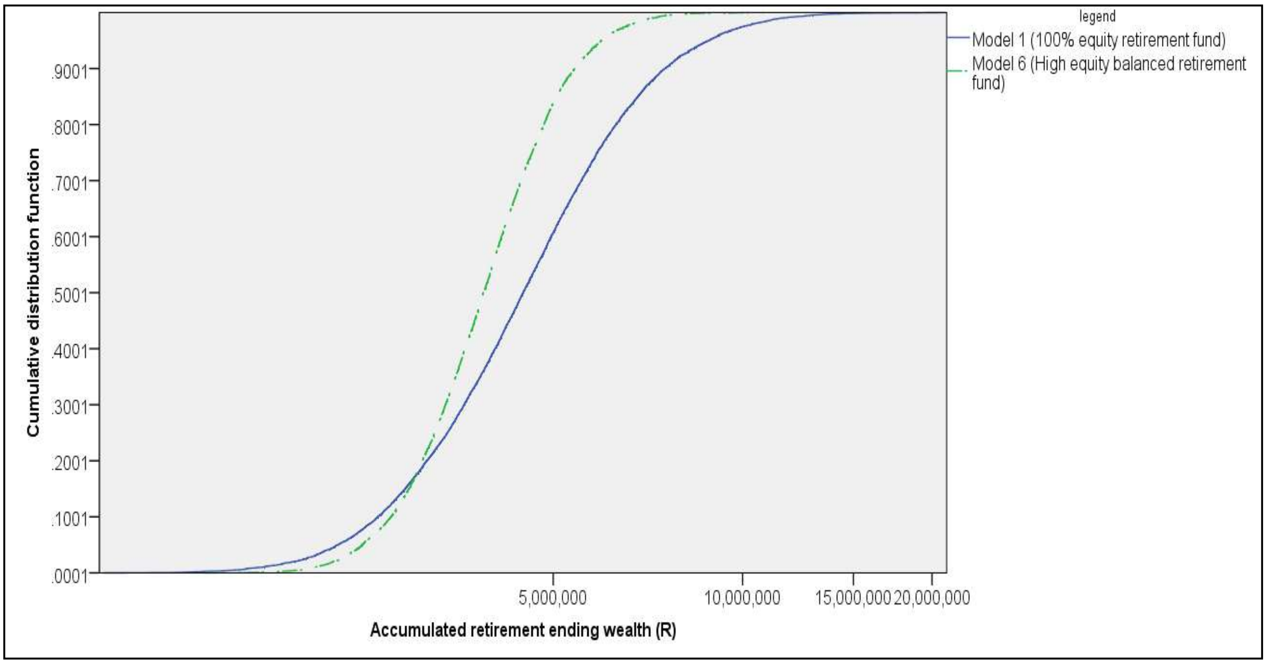


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Figure E51: Cumulative distribution of accumulated retirement ending wealth for Model 1 against Model 6 (10-year investment horizon, 40% tax bracket)

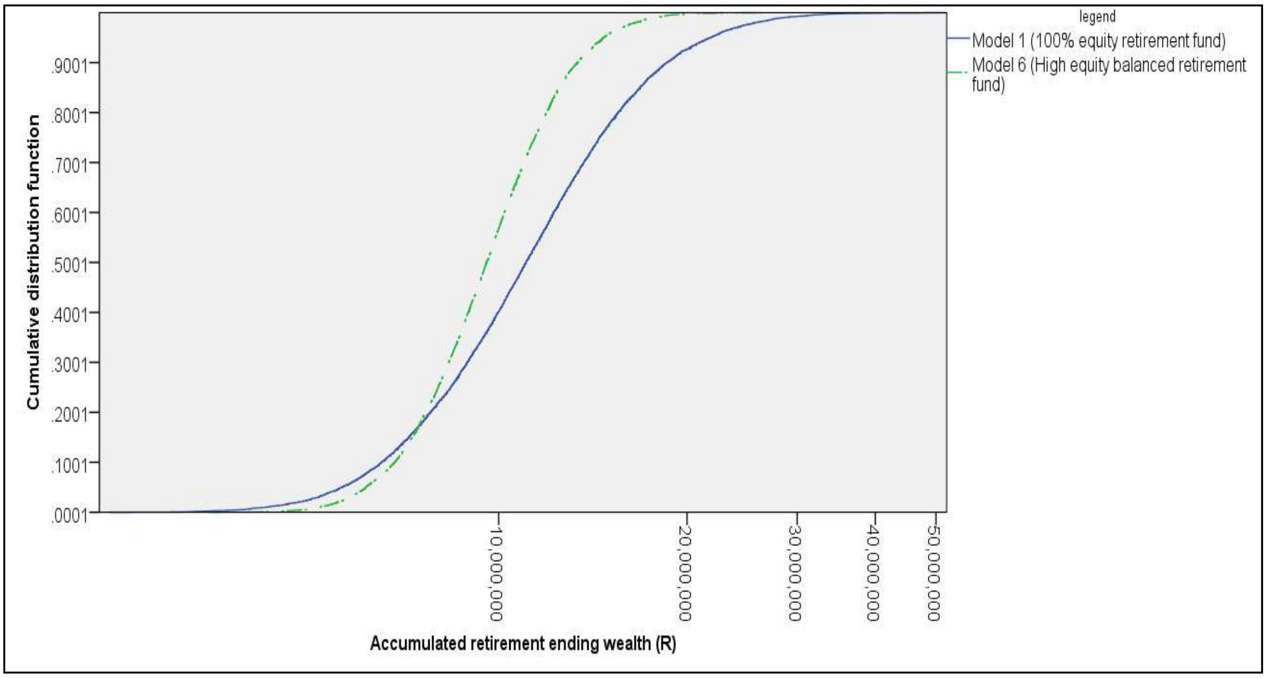

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Figure E52: Cumulative distribution of accumulated retirement ending wealth for Model 1 against Model 6 (20-year investment horizon, 18% tax bracket)

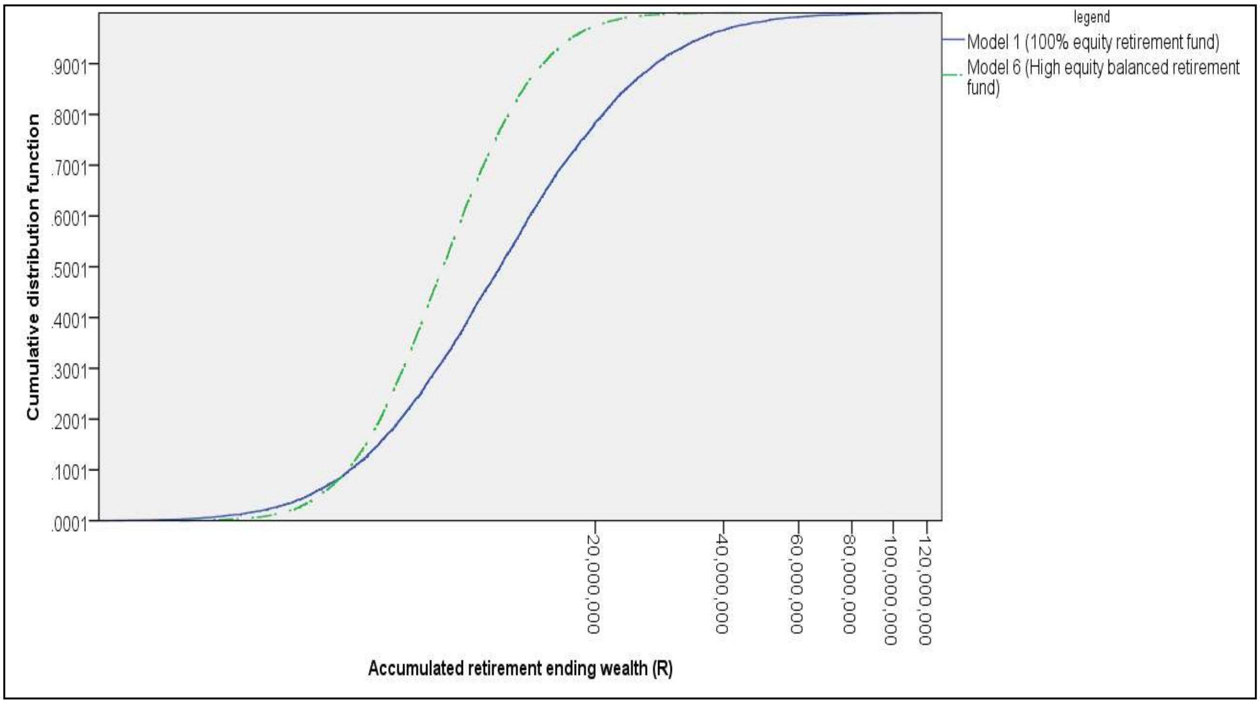

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Figure E53: Cumulative distribution of accumulated retirement ending wealth for Model 1 against Model 6 (20-year investment horizon, 25% tax bracket)

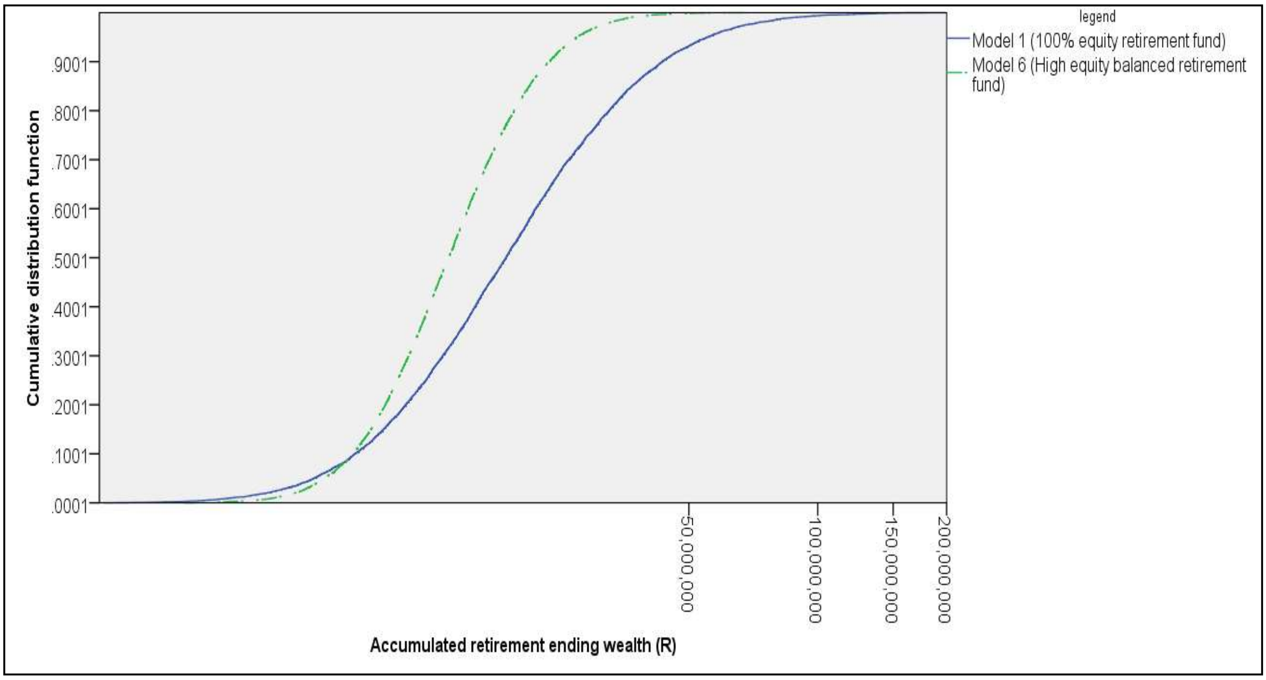

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Figure E54: Cumulative distribution of accumulated retirement ending wealth for Model 1 against Model 6 (20-year investment horizon, 40% tax bracket)

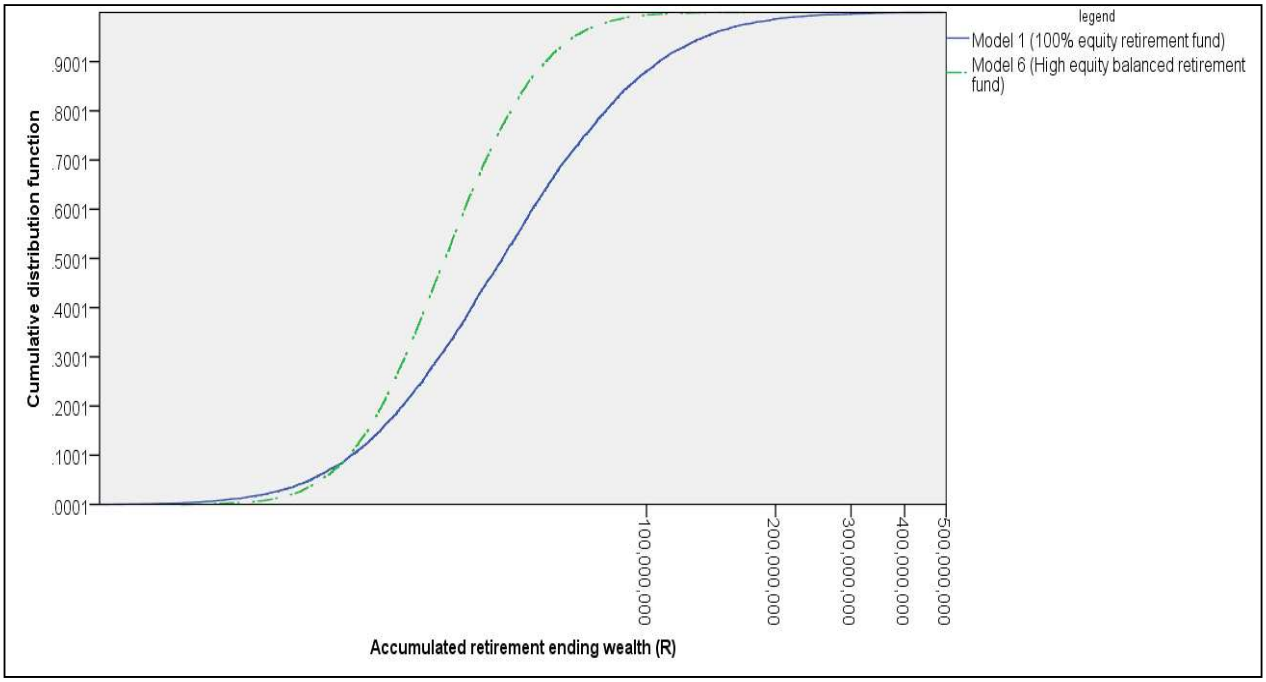

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Figure E55: Cumulative distribution of accumulated retirement ending wealth for Model 1 against Model 6 (30-year investment horizon, 18% tax bracket)

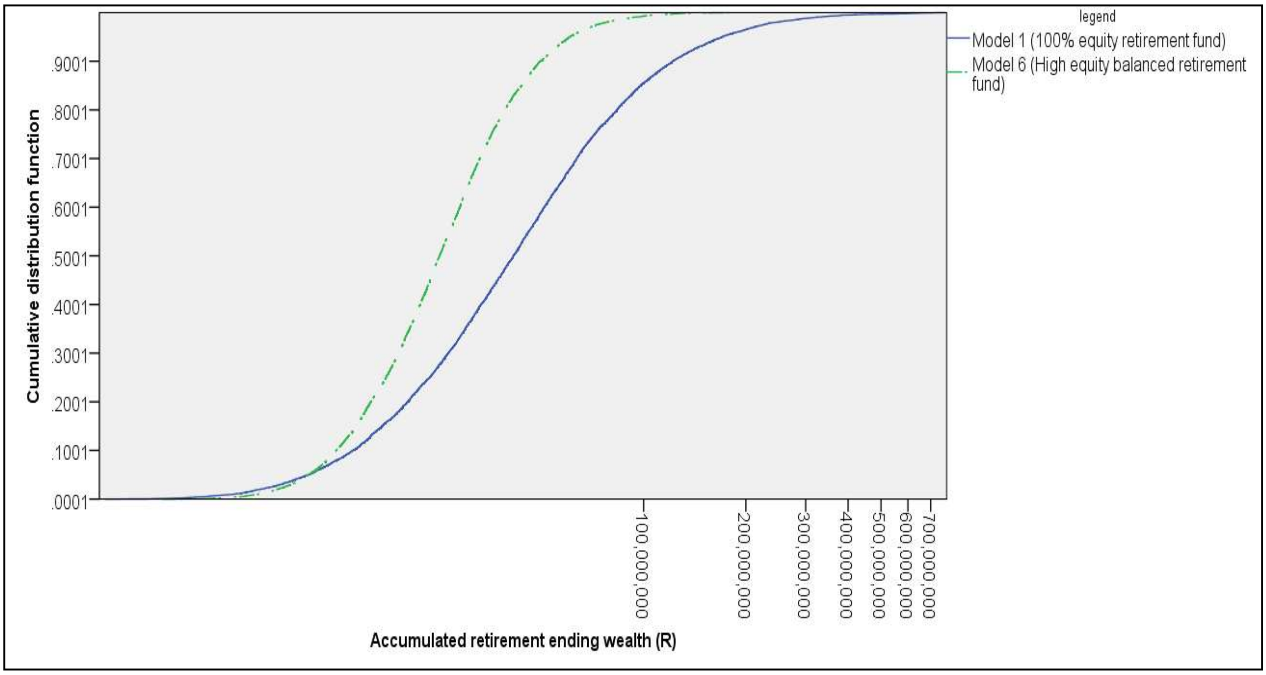

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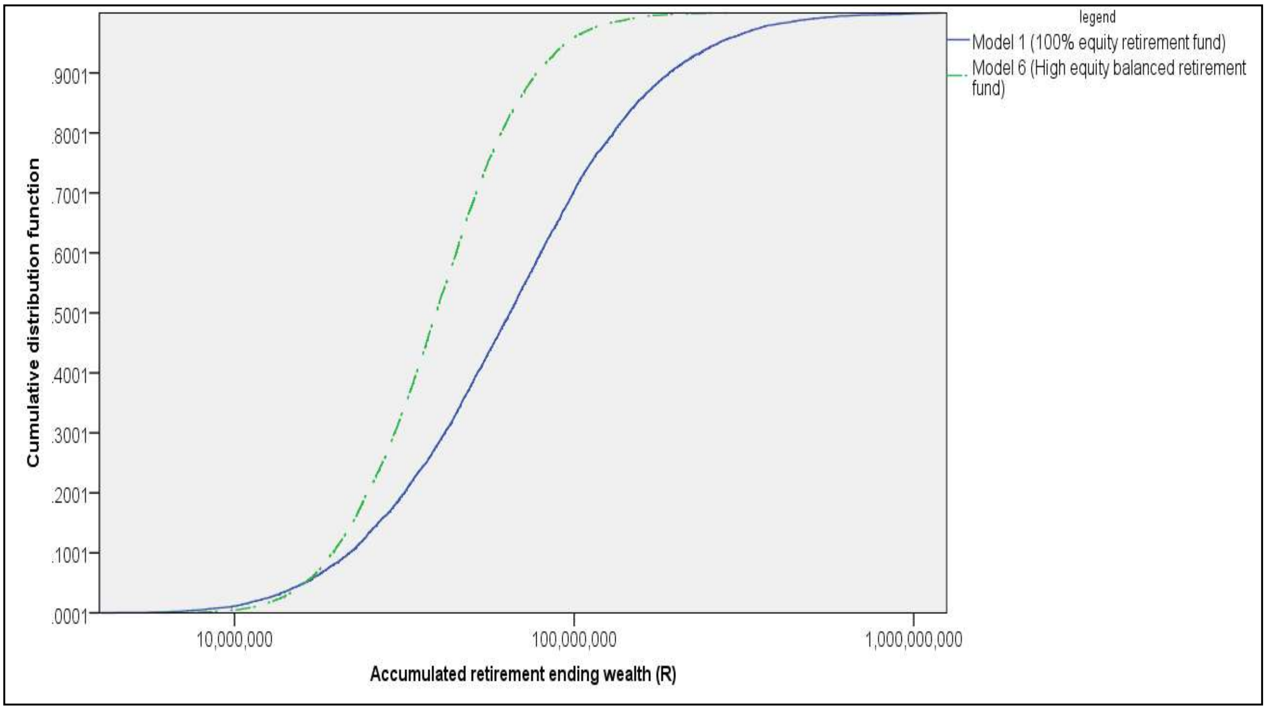
Figure E56: Cumulative distribution of accumulated retirement ending wealth for Model 1 against Model 6 (30-year investment horizon, 25% tax bracket)



