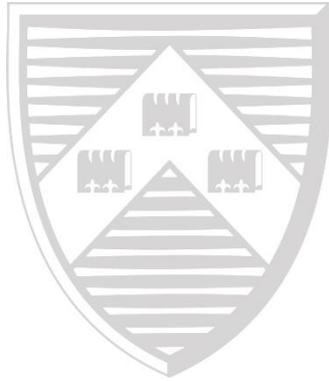


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# Decumulation, Sequencing Risk and the Safe Withdrawal Rate: Why the 4% Withdrawal Rule leaves Money on the Table

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## Abstract

We examine the consequences of alternative popular investment strategies for the decumulation of funds invested for retirement through a defined contribution pension scheme. We examine in detail the viability of specific 'safe' withdrawal rates including the '4%-rule' of Bengen (1994). We find two powerful conclusions; first that smoothing the returns on individual assets by simple trend following techniques is a potent tool to enhance withdrawal rates. Secondly, we show that while diversification across asset classes does lead to higher withdrawal rates than simple equity/bond portfolios, 'smoothing' returns in itself is far more powerful a tool for raising withdrawal rates. In fact, smoothing the popular equity/bond portfolios (such as the 60/40 portfolio) is in itself an excellent and simple solution to constructing a retirement portfolio. Alternatively, trend following enables portfolios to contain more risky assets, and the greater upside they offer, for the same level of overall risk compared to standard portfolios.

**Keywords:** Sequence Risk; Perfect Withdrawal Rate; Decumulation; Trend Following.

**JEL Classification:** G10, G11, G22.

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In this paper we examine alternative popular investment strategies for the decumulation of funds invested for retirement. Usually these are funds created in a defined contribution pension scheme. We examine in detail the viability of specific ‘safe’ withdrawal rates (eg see the ‘4%-rule’ of Bengen (1994) and also Blanchett et al (2016)). Anticipating our empirical findings, we find two powerful conclusions:

(i) Smoothing the returns on individual assets by simple trend following techniques (or similar) is a potent tool to enhance withdrawal rates, (see Clare et al, 2016).

(ii) While diversification across asset classes does lead to higher withdrawal rates than simple equity/bond portfolios, ‘smoothing’ returns in itself is far more powerful a tool for raising withdrawal rates; in fact, smoothing the popular equity/bond portfolios (such as the 60/40 portfolio) is in itself an excellent and simple solution to constructing a retirement portfolio.<sup>1</sup>

The move away from defined benefit (DB) towards defined contribution (DC) and personal savings for pensions is well underway for a wide variety of reasons, comprehensively described in the OECD Pensions Outlook, 2016. This, of course, means that both investment and longevity risk rest with the individual. OECD data on assets and members in DB and DC plans from 2000 to 2015 confirm the increasing prominence of DC plans in many OECD countries and, to the extent new schemes have been introduced in recent decades, they have almost entirely been DC schemes, though the exact arrangements differ between countries, (OECD, 2016). However, assets in occupational DC plans together with those in personal plans exceeded assets in DB plans in most reporting countries. In the United States, around half of private sector employees have no pension saving, only 2% have DB plans with 33% having DC; around 11% have both DB and DC.

The decline in importance of DB saving and the increasing domination of DC means that individuals need to concern themselves with two rather important sets of questions:

*i) how much should I save through my working life, and what sort of investment portfolio should I use,*

and

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<sup>1</sup> Chris Dillow, FT Money, p10, 22/4/2017, points out that if one believes that equity markets are expensive measured by the CAPE ratio, and bond markets are expensive after a 30-year bull market, and that both could well fall together following a shock, then there is no benefit in this diversification. But cash, or switching to cash, offers powerful protection.

*ii) how do I hold my assets in retirement (assuming I will not buy an annuity) such that I can withdraw a 'suitable' regular amount to live on and not run out of money?*

The construction of investment portfolios for both phases has been relatively neglected in the study of retirement planning leading to them being described as the 'known unknowns' (Merton, 2014). Indeed the study of long term accumulation and decumulation usually treats the two processes as completely separate phenomena. For the former, the emphasis is on changing the riskiness of portfolios as retirement beckons. This is usually de-risking in the form of glidepath or target-date investing, by raising the proportion in bonds and reducing the percentage in equities, (eg see Blanchett et al, 2016, Estrada, 2017). For the latter, the issue is what percentage of wealth can be withdrawn for consumption each year in a world with uncertain life expectancy and stochastic returns (see Bengen, 1994, Blanchett et al, 2016). Sometimes, of course, the glidepath glides through the retirement date and becomes the decumulation portfolio, though most discussions distinguish between the two for investing purposes. In this paper we analyse the decumulation phase following retirement.

Withdrawals can be either fixed or variable, nominal or real, with by far the most attention given to fixed, real withdrawals since Bengen (1994) showed that an initial withdrawal rate of 4%, with annual withdrawals subsequently adjusted by inflation, was 'safe' in the sense that, historically, this strategy never depleted a portfolio in the US in less than 30 years and therefore failed. The chosen portfolio was 50% US equity and 50% bonds.

Subsequent research showed that over the 115 years between 1900 and 2014, a 60-40 portfolio of U.S. stocks and bonds had a failure rate of 4.7%, and portfolios with at least 70% in U.S. stocks had an even lower (3.5%) failure rate. However, in other markets much higher failure rates are experienced with the 4% rule (see Pfau, 2010, Blanchett et al, 2016), while some researchers are troubled by current (2017) market conditions that suggest lower than-historical expected returns for stocks and bonds going forward (Crook, 2013) and therefore increased risk of failure. The debate on the pros and cons of the 4% rule, and on fixed real withdrawals more generally, is alive and well.

Variable withdrawals encompass a broad set of strategies in which withdrawals are adjusted based on changing life expectancy (Dus et al, 2005), changing market conditions (Estrada, 2016b), or both (Stout and Mitchell, 2006). Withdrawals depending on market conditions, in

particular, are the subject of extensive study (see references in Suarez et al, 2015 and Clare et al, 2017), for example.

There are of course both pros and cons for fixed and variable withdrawals. Fixed withdrawals are generally easier to understand and, in the case of fixed real withdrawals, they preserve purchasing power. However, they do not adjust to changing market conditions or life expectancy: this may lead to depletion of a retirement portfolio earlier than desired, with calamitous results. Meanwhile variable withdrawals do adjust to changing conditions and hence reduce or eliminate the risk of a very bad outcome. However, they typically are more difficult to understand and implement (see, for example, Stout, 2008) and may require a retiree to reduce their real consumption at some point.

The maximum withdrawal rate, as used in this paper, is defined in Section 2 and belongs to the category of fixed *real* withdrawals and hence keeps real purchasing power constant throughout the decumulation period. However, in practice, if the safe (or maximum withdrawal) rate is updated periodically with new information on (actual returns) during the retirement period, then it will most likely lead to variable withdrawals in both nominal and real terms.

However, there is a crucial common thread to both accumulation and decumulation life-cycle phases which is often overlooked in considering investment performance of a portfolio in the context of saving or dissaving *regular* amounts; namely the threat presented by poor returns occurring at the ‘wrong’ time, otherwise known as ‘*sequence risk*’. For accumulation, it is particularly bad news if large negative returns occur shortly before retirement, while for decumulation it is just as disastrous if they occur just after the start of drawing down from the savings pot (see Figure 1). We explore sequence risk in the context of a 100% US equity portfolio for 20-year decumulation periods in Clare et al (2017) and show that there is no simple statistic to measure the phenomenon, (which is why it may well be largely neglected by researchers), but that simple smoothing using trend following techniques, which removes the large drawdowns associated with major market falls, such as occurred in 2000 and 2008, allows a much better withdrawal rate experience.

Early studies led by Bengen (1994) suggest that the ‘4% rule’ is a sustainable withdrawal rate for retired people with a 30-year life expectancy, ie 4% of initial wealth can be consumed

annually. Bengen (1994) used US data and had a retirement portfolio comprising 50% each of US government bonds and US equities. In a recent paper using annual returns data for 20 countries since 1900, Blanchett et al (2016) suggest that 20<sup>th</sup> century US returns' experience is actually pretty unusual and that most countries would not have generated returns sufficient to provide a 4% drawdown rule: for example, the UK would only have managed 2.8% pa (see FTMoney,4-2-2017).

Similarly, Estrada (2017a), using data on 21 countries over 115 years, and with 11 different combinations of bonds and equities, finds widely varying safe withdrawal rates over time and between countries: the 4% rule and a 60/40 portfolio would have left substantial bequests much of the time in the US, whereas a 100% bond portfolio would have run out of money 65% of the time. If the percentage in stocks was above 50% then the failure rate was less than 10%.

In this paper we ask two closely related questions:

i) while the literature focusses exclusively on bonds and equities, diversification to other asset classes such as commodities has been shown to dramatically improve the risk-return possibilities for investors; we introduce commodities, real estate, and credit (see Clare et al, 2016) and compare the decumulation possibilities with equity/bond portfolios; unsurprisingly the former offer a better withdrawal rate experience in general.

ii) secondly, and to us of far greater importance, we ask the question, rather than worrying whether particular percentages of equity and bond portfolios will give suitable drawdown experience, are there any more general desirable features of decumulation portfolios about which we should be aware? The answer lies in a detailed understanding of the nature of sequence risk. We then explore the withdrawal experience of a range of popular retirement portfolios over the period 1971-2015 for the UK retiree and show how a smoothed investment solution gives a far better withdrawal rate experience: it turns out that smoothing even just a two asset-bond and equity-portfolio leads to superior results which are similar to those for a far more diversified portfolio.

In other words smoothing returns dominates diversification when it comes to improving the decumulation experience. This results in the 4% rule being a lower bound for post-retirement experience even in an environment where some researchers think that only 2-3% pa is feasible, eg, for the UK, Blanchett et al (2016).

The paper is constructed as follows: in section 2 we introduce sequence risk and the perfect withdrawal rate as tools for evaluating alternative portfolio strategies. In section 3, we then look more closely at the ‘4% rule’ which has established this concept as a reference point in the world of retirement planning. Section 4 reviews the debate on the appropriate portfolio choice both approaching retirement and during decumulation, so-called ‘derisking’: should we lower the percentage in equities as we approach retirement and engage in ‘glidepath’ investing, (or similar)? Section 5 compares the performance of several popular decumulation strategies, both smoothed and ‘raw’. Section 6 assesses the effectiveness of put protection to limit drawdown as an alternative to employing trend following. Section 7 concludes with the practical observation that advisers should look closely at sequence risk and its implications for investors who are making regular contributions or withdrawals to or from a pot of wealth. Choosing a strategy with little chance of large drawdowns (ie ‘smoothed’) should raise both the end-value of regular contributions and the withdrawal possibilities in retirement.

