Australian Government

Productivity Commission

Economies of scale in superannuation

Superannuation: Assessing Efficiency and Competitiveness, Inquiry Report no. 91

Technical Supplement 8

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The Productivity Commission

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8 Technical supplement: economies of scale in superannuation

Key points

- The Commission's further analysis confirms that evidence of economies of scale in the superannuation system is compelling. Holding other cost drivers constant, larger scale is strongly associated with lower average system expenses (as distinct from fees charged).

  – This relationship is especially pronounced for administration expenses, where realised scale gains are greater than they are for investment expenses, and across all segments. On the investment side, the relationship is strong for the system as a whole; but more so for public sector and retail funds than for industry and corporate funds.

- Significant scale benefits have been realised over the past 13 years, particularly on the administration side. But significant unrealised economies remain.

  – Holding constant other cost drivers, the 'marginal' (or incremental) gains in system savings (accruing from increases in scale in any year) are estimated to have averaged about $340 million each year, or $4.5 billion in total from 2004 to 2017. These are sizeable savings relative to recorded expenses of about $2.5 billion in 2004 and just over $9 billion in 2017.

  – Data limitations rule out estimation of realised 'cumulative' savings (scale benefits that persist beyond the year in which gains are first realised), but no doubt they have been material.

  – Large cost savings can still be realised, especially from further consolidation. For example, the Commission has (conservatively) estimated that annual cost savings of at least $1.8 billion could be realised if the 50 highest cost funds merged with the 10 lowest cost funds.

  – Even modest economies can materially reduce costs. A one basis point reduction in administration expense ratios for funds with more than $10 billion in assets would result in annual savings of about $130 million.

- Scale benefits can also manifest in investment performance — through increasing returns to scale. Net returns are positively related to size for not-for-profit funds. No corresponding correlation was found for for-profit funds.

- There is little evidence that scale benefits have been systematically passed through to members in the form of lower fees (albeit this finding is based on analysis of only 70 per cent of the system).

  – Despite the realisation of economies of scale since 2004, fees charged to members by the median fund did not fall. Though some funds have likely passed through at least some of the scale gains.

  – Not-for-profit funds, on average, may have passed through some scale economies in higher returns (by investing more heavily in (higher-cost) unlisted assets and securing higher returns as a result), but data limitations preclude a firm finding.

(continued next page)

This work responds to one criterion (of 22) developed by the Commission (PC 2016) for assessing the efficiency and competitiveness of Australia's superannuation system — *Are economies of scale realised and the benefits passed through to members?*

'Economies of scale' exist if a fund's costs per member account (or dollar of assets invested) fall as the fund gets larger. If such costs rise with size, a fund exhibits diseconomies of scale.

Why might analysis of economies of scale provide insights into efficiency and competitiveness? Evidence that economies exist but are not being realised could signal a lack of competitive pressure on funds to reduce costs, or that funds face impediments to gaining scale (for example, barriers to exits or mergers) — contributing to inefficiency. Evidence that economies of scale have been achieved but the gains not passed through to members could also signal a lack of competitive pressure. That said, if funds adopt higher-cost, higher-return investment strategies as they grow (achieving increasing returns to scale), the benefits of scale might be seen in higher net returns rather than lower costs. And funds might also have used any realised gains to fund expenditures that would otherwise have been funded by a fee increase — for example, member services, increases in reserves or to meet the cost of new regulatory requirements. (Unfortunately, lack of data deems such analysis elusive.)

To gain insights into economies of scale in superannuation the Commission has considered five questions.

1. *What is the relationship between average cost and scale for super funds?*

2. *How large have the realised economies of scale been?*

3. *What is the scope of unrealised economies of scale?*

4. *To what extent have benefits from scale economies been passed through to members?*

5. *What is the relationship between returns (in total, and relative to a fund's benchmark) and scale?*

In reaching answers to these questions, this technical supplement summarises previous findings (section 8.1), describes the estimation datasets and methodology (section 8.2), then documents the Commission's findings (section 8.3). Analysis of question 5 is presented at the end of section 8.3.

Throughout this supplement, the term 'costs' is used in references to the general concept of costs, 'expenses' is used in references to administration and investment expenses (reflecting the way these costs are labelled in the data used in this supplement); the term 'fees' is used to represent the prices charged to members; and the 'system' is defined to include only Australian Prudential Regulation Authority (APRA)-regulated funds.[1]

In keeping with requirements under the Commission's Act, the methodology and findings have been subject to external technical peer review by Associate Professor Liana Jacobi.[2] The Commission was also advised by Jim Savage, and the work benefited from consultation with industry participants, including feedback received through a technical workshop.[3,4]

8.1 Previous studies have found evidence of economies of scale but have some gaps

Several Australian researchers have attempted to measure economies of scale in superannuation (table 8.1), adopting various definitions of costs, potential explanatory variables and estimation methods. All found at least some confirming evidence. However, these analyses typically focused primarily on the first research question posed above — *What is the relationship between average cost and scale for super funds?* None considered the question of pass through. And some key estimation issues were not addressed.

None of the studies accounted for funds that have exited the industry (potential survivorship bias). Evidence suggests that those funds were small and high cost, meaning estimates of the relationship between fund size and costs generated using information only for remaining funds will be understated. Nor did these studies address the implications of gaps in the data (potential selection bias).

The Commission has estimated a cost model to quantify the extent of unused scale economies and examine the pass-through of realised scale economies that addresses these estimation issues. Details of the approach follow discussion of the dataset.

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[1] APRA-regulated funds are funds regulated by APRA with more than four members. Small APRA-regulated funds have less than five members.

[2] Liana Jacobi is an Associate Professor of economics at the University of Melbourne. Her research interests are in Bayesian econometrics and their applications to health and labour economics. She also co-chairs the Bayesian analysis and modelling research group.

[3] Jim Savage is Head of Data Science at Lendable Inc., based in the United States, and previously worked at the Grattan Institute, where he contributed to papers on superannuation (Minifie, Cameron and Savage 2014, 2015).

[4] The Commission held a by-invitation technical workshop to present and discuss this further analysis in October 2018. Participants are listed in appendix A to the final inquiry report.

Table 8.1   Recent studies on economies of scale in superannuation[a]

	Study details	Findings
Cummings (2016)	Data from 280 funds, 2004–10. Relationship between fund size and investment returns, and investment and operating expenses controlling for assets, average account balance, and retail and not-for-profit status. Ordinary Least Squares (OLS) regression analysis.	Economies of scale exist in operation and investment (through improved diversification) for not-for-profit funds. Economies of scale exist for operation costs, but not investment costs for retail funds (due to platform structure of the funds).
Higgs and Worthington (2012)	Largest 200 funds in 2011. Relationship between fund size and operating and investment expenses, and between fund size and scope economies from insourcing, controlling for assets, members, net contributions and net rollovers (operating expenses) and assets, investment options, % defined benefits, 5 year average return (investment expenses). OLS regression analysis.	Economies of scale exist in operation and investment up to at least 300 per cent of mean fund size. Economies of scope are weak, only exist at extremely large fund size and only for operation — there are generally cost savings in contracting out.
Sy (2012)	Data from all APRA-regulated funds between 2004–11 with positive expenses, more than 100 members, and greater than $10 million in assets. Relationship between fund size and total direct reported expenses controlling for assets, members, public-offer status, and retail and not-for-profit status. OLS regression analysis.	No economies of scale for retail funds (but there are data problems because of related-party transactions). No relationship between retail fund size and fees (due to dissipation of rent to upstream intermediaries). Weak economies of scale for non-profit funds (high extent of outsourcing reduces the fixed cost base from which fund level economies can arise). Natural asset growth is a much bigger source of scale than consolidation.
Rice Warner (2014)	Relationship between fund size and fees, based on APRA and own expenses data for selected funds. Plots of expenses against fund size.	Economies of scale exist in operation (from growing number of members and average account balances) and in investment (from larger mandates). Limited benefits from scale in operation beyond 400 000 members; investment scale largely exhausted at $10 billion of funds under management.
Minifie, Cameron and Savage (2015)	Relationship between fund size and administration fees. OLS regression analysis.	Fixed administration costs are one third of total fund costs and are the key source of scale. Consolidation of 50 largest funds into 25 funds would save one sixth of total costs ($270 million).

a Most of the studies presented in this table classify superannuation fund costs into operational and investment expenses, but some use the terms 'operational' and 'administration' interchangeably.

8.2 Sufficient data are available but quality creates challenges

Data collected and published by the Australian Prudential Regulation Authority (APRA 2018) and the research firm SuperRatings (SR) were used in the analysis.

Data are available for a reasonably large panel of funds

A fund-level panel dataset was formed using APRA data for 2004 to 2016.[5] The panel is unbalanced — that is, data from some funds are not available for the whole period (typically due to fund mergers or exits).

- Eighteen eligible rollover funds and three 'risk-only' funds (run solely to provide insurance) were excluded because they have distinctly different objectives, and therefore operate differently, from other institutional super funds.

- Funds with fewer than three fund–year observations were also excluded because a robust economies of scale relationship cannot be observed with fewer than three observations. Significant consolidation of corporate funds between 2004 and 2006 (from 751 to 198) made up most of these cases.

- And observations for some funds in some years (fund–year observations) were excluded because they lacked data points for all of the variables: member accounts, asset allocation, annual returns and total assets.[6]

The estimation dataset included 494 funds (table 8.2) accounting for 4138 fund–year observations and representing the majority of the system in terms of assets (from 89 to 100 per cent across the time period, table 8.3). About 60 per cent of the (494) funds were in the panel for at least seven years.

Because APRA data lack information about fees charged to members — data needed to explore the pass through of benefits to members — SR data were purchased and linked with the APRA panel.

One downside, however, is that not all funds provide data to SR. As a result, the data capture a relatively smaller subset of funds in the institutional system (table 8.4), and smaller, higher-cost funds are underrepresented. In 2015-16, for example, funds in the APRA panel had average assets of $2.2 billion and average expenses of $16.2 million; those in the SR panel held average assets of $9.9 billion and had average expenses of $64.1 million. Additional selection bias is introduced into the analysis through use of these data. That said, the SR sample

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5 Data were drawn from annual fund-level statistics in which data for small funds were unmasked.

6 While these data could have been imputed, fund–year observations with this characteristic were immaterial, suggesting that excluding them has little impact on the results. Further, this imputation exercise would have significantly reduced the tractability of the model.

accounted for 42 per cent of assets and 71 per cent of member accounts in the system as at 30 June 2017, making it reasonably representative.

Table 8.2   Funds captured in the panel built from APRA data[a,b]

Number of funds by segment, 2004–2016

Segment	2004-05	2009-10	2015-16	Number of unique funds in the sample[c]
Funds captured				
Corporate	181	74	27	138
Industry	67	58	41	65
Public sector	21	21	17	23
Retail	165	170	115	268
Sub-total	**434**	**323**	**200**	**494**
Funds not captured				
Corporate	342	1	0	693
Industry	7	1	0	10
Public sector	5	11	1	7
Retail	68	1	7	201
Sub-total	**422**	**14**	**8**	**911**
Overall total	**856**	**337**	**208**	**1 469**

a Eligible rollover funds (which hold lost super) and risk-only superannuation funds (which only offer insurance) are excluded from this table. **b** The high number of funds not captured (911) relative to the number of funds in the panel in 2004-05 (856) reflects exits by funds that entered the system over the period but remained in operation for 2 or fewer years. **c** Funds are counted based on their last recorded fund-type, as defined by APRA, many corporate funds in particular have changed their classification to retail over the sample period. Note that for modelling purposes each observation is included based on the recorded fund-type at that date.

