Sequencing Risk and Asset Allocation

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Presented to the Actuaries Institute
2026 All-Actuaries Summit
25-27 May 2026

Abstract

DRIVING A CAR DOWNHILL REQUIRES DIFFERENT SKILLS FROM THOSE REQIRED TO DRIVE THE CAR UPHILL.

Similarly, to secure optimum superannuation member benefits in the decumulation stage, different asset allocation strategies are required from those which apply in the accumulation stage. WHY? *This is primarily due to sequencing risk.*

Many authors have attempted to define sequencing risk. The definitions are usually reasonably consistent with the definition in this paper. Some have illustrated it with simplified examples, but few, if any, have quantified it and then measured it based on historical data.

This research compares the sequencing risk faced by a retiree or an annuitant invested in a balanced portfolio, with that resulting from investing in:

- Australian shares,
- international shares or
- a combination of Australian shares and cash.

Comparisons are also included for Australian direct and listed property, semi-government bonds and inflation-linked government bonds. In the final section results are presented for 'real' sequencing risk allowing for price inflation.

The comparisons use both the *Austmod* historical data and simulated scenarios. The comparisons reveal that Australian shares combined with cash, offers better sequencing risk protection than traditional balanced portfolios.

This paper and presentation are an update and extension of an *Actuaries Digital* article with the same title which was published 30 April 2025:
 https://www.actuaries.asn.au/research-analysis/sequencing-risk-and-asset-allocation

Subsequently, that article was published on *LinkedIn* and since then it has experienced sustained and continuing interest from professional readers.

Keywords: sequencing risk, asset allocation, cumulative decline, negative auto-correlation.

What is sequencing risk?

Sequencing risk is the risk that your accumulated superannuation savings receive a sequence of the worst returns at the worst possible time - the years around your retirement and, in particular, the years just after retirement when account balances are highest and cash flow is usually negative.

Investment returns can vary widely from year-to-year and the timing of this volatility can make a big difference to how much you get to enjoy your retirement.

Many financial planners and retirement income experts and commentators suggest that an optimum retirement strategy should be based on a combination of:

> (a) an account-based pension; and
> (b) a lifetime investment linked insured annuity; or
> (c) a lifetime "group self annuity" (GSA); or
> (d) a guaranteed lifetime or term annuity; and if applicable
> (e) the means-tested Government provided Age Pension.

However, a concern for many is that (a), (b) and (c) are subject to sequencing risk. Also, the cost of sequencing risk is built into the price of (d). Fortunately, the Age Pension provides some offset for part pensioners. The question we will now examine is, how do these sequencing risks vary by asset allocation?

Underlying data used

Tables below use the *Austmod* historical investment performance data described in Sections 3 and 4 of *Australian Investment Performance 1959 to 2022 (and Investment Assumptions for Stochastic Models)* presented to the 2023 International Congress of Actuaries (ICA) in Sydney.

This data is similar to the APRA Heatmap benchmarks but extends back to 30 June 1959 at quarterly intervals. Table 1 (and Tables 6 to 8 in part) is based on a typical balanced portfolio with 70% growth assets (including 29% in international shares). All results are before investment tax, after approximate imputation credits (for the full period) and after investment fees, and therefore should be reasonably realistic for pension and annuity products.

What is "cumulative decline"?

With investment performance, "cumulative decline" is the percentage fall in the relevant unit price over a given period. It's similar to the health "cumulative decline" which is what many, myself included, experience when they turn age 80.

In the tables below:

- the "number of occurrences" is the number of times the unit price has fallen over one or more integral years
- the "average cumulative decline" is the average percentage fall in unit prices for all those occurrences.

Since falls result from negative investment returns the "average cumulative decline" is recorded with a negative sign. Note that if unit prices fall between any two dates, then the compound average annual return between those two dates will always be negative.

For example, in Table 1 there is one occurrence when balanced portfolio investment returns during the 66 years ending 30 September 2025 suffered a cumulative decline over six years. This was between 30 September 1968 and 30 September 1974 when the unit price fell 10.5% from 16.129 at the start of the six-year period to 14.433 at the end. During this 6-year period the compound average annual return was -1.83%.

Sequencing Risk and Asset Allocation

The calculations underlying all Tables do not allow for cash flow (and also the variability of unit prices during quarters may slightly increase the number of occurrences) but nevertheless the number and average of cumulative declines are realistic and reasonable indicators of *relative* sequencing risk outcomes for comparisons over different periods or with different asset allocations.

The following analysis illustrates how "average cumulative declines" and "number of occurrences" are determined for three hypothetical scenarios of 6-year unit prices:

**The following 3 hypothetical scenarios all have a
4 year cumulative decline of 10.00% even though
some intervening year returns are not negative.**

Scenario 1					
Year	Start year Unit Price	One year Decline	Two year Cumulative Decline	Three year Cumulative Decline	Four year Cumulative Decline
1	1.0000				
2	0.9750	-2.50%			
3	0.9500	-2.56%	-5.00%		
4	0.9250	-2.63%	-5.13%	-7.50%	
5	0.9000	-2.70%	-5.26%	-7.69%	-10.00%
6	1.0600	+ ve	+ ve	+ ve	+ ve
Average Cumulative Decline		-2.60%	-5.13%	-7.60%	-10.00%
Number of Occurrences		4	3	2	1

Scenario 2					
Year	Start year Unit Price	One year Decline	Two year Cumulative Decline	Three year Cumulative Decline	Four year Cumulative Decline
1	1.0000				
2	0.9750	-2.50%			
3	1.0500	+ ve	+ ve		
4	0.9250	-11.90%	-5.13%	-7.50%	
5	0.9000	-2.70%	-14.29%	-7.69%	-10.00%
6	1.0600	+ ve	+ ve	+ ve	+ ve
Average Cumulative Decline		-5.70%	-9.71%	-7.60%	-10.00%
Number of Occurrences		3	2	2	1

Scenario 3					
Year	Start year Unit Price	One year Decline	Two year Cumulative Decline	Three year Cumulative Decline	Four year Cumulative Decline
1	1.0000				
2	0.9750	-2.50%			
3	1.0500	+ ve	+ ve		
4	1.0502	+ ve	+ ve	+ ve	
5	0.9000	-14.30%	-14.29%	-7.69%	-10.00%
6	1.0600	+ ve	+ ve	+ ve	+ ve
Average Cumulative Decline		-8.40%	-14.29%	-7.69%	-10.00%
Number of Occurrences		2	1	1	1