## **2. Sequence risk: measurement and importance**

The major risks identified here in both the accumulation and decumulation phases are examples of sequence risk, the risk that investment returns occur in (rather unfortunately) the wrong order. Sequence risk can have as disastrous an impact on savings as it does on withdrawals, though you could argue that with savings’ losses one can simply work and save longer (as many will have done following the recent financial crisis). In a recent paper we have explored the nature of sequence risk (using a 100% US equity portfolio since 1872), and its impact on withdrawal rates, (Clare et al, 2017). In particular we used the idea of Perfect Withdrawal Rates (PWR), (see Suarez et al, 2015), to compare investing strategies. These PWRs are the maximum withdrawal rate possible over a fixed period of time if one had perfect foresight of investment returns, and are a useful metric for comparing investment strategies in the context of withdrawals in retirement (or any other period).

This concept of sequence risk is of particular interest to the decumulation industry. Okusanya (2015) and Chiappinelli and Thirukkonda (2015) both basically point out the importance of ‘path dependency’ of investment returns (i.e. the order in which returns occur). This concept is at least as important to the outcomes of the retirement journey as the total return earned by the investment. Yet portfolio construction, both academic and practical, has typically focussed on total return and volatility, constructing Sharpe or similar performance statistics

as a way of comparing strategies. Using simple arithmetic examples, studies typically show that higher withdrawal rates are always possible when the worst investment years occur later in the decumulation period (for *any given set* of returns). The natural reaction to sequence risk has therefore been to de-risk a portfolio as one approaches ‘retirement’ along the lines of ‘glidepath’ or similar strategies. As pointed out by Estrada (2017a), many of the empirical exercises in this area focus on varying investment returns and individual longevity but assume the returns are *constant* over the decumulation period: this, of course, assumes away sequence risk and all the associated real world problems.

The concept of PWR is a relatively new one to create withdrawal strategies from retirement portfolios and is based not on heuristics and/or empirical testing but on analytics. Suarez et al (2015) and also Blanchett et al (2012) construct a probability distribution for the PWR and apply it sequentially, deriving a new measure of sequence risk in the process. As in Clare et al (2017) we use these ideas to show that a particular class of investment strategies (both simple and transparent) can offer superior (Perfect) Withdrawal Rates across virtually the whole range of return environments. This smoothing of returns leads to a better decumulation experience across virtually all investing time frames.

Here we assume that in the decumulation phase annual withdrawals from the pot of wealth are made on the first day of each year and annual investment returns accrue on the last day of the year: there are no taxes or transactions’ costs. Then for any given series of annual returns there is one and only one constant withdrawal amount that will leave the desired final balance on the account after  $n$  years (the planning horizon). The final balance could well be a bequest or indeed zero. We can think of this as equivalent to finding the fixed-amount payment that will fully pay off a variable-rate loan after  $n$  years.

The basic relationship between account balances in consecutive periods is:

$$K_{i+1} = (K_i - w) \cdot (1 + r_i) \tag{1}$$

where  $K_i$  is the balance at the beginning of year  $i$ ,  $w$  is the yearly withdrawal amount, and  $r_i$  is the rate of return in year  $i$  in annual percent. Applying equation (1) chain-wise over the entire planning horizon ( $n$  years), we obtain the relation between the starting balance  $K_S$  (or  $K_1$ ) and the end balance  $K_E$  (or  $K_n$ ):

$$K_E = \left( \left[ (K_S - w) (1+r_1) - w \right] (1+r_2) - w \right) (1+r_3) \dots - w \cdot (1+r_n) \quad (2)$$

And we solve equation (2) for  $w$  to get:

$$w = [K_S \prod_{i=1}^n (1+r_i) - K_E] / \sum_{i=1}^n \prod_{j=i}^n (1+r_j) \quad (3)$$

Equation (3) provides the constant amount that will draw the account down to the desired final balance if the investment account provides, for example, a 5% return in the first year, 3% in the second year, minus 6% in the third year, etc., or any other particular sequence of annual returns. This figure is called the Perfect Withdrawal Amount (PWA).

Quite simply, if one knew in advance the sequence of returns that would come up in the planning horizon, one would compute the PWA, withdraw that amount each year, and reach the desired final balance exactly and just in time.

Note that the analysis so far offers a number of useful insights into sequence risk measurement. First, equation (3) can be restated in a particularly useful way since the term

$\prod_{i=1}^n (1+r_i)$  in the numerator is simply the cumulative return over the entire retirement period,

(call it  $R_n$ ). The *denominator*, in turn, can be interpreted as a measure of sequencing risk:

$$\begin{aligned} \sum_{i=1}^n \prod_{j=i}^n (1+r_j) &= (1+r_1)(1+r_2)(1+r_3)\dots(1+r_n) + (1+r_2)(1+r_3)\dots(1+r_n) + \\ &(1+r_3)(1+r_4)\dots(1+r_n) + \dots + (1+r_{n-1})(1+r_n) + (1+r_n) \end{aligned} \quad (4)$$

The interpretation of this is straightforward: for any given set of returns equation (4) is *smaller* if the *larger* returns occur *early* in the retirement period and *lower* rates occur at the *end*. This is because the later rates appear more often in the expression. Suarez et al (2015) suggest the use of the reciprocal of equation (4) to capture the effect of sequencing: so let

$S_n = 1 / \sum_{i=1}^n \prod_{j=i}^n (1+r_j)$ . This rises as the sequence becomes more favourable, and even though

one set of returns appearing in two different orders will have the same total return (i.e.  $R_n$  with different  $S_n$  values), so the PWA rates will be different.

Numerous studies provide examples of a sequence of, say, 30 years of returns generated possibly with reference to an historical period or via Monte Carlo simulations, and offer the unique solution of the PWA. It involves withdrawing the same amount every year, giving the desired final balance with no variation in the income stream, no failure and no surplus. Note that Blanchett et al (2012) present a measure similar to PWA called Sustainable Spending Rate (SSR). Suarez et al (2015) point out that the PWA is a generalization of SSR, with SSR being the PWA when the starting balance is \$1 and the desired ending balance is zero.

So every sequence of returns is characterised by a particular PWA value and hence the retirement withdrawal question is really a matter of “guessing” what the PWA will turn out to be (eventually) for each retiree’s portfolio and objectives. So the problem now becomes how to estimate the probability distribution of PWAs from the probability distribution of the returns on the assets held in the retirement account.

We emphasised earlier that whereas in most finance contexts *total* return is the key variable, in both accumulation and decumulation the *order* of returns also matters. An example will make this clearer. Suppose we have three sets of returns in Table 1; clearly the mean, volatility and Sharpe (and indeed Maximum Drawdown) are the same, but the returns’ sequence differ as is evidenced by the different values of Sequence Risk ( $1/S_n$ ) with lower values of this metric associated with higher PWRs.

So in the real world of unforecastable asset returns and the consequent failure of tactical asset allocation culminating in the empirical (and costly) failure of de-risking in general and glidepath investing in particular, what is the solution to the dangers of sequence risk if risk-free investing in TIPS, annuities or similar is not attractive?

The answer lies in removing the chance of large drawdowns: in our related paper (Clare et al, 2017) we discuss how to address sequence risk using the S&P500 index return as our representative portfolio. If we start by accepting that returns are inherently unpredictable and hence we cannot tactically switch investments to avoid large losses at key times - witness the lack of success of multiasset funds say around 2009-10 - then a better option might be to use an investing strategy with lower sequence risk. In our paper we show how one simple strategy called Trend Following (also see Faber, 2007 and Capone and Akant, 2016) leads to smoother investment outcomes but with dramatically improved decumulation experiences.

As an illustration, Table 2 compares the raw performance of the S&P 500 and a trend following approach to the same index<sup>2</sup>. The trend following rule is simply: if the current price is above the 10 month moving average then a position is taken in stocks otherwise the portfolio is held in cash. In Clare et al (2013) we explore different trend rules and find the results remarkably insensitive to the choice of trend filter. The results show a real return of around 2% higher per annum with just two-thirds of the volatility and less than 60% of the maximum drawdown of the index.

The key question in the current context is how smoothing via trend following improves the PWR experience. Figure 1 shows the 20-year PWR rates for the above equity data for both the raw and smoothed S&P500. Clearly the minimum experience is far higher – around 2% pa. We will show this is the case for a range of popular investment portfolios in Section 4 below. Also in Clare et al (2016) we apply the trend following rule to a multi-asset environment with even greater success in terms of returns. But first of all we need to examine the evidence surrounding the fabled ‘4% Rule’: in particular is it replicable outside the US data environment and can simple trend following as explained above give a better outcome even sticking with the narrow 2-asset portfolios of the literature?

### **3. Decumulation and the 4% rule**

As we have indicated, there is a growing body of literature on safe withdrawal rates for retirees; however most of this research is based on the historical returns of assets used by investors in the United States. While there has been some more recent research using projected returns for the United States (Blanchett et al 2015) its applicability to the UK and other countries is questionable. Research by Bengen (1994), among others, suggests an initial safe withdrawal rate from a portfolio is 4% of the assets, where the initial withdrawal amount would subsequently be increased annually by inflation and assumed to last for 30 years (which is the expected duration of retirement). This finding led to the creation of the “4% Rule,” a concept that is often incorrectly applied (see Blanchett, et al, (2016). They point out that, firstly, the “4%” value only applies to the first year of retirement, with subsequent withdrawals assumed to be based on that original amount, increased by inflation; secondly, a retirement period of 30 years may be too short or too long based on the unique attributes of that retiree household, and thirdly that the analysis was based entirely on historical U.S.

returns, which may not be applicable for international retirees today. A number of studies have introduced 'adaptive' rules: Guyton and Klinger (2006) manipulate the inflationary adjustment when rates of return are too low, modifying the withdrawal amount, while Frank, Mitchell, and Blanchett (2011) use adjustment rules dependant on how much the return deviates from the historical averages. Zolt (2013) similarly suggests curtailing the inflationary adjustment to the withdrawal amount in order to increase the portfolio's survival rate where appropriate. The principle being that withdrawal rates 'adapt' to changing circumstances.