Source: PC analysis of unpublished APRA data.

Table 8.3   Assets captured in the panel built from APRA data[a]

Percentage of assets captured by segment, 2004–2016

Segment	2004-05	2009-10	2015-16
Corporate	75.5	100	100
Industry	91.5	100	100
Public sector	99.7	100	100
Retail	87.0	98.4	100
Total	**88.5**	**99.2**	**100**

a The denominator used for this table and other coverage metrics in this supplement (unless otherwise stated) is the sum of assets held by funds captured in the APRA fund-level dataset.

Source: PC analysis of unpublished APRA data.

Table 8.4   **Funds captured by SR fees data**
Number of funds by segment, 2004–2016

Segment	2004-05	2009-10	2015-16	Number of unique funds in the sample
Corporate	0	16	12	16
Industry	20	46	41	50
Public sector	3	14	11	15
Retail	8	45	46	57
Total	**31**	**121**	**110**	**138**

Source: PC analysis of SR data.

The combined APRA–SR panel includes 1316 fund–year observations. All analysis except the work on pass through (which requires the fees data) is based on the larger APRA panel.

Some missing data warrant explicit treatment

The APRA data are characterised by high levels of reporting of zero investment expenses (table 8.5) — for example, just over one quarter of funds (mostly retail) reported zero investment expenses in 2015-16. There are systematic differences between funds that do and do not report zeros. In 2016, for example, the average fund reporting zero investment expenses had an annual net return of 2.2 per cent, compared with 6.2 per cent for the average fund reporting positive investment expenses. Investment expenses clearly are not zero. Funds that report zero are likely outsourcing their investment management or provide platform investments and the investment management fees are captured in lower net returns (that is indirectly), rather than explicitly recorded.

Excluding funds with zero investment expenses from the analysis — one option for dealing with the issue — would give rise to significant selection bias because of the prevalence of the issue among retail funds. Results could not then be interpreted as system representative. The extent of the problem means it warrants explicit treatment via imputation of missing information (detailed below).

| Table 8.5 | **Zero investment expenses reporting in the APRA panel** | | |
| | Per cent, 2004–2016 | | |

	2004-05	*2009-10*	*2015-16*
As a share of all funds			
Total	39.0	33.4	27.5
As a share of funds reporting zero investment expenses			
Corporate	48.5	18.5	10.9
Industry	0.6	1.9	3.6
Public sector	0.0	3.7	9.1
Retail	50.9	75.9	76.4

Source: PC analysis of unpublished APRA data.

In contrast to investment expenses, no more than 3 per cent of funds in any year report zero administration expenses. Rather than drop these funds from the analysis, and lose all of the information they bring to the analysis, their administration expenses were imputed.[7]

Inspection of other variables revealed no other major missing data issues, with the exception of the number of investment options, where inexplicably nearly one quarter of fund–year observations were missing. These data were also imputed. Participants have also pointed to significant underreporting of both administration and investment expenses (Industry Super Australia, sub. 59; APRA, sub. 89). Commission estimates suggest that about $11 billion (or 50 per cent) of fee revenue is not reported in APRA data, with expenses data likely to be similarly underreported. Indirect investment costs likely account for a significant proportion of any underreporting. This issue is noted, but it has not been addressed in the reported results.[8]

And survivorship bias has to be taken into account

Substantial consolidation occurred in the superannuation industry over the decade to 2015-16 (table 8.2). Smaller, higher-cost funds were over-represented among those that exited during this period (figure 8.1) — illustrating the need to correct for survivorship bias in the analysis of the relationship between costs and scale.

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[7] The method used for imputation is described below (box 8.2).

[8] The sensitivity of the results to imputation of implausibly low administration and investment expenses was tested but the resulting estimates were not preferred (annex C).

Figure 8.1   **Smaller, higher-cost funds are over-represented in exits**[a,b,c]

Exits between June 2006 and June 2016 by size and average expenses
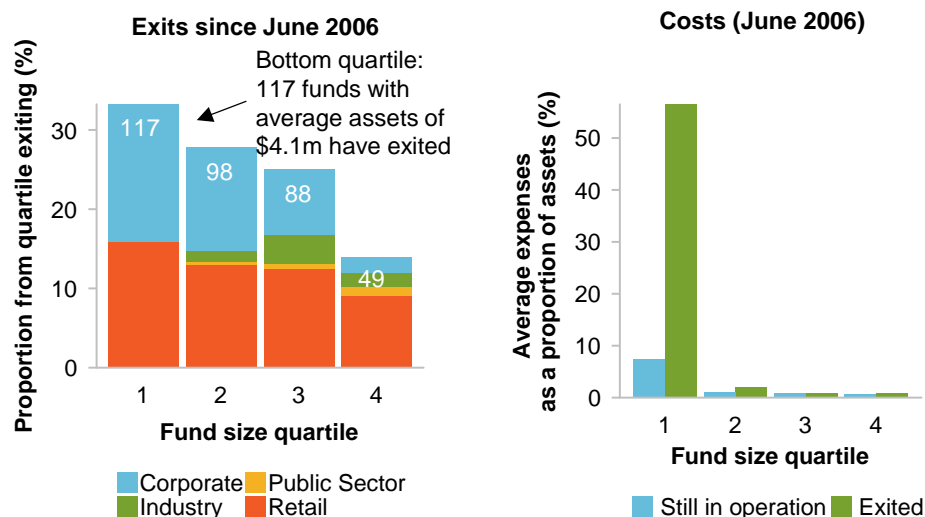
Quartile ranges ($m): 0 to <11, 11 to < 80, 80 to < 658, 658+

Source	PC analysis of unpublished APRA data (2006–2016).
Coverage	513 funds representing 88 per cent of the system by assets in 2005-06. The denominator is the sum of assets for all large APRA-regulated funds.

a A fund is considered to have exited if it left the market in or prior to 2015-16. **b** Fund quartiles were computed using total assets in 2005-06. **c** 2017 data are not included because fund exits are identified by the proceeding year's data.

Economies of scale are present in the raw data

Plotting the data shows — as would be expected — that larger funds record a higher total quantum of administration and investment expenses (as distinct from fees charged) (figure 8.2). The plots also reveal marked differences in the size–expenses relationship for funds in different segments. Retail funds, for example, typically have higher administration expenses than not-for-profit funds of similar size. Plots of *average expenses* show clear evidence of economies of scale, with the exception of the investment expenses reported by industry funds (figure 8.3).

Figure 8.2 **Fund size–expenses relationships vary markedly by fund type**

Total administration and investment expenses by fund size, 2004–2016
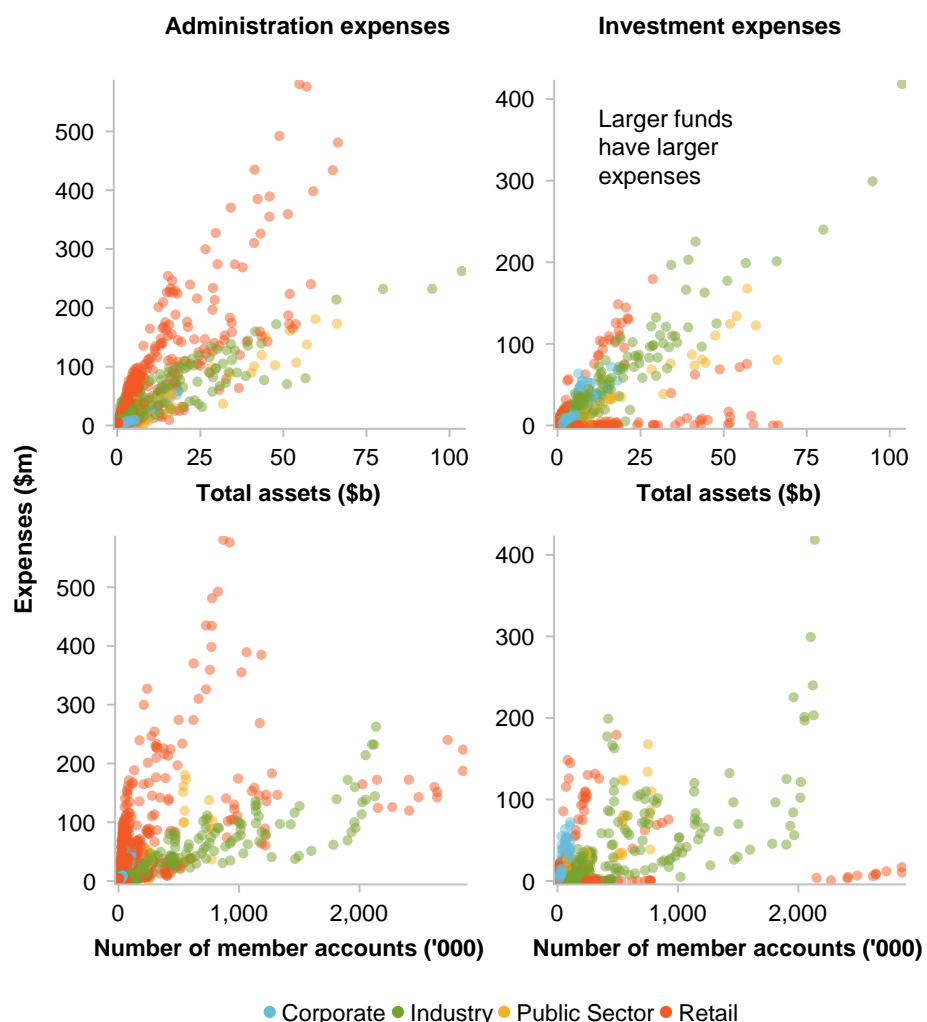
Administration expenses   **Investment expenses**

● Corporate ● Industry ● Public Sector ● Retail

Source	PC analysis of unpublished APRA data (2004–2016).
Coverage	494 funds representing 100 per cent and 91 per cent of the system by assets in 2015-16 and 2004-05 respectively. Excludes funds with less than two years of data.

Figure 8.3   **Economies of scale are evident in the raw data**[a]

Average administration and investment expenses by fund size, basis points (bps), 2004–2016

Administration expenses

Estimated log relationship

Total assets ($b)

Investment expenses

Total assets ($b)

Source	PC analysis of unpublished APRA data (2004–2016).
Coverage	494 funds representing 100 per cent and 91 per cent of the system by assets in 2015-16 and 2004-05 respectively. Excludes funds with less than two years of data.

a The 95 per cent confidence intervals for these relationships are not presented but sit very close to the estimated curves.

