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Quantitative guidelines for retiring (more safely) in South Africa

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ABSTRACT
In this paper we present guidelines for safe withdrawal rates from a living annuity (income drawdown accounts), periodically, to cover living expenses. In essence, a retiree is faced with the risk management problem of outliving their retirement fund (withdrawing too much) versus living below their means (withdrawing too little). The empirical evidence in the literature advocates for a 'safe' 4% annual withdrawal (or spending) rate. Therefore, the object of this paper is to examine withdrawal rates for retirees in the South African economy. Furthermore, we carry out a simulation study using historical data while incorporating longevity and fund management fees. Our analysis emphasises the risks associated with different withdrawal rates and asset allocations. We then give an example of how derivative instruments can increase the success rate of a retirement portfolio.

KEYWORDS
Retirement planning; safe spending rates; income drawdown accounts

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1. INTRODUCTION

1.1 Retirement planning is an important topic for actuaries and financial advisors as it plays a vital role in society, especially in an era of increasing longevity. The demographer, James Vaupel, is reported to have said that "half of the children born in Sweden in 2012 will live to be 104".[1] Moreover, reports of increased longevity abound; see for example, Innovation Hub (Purdy, 2015) reports, "the first person to live to 150 has already been born." In Table 1, we illustrate how life expectancy (and conditional life expectancy) has increased globally over time.[2]

TABLE 1. Life expectancy at birth, at age 60, for global and South African citizens of all sexes

Year	Region	Life expectancy at birth			Life expectancy at age 60		
		Male	Female	Both sexes	Male	Female	Both sexes
2000	Global	64.4	68.7	66.5	17.2	20.2	18.2
	RSA	56.1	62.0	59.0	13.4	17.8	15.7
2005	Global	66.1	70.3	68.2	17.8	20.7	19.3
	RSA	52.6	56.2	54.4	13.4	17.8	15.7
2010	Global	68.0	72.3	70.1	18.4	21.3	19.9
	RSA	55.6	60.4	58.0	1.6	18.1	16.0
2016	Global	69.8	74.2	72.0	19.0	21.9	20.5
	RSA	60.2	67.0	63.6	14.0	18.8	16.6

1.2 Increased longevity does, however, pose challenges. In a recent study, Allianz (2010)[3] surveyed US adults aged between 44 and 75; of the people surveyed, 61% reported being more afraid of outliving their financial assets than dying! Similar findings were reported in a recent survey in the UK,[4] where the majority of the people surveyed believed they were not currently saving enough for retirement.

1.3 To illustrate some of the concerns faced by retirees, we need to look at life expectancy post-retirement. Richman (2017) studied the mortality of those aged 75 and above in the South African population, where he found mortality improvement rates of 0.7% and 0.1% per annum over the period 1985–2011 for males and females respectively. However, mortality rates for the population can be quite different to that of insured (or pensioner) lives. The most recent report focusing on mortality rates of insured (or pensioner) lives in a South African context can be found in CSI (2017) covering the period 2005–2010. Furthermore, Richman &

1 Ennart, H (2012). *Åldrandets gåta* [*The Mystery of Aging*]. Stockholm, Ordfront
2 World Health Organization (2020). Global health observatory data repository. Retrieved from https://apps.who.int/gho/data/view.main.SDG2016LEXv?lang=en
3 Allianz (2010). Outliving your money feared more than death. Online.
4 Institute and Faculty of Actuaries (2019). Savings goals for retirement: Policy briefing. Retrieved from https://www.actuaries.org.uk/system/les/eld/document/Saving.

Velcich (2020) studied insured (or pensioner) lives mortality improvements in South Africa, where they found that from their sample, that mortality improvements are slowing down at all ages.

1.4 It is evident from most recent reports on pensioner mortality in South Africa (CSI, 2017; Richman, 2017; Richman & Velcich, 2020) that pensioners who reach their retirement years could face 20 more years of life with substantial probability. The retiree, therefore, needs to understand the balance between periodic inflation adjusted payments to sustain living expenses and avoid running out of capital—all given an inherently volatile investment environment (e.g., Scott et al., 2009).

1.5 In studies carried out by Butler & Van Zyl (2012a; 2012b), it was found that consumption rates after retirement do not tend to decrease, as popularly believed, and may suggest the need of an upward adjustment of retirement adequacy goals. Furthermore, they conclude that based on their analysis, retirement before the age of 67 is unlikely to be affordable for most households. Cooley et al. (1998) note:

> Most investors who plan for retirement eventually confront the question of how much money they should plan to withdraw from their investment portfolio. The dilemma is that if they withdraw too much, they prematurely exhaust the portfolio, but if they withdraw too little, they unnecessarily lower their standard of living.

1.6 Their conclusions, the so-called '4% safe withdrawal rate', derived for the US-market are often used as a rule-of-thumb by advisors to guide to 'safe' inflation-adjusted spending by retirees (see also Bengen, 1994).