Based on a 50% Bonds / 50% Equity portfolio, the Bengen (1994) safe withdrawal rate bottoms out at 4% around the 1970's. But there are a number of problems extrapolating these results to non-US retirees: firstly, Bengen did not include fees in his analysis; secondly, the analysis assumes retirement lasts 30 years, whereas of course this should vary by retiree while in reality the expected duration of retirement, thus respective modelling period, should vary by retiree. It is certainly the case that for a 65-year old man in the US or UK, expectancy in retirement is just over 20 years, so 30 years is a 'safe' option for simulation. In our analysis below we will describe both 20- and 30-year outcomes, with a strong preference for a 20 year decumulation period concurrent with a 20-year deferred annuity, (see Chen, Haberman and Thomas, 2016). Thirdly, this problem ignores the experience of retirees in other countries. Blanchett et al (2016) calculate safe withdrawal rates for a range of countries, and for the UK a rate of 2.5% pa is proposed as the safe level, with the early years of the 20<sup>th</sup> century especially challenging. Finally, the Bengen analysis assumes that past returns are a reasonable basis for retirees to use today. While the past indeed provides some window into the future, the markets today are in a different place than historical long-term averages, and perhaps this needs to be taken into account when advising a retiree on a safe initial withdrawal rate?<sup>3</sup>

The true safe withdrawal rate varies significantly by country and, of course, target success rate. Based on a comprehensive analysis across 19 countries, Drew and Walk (2014) argue that the 4 per cent rule does present us with an opportunity to form a baseline which can

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<sup>3</sup> We acknowledge the diverse and varied conclusions on the sustainability of the 4 per cent 'golden rule' as proposed by Bengen (2004). Whilst some studies firmly support this withdrawal rate (see Pye, 2000, Guyton, 2004, Guyton and Klinger, 2006), recent literature questions the sustainability of the 4 per cent 'safe withdrawal rate' and its ability to provide retirement portfolios. Spitzer, Strieter, and Singh (2007) and Spitzer (2008) suggest that the 4 per cent rule may be an oversimplification while studies by Sharpe, Scott, and Watson (2007) believe the rule is inefficient. Other studies which oppose the 4% percent rule include Pfau (2011), and Drew and Walk (2014).

dramatically improve the expectations of what is possible in retirement but is not a silver bullet approach to retirement withdrawal decisions. Estrada (2017a) examines the 'Maximum Withdrawal Rate' in the context of failure rates and bequest possibilities for 21 countries and 115 years and for 11 asset allocations, ie different percentages of equities and government bonds. He concludes, unsurprisingly, that these rates vary substantially across countries and over time.

The study by Blanchett et al (2016) provides a consistent set of comparisons. For example, using the historical returns in Japan, a 95% target success rate would yield an initial safe withdrawal rate of .2%, while for the UK a 95% target success rate would yield an initial safe withdrawal rate of 2.8%, (Blanchett et al, 2016, p4). Perhaps unsurprisingly US returns have yielded the highest initial safe withdrawal rates across the 20 countries historically. This suggests initial safe withdrawal rates based on historical US returns may be overly optimistic on a global basis. For example, based on the results in Exhibit 3 of Blanchett (2016), using the US returns and targeting a 90% success rate yields an initial safe withdrawal rate of 3.6% (just edging out Denmark at 3.5%). This is the highest initial safe withdrawal rate among the 20 countries and is considerably higher than the 20 country average, which is 2.30%. UK-based investors have experienced returns that are broadly in-line with other countries historically. The real equity return of 5.23% ranks the UK 9th of 20, the real bond return of 1.54% ranks 13th, and the 50/50 portfolio real return of 3.72% ranks 11th highest. These relatively average returns result in historical safe initial withdrawal rates that are slightly higher (approximately 0.5% higher, on average) than the international averages across different target probabilities of success but lower than the historical US initial withdrawal rates (approximately 0.5% lower, on average).

The Blanchett et al (2016) paper provides a relatively comprehensive overview of safe withdrawal rates for retirees based on both historical returns and forward-looking returns. Overall these findings suggest that financial advisers and retirees in the United Kingdom should use lower initial safe withdrawal rates than noted in prior research - the lower end of the range now starts towards 2.5% or 3.0% and not the previous 4.0%. The generous capital market returns of the prior century that bolstered a comfortable and long-lasting retirement portfolio may give 21st-century retirees a false sense of security.

So what happens if we 'smooth' US equity and bond returns with our simple trend following rule in terms of the retirement experience? Can we do better than the 4% rule? Table 4 below

shows the 20- and 30-year PWAs available from the 50/50 equity/bond portfolio of Bengen (1994) using Monte Carlo simulations. We can see clearly that for both withdrawal periods the bad left tail experiences are far less likely to occur with the smoothed portfolios. While there is a 1% chance of experiencing less than 2.3% pa over 20-years with the simple portfolio, this rises to 4.46% pa with the smoother strategy. Similar improvement is seen over the 30-year horizon. It is certainly the case that better withdrawal experiences sometimes occur with the simple portfolios in the right hand tail but these are of far less importance to the decumulation experience.

Whereas all the focus is on the decumulation experience based on equity and bond portfolios, diversification is possibly the most widely accepted concept in portfolio construction. Why have researchers not added other asset classes? One can only assume that the popularity of the 60/40 portfolio in the US along with the paucity of historical data on other asset classes has led to this focus.

In the next section we examine what happens to withdrawal rates if we add new asset classes and ask whether trend following still has a role in improving the PWA experience.

#### **4. What should be the role of ‘derisking’?**

Here we explore several of the most popular investing strategies recommended by advisers for accumulation and decumulation, such as the 60-40 equity/bond portfolio popularised in the US, along with multi-asset versions. We also investigate different popular approaches to forming portfolios such as risk-weighting (here in the form of risk parity), and returns smoothing in the guise of trend-following, and combinations thereof: we use the PWR concept for comparing the performance of different approaches, using both actual historical calendar periods together with Monte Carlo simulations. The suggestion to diversify to a multiasset context would seem trivially obvious given that the ‘only free lunch in finance is asset diversification’, yet most studies focus on equities and bonds only (eg, Dimension, Fidelity and of course Morningstar). Notwithstanding data issues, the power of adding even a third asset is immediately apparent, eg see Salient who add commodities to the equity and bond US portfolio. These discussions tend to be overshadowed by the equally important question of whether portfolio composition should *change as we go through life?* So-called ‘target date’ funds (TDF), ‘glidepath’ investing and ‘de-risking’ have become popular labels associated with accepted practice, both approaching retirement and indeed during

decumulation. However such simple recommendations have been increasingly challenged in the literature.

In our view, much of the time the diversification literature tends to ignore an issue which is critical to the discussion here, namely, that investors make periodic contributions to their retirement funds during their working years. Hence, the capital accumulated at retirement is a function of both the asset allocation and the size and timing of the contributions. Shiller (2005) was the first to emphasize that investors following a lifecycle strategy choose to have a large exposure to stocks when (they are young and) their savings are low, and a small exposure to stocks when (they are older and) their savings are higher. He evaluated the wisdom of this approach through simulations, found that lifecycle strategies are too conservative, usually underperforming portfolios fully invested in stocks, and concluded that these strategies may not be optimal for investors saving for retirement. Basu and Drew (2009) consider several lifecycle strategies and their mirrors (strategies that remain invested in stocks, bonds, and cash the same amount of time as lifecycle strategies but evolve in the opposite direction, from less aggressive to more aggressive). They find that investors should become more, rather than less aggressive over time. The literature that evaluates the plausibility of lifecycle strategies taking into account the critical role that periodic contributions play on wealth accumulation, besides being scarce, is both recent and largely limited to US data. This is the case with the already-mentioned works of Shiller (2005), Basu and Drew (2009), Ayres and Nalebuff (2010), Basu, Byrne, and Drew (2011), and Arnott (2012).

A key question is should our portfolio construction veer towards 'reduced risk' as we approach decumulation or even during decumulation? While there is no consensus on what the best investment strategy is, current debate questions the benefits of the popular target-date or lifecycle funds in the *accumulation* phase. In a similar vein, Blanchett (2007) compares fixed asset allocations to a wide range of investment paths that reduce the allocation to equity during retirement. He finds that fixed asset allocations provide superior results compared to asset allocations which tend to reduce equity investments in retirement. Arnott, Sherrerd, and Wu (2013) argue that a reverse approach to the target-date fund glidepath with an increasing share of equities delivers greater terminal wealth levels for investors. They yield higher wealth levels than the traditional lifecycle approach even at the left tail of the wealth distribution. Estrada (2014) comprehensively studies the lifecycle investor glidepath in 19 countries, finding that contrarian strategies provide higher upside potential, more limited

downside potential, although with higher uncertainty. Arnott (2012) also argues this case. In a recent and provocative article, he argues that investors would be better off by following a strategy opposite to that implemented by target-date funds. In fact, he argues that if investors focus on the capital accumulated at retirement, instead of making their portfolios more conservative, they should make their portfolios more aggressive as retirement approaches, along the lines of Shiller (2005). This counterintuitive recommendation follows from a rather obvious but often overlooked fact first highlighted by Shiller (2005): Target-date funds expose investors to stocks more in the early years, when the accumulated capital is not large, and less in later years, when the accumulated capital is much larger. Put differently, these funds are aggressive when the portfolio is small and conservative when the portfolio is large, which appears to be suboptimal in terms of capital accumulation.

Despite their growing popularity as long-term savings' vehicles, the idea that conventional target-date funds are inherently dangerous has been addressed by Ezra et al (2009) and more recently by Capone and Akant (2016) who note that the great financial crisis wreaked havoc on 2010 target date funds with the 3 largest in the US losing around 30%+ each in 2008: this unfortunate turn of events reflects sequence risk as outlined above; namely poor (if not disastrous) returns in the investment portfolio occurring at exactly the worst time for the long term saver: ie just before retirement. Capone and Akant (2016) identify 'too much equity' and not enough diversification across sources of risk premia as the fundamental problems here and suggest integrating their multi-asset trend following strategy with conventional target date fund strategies. Although 'trend following' appears in the title of their paper they are not advocating the technique which we apply to the S&P500 above, but rather they add their multi-asset trend-following investing solution ('fund') to existing target date fund solutions (ie an extra diversifying asset which happens to be a conventional trend-following Commodity Trade Advisors (CTA) fund. While any diversification is to be welcomed, and meets their first objection to simple target date funds with limited asset diversification, it still does not directly address the underlying problem of sequence risk, the potentially large drawdowns at the 'wrong' time. They add up to 15% of portfolio value in the form of their CTA to conventional target date fund allocations, still leaving the bond allocation vulnerable to the next (unforeseeable) secular shift upwards in interest rates. However, their acknowledgement that maximum loss is much reduced relative to conventional target date funds is a step in the right direction in addressing sequence risk. In anticipation of our proposal later in this paper, we would advocate subjecting all asset classes to smoothing by

trend-following rather than just adding a CTA component to an otherwise long only conventional target date fund allocation. Indeed, as also advocated by Capone and Akant (2016), an additional benefit to smoothing is the long-run extra performance (both risk-adjusted and absolute) due to trend-following as evidenced across a wide range of asset classes by Faber (2007) and Clare et al (2017).

