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ORIGINAL RESEARCH

Asset allocation of Australian superannuation funds: a markov regime switching approach

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Abstract
We extend an observable Markov Regime Switching framework to assess the switching behaviour of asset classes of Australian superannuation funds across different fund sizes. We identify the most prominent asset class which contributes to the performance of the investment options and what factors trigger funds' decisions on rebalancing their portfolio. We find that smaller funds tend to be more active in switching to aggressive options and the larger funds are more conservative. However, in periods of volatility, the large funds are the risk seekers and tend to switch their asset classes and hence their investment strategies. The asset classes whose values add to the performance of the investment options are equity markets and bond markets with the domestic equity market having better performance than international equity market. The switch for the larger funds is driven by volatility of the equity market.

Keywords Superannuation investment strategies · Asset allocation · Switching · Performance

JEL classification G11 · G23

1 Introduction

Over the recent decades, the pension landscape has changed significantly, and a considerable amount of risk has been transferred from the employers to the employees, that is, we have seen a change in the pension system globally from the defined benefit system (DB) to defined contribution (DC).[1] In the DC system, the employee can voluntarily contribute to her own

[1] In a DB system, the employer guarantees the retirement plan for its employee which is based on a certain formula considering a number of factors, for example, the salary history and the length of the employment.

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retirement fund account and her employer is required to contribute to the account at a certain portion of the employee's salary. These contributions are accumulated over time, which are normally managed and invested by a pension fund in a pool investment. Therefore, it is of particular importance to understand the asset allocation of pension funds and how these decisions affect the funds' performance.

In this study, we extend an observable Markov Regime Switching framework to empirically investigate the asset allocation issue in the Australian pension industry, hereafter referred as Australian superannuation's funds. Thanks to the rich dataset available in Australia, we comprehensively study the issue in multiple dimensions, including across different fund sizes, asset classes and the Global Finance Crisis (GFC, hereafter). Particularly, we focus on the following research questions: (i) What is the likelihood that superannuation funds switch from one investment strategy to another and how long do they stay in one specific strategy? (ii) which asset classes have the most significant contribution to the performance of the investment strategy? and (iii) what factors impact on the superannuation decisions to switch from one investment strategy to another one?

Superannuation funds in Australia provide investors with various ways in which their superannuation balance can be invested. For instance, they can offer broad investment strategies, which include labels like conservative, balanced, growth or they can simply provide investors with a variety of asset classes. Therefore, it becomes very important to assess the asset allocations of the superfunds as they are the key drivers of the investment returns which help the investor build on the retirement nest-egg. Over the recent years, it has become more and more necessary to review the investment returns, even in the case of the most well-diversified multi-asset portfolios. This is because we have had significant periods of volatility caused by many factors including, the financial market crises, unconventional monetary policy, and a low yield environment.

Further, over the years, the Australian Superannuation fund industry has expanded the investment beyond domestic assets and is also known for active investment. The types of investments that a super fund can invest in comprise nearly an unlimited range of assets and asset classes including shares—both Australian shares and international shares. Australian shares often pay franked dividends and generate franking credits. International shares can be hedged or unhedged, which means that movements in the Australian dollar when investing overseas can be considered (hedged) or not considered (unhedged). Other types of investments in superannuation include cash, term deposits and other fixed interest investments such as Australian bonds and international bonds (including corporate bonds). Superannuation funds can invest in infrastructure investments both in Australia and internationally, private equity and invest via hedge funds. Superannuation funds can invest in listed property investment and direct property. With the variety of assets classes which are on offer in the market and with the different valuations reported, the need for proper assessment of asset allocation to generate better returns is of increasing importance and requires further investigation.

In Australia, almost no open DB plans remain these days, see for example, Gunasekera and Powlay (1987) and Bateman and Kingston (2013). Mees (2020) analyses the risk shifting in Australia from DB to DC and identities that in a DC plan, employees are faced with 'sequencing risk', the risk that investment markets might be depressed at the time an employee retires as well as 'longevity risk', the risk that retirees may live longer than there are funds to provide for. In a DC plan, the balance at retirement is comprised of the amount accumulated in his/her individual account at the time of retirement and hence an important aspect of this balance is the investment risk. The DC member is also impacted by the timing of market volatility and market corrections. Hence, our study is important as it assesses one of the key factors that drives the volatility of the retirement balance, that is the investment options that members chose to make in the DC plans.

Asset allocation decisions are very important from a practical viewpoint, and this is also well established from academic literature. From a practical perspective, the decisions that most investment managers and superannuation funds today make on asset allocation are still modern portfolio theory, that is the risk and return of all investment combined in a portfolio rather than an investment in isolation should be considered. To this end, all super funds provide investors with an investment strategy which will keep retirees on track on maximise their retirement income. Investment strategies lays out the percentage that they intend to invest in each asset class. However, it is important to understand that there is the constant need to rebalance investments from time to time to bring them in line with the stated asset allocation objectives. If the value of a particular investment or asset class rises or falls, the proportion it represents in your portfolio will change. For example, if stock markets go up, it will take up a much larger allocation of your overall investments and hence at times it may be required that to sell some shares and buy some bonds to rebalance your portfolio. In a volatile market, superannuation funds, often to help reduce the impact of large market fluctuations and corrections, and hence offer a number of diversified options which include a range of asset classes such as shares, cash and fixed income. Each diversified option is assigned a medium to longer term asset allocation, known as the strategic asset allocation and from there they provide asset allocation ranges at times which are the minimum and maximum amounts we can invest in each asset class.

Academic literature equally reiterates the importance of asset allocation. Ibbotson (2010) analyses the asset allocation policy and how the asset allocation determine the performance and the how the policy mix varies over time. Asset allocation of superannuation funds matters and is important as the retirement balance is largely dependent on the mix of asset classes that the funds chose to invest in. In fact, the asset allocation policy has been known to account for most of the time series variation in portfolio returns of pension funds. Brinson et al. (1986) are among the first studies which analyse the importance of asset allocation in a portfolio. They use data from 91 large US pension plans over 1974–1983 and found that investment policy (the selection of asset classes and their normal weights) dominated investment strategy and explains "explaining on average 93.6% of the variation in total return, although investment strategy can result in significant returns, these are dwarfed by the return contribution from investment policy". These results have been further confirmed by Brinson et al. (1991). A recent study by Vanguard (2017) confirms that funds in US, Canada, UK, Australia, and Japan were proportionally much the same in the degree to which asset allocation was found to explain return variability over time and the dispersion of returns across funds. Other studies which highlight the importance of studying asset allocation of pension funds include Brinson et al. (1991); Ibbotson and Kaplan (2000) for the US, Blake et al. (1999) for UK pension funds and Brown et al. (2010) for university endowment funds. Other US based studies find that the performance of the fund is very important for the investment choice of members, see for example, Sirri and Tufano (1998), Goetzmann and Peles (1996) and Lynch and Musto (2003).[2]

Our study contributes to the literature of pension funds' asset allocation in a number of aspects. In terms of the methodological approach, the hidden Markov Switching models have widely been used to investigate the asset allocation issues in many markets, including stock, bond, and commodities (e.g., Bae et al., 2014; Dias et al., 2015; Reus & Mulvey,

[2] We provide a brief review of the studies which focus on the asset allocation by Australian superannuation funds in Sect. 2.

2016; Nystrup et al., 2019; among others). However, there are very few studies employing the Markov Switching models to investigate the asset allocation issue in pension industry. Siu (2012) is an exception that we found. As we show later in the methodology section, the Markov Switching model is particularly adequate to capture the switching behaviour of the dynamic asset allocation in Australian Superannuation funds among the investment strategies. It is worth noting that investors in Australia can subjectively choose the investment strategies for their superannuation (e.g., growth or balanced options). Besides, the data allows us to identify specific investment strategies at any point in time. We, therefore, propose a Markov Switching model considering investment strategies as observable states for the case of Australian Superannuation. We further extend the univariate Markov Switching Model to its multiple version to assess the impacts of many drivers on the performance of the superannuation industry across different decisions of the asset allocation (or investment strategies).

In addition, different with previous studies (e.g., Battocchio et al., 2007; Siu, 2012; and Devolder et al., 2020) that mainly focus on the theoretical side,[3] we also emphasize on the empirical issues of the asset allocation in the pension industry. The length of 30 years of sample data with 1220 investment options observed in the Australian superannuation industry enables us to comprehensively deliver several new insights in understanding the dynamic switching behaviour of the pension industry. Firstly, we assess the switching behaviour across asset classes of Australian superannuation investment options by defining four broad categories of investment options namely, aggressive, growth, balanced and conservative options. Secondly, we extend the period of analysis to assess how periods of volatility, like the GFC, impact on the switching behaviour across asset classes. Thirdly, we extend our analysis by further considering the switching behaviour across fund size. That is, we consider the weighted proportion of growth and defensive asset across fund size (it should be highlighted that most portfolio determinants studies focus only on large funds). Fourthly, we assess what are the most prominent asset classes which contribute to the performance of the investment options. Finally, we assess the factors that drives the switch in asset classes, hence the switch in investment options.

Our key findings can be summarised as follows. Firstly, we find that the smaller funds tend to be more active in switching to the aggressive option to boost up their performance in the relatively stable period. However, they seem to be more conservative during the volatile period (such as the GFC). This may mainly be due to their limited capacity in risk tolerance. Conversely, the larger funds mostly stayed in the balanced option during the stable period, but they tend to be more active to switch to the growth option during the volatile period. Secondly, our result shows that the domestic equity market is the most significant contributor to the performance of Australian superannuation industry, followed by the international stock market and the domestic bond market. Lastly, we find that the volatility of the equity markets (both domestic and international) are the primary factors affecting the larger Australian superannuation funds' decisions in rebalancing their portfolio.