1.7 In South Africa, retirees typically choose between so-called single life guaranteed annuities and living annuities[5] with their retirement proceeds. A single life guaranteed annuity is an insurance contract that covers the insured pensioner for life and yields a defined income. So-called living annuities allow the pensioner freedom to invest in a wide spectrum of investment vehicles while drawing a monthly amount for pension—currently limited by South African law to between 2.5% and 17.5% per annum. A guaranteed annuity will typically leave no benefit to the pensioner's estate, whereas a living annuity could bequeath a substantial amount to their estate.

1.8 The 4% safe withdrawal rate studies by Cooley et al. (1998; 1999) were performed for retirees in the United States. In Table 2, we demonstrate differences between asset class returns in the United States and South Africa (over the period 1900 to 2015) using reference returns from Dimson et al. (2016). Real asset-class returns are similar in both countries, however, we note that South African inflation is typically significantly higher (and more volatile) than inflation in the United States.

5 Typically referred to as income drawdown accounts in international markets.

TABLE 2. AM/GM arithmetic/geometric mean returns % p.a.

		Asset class returns					
		US			RSA		
	Asset class	AM	GM	Std Dev	AM	GM	Std Dev
Nominal	Equities	11.4%	9.4%	19.9%	14.7%	12.6%	22.9%
	Bonds	5.3%	4.9%	9.0%	7.2%	6.8%	9.6%
	Cash	3.8%	3.8%	2.9%	6.1%	6.0%	5.5%
	Inflation	3.0%	2.9%	4.8%	5.2%	4.9%	7.3%
Real	Equities	8.3%	6.4%	20.1%	9.4%	7.3%	22.1%
	Bonds	2.5%	2.0%	10.4%	2.3%	1.8%	10.5%
	Cash	1.0%	0.8%	4.6%	1.2%	1.0%	6.1%

1.9 Given the importance of retirement planning, a number of research papers can be found in the literature (see, for example, Milevsky & Huang, 2011; Butler & van Zyl, 2012b; Waring & Siegel, 2015; Maré, 2016; Rusconi, 2020; Klein & Sapra, 2020). Moreover, Maré (2016) considers safe withdrawal rates in the South African context using different asset allocations between stocks and bonds, and Rusconi (2020) considers regulatory and government policies in the South African context.

1.10 Although there have been numerous studies on safe withdrawal rates for different asset allocations, fewer studies incorporate transactional fees (costs) and longevity into the analysis. Therefore, the aim of our research is to:

— extend the research done by Maré (2016) by examining withdrawal rates (read synonymously with spending rates) in living annuities for South African retirees using an extended dataset of historical asset class returns from 1900 to 2020 for equity, bonds, cash, and inflation. A basic requirement for any statistical analysis is that some of the statistical properties of the data under study remains stable over time, which corresponds to the stationarity hypothesis (see Cont, 2001). In the analysis, we also considered reducing the historical dataset to more recent historical returns, where we found no difference in the results.

— incorporate transactional fees (costs) and longevity into the analysis. Longevity is a key component in measuring the success of a portfolio, as a portfolio needs to outlast the individual's life expectancy and not a predestined time of, for example, 30 years. Therefore, a typical question would be to ask whether a 5% annual spending rate remains sustainable for South African retirees. Since life expectancy is a vital part of retirement portfolio success, we incorporate the conditional probability of surviving into our simulation.

— consider the impact of hedging some of the downside of the equity market on the portfolio safety.

1.11 Furthermore, we concur with Rusconi (2020) that research of this nature is highly relevant given the well-established markets in South Africa. The data and asset classes used for this study are primarily based on South African assets.

1.12 An outline of the rest of the paper is as follows. In Section 2 we provide detail of our general simulation methodology, which is based on randomly sampling (with replacement) returns in a Monte Carlo simulation based on historical returns. We provide results in Section 3 with details on probabilities of depleting capital for various periods of investment. We provide relevant conclusions and areas for further investigation in Section 4.

2. METHODOLOGY

Cooley et al. (1998; 1999) and Bengen (1994) use a methodology of overlapping periods (also referred to as rolling periods) to calculate end-of-period portfolio values from equities and bond returns. Cooley et al. (2003) also consider a Monte Carlo-based simulation based on the distributional characteristics of the asset classes. In our study we calculate end-of-period portfolio values from equities, bonds, and cash based on a bootstrap simulation analysis of the historical asset returns.

2.1 Portfolio make-up

2.1.1 The retirement portfolio process is typically structured as follows: an asset allocation is decided based on advice from the retiree's financial advisor, with the portfolio weights updated annually (typically at the start of each year). In the cash account, we place a forecasted amount to be withdrawn from the portfolio for the year based on the particular withdrawal rate at retirement and the December inflation rate. Thus, the monthly retirement spending is withdrawn from the cash account. The remaining portfolio value is rebalanced between equity, bonds, and cash according to the specified weighting structure.