In practical terms, Bengen (1994) advises that if future market returns follow behaviour in the past, then a retirement portfolio should hold a 50 to 75% allocation to equities. Milevsky (2001) and Ameriks, Veres, and Warshawsky (2001) demonstrate through simulation the need for holding a substantial equity allocation in a retirement portfolio. Cooley, Hubbard, and Walz (2011) propose that at least 50% of a retirement portfolio should be invested in equities and their findings show increased sustainability of the fund as it tilts more towards equities. They explain that the presence of bonds is mainly to restrain portfolio volatility and provide liquidity to cover an investor's living expenses.

The lifecycle strategy holds a high allocation to equities at the onset but moves towards less volatile assets, such as bonds and cash with increasing age. This is the default investment option in many employer-sponsored and individual retirement plans (see Charlson and Lutton, 2012). In Australia, lifecycle funds are increasing rapidly, expected to catch up or surpass the U.S. in the next decade (QSuper, 2014). The lifecycle approach is implemented with the aim of avoiding insufficient diversification as well as to avoid investment choices that may be age-inappropriate. While it undoubtedly achieves these aims, the relevance of having investments following a predetermined glidepath solely dependent on age appears to us simplistic. Important factors such as account balance, gender, marital status, retirement income expectations and life expectancy improvements influence the asset allocation decision.

It is clear from this discussion that there is no consensus as yet on derisking both towards and during retirement. Below we investigate the safe withdrawal properties (PWRs) of two classes of portfolios: equity/bond and multiasset.

## **5. Portfolio diversification, PWRs and popular retirement strategies**

In this section we compare PWRs for different portfolio strategies in the UK. To anticipate our findings:

i) investors can secure a far better retirement experience with a multiasset investment portfolio, rather than sticking to only equities and bonds, but...

ii) the overlay of trend following on individual asset class returns is the key to a substantially enhanced withdrawal experience (over and above diversification); this leads to....

ii) the surprising finding that sticking to two assets (equities and bonds) but with a trend following overlay, is generally a pretty good outcome for those who cannot find multiasset solutions

#### **(a) Data**

In our related paper (Clare et al, 2017), we explore the issue of sequence risk using monthly US equity returns back to 1872, and show very clearly that the PWR/Safe Withdrawal Rate experience is very substantially enhanced by the simple application of a trend following filter facilitating switching between the S&P and Treasury Bills/cash when the trend enters a downturn.

Blanchett et al (2016) use the ABN Amro/CS/LBS international equity and bond data back to 1900, look at Safe Withdrawal Rates for portfolios composed of the two asset classes, and explore the so-called 4% Safe Withdrawal Rule for the 30 year decumulation period across 20 countries. But today's investing world is increasingly multi asset, with 'Balanced Growth' and similar solutions available. To accommodate multi asset possibilities the data used in this section of the paper runs from 1970 to 2015 inclusive with all observations being monthly sterling total returns. Note that Authers (August, 2016, FT) sees such diversification as part of the pensions 'solution' in the face of malfunctioning target date funds.

We use the first year of data for various calculations and so all results are reported from the beginning of 1971. Equity indices throughout are gross values from MSCI; gilts returns are from the FTSE Actuaries All Stocks Index from 1976 onwards and 20-year gilts prior to this date; commodities are given by the S&P GSCI index and UK Property uses the FTSE Property index for quoted real estate companies until 1990 and the FTSE EPRA UK REIT index thereafter. Where cash rates are referred to these are 3-month UK Treasury Bills. Throughout the paper all returns quoted are real and are relative to the UK Retail Price Index. All values are in British Pounds.

## **(b) Results**

Throughout this section we compare standard “buy-and-hold” investing with trend following whereby risk assets are only held if the particular index is an uptrend. Specifically we use the rule of Faber (2007) that if the index is trading above its 10-month moving average then a long position is taken, otherwise a position in cash is held instead. We explore alternative rules in Clare et al (2013) and offer an exhaustive analysis of similar multi asset models in Clare et al (2016).

Table 4 shows summary statistics for returns for the five asset classes both with and without the trend following overlay. We observe that for standard investments, equities have the highest returns whilst gilts and commodities have the lowest. Gilts have the lowest volatility by some distance with property and commodities both above 20%. The application of the trend following rule to each asset class lead to typically slightly higher returns and considerably lower volatility. This is consistent with the findings of Clare et al (2016). The real maximum drawdowns shown in Table 4 are particularly large, albeit somewhat lower for trend following. During the 1970s the United Kingdom experienced a severe bout of inflation with the general price level increasing at double-digit annual rates for much of the decade. Such an environment made it difficult at times to maintain the purchasing power of portfolios.

Table 5 reports the returns of three different portfolio strategies namely a conventional domestic 60-40 portfolio, i.e. 60% in UK equities and 40% in gilts, a more risk averse 30-70 portfolio of the same assets and finally an equally-weighted multi asset portfolio of the five instruments shown in Table 4. Each of the portfolios is rebalanced monthly. We note for the standard portfolios the multi asset earned around 4.6% on average annually, the 60-40 portfolio around 0.1% less and the 30-70 portfolio gained 3.7% pa. The latter also had the lowest annualized volatility at just above 10%. The application of trend following sees returns increase by between around 0.2% to 0.3% annually for the 60-40 and 30-70 portfolios and by nearly 0.8% for the multi-asset version. Volatility falls markedly, however, for these portfolios with all showing single digit values. Drawdowns also decreases by at least a half.

We alluded earlier to the unusual economic climate in the United Kingdom during the 1970s. Figure 3 displays the annual returns for the multi asset portfolio both with and without trend following. The years 1973 and 1974 saw large negative returns for the standard portfolio with a big turnaround in 1975. The trend following version sees much smaller losses in the first

two years but it also loses money in the subsequent year. We highlight this period because it represents one of the best examples of sequencing risk. An investor commencing decumulation at the start of 1973 experienced two extremely poor years by historical standards and this would have sharply reduced the value of their pension pot without the ability to replenish it. By contrast the period of the 1980s and 1990s was relatively benign and sequencing risk played a much smaller role.

To examine the characteristics of each of the portfolios in a retirement context we use the Perfect Withdrawal Rate (PWR). This is the percentage as a proportion of the initial portfolio value that can be withdrawn at a constant rates that leaves exactly zero money remaining in the investment account at the end of the decumulation period. This value can only be known with the benefit of hindsight but it provides a good measure for comparing investment strategies. In this paper we assume the decumulation period will be 20 years. One of the issues facing retirees is the uncertainty of longevity. This tail-risk can be insured through the purchase of a deferred annuity (or sometimes called longevity annuity). We assume that one of these is bought at the start of the retirement period and thus the aim is to decumulate the remaining investment pot to zero at the end of 20 years (also assuming no bequests), (see Chen et al, 2016). We therefore examine only the investment of this remaining pot of investable funds.

Figure 4 shows the PWRs for the 6 portfolios over the period of study based on the year that decumulation commenced. Withdrawal rates are low to begin with due to the poor sequence of returns in the early 1970s highlighted in Figure 3 and then spike higher. After the early 1980s, the PWRs of the portfolios remain in a fairly narrow band of 7% - 10%. The 60-40 portfolio has the highest PWR after the initial blip for much of the period until near the end when the multiasset trend following portfolio achieves higher rates. In general the trend following portfolios show less variation in PWR over time compared to their standard counterparts. At this point we should note that although the PWRs look very high in 1975, unless a retiree was extremely fortuitous, they would have been invested during the preceding years. Thus, whilst they can take a higher rate of withdrawal relative to pot size at the beginning of decumulation compared to someone retiring two years earlier, it seems highly likely that investment pots in absolute terms in 1975 would be much lower than 1973, i.e. a higher rate of a smaller pot or vice versa. The main advantage that a 1975 retiree could potentially have had would have been the option to perhaps defer retirement by a year or two to enable the investment account to recover.

To further assess the decumulation possibilities of the portfolios we next run Monte Carlo simulations. Random draws with replacement using the annual returns of each strategy are made to create new 20-year return strings from which the PWR is individually calculated. By using annual returns of the portfolios we maintain the integrity of the correlations between asset classes. For each portfolio we run 20,000 simulations. Figure 5 shows the PWR frequency for the six portfolios. The modes of the distributions are very similar in the 6.5% to 7.5% range but their shapes are quite different. Each of the standard portfolios has much larger tails than their trend following counterparts. Retirees are particularly concerned about the ‘bad’ outcomes in the left tail. Trend following substantially reduces the probability of these for only a small reduction in probability of the ‘good’ outcomes in the right tail. The smaller amount of dispersion in the trend following distributions also makes it easier to target sustainable withdrawal rates.

Table 6 shows a breakdown of the distributions by percentile and Figure 6 plots this as a cumulative frequency chart. Comparing the different strategies, we firstly observe that in the lowest percentiles the PWRs are higher for the multi asset portfolios relative to the 60-40 and 30-70 counterparts, presumably as a result of the greater diversification. Furthermore, the application of trend following reduces the probability of achieving a very low PWR. In the case of 30-70, every percentile has a higher PWR using trend following and for multi asset one has to go to the 90<sup>th</sup> percentile to find a higher withdrawal rate. The 60-40 portfolio is the only one that has a higher median value without trend following and is the combination that has the possibility, albeit small, of an exceptionally high PWR.

The takeaway from this analysis is thus that multi asset portfolios are preferable to domestic stock-bond portfolios and that trend following substantially reduces the probability of low withdrawal rates without much loss of unusually positive outcomes.

We next consider two alternative portfolios that typically reside at opposite ends of the risk spectrum. Risk parity is a method whereby, in its basic form, assets are weighted according to the inverse of their volatility. In this case we calculate the volatility of each of the five asset classes in Table 4 over the preceding year, take the reciprocal and then weight relatively based on this. Historically, this has led to higher weightings to bonds and smaller weights to equities, commodities, etc. Indeed over the period of study bonds accounts for approximately three-eighths of the total portfolio on average. This would generally be considered to be a less risky proposition than the equal weight multi asset portfolio described earlier. At the other

end of the spectrum we create a portfolio that is comprised 100% of equity. Specifically the portfolio has a 20% allocation to each of the UK, Europe ex-UK, North America, Japan and Pacific ex-Japan. This is well-diversified globally but is now concentrated to only stocks. We call this the ‘Regional Equity’ portfolio.