The remainder of this paper is structured as follows. Section 2 gives a brief review on the literature that investigates the asset allocation by Australian superannuation funds. Section 3 describes the data employed and the construction of the main variables. We present the empirical framework in Sect. 4. Section 5 discusses the results of the analysis for the switching patterns across funds sizes over time, the performance of the investment options and the

[3] Battocchio et al. (2007) examines the optimal asset allocation of pension funds considering the mortality risk. Siu (2012) investigates the asset allocation problem of a member of the DC pension funds in a hidden Markov regime-switching. Devolder et al. (2020) proposes automatic balance mechanisms for the DC system, which can be applicable for the characteristics of the Italian pension system.

factors that affect the switch across the investment option. We provide robustness analyses in Sect. 6 and the final section concludes the paper.

2 A brief review on asset allocation by Australian superannuation funds

In the Australian context, there are only a few studies which investigate the asset allocation of superannuation funds. Benson et al. (2007) analyzed the asset allocation strategies within the Australian equities, fixed interest and listed property classes of funds and concluded that there is significant ‘momentum investing’ undertaken by fund managers. There are a few other papers which look into the question of market timing, for example, Sinclair (1990) evaluated market timing and stock selection for Australian pooled superannuation funds invested in multiple asset classes; Gallagher (2001) assess the market timing and security selection capabilities of Australian pooled superannuation funds over 8 years from January 1991 to December 1998 and evaluates the performance for the three largest asset classes within diversified superannuation funds and their contribution to overall portfolio return. He concludes that Australian pooled superannuation funds do not exhibit significantly positive security selection or market timing skill. Gharghori et al. (2008) found little evidence that Australian investors can identify high performing superannuation funds. Butt et al. (2018) investigate how retirement plan providers choose default investment strategies for passive members. They argue that passive plan members are different from active members in ways that matter for investment strategy; the willingness to take financial risks; they are also younger, less wealthy and more often female. However, they are also concluded that most plan executives think of passive members as uninterested in their retirement savings, but passive members say they trust their plans, and lack skill rather than interest.

Bateman et al. (2016) study how retirement plan members choose investment options using five information items prescribed by regulators in Australia (ASIC). By looking at a sample of investment options offered by UniSuper (offered to one sector), they conclude that asset allocation information for pre-mixed investment options had the largest impact on choices. Further, Faff et al. (2005), using a sample of 135 months, assess the tactical asset allocation of Australian superannuation funds. They conclude that active managers have been unable to deliver investors with superior returns through tactical asset allocation. The most value enhancing asset class is domestic equities and international shares and domestic fixed interest does not really add value to fund performance. They equally suggest that the factors that affect changes in asset allocation is mainly domestic equities. While Faff et al. (2005) look into the asset classes and their contribution to the performance of funds, our study is different in that we focus on an extended period of time which includes the Global Financial Crisis 2008 (GFC) and captures the trends of investments by Australian Superfunds in recent years. Our study considers how the asset allocation varies across funds sizes given that we have seen the growth of some superfunds in Australia to be quite significant in terms of asset under management. Further, we analyse the period which includes the GFC as the Australian Superannuation industry has been largely affected by the market downturn in 2008.

Gerrans (2012) assessed the behaviour of investors over the GFC period across five superannuation funds. He concludes that an overwhelming number of investors did not change their investment strategy in response to the crisis. Further, Gerrans et al. (2015) tested the individual financial risk tolerance during the crisis using a risk tolerance survey. The results showed that the crisis had an impact on the investors, however, the results were inconclusive in terms of how the crisis has an impact on asset allocation decisions. This study is of equal importance and significance from a practical and industry perceptive given the challenges faced by the Australian superannuation funds. The Australian superannuation fund industry accounts for $2.6 trillion of assets and hence the way in which these assets are invested has a significant influence on the final benefits and balance to its members. The contribution of this study not only fills the gap in the academic literature on asset allocation and their performance of superfund investment options, but it equally provides market insights and has implications on the way individuals chose their investment options in a DC plan. We assess the drivers of investment returns over a long period of time and how investment strategies seem to have shifted over the years and includes a variety of asset classes that superannuation funds invest in. From a market perspective, while market timing or the investments an investor picks can be argued to be the determinants of portfolio success, the most important determinant is asset allocation. That is, how we construct a portfolio is the most important factor. The Australian superannuation industry is known for active investments and has offered investors a diverse range of assets and asset classes to choose from. Therefore, our study focuses on asset allocation of Australian superannuation funds, and more particularly, their dynamic tactical asset allocation as well as the switching pattern across different superannuation fund sizes.

3 Data and construction of variables

3.1 Data source

The data in this paper is sourced from the Morningstar Direct database. The sample is 30 years, ranging from January 1990 to December 2019 (360 months of data), and the original sample consists of 1220 investment options from various Australian superannuation funds. A brief explanation of the data is as follows: the data provide details of the investment options held by the superannuation funds. We obtain the monthly percentage of asset allocation across the asset classes for all the investment options[4] that the superannuation fund has. For each of the investment options, we have access to the percentage allocated to the following asset classes; cash, domestic and international shares, domestic and international fixed income securities, as well as listed (domestic and international) listed and unlisted property on a monthly basis for the 30 years. For each of the superannuation fund, we therefore can assess the historical changes in percentage as to when the investment managers change allocation across each of the asset classes over time on a monthly basis.

Morningstar Direct equally provides information on the fund size. The total assets value is obtained for the period January 1990 to December 2019 for each of the Superfunds on a monthly for the sample period. Cummings (2016) examines the relationship between fund size and performance for superannuation industry sectors in Australia. He suggests that members benefit more from larger superannuation funds for three reasons: (i) larger funds provide more diversification as they have a wider asset class base, (ii) larger funds avoid the scale diseconomies in investment returns documented in studies of equity mutual funds and (iii) larger funds can spread fixed operating costs over a larger asset base. As such in our analysis, we assess the dynamic switching behaviour of investment options using the weighted

[4] For example, a superannuation can have the following investment options: Australian Shares, Balanced; Basic Cash; Bond; Capital Stable; Core Strategy; Diversified; High Growth; Overseas Shares; Super Property; Super Shares.

Table 1 Summary statistics fund size- total assets of funds

Total assets				
Quintile	Mean	5th percentile	95th percentile	SD
1	1,763,919	53,560	5,389,998	1,958,029
2	10,328,915	3,509,999	23,609,999	7,652,810
3	32,319,261	13,261,484	72,956,182	21,500,017
4	109,266,138	41,562,846	239,697,682	68,906,819
5	1,428,407,384	163,879,998	4,245,411,742	4,763,500,176

This table shows the summary statistics for the fund size across five quintiles. The first quintile (Q1) comprises of the smallest 25% of funds in terms of fund size, whereas the fifth quintile (Q5) includes the largest 25% of funds

proportion of growth assets using fund size to be able to assess if there is a difference between the smaller and larger fund in the pattern of switching across investment options over time. Table 1 provides the summary statistics of the quintiles (Q1 to Q5) based on the monthly total assets of the funds. The smallest quintile, Q1, has its 5th and 95th percentile of $53,560 and $5,389,998 respectively. The average total assets for Q1, the smallest fund quintile, is $1,763,919. The total assets of largest funds base in the fifth quintile, Q5, where its 95th is $4,245,411,742. The average total asset for the largest fund quintile is $1,428,407,384.

3.2 Proportion of growth asset and performance of superannuation fund

The objective of this study is to assess the dynamic switching of asset allocation across the investment options held by the superannuation funds. However, with the variety of labels used across the sample of 1220 investment options, we re-define the investment options to only the *four* most widely used labels in the market to achieve label uniformity. Our data enables this classification given we have the historical monthly asset allocation for each of the investment options within each of the superannuation funds. To re-classify the investment option, we follow the classification provided by the Australian Securities and Investment Commission (ASIC), which is defined based on the proportion of growth assets.[5] As we focus on the overall Australian superannuation industry, we aim to identify the investment option that the whole industry stays in each month on average. We perform the three following stages.

In the first stage, we classify the assets into defensive and growth assets. The defensive assets include cash and fixed income securities (domestic and international). The growth assets that we consider include shares (domestic and international) and property (both listed and unlisted). Australian superannuation funds provide investors with a variety of investment options that can suit the investment profiles of investors. These include a mixture of growth assets up to a 'high growth option', where investors have the option of investing up to 100% in growth assets, such as shares and property. On a basis of this growth asset definition, we calculate the monthly proportion of growth asset for each superannuation fund, denoted as $Proportion,\ of\ Growth\ Asset_{f,t}$.

In the second stage, we calculate the monthly proportion of growth asset weighted by fund size for the Australia superannuation industry as follows,

[5] See https://www.moneysmart.gov.au/superannuation-and-retirement/how-super-works/super-investment-options.

$$Proportion\,of\,Growth\,Asset_t = \frac{\sum_{f=1}^{N} Fund\,Size_{f,t} \times Proportion\,of\,Growth\,Asset_{f,t}}{\sum_{f=1}^{N} Fund\,Size_{f,t}} \quad (1)$$

where N is the number of funds in the Australian superannuation industry, and t represents time (or month).

In the final stage, we use the monthly proportion of growth asset estimated in Eq. (1) to construct the monthly categorical variable s_t, representing broader investment options. As mentioned earlier, we unify investment options into *four* labels following the classification of ASIC, hence, $s_t = \{1, 2, 3, 4\}$ with each value representing one of the *four* labels we use. More specifically, $s_t = 1$ denotes the aggressive option (also known as high growth), where the proportion of growth asset is between 85 and 100%. In the growth option, or $s_t = 2$, the proportion of growth assets is between 71 and 84%. Next, the balanced option, or $s_t = 3$, has the proportion of growth assets being between 31 and 70%. Lastly, the conservative option, or $s_t = 4$, has 1–30% as growth assets.