Source: SPSS output

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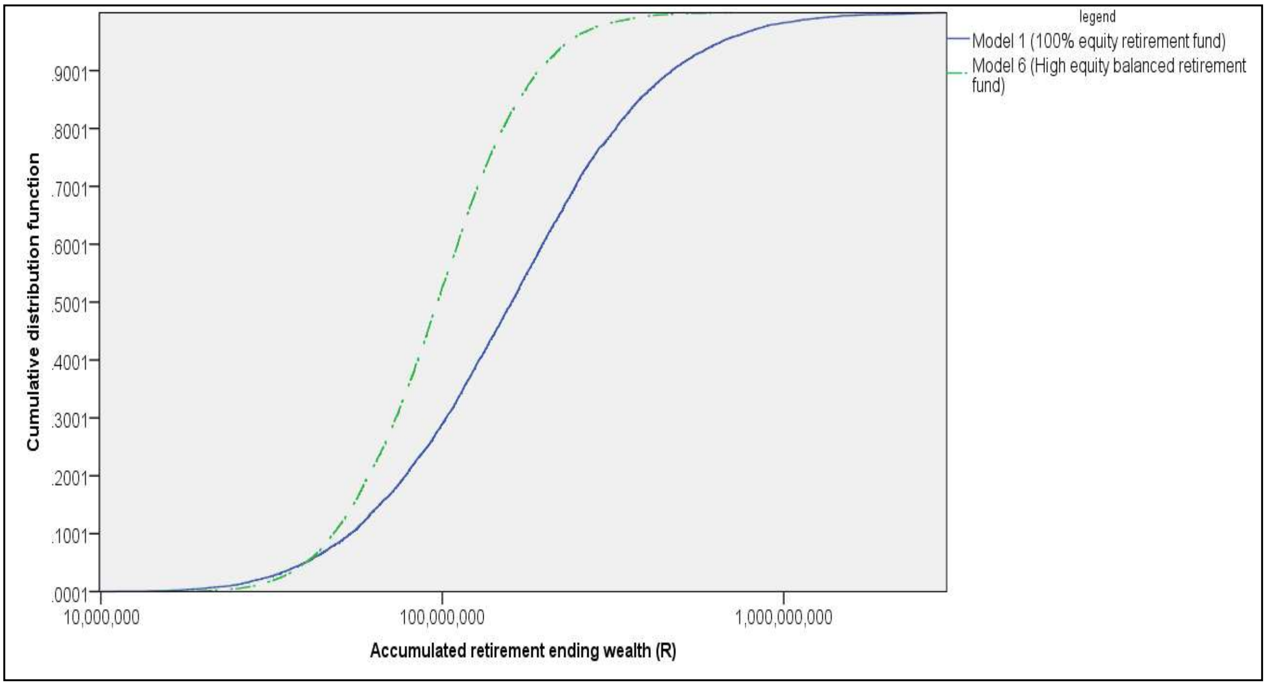
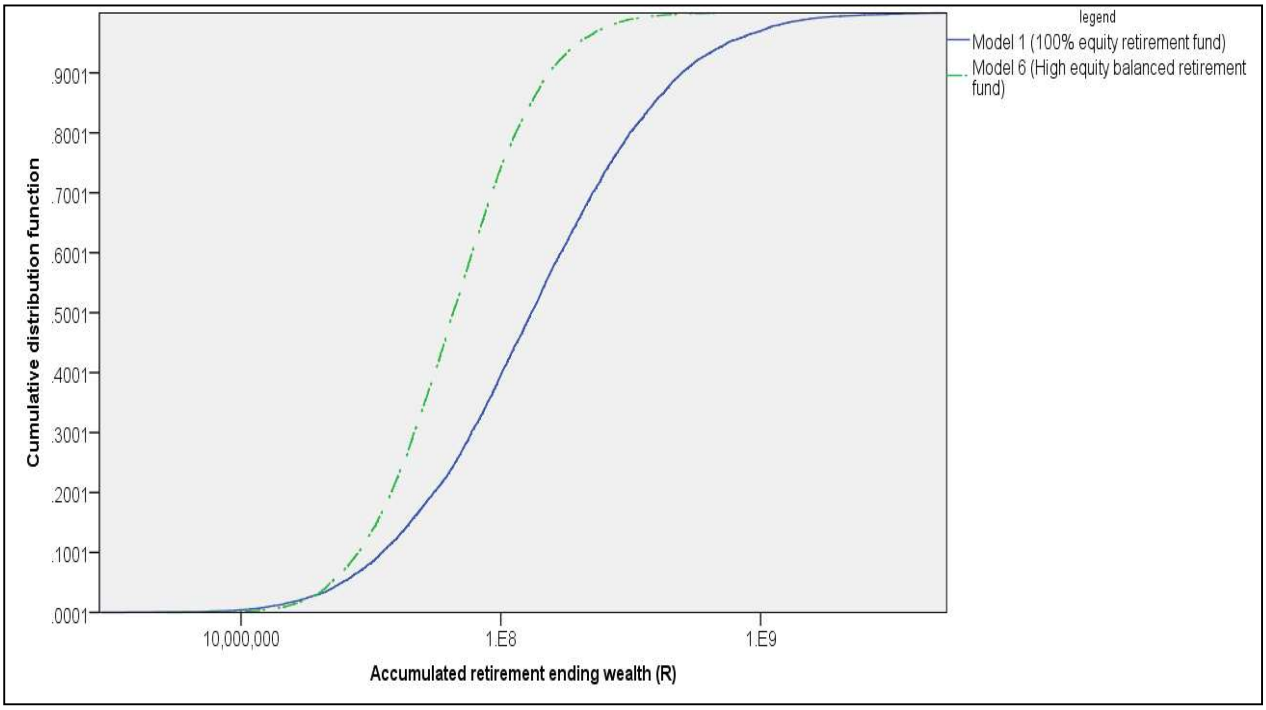
Figure E57: Cumulative distribution of accumulated retirement ending wealth for Model 1 against Model 6 (30-year investment horizon, 40% tax bracket)



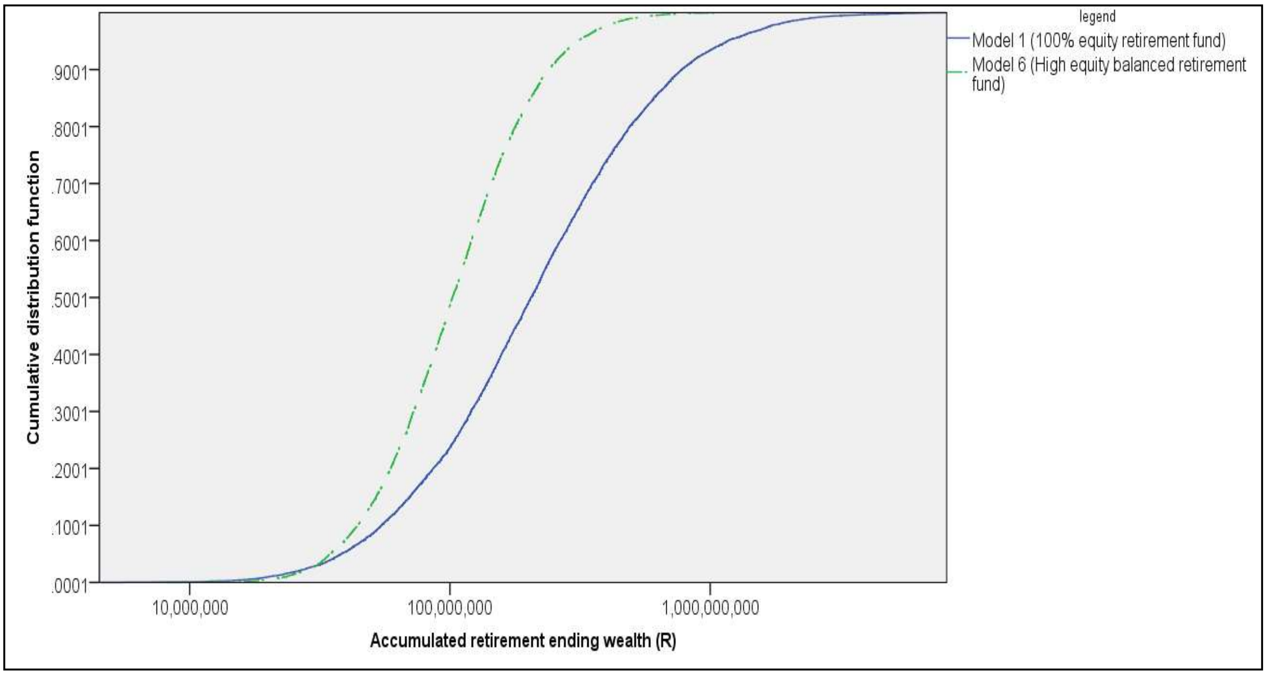
Source: SPSS output

Figure E58: Cumulative distribution of accumulated retirement ending wealth for Model 1 against Model 6 (40-year investment horizon, 18% tax bracket)



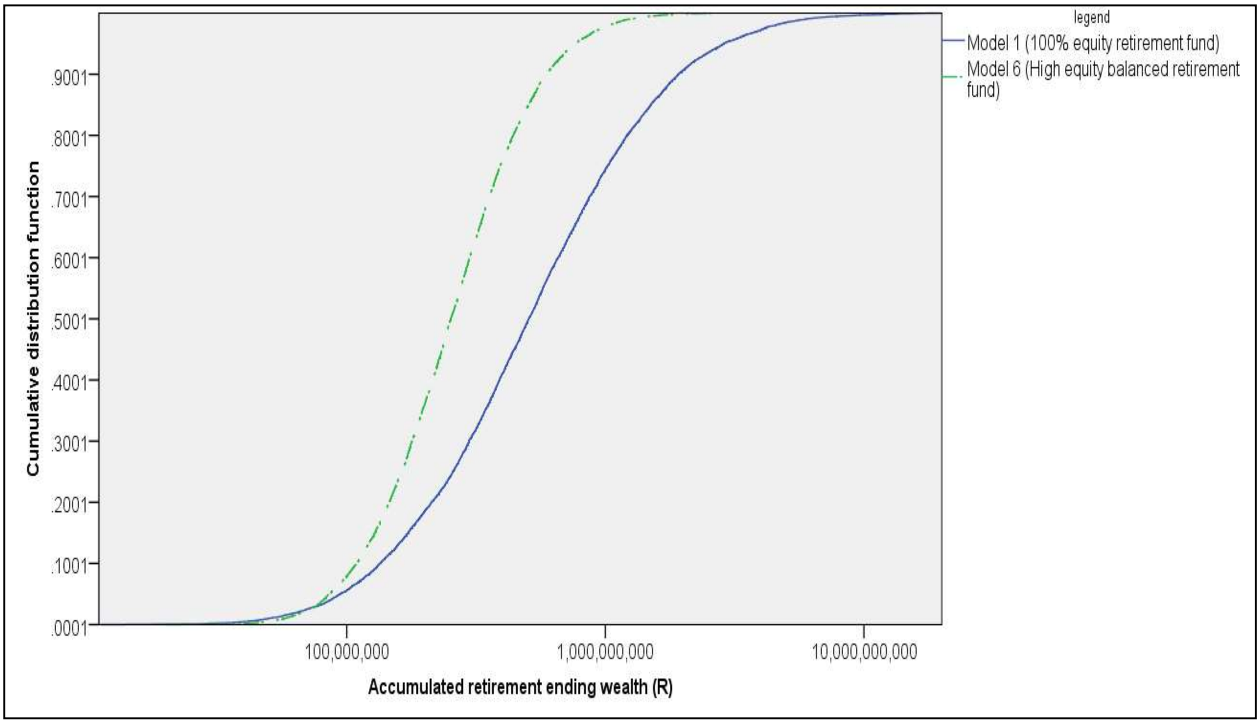
Source: SPSS output

Figure E59: Cumulative distribution of accumulated retirement ending wealth for Model 1 against Model 6 (40-year investment horizon, 25% tax bracket)



Source: SPSS output

Figure E60: Cumulative distribution of accumulated retirement ending wealth for Model 1 against Model 6 (40-year investment horizon, 40% tax bracket)



Source: SPSS output

APPENDIX F: DESCRIPTIVE STATISTICS OF ACCUMULATED RETIREMENT ENDING WEALTH

Table F1: Descriptive statistics of Research Question 2 models: accumulated retirement ending wealth (R) – 10-year investment horizon

	Model 5	Model 6	Model 7	Model 8	Model 10	Model 12
Annualised return implied by arithmetic mean	18.13%	15.63%	15.00%	14.13%	15.36%	13.99%
Arithmetic mean	11 210 817	9 887 293	9 576 759	9 173 077	9 754 067	9 105 526
Median	10 691 861	9 555 545	9 382 732	9 073 755	9 534 147	8 958 620
Minimum	3 269 061	3 451 057	4 027 727	4 902 036	5 164 722	5 311 494
Maximum	37 278 380	26 698 281	21 371 117	17 798 972	21 082 261	17 206 066
25th per centile	8 615 342	7 997 809	8 092 740	8 094 221	8 459 735	8 135 772
75th per centile	13 150 266	11 427 129	10 818 238	10 132 083	10 814 311	9 952 347
Range	34 009 319	23 247 224	17 343 390	12 896 936	15 917 538	11 894 573
Interquartile range	4 534 924	3 429 321	2 725 498	2 037 862	2 354 576	1 816 576
Standard deviation	3 654 823	2 658 526	2 100 106	1 527 005	1 837 041	1 397 363
Variance	1.339E+13	7.068E+12	4.410E+12	2.332E+12	3.375E+12	1.953E+12
Skewness	1.037	0.840	0.669	0.477	0.813	0.650
Kurtosis	2.036	1.378	0.943	0.556	1.312	0.889

Source: SAS and SPSS output

Table F2: Descriptive statistics of Research Question 2 models: accumulated retirement ending wealth (R) – 20-year investment horizon

	Model 5	Model 6	Model 7	Model 8	Model 9	Model 10	Model 11	Model 12
Annualised return implied by arithmetic mean	18.10%	15.64%	15.01%	14.15%	15.74%	16.76%	14.20%	14.81%
Arithmetic mean	49 225 929	37 126 846	34 558 395	31 389 683	37 564 882	42 187 047	31 558 285	33 810 852
Median	43 089 881	33 870 050	32 485 492	30 312 527	35 278 386	38 269 710	30 203 302	31 741 302
Minimum	8 155 560	8 188 481	8 949 477	9 369 401	11 156 387	9 996 429	11 108 891	10 069 695
Maximum	272 753 088	169 381 881	116 489 987	75 964 393	124 462 043	159 200 398	78 060 032	108 720 231
25th per centile	30 845 818	25 707 373	25 941 719	25 511 849	28 533 381	29 338 408	25 433 447	25 486 049
75th per centile	60 642 197	44 943 069	40 914 692	36 056 577	43 845 360	50 761 467	36 128 908	39 788 542
Range	264 597 528	161 193 400	107 540 510	66 594 992	113 305 656	149 203 969	66 951 141	98 650 536
Interquartile range	29 796 378	19 235 696	14 972 973	10 544 727	15 311 978	21 423 059	10 695 461	14 302 492
Standard deviation	26 683 455	16 206 198	12 118 194	8 199 162	12 782 526	18 333 559	8 545 838	11 742 916
Variance	7.120E+14	2.626E+14	1.469E+14	6.723E+13	1.634E+14	3.361E+14	7.303E+13	1.379E+14
Skewness	1.819	1.443	1.133	0.808	1.237	1.481	1.003	1.199
Kurtosis	5.678	3.651	2.266	1.126	2.461	3.533	1.611	2.387

Source: SAS and SPSS output

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Table F3: Descriptive statistics of Research Question 2 models: accumulated retirement ending wealth (R) – 30-year investment horizon

	Model 5	Model 6	Model 7	Model 8	Model 9	Model 10	Model 11	Model 12
Annualised return implied by arithmetic mean	18.09%	15.63%	15.00%	14.13%	16.61%	17.28%	14.72%	15.13%
Arithmetic mean	178 247 972	111 829 643	99 363 153	84 815 063	134 589 420	152 693 842	94 559 145	101 945 633
Median	143 508 353	96 725 520	90 319 611	80 456 137	115 717 030	127 021 992	85 766 612	90 327 242
Minimum	16 832 756	14 745 588	17 717 486	22 605 080	21 293 559	18 655 398	20 288 835	18 975 315
Maximum	1 333 403 541	706 696 843	441 011 635	286 031 017	813 265 545	1 225 697 504	458 951 548	633 584 030
25th per centile	92 271 990	67 286 060	67 066 203	64 210 679	81 778 954	85 886 129	64 458 043	65 177 339
75th per centile	220 037 503	137 427 000	120 743 618	100 120 760	163 984 351	188 635 892	113 608 739	124 473 643
Range	1 316 570 785	691 951 256	423 294 150	263 425 937	791 971 986	1 207 042 106	438 662 713	614 608 715
Interquartile range	127 765 513	70 140 940	53 677 417	35 910 081	82 205 397	102 749 763	49 150 696	59 296 303
Standard deviation	134 071 637	66 178 794	46 445 665	29 141 164	78 215 679	101 284 188	43 223 705	53 362 728
Variance	1.798E+16	4.380E+15	2.157E+15	8.492E+14	6.118E+15	1.026E+16	1.868E+15	2.848E+15
Skewness	2.633	2.044	1.549	1.105	2.036	2.291	1.624	1.840
Kurtosis	11.537	7.226	4.228	2.363	6.948	8.779	4.721	6.098

Source: SAS and SPSS output

Table F4: Descriptive statistics of Research Question 2 models: accumulated retirement ending wealth (R) – 40-year investment horizon

	Model 5	Model 6	Model 7	Model 8	Model 9	Model 10	Model 11	Model 12
Annualised return implied by arithmetic mean	18.09%	15.63%	14.99%	14.13%	17.04%	17.52%	14.98%	15.27%
Arithmetic mean	617 002 951	317 752 702	268 381 004	214 031 807	463 396 038	527 552 000	267 206 159	288 886 306
Median	441 711 075	252 401 660	231 151 849	197 286 893	357 871 632	390 983 454	225 731 463	235 609 555
Minimum	20 139 905	20 131 812	28 945 963	40 080 903	36 089 922	29 028 155	33 515 186	27 299 461
Maximum	7 182 152 997	2 771 708 308	1 668 882 907	838 298 725	4 176 090 422	5 324 586 495	1 860 045 591	2 277 557 109
25th per centile	260 250 603	162 791 045	160 472 028	149 439 226	225 929 367	239 305 284	154 594 398	158 517 584
75th per centile	753 862 675	392 136 144	330 005 273	257 843 103	573 281 248	650 205 970	328 965 858	358 061 012
Range	7 162 013 092	2 751 576 497	1 639 936 944	798 217 822	4 140 000 500	5 295 558 340	1 826 530 404	2 250 257 648
Interquartile range	493 612 072	229 345 099	169 533 245	108 403 877	347 351 881	410 900 686	174 371 460	199 543 427
Standard deviation	601 955 980	242 520 370	159 559 566	91 927 443	374 030 746	467 490 636	168 756 102	200 761 416
Variance	3.624E+17	5.882E+16	2.546E+16	8.451E+15	1.399E+17	2.185E+17	2.848E+16	4.031E+16
Skewness	3.455	2.719	2.016	1.374	2.793	3.062	2.243	2.466
Kurtosis	19.717	12.762	7.003	3.176	12.943	15.372	8.827	10.612