Table 7 reports the summary statistics for the two new portfolios both with and without trend following. The standard risk parity portfolio does indeed have a lower volatility than any of the comparable standard portfolios in Table 5 at just 9.6% but the return at 4.5% is only slightly lower than the 60-40 and equal weight multi asset portfolios. By contrast the regional equity portfolio has an annual return of nearly 5.9% and a volatility in excess of 15%. As before, we note that the application of trend following considerably reduces the volatility of the portfolios without any loss of return; in fact there is a small improvement in returns.

Once again we run 20,000 Monte Carlo simulations of each of the four new alternative portfolios and the PWR frequencies are plotted in Figure 7. The difference between the low and high volatility portfolios is readily apparent here, with the latter showing much greater dispersion in PWR as expected. Trend following once again reduces this, though, with Risk Parity TF showing a very substantial peak in the distribution at 7.5% and small tails.

Table 8 shows the PWR for various percentiles of the alternative portfolios and Figure 7 plots these as a cumulative frequency diagram. Once again we observe that trend following reduces the chance of a low PWR experience without losing too much of the potential upside. The probability of a PWR below 5% is small with both of the TF portfolios (5% is the PWR for a portfolio that earns a constant 0% real return of the entire decumulation period). In Figure 8 we observe that the ‘crossover’ between standard and trend following occurs with a cumulative frequency of around 60%, i.e. approximately 60% of the time the trend following portfolio achieved a higher PWR than its standard equivalent, and, most importantly, this was at lower levels of PWR.

In order to achieve the highest PWRs one has to take additional risk and the regional equity portfolio provides this. Figure 8 shows that the crossover between the two standard portfolios occurs at around the 30<sup>th</sup> percentile but it is much lower for the trend following varieties at around the 14<sup>th</sup> percentile. Trend following thus gives greater scope for holding more risky assets. This is clearly directly relevant to the de-risking/glidepath discussion: yes you should remain in risky assets but to take full advantage of the potential higher returns one should smooth returns. Our evidence for the period to 2015 is, therefore, that PWRs significantly

higher than 4% can be achieved at significantly reduced drawdown and sequence risk through smoothing.

## **6. What about Put Protection as an Alternative Strategy?**

Using trend following to provide drawdown protection offers a simple alternative to the obvious competing strategy of buying derivatives to achieve the same end. As AQR emphasise, “Unfortunately, in the typical use case, put options are quite ineffective at reducing drawdowns versus the simple alternative of statically reducing exposure to the underlying asset.” (p 1, Israelov, 2017).

Basically in the case of equities, unless the options’ purchases and their maturities are timed precisely right around equity drawdowns of uncertain length, then they may result in little downside protection, and even make things worse by increasing rather than decreasing drawdowns and volatility per unit of expected return.

A popular strategy in the US equity market is to buy protective puts combined with the S&P500 equity portfolio<sup>4</sup>. Is this an effective tail hedge? Israelov (2017) shows that portfolios which are protected with put options have worse peak-to-trough drawdown characteristics per unit of expected return than portfolios that have instead simply statically reduced their equity exposure in order to reduce risk.

So changing portfolio allocation between the risky asset and cash (so-called ‘divestment’) will give a better result than buying put protection, unless the drawdown coincides with the option expiry cycle. In fact the paper suggests that investing 40% in equity and 60% in cash has given similar returns as the protected puts strategy but with under half the volatility and much improved peak-to -trough drawdown experience.

In this case, the author chooses the CBOE S&P500 5% Put Protection index among the many possibilities for protective overlay. In general, the quality of protection improves when the option maturity is most closely aligned with the length of the peak-to-trough drawdown cycle. Quite simply, monthly options do a less bad job at protecting against drawdowns that

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<sup>4</sup> An earlier proposal based on a collar of puts and calls targeted at increasing fund longevity is presented by Milevsky and Posner (2014). They demonstrate an extension of the life of a fund in retirement, especially at high withdrawal rates but don’t compare the performance of the collar with alternatives such as trend following.

last about a month than those that last about a year. But, of course, who can tell how long future drawdowns will last?

As Israelov (2017) states: “For those who are concerned about their equity’s downside risk, reducing their equity position is significantly more effective than buying protection. Sized to achieve the same average return, divesting has lower drawdowns, lower volatility, lower equity beta, and a higher Sharpe ratio than does buying put options.”

This approach also echoes the views of Ilmanen (2016). He refers to index put buying as protection for equity portfolios as (looking at historical data) “roughly a minus one Sharpe strategy”. Of course very fast bear markets and crashes can be protected against by using puts, but this is so expensive relative to the slow crash alternative (moving into cash) which is so successful in the long run: “Trend-following has a clear positive Sharpe ratio, and it has done well in most of the historical bear markets over the past hundred years”.

How about more sophisticated timing mechanisms for buying protection? Strub (2013) introduces an algorithm for tail risk hedging and compares it with using Extreme Value Theory (EVT) to estimate Conditional Value at Risk (CVaR), and applies it to the S&P 500 and MSCI Emerging Markets equity indexes between 2000 and 2012. Performance is compared to cash and options-based tail hedging strategies. The cash-based methods are shown to significantly increase risk-adjusted returns and reduce drawdowns, while the options-based strategy suffers a decrease in performance from 2003 onwards due to the increase in the cost of puts with respect to calls.

It would seem, then, that divesting (albeit temporarily) offers a much better solution to reducing drawdowns (ie, managing tail risk) than either buying puts systematically or trying to time their purchases using conditioning information as in Strub, though of course there are an infinity of such alternatives. Unless one knows when a ‘fast crash’ is about to occur and can time the option purchase cycle to good effect, then switching to cash via a trend following rule appears to be the best solution.

## **7. Conclusion**

In this paper we examine a variety of portfolios, both conventional domestic equity and bonds and multi asset, and look at them in the context of retirement decumulation. Using UK data we find that multi asset portfolios for the most part offer an improvement on 60-40 and

30-70 stock-bond investments with smaller probabilities of low safe withdrawal rates. The exception comes for those seeking the very highest PWRs where there is little choice but to accept a large equity component.

The application of a trend following filter to the assets within each portfolio substantially improves the performance by reducing volatility and maximum drawdown without any loss of return. A result of this is much less variable PWRs, particularly through eliminating many of the lowest PWRs, but without too much reduction in the chance of unusually high outcomes. Trend following enables portfolios to contain more risky assets, and the greater upside they offer, for the same level of overall risk and significantly less maximum drawdown and sequence risk compared to standard portfolios.

One might ask; if smoothing enhances the decumulation experience so effectively, why not simply use derivatives to achieve the same outcome? This choice is resoundingly rejected in a number of recent studies including Strub (2013) and Israelov (2017), and the comments of Illmanen (2016). Intuitively, options are expensive and if one used a market timing factor such as movements in the VIX then one would tend to buy protection just when everyone else wanted it - and hence it would be especially expensive.<sup>5</sup> On the other hand switching to cash as part of a trend following strategy, as proposed in this paper, is ‘cheap’ to buy and hold. This is the focus of the next stage of research.

## References

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Ameriks, J., Veres, R. and Warshawsky, M. J. (2001). Making retirement income last a lifetime, *Journal of Financial Planning*, 14(12), 60-76.

Arnott, R. (2012). The Glidepath Illusion. Research Affiliates.

Arnott, R., Sherrerd, K., and Wu, L. (2013). The Glidepath Illusion...and Potential Solutions, *The Journal of Retirement*, 1(2), 13-28.

Ayres, I., and Nalebuff, B. (2010). *Lifecycle Investing – A New, Safe and Audacious Way to Improve the Performance of Your Retirement Portfolio*. New York: Basic Books.

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<sup>5</sup> Chris Dillow, FT Money, p10, 22/4/2017

- Basu, A., and Drew, M. (2009), Portfolio Size Effect in Retirement Accounts: What Does it Imply for Lifecycle Asset Allocation Funds?, *Journal of Portfolio Management*, 35, 61-72.
- Basu, A., Byrne, A., and Drew, M. (2011), Dynamic Lifecycle Strategies for Target Date Retirement Funds, *Journal of Portfolio Management*, Winter, 83-96.
- Bengen, W. P. (1994), Determining Withdrawal Rates Using Historical Data, *Journal of Financial Planning*, 7(1), 171-180.
- Blanchett, D. (2007), Dynamic Allocation Strategies for Distribution Portfolios: Determining the Optimal Distribution Glide Path, *Journal of Financial Planning* 20, 12 (December): 68-81.
- Blanchett, D., Buffenoir, M., Kemp, D. and Watt, S. (2016). Safe Withdrawal Rates for Retirees in the United Kingdom, Morningstar Research.
- Blanchett, D., Kowara, M., and Chen, P. (2012). Optimal Withdrawal Strategy for Retirement Income Portfolios, *The Retirement Management Journal*, 2, 7-20.
- Blanchett D., Finke, M., and Pfau, W.D. (2015). Optimal Portfolios for the Long-Run, mimeo.
- Capone, R. and Akant, A. (2016). Trend Following Strategies in Target-Date Funds, AQR Capital Management Working Paper.
- Charlson, J., and Lutton, L. (2012). Target-Date Series Research Paper: 2012 Industry Survey, *Morningstar Fund Research*, May, 1-58.
- Chen, A., Haberman, S. and S. Thomas, (2016) Why Deferred Annuities Make Sense, SSRN Working Paper, 2797795.
- Chiappinelli, P., and Thirukkonda, R. (2015). Who Ate Joe's Retirement Money? GMO White Paper
- Clare, A., J. Seaton, P.N. Smith and S.H. Thomas, (2013). Breaking in to the Blackbox: Trend Following, Stop Losses and the Frequency of Trading – The Case of the S&P500, *Journal of Asset Management*, Vol. 14, 182-194.
- Clare, A., Seaton, J., Smith, P.N., and Thomas S., (2016). The Trend is Our Friend: Risk Parity, Momentum and Trend Following in Global Asset Allocation, *Journal of Behavioral and Experimental Finance*. 9, 63-80.
- Clare, A., Seaton, J., Smith, P.N., and Thomas S., (2017). Reducing sequence risk using trend following investment strategies and the CAPE, *Financial Analysts Journal*, (forthcoming).
- Crook, M. (2013). How Did the Financial Crisis Impact Retirees' Safe Withdrawal Rate? A Markets- Based Answer, *Journal of Investing*, 22, 1, 41- 48.
- Cooley, P., Hubbard, C., and Walz D., (2011). Portfolio Success Rates: Where to Draw the Line, *Journal of Financial Planning*, 24, 48-60.
- Drew, M., and Walk, A. (2014). *How Safe are Safe Withdrawal Rates in Retirement? An Australian Perspective*, Finsia, Sydney.
- Dus, I., Maurer, R., and Mitchell, O. (2005). Betting on Death and Capital Markets in Retirement: A Shortfall Risk Analysis of Life Annuities Versus Phased Withdrawal Plans, *Financial Services Review*, 14, 169- 196.