Figure 1 shows the proportion of weighted average growth assets across the five quintiles and Fig. 2 shows the investment options of the superannuation's funds over time. Both figures indicate that the smaller funds (e.g., Q1) tend to be more active in switching to the aggressive options and they are more active in a relatively stable period. In contrast, they seem to be quite passive in volatile period for example, the GFC period between 2007 and 2009.[6] The larger funds (e.g., Q5) are seen to be more conservative given they are mainly in the balanced option, $s_t = 3$. In contrast to the smaller funds, however, they tend to be more active in the volatile period and switch from balanced option to more growth options, $s_t = 2$, but otherwise they have a more stable strategy during the stable periods.

We provide some further summary statistics, in Table 2, on the weighted proportion of growth assets in each quintile as well the corresponding weighted average returns. We obtain the monthly price index for each superannuation fund from which we can derive the weighted average return across each quintile similar to the construction of the weighted proportion of growth assets shown in Eq. (1). Table 2 supports the figures presented earlier with the monthly weighted average growth percentage as highest in Q1 at 74.02% compared to an average of 63.06% for the largest fund quintile. The corresponding monthly weighted average returns also reflect the higher level of risk by holding more in growth assets with the mean of 0.566% for the smaller size funds in Q1 and a mean of 0.529% for the larger size funds in Q5.

4 Modelling framework

The preliminary analysis of the data discussed in Sect. 3 provides us with some indication on the behaviour of Australian superfunds across the four investment options. To further investigate the likelihood that superannuation funds remain in an investment strategy over the sample period and how long do they stay in that specific strategy, we respectively calculate the duration and the probability that the overall Australian superannuation industry stays in each of the investment options as follows,

$$Average\,duration(s_t = m) = \frac{\sum_{d=1}^{D_m} Duration_d(s_t = m)}{D_m} \quad (2)$$

[6] In this study, following Lane (2012), Bekaert et al. (2014), and Dungey and Gajurel (2014), we define the GFC over a period of 24 months from August 2007 to July 2009.

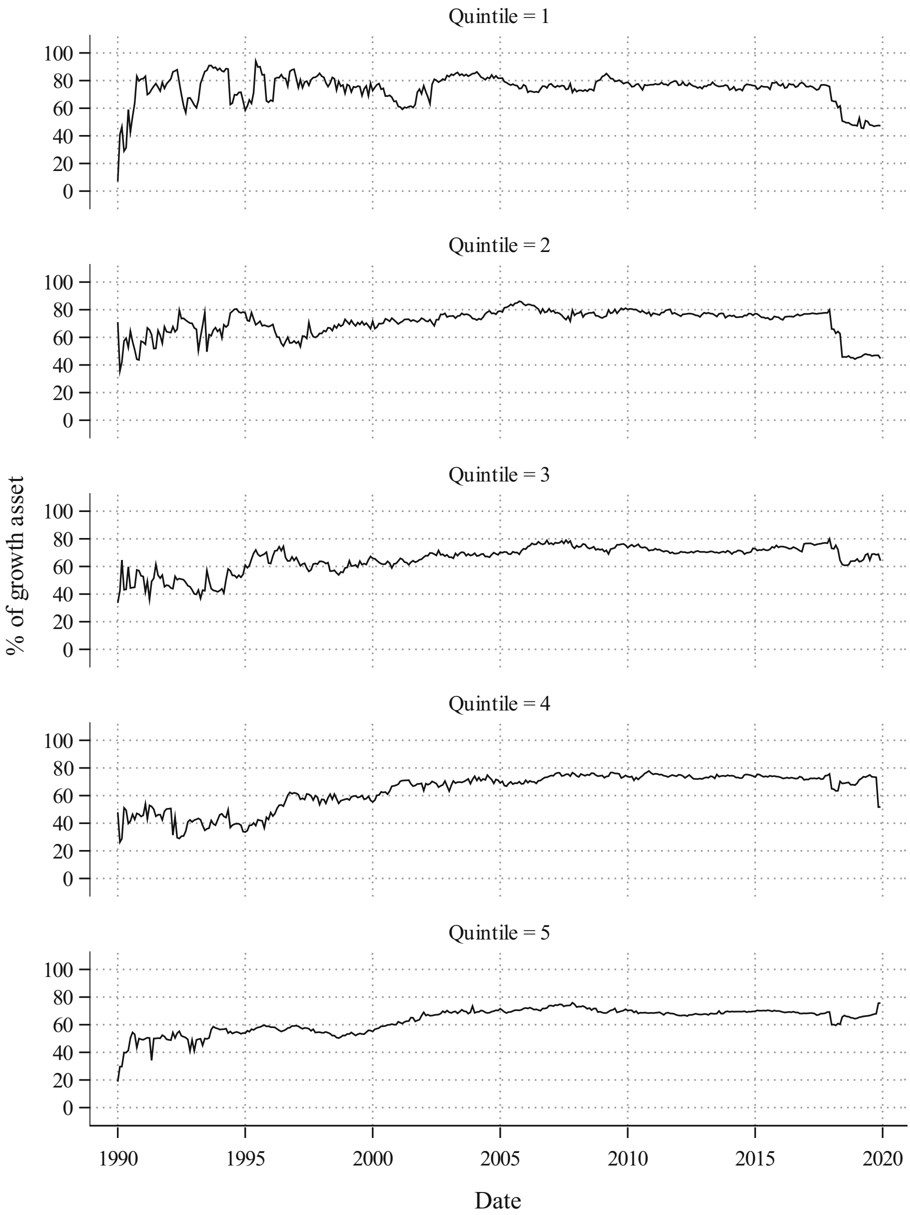

Fig. 1 Proportion of weighted average growth asset in Australian superannuation industry

$$Probability(s_t = m) = \frac{\sum_{t=1}^{T} I(s_t = m)}{T} \tag{3}$$

where m denotes the investment options (i.e., m can be 1, 2, 3 and 4 corresponding to aggressive, growth, balanced, and conservative options), D_m is number of time that the

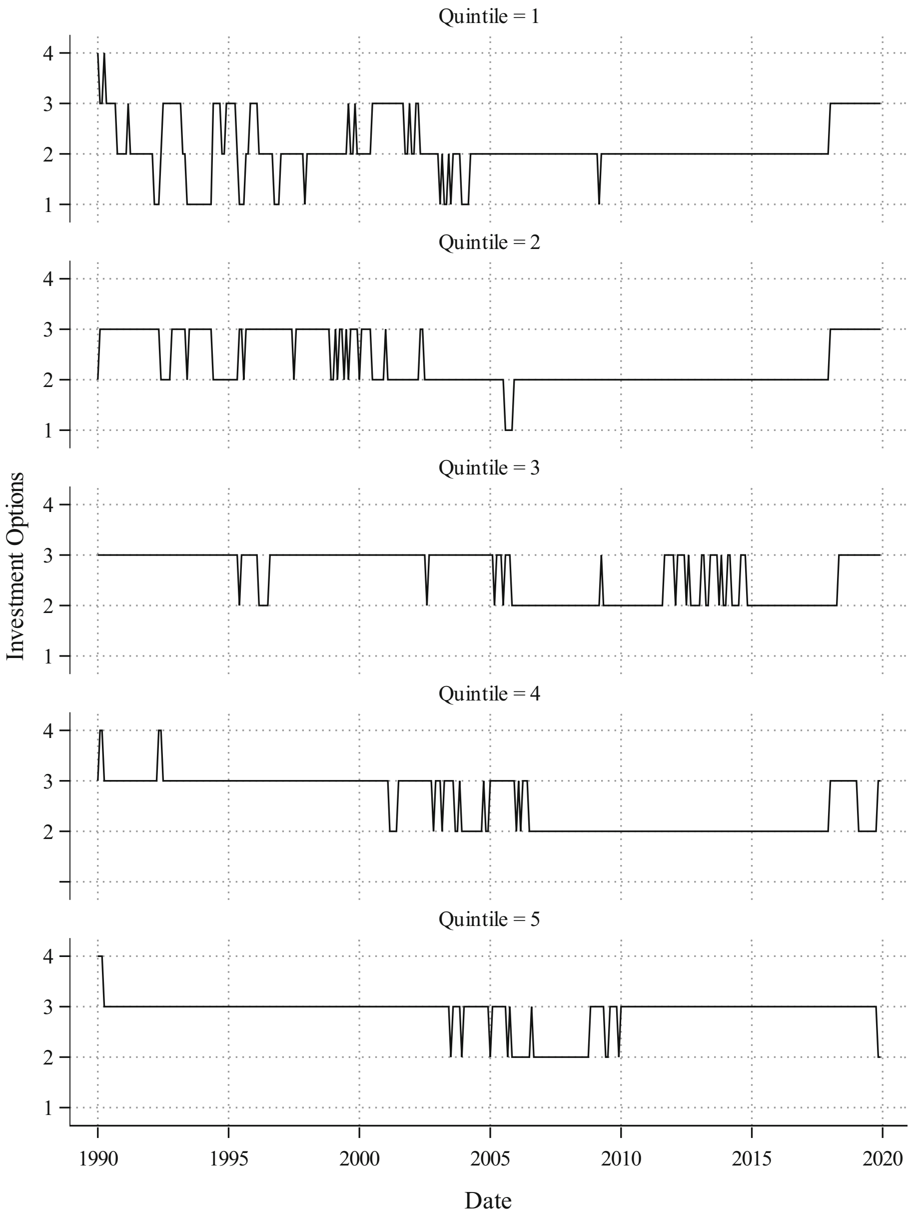

Fig. 2 Investment options of Australian superannuation Industry

overall Australian superannuation industry switches to the investment option *m*. Duration is measured in months.