2.1.2 In practice, institutions often demand a fee, such as advisor fees, for managing a retirement portfolio. These costs could have a significant impact on the success of a retirement portfolio and should be taken into account in retirement planning. Often there are three costs associated in the managing of a retirement portfolio, namely fund management fees, platform fees, and advisor fees. The fund management fees are typically structured as follows:

— Cash: 0.25% p.a.
— Bonds: 0.5% p.a.
— Equity: 0.75% p.a.

where the platform and advisor fees are 0.5% and 1%, respectively, of the total portfolio value per annum.

2.2 The data

2.2.1 In this study, we will be making use of historical asset class returns as a guide to future returns. The data used comprises historical equity, bonds, cash, and inflation total return performances in South Africa for the period 1900 to 2020.[6] This data consisted of monthly and yearly rates (see Table 3). When only yearly rates were available, we

6 Sourced from Firer & McLeod (1999), Firer & Staunton (2002), and I-Net.

approximated the monthly rates by using the 12th root function of the yearly return rate and adjusting this rate with a monthly seasonal adjustment factor based on average corresponding returns so that the monthly returns match the yearly return.

TABLE 3. Data summary

	Yearly data	Monthly data
Equity	1900–1959	1925–2020
Bonds	1900–1945	1946–2020
Cash	1900–1928	1929–2020
Inflation	1900–1938	1939–2020

2.2.2 The stylised facts present in the data are generally not easy to exhibit by using stochastic processes,[7] hence the preferred use of historical returns in this simulation study. Although, historical returns do not necessary reflect future returns, the underlying statistical properties, to some extent, remain stable over time. Figure 1a through Figure 1c show the historical monthly returns over the period 1900 to 2020 for a portfolio consisting of equity, bonds and cash in South Africa. While the individual asset-class returns are summarised in Table 2, portfolios typically consist of a range of asset classes. Therefore, in Figure 1, we show the historical returns for a typical balanced portfolio asset allocation. The sample correlation matrix, based on total returns, is shown in Table 4.

TABLE 4. Correlation matrix

	Equity	Bonds	Cash	Inflation
Equity	1.0000	0.2434	0.0455	0.0342
Bonds	0.2434	1.0000	0.2144	0.0332
Cash	0.0455	0.2144	1.0000	0.4391
Inflation	0.0342	0.0332	0.4391	1.0000

2.2.3 It is worthwhile to note that the South African equity market has witnessed a period of low growth over the last decade, in line with emerging markets, whereas the USA has had a tremendous equity bull market over the same period. Withdrawals from a retirement fund under a bear market are far more costly than withdrawals under a bull market and could drastically reduce the success of the fund. This is known as sequence risk.[8]

2.2.4 It is important to note that our analysis is based on index returns; this decision is based on data limitations—the longest representative dataset available is limited to equity, bond and cash returns. Furthermore, growth assets here are represented by equities, while we would typically add some property exposure in practice as well. In the fixed income