- Ezra, D., Collie, B., and Smith M., (2009). *The Retirement Plan Solution: The Reinvention of Defined Contribution*. John Wiley & Sons.
- Estrada, J. (2014). The Glidepath Illusion: An International Perspective, *Journal of Portfolio Management*, Summer, 52-64.
- Estrada, Javier (2016a). “The Retirement Glidepath: An International Perspective.” *Journal of Investing*, 25, 2, 28-54.
- Estrada, J. (2016b). Global Asset Allocation in Retirement: Buffett’s Advice and a Simple Twist, *Journal of Retirement*, 4(2), 54- 69.
- Estrada, J. (2017). Refining the Failure Rate, *Journal of Retirement*, 4(3), 63- 76.
- Estrada, J. (2017a). Maximum Withdrawal Rates: An Empirical and Global Perspective, SSRN 2914078.
- Ezra, D., Collie, B., and Smith M., (2009). *The Retirement Plan Solution: The Reinvention of Defined Contribution*. John Wiley & Sons.
- Faber, M., (2007). A Quantitative Approach to Tactical Asset Allocation, *Journal of Wealth Management*, 16, 69-79.
- Frank, L.R., Mitchell, J.B. and Blanchett, D.M., (2011). Probability-of-Failure-Based Decision Rules to Manage Sequence Risk in Retirement, *Journal of Financial Planning*, 24, 46-55.
- Guyton, J. (2004). Decision Rules and Portfolio Management for Retirees: Is the ‘Safe’ Initial Withdrawal Rate Too Safe? *Journal of Financial Planning*, 17(10), 50-58.
- Guyton, J., and Klinger, W., (2006). Decision Rules and Maximum Initial Withdrawal Rates, *Journal of Financial Planning*, 19(3), 49-57.
- Ilmanen, A. (2016). Smart Investing in an Environment of Low Expected Returns, *Journal of Investment Consulting*, 17(2), 4-12.
- Israelov, R., (2017). The Elusive Benefits of Protective Puts, AQR Capital Management Working Paper.
- Milevsky, M. 2001. Spending Your Retirement in Monte Carlo, *Journal of Retirement Planning*, January/February, 21-29.
- Merton, R.C., (2014). The Crisis in Retirement Planning, *Harvard Business Review*, July-August.
- Milevsky, M.A. and Posner, S.E., (2014), Can Collars Reduce Retirement Sequencing Risk? *The Journal of Retirement*, Spring, 46-56.
- OECD, (2016). Pensions Outlook, Paris.
- Okusanya, A., (2015). Pound Cost Ravaging, Aviva for Advisers Paper.
- Pfau, W. (2010). An International Perspective on Safe Withdrawal Rates: The Demise of the 4% Rule?, *Journal of Financial Planning*, 23, 12, 52- 61.
- Pfau, W. (2011). Can We Predict the Sustainable Withdrawal Rate for New Retirees?, *Journal of Financial Planning*, 24, 8, 40- 47.

- Pfau, W.D., (2014). New Research on How to Choose Portfolio Return Assumptions, *Advisor Perspectives*, 8, 1-7.
- Pye, G.B., (2000). Sustainable Investment Withdrawals, *Journal of Portfolio Management*, 26, 73-83.
- Shiller, R., (2001). *Irrational Exuberance*. Princeton University Press.
- Sharpe, W., Scott, J., and Watson J. (2007). *Efficient Retirement Financial Strategies*, Stanford University paper.
- Spitzer, J., Strieter, J., and Singh, S. (2008). Adaptive Withdrawals, *Journal of Investing*, 17, 104-113.
- Stout, R.G. (2008). Stochastic Optimization of Retirement Portfolios Asset Allocations and Withdrawals, *Financial Services Review*, 17, 1-15.
- Stout, R.G., and Mitchell J.B., (2006). Dynamic Retirement Withdrawal Planning, *Financial Services Review*, 15, 117-131.
- Strub, I.S., (2013), Tail Hedging Strategies, The Cambridge Strategy (Asset Management) Ltd, mimeo.
- Suarez, E.D., Suarez, A. and Walz D.T., (2015), The Perfect Withdrawal Amount: A Methodology for Creating Retirement Account Distribution Strategies, Trinity University Working Paper.
- Zolt, D.M., (2013). Achieving a Higher Safe Withdrawal Rate with Target Percentage Adjustment, *Journal of Financial Planning*, 26, 51-59.

**Table 1**

Summary statistics for S&P500:

1872-2014	Raw	Trend-Adjusted(Smoothed)
Annualized Real Return (%)	6.82	8.84
Annualized Real Volatility (%)	14.29	9.86
Maximum Real Drawdown (%)	76.8	β4.88

**Table 2**

### Example of Sequence Risk

In this table we show the impact on Sequence risk ( $1/S_n$ ) and the Perfect Withdrawal Rate (PWR) of three series of returns which have the same arithmetic mean (Mean), standard deviation (St. Dev.) and maximum drawdown (Max Draw).

Year	Return set 1	Return set 2	Return set 3
1	20%	-20%	0%
2	10%	-10%	10%
3	0%	0%	-10%
4	-10%	10%	-20%
5	-20%	20%	20%
Mean	0.00%	0.00%	0.00%
St. Dev.	15.8%	15.8%	15.8%
Max Draw	-20.0%	-20.0%	-20.0%
$1/S_n$	3.98	5.98	4.92
PWR	23.87%	15.90%	19.30%

**Table 3**

Distribution of 50-50 Portfolio PWRs from 20,000 Monte Carlo Simulations				
Percentile	PWR Time Frame (Years)			
	20		30	
	50-50	50-50TF	50-50	50-50TF
1	2.30	4.46	1.49	3.25
5	3.48	5.16	2.45	3.89
10	4.23	5.60	3.05	4.27
25	5.67	6.37	4.25	4.97
50	7.31	7.33	5.73	5.86
75	8.91	8.39	7.37	6.87
90	10.53	9.46	8.90	7.87
95	11.57	10.12	9.91	8.50
99	13.74	11.40	11.87	9.77

**Table 4**

<b>Asset Class Summary Statistics: 1971-2015</b>					
	UK Equity	Global Equity	Gilts	Commodities	Property
<i>Standard</i>					
Annualized Real Return (%)	5.08	4.67	2.60	1.82	3.39
Annualized Real Volatility (%)	19.05	15.21	10.12	20.75	25.40
Maximum Real Drawdown (%)	73.85	51.72	59.43	77.03	80.55
<i>Trend Following</i>					
Annualized Real Return (%)	5.69	5.57	2.85	3.55	5.79
Annualized Real Volatility (%)	13.98	11.89	8.75	17.34	17.77
Maximum Real Drawdown (%)	29.10	44.01	42.87	56.82	70.81

**Table 5**

<b>Portfolio Summary Statistics: 1971-2015</b>			
	60% UK Equity - 40% Gilts	30% UK Equity - 70% Gilts	Equal Weight Multi Asset
<i>Standard</i>			
Annualized Real Return (%)	4.54	3.73	4.62
Annualized Real Volatility (%)	13.04	10.12	11.78
Maximum Real Drawdown (%)	67.21	62.66	45.17
<i>Trend Following</i>			
Annualized Real Return (%)	4.86	3.96	5.38
Annualized Real Volatility (%)	9.45	7.81	8.62
Maximum Real Drawdown (%)	25.18	29.19	21.20

**Table 6**

<b>Distribution of Portfolio PWRs from 20,000 Monte Carlo Simulations</b>						
Percentile	60-40	30-70	Multi	60-40 TF	30-70 TF	Multi TF
1	2.18	2.67	4.46	4.41	3.09	5.21
5	3.39	3.73	5.20	5.04	4.15	5.84
10	4.15	4.38	5.66	5.42	4.82	6.22
25	5.68	5.59	6.46	6.13	6.00	6.93
50	7.44	7.01	7.49	7.01	7.45	7.80
75	9.23	8.41	8.64	7.97	8.95	8.77
90	10.94	9.76	9.78	8.96	10.37	9.73
95	12.05	10.55	10.53	9.59	11.22	10.32
99	14.61	12.33	11.91	10.87	12.76	11.48

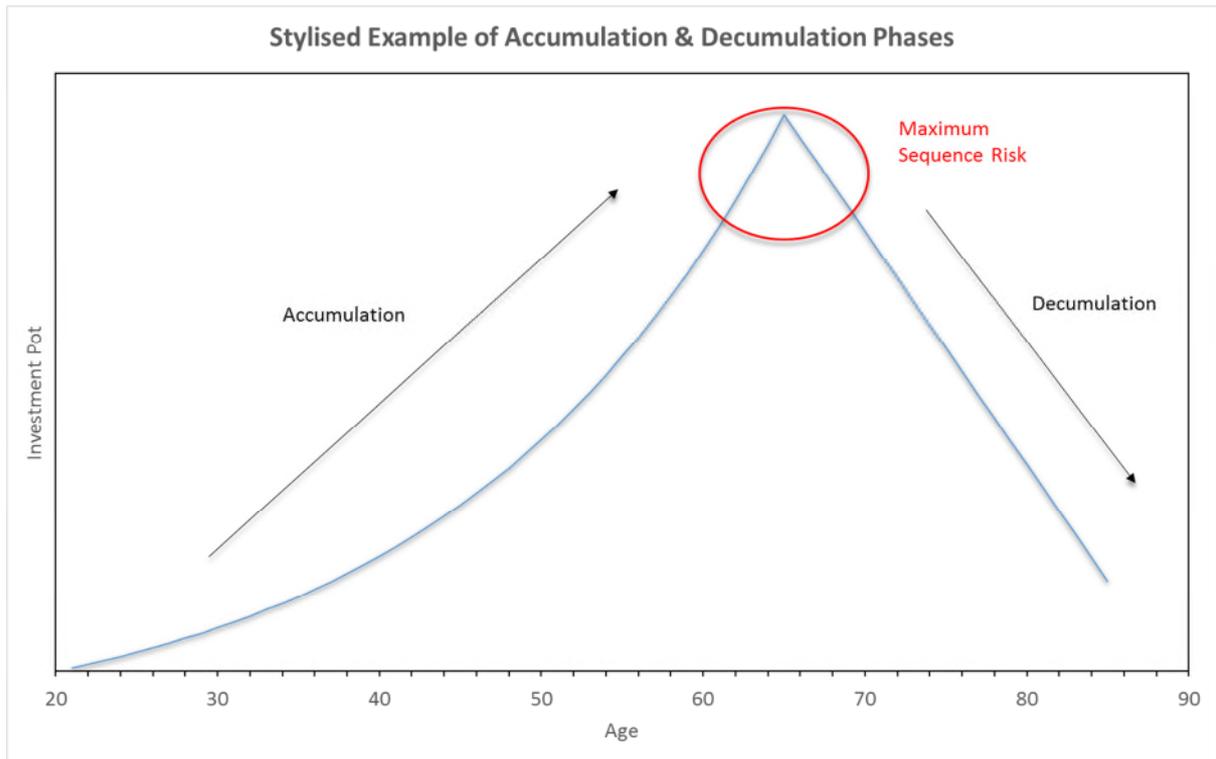
**Table 7**

<b>Alternative Portfolio Summary Statistics: 1971-2015</b>		
	Multi Asset Risk Parity	Regional Equity
<i>Standard</i>		
Annualized Real Return (%)	4.46	5.86
Annualized Real Volatility (%)	9.64	15.32
Maximum Real Drawdown (%)	48.26	55.42
<i>Trend Following</i>		
Annualized Real Return (%)	4.93	6.41
Annualized Real Volatility (%)	7.22	10.86
Maximum Real Drawdown (%)	21.59	26.96