In addition, we investigate the probability that Australian superannuation industry switch from one investment option to another option by constructing the transition probabilities among options. The maximum likelihood estimates of the transition probabilities can be

Table 2 Summary statistics of weighted proportion of growth asset and return of Australian superannuation industry

	Weighted proportion of growth asset (%)					Weighted average return (%)				
Quintile	1	2	3	4	5	1	2	3	4	5
Mean	74.02	70.80	65.71	63.68	63.06	0.566	0.504	0.534	0.513	0.529
Min	7.08	35.73	33.60	26.30	18.76	− 11.440	− 10.251	− 8.304	− 9.532	− 8.751
Max	94.04	86.11	79.95	77.83	75.93	5.636	5.072	5.142	4.743	4.489
SD	10.61	9.66	9.63	12.88	8.80	2.117	2.077	1.895	1.852	1.808
Obs	360	360	360	360	360	359	359	359	359	359

This table shows the summary statistics for the proportion of growth asset and the average returns weighted by fund sizes across five quintiles of Australian superannuation funds straightforwardly calculated as:

$$p_{i,j} = \frac{n_{i,j}}{\sum_{m=1}^{4} n_{i,m}} \tag{4}$$

where, $p_{i,j} = Probability(s_{t+1} = j|s_t = i)$, that is, probability that Australian superannuation industry switch its investment from strategy *i* at time *t* to strategy *j* at time *t + 1*. $n_{i,j}$ is number of times that Australian superannuation industry switch its investment strategy from *i* to *j*.

In our next analysis, we assess how market conditions affect the performance of the Australian superannuation industry in each investment options across the different quintiles. The performance of the Australian superannuation industry is largely affected by the performance of the asset classes that they invest in. The objective of any superannuation fund (hereafter, superfund) is to be able to maintain the return that they are providing to its members. As a result, the Australian superfunds invest largely in shares (domestic and international), and bonds (domestic and international). Also, they invest largely in infrastructure and unlisted property to achieve their goal of stable flows to investors. Hence, some common factors that affect the returns include the Australian equities, international equities, Australian bonds, and property among others. We therefore extend the univariate Markov Switching model to a multiple observable Markov Regime Switching model specified as follows,

$$r_t = \varphi_{(s_t)} + \beta'_{(s_t)} X_t^{(i)} + \varepsilon_t \varepsilon_t \sim N\left(0, \sigma^2_{(s_t)}\right) \tag{5}$$

where, r_t is the value-weighted monthly return of Australian superfunds realized at end of month *t*. $X_t^{(i)}$ is a vector of explanatory variables that represents market conditions affecting the superfunds' performance. $X_t^{(i)}$ include the monthly price changes of market indices representing asset classes that Australian superfunds invested in. The index *i* indicate the lag threshold that we collect data to calculate monthly price changes. Our main analysis bases on $i = 0$, that means we collect monthly prices at the last day of each month to calculate monthly price changes. To account for predictability of the model using past information, we also perform robustness analyses (presented in Sect. 6) for $i = 1$, 5, and 15.[7]

In our study, we use the ASX All Ordinaries Index, the MSCI World Index, the Australia 10-year government bond index, and the Australian house price index to characterize the domestic equity, international equity, domestic bond, and domestic property market, respectively. We obtain the Australian house price index data provided by CoreLogic via the Securities Industry Research Centre of Asia Pacific (SIRCA) platform, while other indices are collected from Datastream. We present the summary statistics of the control variables in Table 3. In addition, to ensure that our results are not biased due to multicollinearity, we conduct the pairwise correlation analyses as reported in Table 4. We find that, in general, the covariates are not highly correlated to produce the multicollinearity, except for the pair of Australian equity—MSCI returns/volatilities (staying at 74.4%/79.7%). Therefore, alongside our main analysis which includes information of both Australian equity and MSCI, we conduct the robustness analyses that either exclude information of Australian equity or MSCI from the models.[8]

In our model, we allow all parameters (including the variation of the error term, (σ) to be regime dependent. That is, the effects of market conditions on Australian superfunds'

[7] For $i = 1$, 5, and 15, we respectively collect the prices at the 29th, 25th, and 15th day of each month to calculate the monthly price changes included in $X_t^{(i)}$ vector. This is corresponding to the use of lags of 1, 5, and 15 days in explaining the monthly performance of Australian superfunds.

[8] The details on these robustness checks are presented in Sect. 6.

Table 3 Summary statistics of control variables

Variable	Mean	Min	Max	SD	Obs
r_{AUEq}	0.390	– 15.088	7.855	3.743	359
r_{MSCI}	0.392	– 17.981	9.551	3.992	359
r_{AUBond}	0.241	– 8.006	6.442	2.411	359
r_{AUHPI}	0.384	– 1.090	2.039	0.588	359
$\hat{\sigma}_{AUEq}$	14.043	7.101	63.837	6.654	359
$\hat{\sigma}_{MSCI}$	16.547	5.307	92.562	12.007	359
$\hat{\sigma}_{AUBond}$	5.809	5.394	10.292	0.656	359
$\hat{\sigma}_{AUHPI}$	0.052	0.034	0.150	0.018	359
r_{AUD}	– 0.011	– 8.767	17.865	3.367	359
r_{AUGDP}	0.840	– 9.781	8.152	2.903	359
r_{AUCPI}	0.610	– 0.449	3.774	0.545	359

This table shows the descriptive statistics for the control variables employed in Eqs. (5) and (7)

performance are different among investment options. This follows economic intuition that the sensitivity of different investment strategies to changes in market conditions are different due to their different level of risks.

The model's parameters can be estimated by maximizing the following log likelihood function[9]:

$$l = \sum_{m=1}^{4}\sum_{t=1}^{T} I(s_t = m)\ln\left[\left(\frac{1}{\sqrt{2\pi\sigma_{(s_t=m)}}}\right)^T \exp\left(-\frac{1}{2\sigma^2_{(s_t=m)}}\varepsilon_t^2\right)\right] \quad (6)$$

In addition to the markets' impacts on performance of superfunds, it is also important to understand how the market conditions affect the funds' decisions to rebalance their portfolio. This information helps policy makers and investors to foresee reactions of the superfunds given a change in the market conditions. It is intuitive to conjecture that not only changes in market performance but also the changes in risk level of the markets can affect the superfunds' decisions on portfolio rebalancing. Therefore, we explore the effects of market conditions in terms of both return and risk aspects on the probability that Australian superfunds will stay in an investment option. Given that most of observable investment options are in the balanced option and the growth investment option across the different quintile, we model the probability that the fund will stay in these two options using a probit model, which can be specified as follows

$$\Pr(s_t = m) = \Phi\left(\alpha_m + \theta_m' Z_t^{(i)}\right) \quad (7)$$

[9] We note that this maximization procedure follows similar spirits of Haldrup and Nielsen (2006; Haldrup et al., 2010) and Do et al. (2014)'s maximum likelihood approach, in which they develop the likelihood functions to estimate the observable Markov-switching autoregressive models for electricity and stock markets. This procedure is different with estimating the model separately using four linear regressions for four states. This is due to the procedure utilizes all available information for maximization process in one step, while the ordinary least square for each separate model only uses information of a single state in each optimization. It is also worth noting that the application of observable states for investment options is particularly appropriate in our analyses. This is because, in Australia (or New Zealand) investors can subjectively choose a specific investment option that they would like to pour their money in.

Table 4 Correlation matrix among control variables

Variable	r_{AUEq} (%)	r_{MSCI} (%)	r_{AUBond} (%)	r_{AUHPI} (%)	r_{AUD} (%)	r_{AUGDP} (%)	r_{AUCPI} (%)	$\hat{\sigma}_{AUEq}$ (%)	$\hat{\sigma}_{MSCI}$ (%)	$\hat{\sigma}_{AUBond}$ (%)	$\hat{\sigma}_{AUHPI}$ (%)
r_{AUEq}	100										
r_{MSCI}	74.4	100									
r_{AUBond}	1.6	− 12.0	100								
r_{AUHPI}	12.6	10.4	− 17.2	100							
r_{AUD}	− 40.8	− 50.7	20.9	− 15.5	100						
r_{AUGDP}	− 1.3	3.7	− 17.4	19.0	− 15.8	100					
r_{AUCPI}	1.9	0.4	− 6.1	− 4.0	− 11.3	− 9.7	100				
$\hat{\sigma}_{AUEq}$	− 4.5	− 0.6	1.4	− 10.2	− 7.8	− 11.7	− 1.8	100			
$\hat{\sigma}_{MSCI}$	− 3.2	0.4	3.2	2.9	− 13.0	− 11.1	− 3.8	79.7	100		
$\hat{\sigma}_{AUBond}$	− 3.2	0.9	− 7.8	4.2	0.6	6.4	2.4	18.4	15.3	100	
$\hat{\sigma}_{AUHPI}$	0.4	− 0.9	1.0	− 9.4	− 8.7	− 22.0	13.1	16.1	19.6	0.0	100

This table shows the pairwise correlations among control variables employed in Eqs. (5) and (7) where $Z_t^{(i)}$ is the vector of explanatory variables that collect all proxies of market performance included in $X_t^{(i)}$ as well as the risk level of corresponding markets considered in Eq. (5). The index i indicates the lag threshold of the data that we collect as discussed earlier.[10] We also include controls for macro-economic environment including changes in AUD/USD exchange rate, GDP growth, and inflation. To proxy the time-varying risk level of a market j, we estimate conditional volatilities extracted from the AR(1)—GARCH(1, 1) model proposed by Bollerslev (1986) as follows[11]:

$$\begin{cases} r_{jt} = \varphi_j + r_{jt-1} + \varepsilon_{jt}\varepsilon_{jt} \sim iid\left(0, \sigma_{jt}\right) \\ \sigma_{jt} = \alpha_j \sigma_{jt-1} + \beta_j \varepsilon_{jt-1} \end{cases} \tag{8}$$

By using the probit model shown in Eq. (7), θ_m represents the effect of market conditions on the probability that the superfunds will stay in the investment strategy m. In our model (7) for Australian superfunds, we consider the two observable states, $s_t = 2$, (growth options) and $s_t = 3$, (balanced option) due to most of the observations are in these two options as discussed earlier.