Pass-through of economies of scale (through lower average fees) is not evident on casual inspection of the data. If average costs decline as a fund grows and are passed through to members in the form of lower fees 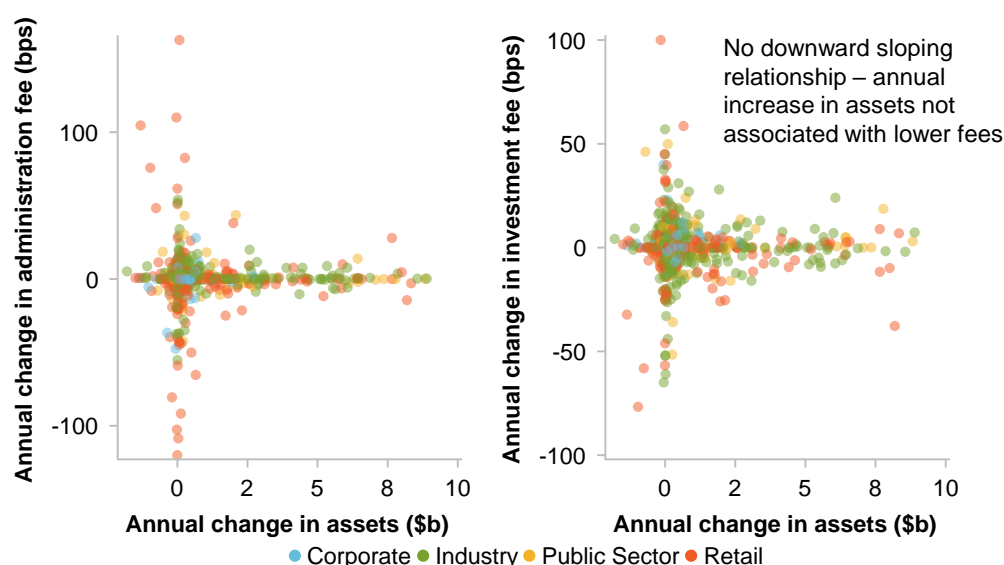one might expect to see fees falling from year to year as funds become larger.[9] The raw data do not suggest a clear relationship of this type (figure 8.4).

Figure 8.4   **Pass-through is not evident on casual inspection of year on year changes in expenses and fees over time**

Annual basis point (bps) changes in administration and investment fees by annual change in size, 2004–2016

Source	PC analysis of SuperRatings and APRA data (2004–2016).
Coverage	118 funds representing 81 per cent and 39 per cent of the system by assets in 2015-16 and 2005-06 respectively for administration and investment. Excludes funds with less than two years of data.

That said, it might be that falls in fees lag the declines in average costs achieved with greater scale by more than a year (for example, because cost reductions come through contract renegotiations that do not happen annually). But a systematic relationship between changes in costs and changes in fees is not apparent when changes over a longer period (specifically, over the 13 years from 2004 to 2017) are compared (figure 8.5). Only about one half of funds (represented by the yellow and blue arrows) saw reported average expenses and average fees move in the same direction over this period (though the picture is muddied for investment expenses by the significant zero reporting and underreporting).

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9   Fees were aggregated from product level data to fund level by taking the average of fees for products available for a fund in the dataset. See annex C for further details.

Figure 8.5 **Nor is pass-through evident on casual inspection when changes between 2004 and 2017 are considered**[a,b]

Changes in fees by changes in expenses, basis points (bps), 2004–2017

Lower cost and lower fee funds have tended to have increasing fees

Each arrow is a fund. This fund started in 2006 with fees of 77bps and expenses of 68bps. In 2017 (not shown) with fees of 59bps and expenses of 28bps.
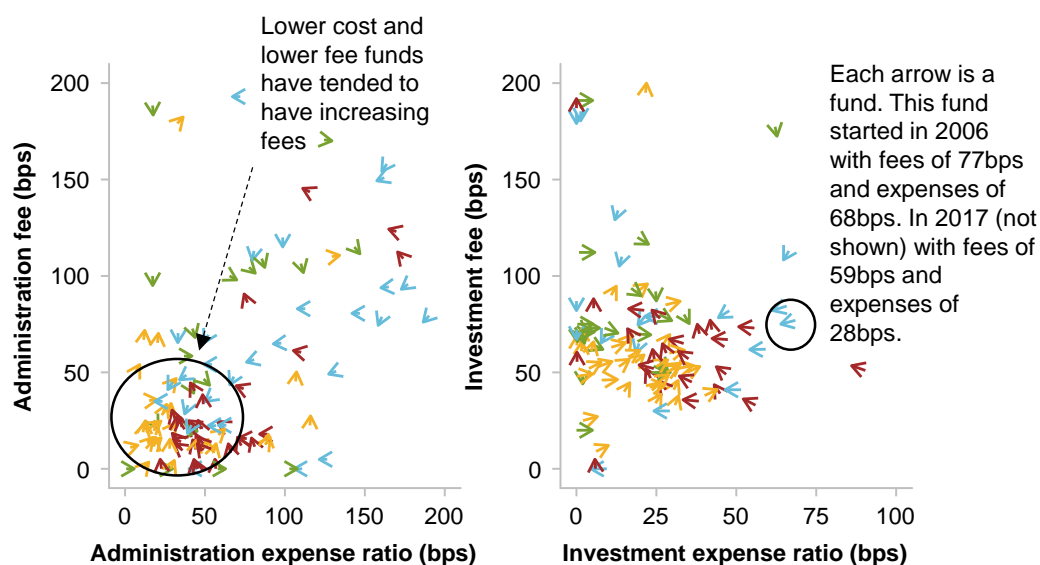
How to interpret the arrows — trajectories, not extent

Increasing fees Decreasing average cost

Increasing fees and average cost

Decreasing fees and average cost (consistent with pass-through)

Decreasing fees Increasing average cost
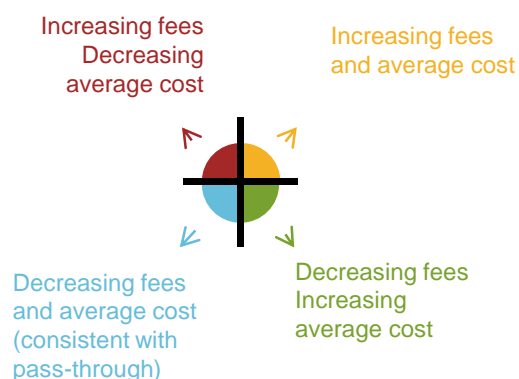
Source PC analysis of unpublished APRA data and SR data.

Coverage 118 funds representing 39 per cent and 81 per cent of the system by assets in 2005-06 and 2015-16, respectively. Excludes funds with less than two years of data.

Distribution of funds by direction of fee and average cost change

	Administration (per cent of funds)	Investment (per cent of funds)
Increasing fees, decreasing average cost	28	25
Increasing fees, increasing average cost	25	32
Decreasing fees, decreasing average cost	31	21
Decreasing fees, increasing average cost	16	23
Total	**100**	**100**

a The whole sample spans 2004–2017, but individual funds may have joined the market later, or exited the market pre-2017. **b** Differences between starting reported expenses and fees could be due to underreporting or assumptions used to calculate fees (for example, calculated for a member with $50 000 balance).

Variables included in the analysis — informed by consultation

Previous research and consultation with a group of participants — technical experts and practitioners identified from the Commission's stage 1 study (PC 2016) — informed the variables included in the analysis (table 8.6). Aside from the key scale variables (total assets and number of member accounts at the end of the financial year), variables were included because they were considered to be key drivers of fund costs whose omission would muddy the estimation of the scale–cost relationship.

Table 8.6   **Variables used in the analysis**[a,b]

Variable	Admin	Investment	Issues/comments
Admin expenses	✓		See previous discussion.
Investment expenses		✓	See previous discussion.
Total assets at the end of the financial year	✓	✓	*Key scale variable,* interacted to allow economies of scale relationships to vary on average by fund type.
			May be timing issues and lumpiness by using an end of period stock measure as it not a perfect measurement of size of the fund throughout the financial year.
			Also used to construct a Hausman instrument (sum of all assets except fund i in the system) for auxiliary models.
Number of member accounts	✓	✓	*Key scale variable,* interacted to allow economies of scale relationships to vary on average by fund type.
			Maybe timing issues and lumpiness by using an end of period stock measure.
			Some missing data.
			Also used to construct a Hausman instrument (sum of all assets except fund i in the system) for auxiliary models.
Net contributions		✓	Net contributions are calculated as total member contributions minus total member benefits paid.
			Included in investment because a net positive position means inflows can be used to reposition portfolios without needing to sell assets and incur transaction costs.
Net rollovers	✓	✓	Included in investment because a net positive position means inflows can be used to reposition portfolios without needing to sell assets and incur transaction costs.
Net insurance flows	✓		Included in administration to represent the costs of processing insurance claims.
Introduction of Stronger Super	✓	✓	A dummy variable representing the period in the sample for which the Stronger Super reforms apply (post 2013-14 inclusive).
Introduction of significant reporting-framework changes	✓	✓	A dummy variable representing the period from 2014 onwards, to capture significant changes in the APRA reporting framework, particular on asset allocation.
			Interacted with asset allocation to allow for a structural break in the type of asset allocation data reported.
Fund type indicators	✓	✓	Corporate, industry, public sector and retail. Used to capture differences in economies of scale by fund type.

(continued next page)

Table 8.6   (continued)

Variable	Admin	Investment	Issues/comments
Asset allocation data		✓	Some missing data.
			Asset classes included in the model are Australian Fixed income, International Fixed income, Australian Listed equity, International Listed equity, Listed Property, Unlisted Property and Other.
			In alternative specifications (annex D), these have been aggregated into fixed income, equity, listed property and other (with unlisted property being included in other) for model parsimony.
			Classes are different from those used in returns analysis, as the Commission has avoided making additional adjustments and assumptions for this analysis.
			Composition of 'Other' may differ markedly between funds.
			Unlisted assets are not accurately captured prior to 2014.
Proportion of in-house managed investments		✓	The Commission collected the proportion of in-house managed investments from 10 funds.
			The Commission tested the inclusion of this variable in an alternative specification (annex C).
Number of investment options	✓	✓	Significant missing data.
			Included to represent the costs of administering large arrays of investment options and incurring larger transaction costs for wrap products.
Annual returns		✓	Used in auxiliary models both by itself and as a Hausman instrument (sum of all returns except fund i in the system).

a APRA provides fund-level financial data to the public, but data for many funds — particularly smaller ones — is 'masked' for privacy reasons. The Commission has used unmasked fund-level financial data. **b** All data cover the period 30 June 2004 to 30 June 2017.

A cost function sits at the centre of the modelling work

A cost function relating funds' characteristics (detailed in table 8.6), including scale, to expenses (costs) is at the centre of the Commission's cost modelling approach. Results derived from this modelling were used in a variety of ways (box 8.1) to obtain answers to the first four of the Commission's questions. Regression analysis, controlling for key factors that are likely to influence returns — in particular, asset allocation — was used to capture the returns–scale relationship, delivering an answer to the fifth question.

| Box 8.1 | **Use of modelling results to answer research questions** |

Answers to the Commission's research questions were derived as follows.

- Question: *What is the relationship between average cost and scale for super funds?*
  Approach: Results from the cost functions were used to estimate the relationship between average costs and scale for each of the funds in the panel.
  Where: pp. 19–24.

- Question: *How large have realised economies of scale been?*
  Approach: The estimated cost functions were used to decompose the actual change in costs over time into contributions from different cost drivers to isolate the extent of realised economies of scale for each of the funds in the panel.
  Where: pp. 24–31.

- Question: *What is the scope of unrealised economies of scale?*
  Approach: Projections from the costs function for funds of different scale were used to estimate the extent of unrealised economies of scale in the Australian super industry.
  Where: pp. 31–32.

- Question: *To what extent have the benefits from scale economies been passed through to members?*
  Approach: Changes in fees were regressed on cost changes (due only to size) estimated from the cost function to determine the extent to which any realised economies of scale have been passed through to members of super funds for each of the funds in the panel. This involved using econometric regression analysis.
  Where: pp. 33–38.