Table 1: Balanced portfolio

TABLE 1

Mixture Balanced *Austmod*				Mixture Balanced *Austmod*				Mixture Balanced *Austmod*				Mixture Balanced *Austmod*		
65 Yrs ending 31/03/2025				**66 Yrs ending 30/06/2025**				**66 Yrs ending 30/09/2025**				**66 Yrs ending 31/12/2025**		
Cumulative Years of Decline	Number of Occurrences	Average Cumulative Decline		Cumulative Years of Decline	Number of Occurrences	Average Cumulative Decline		Cumulative Years of Decline	Number of Occurrences	Average Cumulative Decline		Cumulative Years of Decline	Number of Occurrences	Average Cumulative Decline
1	10	-7.8%		1	11	-7.3%		1	15	-5.9%		1	11	-8.1%
2	5	-13.5%		2	7	-11.4%		2	5	-14.0%		2	7	-11.9%
3	6	-9.2%		3	5	-10.4%		3	5	-11.5%		3	6	-10.1%
4	3	-3.7%		4	2	-8.3%		4	3	-11.8%		4	3	-9.4%
5	1	-5.3%		5	1	-9.6%		5	3	-8.6%		5	3	-6.3%
6	0	...		6	0	...		6	1	-10.5%		6	1	-9.2%
7	0	...		7	0	...		7	1	-0.5%		7	0	...
8	0	...		8	0	...		8	0	...		8	0	...
9	0	...		9	0	...		9	0	...		9	0	...
10	0	...		10	0	...		10	0	...		10	0	...
11	0	...		11	0	...		11	0	...		11	0	...
12	0	...		12	0	...		12	0	...		12	0	...
13	0	...		13	0	...		13	0	...		13	0	...
14	0	...		14	0	...		14	0	...		14	0	...
15	0	...		15	0	...		15	0	...		15	0	...
16	0	...		16	0	...		16	0	...		16	0	...
17	0	...		17	0	...		17	0	...		17	0	...
18	0	...		18	0	...		18	0	...		18	0	...
19	0	...		19	0	...		19	0	...		19	0	...
20	0	...		20	0	...		20	0	...		20	0	...
Compound av. Return p.a.		*9.24%*		*Compound av. Return p.a.*		*9.34%*		*Compound av. Return p.a.*		*9.32%*		*Compound av. Return p.a.*		*9.26%*
Standard Deviation		11.0%		Standard Deviation		10.8%		Standard Deviation		12.3%		Standard Deviation		11.6%
Auto-correln. Lag 1 year		0.071		Auto-correln. Lag 1 year		0.170		Auto-correln. Lag 1 year		0.021		Auto-correln. Lag 1 year		-0.026
Auto-correln. Lag 2 years		-0.011		Auto-correln. Lag 2 years		-0.111		Auto-correln. Lag 2 years		-0.042		Auto-correln. Lag 2 years		-0.038

Table 1 considers periods ending 31 March, 30 June, 30 September and 31 December 2025.

In this table, there are an average of 11 occurrences (per 65 or 66 years) of declines occurring over three years or longer. These would be worrying sequences for retirees. Negative returns over only 1 or 2 years would be of less concern to retirees. They would usually hope to be able to quickly recover from these shorter-term poor results. Thus, the analyses in this paper focus on declines occurring over three years or longer. In effect this is like saying that you need a unit price fall over at least three years before a "sequence" of negative annual returns can become evident.

The highest average cumulative decline (of -14.0%) occurs over two years. Though not recorded in the table, the maximum cumulative decline (of -31.6%) also occurs over two years. In all tables, the maximum cumulative decline is usually approximately twice the average cumulative decline.

The average investment return over each of the four quarter-end periods is almost identical. The September quarter-end is notorious for high volatility and had the highest standard deviation (of 12.3%).

> *With a typical balanced portfolio, only once did a cumulative decline occur over seven years and this was just -0.5%. Cumulative declines never occurred over longer than seven years.*

Table 1 shows that average auto-correlations over one year are slightly positive (i.e. a good year is more likely to be followed by another good year). However, auto-correlations are negative over two-year periods (a high two-year return is more likely to be followed by a lower two years).

In the ten tables in this paper, auto-correlations have been shown for only one and two year lags to reduce the complexity of the tables. Nevertheless, the References to this paper show that the full impact of Australian share negative auto-correlations appears to be a feature for lags up to 5.5 years. For lags of six years and beyond the auto-correlations are often significantly positive.

Table 2: Australian Shares

TABLE 2

	Austn. Shares *Austmod* 65 Yrs ending 31/03/2025			Austn. Shares *Austmod* 66 Yrs ending 30/06/2025			Austn. Shares *Austmod* 66 Yrs ending 30/09/2025			Austn. Shares *Austmod* 66 Yrs ending 31/12/2025		
	Cumulative Years of Decline	Number of Occurrences	Average Cumulative Decline	Cumulative Years of Decline	Number of Occurrences	Average Cumulative Decline	Cumulative Years of Decline	Number of Occurrences	Average Cumulative Decline	Cumulative Years of Decline	Number of Occurrences	Average Cumulative Decline
	1	16	-9.4%	1	13	-9.5%	1	18	-10.1%	1	16	-11.1%
	2	8	-12.1%	2	10	-10.6%	2	11	-9.9%	2	10	-11.6%
	3	5	-8.1%	3	4	-11.2%	3	4	-15.4%	3	4	-11.4%
	4	0	...	4	1	-5.8%	4	2	-24.0%	4	3	-12.1%
	5	1	-1.1%	5	1	-11.3%	5	2	-16.2%	5	3	-6.4%
	6	0	...	6	0	...	6	1	-16.5%	6	1	-10.8%
	7	0	...	7	0	...	7	0	...	7	0	...
	8	0	...	8	0	...	8	0	...	8	0	...
	9	0	...	9	0	...	9	0	...	9	0	...
	10	0	...	10	0	...	10	0	...	10	0	...
	11	0	...	11	0	...	11	0	...	11	0	...
	12	0	...	12	0	...	12	0	...	12	0	...
	13	0	...	13	0	...	13	0	...	13	0	...
	14	0	...	14	0	...	14	0	...	14	0	...
	15	0	...	15	0	...	15	0	...	15	0	...
	16	0	...	16	0	...	16	0	...	16	0	...
	17	0	...	17	0	...	17	0	...	17	0	...
	18	0	...	18	0	...	18	0	...	18	0	...
	19	0	...	19	0	...	19	0	...	19	0	...
	20	0	...	20	0	...	20	0	...	20	0	...
	Compound av. Return p.a.		*11.77%*	*Compound av. Return p.a.*		*12.17%*	*Compound av. Return p.a.*		*12.02%*	*Compound av. Return p.a.*		*11.89%*
	Standard Deviation		18.6%	Standard Deviation		18.6%	Standard Deviation		22.0%	Standard Deviation		20.1%
	Auto-correln. Lag 1 year		-0.073	Auto-correln. Lag 1 year		0.055	Auto-correln. Lag 1 year		-0.188	Auto-correln. Lag 1 year		-0.207
	Auto-correln. Lag 2 years		-0.189	Auto-correln. Lag 2 years		-0.260	Auto-correln. Lag 2 years		-0.066	Auto-correln. Lag 2 years		-0.125

Table 2 considers the same periods as for Table 1.

In this table, there are an average of 8 occurrences (per 65 or 66 years) of declines occurring over three years or longer. These would be worrying sequences for retirees, but they are 3 fewer in number than for a balanced portfolio. The highest average cumulative decline (of -24.0%) occurs over four years. Though not recorded in the table, the maximum cumulative decline (of -44.5%) occurs over two years, as for the balanced portfolio.

Again, the average investment return over each of the four quarter-end periods is almost identical and the September quarter-end had the highest standard deviation (of 22.0%).

> *With 100% Australian shares only twice did a cumulative decline occur over six years and declines never occurred over longer than six years (shorter than the seven years for a balanced portfolio).*

These favourable results are mainly due to the negative auto-correlations for lags of both one and two years recorded in the last two lines of Table 2. Note that in Table 2, negative auto-correlations are evident for 7 of the 8 recorded auto-correlations.