5 Results and discussion

5.1 Switching behaviour across fund size

We start our analysis by considering the switching behaviour across the different investment strategies for the different fund sizes. As highlighted in the previous section, we do a quintile analysis. We calculate the duration and probability that the superannuation funds stayed in each of the investment options using Eqs. (2) and (3) as detailed in the data section. Table 5 reports the duration and the probability that the superannuation fund stayed in each of the investment option across our whole sample period and Table 6 reports the results during the GFC period from August 2007 through to July 2009. In both tables, Panel A reports the total duration in months for each investment options across each of the quintile (Q1 indicating the smallest funds and Q5 the largest), panel B reports the average duration and panel C provide the probability that each of the superannuation stayed in each of the investment option.

Overall, the three panels of Table 5 confirms our observations from Figs. 1 and 2. Over the total sample period, panel A indicate that smaller funds represented by Q1 and Q2 (Q1's average total assets of \$1,763,919 and Q2's average total assets of \$10,328,915), have a more aggressive strategy, with the smallest funds having assets held in the growth strategy for 253 months out of the 360 months and funds in Q2 having investment held on the growth option for 230 months. In contrast, the medium to largest funds, Q3 (an average total assets of \$32,319,261) to Q5 (an average total assets of \$1,428,407,384) hold assets in the growth option for 136 months down to 44 months out of the whole sample. The largest funds seem to hold the investment mostly in the balanced option for most of the time. The medium sized funds, in Q3, tend to hold their investment in the balanced investment option for 224 months and the largest superannuation funds tend to hold it for at least 313 months in the balanced option. Panel B and panel C further confirms these observations with the average duration in the growth investment option is higher for Q1 and Q2 at 12.65 and 15.33 and for the largest

[10] We present the result of $i = 0$ in our main analysis. For robustness checks, we use $i = 1$, 5, and 15 days similar to our description in footnote 7.

[11] The optimal lag order is determined by the smallest Akaike Information Criteria, which also passes the serial correlation test for the error term indicating that the models are well specified.

Table 5 Duration and probability that Australian superannuation industry stayed in each investment option over the full sample

Quintile	1	2	3	4	5
Panel A: Total duration (months) that Australian Super Industry stayed in each option					
Aggressive ($s_t = 1$)	31	4	0	0	0
Growth ($s_t = 2$)	253	230	136	169	44
Balanced ($s_t = 3$)	74	126	224	187	313
Conservative ($s_t = 4$)	2	0	0	4	3
Total	360	360	360	360	360
Panel B: Average duration (months) that Australian Super Industry stayed in each option					
Aggressive ($s_t = 1$)	3.10	4.00	0	0	0
Growth ($s_t = 2$)	12.65	15.33	9.07	16.90	4.89
Balanced ($s_t = 3$)	5.69	9.00	14.00	14.38	34.78
Conservative ($s_t = 4$)	1.00	0	0	2.00	3.00
Panel C: Probability that Australian Super Industry stayed in each option					
Aggressive ($s_t = 1$)	8.6%	1.1%	0.0%	0.0%	0.0%
Growth ($s_t = 2$)	70.3%	63.9%	37.8%	46.9%	12.2%
Balanced ($s_t = 3$)	20.6%	35.0%	62.2%	51.9%	86.9%
Conservative ($s_t = 4$)	0.6%	0.0%	0.0%	1.1%	0.8%

This table reports the duration and probability on a quintile basis for superannuation finds over the whole sample. Note that, Q1 represents the smallest funds and Q5 are the largest funds in terms of fund size

The average duration in Panel B is calculated as: $Average\,duration(s_t = m) = \frac{\sum_{d=1}^{D_m} Duration_d(s_t=m)}{D_m}$

And, the probability that Australian superannuation stays in an investment option is calculated as: $Probability(s_t = m) = \frac{\sum_{t=1}^{T} I(s_t=m)}{T}$

funds in Q5, the largest average duration at 34.78 for the balanced option. The probability that the largest funds will stay in the balance investment option is at 86.9%, while the probability that the smallest fund in Q1 will stay in the growth option is at 70.3%. Similarly, Table 6 shows that during the GFC period, on average funds in Q1 to Q4, that is the small to medium sized, stayed mainly in the growth funds for most of the time which varies between 23 and 24 months. The largest funds in Q5 show most of the time they stayed in a growth option with 17 months on average and 7 months in the balanced option. Panel B and Panel C of this table further supports these results.

We further calculate the transition probability using Eq. (4) and the results are reported in Table 7 (full sample) and Table 8 (the GFC period). Both tables show the likelihood that the Australian superannuation industry switches from the "row" option in month *t* to the "column" option in month *t* + *1*. Panel A and Panel B reports the probabilities that the smaller funds will switch their investment strategy monthly. The results here indicate that smaller fund tend to hold more assets in the growth option. More specifically, the probability that Q1 and Q2 funds stay in the growth option is 92.1% and 93.5%, respectively. In addition, the probabilities that they switch from a balanced option in month *t* to a growth option in month *t* + *1* are respectively 15.1% (Q1) and 10.4% (Q2). The panel E shows the results of the larger fund quintile (Q5). Larger funds seem once again to hold most of the investment options in

Table 6 Duration and probability that Australian superannuation industry stayed in each investment option during the Global Financial Crisis period

Quintile	1	2	3	4	5
Panel A: Total duration (months) that Australian Super Industry stayed in each option					
Aggressive ($s_t = 1$)	1	0	0	0	0
Growth ($s_t = 2$)	23	24	23	24	17
Balanced ($s_t = 3$)	0	0	1	0	7
Conservative ($s_t = 4$)	0	0	0	0	0
Total	24	24	24	24	24
Panel B: Average duration (months) that Australian Super Industry stayed in each option					
Aggressive ($s_t = 1$)	1	0	0	0	0
Growth ($s_t = 2$)	11.5	24	11.5	24	8.5
Balanced ($s_t = 3$)	0	0	1	0	7
Conservative ($s_t = 4$)	0	0	0	0	0
Panel C: Probability that Australian Super Industry stayed in each option					
Aggressive ($s_t = 1$)	4.2%	0.0%	0.0%	0.0%	0.0%
Growth ($s_t = 2$)	95.8%	100.0%	95.8%	100.0%	70.8%
Balanced ($s_t = 3$)	0.0%	0.0%	4.2%	0.0%	29.2%
Conservative ($s_t = 4$)	0.0%	0.0%	0.0%	0.0%	0.0%

This table reports the duration and probability on a quintile basis for superannuation finds over the GFC period. Note that, Q1 represents the smallest funds and Q5 are the largest funds in terms of fund size

The average duration in Panel B is calculated as: $Average\, duration(s_t = m) = \frac{\sum_{d=1}^{D_m} Duration_d(s_t=m)}{D_m}$

And, the probability that Australian superannuation stays in an investment option is calculated as: $Probability(s_t = m) = \frac{\sum_{t=1}^{T} I(s_t=m)}{T}$

the balanced option with a probability that it will stay in the balanced option at 97.1%. The larger funds do not seem to be as active as the smaller funds in switching the investment strategy. This is shown by the probability that a large superannuation fund switches from a balanced investment option to a growth option is marginal (only 2.9%).

Table 8 shows that our results obtained using the full sample do not change in the GFC period. The probability that small funds stay in the growth option is at 95.7% for Q1 and 100% for Q2, while for Q5, the probability that a large fund will stay in the balanced option is 85.7%. However, the likelihood that Q5 funds switch from a balanced option to a growth option increase to 14.3% in the GFC period. Based on these tables and the figures reported in the previous section, we therefore conclude that (1) the smaller funds tend to be more active in switching to more aggressive options and they tend to be more active during stable periods, however they look passive during the GFC (Figs. 1, 2); (2) the larger funds are more conservative since they are mostly in the balanced option. In contrast to the smaller funds, they tend to be more active in volatile periods when switching between balanced and growth options and have a passive asset allocation during stable periods.

Our results draw attention to the ongoing debate on active versus passive style of investment. The smaller superannuation funds tend to have a more active style as they are seeking to outperform and aim to provide a better return. They do so on the ground that if their

Table 7 Probability that Australian superannuation industry switch from one option to another option over the full sample

Switch from (row) to (column)	Aggressive ($s_t = 1$)	Growth ($s_t = 2$)	Balanced ($s_t = 3$)	Conservative ($s_t = 4$)
Panel A: Quintile = 1				
Aggressive ($s_t = 1$)	67.7%	29.0%	3.2%	0.0%
Growth ($s_t = 2$)	4.0%	92.1%	4.0%	0.0%
Balanced ($s_t = 3$)	0.0%	15.1%	83.6%	1.4%
Conservative ($s_t = 4$)	0.0%	0.0%	100.0%	0.0%
Panel B: Quintile = 2				
Aggressive ($s_t = 1$)	75.0%	25.0%	0.0%	0.0%
Growth ($s_t = 2$)	0.4%	93.5%	6.1%	0.0%
Balanced ($s_t = 3$)	0.0%	10.4%	89.6%	0.0%
Conservative ($s_t = 4$)	–	–	–	–
Panel C: Quintile = 3				
Aggressive ($s_t = 1$)	–	–	–	–
Growth ($s_t = 2$)	0.0%	89.0%	11.0%	0.0%
Balanced ($s_t = 3$)	0.0%	6.7%	93.3%	0.0%
Conservative ($s_t = 4$)	–	–	–	–
Panel D: Quintile = 4				
Aggressive ($s_t = 1$)	–	–	–	–
Growth ($s_t = 2$)	0.0%	94.1%	5.9%	0.0%
Balanced ($s_t = 3$)	0.0%	5.4%	93.5%	1.1%
Conservative ($s_t = 4$)	0.0%	0.0%	50.0%	50.0%
Panel E: Quintile = 5				
Aggressive ($s_t = 1$)	–	–	–	–
Growth ($s_t = 2$)	0.0%	81.4%	18.6%	0.0%
Balanced ($s_t = 3$)	0.0%	2.9%	97.1%	0.0%
Conservative ($s_t = 4$)	0.0%	0.0%	33.3%	66.7%

This table shows the probability that the Australian Superannuation switches from the *row* option in month *t* to the *column* option in month *t + 1*. The "–" means there is no observation that the Australian Superannuation stays in the *row* option. The transition probability is calculated as, $p_{i,j} = \frac{n_{i,j}}{\sum_{m=1}^{4} n_{i,m}}$ where, $p_{i,j} = Probability(s_{t+1} = j|s_t = i)$, that is, probability that Australian superannuation switches from option *i* at time *t* to option *j* at time *t + 1*. $n_{i,j}$ is number of times that Australian superannuation switches investment option *i* to *j*

investment decisions are successful, this can significantly boost the value of the fund. The smaller superannuation funds try to add value by taking advantage of the volatile nature of the equity markets and hence focus largely on the equity markets. In contrast, in crisis periods for example, the GFC, and other extreme volatile periods as shown in our results, the smaller funds tend to be holding off the active switching of asset class as in the volatile period, they can possibly end up with too many decisions which can be risky and unsuccessful, this can have an adverse impact on the value of the superannuation fund.