- Question: *What is the relationship between returns (relative to a fund's benchmark) and scale?*
  Approach: Net returns were regressed against fund size to determine if larger funds obtain higher returns. A similar analysis was conducted using returns relative to benchmarks to identify if larger funds make better investment decisions. This involved using econometric regression analysis.
  Where: pp. 38–44.

Data characteristics (and problems) were tackled in a variety of ways

Challenges posed by missing data, and the need to appropriately capture other characteristics of the data, mandated a variety of approaches in the modelling work (box 8.2).

Adoption of a Bayesian statistical framework enabled solutions to all of the modelling issues to be implemented in a coherent way.[10] More detail on Bayesian analysis and the Commission's modelling strategy is presented in annexes A and B, respectively.

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[10] Use of a Bayesian framework was suggested by the consultant to the analysis, Jim Savage, and confirmed by Liana Jacobi in her technical peer review.

Box 8.2 Approaches to missing data and other data characteristics

As a bundle, missing information and other characteristics of the data raised some formidable technical challenges. These were addressed in a variety of ways.
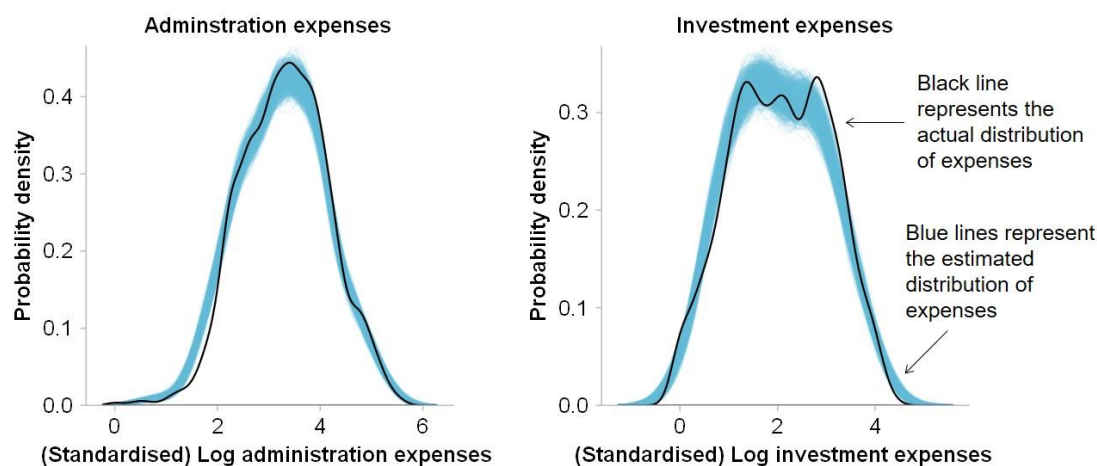
- Gaps in data on expenses and the number of investment options were addressed using imputation. Predictions of missing data for a given fund–year combination were generated using regressions based on the information that was observed for the fund. Tractability constraints ruled out the use of imputation in the pass-through model. As a consequence, the pass-through results must be interpreted as relevant only to the sub-sample of funds used in the analysis, and not as system representative.

- To allow for the possibility of different relationships between scale and administration and investment expenses, the two expenses were modelled separately.

- Investment and administration expenses (the dependent variables), total assets, number of member accounts and number of investment options (all independent variables) were included in the model in logarithmic form.[a,b]

- A Heckman correction approach was used to correct for survivorship bias (Heckman 1979).[c]

- Large variation in the shape of cost functions across funds was addressed using multilevel modelling — effectively, estimation of separate cost curves for each fund. This enabled the derivation of more defensible results in those parts of the analysis that pose 'what if' questions. For example, what cost savings might arise if funds were larger by some amount? Use of system or segment curves for this analysis would impose the assumption that the impact would be similar for all funds (or members of a segment). This would clearly not be accurate. The multilevel approach also enabled analysis of the extent to which individual funds' cost curves exhibit economies of scale, taking into account other factors that influence costs.[d]

[a] Plots supporting the use of log transformations of investment and administration expenses and allowing for fund-level variation in the size–expenses relationship are included in annex F. [b] The model imposes an assumption that a fund can only experience economies of scale or diseconomies of scale. But testing of this assumption reveals that most funds' experiences fit one of these cases. [c] It is assumed that funds make their decision about whether to stay in the market in any year based on their outcomes in the preceding year. The cost model is therefore estimated on data covering 2004–16. Costs are predicted forward to 2017, so that estimates of realised and unrealised economies of scale and the pass-through model are based on data to 2017. [d] Multilevel modelling also has the advantage that it puts less weight on information from funds that appear to be markedly different from their peers — a strong plus given many funds report data of questionable quality.

The modelling does a good job of representing the data

Comparisons of the raw data and predictions from the model indicated that the cost models fit the data well (figure 8.6). For example, the distribution of the (log) administration expenses data (captured by the black line) sits within the distributions of predicted administration expenses (captured by the set of blue lines) at most levels of expenses. A similar conclusion emerges for investment expenses and when the original raw data (rather than log transformations) are considered (annex D).

Figure 8.6   **The models for both administration and investment expenses fit the data well**

Source	PC analysis of unpublished APRA data.
Coverage	494 funds representing 100 per cent and 91 per cent of the system by assets in 2015-16 and 2004-05 respectively. Excludes funds with less than two years of data.

Estimated economy of scale gains are likely to be a lower bound

Restrictions that prevent the trustees of registrable superannuation entities from directly realising profits mean that any realised gains from economies of scale not resulting in lower fees can only manifest in increased expenses or operational reserves. Stakeholders suggested some scenarios where economies of scale gains might not be reflected in lower expenses:

- higher related party expenses. To secure the gains from scale as profit, some funds might keep related-party administration and investment expenses artificially high

- more investments in higher-costs asset classes (such as unlisted assets)

- increased expenditure on member services. In recent years, funds have invested more heavily in member services, particularly through digital transformations. (Some funds have financed these investments from operational reserves.)

- meeting increased regulatory costs arising from changes in the prudential standards (for example, the Stronger Super reforms in 2013).

Gains from scale that do not translate into lower expenses have the potential to lead to underestimates of economies of scale if the drivers of expenses noted above cannot be adequately captured by variables in the model. (And it is not possible, for example, for the Commission to determine whether related-party expenses have been inflated and whether member services have been expanded.) For example, if funds move into more expensive asset classes as they get bigger, but the costs of investing in those asset classes are not

accurately captured in the model, the estimation procedure will conflate those higher investment costs with the changes in costs associated with scale, meaning the estimated gains from scale will be understated.

8.3   Evidence of economies of scale is compelling

Economies exist at the system and segment level

When other factors that influence administration expenses (as distinct from fees charged) are held constant, Commission modelling suggests a clear relationship with scale for all segments of the system. That is, average administration expenses are typically lower in larger funds, with corporate funds realising economies most rapidly.[11]

A similar result exists on the investment side, though the evidence suggests economies of scale in investment expenses are more pronounced for public sector and retail funds (and for the system as a whole) than for industry and corporate funds. As discussed further below, this may reflect the greater use of (higher-cost) unlisted assets by industry funds, with members (potentially) benefiting through higher returns, although data limitations preclude a firm conclusion on this point.

While it is difficult to illustrate these aggregate relationships through traditional figures, the presence of economies of scale can be seen in the 'power coefficients' estimated for each segment (box 8.3; table 8.7).[12] Given these parameters are estimated with uncertainty, a range of estimates spanning the likely true values is reported (box 8.4). For each segment, the range lies between zero and one (the closer the value to zero, the stronger the economies relationship[13]), indicating economies are evident, though the coefficient for investment expenses for industry funds is about one at the top of the distribution[14] — indicating (with 10 per cent probability) that investment costs might not decrease with size for the average industry fund.

Model outputs indicate about a 90 per cent chance that the system cost curves for both administration or investment expenses exhibit economies of scale.[15]

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[11] Participants suggested that the result for corporate funds might reflect economies stemming from companies' use of their own human resources and payroll systems to administer super.

[12] Averaging the fund-specific effects derived from the multi-level modelling (box 8.2) and the impacts of other variables produces a figure that can be hard to interpret.

[13] Strictly speaking, the power coefficient measures the degree of concavity in the relationship. This could be loosely interpreted as 'strength' in the sense that it implies economies of scale are more quickly realised.

[14] And reaches a value of one at the 50th percentile in results generated as part of sensitivity testing of the model.

[15] The system level estimate is calculated from draws from the model's posterior distribution — an output of Bayesian estimated models (annex A).

Further, the potential impact of economies of scale is evident in estimates of how expenses might fall as funds grow. For example, the results imply that, on average, administration expenses (as a share of assets) for an industry fund starting at 65 basis points would fall to 50 basis points (or by 23 per cent) with an increase in size from $500 million to $1 billion.[16] Similarly on the investment expenses side, on average, an industry fund starting at 40 basis points would experience a fall to 37 basis points (or by 7 per cent).

Box 8.3   Power coefficients as an indicator of economies of scale

'Power coefficients', calculated from the estimated coefficients relating to scale, capture the strength of the economies of scale relationship.

A value between zero and one indicates that, when all of the other factors that might influence expenses are taken into account, the relationship between average costs and scale exhibits economies. And the closer the value to zero, the stronger the relationship. Values above one are consistent with diseconomies and values below zero arise when the data suggest that a fund's total costs would fall with larger size.

Power coefficients can be calculated for individual funds (by adding fund-specific scale terms to segment-level scale terms) or at the segment level (by only considering segment-level scale terms).

More detail on the interpretation of scale parameters (and how they are calculated) is presented in annex B.

Table 8.7   Segment power coefficients suggest economies of scale evident[a,b]

	10th percentile	50th percentile	90th percentile	Marginal effect[c] (%)
Administration				
Industry	0.57	0.63	0.70	23
Retail	0.65	0.69	0.74	19
Corporate	0.43	0.48	0.53	30
Public sector	0.43	0.55	0.67	27
Investment				
Industry	0.80	0.89	0.99	7
Retail	0.53	0.59	0.65	25
Corporate	0.70	0.76	0.84	15
Public sector	0.41	0.53	0.64	28

a A power coefficient of less than one indicates economies of scale. The lower the coefficient, the stronger the economies. **b** Multiple power coefficients, spanning a range of values, are generated for each segment by the modelling, reflecting the fact that the coefficients are estimated with uncertainty. Values from different percentiles of that distribution indicate that uncertainty. The value at the 90th percentile, for example, can be interpreted as meaning that '*there is only a 10 per cent probability that the true parameter value is greater than this figure*'. **c** The percentage reduction in average expenses (using median estimates) of a fund increasing in size from $500 million to $1 billion.

Source	PC analysis of unpublished APRA data.
Coverage	494 funds representing 100 per cent and 91 per cent of the system by assets in 2015-16 and 2004-05 respectively. Excludes funds with less than two years of data.

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16 A 'basis point' equals one one-hundredth of one percentage point. So 50 basis points is equivalent to 0.5 per cent, or half of one per cent.

And even small falls in average costs for funds that have already achieved considerable scale (and are typically on a flatter section of their cost curve), would translate into material savings. For example, a one basis point reduction per year in administration expense ratios for funds with assets of over $10 billion (currently about 35 basis points on average) would translate to about $130 million in savings per year.