7 See, for example, Cont (2001).
8 See, for example, Blanchett et al. (2013).

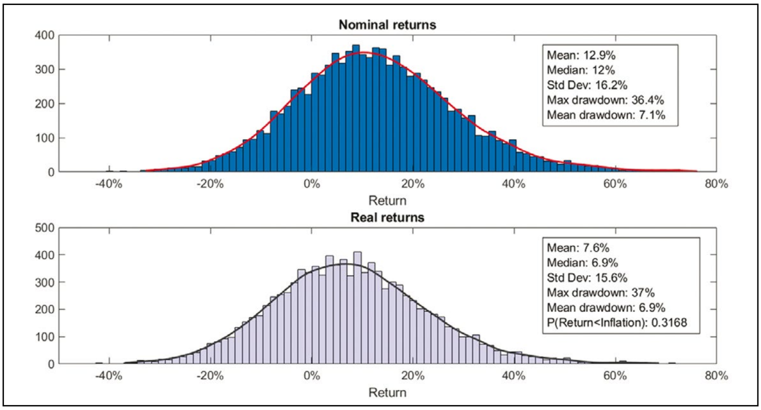


FIGURE 1A. Portfolio (90% equity and 10% cash) return

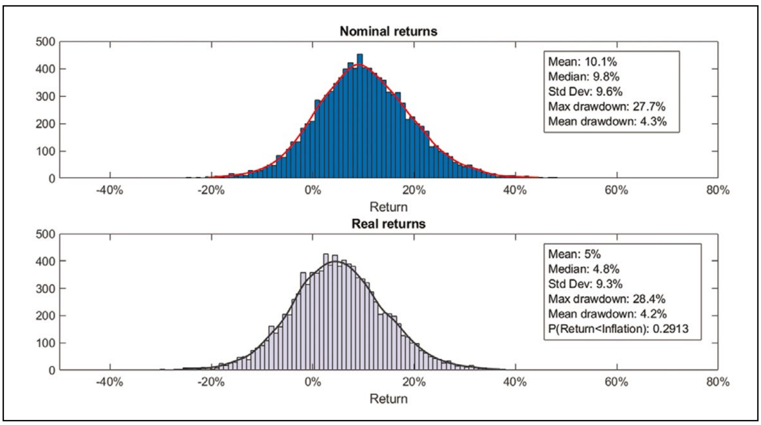


FIGURE 1B. Portfolio (50% equity, 40% bonds and 10% cash) return

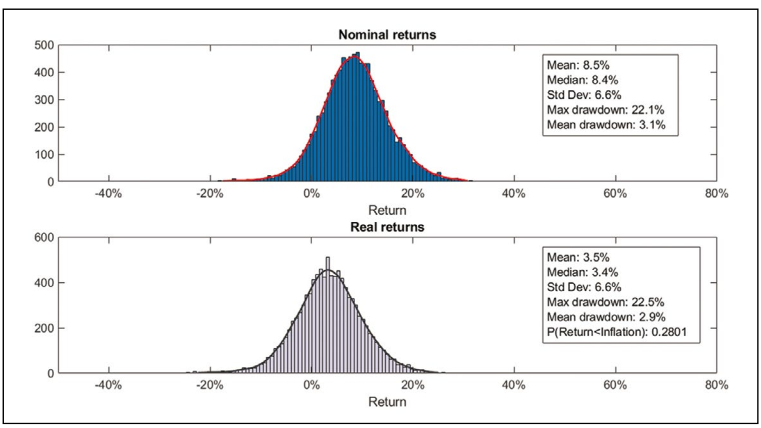


FIGURE 1C. Portfolio (25% equity, 65% bonds and 10% cash) return

FIGURE 1: Yearly returns for three scenarios of asset class allocations from 1900 to 2020

investment space one would typically choose between a variety of bonds, which could alter risk/return ratios relative to the index-based returns contained in the data.

2.3 Simulation by random sampling

2.3.1 Our methodology is based on a Monte Carlo simulation using the historical return data for our asset classes (see Figure 1). Our data consist of monthly South African total returns for each asset class, i, namely cash, bonds and equity (i.e., we assume full reinvestment of interest, dividend proceeds and incidental accruals) over the period January 1900 to April 2020, i.e., $X_1^{(i)}, X_2^{(i)}, \ldots, X_{1444}^{(i)}$. From these historical returns we assume each X_j has equal probability of being selected. Furthermore, the j^{th} sampled return is then used across all asset classes to keep the correlation structure intact. Therefore, each path constitutes a random scenario based on the monthly bootstrapped returns.

2.3.2 We consider an investment portfolio with a yearly rebalanced fixed asset allocation between equities, bonds and cash, and draw an income from the cash account on a monthly basis (income is adjusted monthly for inflation, i.e., we look at real spending rates). Firstly, we consider the Monte Carlo simulation over fixed investment periods of 15, 20, 25 and 30 years, assuming no mortality, indicating the intended holding period of the portfolio for the retiree. It is important to consider success rates for a fixed investment period, as it gives a retiree a better understanding for retirement planning as the retiree's longevity is unknown. Secondly, we consider the simulation incorporating longevity using the South African pensioner mortality tables (CSI, 2017) covering mortality in the years 2005–2010, and thirdly, we incorporate portfolio costs into the simulation. The monthly portfolio value is, therefore, a function of the simulated investment returns less the inflation-adjusted amounts withdrawn (inclusive of levied costs) by the retiree.

2.3.3 We consider a portfolio to be successful if it has capital left at the end of the specific investment period considered. We report the portfolio success rates, i.e., the percentage of portfolio values that are non-negative at the end of an investment period based on the simulations described above (see Bengen, 1994; Cooley et al., 1998, 1999). It is important to note that our analysis does not account for taxes; although, in principle, these can easily be taken into account.

3. RESULTS

3.1.1 Practically, safe withdrawal rates are heavily dependent on the retiree's longevity. In Table 5, we demonstrate portfolio success rates as a function of spending rates versus varying asset allocations over a period of 15, 20, 25, and 30 years, ignoring longevity. Specifically, the full year's withdrawal amount is placed into a cash account at the beginning of each year, and the remaining portfolio value is allocated between equity and bonds.

3.1.2 It is evident from the table that higher spending levels result in portfolios that will fail the retiree within the total investment period, independent of the chosen asset allocation. It is, however, interesting to note from the results that portfolios with more growth assets, such as equities, have a higher propensity for success than portfolios that are more fixed-income oriented.

3.1.3 To measure the extent of ruin, it is also instructive to consider the conditional expected time to failure of the portfolio—we call this the fugit.[9] More specifically, in this context, the fugit is defined to be the expected life of the portfolio given that the portfolio was unsuccessful before the intended holding period, e.g., 30 years. The fugit is expressed in monthly periods; 200 months would, for example, mean the average failed portfolio lasts 200 months out of the full intended investment period of 360 months. In Table 6, we demonstrate the portfolio fugit along with the standard deviation in the time to ruin as a function of spending rates versus varying asset allocations over a period of 30 years.