Source: SAS and SPSS output

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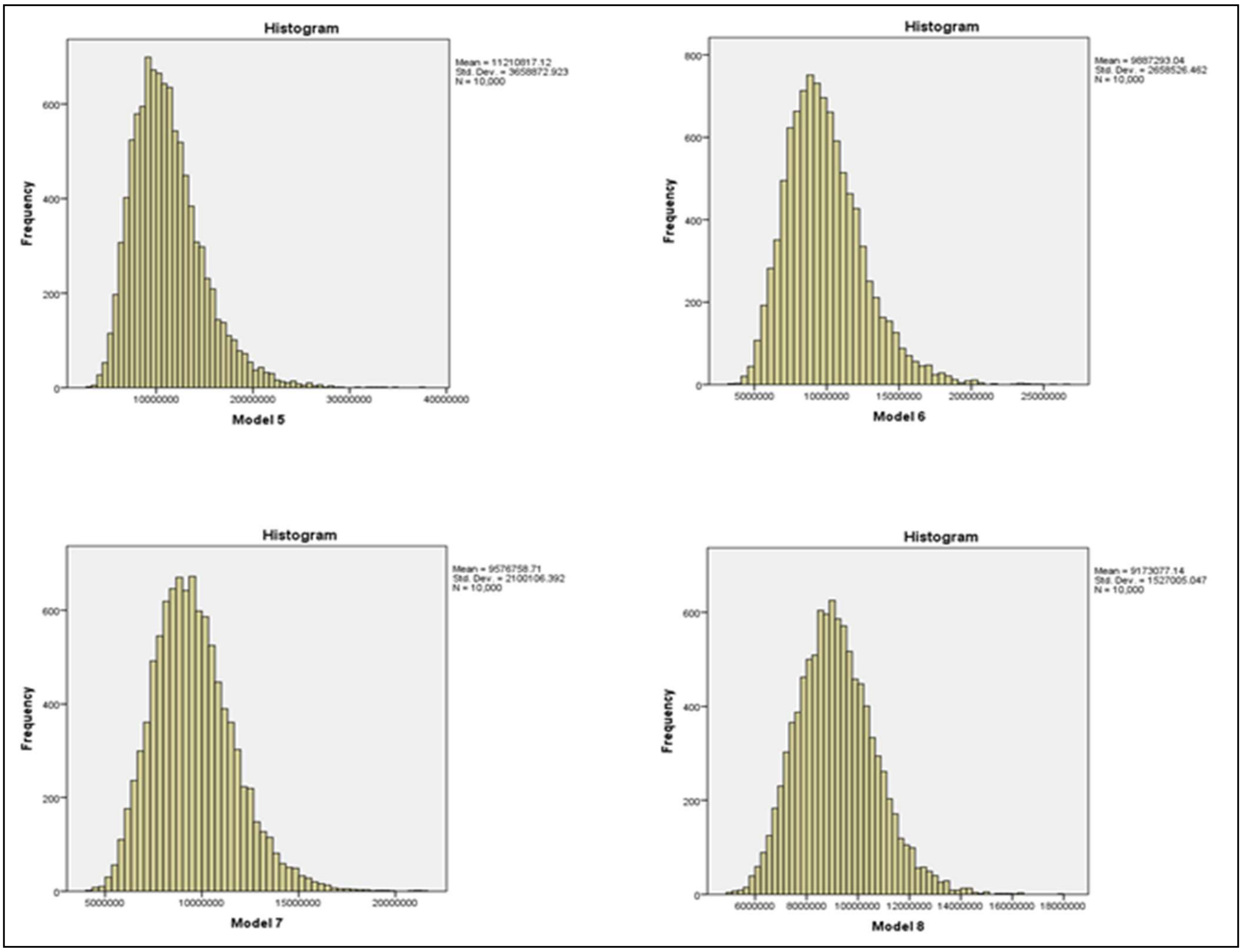
APPENDIX G: HISTOGRAMS OF ACCUMULATED RETIREMENT ENDING WEALTH

Figure G1: Histograms of accumulated retirement ending wealth for Models 5 to 8 – 10-year investment horizon



Source: SPSS output

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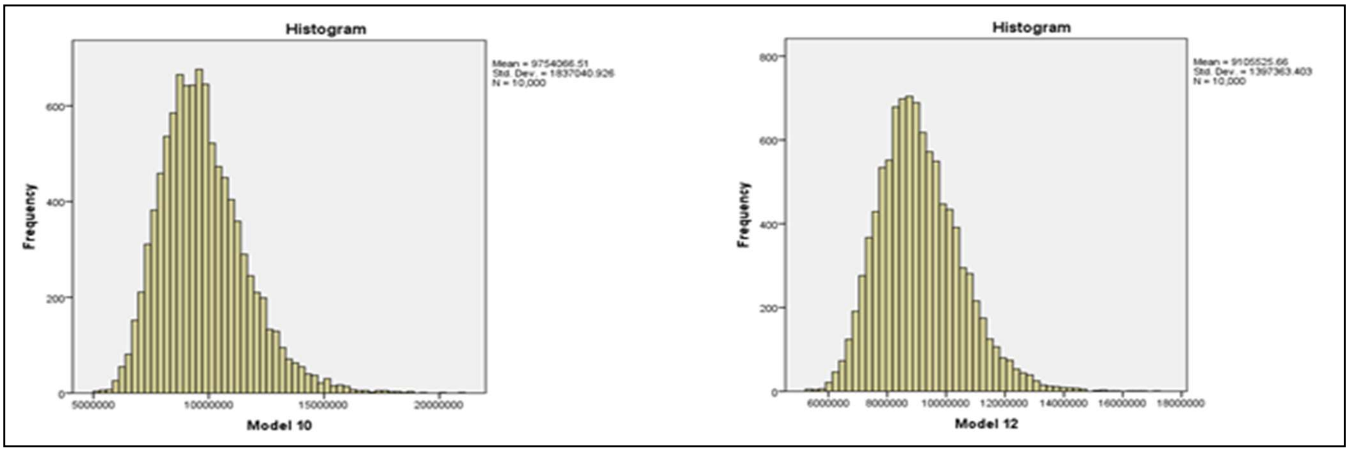
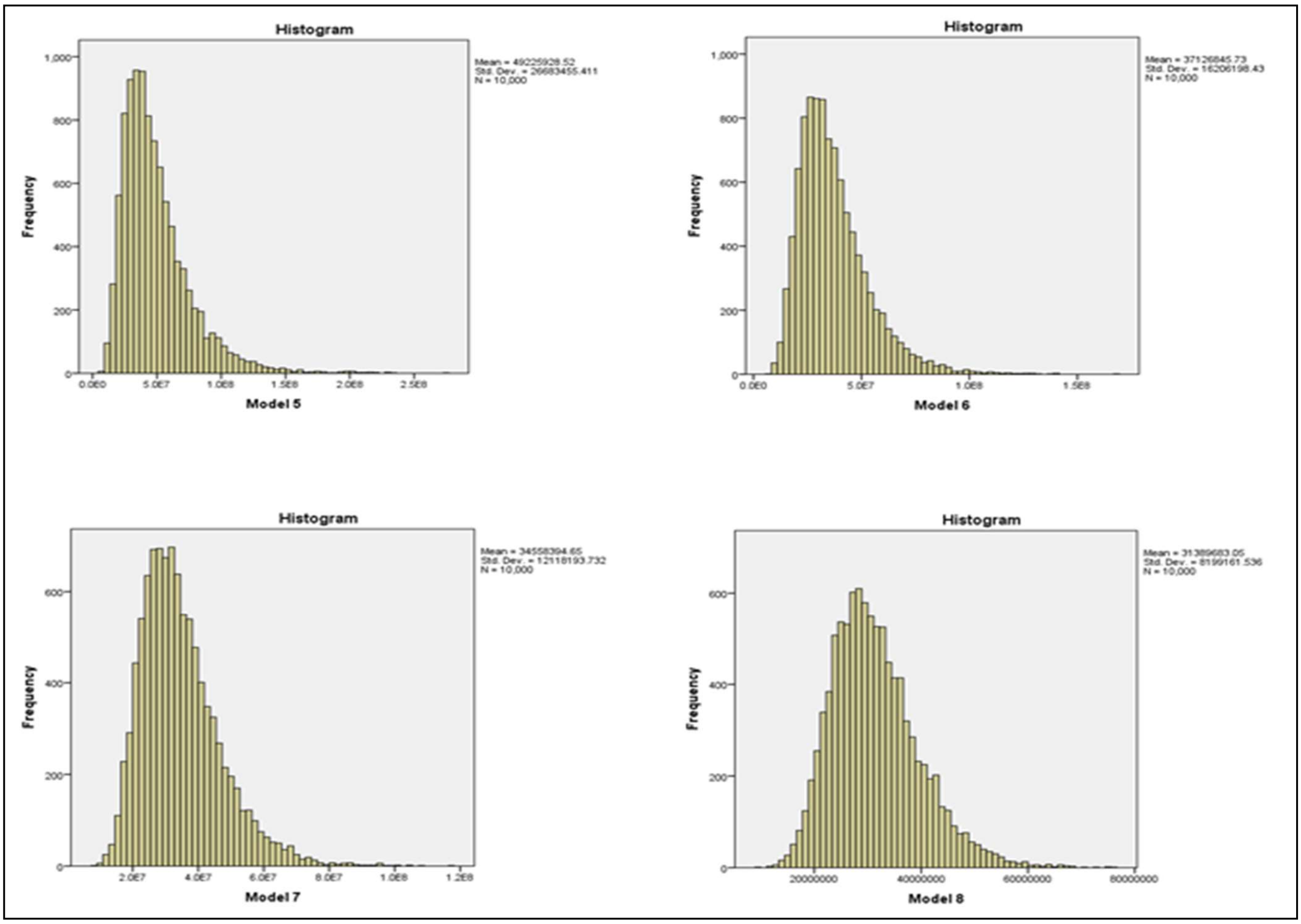
Figure G2: Histograms of accumulated retirement ending wealth for Models 10 and 12 – 10-year investment horizon



Source: SPSS output

Figure G3: Histograms of accumulated retirement ending wealth for Models 5 to 8 – 20-year investment horizon



Source: SPSS output

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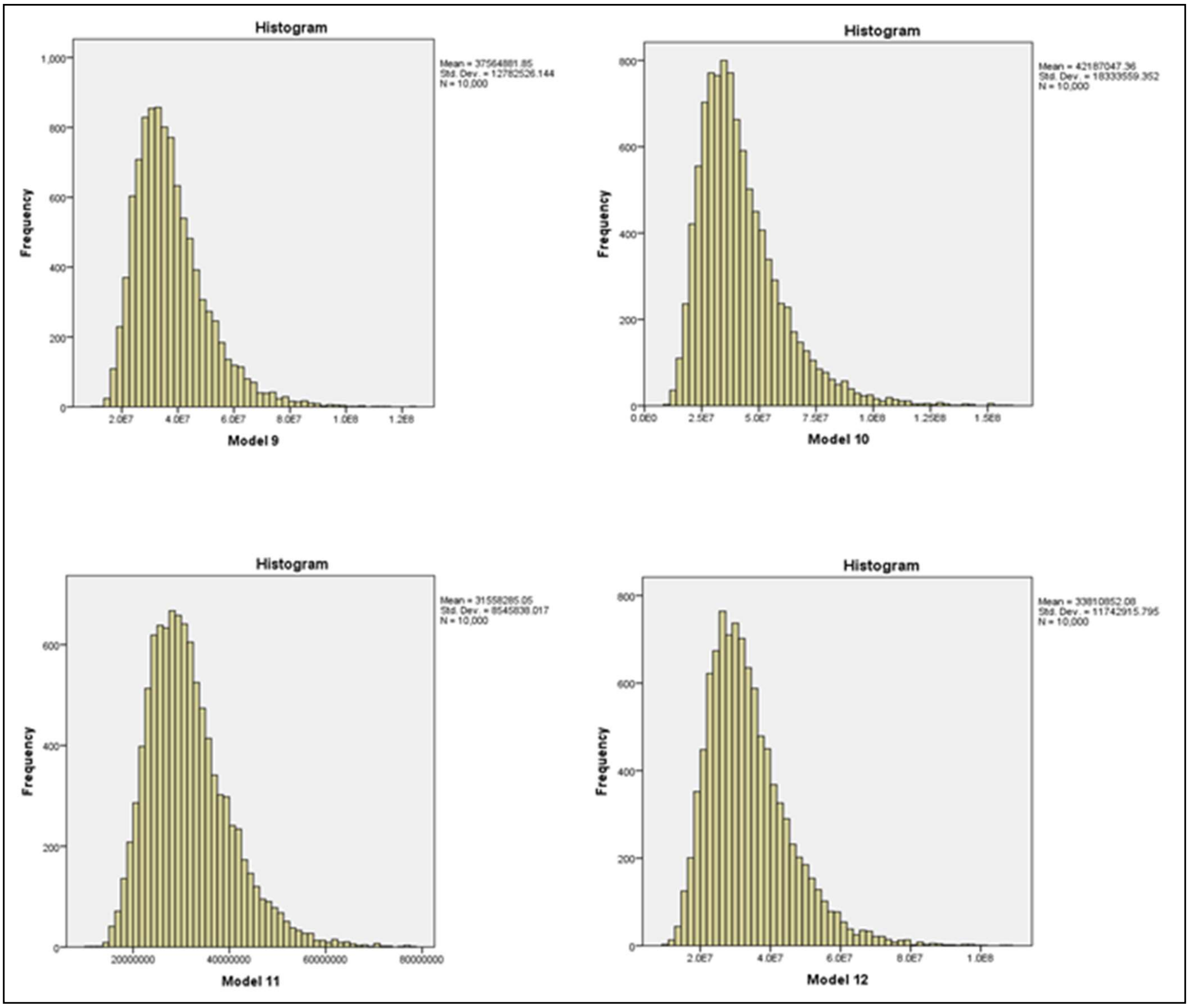
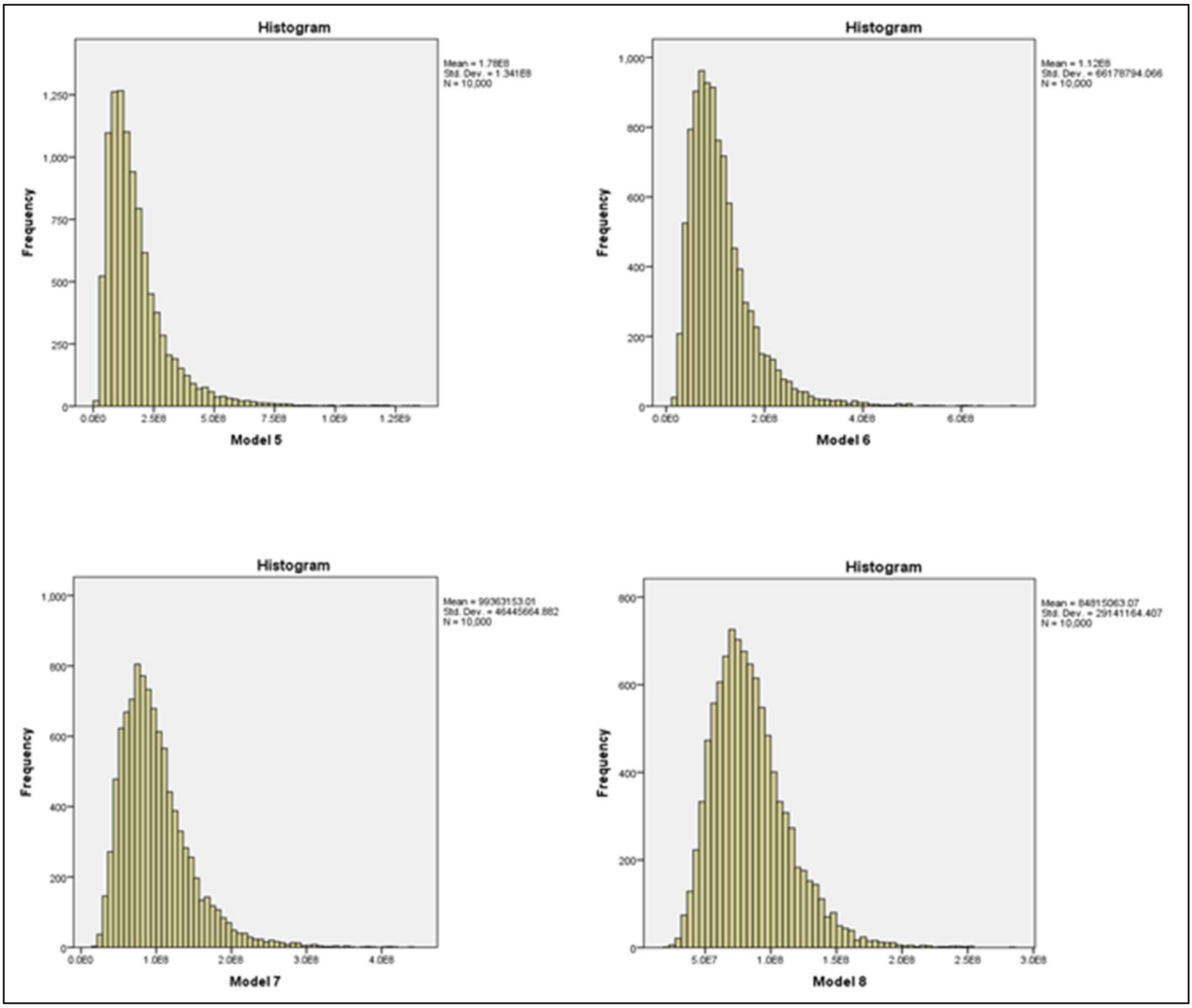
Figure G4: Histograms of accumulated retirement ending wealth for Models 9 to 12 – 20-year investment horizon



Source: SPSS output

Figure G5: Histograms of accumulated retirement ending wealth for Models 5 to 8 – 30-year investment horizon



Source: SPSS output

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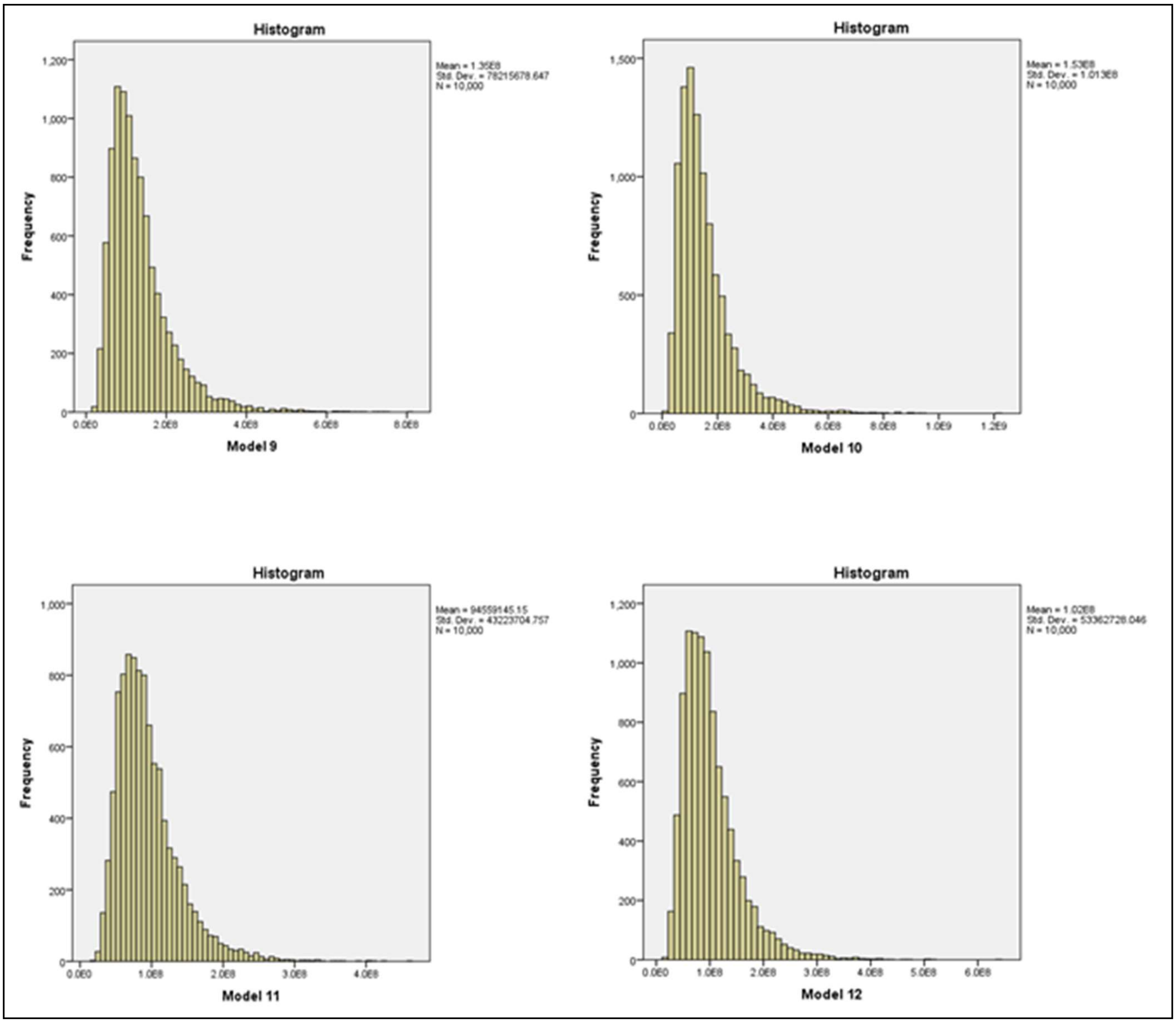
Figure G6: Histograms of accumulated retirement ending wealth for Models 9 to 12 – 30-year investment horizon