The findings of economies of scale in administration expenses is consistent with past studies (table 8.1). Cummings (2016) found evidence of economies of scale in operating expenses for both retail and not-for-profit funds as assets increase, and Minifie, Cameron and Savage (2015) had similar findings as the number of member accounts rise. For investment expenses, Higgs and Worthington (2012) found economies of scale across the system (however their results only utilise a single year of data).

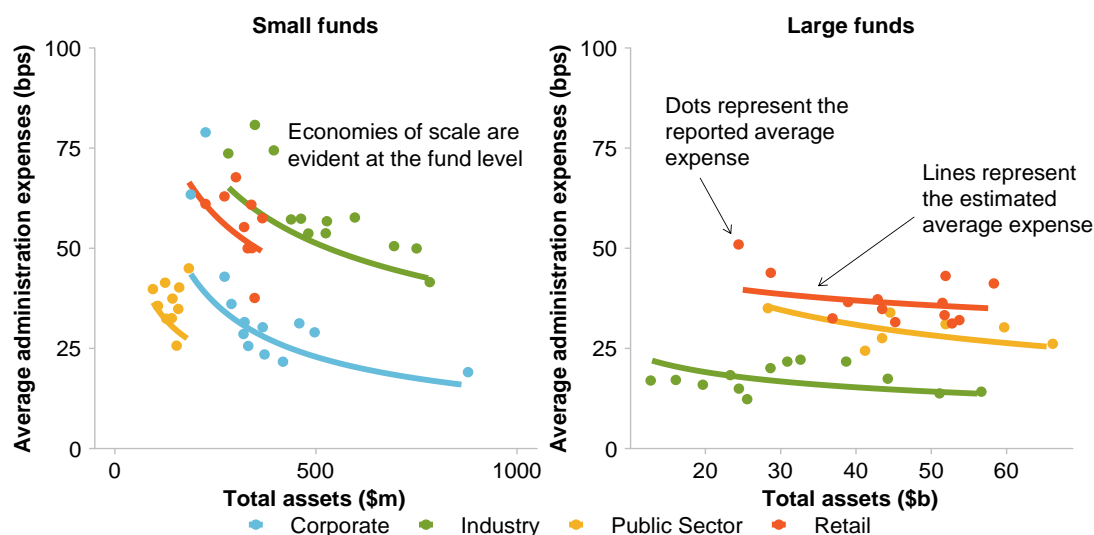### Box 8.4   How are Bayesian outputs interpreted?

Bayesian methods deliver parameter estimates spanning a range of possible values. The choice of which statistic to present requires judgment. In this work, the median (50th percentile) is preferred as it represents outcomes with a reasonable chance of occurring and is not skewed, as the mean can be, by outlier draws. Uncertainty associated with an estimate is often indicated by presenting values from percentiles at the top and bottom of the span. The value at the 90th percentile, for example, can be interpreted as meaning that '*there is only a 10 per cent probability that the true parameter value is greater than this figure*'. Values between the 2.5th and 97.5th percentiles can be interpreted as indicating that '*there is a 95 per cent chance that the true parameter value lies in this range*'. This is sometimes referred to as a *credibility interval.*

Economies of scale are also evident at the fund level

As noted above (box 8.2), use of a multilevel model has the advantage of shedding light on the relationship between costs and scale at a fund level (by adding fund-specific effects to segment effects). To illustrate this point, figures 8.7 and 8.8 provide examples of estimated average cost curves *for selected funds* — holding constant factors other than scale that are associated with expenses.

Power coefficients can also be generated for individual funds. Those estimates indicate, for both administration and investment expenses (as distinct from fees charged), that at least half of all funds almost certainly have cost curves that exhibit economies of scale — that is, they have power coefficients that are less than one (with 97.5 per cent probability) (figures 8.9 and 8.10). Consistent with observations at a segment level, however, industry funds are less likely to be in this group for investment expenses.

Figure 8.7　Examples of economies of scale in administration expenses[a,b,c]

Projected average administration expenses, **selected** funds, basis points (bps)

a Each line represents the median estimated cost curve for a single fund chosen for illustrative purposes; the curves are not representative of all funds within a segment. **b** Curves estimated using data over 2004–2016. Small funds had assets of less than **$1 billion**, and large funds of more than **$50 billion**, when last observed in the data. **c** No example is presented for a large corporate fund — no corporate fund in the dataset is large.

Source: PC analysis of unpublished APRA data and SR data — sample of funds.

Figure 8.8　**Examples of economies of scale in investment expenses**[a,b,c]

Predicted average investment expenses, **selected** funds, basis points (bps)

a Each line represents the median estimated cost curve for a single fund chosen for illustrative purposes; the curves are not representative of all funds within a segment. **b** Curves estimated using data over 2004–2016. Small funds had assets of less than **$1 billion**, and large funds of more than **$50 billion**, when last observed in the data. **c** No example is presented for a large corporate fund — no corporate fund in the dataset is large.

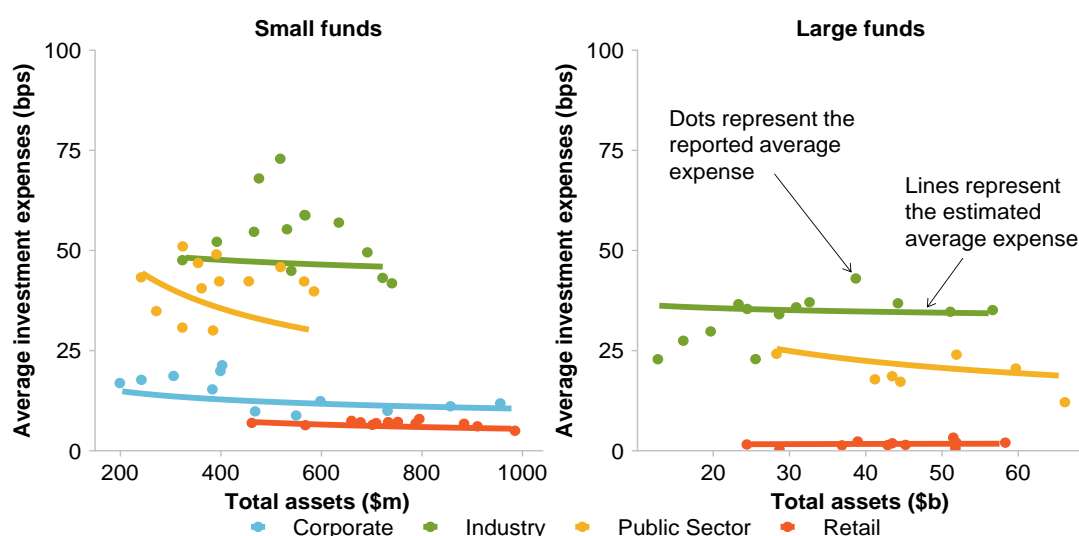*Source*: PC analysis of unpublished APRA data and SR data — sample of funds.

Figure 8.8   Examples of economies of scale in investment expenses[a,b,c]

Predicted average investment expenses, **selected** funds, basis points (bps)

Figure 8.9   Most funds' administration cost functions exhibit economies of scale[a]

Power coefficient estimates, administration expenses

Source	PC analysis of unpublished APRA data.
Coverage	494 funds representing 100 per cent and 91 per cent of the system by assets in 2015-16 and 2004-05 respectively. Excludes funds with less than two years of data.

a The power coefficient summarises the relationship between costs and scale in a fund's cost function. Estimates spanning the 2.5th and 97.5th percentiles are presented for each fund. Black dots represent the median for each fund.

Figure 8.10　**Most funds' investment cost functions exhibit economies of scale**[a]

Power coefficient estimates, investment expenses

Source	PC analysis of unpublished APRA data.
Coverage	494 funds representing 100 per cent and 91 per cent of the system by assets in 2015-16 and 2004-05 respectively. Excludes funds with less than two years of data.

a The power coefficient summarises the relationship between costs and scale in a fund's cost function. Estimates spanning the 2.5th and 97.5th percentiles are presented for each fund. Black dots represent the median for each fund.
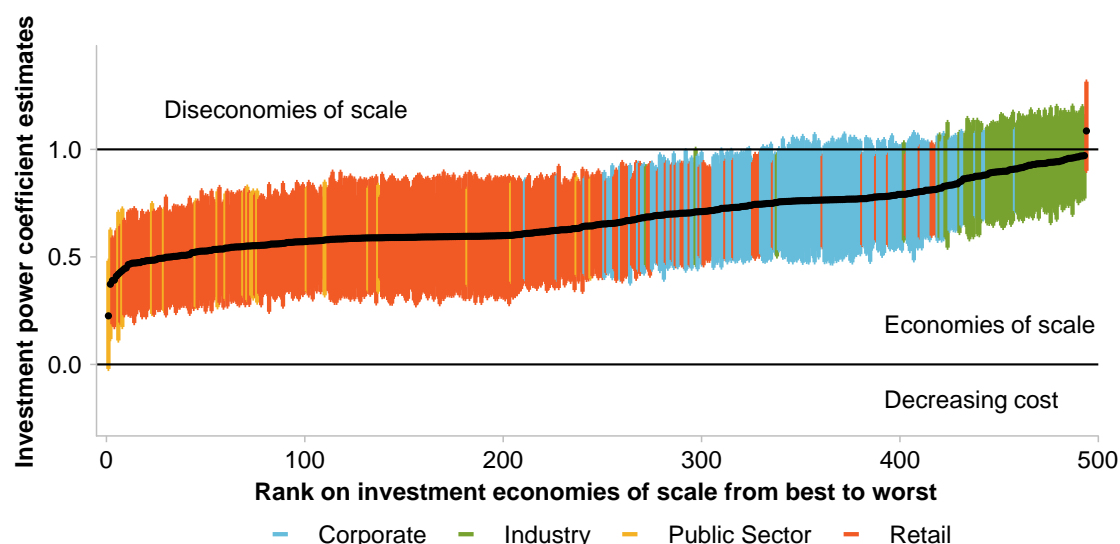
Economies of scale have been realised across the system since 2004 but other expenses have risen

Gains are evident

Over the period 2004 to 2017, abstracting from other factors that influence costs, the modelling estimates reveal that the majority of funds have realised economies of scale in administration (figure 8.11) and investment (figure 8.12) expenses. In other words, if nothing else that impacts fund expenses had changed over this period, average expenses (as distinct from fees charged) would have fallen for most funds. The black line in each figure plots individual fund's estimated expenses in 2004 (or whenever a fund first appears in the dataset), ranked from lowest to highest. The dots represent estimated expenses in 2017 (or whenever a fund exited the system). The majority of dots in both figures fall below the black line, illustrating realised economies. Larger realised gains are evident for administration than for investment expenses.

Figure 8.11 **Most funds have realised scale benefits in administration expenses**[a,b]

Projected cost changes, basis points (bps), 2004–17, administration expenses

a The black line denotes the estimate average cost for funds in 2004 (or their first year of operation). The dots denote their estimated average costs with their assets and number of member accounts for 2017 (or their last year of operation). The vertical gap between the dots and the black line represent the fund's estimated average cost reduction or increase from scale. Funds are ordered by estimated average cost in 2004. **b** Starting estimated average costs close to zero for some funds are likely to be due to underreported costs.