TABLE 5. Portfolio success rate given withdrawal rate vs asset allocation (equity, bonds & cash) over 30-year period

Payout period	4%	5%	6%	7%	8%	9%	10%
100% equity							
15 years	100%	99%	96%	88%	80%	67%	54%
20 years	98%	94%	87%	75%	62%	47%	33%
25 years	96%	89%	78%	64%	49%	36%	24%
30 years	94%	84%	70%	56%	42%	29%	19%
75% equity / 25% bonds							
15 years	100%	99%	97%	91%	79%	63%	43%
20 years	99%	96%	86%	71%	53%	36%	21%
25 years	97%	89%	75%	56%	38%	22%	12%
30 years	94%	83%	66%	46%	28%	16%	8%
50% equity / 50% bonds							
15 years	100%	100%	98%	92%	75%	51%	29%
20 years	100%	97%	85%	64%	38%	19%	7%
25 years	98%	88%	66%	40%	19%	7%	2%
30 years	95%	78%	51%	26%	10%	4%	1%
25% equity / 75% bonds							
15 years	100%	100%	99%	90%	63%	30%	9%
20 years	100%	97%	77%	42%	13%	3%	0%
25 years	98%	81%	43%	13%	2%	0%	0%
30 years	91%	59%	22%	4%	1%	0%	0%
100% bonds							
15 years	100%	100%	97%	74%	34%	8%	1%
20 years	99%	89%	48%	12%	2%	0%	0%
25 years	90%	48%	10%	1%	0%	0%	0%
30 years	66%	20%	2%	0%	0%	0%	0%

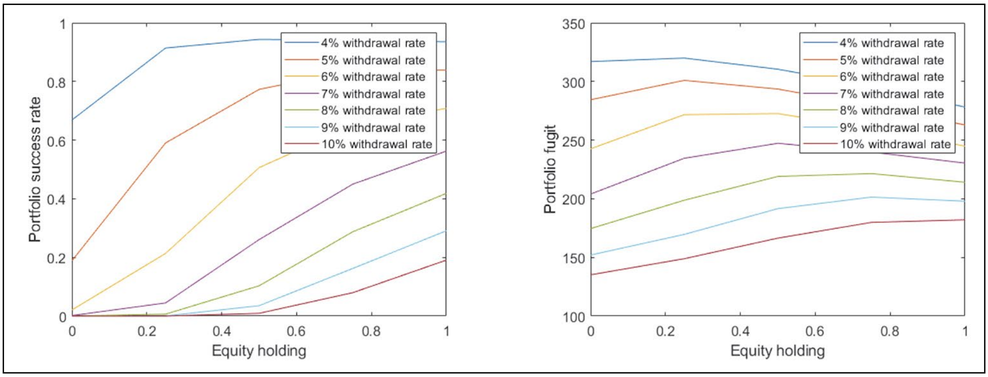
9 The term 'fugit' was first introduced by Garman (1989) and was used to represent the optimal date to exercise an American option.

3.1.4 A key conclusion from Table 6 pertains to the spending rate—to sustain higher spending rates a retiree needs to be willing to allocate more to risk-bearing assets. This can be seen by the shaded values in Table 6 which represents the largest expected time to ruin for each withdrawal rate. However, this strategy comes with an increase in the variation in the time to ruin. This needs to be clearly understood and forms a key consideration in the financial advisor discussion process. Asset allocation appears to be of lesser concern when spending is low.

TABLE 6. Fugit given withdrawal rate and asset allocation (equity, bonds & cash) over 30-year period

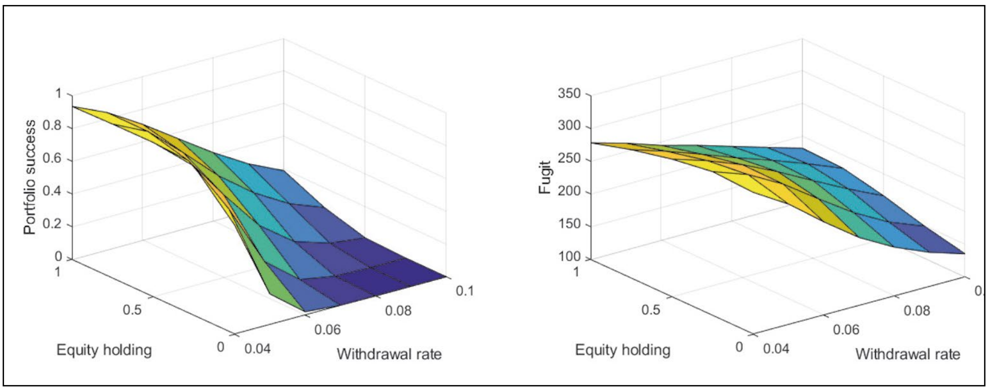
	Withdrawal rate						
Asset allocation	4%	5%	6%	7%	8%	9%	10%
100% stocks							
Mean	272.8	262.4	247.1	230.4	212.7	198.1	181.2
Standard deviation	53.6	56.9	61.1	63.6	64.6	64.5	63.2
75% stocks/25% bonds							
Mean	291.7	275.0	259.2	241.8	219.7	200.1	178.8
Standard deviation	45.7	50.8	55.7	59.1	59.9	59.7	56.2
50% stocks/50% bonds							
Mean	306.4	293.3	272.0	245.5	218.4	191.2	165.8
Standard deviation	37.1	44.9	50.1	53.4	53.2	50.0	42.4
25% stocks/75% bonds							
Mean	318.7	299.5	269.4	232.7	197.2	168.8	147.7
Standard deviation	30.8	39.2	45.2	44.9	38.0	29.0	23.4
100% bonds							
Mean	315.7	283.9	241.9	203.0	173.3	151.5	134.2
Standard deviation	30.3	39.4	39.6	31.9	25.2	20.0	16.2