Source: SPSS output

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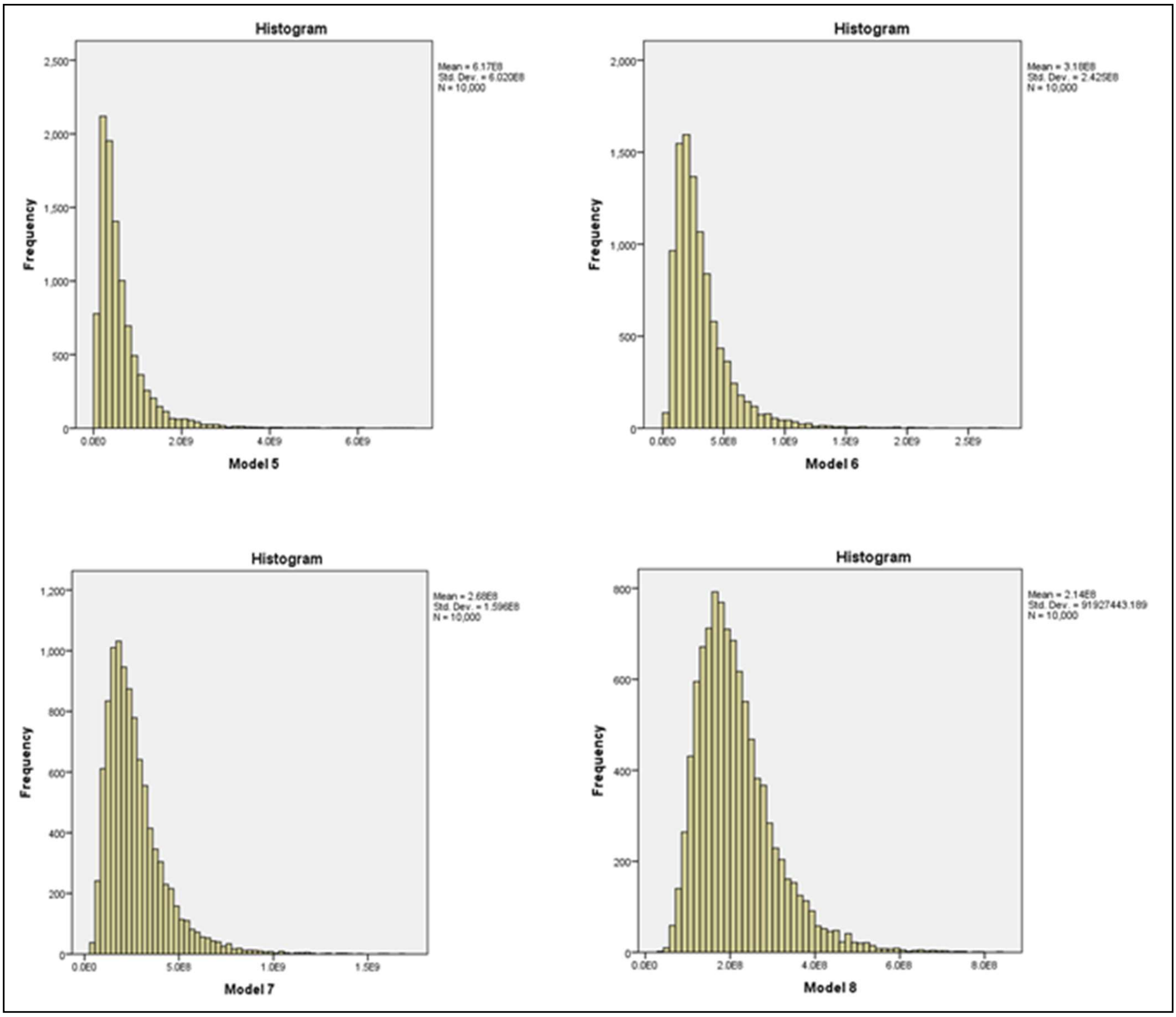
Figure G7: Histograms of accumulated retirement ending wealth for Models 5 to 8 – 40-year investment horizon



Source: SPSS output

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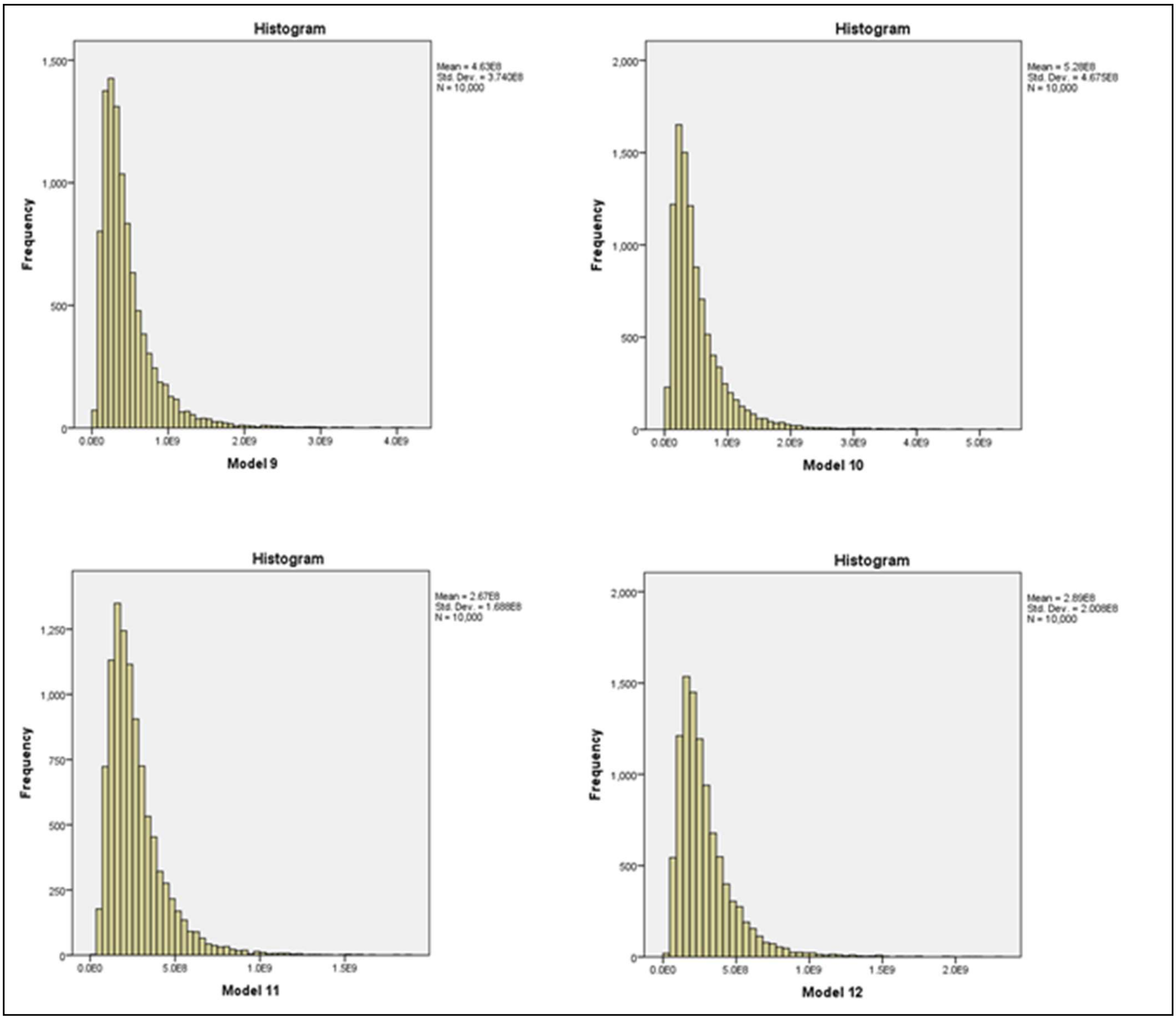
Figure G8: Histograms of accumulated retirement ending wealth for Models 9 to 12 – 40-year investment horizon



Source: SPSS output

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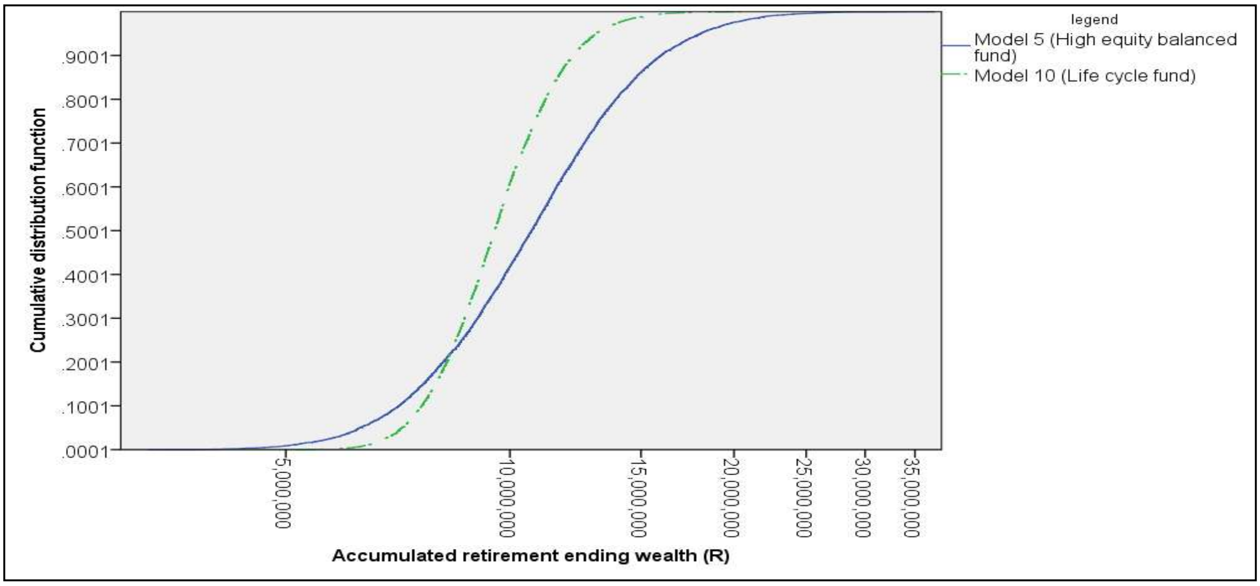
APPENDIX H: CUMULATIVE DISTRIBUTION FUNCTIONS HYPOTHESES 2A TO 2B

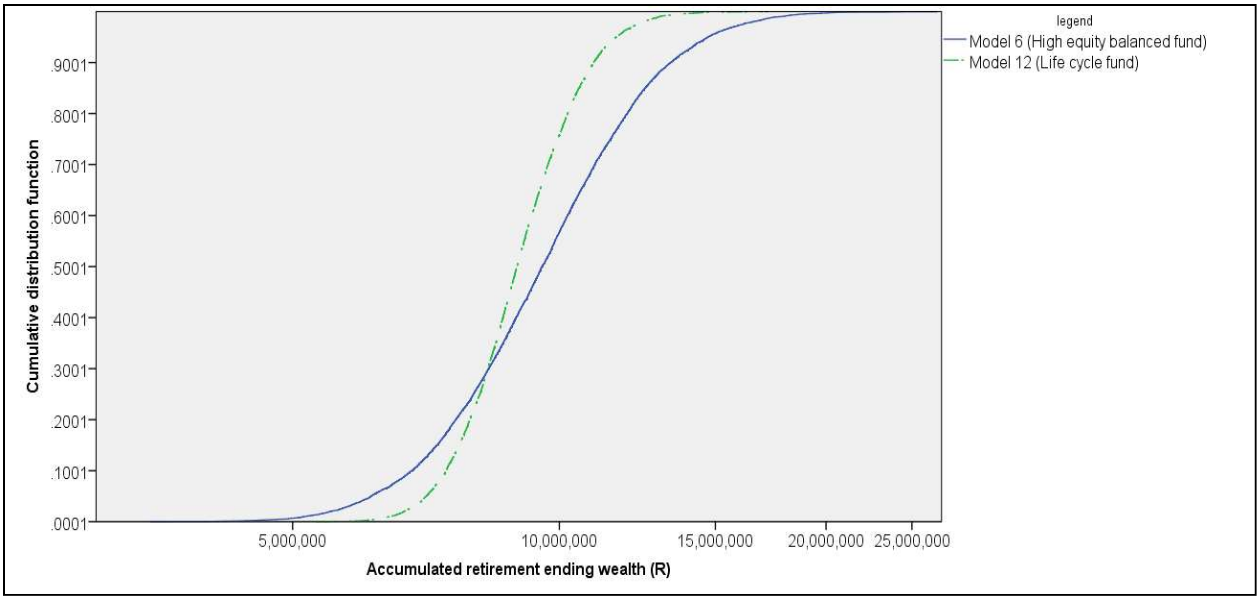
H1. HYPOTHESIS 2A

Figure H1: Cumulative distribution functions of accumulated retirement ending wealth for Model 10 against Model 5 (10-year investment horizon)



Source: SPSS output

Figure H2: Cumulative distribution functions of accumulated retirement ending wealth for Model 12 against Model 6 (10-year investment horizon)



Source: SPSS output

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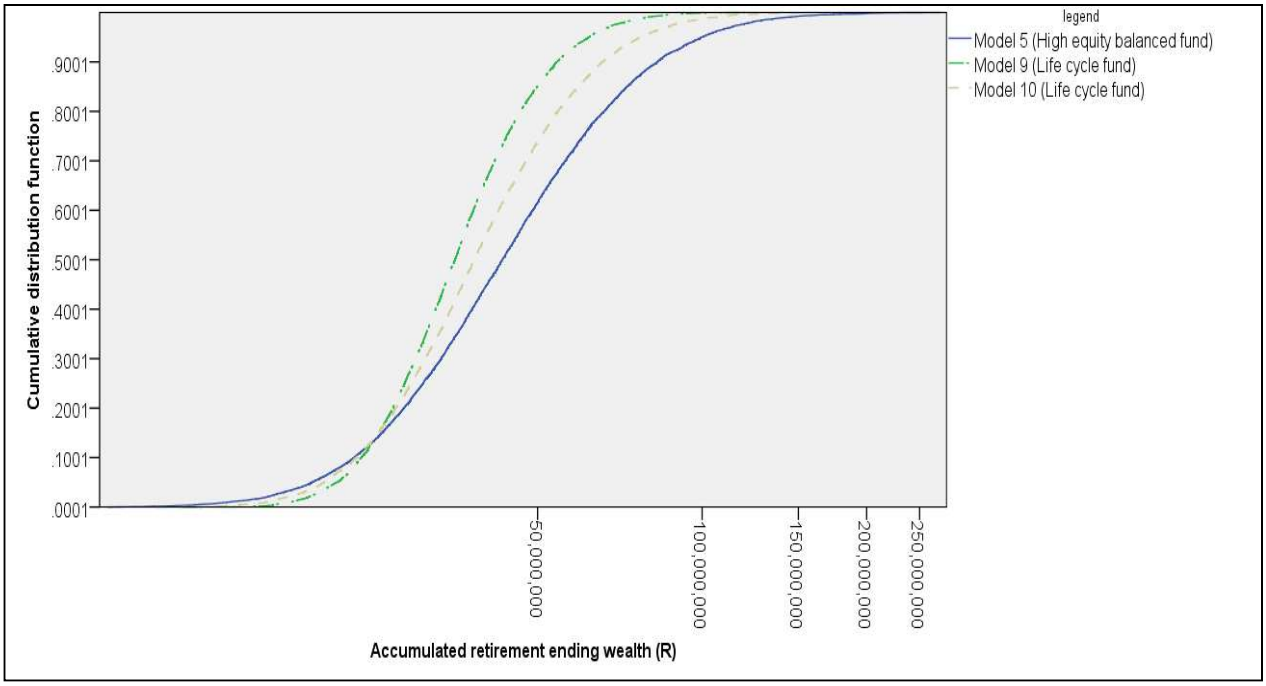
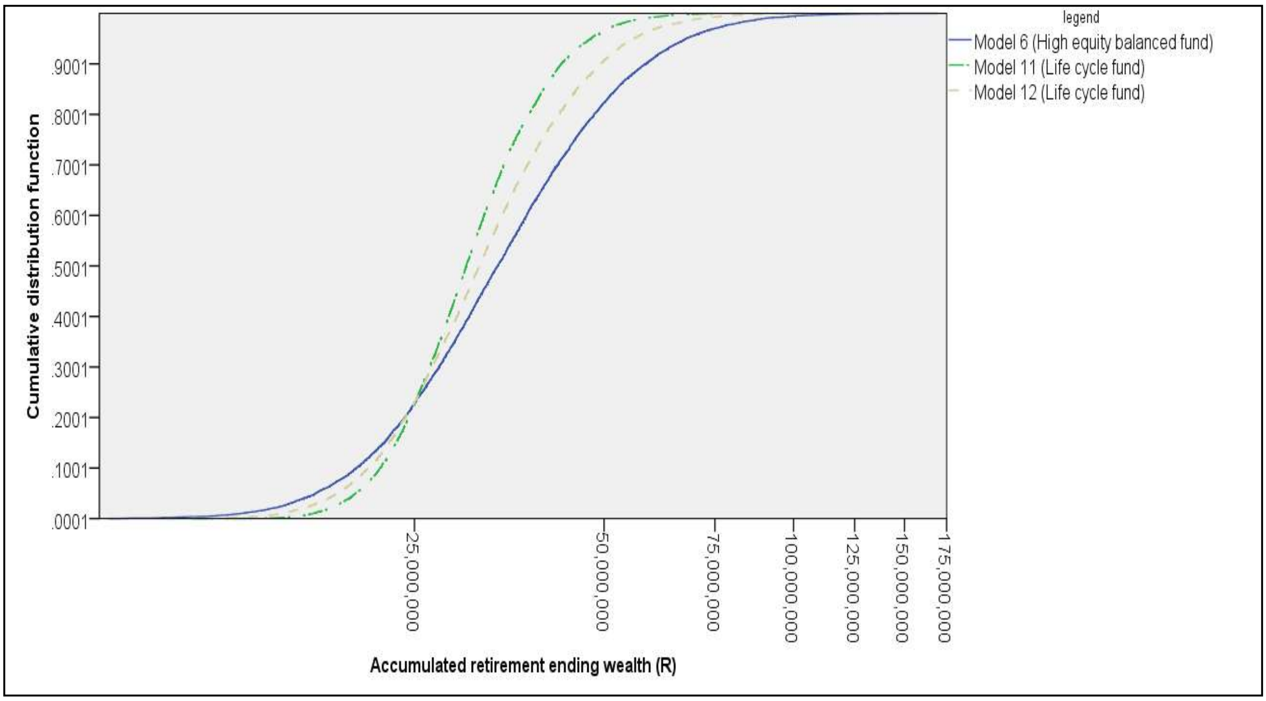
Figure H3: Cumulative distribution functions of accumulated retirement ending wealth for Models 9 and 10 against Model 5 (20-year investment horizon)



Source: SPSS output

Figure H4: Cumulative distribution functions of accumulated retirement ending wealth for Models 11 and 12 against Model 6 (20-year investment horizon)