Table 8 Probability that Australian superannuation industry switch from one option to another option for Global Financial Crisis period

Switch from (row) to (column)	Aggressive ($s_t = 1$)	Growth ($s_t = 2$)	Balanced ($s_t = 3$)	Conservative ($s_t = 4$)
Panel A: Quintile = 1				
Aggressive ($s_t = 1$)	0.0%	100.0%	0.0%	0.0%
Growth ($s_t = 2$)	4.3%	95.7%	0.0%	0.0%
Balanced ($s_t = 3$)	–	–	–	–
Conservative ($s_t = 4$)	–	–	–	–
Panel B: Quintile = 2				
Aggressive ($s_t = 1$)	–	–	–	–
Growth ($s_t = 2$)	0.0%	100.0%	0.0%	0.0%
Balanced ($s_t = 3$)	–	–	–	–
Conservative ($s_t = 4$)	–	–	–	–
Panel C: Quintile = 3				
Aggressive ($s_t = 1$)	–	–	–	–
Growth ($s_t = 2$)	0.0%	95.7%	4.3%	0.0%
Balanced ($s_t = 3$)	0.0%	100.0%	0.0%	0.0%
Conservative ($s_t = 4$)	–	–	–	–
Panel D: Quintile = 4				
Aggressive ($s_t = 1$)	–	–	–	–
Growth ($s_t = 2$)	0.0%	100.0%	0.0%	0.0%
Balanced ($s_t = 3$)				
Conservative ($s_t = 4$)				
Panel E: Quintile = 5				
Aggressive ($s_t = 1$)	–	–	–	–
Growth ($s_t = 2$)	0.0%	94.1%	5.9%	0.0%
Balanced ($s_t = 3$)	0.0%	14.3%	85.7%	0.0%
Conservative ($s_t = 4$)	–	–	–	–

This table shows the probability that the Australian superannuation fund switches from the *row* option in month *t* to the *column* option in month *t + 1*. The "–" means there is no observation that the Australian Superannuation stays in the *row* option. The transition probability is calculated as, $p_{i,j} = \frac{n_{i,j}}{\sum_{m=1}^{4} n_{i,m}}$ where, $p_{i,j} = Probability(s_{t+1} = j | s_t = i)$, that is, probability that Australian superannuation switches from option *i* at time *t* to option *j* at time *t + 1*. $n_{i,j}$ is number of times that Australian superannuation switches investment option *i* to *j*

In contrast, the larger funds, with a much larger asset base tend to be more passive and have a stable investment strategy with most of the large funds having a balanced option over the sample period. Passive strategies involve mainly the replication of a particular index with the objective to match the index return. Recently, it has been reported[12] that in Australia "around 12% of all funds under management in Australia were invested in index funds a

[12] See Australian Financial Review: Active vs passive investing: There may be a message in the very long-term picture: https://www.afr.com/business/banking-and-finance/investment-banking/karen-maley-on-the-active-v-passive-investment-20170427-gvu39r.

decade ago. Now it is almost double that amount, with more than 20% (in excess of $400 billion) invested in funds that track an index, such as the ASX 100, or the ASX 300". Further it has been highlighted that "it's not too far-fetched to say that around 50%—or $1 trillion—of Australia's superannuation savings is following an index, whether explicitly or otherwise, and the other $1 trillion that is being actively managed is under threat." The large superannuation funds in Australia were mostly affected by the GFC and has had a significant impact on the superannuation funds long term investment strategies and asset allocation, see (OECD report, 2015). Importantly, this has promoted increased focus on proper risk management and on less risky investment strategies. However, in periods of volatility in the market, the large superannuation funds seem to be active in switching the investment strategy. This is because with the large asset base they have they can afford to take advantage of the risk with a view to benefit from the volatility and hence an active approach to investing makes sense in volatile, unpredictable markets for these large funds. With the large asset base that these funds have invested considerably in other assets in addition to the equity and bond markets, they still get the benefits of diversification.

5.2 Impact of asset classes on performance of investment strategies

Our next research question in this paper is to assess which asset classes have the most significant contribution to the performance of the investment options of the superannuation fund. We obtain the monthly price index for all the investment options in this study and calculate the return. We assess to what extent changes in tactical asset allocation impacts on the performance of the investment options. The strategic asset allocation is reviewed for most superannuation on average every 3 to 5 years where the funds consider the expected returns, variances and co-variance of asset classes, see for example, Campbell and Viceria (2002). However, as investment opportunities changes over time, it becomes very important to assess the tactical asset allocation, that is the switch in the asset classes that will reduce the deviation from any long term expected return (e.g., Barberis, 2000; Pastor & Stambaugh, 2001).

In the Australian context, traditionally under the defined benefit scheme, the superannuation funds have been investing largely in the equity and bond markets. With the shift to defined contribution over the years, there has been a shift from the traditional asset classes to an investment in alternative asset classes. Further, with the recent non-conventional low-yield economic climate, in order to maximise returns, the superannuation funds have been increasingly investing in properly and infrastructure. The main advantage of non-traditional investments is that it can increase the diversification benefit and provide a more efficient investment mechanism for gaining exposure to certain assets, and thereby allowing for improvement in the risk adjusted return of an investment portfolio. The Australian superannuation funds hold investment in both listed and unlisted property. This is considered as a long-term investment which aligns with the longer-term investment horizon of investors. Superannuation funds in Australia invest in property given that it includes an income component from rents and capital growth from increases in valuations. While property is less liquid than other assets like equity and bonds, investors receive a return premium as a trade-off for this illiquidity given that property has delivered higher returns with lower volatility. Our dataset provides us with the monthly asset allocation of equity, bond as well as property investment held by Australian superannuation funds. Hence, we assess what are the most prominent factors that contribute to the returns of the investment options and we consider the return on the domestic equity market, the return on the international equity market, the return in domestic bonds and the return based on the monthly house price index. We estimate the parameters using a Markov Switching model to capture the switch across the investment options. We report the results in Table 9 across the five quintiles and due to data availability, we report mostly the performance across the growth (where most of the small funds hold their investment) and the balanced investment options (where most of the large funds hold their investment strategy).

Analysis of Table 9 indicates that the most dominant asset classes which contribute to the performance of the investment options include the equity and bond markets. These are the most important contributors to the performance for the growth and balanced investment options. These observations are consistent across all quintiles and hence across all fund sizes. Our results are in line with the Productivity Commission report[13] in 2018, which highlight that while larger funds can perform better, they do not always and that there are no conclusive links between size and performance. These findings are equally consistent with Cummings (2016) who finds that fund size has a positive impact on the performance of not-for profit funds but not for retail funds.

Our results show that the equity investment (both domestic and international) is the value-adding asset class. However, the domestic equity market is the most prominent asset class as compared to the international equity market. Hence, our results of the domestic equity market are consistent with the finding of Faff et al. (2005). Faff et al. (2005) address the tactical asset allocation and the performance of funds in Australia. They find that active managers have been unable to deliver investors with superior returns through tactical asset allocation. They conclude that the most successful asset class, domestic equities, has been value-enhancing, while international shares and domestic fixed interest have generally detracted value. The domestic equity home bias was largely prevalent pre and even after the GFC in Australia. The period after the GFC was a relatively strong period for the Australian equity market where the performance was relatively better than other global markets because of the continuing demand from a Chinese-induced commodity boom. Australian investors' strong bias towards local equities has been widely documented, see for example, Steinfort and Gray (2012). These studies found that the size of the home country equity bias tends to depend on many factors, including familiarity with the home market, local taxation, such as dividend imputation, currency volatility and transaction costs.

Our contrasting results with Faff et al. (2005) of the international equity market can be clearly explained by the growing attention of international diversification post GFC and the more recent sample period that we are considering in our study. Post GFC, superannuation funds and investors have started to consider the benefits of investing in the international equity markets. The international equity market provides an opportunity to have access to a more diverse range of sectors as compared to the domestic equity market (mostly driven by the banking and resources sector). While investing in international equity markets can bring more volatility, it can equally provide hedge against country specific risk.

An interesting observation from Table 9 is that while the superannuation funds invest in property, the returns of the investment options are not positively affected by the return on the house price index. Hence, we conclude that that investments in property are not value enhancing to the performance of these investment options and the asset class which adds most value is equities. Following the GFC, the superannuation funds started to diversify their portfolio and flied away from the equity markets to include property investment in their portfolio. The returns of the Australian superannuation funds have been very sluggish post

[13] See: Investment performance: Mega super funds fail to deliver best returns: http://www.superguide.com.au/boost-your-superannuation/comparing-super-funds-bigger-mean-better-returns.