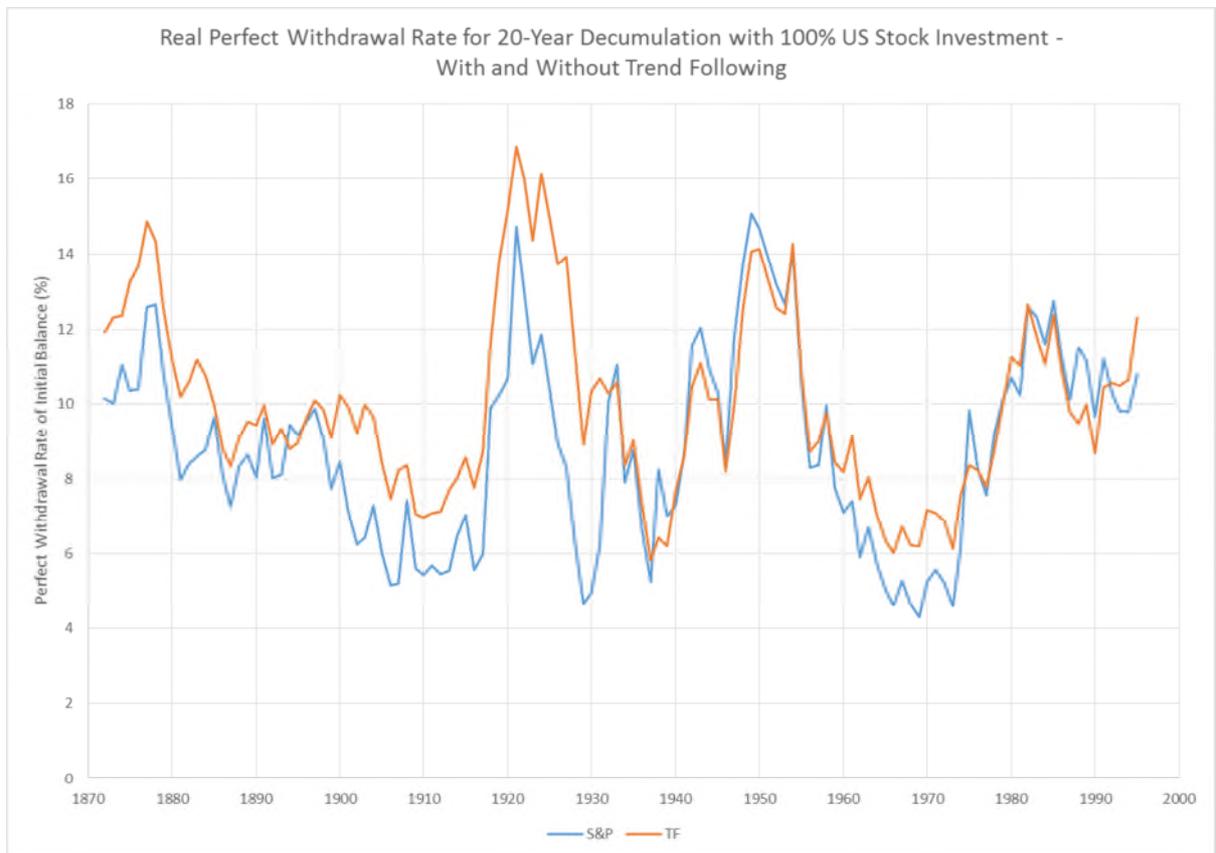
**Table 8**

<b>Distribution of Alternative Portfolio PWRs from 20,000 Monte Carlo Simulations</b>				
Percentile	Risk Parity	Regional Equity	Risk Parity TF	Regional Equity TF
1	3.23	2.49	5.19	4.50
5	4.29	3.65	5.80	5.39
10	4.95	4.43	6.15	5.96
25	6.11	5.96	6.79	6.97
50	7.39	8.02	7.55	8.31
75	8.67	10.38	8.40	9.82
90	9.83	12.67	9.20	11.39
95	10.51	14.05	9.70	12.41
99	12.04	16.53	10.73	14.34