Source: SPSS output

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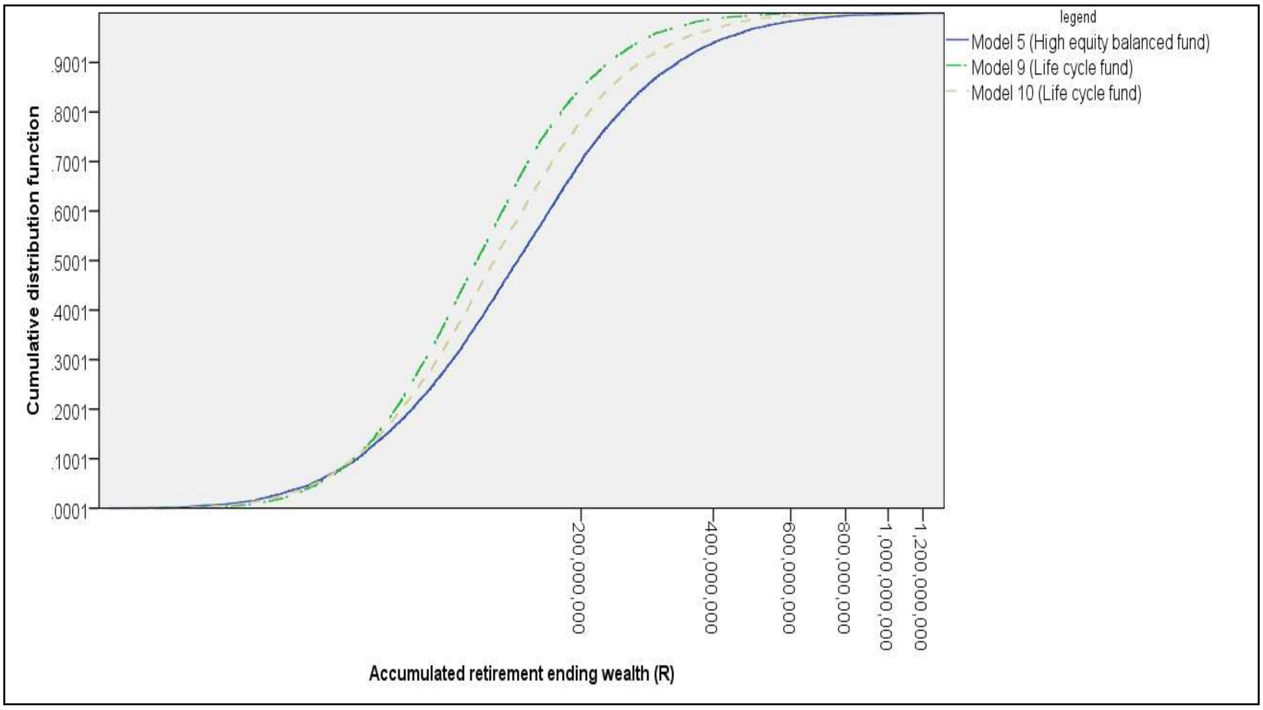
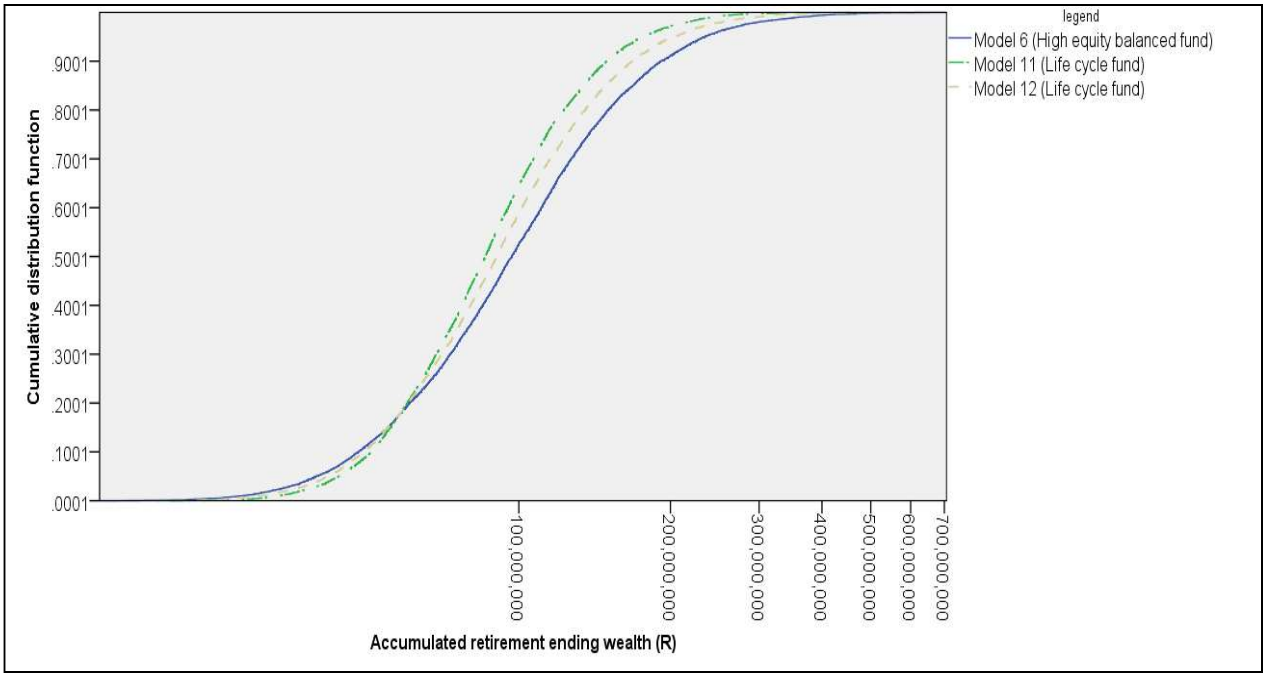
Figure H5: Cumulative distribution functions of accumulated retirement ending wealth for Models 9 and 10 against Model 5 (30-year investment horizon)



Source: SPSS output

Figure H6: Cumulative distribution functions of accumulated retirement ending wealth for Models 11 and 12 against Model 6 (30-year investment horizon)



Source: SPSS output

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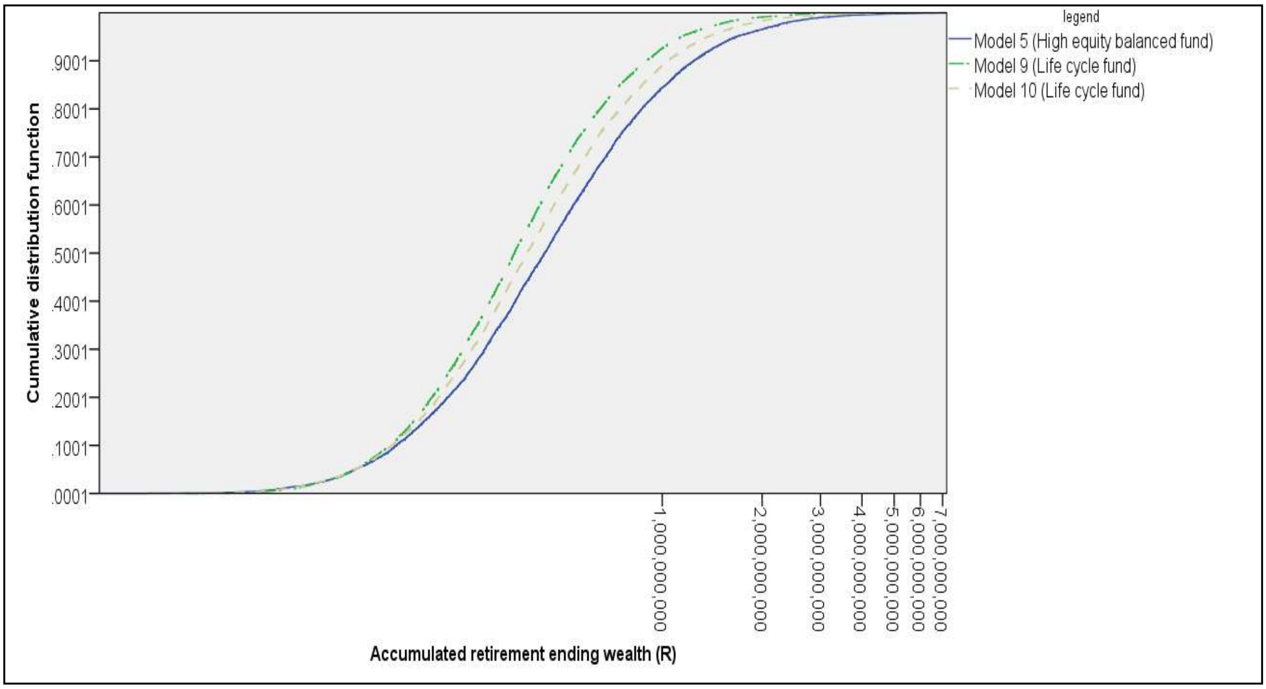
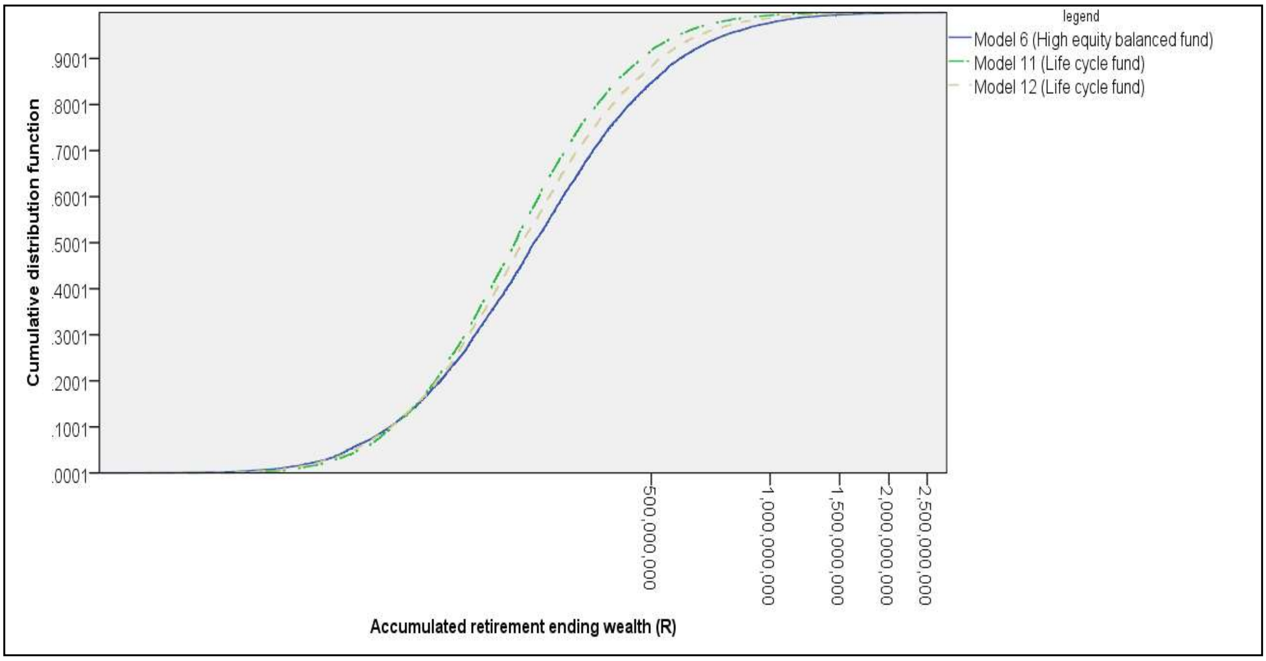
Figure H7: Cumulative distribution functions of accumulated retirement ending wealth for Models 9 and 10 against Model 5 (40-year investment horizon)



Source: SPSS output

Figure H8: Cumulative distribution functions of accumulated retirement ending wealth for Models 11 and 12 against Model 6 (40-year investment horizon)



Source: SPSS output

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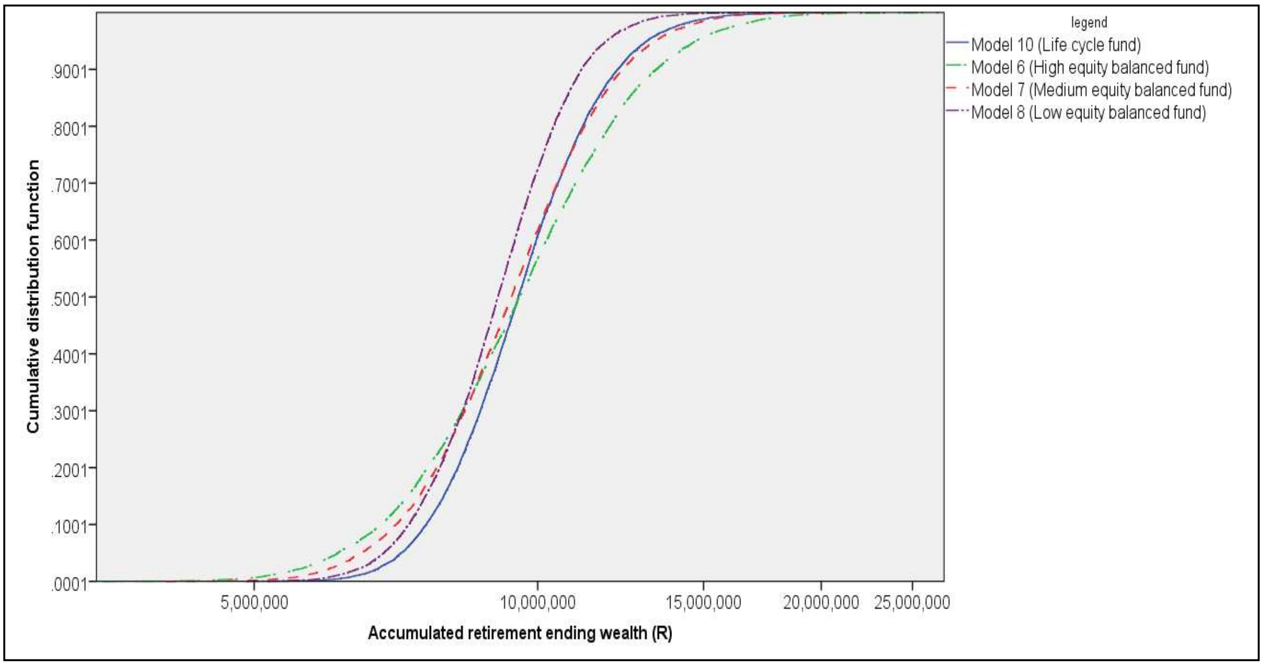
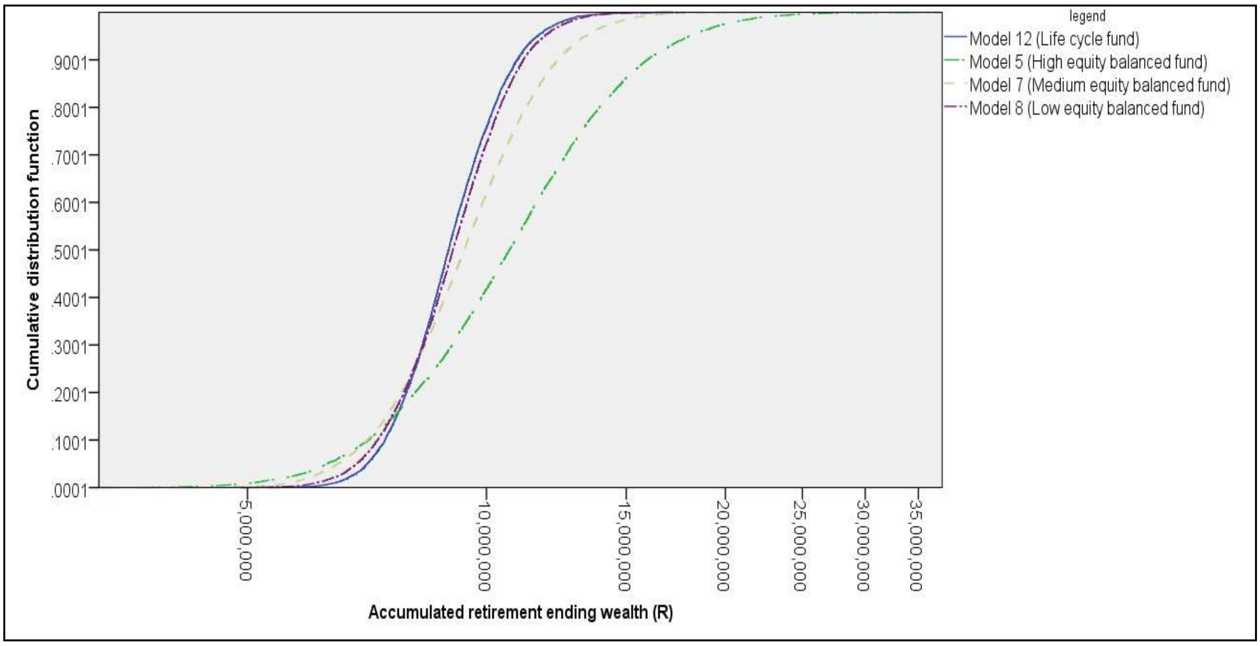
H2. HYPOTHESIS 2B

Figure H9: Cumulative distribution functions of accumulated retirement ending wealth for Model 10 against Models 6, 7 and 8 (10-year investment horizon)



Source: SPSS output

Figure H10: Cumulative distribution functions of accumulated retirement ending wealth for Model 12 against Models 5, 7 and 8 (10-year investment horizon)



Source: SPSS output

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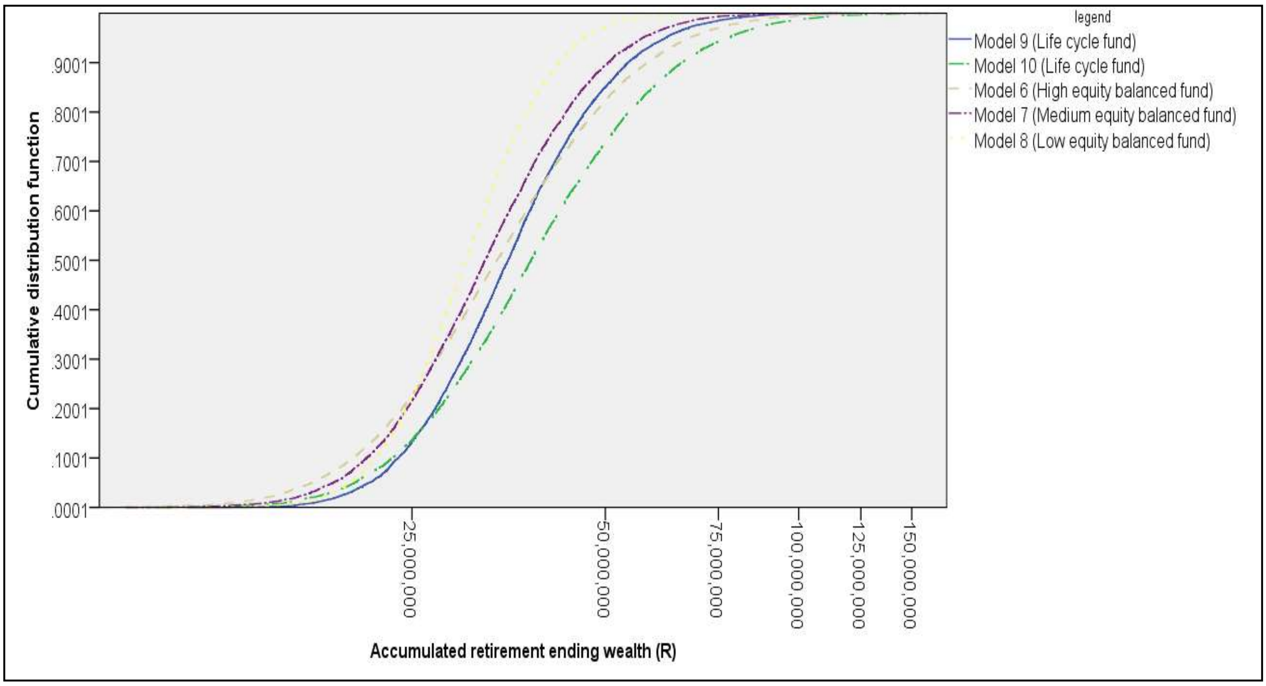
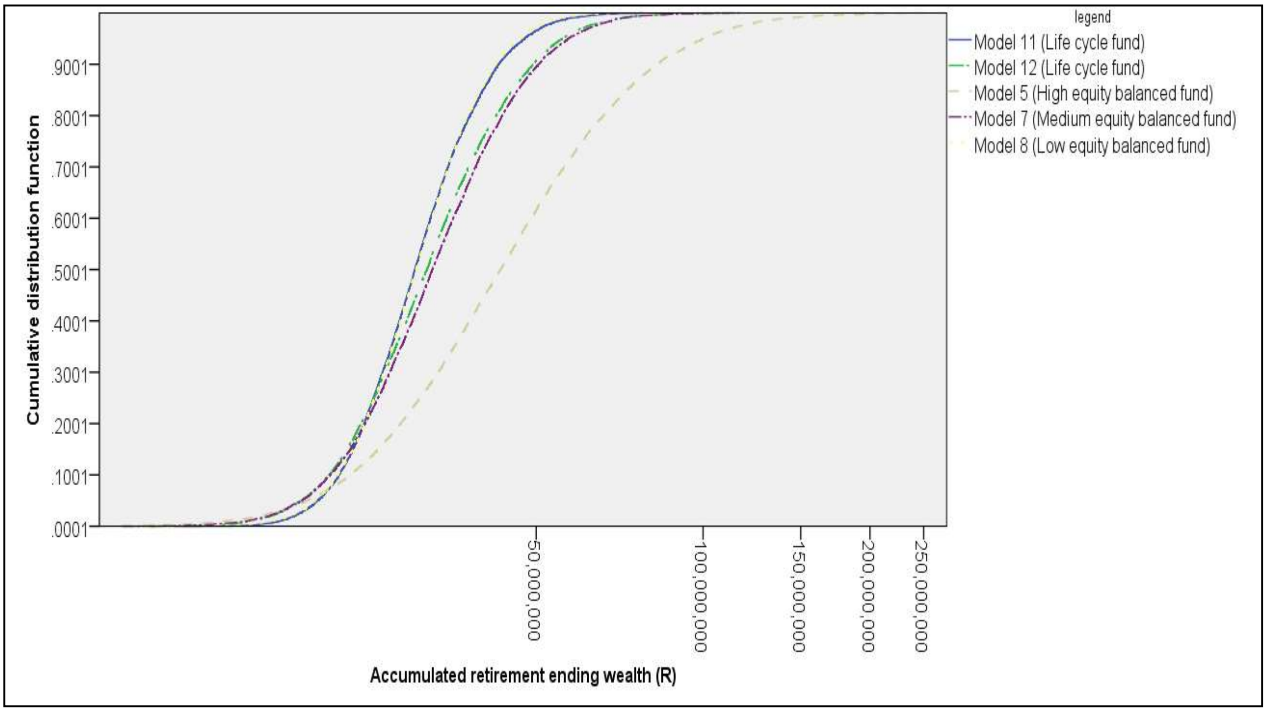
Figure H11: Cumulative distribution functions of accumulated retirement ending wealth for Models 9 and 10 against Models 6, 7 and 8 (20-year investment horizon)