Table 9 Effects of market performance on the performance of the Australian superannuation for the full sample

Quintile	1	2	3	4	5
Aggressive (s_t = 1)					
r_{AUEq}	0.391***				
	(0.047)				
r_{MSCI}	0.125**				
	(0.055)				
r_{AUBond}	− 0.018				
	(0.041)				
r_{AUHPI}	0.03				
	(0.234)				
$\hat{\sigma}_{(s_t=1)}$	0.534***				
	(0.036)				
Growth (s_t = 2)					
r_{AUEq}	0.385***	0.388***	0.336***	0.389***	0.366***
	(0.017)	(0.021)	(0.031)	(0.021)	(0.051)
r_{MSCI}	0.205***	0.205***	0.247***	0.19***	0.234***
	(0.016)	(0.021)	(0.032)	(0.022)	(0.054)
r_{AUBond}	0.085***	0.067***	0.14***	0.076***	0.129***
	(0.018)	(0.022)	(0.032)	(0.022)	(0.048)
r_{AUHPI}	0.056	0.056	0.13	0.041	− 0.093
	(0.073)	(0.079)	(0.11)	(0.077)	(0.136)
$\hat{\sigma}_{(s_t=2)}$	0.63***	0.732***	0.723***	0.592***	0.562***
	(0.022)	(0.035)	(0.044)	(0.032)	(0.06)
Balanced (s_t = 3)					
r_{AUEq}	0.301***	0.2***	0.3***	0.258***	0.3***
	(0.02)	(0.029)	(0.016)	(0.021)	(0.014)
r_{MSCI}	0.096***	0.191***	0.124***	0.105***	0.142***
	(0.017)	(0.026)	(0.014)	(0.018)	(0.013)
r_{AUBond}	0.079***	0.065**	0.041**	0.045**	0.026*
	(0.022)	(0.033)	(0.017)	(0.022)	(0.015)
r_{AUHPI}	0.145*	− 0.105	− 0.186**	− 0.177*	− 0.057
	(0.076)	(0.162)	(0.072)	(0.098)	(0.064)
$\hat{\sigma}_{(s_t=3)}$	0.435***	0.862***	0.62***	0.729***	0.629***
	(0.027)	(0.06)	(0.029)	(0.037)	(0.025)
− 2 log likelihood	790.52	692.12	717.40	578.27	605

This table reports the estimated parameters for the following Markov-Switching model using the *full sample*: $r_t = \varphi_{(s_t)} + \beta'_{(s_t)} X_t + \varepsilon_t \; \varepsilon_t \sim N\left(0, \sigma^2_{(s_t)}\right)$

***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively

GFC and it is only in the year 2017 that the Australian superannuation funds posted a double-digit return. While the CoreLogic data from SIRCA show that in 2016 the total return from property prices in Australian capital cities doubled in a short period of time, this asset class cannot outperform in the longer term.[14] Recently, the Australian housing market has seen a slowdown in the prices, and this can be attributed to the tougher lending criteria imposed on the banks by the Australian Prudential Regulation Authority. Hence the performance of the property can be argued to be short-lived and not sustainable over the longer term. The returns analysis from ratings companies like Chantwest further highlight that the returns of the Australian superannuation funds has been mainly driven by the global equities, which rallied thanks to low interest rates, the expectation of tax cuts in the US and a global economic recovery. Australian shares while being quite concentrated have added more than 10%.

We further run a sub-sample analysis to assess the asset classes which contributed to the returns over the GFC period. We report the results in Table 10. Consistent with the results of the full sample in Table 9, the asset class which adds more value to the return across all quintiles of the growth investment option is the equity market. Both the domestic and the international equity markets have contributed to the returns. The domestic bond market does not seem to have the same impact as in the full sample, except for the largest funds in Q5 where the domestic bond market is positive and significant. The standard deviation, which measures volatility, across both Tables 9 and 10 are significant, but volatility is obviously higher with higher parameter estimates in the GFC sample. Hence, our overall conclusion on the asset classes which contribute mostly to the returns of the investment options can be summarised as follows: (1) the asset classes which value add to the performance of the investment options is the equity market and bonds markets; (2) the domestic equity market seems to add more value to the returns as compared to the international equity market-overall and these results seem to be consistent both for the full sample and the GFC analysis; (3) investment in the real estate does not add value to the returns of the investment options and this is the case across all fund size.

5.3 Factors that drive Australian superannuation funds to rebalance portfolio

The initial data analysis indicates that we do have switching in the asset classes which leads to the switch among the four investment options, see Figs. 1 and 2. Smaller funds, in Q1 and Q2, show more switching between the growth and balanced investment option and this happened mostly prior to the GFC period. The smallest fund, in Q1, seem to be taking more risk by switching to the aggressive option as well. The medium sized funds switch is mainly between the growth and balanced fund but most of the switch seem to be in the period of 2012 to 2015. The larger funds in Q4 and Q5 switch mostly between balanced and growth options and this is for the period pre GFC, around the year 2003/2004 to a post GFC to 2010 (for Q5). Hence, we assess in this section what really drive the Australian superannuation funds rebalance their portfolio. In other words, we answer which factors affect the fund's decisions on regarding staying or leaving an investment option. Due to the data limitation, we only estimate the probability that the fund will stay in these two options, balanced and growth options, using a multinomial probit model.[15] The results are reported in Table 11.

[14] See: AFR: "Super fund returns outpace property", date 1 Jan 2018b: https://www.afr.com/personal-finance/superannuation-and-smsfs/super-fund-returns-outpace-property-20180101-h0bxm5.

[15] There are a limited number of observations that each fund quintile staying in conservative or aggressive options.

Table 10 Effect of the market performance on the performance of the Australian superannuation during the Global Financial Crisis period

Quintile	1	2	3	4	5
Growth ($s_t = 2$)					
r_{AUEq}	0.335***	0.372***	0.375***	0.388***	0.391***
	(0.087)	(0.09)	(0.102)	(0.09)	(0.079)
r_{MSCI}	0.299***	0.277***	0.203*	0.188**	0.201**
	(0.079)	(0.083)	(0.098)	(0.083)	(0.08)
r_{AUBond}	0.089	0.125	0.116	0.042	0.221**
	(0.072)	(0.076)	(0.084)	(0.076)	(0.086)
r_{AUHPI}	0.062	0.061	− 0.164	0.003	− 0.024
	(0.271)	(0.285)	(0.313)	(0.284)	(0.203)
$\hat{\sigma}_{(s_t=2)}$	0.885***	0.931***	1.016***	0.926***	0.644***
	(0.131)	(0.134)	(0.145)	(0.134)	(0.11)
Balanced ($s_t = 3$)					
r_{AUEq}					0.311**
					(0.139)
r_{MSCI}					0.288***
					(0.087)
r_{AUBond}					− 0.153
					(0.118)
r_{AUHPI}					− 0.963
					(0.97)
$\hat{\sigma}_{(s_t=3)}$					0.562***
					(0.15)
− 2 log likelihood	26.00	64.67	32.38	64.44	45.08

This table reports the estimated parameters for the following Markov-Switching model using the *Global Financial Crisis sample*: $r_t = \varphi_{(s_t)} + \beta'_{(s_t)} X_t + \varepsilon_t \; \varepsilon_t \sim N\left(0, \sigma^2_{(s_t)}\right)$

***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively

Interestingly, Table 11 shows that the likelihood that the Australian superannuation funds stay in an investment option is not significantly affected by the assets' returns. Instead, the volatilities of the assets impact their decisions. More specifically, an increase in the volatility of the Australian equity market elevates (decreases) the probability of staying in the growth (balanced) option. Meanwhile, an increase in the volatility of the international stock market leads to a decrease (an increase) in the likelihood that Australian superfunds staying in the growth (balanced) option. These results may reflect the confidence of the Australian superfunds in their diversification capacity to protect themselves against the domestic market's volatility, but they are less confidence to be immunised against the volatility in international market.

The volatility of the domestic bond and housing market seem to be a significant factor that causes a switch from an investment option for medium funds (Q2, Q3, and Q4), where an increase in the volatility of housing market (domestic bond) motivates funds to switch from

Table 11 Effect of market conditions on the chance that Australian superannuation stays in an investment option

Quintile	1	2	3	4	5
Growth ($s_t = 2$)					
r_{AUEq}	− 0.049	0.014	0.003	0.012	0.066
	(0.035)	(0.036)	(0.034)	(0.033)	(0.043)
r_{MSCI}	0.033	− 0.052	− 0.041	− 0.007	− 0.078*
	(0.034)	(0.035)	(0.034)	(0.033)	(0.043)
r_{AUBond}	0.031	0.043	0.002	0.000	− 0.034
	(0.036)	(0.036)	(0.034)	(0.033)	(0.042)
r_{AUHPI}	0.216	0.473***	0.073	− 0.104	0.322*
	(0.138)	(0.148)	(0.134)	(0.133)	(0.171)
$\log(\hat{\sigma}_{AUEq})$	0.694**	1.102***	1.884***	0.967***	1.15***
	(0.313)	(0.333)	(0.325)	(0.304)	(0.404)
$\log(\hat{\sigma}_{MSCI})$	− 0.447**	− 0.34*	− 1.298***	− 0.437**	− 0.944***
	(0.198)	(0.205)	(0.22)	(0.192)	(0.279)
$\log(\hat{\sigma}_{AUBond})$	− 0.724	− 1.262	− 2.422***	− 1.741**	− 1.286
	(0.78)	(0.797)	(0.878)	(0.781)	(1.117)
$\log(\hat{\sigma}_{AUHPI})$	0.094	1.37***	0.648*	1.936***	0.561
	(0.343)	(0.386)	(0.333)	(0.37)	(0.418)
r_{AUD}	− 0.003	− 0.036	− 0.038	0.003	0.015
	(0.028)	(0.029)	(0.027)	(0.027)	(0.034)
r_{AUGDP}	0.033	− 0.058**	− 0.038	− 0.036	0.068*
	(0.028)	(0.03)	(0.028)	(0.027)	(0.037)
r_{AUCPI}	− 0.367**	0.677***	− 0.13	− 0.25*	0.443**
	(0.155)	(0.209)	(0.148)	(0.146)	(0.174)
R^2	7.83%	23.59%	23.74%	20.17%	15.57%
Balanced ($s_t = 3$)					
r_{AUEq}	0.052	− 0.019	− 0.003	− 0.012	− 0.066
	(0.039)	(0.036)	(0.034)	(0.033)	(0.043)
r_{MSCI}	− 0.054	0.052	0.041	0.007	0.078*
	(0.037)	(0.035)	(0.034)	(0.033)	(0.043)
r_{AUBond}	− 0.034	− 0.037	− 0.002	0	0.034
	(0.04)	(0.036)	(0.034)	(0.033)	(0.042)
r_{AUHPI}	− 0.297*	− 0.462***	− 0.073	0.104	− 0.322*
	(0.154)	(0.149)	(0.134)	(0.133)	(0.171)
$\log(\hat{\sigma}_{AUEq})$	− 1.32***	− 1.111***	− 1.884***	− 0.967***	− 1.15***
	(0.371)	(0.334)	(0.325)	(0.304)	(0.404)
$\log(\hat{\sigma}_{MSCI})$	0.608***	0.403*	1.298***	0.437**	0.944***