Figure 8.12   **A similar story for investment expenses**[a,b]

Projected cost changes, basis points (bps), 2004–17, investment expenses

Source	PC analysis of unpublished APRA data.
Coverage	494 funds representing 100 per cent and 91 per cent of the system by assets in 2015-16 and 2004-05 respectively. Excludes funds with less than two years of data.

a The black line denotes the estimate average cost for funds in 2004 (or their first year of operation). The dots denote their estimated average costs with their assets and number of member accounts for 2017 (or their last year of operation). The vertical gap between the dots and the black line represent the fund's estimated average cost reduction or increase from scale. Funds are ordered by estimated average cost in 2004. **b** Starting estimated average costs close to zero for some funds are likely to be due to underreported costs (or imputed values that are estimated as larger than zero for zero expense reporting funds, but still small). The number of observations with low starting estimated average costs reinforces the problem of underreporting.

… and translate to significant system savings

At a system level, potential cost savings associated with scale could be achieved through:

- organic growth in funds' assets stemming from investment returns or contributions

- the exit of higher cost funds from the system and the transfer of their assets to lower cost funds.

The approach used to calculate the savings from each of these sources is presented in box 8.5.

Box 8.5   **Calculating system savings from realised economies of scale**

The Commission has estimated realised economies of scale from two sources.

1. Reductions in costs generated by organic growth (due to investment returns or contributions). This is calculated by multiplying the stock of assets for a fund in a given year and the fund's additional assets excluding net rollovers, by the difference between the fund's:

    (a) estimated average cost in the previous year

    (b) estimated average cost with the current year's assets (other variables held constant).

2. The gains generated from funds exiting the system and their members moving to (typically) lower cost funds. This is calculated by multiplying the value of net rollovers by the difference between:

    (a) the estimated average costs of the leaving funds

    (b) the estimated average system cost in the same year.

These calculations are not perfect and likely understate the full extent of savings. First, because the calculations are performed on a year-by-year basis they only capture these 'marginal' savings and miss any cumulative savings. For example, in the *highly* stylised figure below, the average expense ratio falls over the first year depicted, with savings represented by area A. In the following year, the ratio falls further, with savings represented by area C. The Commission's modelling captures these (marginal) changes. But there are also potential gains in the second year, represented by the area B — that is, gains realised in the first year likely persist into the future. Similar arguments can be made for later years. These cumulative gains are not captured in the Commission's estimates. Second, the estimated average system cost used in calculating the gains from funds exiting the system is likely to be high relative to the costs in the funds that actually receive assets from exiting funds.

A *highly* stylised illustration of potential system savings
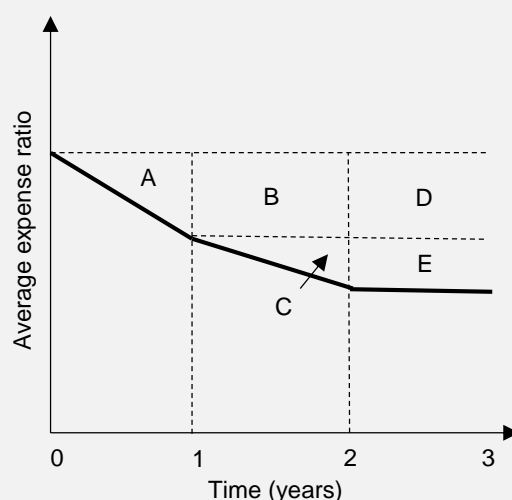
Derivation of estimates of the size of both cumulative savings and those stemming from funds exits would require data on the flow of assets between funds, and this is not recorded in the data. The Commission has, therefore, taken a more conservative approach in deriving estimates of both realised (and unrealised) gains.

Holding constant other factors that influence costs, between 2004 and 2017, *marginal* system savings — that is, the incremental gains accrued from year to year (further defined in box 8.5) — associated with realised economies of scale are conservatively estimated to have averaged about $340 million a year — or (with 50 per cent probability) to have totalled about $4.5 billion for the period (figure 8.13; table 8.8).

These are significant savings (and, as discussed in box 8.5, are likely to be underestimates). For context, recorded expenses for APRA-regulated funds were about $2.5 billion in 2004 and just over $9 billion in 2017.

Figure 8.13   **Large system savings from realised economies of scale**[a,b,c]

Median marginal cost savings associated with realised economies of scale (EOS), 2005–2017

| Source | PC analysis of unpublished APRA data. |
| Coverage | 494 funds representing 100 per cent and 91 per cent of the system by assets in 2015-16 and 2004-05 respectively. Excludes funds with less than two years of data. |

[a] Many factors contribute to these being underestimates (two key ones are described in box 8.5). On the other hand, the full extent of transition costs cannot be observed in APRA data — a source of overestimation in these estimates. [b] Funds that reported asset allocations which included other assets of more than 95 per cent were excluded from this calculation. [c] The larger estimate for 2017 was influenced by a significant increase in reported net assets for Australian public service super funds. The effect of this is likely to be in the order of $150 million. The smaller estimates for 2008 and 2009 reflect the impact of the global financial crisis.

Source: PC analysis of unpublished APRA data.

Table 8.8   **Large system savings from realised economies of scale[a,b]**
Marginal cost savings associated with realised EOS between 2004 and 2017

	Average marginal savings per year[c] ($ million)	Total marginal savings across the period ($ billion)
With 90% probability system marginal realised economies of scale are at least	264	3.4
With 50% probability system marginal realised economies of scale are at least	344	4.5
With 10% probability system marginal realised economies of scale are at least	490	6.4

Many factors contribute to these being underestimates (two key ones are described in box 8.5)). On the other hand, the full extent of transition costs cannot be observed in APRA data — a source of overestimation in these estimates. **b** Funds that reported asset allocations which included other assets of more than 95% were excluded from this calculation. **c** Average in this case refers to average annual marginal savings over the 14 year period.

Source: PC analysis of unpublished APRA data.

But realised gains associated with scale have not been fully reflected in reported expenses

A question to ask and answer at this point is 'how do changes in reported expenses compare with the changes associated only with realised economies of scale (that is, the estimated changes in expenses when cost drivers other than scale are held constant)'?

Inspection of data for funds that were in the APRA panel in 2004 and/or 2017 reveals that reported administration expenses were markedly lower in 2017 than in 2004, while reported investment expenses were marginally lower (figure 8.14). Differences in administration expenses between the two points in time were driven, particularly, by lower expenses for retail and industry funds, while lower investment expenses for retail and public sector funds were offset by higher expenses for industry funds. These observations are consistent with the analysis presented in chapter 3 of the Commission's report.

But the economies of scale analysis that has to lie behind an answer to the question posed above draws on data that includes funds within the APRA panel *at any point* between 2004 and 2017. Many funds were in the dataset for a relatively short period of time. In order to generate a robust comparison of reported and estimated changes in expenses, reported expenses for each fund were calculated as the difference in their reported expenses between the first and last years in which they appear in the data. So, for example, if a fund entered in 2010 and exited in 2014, the difference in their reported expenses is calculated as the difference between whatever expenses they reported in those two years. Not surprisingly, the calculated differences in reported expenses for many funds are relatively small.

Figure 8.14   **Reported average administration expenses have fallen markedly at a system level; investment expenses much less so**
2004–2017

Source	PC analysis of unpublished APRA data.
Coverage	494 funds representing 100 per cent and 91 per cent of the system by assets in 2015-16 and 2004-05 respectively. Excludes funds with less than two years of data.

In comparing changes in reported and estimated expenses, the Commission has used medians of the differences in reported expenses and estimated realised economies of scale for all funds in the APRA panel.[17] As would be expected, this median difference in reported expenses is markedly smaller than the figure implied by comparison of the system-level means in 2004 and 2017 depicted in figure 8.14.

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[17] Calculating a weighted mean for funds in the sample for different time periods would have been challenging given the large increases in size experienced by some funds.

The Commission's comparison of changes in reported and estimated expenses suggests that not all realised gains associated with scale have been reflected in lower reported costs:

- the median difference in reported administration expenses was about 3 basis points. Holding constant other factors that influence administration expenses, the median estimated gains from scale for the same set of funds was 8 basis points over the period.[18] There are a number of potential explanations for this observation. Inquiry participants noted that funds have significantly invested in member services over recent years. Funds may have also incurred costs associated with regulatory change (for example, the introduction of SuperStream)

- the median difference in reported investment expenses was smaller (around 1 basis point). Holding constant other factors that influence investment expenses, the median estimated gains from scale were also about 1 basis point over the period.[19]

Consistent with these observations for administration expenses, there has also been incomplete pass through of realised gains from scale to the fees charged to members (discussed below) — though this analysis only applies to the subset of funds with fees data.

Unrealised economies of scale are large

Clearly, organic growth in the system will deliver further gains from economies of scale in the future. But gains can and should also come from consolidation — particularly the exit of higher cost funds. The Commission has estimated the potential system savings that would arise if higher-cost funds merged with the lowest cost funds **and** those lowest cost funds experienced economies of scale as they increased in size.[20]

As for realised gains, estimated potential savings are significant. For example, savings from a scenario where mergers occurred between the 50 highest cost and 10 lowest cost funds (agnostic of fund type) are estimated to be at least $1.8 billion (with 50 per cent probability)

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[18] This is calculated as the median gap from figure 8.11. While the sample is over 2004–2017, funds may have entered after 2004 and left before 2017. Funds with imputed expenses are excluded from this calculation.

[19] This is calculated as the median gap from figure 8.12. While the sample is over 2004–2017, funds may have entered after 2004 and left before 2017. Funds with imputed expenses are excluded from this calculation. The estimated gains from scale in investment expenses are much lower than the gains in administration expenses for two reasons: 1) the power coefficient for industry funds is much larger when estimating investment costs, which reduces the gains available to industry funds and 2) reported investment expenses are typically lower than administration expenses and subject to significant underreporting, which reduces the scope for gains (as shown in figure 8.12).

[20] Cost savings were calculated for a range of scenarios, each with progressively more funds being assumed to exit. Funds were assumed to merge with the 10 lowest cost funds with total average costs greater than 45 basis points (to avoid allocating assets to funds with underreported expenses). The mergers were conducted at random, but in proportion such that the lowest cost fund received more of the incoming assets than other funds.

(figure 8.15).[21] And even under some conservative scenarios where the lowest cost group includes some funds estimated to have diseconomies of scale in investment, the potential gains are still at least as large as $750 million.

If the median cost saving from these gains was passed through to *all* members as lower fees (a reduction of about 10 basis points) then holding all other costs constant an average member within the system would be $22 000 better off in retirement. (This benefit to members may appear modest relatively to Commission's cameos in the report, but disparate to those cameos this benefit applies to all members.) Gains to members of higher cost funds would be markedly larger.