Source: SPSS output

Figure H12: Cumulative distribution functions of accumulated retirement ending wealth for Models 11 and 12 against Models 5, 7 and 8 (20-year investment horizon)



Source: SPSS output

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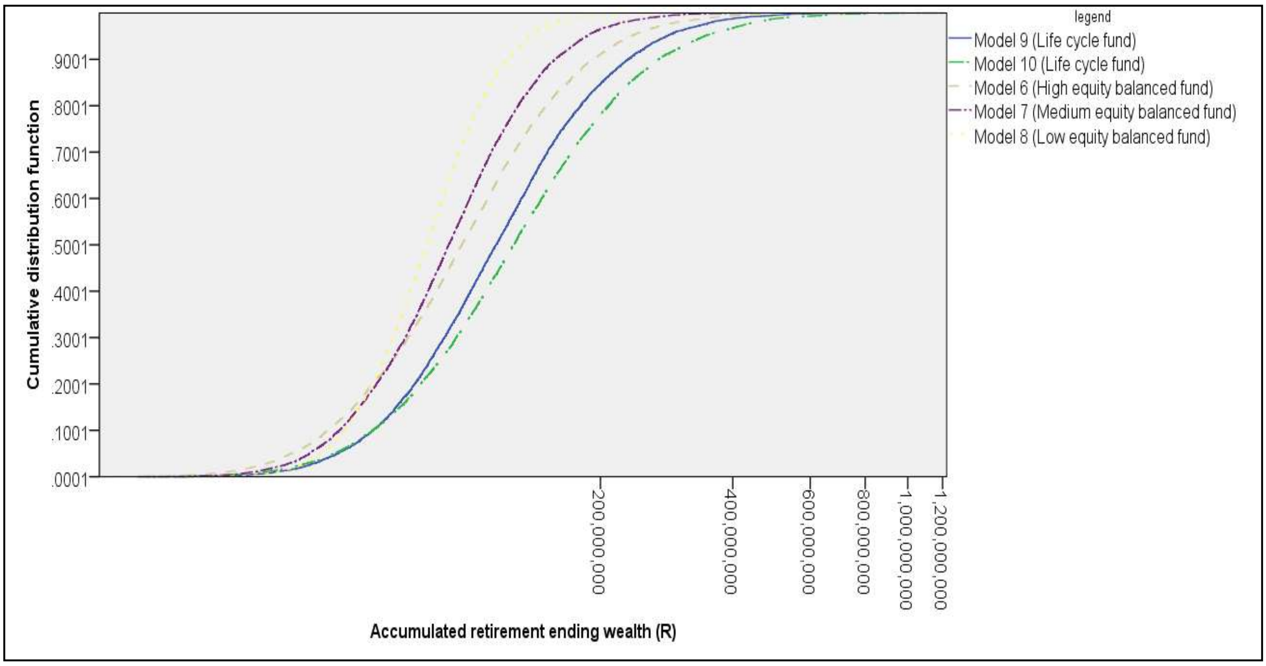
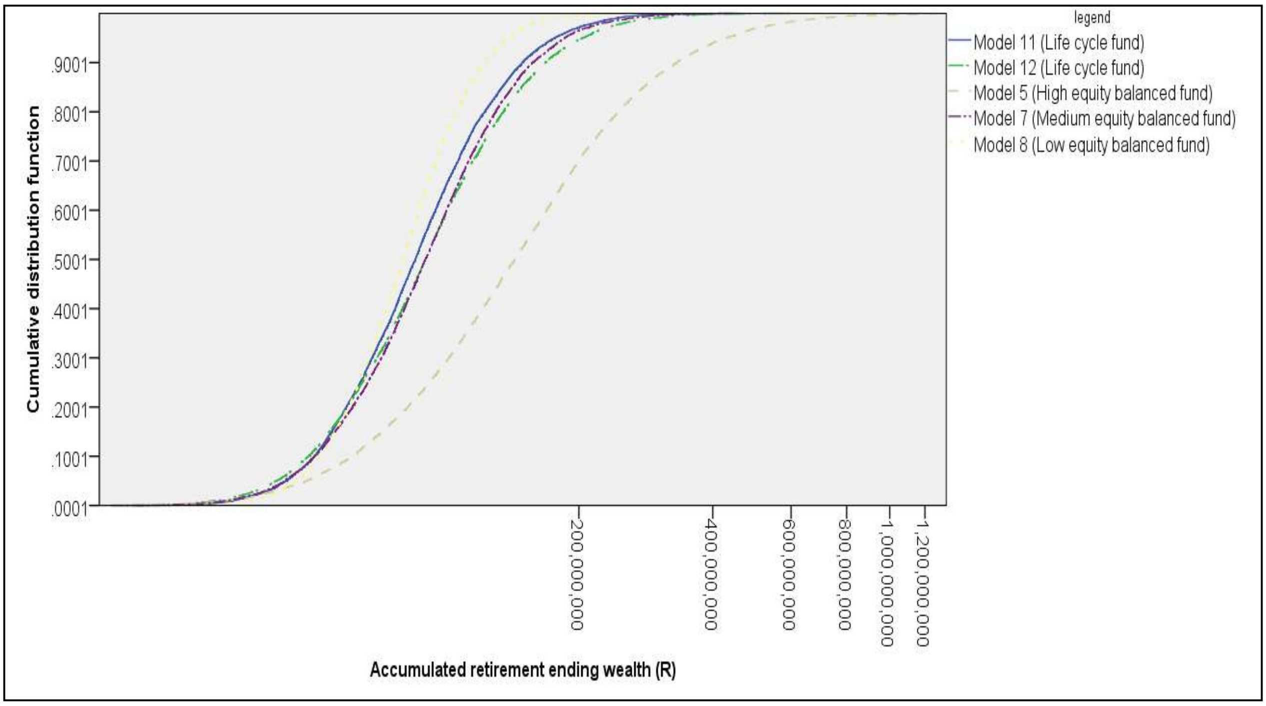
Figure H13: Cumulative distribution functions of accumulated retirement ending wealth for Models 9 and 10 against Models 6, 7 and 8 (30-year investment horizon)



Source: SPSS output

Figure H14: Cumulative distribution functions of accumulated retirement ending wealth for Models 11 and 12 against Models 5, 7 and 8 (30-year investment horizon)



Source: SPSS output

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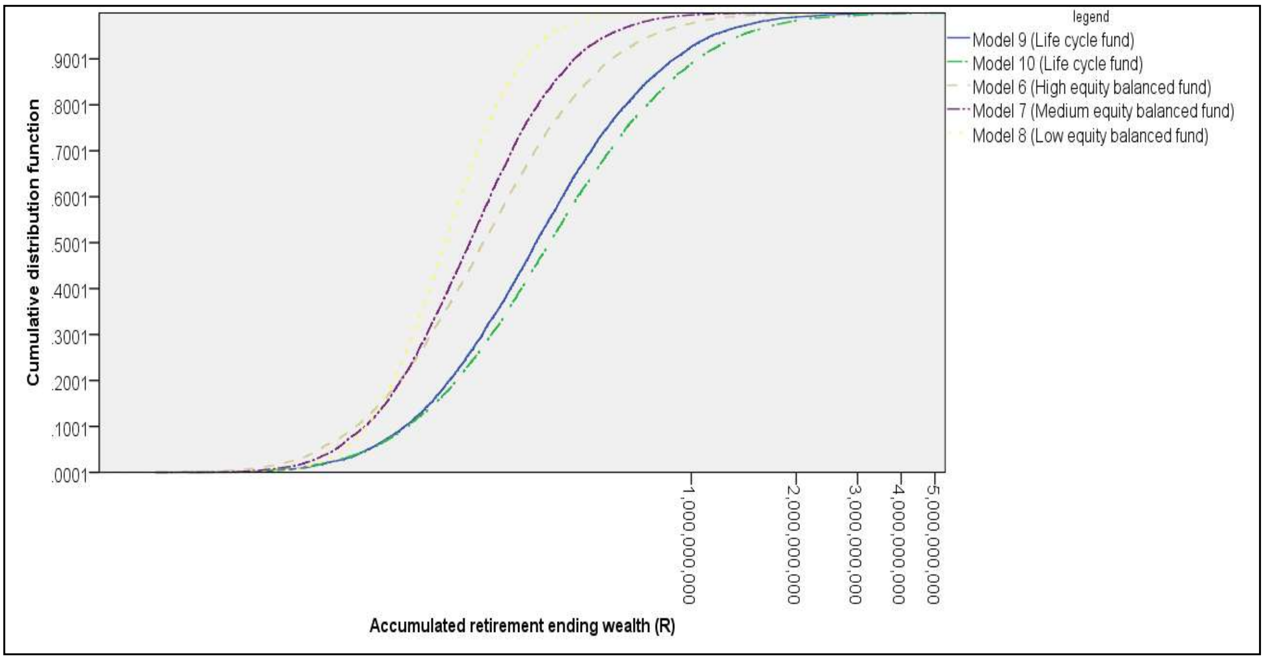
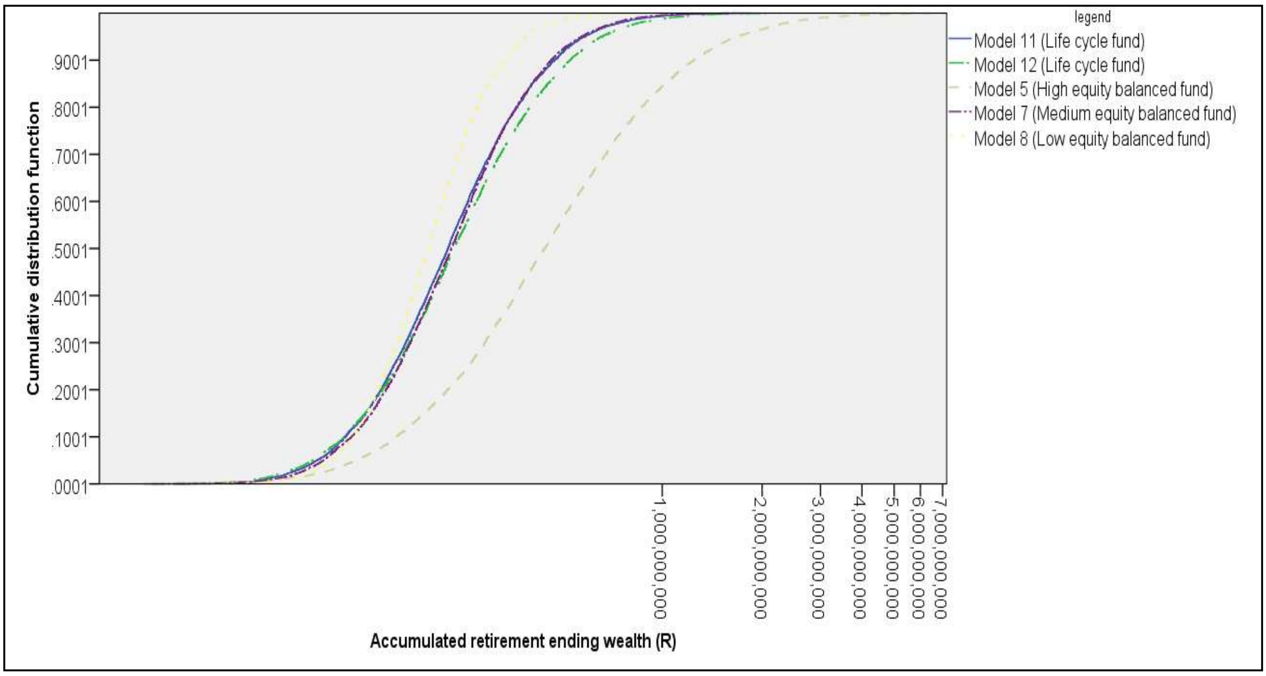
Figure H15: Cumulative distribution functions of accumulated retirement ending wealth for Models 9 and 10 against Models 6, 7 and 8 (40-year investment horizon)



Source: SPSS output

Figure H16: Cumulative distribution functions of accumulated retirement ending wealth for Models 11 and 12 against Models 5, 7 and 8 (40-year investment horizon)



Source: SPSS output

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ADDENDUM

POST-RETIREMENT TAX IMPLICATIONS OF ACCUMULATED RETIREMENT ENDING WEALTH

1. INTRODUCTION

The following addendum includes additional analysis that considers the post-retirement tax implications of retirement funds and direct investments. The addendum was added based on recommendations from the examiners. In particular, the post-retirement tax implications of direct investments versus Regulation 28 compliant retirement funds may influence the ASD results reported in the thesis.

Although retirement funds result in a tax break before retirement as contributions are tax deductible, all withdrawals will be taxed at the applicable personal income tax rate post retirement. Contrast this with the tax implications of direct investments: before retirement any contributions to such portfolios are not tax deductible. However, any withdrawals from a direct investment fund will be taxed at the capital gains tax rate which is much lower than the personal income tax that an individual would be exposed to.

As the post-retirement horizon was not the focus of the thesis, the following addendum includes a basic analysis of the post-retirement tax implications on the accumulated retirement ending wealth and subsequent ASD results of direct investments versus retirement funds by assuming that the accumulated retirement ending wealth is liquidated at retirement and considering the tax implications that apply in this instance. The post-retirement tax implications were not extensively researched and this would be a valuable area for future research.

2. RESEARCH QUESTION AND HYPOTHESES

The research question and related hypotheses which are the focus of this addendum, are Research Question 1 and hypothesis 1A and 1B.

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Research Question 1: *Is a fund fully invested in equities optimal compared with a high equity balanced retirement fund with maximum equity allocation of 75 percent?*

Hypothesis 1A(10, 20, 30, 40 years)

H_0: A 100 percent local equity direct investment fund (Model 2) does not dominate a high equity balanced retirement fund with 75 percent local equity (Model 5) by first-order stochastic dominance (FSD) or almost stochastic dominance (ASD).

H_a: A 100 percent local equity direct investment fund (Model 2) dominates a high equity balanced retirement fund with 75 percent local equity (Model 5) by first-order stochastic dominance (FSD) or almost stochastic dominance (ASD).

Hypothesis 1B(10, 20, 30, 40 years)

H_0: A 95 percent equity direct investment fund with a 70/25 percent local/foreign equity split (Model 4) does not dominate a high equity balanced retirement fund with a 50/25 percent local/foreign equity split (Model 6) by first-order stochastic dominance (FSD) or almost stochastic dominance (ASD).

H_a: A 95 percent equity direct investment fund with a 70/25 percent local/foreign equity split (Model 4) dominates a high equity balanced retirement fund with a 50/25 percent local/foreign equity split (Model 6) by first-order stochastic dominance (FSD) or almost stochastic dominance (ASD).

3. MODELS APPLICABLE TO HYPOTHESIS 1A AND 1B

The models applicable to Hypothesis 1A are as follows:

Model	Type of fund	Retirement fund or Direct investment fund	Ending asset allocation* (%)	Glide path period (years)
Model 2	Equity	Direct investment	100/0/0/0	N/A
Model 5	Balanced - High equity (no foreign exposure)	Retirement fund	75/0/15/10	N/A
*Local equity/foreign equity/local fixed income/local money market				

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The models applicable to Hypothesis 1B are as follows:

Model	Type of fund	Retirement fund or Direct investment fund	Asset allocation* (%)	Glide path period (years)
Model 4	Equity	Direct investment	70/25/0/5	N/A
Model 6	Balanced - High equity (25% foreign equity exposure)	Retirement fund	50/25/15/10	N/A
*Local equity/foreign equity/local fixed income/local money market				

The following section articulates the method and basic assumptions that were applied to include the post-retirement tax implications of direct investments versus retirement funds.

4. METHOD: POST-RETIREMENT TAX IMPLICATIONS

To consider the post-retirement tax implications of direct investments versus retirement funds, basic adjustments with simplified assumptions were made to the simulated accumulated retirement ending wealth values for model 2 and 4 (direct investments) and model 5 and 6 (retirement funds). Thereafter, the FSD and ASD results were determined in similar fashion to what was the case in the thesis using the adjusted accumulated retirement ending wealth values.

4.1 APPLICABLE TO DIRECT INVESTMENTS AND RETIREMENT FUNDS

- Irrespective of whether a direct investment or retirement fund model are considered, it is assumed that the accumulated retirement ending wealth is liquidated on the retirement date. The researcher acknowledges that this is a simplified assumption especially considering the retirement reforms proposals that include compulsory annuitisation. However, as the post-retirement decisions and consequential tax implications on direct investments versus retirement funds were not the focus of the study, a simplified assumption in this regard is considered sufficient for preliminary conclusions to be drawn.

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- Individuals qualify for an annual rebate for income tax payable while individuals over the age of 65 also qualify for a secondary rebate. Irrespective of whether the model is a direct investment or retirement fund, the annual and secondary rebates were not applied when considering the post-retirement tax implications as both models (direct investments versus retirement funds) would have the same benefit.
- Additionally, any interest exemptions or capital gains exclusions are not modelled. Firstly, as indicated in the retirement reforms proposals, the interest exemption is likely to be phased out. With regards to the capital gains exclusions, it can be applied to any transaction which results in capital gains. Depending on the financial position and transactions of an individual in a particular year, there may be no exclusion left to apply to the individual's retirement savings activities.
- A further matter to consider is the fact that the tax bracket in which the individual was in the pre-retirement years, may be different in the post retirement years as the tax bracket at which the individual will be taxed, is a factor of the taxable income at that particular point in time. As the simulations have very varied outcomes, some simulated results could be taxed at a higher or lower rate than was applicable in the pre-retirement years. Additionally, the tax rate will also be a factor of whether the model relates to a direct investment or a retirement fund.