3.1.5 In Figure 2 and Figure 3, we show the portfolio success rates across different withdrawal rates and equity holdings, thus confirming that portfolios with higher success and longevity have larger equity allocation. In Figure 4, we show some descriptive measures calculated from the 10 000 Monte Carlo simulations with a 75% equity ratio and a 5% initial portfolio withdrawal. Although we expect the portfolio to have a positive balance at $T=30$ years, it is also evident from Figure 4a that there is a 5% chance that the portfolio will run out of money within 245 months (i.e., approximately 20 years). This is obviously not a desirable outcome for retirees, even with low probability. In Figure 4b, we show the conditional probability of portfolio success at time, t, given success at time, $t-1$, where $t \in [0,360]$ months. We note that the conditional probability of success drastically increases from around 200 months, indicating the importance of effective early portfolio management.



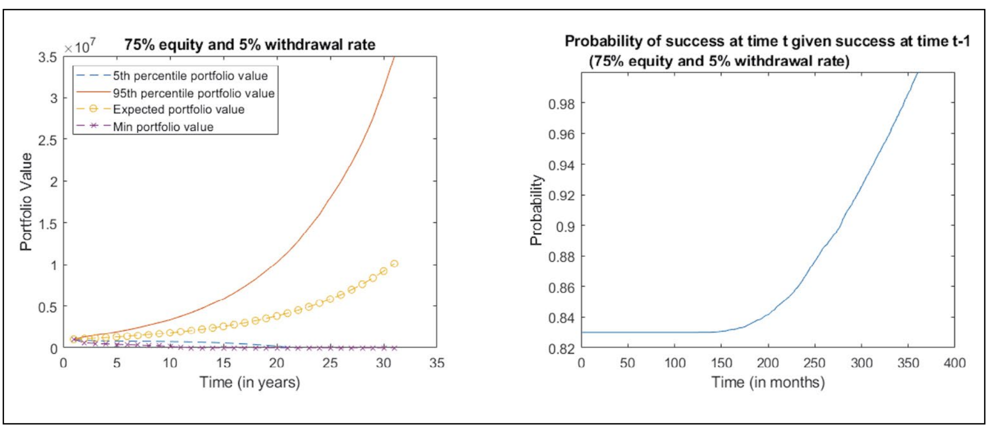
(a) Portfolio success (b) Portfolio fugit

FIGURE 2. Portfolio success and fugit over a 30-year period



(a) Portfolio success (b) Portfolio fugit

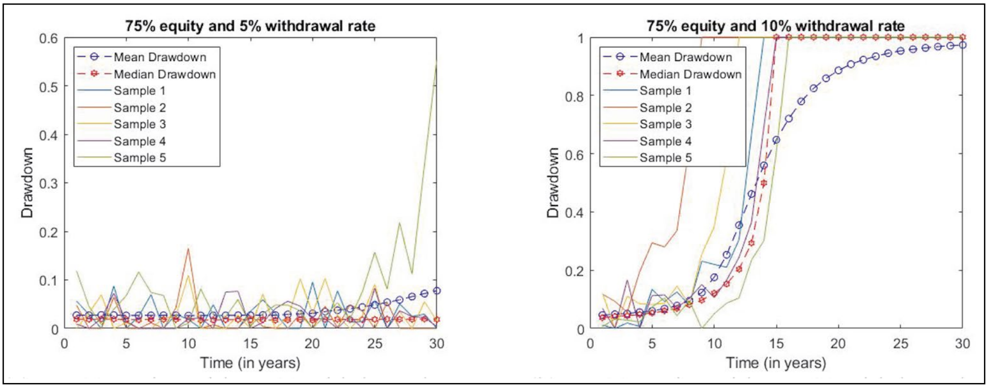
FIGURE 3. Portfolio success and fugit over a 30-year period



(a) Portfolio value over time (b) Portfolio success probability over time

FIGURE 4. Portfolio descriptive measures over time

3.1.6 Figure 5 shows the mean and median drawdown per year (measured as a proportion of the portfolio value) for the 10 000 simulated scenarios. Due to the inflation adjusted withdrawals, the drawdown increases exponentially over time. Furthermore, we also show the drawdown for the first five simulations.