The prevalence of negative auto-correlations for Australian shares over lags of up to 5.5 years was established in my various ICA Papers on Australian investment performance. The significance of this was explained and explored in the following three Actuaries Digital articles by Cary Helenius and myself [1]:

actuaries.digital/2024/01/16/negative-auto-correlations-with-share-investments/

actuaries.digital/2024/01/22/significance-of-negative-investment-auto-correlations/

actuaries.digital/2024/03/28/more-negative-investment-auto-correlations/

Table 3: Australian and international shares and fixed interest

TABLE 3

Austn. Shares *Austmod* 66 Yrs ending 31/12/2025			Hedged International Shares *Austmod* 66 Yrs ending 31/12/2025			Unhedged International Shares *Austmod* 66 Yrs ending 31/12/2025			Australian Fixed Interest *Austmod* 66 Yrs ending 31/12/2025		
Cumulative Years of Decline	Number of Occurrences	Average Cumulative Decline	Cumulative Years of Decline	Number of Occurrences	Average Cumulative Decline	Cumulative Years of Decline	Number of Occurrences	Average Cumulative Decline	Cumulative Years of Decline	Number of Occurrences	Average Cumulative Decline
1	16	-11.1%	1	17	-12.0%	1	18	-11.4%	1	9	-5.4%
2	10	-11.6%	2	9	-18.8%	2	10	-23.0%	2	6	-9.3%
3	4	-11.4%	3	7	-22.6%	3	11	-26.0%	3	5	-9.9%
4	3	-12.1%	4	10	-10.3%	4	12	-23.0%	4	6	-5.4%
5	3	-6.4%	5	5	-8.5%	5	12	-22.6%	5	4	-2.8%
6	1	-10.8%	6	1	-24.6%	6	11	-19.0%	6	2	-2.2%
7	0	...	7	1	-10.3%	7	9	-21.0%	7	0	...
8	0	...	8	1	-12.5%	8	9	-17.7%	8	0	...
9	0	...	9	1	-18.9%	9	7	-25.1%	9	0	...
10	0	...	10	0	...	10	6	-29.1%	10	0	...
11	0	...	11	0	...	11	5	-31.7%	11	0	...
12	0	...	12	0	...	12	5	-24.7%	12	0	...
13	0	...	13	0	...	13	4	-22.1%	13	0	...
14	0	...	14	0	...	14	3	-14.7%	14	0	...
15	0	...	15	0	...	15	1	-3.9%	15	0	...
16	0	...	16	0	...	16	0	...	16	0	...
17	0	...	17	0	...	17	0	...	17	0	...
18	0	...	18	0	...	18	0	...	18	0	...
19	0	...	19	0	...	19	0	...	19	0	...
20	0	...	20	0	...	20	0	...	20	0	...
Compound av. Return p.a.	11.89%		*Compound av. Return p.a.*	10.50%		*Compound av. Return p.a.*	8.74%		*Compound av. Return p.a.*	6.74%	
Standard Deviation	20.1%		Standard Deviation	17.5%		Standard Deviation	18.4%		Standard Deviation	8.2%	
Auto-correln. Lag 1 year	-0.207		Auto-correln. Lag 1 year	-0.054		Auto-correln. Lag 1 year	0.118		Auto-correln. Lag 1 year	0.262	
Auto-correln. Lag 2 years	-0.125		Auto-correln. Lag 2 years	-0.128		Auto-correln. Lag 2 years	-0.010		Auto-correln. Lag 2 years	0.086	

In this table, all results vary considerably between the four investment classes. As expected, the results for hedged international shares are closest to those for Australian shares. But it should be noted that even for hedged international shares, cumulative declines occur over up to nine years (compared with up to only six years for Australian shares).

Also, both the number of occurrences and the average cumulative declines for hedged international shares (with one exception for each) exceed those for Australian shares.

> *Retirees should take note that for unhedged international shares, cumulative declines occurred over up to 15 years. Also, because of long-term currency cycles, with only two exceptions, both the number of occurrences and the average cumulative declines for unhedged international shares significantly exceeded those for both hedged international shares and Australian shares.*

In Table 3, for Australian fixed interest, the average investment returns, standard deviations, and average cumulative declines are all significantly less than those for the three share asset classes. However, it is interesting to note that the number of occurrences of cumulative declines:

- are double those for Australian Shares at 4 and 6 years,
- exceed those for Australian Shares at 3 and 5 years, and
- extend to six years, equal to that for Australian shares (albeit at a much lower level).

Consistent with the three paragraphs immediately above, it should be noted that positive auto-correlations are evident for both unhedged international shares and Australian fixed interest.

In this table, the number of declines occurring over three years or longer is:

- 11 for Australian Shares (averaging -10.2% over 3 years or longer),
- 26 for hedged international shares (averaging -14.2% over 3 years or longer),
- 95 for unhedged intern'l shares (averaging -22.7% over 3 years or longer), and
- 17 for Australian Fixed Interest (averaging -5.7% over 3 years or longer).

Table 3a: Australian Property, Inflation-Linked Bonds and Govt. Semis. 0-3 yrs.

TABLE 3a

Australian Listed Property Trusts *Austmod* 66 Yrs ending 31/12/2025			Australian Direct Property *Austmod* 66 Yrs ending 31/12/2025			Inflation Linked Government Bonds *Austmod* 66 Yrs ending 31/12/2025			Australian Govt. Semis 0-3 yrs *Austmod* 66 Yrs ending 31/12/2025		
Cumulative Years of Decline	Number of Occurrences	Average Cumulative Decline	Cumulative Years of Decline	Number of Occurrences	Average Cumulative Decline	Cumulative Years of Decline	Number of Occurrences	Average Cumulative Decline	Cumulative Years of Decline	Number of Occurrences	Average Cumulative Decline
1	13	-9.9%	1	8	-7.8%	1	7	-4.9%	1	3	-2.1%
2	7	-20.6%	2	8	-10.1%	2	4	-4.2%	2	1	-2.8%
3	6	-28.4%	3	7	-11.6%	3	3	-2.9%	3	1	-1.0%
4	5	-37.7%	4	4	-13.6%	4	2	-1.6%	4	0	...
5	5	-36.7%	5	3	-15.6%	5	1	-0.2%	5	0	...
6	6	-28.2%	6	3	-9.0%	6	0	...	6	0	...
7	7	-17.3%	7	2	-4.3%	7	0	...	7	0	...
8	6	-11.0%	8	0	...	8	0	...	8	0	...
9	3	-6.7%	9	0	...	9	0	...	9	0	...
10	0	...	10	0	...	10	0	...	10	0	...
11	0	...	11	0	...	11	0	...	11	0	...
12	0	...	12	0	...	12	0	...	12	0	...
13	0	...	13	0	...	13	0	...	13	0	...
14	0	...	14	0	...	14	0	...	14	0	...
15	0	...	15	0	...	15	0	...	15	0	...
16	0	...	16	0	...	16	0	...	16	0	...
17	0	...	17	0	...	17	0	...	17	0	...
18	0	...	18	0	...	18	0	...	18	0	...
19	0	...	19	0	...	19	0	...	19	0	...
20	0	...	20	0	...	20	0	...	20	0	...
Compound av. Return p.a.		9.15%	*Compound av. Return p.a.*		7.76%	*Compound av. Return p.a.*		7.78%	*Compound av. Return p.a.*		7.45%
Standard Deviation		15.1%	Standard Deviation		7.8%	Standard Deviation		7.9%	Standard Deviation		5.7%
Auto-correln. Lag 1 year		-0.019	Auto-correln. Lag 1 year		0.613	Auto-correln. Lag 1 year		0.207	Auto-correln. Lag 1 year		0.682
Auto-correln. Lag 2 years		0.009	Auto-correln. Lag 2 years		0.198	Auto-correln. Lag 2 years		0.056	Auto-correln. Lag 2 years		0.571