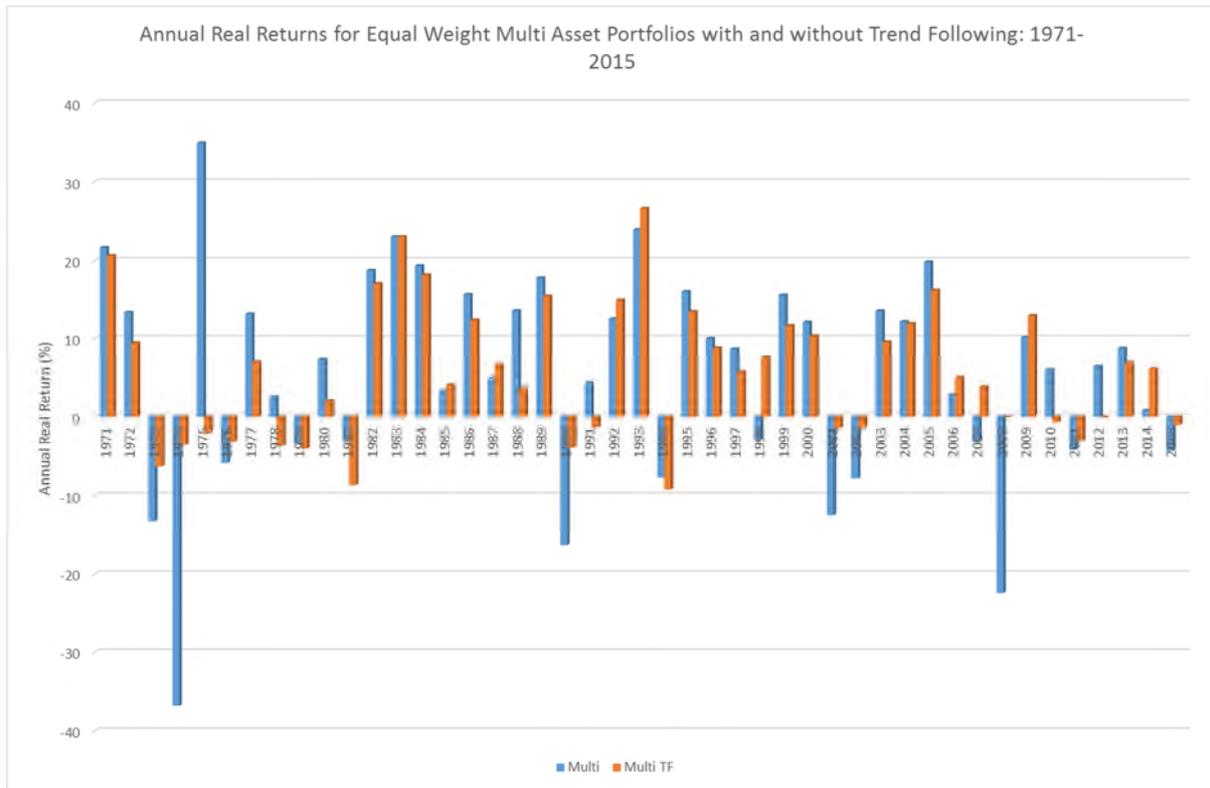
**Figure 1**



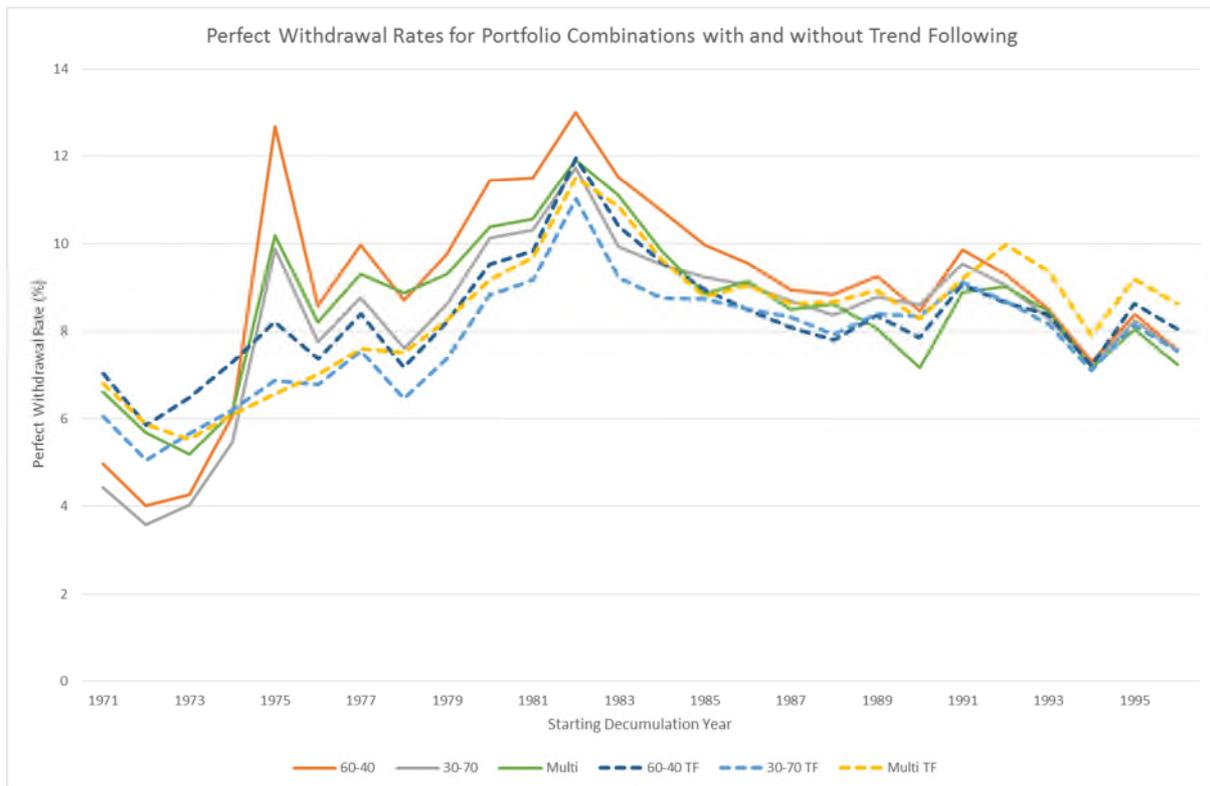
**Figure 2**



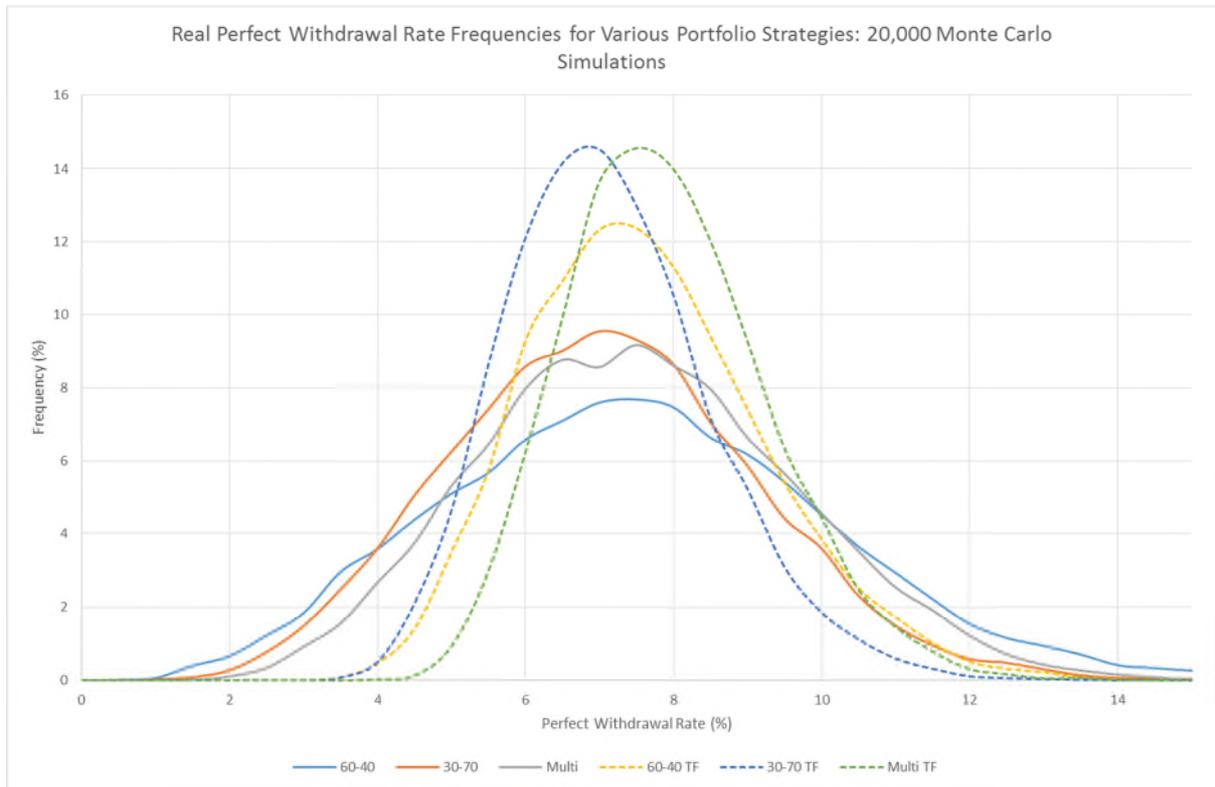
**Figure 3**



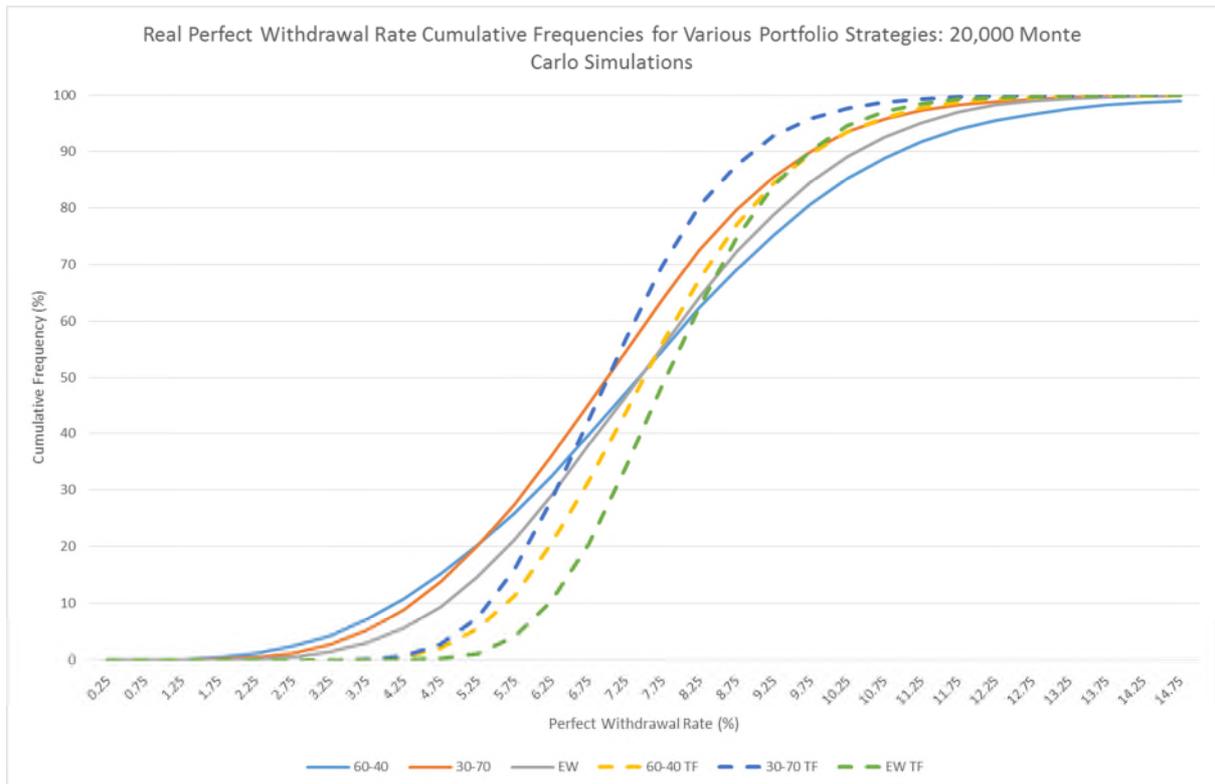
**Figure 4**



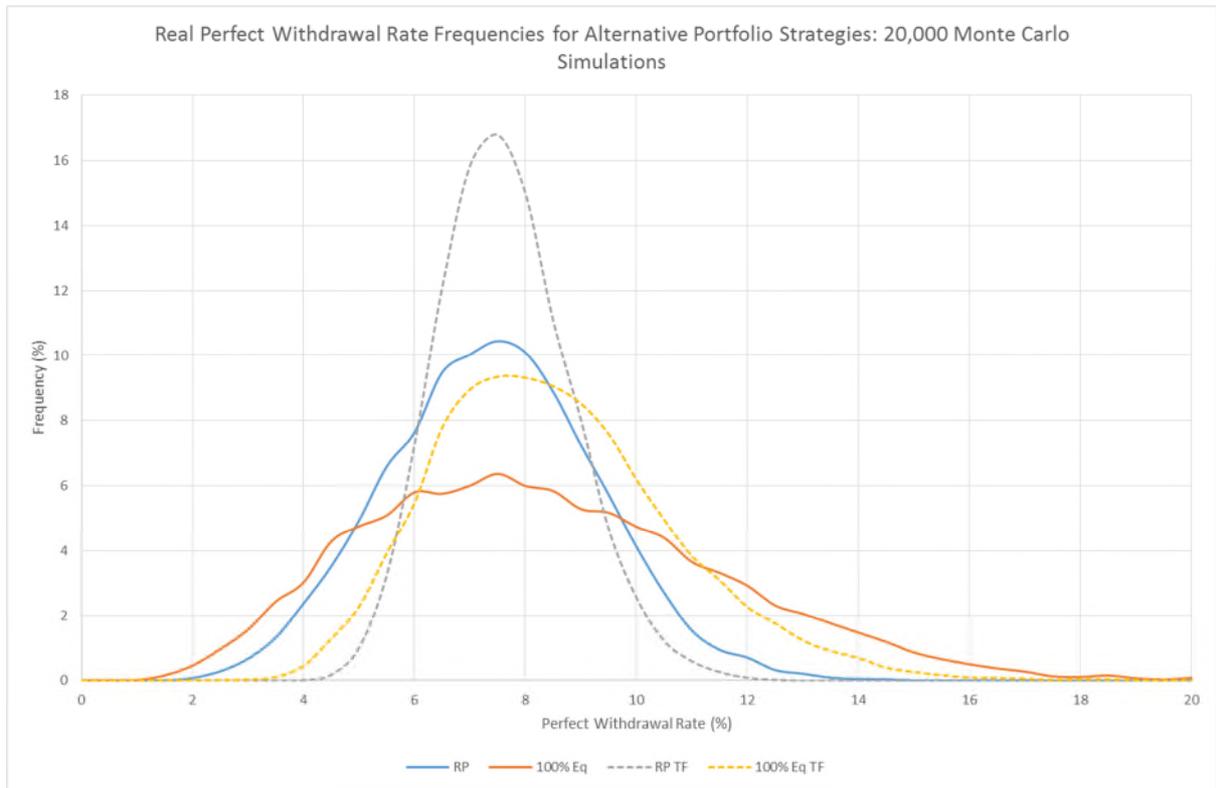
**Figure 5**



**Figure 6**



**Figure 7**



**Figure 8**