(a) 75% equity with a 5% withdrawal rate (b) 75% equity with a 10% withdrawal rate

FIGURE 5. Drawdown as a portion of the portfolio capital; the figures also include five sample paths of the 10 000 simulated paths)

3.1.7 Furthermore, the relationship between the mean yearly drawdown (as a proportion of the portfolio value), and fugit is shown in Figure 6. The inverse relationship between the mean yearly drawdown and fugit is clearly evident in Figure 6, where an average yearly drawdown in excess of 10% is unlikely to last for a 30-year period.

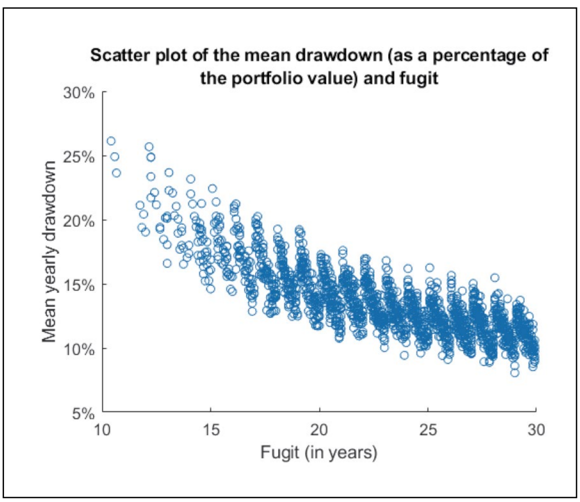


FIGURE 6. Relationship between the mean yearly drawdown (as a portion of the portfolio value) and fugit

3.1.8 In Table 7, we incorporate longevity into our simulation. Here we are simulating the portfolio given the conditional probability of surviving[10] between x and $x+t$. Factoring longevity into the simulation improved the expected success rates of the portfolio. Furthermore, in Table 8, we factor fund management costs into the simulation. In our analysis, costs reduced the portfolio success by up to 4%. This is obviously not a desirable outcome on an already strained problem.

TABLE 7. Success rates with longevity

	Withdrawal rate as percentage of initial investment value						
Asset allocation	4%	5%	6%	7%	8%	9%	10%
100% equity/0% bonds	99%	96%	92%	87%	79%	72%	63%
75% equity/25% bonds	99%	97%	92%	85%	75%	66%	58%
50% equity/50% bonds	99%	97%	90%	80%	70%	60%	51%
25% equity/75% bonds	99%	94%	84%	72%	61%	52%	45%
0% equity/100% bonds	97%	87%	74%	63%	53%	46%	40%

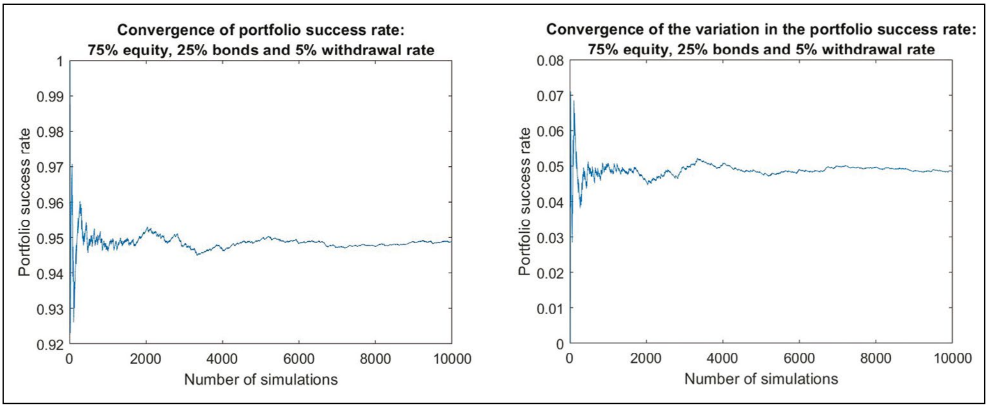
TABLE 8. Success rates with fund costs and longevity

	Withdrawal rate as percentage of Initial investment value						
Asset allocation	4%	5%	6%	7%	8%	9%	10%
100% equity/0% bonds	98%	95%	89%	82%	75%	67%	58%
75% equity/25% bonds	99%	95%	89%	80%	71%	61%	54%
50% equity/50% bonds	99%	94%	86%	76%	64%	55%	47%
25% equity/75% bonds	98%	91%	79%	66%	56%	48%	42%
0% equity/100% bonds	94%	82%	69%	59%	50%	44%	39%

3.1.9 The convergence of the sample mean and variance of portfolio success rates is shown in Figure 7. Qualitatively, we see that the convergence graphs reach a flat region, indicating convergence of the sample moments.

3.1.10 Retirees are often advised to carry portfolios with lower risk at retirement. That is, they are advised to hold portfolios that have a larger asset allocation in fixed income and cash-based securities. In Table 9, we show that this could drastically reduce the success rates of a portfolio.