In this table, the number of declines occurring over three years or longer is:

- 38 for Australian Listed Property   (averaging -24.2% over 3 years or longer),
- 19 for Australian Direct Property   (averaging -11.5% over 3 years or longer),
- 6 for Inflation-Linked Govt. Bonds (averaging -2.0% over 3 years or longer), and
- 1 for Austn. Govt. Semis 0 - 3 yrs. (equal to -1.0% over 3 years).

Thus, from a sequence risk viewpoint, Australian Government Semis 0 - 3 years fare very well and their 66-year compound annual return (7.45%) is just over 0.5% p.a. greater than that for Cash (6.87%). However projected future margins are even higher, and more relevant. Based on my ICA 2023 paper a margin of 1.1% p.a. is suggested. The before tax and fees projected medium/long term compound average annual returns in that paper are:

Australian Shares	9.3%	Inflation-Linked Government	6.3%
Australian Listed Property	8.2%	Australian Government Semis	5.6%
Australian Direct Property	7.0%	Cash	4.5%
AWOTE	3.47%	CPI	2.48%

The number of declines occurring over three years or longer for the two Property investment classes are both far higher than the 11 declines for Australian Shares in Table 3 above. Also, it should be noted that for the two Property investment classes, cumulative declines occur over up to nine or seven years (compared with up to only six years for Australian shares).

The average negative declines occurring over three years or longer for the Listed Property Trusts (-24.2%) are over twice those for Australian Shares (-10.2%) in Table 3 above. The average negative declines occurring over three years or longer for Australian Direct Property (-11.5%) are slightly worse than those for Australian Shares (-10.2%%) and their 66-year compound return p.a. (7.76%) is over 4% p.a. less than that for Australian Shares (11.89%).

Table 4: Australian "All Ords Accumulation" over 126 years

TABLE 4

	Austn. Shares *AllOrds Accum* 66 Yrs ending 31/12/1965			Austn. Shares *AllOrds Accum* 66 Yrs ending 31/12/1985			Austn. Shares *AllOrds Accum* 66 Yrs ending 31/12/2005			Austn. Shares *AllOrds Accum* 66 Yrs ending 31/12/2025	
Cumulative Years of Decline	**Number of Occurrences**	**Average Cumulative Decline**	**Cumulative Years of Decline**	**Number of Occurrences**	**Average Cumulative Decline**	**Cumulative Years of Decline**	**Number of Occurrences**	**Average Cumulative Decline**	**Cumulative Years of Decline**	**Number of Occurrences**	**Average Cumulative Decline**
1	10	-5.8%	1	13	-11.2%	1	15	-10.2%	1	16	-12.0%
2	4	-13.5%	2	8	-16.3%	2	7	-13.0%	2	9	-14.1%
3	2	-15.5%	3	4	-15.6%	3	2	-15.6%	3	4	-12.6%
4	1	-0.1%	4	3	-11.0%	4	2	-16.5%	4	3	-17.6%
5	0	...	5	1	-33.8%	5	1	-33.8%	5	3	-13.9%
6	0	...	6	1	-23.3%	6	1	-23.3%	6	1	-23.3%
7	0	...	7	0	...	7	0	...	7	0	...
8	0	...	8	0	...	8	0	...	8	0	...
9	0	...	9	0	...	9	0	...	9	0	...
10	0	...	10	0	...	10	0	...	10	0	...
11	0	...	11	0	...	11	0	...	11	0	...
12	0	...	12	0	...	12	0	...	12	0	...
13	0	...	13	0	...	13	0	...	13	0	...
14	0	...	14	0	...	14	0	...	14	0	...
15	0	...	15	0	...	15	0	...	15	0	...
16	0	...	16	0	...	16	0	...	16	0	...
17	0	...	17	0	...	17	0	...	17	0	...
18	0	...	18	0	...	18	0	...	18	0	...
19	0	...	19	0	...	19	0	...	19	0	...
20	0	...	20	0	...	20	0	...	20	0	...
Compound av. Return p.a.		*12.98%*	*Compound av. Return p.a.*		*13.90%*	*Compound av. Return p.a.*		*13.81%*	*Compound av. Return p.a.*		*12.24%*
Standard Deviation		11.4%	Standard Deviation		19.1%	Standard Deviation		20.1%	Standard Deviation		21.0%
Auto-correln. Lag 1 year		0.085	Auto-correln. Lag 1 year		-0.019	Auto-correln. Lag 1 year		-0.147	Auto-correln. Lag 1 year		-0.202
Auto-correln. Lag 2 years		-0.169	Auto-correln. Lag 2 years		-0.240	Auto-correln. Lag 2 years		-0.204	Auto-correln. Lag 2 years		-0.158

Table 4 spans 126 years, with 66-year periods commencing 1900, 1920, 1940 and 1960.

To further explore whether the negative auto-correlations and the above sequencing results are simply a feature of the past 66 years or whether they have been a feature of the Australian share market for longer periods of time, we sourced and updated a database produced by Marketindex.com.au. This database includes data for 122 years of December year-end Australian share market returns from December 1900. It was then updated to produce a 126-year database to the end of December 2025.

The data is based on the *All Ordinaries* accumulation index from 1980 and prior to this date, it used a number of different approaches and sources to compile the database. In comparison, the *Austmod* "share" sector is primarily based on National Mutual EFG unit prices until 2009 and then the ASX 300 Accumulation Index.

In Table 4, there are an average of 7 occurrences (per 66 years) of declines occurring over three years or longer. This compares with an average of 8 occurrences for the *Austmod* "share" sector in Table 2. The highest average cumulative decline (of -33.8%) occurs over five years. This relates to the five years ending 31 December 1974. For the four overlapping 66-year periods ending 1965, 1985, 2005 and 2025 respectively:

- *All Ordinaries accumulation index cumulative declines never exceeded six years, which is the same as for the Austmod Australian shares in Table 2;*
- *auto-correlations at a lag of one year became increasingly negative (i.e. .085, -.019, -.147 then -.202 for the 66 years ending 2025); and*
- *auto-correlations at a lag of two years were all negative (i.e. -.169, -.240. -.204 and -.158).*

As expected, all the Table 4 results for the 66-year period ending 2025 are similar to Tables 2, 3, 5 and 6 *Austmod* Australian shares result for the 66-year period ending 31 December 2025 except that the average cumulative declines for the *All Ordinaries* accumulation index are all higher than for the *Austmod* Australian shares. This could be partly due to the former including many smaller companies who collectively struggled to recover from extended downturns.