4.2 APPLICABLE TO DIRECT INVESTMENTS

- In the thesis, the tax implications of the tax year ending 28 February 2015 were applied and this remains the foundation for the additional analysis. The implication is that the future value of all taxable income brackets at age 65 must be projected and applied. The simplified assumption was made to adjust the upper bound of each taxable income range at the rate of inflation that was consistently used in the thesis namely 4.5 percent per annum. The subsequent band's lower range is consequently R1 more than the calculated upper bound for the previous tax band. Table 1 shows the tax rates that was applicable to the year of assessment ending 28 February 2015 with Table 2 showing the tax table that would be applicable upon retirement.

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Table 1: Tax rates (year of assessment ending 28 February 2015)

Taxable income (R)	Rate of tax (R)
R0 – R174 550	18% of taxable income
R174 551 – R272 700	R31 419 + 25% of taxable income above 174 550
R272 701 – R377 450	R55 957 + 30% of taxable income above 272 700
R377 451 – R528 000	R87 382 + 35% of taxable income above 377 450
R528 001 – R673 100	R140 074 + 38% of taxable income above 528 000
R673 101 and above	R195 212 + 40% of taxable income above 673 100

Table 2: Tax rates - projected to future value at retirement (40 years)

Taxable income (R)	Rate of tax (R)
R0 – R1 015 246	18% of taxable income
R1 015 247 – R1 586 123	R182 744 + 25% of taxable income above 1 015 246
R1 586 124 – R2 195 387	R325 463 + 30% of taxable income above 1 586 123
R2 195 388 – R3 071 040	R508 242 + 35% of taxable income above 2 195 387
R3 071 041 – R3 914 995	R841 721 + 38% of taxable income above 3 071 040
R3 914 996 and above	R1 135 423 + 40% of taxable income above 3 914 995

- The basic premise for the analysis is that, if the accumulated retirement ending wealth is liquidated at retirement, the direct investment model will be subject to capital gains tax only. As described in the thesis, capital gains tax is applied at a rate of 33.3 percent of the realised gains (as was the case for the tax year ending 28 February 2015), which is included in the taxable income of the individual. Each accumulated retirement ending wealth simulated is adjusted by the taxes payable.
- The following method was therefore followed to adjust the original accumulated retirement ending wealth values:
  - *Step 1: Calculate the capital gains portion of each accumulated retirement ending wealth value*

    The capital gains portion of each accumulated retirement ending wealth value, is the difference between the accumulated retirement ending wealth value and the contributions that were made during the pre-retirement years. The latter is shown in Table 3 for each investment horizon and tax bracket.

    Capital gains portion = Original accumulated retirement ending wealth *minus* pre-retirement contributions *(Equation 1)*

Table 3: Total contributions during pre-retirement years

Investment horizon/	10-year	20-year	30-year	40-year

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Tax bracket				
18% tax bracket	R988 103	R1 624 371	R2 034 081	R2 297 903
25% tax bracket	R1 411 936	R2 321 119	R2 906 572	R3 283 557
40% tax bracket	R2 788 046	R4 583 347	R5 739 389	R6 483 799

- *Step 2: Calculate the taxes payable*

  33.33 percent of the capital gains calculated in step 1, is considered to be the taxable income for the particular simulation. The taxable income is then compared with the projected tax brackets shown in Table 2 and the taxes payable calculated based on the applicable tax rate.

  Taxes payable = capital gains portion x 0.3333 x approriate tax rate (as per projected tax table) *(Equation 2)*

- *Step 3: Calculate the adjusted accumulated retirement ending wealth*

  Finally, the taxes payable are deducted from the accumulated retirement ending wealth value for each simulation to incorporate the post-retirement tax implications.

  Adjusted accumulated retirement ending wealth = original accumulated retirement ending wealth *minus* taxes payable *(Equation 3)*

4.3 APPLICABLE TO RETIREMENT FUNDS

- In the thesis, the tax implications of the tax year ending 28 February 2015 were applied and this remains the foundation for the additional analysis. In contrast to direct investments, retirement funds are not taxed according to the income tax table that was shown in the thesis (and repeated here). Retirement fund benefits are taxed based on the retirement fund lump sum benefits tax table applicable at age 65. The implication is that the future value of all the retirement fund lump sum benefit tax brackets at age 65 must be projected based on the applicable tax table for the year of assessment ending 28 February 2015 and the latter applied to consider the post-retirement tax implications. The simplified assumption was made to adjust the upper bound of each lump sum range at the rate of inflation that was consistently used in the thesis namely 4.5 percent per annum. The subsequent

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band's lower range is consequently R1 more than the calculated upper bound for the previous tax band. Table 4 shows the retirement fund lump sum benefits tax table that was applicable to the year of assessment ending 28 February 2015 while Table 5 presents the tax table that would be applicable upon retirement.

Table 4: Tax table - Retirement fund lump sum benefits (year of assessment ending 28 February 2015

Lump sum	Rate of tax
R0-R500 000	0% of taxable income
R500 001-R700 000	18% of taxable income above R500 000
R700 001-R1 050 000	R36 000+27% of taxable income above R700 000
R1 050 001 and above	R120 500+36% of taxable income above R1 050 000

Table 5: Tax table - Retirement fund lump sum benefits (projected to future value at retirement (40 years)

Lump sum	Rate of tax
R0-R2 908 182	0% of taxable income
R2 908 183-R4 071 455	18% of taxable income above R2 908 182
R4 071 456-R6 107 183	R209 389 + 27% of taxable income above R4 071 455
R6 107 184 and above	R759 035 + 36% of taxable income above R6 107 183

- The basic premise is that, if the accumulated retirement ending wealth is liquidated at retirement, the retirement fund model will be subject to the retirement fund lump sum benefits tax table.
- The following method was therefore followed to adjust the original accumulated retirement ending wealth values:
- The following were therefore applied to the accumulated retirement ending wealth values:
    - *Step 1: Calculate the taxes payable*

      In the case of the retirement fund models, the original accumulated retirement ending wealth value of each simulation, is equivalent to the retirement fund lump sum benefit at retirement. The applicable taxes payable are calculated based on the original accummulated retirement ending wealth value and corresponding retirement lump sum benefits tax bracket.

      Taxes payable = Original accumulated retirement ending wealth x approriate tax rate (as per projected retirement lum sum benefits tax table)

(Equation 4)

- *Step 2: Calculate the adjusted accumulated retirement ending wealth*

  The original accumulated retirement ending wealth is reduced by the taxes payable (as per step 1) which results in the adjusted accumulated retirement ending wealth which incorporates the post-retirement tax implications.

  Adjusted accumulated retirement ending wealth = original accumulated retirement ending wealth *minus* taxes payable *(Equation 5)*

5. RESULTS AND FINDINGS

5.1 HYPOTHESIS 1A

5.1.1 Results and key findings

Figure 1 presents the cumulative distribution functions for Model 2 (direct investment fund) and Model 5 (high equity balanced retirement fund) for an 18 percent tax bracket individual and a 10-year investment horizon.

Figure 1: Cumulative distribution functions of adjusted accumulated retirement ending wealth for Model 2 against Model 5 (10-year investment horizon, 18% tax bracket)

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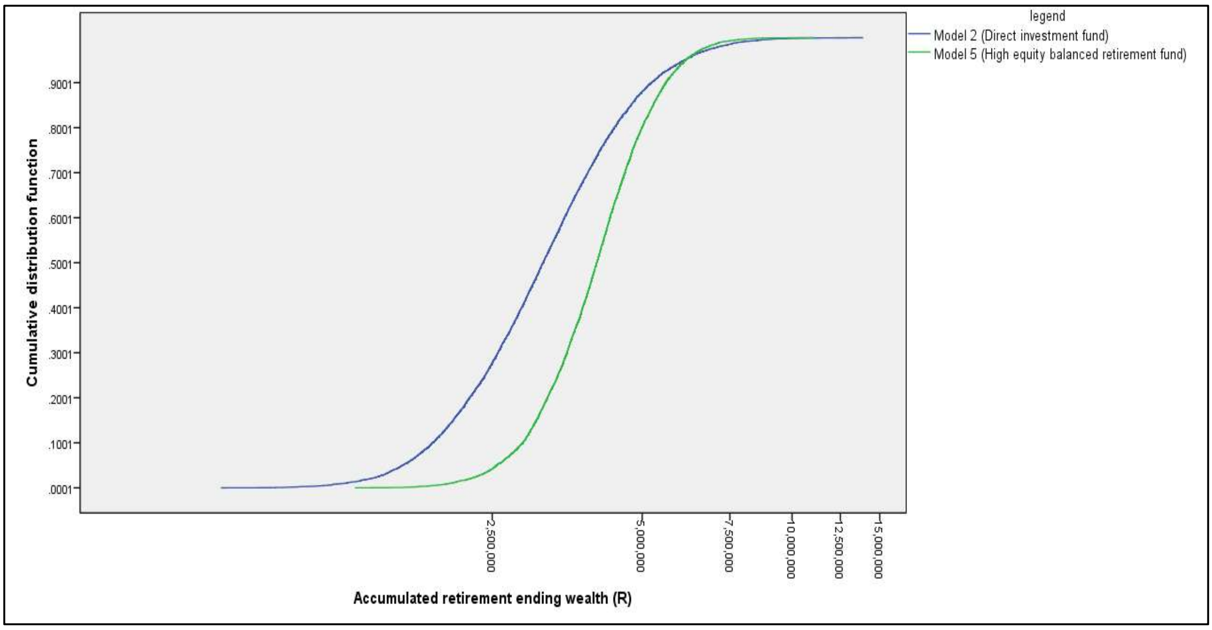

Source: SPSS output

The first observation is that the cumulative distribution functions of the two models cross, violating the strict FSD principle that one model should consistently be below or to the right of the other to dominate by FSD. This is at a cumulative probability of approximately 0.9535 and an accumulated retirement ending wealth value of approximately R4.33 million. However, there is still a chance that one of the models may dominate the other by ASD. For any accumulated retirement ending wealth value of below approximately R4.33 million where the cumulative distribution functions cross, the cumulative distribution function of Model 5 is below or to the right of Model 2. For this section, Model 5 is the optimal choice compared with Model 2, as Model 5 has a greater accumulated retirement ending wealth for each cumulative probability value. The opposite is true to the right of an accumulated retirement ending wealth of approximately R4.33 million.

The ε value to test for ASD of one model against another is calculated as the area of SD violation divided by non-SD violation. For testing Hypothesis 1A, the ε values for Model 2 against Model 5 would be calculated as the area enclosed by the cumulative distribution functions to the left of R4.33 million (area A) divided by the area enclosed by the cumulative distribution functions to the right of R4.33 million (area B). Because Area A is significantly larger than Area B in Figure 1, the resulting ε value is much higher than the threshold value of 0.01. On the other hand, to test for ASD of Model 5

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over Model 2, the ε value would be calculated as Area B divided by Area A, which is the inverse of the ε value for Model 2 over Model 5. Using the latter method, one has to be cognisant of the sensitivity of the values due to rounding.

Because Area A is much greater than the area where Model 2 is optimal, the cumulative distribution functions indicate that Model 5 is likely to dominate Model 2 by ASD if the ε value is between 0 and 0.01 and that Model 2 is unlikely to dominate Model 5 (the latter comparison being consistent with what is required to test the null hypothesis). This is confirmed by the ε values for Model 2 against Model 5, which are significantly higher than the threshold value of 0.01 for all sub-hypotheses (Table 6). To provide additional insights, the table also indicates the instances where Model 5 dominates Model 2 (with the symbol "***"): for the 10-year investment horizon, Model 5 dominates Model 2 by ASD for the 40 percent tax bracket.

For ease of comparison, Table 6 also includes the ε values for Model 2 against Model 5 as per the original thesis (section 4.5.1.1.1, Table 4-9) which did not consider the post-retirement tax implications.

Table 6: ASD results of Model 2 against Model 5

Area of SD violation relative to non-violation (ε)** Direct investment fund model – Model 2 (100/0/0/0, equity fund) AGAINST Balanced fund model - Model 5 (75/0/15/10, retirement fund)				
Tax bracket/ Time horizon	**With/without post-retirement tax implications**	**18% tax bracket**	**25% tax bracket**	**40% tax bracket**
10 years	With	**32.6648**	**38.6091**	**853.7122*** **
	Without (original in thesis)	*(113.6364***)*	*(2500.0000***)*	*(No value***)*
20 years	With	**3.28107**	**2.0538**	**8.4964**
	Without (original in thesis)	*(6.2073)*	*(29.7619)*	*(17 972.6815***)*
30 years	With	**6.3975**	**7.2017**	**2.0388**
	Without (original in thesis)	*(1.7730)*	*(5.3135)*	*(1111.1111***)*
40 years	With	**32.6239**	**12.4670**	**1.1241**
	Without (original in thesis)	*(1.2436)*	*(2.0589)*	*(23.2019)*
†FSD				

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¥ Value of zero shown due to rounding, does not exhibit FSD in the truest form. ** Almost stochastic dominance exists for threshold value of $0 < \varepsilon < 0.01$. *** Model 5 dominates Model 2 by FSD if ε value shows "No value" or ASD in all other cases.

In the following sections, the ε value results for all the investment horizons and tax brackets shown in Table 6, which also includes the original results from the thesis, are discussed.

5.1.1.1 Key findings: Inclusion of post-retirement tax implications

In all instances, the ε values are greater than the threshold value of 0.01 and so the null hypothesis cannot be rejected. Furthermore, there is no clear pattern as to whether an increase in the investment horizon would make it more or less likely for Model 2 to dominate Model 5.

Given the nature of the result, the alternative is also considered; that is whether the high equity balanced retirement fund dominates the direct investment fund by ASD or FSD. Only in one instance, this is the case with Model 5 dominating Model 2 by ASD. In particular, this is for the 40 percent tax bracket, 10-year investment horizon.

5.1.1.2 Key findings: Comparative analysis of original results with additional analysis

A comparative analysis of the original results which excluded post-retirement tax implications versus the additional analysis which includes the post-retirement tax implications lead to some interesting findings.

The inclusion of the post-retirement tax implications have an impact on all of the stochastic dominance results. However, the additional and original analysis concur that Model 2 (the direct investment model) does not dominate the Model 5 (high equity balanced retirement fund) by FSD or ASD. Hence, in all instances, the null hypothesis could not be rejected because the ε values were still higher than the threshold value of 0.01.

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Noteworthy though, is the fact that in the analysis which considers the post-retirement tax implications, there is only one instance where Model 5 dominated Model 2 (high equity balanced retirement fund dominating the direct investment fund). This was for the 40 percent tax bracket, 10-year investment horizon (dominance by ASD). In the analysis which did not consider the post-retirement tax implications, there were a number of instances where Model 5 dominated Model 2 (either by FSD or ASD). In particular, this was for the 18, 25 and 40 percent tax brackets and 10-year investment horizon; 40 percent tax bracket and 20-year investment horizon and 40 percent tax bracket and 30-year investment horizon. The inclusion of the post-retirement tax implications therefore removes most of the instances where Model 5 (high equity balanced retirement fund) dominated Model 2 (the direct investment model) in the original thesis where post-retirement tax effects were not taken into account.

Given the inconsistency of the results over different investment horizons and tax brackets, in most instances individuals should remain indifferent between the two models based on the stochastic dominance results (whether considering the post-retirement tax implications or not).

Furthermore, as the point was raised in the thesis, it is worth mentioning that if the cumulative distribution functions of two models were compared but the individual had a clear retirement target, this may influence what would be deemed the most appropriate model as it will be based on likelihood of achieving the particular retirement target (this approach was elaborated on in the discussion pertaining to Figure 1 in section 5.1.1 and addressed in the thesis).

5.1.2 Summary

Table 7 shows a summary of the findings pertaining to Hypothesis 1A. The results indicate that for all sub-hypotheses, Model 2 (the direct equity fund with a 100 percent allocation to local equities) fails to dominate Model 5 (the Regulation 28 balanced fund with a 75 percent allocation to local equities) by FSD or ASD and therefore fails to reject the null hypothesis.

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Table 7: Summary of findings – Hypothesis 1A

Hypothesis 1A

H_0: A 100 percent local equity direct investment fund does not dominate a high equity balanced retirement fund (75 percent local equity) by first-order stochastic dominance (FSD) or almost stochastic dominance (ASD).

H_a: A 100 percent local equity direct investment fund dominates a high equity balanced retirement fund (75 percent local equity) by first-order stochastic dominance (FSD) or almost stochastic dominance (ASD).

Time horizon/ Tax bracket	10 years	20 years	30 years	40 years
18 percent	**Sub-hypothesis 1A$^{10\ years}$** Fail to reject the null hypothesis	**Sub-hypothesis 1A$^{20\ years}$** Fails to reject the null hypothesis	**Sub-hypothesis 1A$^{30\ years}$** Fails to reject the null hypothesis	**Sub-hypothesis 1A$^{40\ years}$** Fails to reject the null hypothesis
25 percent	**Sub-hypothesis 1A$^{10\ years}$** Fails to reject the null hypothesis	**Sub-hypothesis 1A$^{20\ years}$** Fails to reject the null hypothesis	**Sub-hypothesis 1A$^{30\ years}$** Fails to reject the null hypothesis	**Sub-hypothesis 1A$^{40\ years}$** Fails to reject the null hypothesis
40 percent	**Sub-hypothesis 1A$^{10\ years}$** Fails to reject the null hypothesis	**Sub-hypothesis 1A$^{20\ years}$** Fails to reject the null hypothesis	**Sub-hypothesis 1A$^{30\ years}$** Fails to reject the null hypothesis	**Sub-hypothesis 1A$^{40\ years}$** Fails to reject the null hypothesis

5.2 HYPOTHESIS 1B

5.2.1 Results and key findings

Figure 2 presents the cumulative distribution functions for Model 4 (direct investment model) and Model 6 (high equity balanced retirement fund) for an 18 percent tax bracket individual with a 10-year investment horizon.

In Figure 2, the cumulative distribution functions of Model 4 and Model 6 cross, violating the strict FSD principle. This is at a cumulative probability of approximately 0.9896 and an adjusted accumulated retirement ending wealth value of approximately R4.2 million (it is not visible on the graphs because it is at an area where the two cumulative distribution functions are very close to each other). For any accumulated retirement ending wealth value of below approximately R4.2 million where the cumulative distribution functions cross, the cumulative distribution function of Model 6 is below or to the right of Model 4 with the area shown on the figure as Area A, enclosed by the cumulative distribution functions. For this section, Model 6 is optimal

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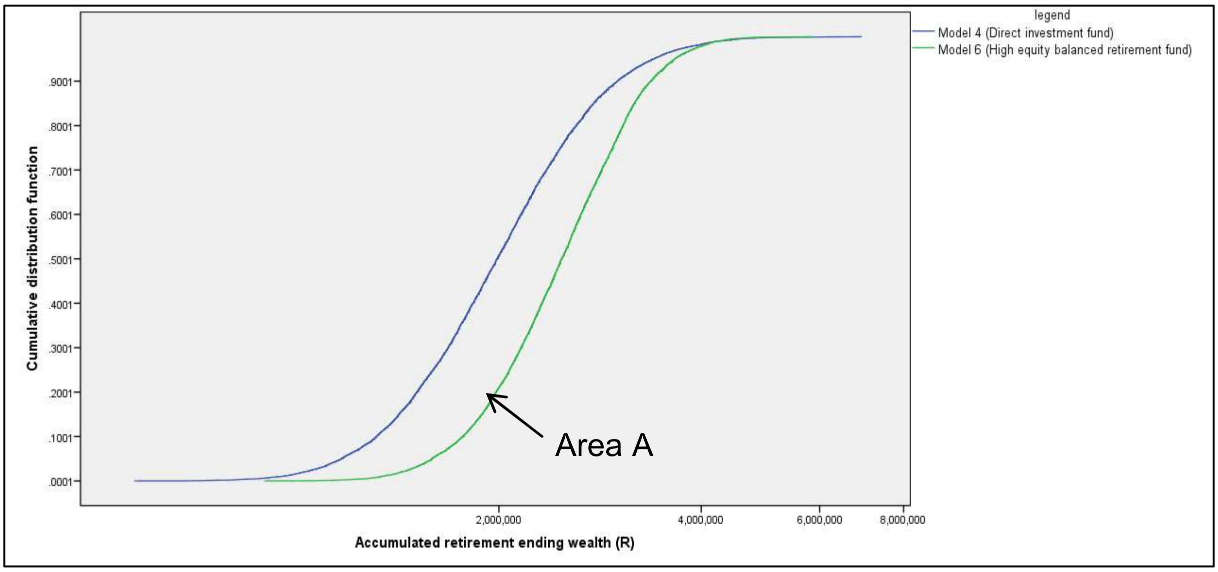
compared with Model 4 while the opposite is true to the right of an accumulated retirement ending wealth of approximately R4.2 million.