10 The conditional survival probabilities for the simulation were obtained from CSI (2017).



(a) Convergence of the mean portfolio success rates

(b) Convergence of the variation in the portfolio success rates

FIGURE 7. Convergence of the sample mean and variance of portfolio success rates as functions of the number of Monte Carlo simulations

TABLE 9. Portfolio with larger cash allocation

	Withdrawal rate as percentage of initial investment value						
Asset allocation	4%	5%	6%	7%	8%	9%	10%
85% equity/0% bonds/15% cash	55%	48%	42%	37%	33%	30%	27%
75% equity/10% bonds/15% cash	53%	46%	41%	36%	32%	29%	27%
50% equity/35% bonds/15% cash	50%	44%	38%	35%	31%	28%	26%
25% equity/60% bonds/15% cash	47%	41%	37%	33%	30%	27%	25%
0% equity/85% bonds/15% cash	44%	39%	35%	31%	28%	26%	24%

3.1.11 The results above indicate that we need to be very conscious of our spending habits. We also need to ensure that we hold sufficient growth assets, although these could introduce more uncertainty to our portfolios. We can, however, mitigate some of the downside risks associated with growth assets. In Table 10, we detail results where we protect equity holdings against downside moves. To pay for the protection we sacrifice some upside returns, in this case 50% of the return above 4%. This is done as follows,

Protection:

$$floor = -0.03,\ cap = 0.04,\ participation = 0.5,\ \text{cost} = 0.001,\ X = one - month\,equity\,return$$

$$payoff = X + \max(0, floor - X) - participation \times \max(0, X - cap) - \text{cost}$$

TABLE 10. Protecting equity returns for 5% and 10% spending rates

		5%		10%	
Asset allocation	Protected equity	Success	Fugit	Success	Fugit
75% equities / 25% bonds	No	83%	279.8	8%	179.7
75% equities / 25% bonds	Yes	95%	312.6	3%	187.0
50% equities / 50% bonds	No	78%	293.6	1%	166.5
50% equities / 50% bonds	Yes	88%	315.5	0%	165.5
25% equities / 75% bonds	No	59%	300.7	0%	148.7
25% equities / 75% bonds	Yes	61%	310.8	0%	147.8

3.1.12 The results in Table 10 are encouraging, with improvements in both the fugit and success rates in lower withdrawal rates. Moreover, these results further illustrate the main challenge encountered by retirees is that large withdrawals are not sustainable for the success of a retirement portfolio. The derivative protection strategy illustrated above can easily be implemented by buying put options and selling call options on the index on a rolling one-month basis. Our analysis here is based on long-term average costs.

4. DISCUSSION OF RESULTS AND CONCLUSION

4.1 We have presented a simulation-based approach to analyse withdrawal rates for retirement-based portfolios in a South African setting. In our approach we consider the distribution of terminal account balances and also calculate the probability of the investor's capital being depleted. This corresponds to the notion of a safe withdrawal rate. Our results show clearly that portfolio success rate is a rapidly decaying function of retirement spending (measured on an annual inflation-adjusted percentage basis). The notion of the portfolio fugit provides insight into the expected failure time (or extent of ruin) of a portfolio and provides insight into establishing the effects of path-dependence on portfolio success.

4.2 We observe, for low withdrawal rates, that asset allocation does not have a large influence on the success of the portfolio. When we consider larger withdrawal rates, however, a higher percentage of growth assets (such as equity) is needed, and even then the portfolio is not necessarily sustainable.

4.3 We also detail that there are options to increase investment results, which entail growth asset protection by use of derivative instruments; in this paper, we provided a proof of concept towards this, however, more work needs to be performed in this area.

4.4 Scott et al. (2009) and Waring & Siegel (2015) criticised the notion of withdrawing a fixed real amount from an inherently volatile portfolio. We concur, the results obtained here indicate moderation and a cautious approach. The risk associated with the investment environment is significant, while we expect the risky nature to be maintained in future years, there can be no guarantee that historical returns would be maintained.

4.5 Cooley et al. (2003) note that "a portfolio is only successful if it lasts as long as required by the retiree"—this motivates our use of incorporating longevity into the simulation of the portfolio success rate. It should be noted that other measures could be used and investigated as well.

4.6 In conclusion our results showed that withdrawal rates depend critically on the investor's portfolio makeup and life expectancy. Withdrawal rates in excess of 5% is not sustainable over a 30-year period, regardless of the portfolio makeup. Furthermore, our simulation showed that the portfolio fugit is often shorter than the retiree's life expectancy for larger withdrawal rates. This indicates that retirees need to buy some life annuities in addition to living annuities. The 'optimal' incorporation of life annuities into one's retirement portfolio could safeguard against a complete loss of income—this reflects an area of future research.

4.7 Further research could be carried out in recalculating safe withdrawal rates each year based on the portfolio value, economic climate, and expected lifetime in order to decrease the likelihood of running out of money before end of life. To achieve this, forward looking return information would be vitally important.

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