Table 5: Australian Shares simulated results

TABLE 5

Austn. Shares *Austmod* 66 Yrs ending 31/12/2025			Austn. Shares *Simulated with cross and AUTO correlations* Average of 1000 simulations of 100 years scaled down to 66 years			Austn. Shares *Simulated with cross c. but ZERO auto correlations* Average of 1000 simulations of 100 years scaled down to 66 years			Austn. Shares *Simulated RATIOS of with ZERO auto results to with AUTO results* Average of 1000 simulations of 100 years scaled down to 66 years		
Cumulative Years of Decline	Number of Occurrences	Average Cumulative Decline	Cumulative Years of Decline	Number of Occurrences	Average Cumulative Decline	Cumulative Years of Decline	Number of Occurrences	Average Cumulative Decline		Number of Occurrences	Average Cumulative Decline
1	16	-11.1%	1	14.42	-10.4%	1	14.32	-10.5%		99%	101%
2	10	-11.6%	2	9.61	-12.0%	2	10.35	-13.5%		108%	113%
3	4	-11.4%	3	6.64	-13.0%	3	7.70	-15.2%		116%	117%
4	3	-12.1%	4	4.33	-13.6%	4	5.87	-16.4%		135%	121%
5	3	-6.4%	5	2.89	-14.2%	5	4.47	-17.4%		155%	123%
6	1	-10.8%	6	1.78	-14.9%	6	3.45	-18.1%		195%	122%
7	0	...	7	1.30	-15.4%	7	2.67	-19.1%		205%	124%
8	0	...	8	.93	-16.7%	8	2.16	-19.3%		233%	115%
9	0	...	9	.73	-17.3%	9	1.70	-20.3%		231%	118%
10	0	...	10	.54	-18.9%	10	1.38	-20.9%		253%	111%
11	0	...	11	.43	-20.6%	11	1.10	-21.9%		255%	107%
12	0	...	12	.34	-21.4%	12	.91	-22.2%		272%	103%
13	0	...	13	.28	-21.7%	13	.79	-20.9%		284%	96%
14	0	...	14	.23	-21.9%	14	.64	-20.6%		282%	94%
15	0	...	15	.19	-23.3%	15	.51	-20.7%		272%	89%
16	0	...	16	.15	-24.1%	16	.40	-21.0%		273%	87%
17	0	...	17	.14	-22.2%	17	.33	-21.8%		238%	98%
18	0	...	18	.11	-23.3%	18	.27	-21.5%		244%	92%
19	0	...	19	.09	-24.0%	19	.24	-19.4%		260%	81%
20	0	...	20	.07	-24.7%	20	.18	-20.8%		242%	84%
Compound av. Return p.a.		*11.89%*	*Compound av. Return p.a.*		*11.89%*	*Compound av. Return p.a.*		*11.89%*	Avg 1-10 yrs	173%	116%
Standard Deviation		20.1%	Standard Deviation		20.1%	Standard Deviation		20.1%	Avg 11-20 yrs	262%	93%
Auto-correln. Lag 1 year		-0.207	Auto-correln. Lag 1 year		-0.149	Auto-correln. Lag 1 year		-0.008			
Auto-correln. Lag 2 years		-0.125	Auto-correln. Lag 2 years		0.011	Auto-correln. Lag 2 years		-0.018	Average	218%	105%

The second section in Table 5 is simulated *Austmod* Australian shares based on Section 18 of *Australian Investment Performance 1959 to 2022 (and Investment Assumptions for Stochastic Models)* except that:

- average investment returns and standard deviations have been set equal to the 66-year historical results to aid comparison with the first section; and
- the technique for determining 'S sector' auto-correlations has been improved.

The third section in Table 5 is the same as the second section except that auto-correlation inputs have been set to zero. The very small residual auto-correlations in the simulated output are mainly due to cross-correlation effects.

The fourth section in Table 5 shows the ratios of third section cumulative declines to those from the second section.

> *The number of simulated occurrences of cumulative declines over longer periods often more than doubles when auto-correlations are not allowed for and there is a small increase (with ratios of 101% to 124%) in most average cumulative declines. These results are solely due to auto-correlation.*
>
> *This clearly shows that simulation modelling which does not allow for auto-correlations significantly overstates sequencing risk from Australian shares.*

Table 6: Combining Australian Shares and cash

Table 3 above shows that the international share portfolios have suffered higher sequencing risk than Australian shares. Also, a close examination of Tables 1 and 2 shows that, apart from increased one-year cumulative declines (both in number and quantum) and increased two-year cumulative declines (in number only), a portfolio of solely Australian shares has:

- lower overall sequencing risk, and
- better long-term investment returns than a typical balanced portfolio.

The following examines each of these aspects in more detail.

Sequencing risk
From Tables 1 and 2, the number of declines occurring over three years or longer is:

- 11 the Balanced Portfolio   (averaging -9.0% over 3 years or longer), and
- 8 for Australian Shares   (averaging -11.7% over 3 years or longer).

Investment returns
- based on Tables 1 and 2, the historical average 65- or 66-year compound annual returns across the four calendar quarter-ends were 9.29% for the Balanced Portfolio and 11.96% for Australian Shares, a significant difference of 2.67% (the average standard deviations were 8.4% higher for Australian Shares but for a retiree, sequencing risk is more relevant) and

- based on my ICA 2023 paper the before tax and fees projected medium/long term compound average annual returns were 7.8% for the Balanced Portfolio and 9.3% for Australian Shares, a sizeable difference of 1.5%. After allowing for imputation credits and fees this difference increases to 2.3%.

These features (and the Table 3 and 3a conclusions) suggest that a combination of just Australian shares and cash, such as in Table 6 below, might have merit. Another possibility might be to substitute part of the Cash components with Australian Government Semis 0 - 3 years.

TABLE 6

Austn. Shares *Austmod* — 66 Yrs ending 31/12/2025

Cumulative Years of Decline	Number of Occurrences	Average Cumulative Decline
1	16	-11.1%
2	10	-11.6%
3	4	-11.4%
4	3	-12.1%
5	3	-6.4%
6	1	-10.8%
7	0	...
8	0	...
9	0	...
10	0	...
11	0	...
12	0	...
13	0	...
14	0	...
15	0	...
16	0	...
17	0	...
18	0	...
19	0	...
20	0	...
Compound av. Return p.a.		*11.89%*
Standard Deviation		20.1%
Auto-correln. Lag 1 year		-0.207
Auto-correln. Lag 2 years		-0.125

75% Austn. Shares 25% Cash *Austmod* — 66 Yrs ending 31/12/2025

Cumulative Years of Decline	Number of Occurrences	Average Cumulative Decline
1	14	-7.8%
2	7	-9.4%
3	3	-5.5%
4	1	-9.8%
5	1	-4.3%
6	0	...
7	0	...
8	0	...
9	0	...
10	0	...
11	0	...
12	0	...
13	0	...
14	0	...
15	0	...
16	0	...
17	0	...
18	0	...
19	0	...
20	0	...
Compound av. Return p.a.		*10.61%*
Standard Deviation		15.1%
Auto-correln. Lag 1 year		-0.172
Auto-correln. Lag 2 years		-0.086