Figure 8.15   **Unrealised economies of scale — a source of large potential savings**[a,b]
Estimated savings per annum, $billion
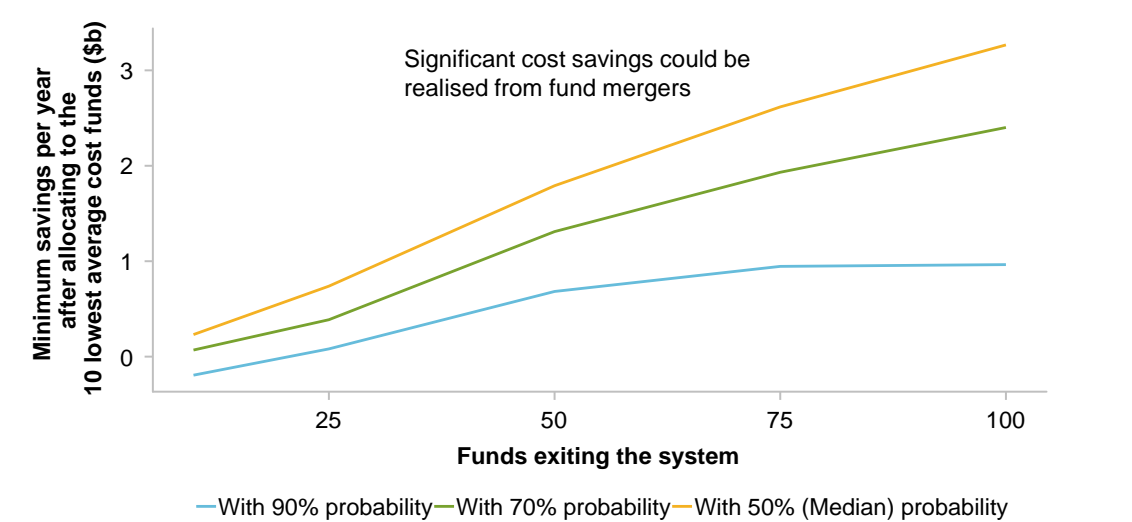
Source	PC analysis of unpublished APRA data.	
Median coverage[c]	By funds	By assets
	107 (out of 180)	$705b (out of $1532.7b)

a Funds with estimated total average costs of less than 45 basis points were excluded from this analysis (to avoid allocating assets to funds with underreported expenses). **b** The 90 per cent probability curve shows a flattening of the savings because the group of lowest cost funds includes estimates for industry funds that exhibit diseconomies of scale. Similarly as funds are allocated to the lowest 10 at random, if industry funds have diseconomies of scale, then it is possible for the curves to start with losses. **c** Because funds with estimated total average costs of less than 45 basis points were excluded, the number of funds excluded varies across each posterior draw.

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[21] These estimates do not take into account transition costs, nor potential strategic responses by funds or changes in member behaviour — for example, increasing contributions to a lower cost fund.

No evidence that EOS gains have been systematically passed-through as lower fees

Despite the realisation of economies of scale between 2004 and 2017, there was little change in the actual fees charged to members (as a percentage of assets) for *the median fund (*for which data on fees is available). (But there has been a reduction in the average (mean) investment fee for the retail segment, driven by significant reductions in fees by some large funds.)

At a system level, for example, the estimate of the median reduction in average expenses *attributable to size changes alone* between 2004 and 2017 lies between 10 and 18 basis points for administration expenses (captured by the vertical purple line in figure 8.16 which also depicts the mid-point of the range, - 14), and between 0 to 4 basis points for investment expenses (captured by the vertical purple line in figure 8.17 with a mid-point value of -2). In contrast, median fees (captured by the purple dot in each figure) barely changed and sit well above the top of the span of estimates for the median reduction in average expenses for both administration and investment.

Figure 8.16 **Administration fees have increased despite economies of scale gains in administration expenses**[a,b]

Median fee change, basis points (bps), compared with size-related changes in average expenses over 2004–2017

Source	PC analysis of SuperRatings and APRA data.		
Coverage	118 funds representing 81 per cent and 39 per cent of the system by assets in 2015-16 and 2005-06 respectively for administration and investment. Excludes funds with less than two years of data.		
Survivor bias	No.	Selection bias	Yes.

a Dots capture the median of actual fee changes within the system or a segment between 2004 and 2017. Lines represent the 95 per cent range for fund-level estimates of the median change in expenses associated with changes in scale over this period. Crosses represent the median of that range. The time period for the actual change in fees can differ between funds, depending on when they entered/exited. b Mid-point represents the 50th percentile of the estimated range.

Figure 8.17   **Investment fees have increased despite economies of scale gains in investment expenses, though those gains are smaller**[a,b,c]

Median fee change, basis points (bps) compared with size-related changes in average costs over 2004–2017

Source	PC analysis of SuperRatings and APRA data.
Coverage	118 funds representing 81 per cent and 39 per cent of the system by assets in 2015-16 and 2005-06 respectively for administration and investment. Excludes funds with less than two years of data.
Survivor bias	No. Selection bias Yes.

a Dots capture the median of actual fee change within the system or a segment between 2004 and 2017. Lines represent the 95 per cent range for fund-level estimates of the median change in expenses associated with changes in scale over this period. Crosses represent the median of that range. The time period for the actual change in fees can differ between funds, depending on when they entered/exited and. **b** Over the period, average investment fees in investment reduced for the retail segment, driven by significant reductions for some large funds. **c** Mid-point represents the 50th percentile of the estimated range.

In other words, *the average fund* did not pass through the lower average costs realised with greater scale to their members in the form of lower fees. Underlying the average, however, some funds might have passed through at least some of the gains over the period.

A similar result arises from the pass-through component of the Commission's model, which compares annual changes in estimated cost savings to annual changes in fees. For example, in the case of administration expenses, the largest share of lower expenses that might have been passed through by the industry segment in a year was in the order of 20 per cent (figure 8.18). And, on average, the industry segment potentially increased fees to members, despite the gains realised from scale (an outcome captured in the fact that the extent of pass-through was potentially negative). Similar conclusions apply for investment expenses (figure 8.19). And plots of the estimated extent to which individual funds passed through realised gains in the

form of lower fees reveal relatively little variation, especially for investment expenses (figures 8.20 and 8.21), but also indicate the possibility that some funds might have passed through some gains.

As mentioned previously, this result could be explained by funds increasing the size of their operational reserves, investing in improved members services or spending to enable compliance with new regulatory requirements. On the investment side, it is possible that some funds used economies of scale gains to invest more heavily in unlisted asset classes, which may then have led to higher net returns for members (this is discussed further below). Finally, it is also possible that data limitations (including underreporting of expenses and patchy fee data) are muddying the analysis.

Figure 8.18   **Little pass-through of economies of scale gains in administration expenses via lower fees — by segment**[a]

Annual share of realised EOS administration expense gains passed through as lower fees, per cent
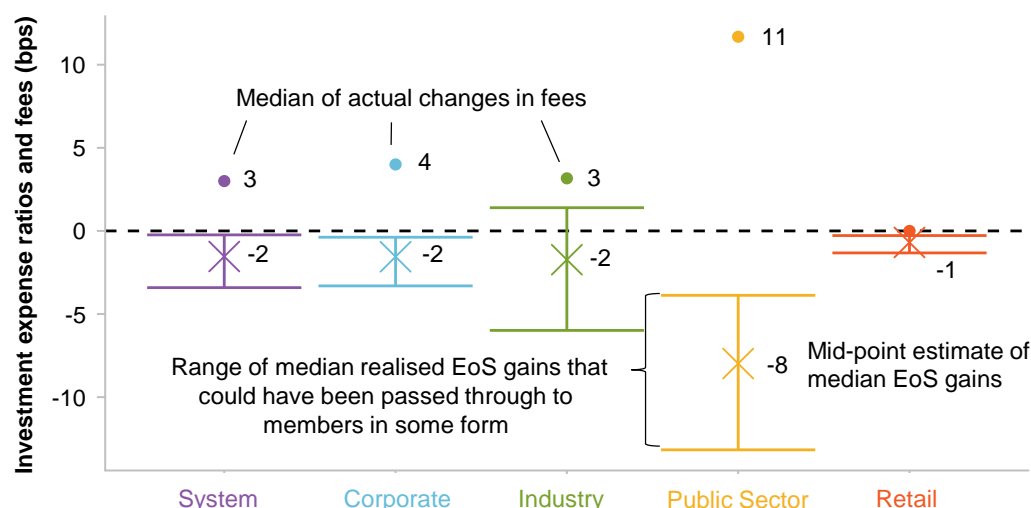

Source	PC analysis of SuperRatings and APRA data.
Coverage	134 funds representing 84 per cent and 53 per cent of the system by assets in 2015-16 and 2005-06 respectively for administration and investment. Excludes funds with less than two years of data.
Survivor bias	No. **Selection bias** Yes.

a Bars represent the 95 per cent probability range for a segment's coefficient. Dots represent the median.

Figure 8.19   **Little pass-through of economies of scale gains in investment expenses via lower fees — by segment**[a]

Annual share of realised EOS investment management expense gains passed through as lower fees, per cent

Source	PC analysis of SuperRatings and APRA data.		
Coverage	134 funds representing 84 per cent and 53 per cent of the system by assets in 2015-16 and 2005-06 respectively for administration and investment. Excludes funds with less than two years of data.		
Survivor bias	No.	Selection bias	Yes.

a Bars represent the 95 per cent probability range for a segment's coefficient. Dots represent the median.

Figure 8.20   **Little evidence of pass-through of administration expense savings from economies of scale gains — fund level**[a]

Share of realised economies of scale gains in administration expenses passed through as lower fees, per cent

Sources	PC analysis of SuperRatings and APRA data.		
Coverage	134 funds representing 84 per cent and 53 per cent of the system by assets in 2015-16 and 2005-06 respectively for administration and investment. Excludes funds with less than two years of data.		
Survivor bias	No.	**Selection bias**	Yes.

a Bars capture the 95 per cent probability range for a fund's coefficient. The black dots represent the median for each fund.

Figure 8.21   **Little evidence of pass-through of investment management expense savings from economies of scale gains — fund level**[a]

Share of realised economies of scale in investment expense gains passed through as lower fees
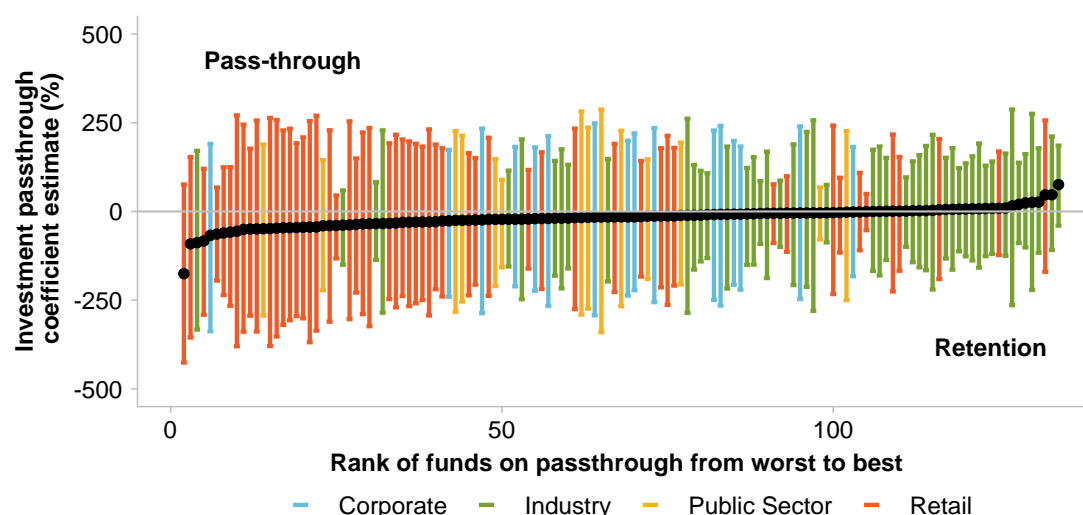
Sources	PC analysis of SuperRatings and APRA data.
Coverage	134 funds representing 84 per cent and 53 per cent of the system by assets in 2015-16 and 2005-06 respectively for administration and investment. Excludes funds with less than two years of data.
Survivor bias	No. Selection bias Yes.

a Bars capture the 95 per cent probability range for a fund's coefficient. The black dots represent the median for each fund.