Figure 2: Cumulative distribution functions of adjusted accumulated retirement ending wealth for Model 4 against Model 6 (10-year investment horizon, 18% tax bracket)



Source: SPSS output

Because Area A, which is the stochastic dominance area for Model 6, is much greater than the area where Model 4 is optimal, the cumulative distribution functions indicate that Model 6 is likely to dominate Model 4 by ASD if the ε value is between 0 and 0.01 and that Model 4 is unlikely to dominate Model 6 (the latter being consistent with what is required to test the null hypothesis). This is confirmed by the ε values for Model 4 against Model 6, which are significantly higher than the threshold value of 0.01 for most sub-hypotheses (Table 8). This results in a failure to reject the null hypothesis in most of the cases. Additionally, there are no instances where Model 6 dominates Model 4.

For ease of comparison, Table 8 also includes the ε values for Model 4 against Model 6 as per the original thesis (section 4.5.1.2.1, Table 4-11) which did not consider the post-retirement tax implications.

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Table 8: ASD results of Model 4 against Model 6

Area of SD violation relative to non-violation (ε)** Direct investment fund model – Model 4 (70/25/0/5, equity fund) VERSUS Balanced fund model - Model 6 (50/25/15/10, retirement fund)				
Tax bracket/ Time horizon	**With/without post-retirement tax implications**	**18% tax bracket**	**25% tax bracket**	**40% tax bracket**
10 years	With	**0.0000¥**	**0.0033****	**0.0000¥**
	Without (original in thesis)	*(1 000.0000***)*	*(No value***)*	*(No value***)*
20 years	With	**0.6065**	**0.9793**	**0.0161**
	Without (original in thesis)	*(21.0849)*	*(289.7379)*	*(No value***)*
30 years	With	**0.0791**	**0.2340**	**0.0686**
	Without (original in thesis)	*(5.0630)*	*(28.4849)*	*(No value***)*
40 years	With	**0.0356**	**0.1395**	**0.1396**
	Without (original in thesis)	*(2.3359)*	*(11.0988)*	*(2 000.0000***)*

†FSD
¥ Value of zero shown due to rounding, does not exhibit FSD in the truest form.
** Almost stochastic dominance exists for threshold value of 0 < ε < 0.01.
*** Model 6 dominates Model 4 by FSD if ε value shows "No value" or ASD in all other cases.

In the following sections, the ε value results for all the investment horizons and tax brackets shown in Table 8, which also includes the original results from the thesis, are discussed.

5.2.1.1 Key findings: Inclusion of post-retirement tax implications

In most instances, the null hypothesis cannot be rejected because the ε values are greater than the threshold value of 0.01. The exceptions are for the 18, 25 and 40 percent tax brackets respectively with a 10-year investment horizon. Furthermore, there is no clear pattern as to whether an increase in the investment horizon would make it more or less likely for Model 4 to dominate Model 6.

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5.2.1.2 Key findings: Comparative analysis of original results with additional analysis

A comparative analysis of the original results which excluded post-retirement tax implications versus the additional analysis which includes the post-retirement tax implications lead to some interesting findings.

The inclusion of the post-retirement tax implications, has an impact on all of the stochastic dominance results. Furthermore, the additional and original analysis concur that Model 4 (the direct investment model) does not dominate Model 6 (high equity balanced retirement fund) by FSD or ASD for all tax brackets and the 20-, 30- and 40-year investment horizons respectively. In these instances, the null hypothesis could not be rejected because the ε values remained higher than the threshold value of 0.01.

Noteworthy however, is the discrepancy in findings regarding the 10-year investment horizon for the 18, 25 and 40 percent tax brackets respectively. In the analysis which considers the post-retirement tax implications, the null hypotheses are rejected as the ε values are below the threshold value of 0.01. In contrast, the analysis that did not consider the post-retirement tax implications failed to reject the null hypotheses in these particular instances. This finding indicates that the inclusion of the post-retirement tax implications results in, over a 10-year investment horizon, Model 4 (the direct investment model) dominating Model 6 (the high equity balanced retirement fund). Given the simplified assumptions of the analysis as well as the other factors that contribute to the likelihood of one model dominating another which was highlighted in the thesis, generalisations based on the results would however be inappropriate.

The thesis also highlighted the instances where Model 6 dominates Model 4. With regards to the original results, Model 6 dominated Model 4 by FSD or ASD in the following instances:

- 40 percent tax bracket, all investment horizons
- 18 and 25 percent tax bracket respectively, 10-year investment horizon

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Inclusion of the post-retirement tax implications, indicate that in no instances do Model 6 dominate Model 4 by FSD or ASD. Broadly speaking, this may suggest that the post-retirement tax implications removes the instances where the high equity balanced retirement fund (Model 6) dominated the direct investment fund (Model 4) in the original thesis that did not consider post-retirement tax implications. However, given the simplified nature of the post-retirement tax implication analysis, generalisations would be inappropriate.

Given the inconsistency of the results over different investment horizons and tax brackets, in most instances individuals should remain indifferent between the two models based on the stochastic dominance results (whether considering the post-retirement tax implications or not).

Finally, as the point was raised in the thesis (and similar to the key findings for hypothesis 1B), if the cumulative distribution functions of two models were compared. but an individual had a clear retirement target, this may influence what would be deemed the most appropriate model as it will be based on likelihood of achieving the particular retirement target (this approach was elaborated on in the discussion pertaining to Figure 1 in section 5.1.1, Figure 2 in section 5.2.1 and addressed in the thesis).

5.2.2 Summary

Table 9 shows a summary of the findings pertaining to Hypothesis 1B. The results indicate that for most sub-hypotheses, Model 4 (direct equity fund with a 95 percent allocation to equities, including 25 percent foreign equity exposure) fails to dominate Model 6 (high equity balanced retirement fund with a 75 percent allocation to equities, including 25 percent foreign equity exposure) by FSD or ASD except for the 10-year investment horizon (all tax brackets).

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Table 9: Summary of findings – Hypothesis 1B

Hypothesis 1B

H_0: A 100 percent equity direct investment fund (75/25 percent local/foreign equity split) fails to dominate a high equity balanced retirement fund (50/25 percent local/foreign equity split) by first-order stochastic dominance (FSD) or almost stochastic dominance (ASD).

H_a: A 100 percent equity direct investment fund (75/25 percent local/foreign equity split) dominates a high equity balanced retirement fund (50/25 percent local/foreign equity split) by first-order stochastic dominance (FSD) or almost stochastic dominance (ASD).

Time horizon/ Tax bracket	10 years	20 years	30 years	40 years
18 percent	**Sub-hypothesis 1B$^{10\ years}$** Reject the null hypothesis	**Sub-hypothesis 1B$^{20\ years}$** Fails to reject the null hypothesis	**Sub-hypothesis 1B$^{30\ years}$** Fails to reject the null hypothesis	**Sub-hypothesis 1B$^{40\ years}$** Fails to reject the null hypothesis
25 percent	**Sub-hypothesis 1B$^{10\ years}$** Reject the null hypothesis	**Sub-hypothesis 1B$^{20\ years}$** Fails to reject the null hypothesis	**Sub-hypothesis 1B$^{30\ years}$** Fails to reject the null hypothesis	**Sub-hypothesis 1B$^{40\ years}$** Fails to reject the null hypothesis
40 percent	**Sub-hypothesis 1B$^{10\ years}$** Reject the null hypothesis	**Sub-hypothesis 1B$^{20\ years}$** Fails to reject the null hypothesis	**Sub-hypothesis 1B$^{30\ years}$** Fails to reject the null hypothesis	**Sub-hypothesis 1B$^{40\ years}$** Fails to reject the null hypothesis

6. CLOSING REMARKS

Regarding hypothesis 1A, the inclusion of the post-retirement tax implications did influence the FSD and ASD results. However, the results did not impact the findings pertaining to the hypothesis; that is, in all instances the direct investment funds still do not dominate the high equity balanced funds by ASD or FSD.

The null hypothesis as to whether high equity balanced funds dominate direct investment funds, was also considered in the additional analysis. With regards to Model 5 (high equity balanced retirement fund) and Model 2 (direct investment fund), neither model had any foreign equity exposure. While there were four instances in the original analysis where Model 5 dominated Model 2, it was only the case in one instance when including the post-retirement tax implications. The inclusion of the post-retirement tax implications therefore results in Model 5 in most instances not dominating Model 2 by ASD or FSD.

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Regarding hypothesis 1B, the inclusion of the post-retirement tax implications did influence the FSD and ASD results. In addition, the results did impact the findings pertaining to some sub-hypotheses. That is, in all instances the direct investment funds did not dominate the high equity balanced funds by ASD or FSD (similar to the original findings) except in the following instances: the 10-year investment horizon and an 18, 25 and 40 percent tax bracket respectively. Over a 10-year investment horizon, the inclusion of the post-retirement tax implications indicates that the direct investment fund dominates the high equity balanced retirement fund.

The null hypothesis as to whether high equity balanced funds dominate direct investment funds, was also considered in the additional analysis. With regards to Model 6 (high equity balanced retirement fund) and Model 4 (direct investment fund), both models had a foreign equity exposure. While there were six instances in the original analysis where Model 6 dominated Model 4, there was no such instances in the additional analysis. The inclusion of the post-retirement tax implications therefore results in Model 6 not dominating Model 4 by ASD or FSD.

Similar to the original findings, the analysis which considers the post-retirement tax implications did not provide conclusive evidence that direct investment funds dominate high equity balanced retirement funds. Additionally, the inclusion of the post-retirement tax implications also seems to make it more unlikely for the high equity balanced retirement funds, to dominate the direct investment fund models.

Despite the informational value of the additional analysis, it would be inappropriate to make generalisations based on the results given the simplified nature of the analysis. Additionally, it was highlighted in the thesis that any results will be influenced by the asset class characteristics, investment horizon and asset allocations of the models. This may however present an area for further research.

7. DESCRIPTIVE STATISTICS OF THE ADJUSTED ACCUMULATED RETIREMENT ENDING WEALTH

The descriptive statistics of the adjusted accumulated retirement ending wealth in shown in the remainder of the addendum.

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Table 10: Descriptive statistics of Research Question 1 models: accumulated retirement ending wealth (R) – 10- and 20-year investment horizons, 18% tax bracket

	10-year investment horizon				20-year investment horizon			
	Direct investments		Retirement funds		Direct investments		Retirement funds	
	Model 2	Model 4	Model 5	Model 6	Model 2	Model 4	Model 5	Model 6
Arithmetic mean	2 391 165	2 094 237	2 833 716	2 536 380	10 511 550	7 826 433	9 596 526	7 581 033
Median	2 211 049	1 987 503	2 772 636	2 477 964	8 624 882	6 862 026	8 591 020	7 060 839
Minimum	498 713	573 333	847 740	894 935	1 087 054	1 198 705	2 114 919	2 123 456
Maximum	9 806 754	6 933 089	7 626 499	5 870 561	85 462 941	48 643 891	46 707 376	29 551 238
Range	9 308 041	6 359 756	6 778 759	4 975 626	84 375 887	47 445 186	44 592 457	27 427 782
Interquartile range	1 185 195	873 024	1 085 651	879 376	7 344 170	4 723 642	4 945 195	3 192 478
Standard deviation	988 296	697 564	822 898	634 632	7 335 309	4 218 546	4 444 924	2 716 211
Variance	9.767E+11	4.866E+11	6.772E+11	4.028E+11	5.381E+13	1.780E+13	1.976E+13	7.379E+12
Skewness	1.315	1.067	0.629	0.529	2.450	1.828	1.793	1.384
Kurtosis	3.112	2.098	0.706	0.405	10.222	5.888	5.597	3.510

Source: SAS and SPSS output

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Table 11: Descriptive statistics of Research Question 1 models: accumulated retirement ending wealth (R) – 30- and 40-year investment horizons, 18% tax bracket

	30-year investment horizon				40-year investment horizon			
	Direct investments		Retirement funds		Direct investments		Retirement funds	
	Model 2	Model 4	Model 5	Model 6	Model 2	Model 4	Model 5	Model 6
Arithmetic mean	38 987 298	23 491 828	31 022 603	19 999 259	142 218 557	68 031 945	103 841 164	54 175 743
Median	27 343 113	18 822 425	25 257 106	17 492 732	81 602 338	47 720 002	74 748 650	43 329 690
Minimum	1 983 006	1 962 021	4 076 435	3 659 039	2 216 434	2 520 602	4 702 492	4 700 960
Maximum	5E+8	2E+8	2E+8	1E+8	3E+9	1E+9	1E+9	5E+8
Range	488 072 506	217 972 732	218 663 215	115 068 397	3 174 257 166	994 054 165	1 188 731 538	456 748 424
Interquartile range	30 795 749	16 693 013	21 204 774	11 641 035	121 023 791	54 149 112	81 922 908	38 063 529
Standard deviation	40 551 978	17 988 339	22 251 509	10 983 801	200 800 387	69 738 592	99 904 340	40 250 189
Variance	1.644E+15	3.236E+14	4.951E+14	1.206E+14	4.032E+16	4.863E+15	9.981E+15	1.620E+15
Skewness	3.885	2.843	2.633	2.043	5.342	3.907	3.455	2.719
Kurtosis	24.388	13.742	11.537	7.225	45.647	25.923	19.717	12.762

Source: SAS and SPSS output

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Table 12: Descriptive statistics of Research Question 1 models: accumulated retirement ending wealth (R) – 10- and 20-year investment horizons, 25% tax bracket

	10-year investment horizon				20-year investment horizon			
	Direct investments		Retirement funds		Direct investments		Retirement funds	
	Model 2	Model 4	Model 5	Model 6	Model 2	Model 4	Model 5	Model 6
Arithmetic mean	3 411 214	2 988 360	4 153 220	3 761 228	14 905 780	11 050 708	14 201 874	11064 433
Median	3 159 447	2 837 777	4 052 044	3 697 964	12 168 908	9 690 099	12 612 297	10 221 694
Minimum	712 629	818 672	1 324 427	1 398 160	1 553 327	1 709 593	3 232 868	3 243 805
Maximum	13 886 368	9 784 824	11 105 441	8 362 133	1E+8	68 788 632	72 161 515	45 358 464
Range	13 173 739	8 966 152	9 781 014	6 963 973	120 382 866	67 079 039	38 918 647	42 114 659
Interquartile range	1 693 567	1 246 774	1 393 507	1 089 039	10 365 635	6 600 875	7 725 883	4 987 611
Standard deviation	1 399 805	990 907	1 093 836	833 659	10 435 470	5 934 167	6 920 789	4 204 824
Variance	1.959E+12	9.819E+11	1.196E+12	6.950E+11	1.089E+14	3.521E+13	4.790E+13	1.768E+13
Skewness	1.286	1.041	0.689	0.519	2.473	1.848	1.817	1.438
Kurtosis	2.989	1.981	1.088	0.657	10.379	6.009	5.672	3.643

Source: SAS and SPSS output

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Table 13: Descriptive statistics of Research Question 1 models: accumulated retirement ending wealth (R) – 30- and 40-year investment horizons, 25% tax bracket

	30-year investment horizon				40-year investment horizon			
	Direct investments		Retirement funds		Direct investments		Retirement funds	
	Model 2	Model 4	Model 5	Model 6	Model 2	Model 4	Model 5	Model 6
Arithmetic mean	55 538 339	33 091 581	47 657 411	30 435 822	203 038 338	95 464 949	161 421 918	83 829 480
Median	38 886 856	26 514 395	38 649 786	26 519 480	116 419 808	67 073 728	115 970 581	66 884 643
Minimum	2 833 588	2 795 477	5 804 111	5 250 945	3 167 141	3 590 401	6 661 616	6 659 518
Maximum	7E+8	3E+8	3E+8	2E+8	5E+9	1E+9	2E+9	7E+8
Range	697 239 465	306 808 322	341 373 219	179 424 805	4 535 624 793	1 386 109 357	1 857 034 562	713 454 805
Interquartile range	44 005 140	23 491 089	33 128 279	18 186 822	172 935 220	75 915 472	127 988 411	59 466 769
Standard deviation	57 936 288	25 318 861	34 763 392	17 159 480	286 929 615	97 480 045	156 080 846	62 882 978
Variance	3.357E+15	6.410E+14	1.208E+15	2.944E+14	8.233E+16	9.502E+15	2.436E+16	3.954E+15
Skewness	3.887	2.837	2.633	2.044	5.342	3.889	3.455	2.719
Kurtosis	24.402	13.685	11.537	7.226	45.648	25.693	19.717	12.762

Source: SAS and SPSS output

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Table 14: Descriptive statistics of Research Question 1 models: accumulated retirement ending wealth (R) – 10- and 20-year investment horizons, 40% tax bracket

	10-year investment horizon				20-year investment horizon			
	Direct investments		Retirement funds		Direct investments		Retirement funds	
	Model 2	Model 4	Model 5	Model 6	Model 2	Model 4	Model 5	Model 6
Arithmetic mean	6 686 059	5 862 261	8 611 941	7 764 852	29 103 858	21 264 182	32 944 145	25 200 732
Median	6 224 151	5 593 650	8 282 343	7 555 100	23 673 827	18 599 351	29 017 075	23 116 383
Minimum	1 407 177	1 614 104	3 204 103	3 353 339	3 067 244	3 361 989	6 659 109	6 680 179
Maximum	27 000 750	18 834 110	25 297 714	18 526 451	2E+8	1E+8	2E+8	1E+8
Range	25 593 573	17 217 306	22 093 611	15 173 112	237 291 746	129 357 822	169 342 418	103 163 776
Interquartile range	3 267 648	2 425 073	2 902 351	2 194 766	20 328 918	12 591 372	19 069 682	12 310 846
Standard deviation	2 693 647	1 906 647	2 346 086	1 706 134	20 534 514	11 381 024	17 077 411	10 371 967
Variance	7.256E+12	3.635E+12	5.504E+12	2.911E+12	4.217E+14	1.295E+14	2.916E+14	1.076E+14
Skewness	1.262	0.988	1.024	0.822	2.495	1.871	1.819	1.443
Kurtosis	2.987	1.822	2.026	1.374	10.512	6.135	5.678	3.651

Source: SAS and SPSS output

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Table 15: Descriptive statistics of Research Question 1 models: accumulated retirement ending wealth (R) – 30- and 40-year investment horizons, 40% tax bracket

	30-year investment horizon				40-year investment horizon			
	Direct investments		Retirement funds		Direct investments		Retirement funds	
	Model 2	Model 4	Model 5	Model 6	Model 2	Model 4	Model 5	Model 6
Arithmetic mean	109 260 221	63 164 882	115 518 253	73 010 522	400 506 888	179 877 144	396 321 440	204 801 280
Median	76 367 327	50 642 808	93 284 897	63 343 884	229 466 054	126 921 063	284 134 639	162 976 614
Minimum	5 595 275	5 483 744	12 212 515	10 876 727	6 253 923	7 041 894	14 329 090	14 323 910
Maximum	1E+9	6E+8	9E+8	5E+8	9E+9	3E+9	5E+9	2E+9
Range	1 376 367 134	583 598 180	842 605 302	442 848 804	8 955 747 812	2 583 686 511	4 583 688 379	1 761 008 958
Interquartile range	86 893 670	44 737 428	81 769 928	44 890 201	341 482 566	142 423 595	315 911 726	146 780 864
Standard deviation	114 392 294	48 099 827	85 805 848	42 354 428	566 577 940	182 053 103	385 251 827	155 213 067
Variance	1.309E+16	2.314E+15	7.363E+15	1.794E+15	3.210E+17	3.314E+16	1.484E+17	2.409E+16
Skewness	3.888	2.824	2.633	2.044	5.342	3.857	3.455	2.719
Kurtosis	24.410	13.566	11.537	7.226	45.648	25.312	19.717	12.762

Source: SAS and SPSS output