50% Austn. Shares 50% Cash *Austmod* — 66 Yrs ending 31/12/2025

Cumulative Years of Decline	Number of Occurrences	Average Cumulative Decline
1	11	-4.2%
2	3	-8.7%
3	0	...
4	1	-1.2%
5	0	...
6	0	...
7	0	...
8	0	...
9	0	...
10	0	...
11	0	...
12	0	...
13	0	...
14	0	...
15	0	...
16	0	...
17	0	...
18	0	...
19	0	...
20	0	...
Compound av. Return p.a.		*9.35%*
Standard Deviation		10.4%
Auto-correln. Lag 1 year		-0.075
Auto-correln. Lag 2 years		0.014

Mixture Balanced *Austmod* — 66 Yrs ending 31/12/2025

Cumulative Years of Decline	Number of Occurrences	Average Cumulative Decline
1	11	-8.1%
2	7	-11.9%
3	6	-10.1%
4	3	-9.4%
5	3	-6.3%
6	1	-9.2%
7	0	...
8	0	...
9	0	...
10	0	...
11	0	...
12	0	...
13	0	...
14	0	...
15	0	...
16	0	...
17	0	...
18	0	...
19	0	...
20	0	...
Compound av. Return p.a.		*9.26%*
Standard Deviation		11.6%
Auto-correln. Lag 1 year		-0.026
Auto-correln. Lag 2 years		-0.038

Table 6 shows historical (not simulated) results. The four sections comprise 100%, 75%, 50% and 32% allocations to Australian shares. The 50%/50% combination is consistent with two recent articles[2] by Cary Helenius which also illustrate results from a dynamic combination of shares and cash.

In Table 6, the number of declines occurring over three years or longer is:

- 5 for the 75%/25% combination   (averaging -6.1% over 3 years or longer),
- 13 for the balanced portfolio   (averaging -9.0% over 3 years or longer).

> *Apart from increased one-year cumulative declines (in number but not quantum) the 75%/25% combination experienced much less sequencing risk yet had higher investment returns than a typical balanced portfolio.*
>
> *This extraordinary result demonstrates how the benefits that flow from negative auto-correlations at lags up to about 5.5 years can offset the adverse impact of higher volatility (i.e., higher standard deviations).*

Similarly, the 50%/50% combination experienced less sequencing risk and had a lower standard deviation than a typical balanced portfolio, with an investment return marginally greater than a typical balanced portfolio.

Further indirect benefits of these Australian shares and cash combinations are that:

- they are highly liquid;
- they are easily accessible to individuals and Self-Managed Super Funds; and
- the combinations between Australian shares and cash can be varied over time or between individuals to suit their risk profiles.

Based on 66-year historical evidence, consideration of Table 6 concluded that apart from increased one-year and some two-year cumulative declines the 75%/25% combination experienced less sequencing risk yet had higher investment returns than a typical balanced portfolio. It is informative to examine whether this conclusion holds over shorter periods. Table 7 below therefore considers two non-overlapping 33-year periods ending 31 December 1992 and 31 December 2025.

Table 7: Combining Australian Shares and cash – 33-year periods

TABLE 7

	75% Austn. Shares 25% Cash *Austmod* 33 Yrs ending 31/12/1992			Mixture Balanced *Austmod* 33 Yrs ending 31/12/1992			75% Austn. Shares 25% Cash *Austmod* 33 Yrs ending 31/12/2025			Mixture Balanced *Austmod* 33 Yrs ending 31/12/2025		
Cumulative Years of Decline	Number of Occurrences	Average Cumulative Decline	Cumulative Years of Decline	Number of Occurrences	Average Cumulative Decline	Cumulative Years of Decline	Number of Occurrences	Average Cumulative Decline	Cumulative Years of Decline	Number of Occurrences	Average Cumulative Decline	
1	8	-7.7%	1	6	-6.4%	1	6	-8.0%	1	5	-10.0%	
2	3	-12.7%	2	3	-11.8%	2	4	-7.0%	2	4	-11.9%	
3	2	-6.4%	3	2	-12.6%	3	1	-3.6%	3	4	-8.8%	
4	0	...	4	1	-6.0%	4	1	-9.8%	4	2	-11.0%	
5	1	-4.3%	5	1	-8.1%	5	0	...	5	2	-5.4%	
6	0	...	6	1	-9.2%	6	0	...	6	0	...	
7	0	...	7	0	...	7	0	...	7	0	...	
8	0	...	8	0	...	8	0	...	8	0	...	
9	0	...	9	0	...	9	0	...	9	0	...	
10	0	...	10	0	...	10	0	...	10	0	...	
11	0	...	11	0	...	11	0	...	11	0	...	
12	0	...	12	0	...	12	0	...	12	0	...	
13	0	...	13	0	...	13	0	...	13	0	...	
14	0	...	14	0	...	14	0	...	14	0	...	
15	0	...	15	0	...	15	0	...	15	0	...	
16	0	...	16	0	...	16	0	...	16	0	...	
17	0	...	17	0	...	17	0	...	17	0	...	
18	0	...	18	0	...	18	0	...	18	0	...	
19	0	...	19	0	...	19	0	...	19	0	...	
20	0	...	20	0	...	20	0	...	20	0	...	
Compound av. Return p.a.		*12.25%*	*Compound av. Return p.a.*		*10.51%*	*Compound av. Return p.a.*		*9.00%*	*Compound av. Return p.a.*		*8.02%*	
Standard Deviation		18.0%	Standard Deviation		13.0%	Standard Deviation		11.5%	Standard Deviation		10.2%	
Auto-correln. Lag 1 year		-0.119	Auto-correln. Lag 1 year		0.033	Auto-correln. Lag 1 year		-0.311	Auto-correln. Lag 1 year		-0.120	
Auto-correln. Lag 2 years		-0.174	Auto-correln. Lag 2 years		-0.136	Auto-correln. Lag 2 years		-0.077	Auto-correln. Lag 2 years		-0.006	

In Table 7, the number of declines occurring over three years or longer for the first 33-year period (ending 31 December 1992) is:

- 3 for the 75%/25% combination (averaging -5.7% over 3 years or longer),
- 5 for the balanced portfolio (averaging -9.7% over 3 years or longer).

In Table 7, the number of declines occurring over three years or longer for the second 33-year period (ending 31 December 2025) is:

- 2 for the 75%/25% combination (averaging -6.7% over 3 years or longer),
- 8 for the balanced portfolio (averaging -8.5% over 3 years or longer).