Table 11 (continued)

Quintile	1	2	3	4	5
	(0.218)	(0.206)	(0.22)	(0.192)	(0.279)
$\log(\hat{\sigma}_{AU\,Bond})$	0.568	1.372*	2.422***	1.741**	1.286
	(0.905)	(0.796)	(0.878)	(0.781)	(1.117)
$\log(\hat{\sigma}_{AUHPI})$	− 0.556	− 1.239***	− 0.648*	− 1.936***	− 0.561
	(0.388)	(0.385)	(0.333)	(0.37)	(0.418)
r_{AUD}	0.023	0.032	0.038	− 0.003	− 0.015
	(0.032)	(0.029)	(0.027)	(0.027)	(0.034)
r_{AUGDP}	− 0.086***	0.054*	0.038	0.036	− 0.068*
	(0.032)	(0.03)	(0.028)	(0.027)	(0.037)
r_{AUCPI}	0.441**	− 0.719***	0.13	0.25*	− 0.443**
	(0.175)	(0.212)	(0.148)	(0.146)	(0.174)
R^2	18.27%	22.71%	23.74%	20.17%	15.57%

This table reports the estimated parameters for the following probit models using the *full sample*: $\Pr(s_t = m) = \Phi(\alpha_m + \theta_m' Z_t)$
***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively

balanced (growth) option to growth (balanced) option. This is shown by a combination of the estimated results that an increase in the volatility of housing market increases the likelihood of staying in the growth option but decreases that in the balanced option. However, we observe the opposite trend in case of domestic bond.[16]

6 Robustness analyses

6.1 Lag information

In this section, we discuss additional analyses using the lag information of the asset classes used in Eqs. (5) and (7) to explain the Australia superfund performance and likelihood that it stays in growth and balanced option. More specifically, we choose alternative values of i as 1, 5, and 15 to check the robustness of our main findings and to verify the predictability of the asset classes. These choices are corresponding to the lag of 1, 5, and 15 days of the asset classes that we collect to calculate the monthly price changes compared to the time that the superfund performance is realized.

The results are presented from Table A1 to Table A6 in Online Appendix A. We find that the main findings discussed in Sect. 5 remain highly consistent. The equity and bond asset classes have added values to the performance of Australian superfunds, in which the domestic equity tends to have larger impact than the international equity. Besides, that is the risk level of the asset class, which drives the rebalancing decision of the Australian superfunds on investment options rather than the returns. While the economic relationships discussed in Sect. 5 remain unchanged and still statistically significant, we find that the magnitudes of these relationships have decreased. This is consistent with our expectation since the advanced

[16] We are indebted to the anonymous referees for suggestions on these additional analyses.

technology in trading platform enables the faster information processing in the market and hence, the "lagger" information should have less explanatory power.

6.2 Multicollinearity

As per our correlation analysis shown in Table 4 and discussed in Sect. 4, the return (volatility) of Australian equity is highly correlated with the return (volatility) of the MSCI (a proxy of international equity). This leads to a concern of multicollinearity that may cause bias in our findings. We address this concern by two alternative analyses that excludes either the information of Australian or international equity from the model (5) and (7).

We report the results that excludes information of international equity (MSCI) in Tables A7 and A8 in the Online Appendix A. Meanwhile, the Tables A9 and A10 show the results when excluding the information of Australian equity. Overall, we find that our main findings are highly robust in terms of both economic relationships and statistical significance. Particularly, we still find that, in general, the contribution of the Australian equity to the performance of Australian superfunds is higher than that of the international equity. As a result, we conclude that our main findings are not biased due to multicollinearity.

6.3 New Zealand superannuation

We have documented many interesting findings on the Australian superfunds so far and one of the natural extensions is that whether these characteristics apply to other countries. As we have limited access to data of superannuation funds in other countries, especially the detail information about the investment options, we can only replicate our main analyses on the New Zealand superannuation funds. The choice of New Zealand market is interesting to compare with Australian market in two dimensions. Firstly, the superannuation system in New Zealand is quite similar to Australia in terms of investment options but it is different in the essence that on top of what investor will get from previous regular contribution in a superfund plus investment return when (s)he reaches 65 years old, investor will also get the fixed periodic payment as pension from the government. Secondly, the size of New Zealand superfunds is much smaller than Australian superfunds,[17] and the contribution is voluntary in New Zealand (i.e., if employee decides not to contribute, the employer does not need to contribute for the employee). Besides, it is worth noting that the minimum rate of employer contribution in New Zealand is much smaller than in Australia too (3% versus 10% as in 2021).

We report the results on duration and dynamic switching of New Zealand superfunds' asset allocation for full sample and the GFC period from Table B1 to B4 in Online Appendix B. Meanwhile, the results on the impacts of asset classes on New Zealand superfunds' performance are reported in Table B5 and B6, and finally, Table B7 presents the factors that drives rebalancing decision of New Zealand superfunds on investment options. We note that the monthly House Price Index of New Zealand is only available from 2003, therefore, we exclude this information to preserve the length of our New Zealand sample, which ranges from Feb 2000 to Dec 2019.

We note some distinctive results in our New Zealand sample compared to the Australia one. First, New Zealand superfunds mostly stick with the balanced option with the probabilities

[17] The average fund size of the largest fund quintile (Q5) in New Zealand is around NZD800 million while that in Australia is nearly AUD1.5 billion. We do not report the summary statistics of New Zealand superfunds to conserve space.

ranging from 85.4 to 98.7%. Second, New Zealand superfunds are passive in the essence that they do not actively switch among investment options. These distinctive characteristics of New Zealand superfunds compared to Australia superfunds can be explained by the voluntary contribution, low minimum rate of employer contribution, and fixed periodic payment made by the government at retirement. The combination of these factors can lead to a belief of an investor that the switch among investment options does not significantly increase the performance of the superannuation investment. As a results, majority of investors may just let the system to enrol in the default choice, which is the balanced option, and keep staying there.

For other analyses regarding the impacts of asset classes on New Zealand superfunds' performance and the factors that drives rebalancing decision of New Zealand superfunds on investment options, we generally find similar results as in Australia.

7 Conclusion

The type of investment held by superannuation funds in Australia is very important given the variety of asset classes that the superannuation invests, and the contribution of these assets to the return of the superannuation funds. In this paper, we extend the univariate Markov Switching Model to a multiple version of observable Markov Switching model to analyse the switching behaviour of Australian superannuation funds across asset classes from 1990 to 2017.

Our empirical investigations deliver several important findings, which can be summarized as follows: (1) the smaller funds tend to be more active in switching to aggressive options and they tend to be more active during stable periods. Nevertheless, they seem to be passive during the GFC. In contrast, the larger funds are more conservative since they are mostly in the balanced option. The larger funds tend to switch mostly in the volatile periods for instance during the GFC period. (2) The returns from these investment options are largely dependent on the asset classes that the superannuation funds do invest. However, the asset class which adds most value to the performance of these investment options is the domestic equity market. International equity and the domestic bond market also contribute significantly to the performance of the investment options. Investment in the real estate (i.e., property market), however, does not add significant value to the returns of the investment options. This is consistent across all fund sizes. (3) Finally, we find that the main factors affecting the larger funds' decisions in switching their investment strategy is the volatility of the equity markets (both domestic and international markets). Our results align with the practice in that in the Australian context there is a large number of small superannuation fund and as per the prudential regulator, these superannuation funds with less than $30 billion in assets are labelled as "uncompetitive" with insufficient scale and governance capabilities and hence can be forced to be merged and hence to stay competitive and attract members they have to deliver on the results for members that is returns. These small funds therefore tend to switch and rebalance their portfolios to maintain stated return objectives and stay attractive in the market. For the large funds, they are willing to take the risk in volatile periods like GFC as they equally hold a large portion of assets in Australia a which include the illiquid or unlisted asset like properties, which is a safety for them in volatile period which is not available for the smaller funds. Further, with approximately 50% of asset investment in equity markets by these institutional investors, the large superannuation funds place substantial important to equity as an asset class in their strategic asset allocation.

Our findings remain highly consistent under different robustness analyses, including the utilization of the lag information of asset classes and an accountability for the potential multicollinearity. Our extended analyses on New Zealand superfunds delivers some interestingly distinctive results compared to Australia superfunds, which can be attributed to the different characteristics in the New Zealand superannuation system. We observe that New Zealand superfunds mostly stay in the balanced options and rarely switch their investment options. This passive and more conservative behaviour can be explained by the voluntary contribution, low minimum employer contribution rate and fixed periodic government payment at retirement.

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