This shows that in both periods the 75%/25% combination experienced less sequencing risk than the balanced portfolio and this conclusion held more strongly in the second period than the first. Consistent with the improving Australian share auto-correlation trends over 126 years (see page 9):

- *auto-correlations for the 75/25 combination at a lag of one year became increasingly negative (i.e. -.119 for the first 33-year period then -.311 for the second period).; and*
- *auto-correlations for the 75/25 combination at a lag of two years were negative for both 33-year periods (i.e. -.174 and -.077).*

Table 8: Combining Australian Shares and cash – "Real" analysis

TABLE 8

	Austn. Shares *Austmod* 66 Yrs ending 31/12/2025			75% Austn. Shares 25% Cash *Austmod* 66 Yrs ending 31/12/2025			50% Austn. Shares 50% Cash *Austmod* 66 Yrs ending 31/12/2025			Mixture Balanced *Austmod* 66 Yrs ending 31/12/2025		
Cumulative Yrs of Real Decline	Number of Occurrences	Av Real Cumulative Decline		Cumulative Yrs of Real Decline	Number of Occurrences	Av Real Cumulative Decline	Cumulative Yrs of Real Decline	Number of Occurrences	Av Real Cumulative Decline	Cumulative Yrs of Real Decline	Number of Occurrences	Av Real Cumulative Decline
1	18	-14.8%	1	16	-12.4%	1	15	-8.8%	1	18	-9.1%
2	15	-15.7%	2	16	-11.0%	2	16	-7.5%	2	15	-12.9%
3	13	-13.4%	3	11	-11.8%	3	9	-10.3%	3	12	-16.4%
4	9	-20.1%	4	8	-17.9%	4	6	-18.8%	4	11	-19.2%
5	8	-23.5%	5	8	-19.5%	5	8	-15.3%	5	9	-24.5%
6	5	-32.3%	6	5	-27.9%	6	5	-23.1%	6	10	-21.5%
7	6	-23.6%	7	6	-20.9%	7	6	-17.9%	7	9	-22.0%
8	5	-20.0%	8	5	-17.4%	8	5	-14.7%	8	9	-21.8%
9	4	-19.8%	9	4	-16.8%	9	4	-13.7%	9	11	-18.6%
10	4	-17.1%	10	5	-11.4%	10	6	-8.1%	10	10	-20.5%
11	2	-10.0%	11	2	-7.8%	11	2	-5.3%	11	10	-19.6%
12	1	-5.9%	12	1	-5.3%	12	1	-4.8%	12	11	-15.2%
13	1	-4.3%	13	1	-3.9%	13	2	-2.0%	13	9	-13.9%
14	0	...	14	0	...	14	0	...	14	9	-10.0%
15	0	...	15	0	...	15	0	...	15	9	-6.8%
16	0	...	16	0	...	16	0	...	16	5	-4.0%
17	0	...	17	0	...	17	0	...	17	2	-4.7%
18	0	...	18	0	...	18	0	...	18	1	-7.3%
19	0	...	19	0	...	19	0	...	19	1	-3.5%
20	0	...	20	0	...	20	0	...	20	0	...
Compound av. Return p.a.	*11.89%*		*Compound av. Return p.a.*	*10.61%*		*Compound av. Return p.a.*	*9.35%*		*Compound av. Return p.a.*	*9.26%*	
Standard Deviation	20.1%		Standard Deviation	15.1%		Standard Deviation	10.4%		Standard Deviation	11.6%	
Auto-correln. Lag 1 year	-0.207		Auto-correln. Lag 1 year	-0.172		Auto-correln. Lag 1 year	-0.075		Auto-correln. Lag 1 year	-0.026	
Auto-correln. Lag 2 years	-0.125		Auto-correln. Lag 2 years	-0.086		Auto-correln. Lag 2 years	0.014		Auto-correln. Lag 2 years	-0.038	

Table 8 is the same as Table 6 but the results are presented for 'real' sequencing risk allowing for price inflation.

In this table:

- the "number of occurrences" is the number of times the unit price (after deflating it to reflect historical increases in CPI) has fallen over one or more integral years,
- the "average real cumulative decline" is the average percentage fall in the deflated unit prices for all those occurrences (since these falls result from negative real investment returns the "average real cumulative decline" is recorded with a negative sign).

The following paragraphs compare Table 8 with Table 6.

As expected, the duration and total number of declines increase. In effect, to achieve a positive real return, "the bar has been raised" from what was needed to get a positive nominal return. The cumulative years of real declines is much greater than the cumulative years of nominal declines.

For example, in Table 8, the number of real declines occurring over three years or longer is:

- 56 for the 75%/25% combination   (averaging -16.6% over 3 years or longer),
- 138 for the balanced portfolio   (averaging -16.9% over 3 years or longer),

whereas in Table 6, the number of nominal declines occurring over three years or longer was:

- 5 for the 75%/25% combination   (averaging -6.1% over 3 years or longer),
- 13 for the balanced portfolio   (averaging -9.0% over 3 years or longer).

The second and third sections of both Tables 6 and 8 each include 25% more Cash than the previous sections. In the first three sections of Table 6 each additional 25% Cash component progressively improves (i.e. reduces) sequencing risk.

However, in the first three sections of Table 8 each additional 25% Cash component leaves both the number and quantum of real declines only marginally improved. For example, in Table 8 the number of real declines occurring over three years or longer is:

- 58 for Australian shares   (averaging -19.4% over 3 years or longer),
- 56 for the 75%/25% combination   (averaging -16.6% over 3 years or longer), and
- 54 for the 50%/50% combination   (averaging -13.8% over 3 years or longer).

Regarding the conclusions in Table 6 relating to the favourable comparisons of the 75%/25% and 50%/50% combinations vis-vis a typical balanced portfolio, the favourable comparisons still stand on a real basis, as for the nominal basis.

The following analysis is intended to give a better understanding of the impact of price inflation on sequencing risk. For four of the asset allocations recorded in Tables 3 and 3a, the number of nominal declines occurring over three years or longer was:

- 1 for Austn. Govt. Semis 0 - 3 yrs.   (equal to -1.0% over 3 years)
- 6 for Inflation-Linked Govt. Bonds   (averaging -2.0% over 3 years or longer),
- 17 for Australian Fixed Interest   (averaging -5.7% over 3 years or longer), and
- 19 for Australian Direct Property   (averaging -11.5% over 3 years or longer).

Note that these four asset allocations are ranked by increasing nominal sequencing risk and that that the same ranking applies for both the number and the quantum of declines. **Table 9 below includes these same four asset allocations sorted in the same order, but the results are presented for 'real' sequencing risk allowing for price inflation.**

TABLE 9

Australian Govt. Semis 0-3 yrs *Austmod* 66 Yrs ending 31/12/2025			Inflation Linked Government Bonds *Austmod* 66 Yrs ending 31/12/2025			Australian Fixed Interest *Austmod* 66 Yrs ending 31/12/2025			Australian Direct Property *Austmod* 66 Yrs ending 31/12/2025		
Cumulative Yrs of Real Decline	Number of Occurrences	Av Real Cumulative Decline	Cumulative Yrs of Real Decline	Number of Occurrences	Av Real Cumulative Decline	Cumulative Yrs of Real Decline	Number of Occurrences	Av Real Cumulative Decline	Cumulative Yrs of Real Decline	Number of Occurrences	Av Real Cumulative Decline
1	13	-3.8%	1	21	-4.8%	1	23	-6.0%	1	13	-7.6%
2	9	-8.9%	2	15	-8.0%	2	16	-12.2%	2	14	-10.7%
3	9	-11.5%	3	11	-12.3%	3	16	-14.9%	3	13	-13.5%
4	10	-12.7%	4	11	-12.8%	4	16	-17.5%	4	13	-13.3%
5	12	-12.1%	5	10	-13.4%	5	17	-18.7%	5	15	-10.1%
6	13	-12.0%	6	11	-11.5%	6	15	-22.9%	6	10	-12.6%
7	13	-12.5%	7	13	-10.1%	7	16	-23.6%	7	10	-9.1%
8	12	-13.8%	8	12	-11.7%	8	16	-25.1%	8	5	-10.2%
9	12	-13.5%	9	12	-11.7%	9	15	-28.1%	9	4	-6.3%
10	13	-11.9%	10	13	-11.1%	10	15	-29.9%	10	2	-5.2%
11	14	-9.9%	11	12	-11.1%	11	16	-29.1%	11	1	-4.1%
12	13	-8.4%	12	12	-9.1%	12	15	-31.9%	12	0	...
13	12	-7.2%	13	11	-9.2%	13	16	-30.2%	13	0	...
14	10	-5.9%	14	9	-9.3%	14	15	-32.9%	14	0	...
15	8	-4.1%	15	10	-7.0%	15	14	-34.9%	15	0	...
16	3	-5.9%	16	8	-6.2%	16	14	-33.3%	16	0	...
17	3	-3.7%	17	5	-7.7%	17	14	-30.9%	17	0	...
18	2	-2.2%	18	3	-9.1%	18	14	-27.6%	18	0	...
19	0	...	19	3	-6.8%	19	12	-28.8%	19	0	...
20	0	...	20	1	-8.2%	20	11	-29.1%	20	0	...
Compound av. Return p.a.		7.45%	*Compound av. Return p.a.*		7.78%	*Compound av. Return p.a.*		6.74%	*Compound av. Return p.a.*		7.76%
Standard Deviation		5.7%	Standard Deviation		7.9%	Standard Deviation		8.2%	Standard Deviation		7.8%
Auto-correln. Lag 1 year		0.682	Auto-correln. Lag 1 year		0.207	Auto-correln. Lag 1 year		0.262	Auto-correln. Lag 1 year		0.613
Auto-correln. Lag 2 years		0.571	Auto-correln. Lag 2 years		0.056	Auto-correln. Lag 2 years		0.086	Auto-correln. Lag 2 years		0.198

Sorted in the same order as above, the number of real declines occurring over three years or longer is:

- 159 for Austn.Govt. Semis 0-3 yrs. (averaging -10.3% over 3 years or longer)
- >167 for Infln-Linked Govt. Bonds (averaging -10.4% over 3 to 20 years),
- >267 for Australian Fixed Interest (averaging -26.9% over 3 to 20 years), and
- 73 for Australian Direct Property (averaging -11.1% over 3 years or longer).

For these four asset allocations, Australian Direct Property has moved from <u>worst nominal</u> sequencing risk to <u>best real</u> sequencing risk (though its real average declines are marginally worse than for Austn.Govt. Semis 0-3 yrs and Inflation-Linked Govt. Bonds).

In Table 3, Australian Fixed Interest never had nominal cumulative declines longer than 6 years but in Table 9 it has real cumulative declines much longer than 20 years. In Table 3a, Australian Inflation-linked Bonds never had nominal cumulative declines longer than 5 years but in Table 9 they have real cumulative declines up to 20 years.

It seems clear from these results that the impact of price inflation on sequencing risk is important and can significantly influence optimal asset allocation decisions. Whether decumulation asset allocation decisions should be based on nominal or real sequencing risk will depend on whether a retiree's personal objectives are, for example, based on:

(a) seeking the best long-term investment returns subject to a secondary regard to avoiding nominal-based sequencing risk, or
(b) seeking an inflation-protected income for say 30-year periods subject perhaps to a secondary regard of achieving good long-term investment returns.

Conclusions

As identified in the above sections the key conclusions are:

With a typical balanced portfolio, only once did a cumulative decline occur over seven years and this was just -0.5%. Cumulative declines never occurred over longer than seven years.

With 100% Australian shares only twice did a cumulative decline occur over six years and declines never occurred over longer than six years (shorter than the seven years for a balanced portfolio).

Retirees should take note that for unhedged international shares, cumulative declines occurred over up to 15 years. Also, because of long-term currency cycles, with only two exceptions, both the number of occurrences and the average cumulative declines for unhedged international shares significantly exceeded those for both hedged international shares and Australian shares.

For the four overlapping 66-year periods ending 1965, 1985, 2005 and 2025 respectively:

- *All Ordinaries accumulation index cumulative declines never exceeded six years, which is the same as for the Austmod Australian shares in Table 2;*
- *auto-correlations at a lag of one year became increasingly negative (i.e. .085, -.019, -.147 then -.202 for the 66 years ending 2025); and*
- *auto-correlations at a lag of two years were all negative (i.e. -.169, -.240. -.204 and -.158).*

The number of simulated occurrences of cumulative declines over longer periods often more than doubles when auto-correlations are not allowed for and there is a small increase (with ratios of 101% to 124%) in most average cumulative declines. These results are solely due to auto-correlation.

This clearly shows that simulation modelling which does not allow for auto-correlations significantly overstates sequencing risk from Australian shares.

> *Apart from increased one-year cumulative declines (in number but not quantum) the 75%/25% combination experienced much less sequencing risk yet had higher investment returns than a typical balanced portfolio.*
>
> *This extraordinary result demonstrates how the benefits that flow from negative auto-correlations at lags up to about 5.5 years can offset the adverse impact of higher volatility (i.e., higher standard deviations).*

Consistent with the improving Australian share auto-correlation trends over 126 years (see page 9):

> - *auto-correlations for the 75/25 combination at a lag of one year became increasingly negative (i.e. -.119 for the first 33-year period then -.311 for the second period).; and*
> - *auto-correlations for the 75/25 combination at a lag of two years were negative for both 33-year periods (i.e. -.174 and -.077).*

Most importantly, setting asset allocation strategies in the <u>accumulation stage</u> should involve:

- seeking to maximise long term investment returns,
- consistent with member ***volatility risk*** tolerances,
- with the latter commonly monitored in the form of standard deviations, and
- with a 'watchful eye' on liquidity, skewness and kurtosis.

However, the research in this paper suggests that asset allocation strategies in the <u>decumulation stage</u> should involve:

- seeking to maximise long term investment returns,
- consistent with member ***sequence risk*** tolerances,
- with the latter monitored in the form of cumulative declines, and
- with a 'watchful eye' on liquidity, auto-correlations and standard deviations.

The above recognises that sequencing risk is mitigated by higher levels of contributions in the accumulation stage, but is impacted adversely by increasing levels of drawdown in the decumulation stage.

More work

The historical results in Tables 6 and 7 could usefully be supplemented with investigation of historical experience over say 10-year or 20-year periods rather than the 66 years and 33 years adopted here, and with further forward-looking simulations to test the current conclusions. Based on the research above, and that in the References below, it is expected that this will further re-enforce the validity of the above Conclusions.

It might also be informative, for both retirees and their advisors, to include specified withdrawals at regular intervals in further historical comparisons of different asset allocations.

Acknowledgments

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About the author

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Colin Grenfell is a retired actuary and superannuation consultant. He is a member and former Convenor of the Actuaries Institute Superannuation Projections and Disclosure (SPD) subcommittee. In 2018 he was awarded the Institute's Spirit of Volunteering Award. Colin has a long-standing passion for stochastic and historical investment simulation modelling. He is the designer and owner of the *Austmod* investment simulation model. Prior retirement, Colin held a variety of superannuation, actuarial and investment roles with National Mutual Life. During the past 20 years he has held various superannuation trustee directorships and was a part-time member of the Superannuation Complaints Tribunal (SCT).