Economies of scale gains may have been passed-through as higher returns

Some participants suggested that increased investment in unlisted assets might account for the lack of pass-through seen in investment expenses for industry funds and indeed, the lack of estimated realised gains from scale in investment more generally.[22] Unlisted assets (which incur higher investment costs), typically obtain higher net returns over time (partly in compensation for the illiquidity of the assets). This means that if increased investment in unlisted assets consumed some of the cost savings from increased scale, members may have ultimately benefited via higher returns, and so these higher fees can be viewed as efficient

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22 This could occur if the model struggles to account for increased costs from asset allocation as funds get larger due to data limitations.

from a member's perspective.[23] Unlisted assets could contribute to increased investment expenses if larger funds invest more heavily in unlisted assets as they grow, or there has been a broader move across the system towards unlisted investments over a period in which the system has grown.

To assess participants' hypothesis, the Commission looked for evidence of:

- a relationship between fund size and net returns (and whether any relationship can be explained by the proportion of assets invested in unlisted assets)

- larger funds investing more heavily in unlisted assets or a broader increase in investment in unlisted assets.

In short, the Commission found that:

- larger not-for-profit funds do obtain higher net returns, but no corresponding relationship exists for retail funds

- there is weak evidence that unlisted assets account for higher net returns for not-for-profit funds — data limitations make it difficult to make firm conclusions

- there is also little evidence to suggest that larger funds invest in more unlisted assets — at least in recent years.

Larger funds obtain higher returns

To assess whether a relationship between fund size and net returns exists, the Commission analysed average annual (or annualised) net returns over the period 2014 to 2017. On the plus side, using annualised data gives rise to figures that are more easily interpreted than the alternative scenario of using annual returns for each year.[24] But one downside of this approach is that funds that operated for only part of the period must be excluded to ensure, for comparability, that all funds faced the same economic conditions.

Inspection of the raw data reveals an association between fund size and annualised net returns (figure 8.22), with the relationship positive for funds in the industry, corporate and public sector segments and weakly negative for retail funds.[25] For example, the largest industry funds experienced average net returns that were two percentage points higher than the smallest funds.

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[23] The Commission's supplementary paper on investment performance analysed survey data from funds and found that unlisted asset classes had higher net returns, but lower returns relative to benchmarks, between 2008–2017.

[24] In addition to analysing annualised/average data, the Commission also conducted a panel analysis with similar findings. The results are presented in annex G.

[25] A similar relationship is found using data from 2004 to 2017.

And this relationship for not-for-profit funds is in the same order of magnitude as the realised cost savings.[26]

Figure 8.22   **Net returns increase with scale for all segments except retail**[a]

Annualised net returns (per cent) by average net assets, 2014–2017

Source	PC analysis of unpublished APRA data (2014–2017).		
Coverage	178 funds representing 92 per cent of the system in 2013-14.		
Survivor bias	Yes.	Selection bias	No.

a Excludes eligible rollover funds and insurance only funds. This figure only includes funds which have been in operation in all years from 2014 to 2017. For each fund, net assets are taken as an average over the time period.

But weak evidence that unlisted assets account for higher net returns in not-for-profits

Higher net returns for larger not-for-profit funds could be due to an uptake of unlisted asset classes as funds increase in size (as hypothesised earlier). Another possibility is that larger not-for-profit funds are better at making investment decisions within asset classes and including unlisted asset classes.

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26 For example, (as noted above) the estimated cost model suggests that an industry fund that increased in scale from $500 million of assets to $1 billion would, on average, reduce its expenses by 18 basis points in total. For the same increase in size, the estimated returns relationship implies an increase in net returns of 22 basis points.

There is limited evidence that the stronger net returns recorded by larger not-for-profit funds are due to higher exposure to unlisted asset classes. A simple regression of annualised net returns on fund size and asset allocation finds a statistically significant positive correlation between net returns and the proportion of assets held in unlisted infrastructure and a muted (but still statistically significant) relationship between net returns and size.[27] However, the relationship with unlisted infrastructure assets is no longer statistically significant (though the sign remains positive) when fund type is included in the analysis. This could indicate that there is not enough variation between variables measuring the proportion of assets in unlisted infrastructure and fund type for the model to differentiate between the impacts (this problem is called 'collinearity' and is exacerbated by small sample sizes). On the other hand, the possibility that unlisted infrastructure has a limited impact on net returns once other factors are accounted for cannot be discounted through reference to these results.

Analysis of benchmark-adjusted returns, which account for asset allocation and capture the extent to which a fund outperforms a benchmark (or adds value), and size, enables testing of the possibility that larger funds make better investment decisions. This analysis suggests that factors other than the proportion of funds invested in unlisted assets (and asset allocation more generally) have contributed to the higher net returns obtained by not-for-profit larger funds.[28] Specifically, a positive relationship between size and benchmark-adjusted returns is found, including when fund type is taken into account (figure 8.23) — which is consistent with larger funds making better investments for a given asset class.

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[27] The strong positive correlation between net returns and the proportion of assets held in unlisted assets is unsurprising because unlisted infrastructure has performed very well over recent years, as shown in the Commission's supplementary paper on investment performance. The proportion of funds in defensive asset classes is negatively correlated with net returns. There is no statistically significant correlation between net returns and the proportion of private equity. Results are presented in annex G.

[28] Fund-specific benchmarks were calculated using asset allocation data and asset class-specific benchmark returns following the updated assumptions detailed in the supplementary paper on investment performance.

Figure 8.23   **Fund size vs benchmark adjusted returns**[a,b]
2014–2017

Source	PC analysis of unpublished APRA data (2014–2017).		
Coverage	178 funds representing 92 per cent of the system in 2013-14.		
Survivor bias	Yes.	Selection bias	No.

a Excludes eligible rollover funds and insurance only funds. This figure only includes funds which have been in operation in all years from 2014 to 2017. For each fund, net assets are taken as an average over the time period. The benchmark adjusted return is calculated as the difference between the actual annualised net return and the benchmark annualised net return, where the construction of the benchmark portfolios follow the assumptions in technical supplement 4. **b** Because this analysis is based on data only covering the period 2014–2017, it is not comparable with the results presented in the supplementary paper on investment performance.

Nor does the evidence suggest that larger funds invest more in unlisted assets — at least in recent years

The Commission has not been able to find evidence of a relationship between fund size and the proportion of funds invested in unlisted assets using data for 2014–2017 (the years for which high quality asset allocation data are available). While the relationship between fund size and the proportion of unlisted assets held is positive for corporate and public sector funds, and to a less extent for retail funds (figure 8.24), these relationships are not statistically significant. There is no discernible trend for industry funds — and indeed a wide band of variation — suggesting that investing in unlisted assets was not correlated with fund size over this time period.

Furthermore, over this period there is no obvious positive trend in the proportion of funds invested in unlisted assets (figure 8.25). This result is consistent with analysis of asset allocation data obtained from the Commission's funds survey (though the data are subject to sample selection and survivor bias caveats).

That said, it is still possible that some funds have used scale benefits to invest in more unlisted assets. The Commission's analysis is limited to the past four years (given the data constraints), which means that any trends that existed in the earlier years in the Commission's expense dataset (2004–2013) cannot be observed.

Figure 8.24 **Average proportion of assets held in unlisted asset classes**[a]
2014–2017

Source	PC analysis of unpublished APRA data (2014–17).		
Coverage	178 funds representing 92 per cent of the system in 2013-14		
Survivor bias	Yes.	**Selection bias**	No.

a Excludes eligible rollover funds and insurance only funds. This figure only includes funds which have been in operation in all years from 2014 to 2017. For each fund, net assets are taken as an average over the time period. Unlisted asset classes refer to unlisted infrastructure, unlisted property, and private equity.

Figure 8.25   **Exposure to unlisted assets has not increased in recent years**[a]

Proportion of unlisted assets, 2014–2017

Source	PC analysis of unpublished APRA data (2014–17).		
Coverage	178 funds representing 92 per cent of the system in 2013-14		
Survivor bias	Yes.	**Selection bias**	No.

a Excludes eligible rollover funds and insurance only funds. This figure only includes funds which have been in operation in all years from 2014 to 2017.

Annex A: An introduction to Bayesian methods

As a group, the modelling issues involved in this analysis raised some formidable technical challenges, particularly when it came to computing standard errors for the estimated parameters. In theory, these could have been tackled using traditional (frequentist) statistical techniques. In reality, the modelling would not have been tractable. A Bayesian framework was adopted, enabling solutions to modelling issues (box 8.4 above) to be implemented using a coherent approach.

Bayesian methods use probability theory to combine data with prior information — information about the uncertainty associated with parameters before any analysis takes place — to make inferences about model parameters (Gelman, Andrew 2016).

Bayesian methods represent uncertainty using probability distributions. Prior probability distributions are specified first and are then updated with information arising from the data, given the assumed model structure. The resultant probability distribution (termed the posterior probability distribution) can be interpreted as the distribution of possible values that a parameter can take.

The use of priors is particularly helpful when the data are of poor quality. Priors 'pull' model estimates away from extreme values — a process called regularisation.[29] Use of priors is effective at limiting model overfitting (the problem of model estimates corresponding too closely to a particular set of data, and failing to properly account for additional data or predict future observations).

Aside from providing a better representation of uncertainty, Bayesian methods are relatively effective at estimating complex models, incorporating information from limited or missing data and combining different sources of information (including different data sources) in a coherent framework. These benefits — together with advances in computation power — have led to Bayesian methods becoming more popular in both academia and business in recent years. (For example, they have been used to analyse higher education participation rates (Goldstein, Browne and Charlton 2018), labour force participation (Evans, Moore and Rees 2018), interest rates (McCririck and Rees 2017) and the impact of microcredit expansions (Meager forthcoming).)

Why use Bayesian methods?

Bayesian methods have a number of key advantages over traditional (or frequentist) approaches that could be used for this modelling task. They:

- allow for a more flexible and robust analysis of data. The estimation approach is the same irrespective of model complexity. Models are defined, prior probability distributions are

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[29] The regularisation of fund-specific parameters is particularly effective in a Bayesian framework as the priors for fund-specific parameters can be determined endogenously from information from the full set of funds. This helps the regularisation to be more targeted.

chosen, and the posterior distribution is calculated by conditioning on observed data. Any model that can be defined can be modelled without needing to resort to any ad-hoc modelling solutions

- make better use of all available information. Priors allow modellers to incorporate information from sources other than data (for example, past research). A Bayesian framework also provides a simple approach for imputing missing values (they are estimated jointly with the rest of the model), which means that missing values do not need to be dropped

- intuitively accounts for uncertainty in model parameters, leading to a simpler interpretation of uncertainty (discussed below).

How should parameter estimates be interpreted?

The posterior distributions that flow out from a Bayesian-estimated model are often simplified for presentation using summary statistics. In this supplement, medians of the parameter posterior distributions are presented to give an indication of an average effect. The uncertainty associated with parameter values is often reported using the 2.5 and 97.5 percentiles of the posterior distribution — sometimes as a shaded area, sometimes as lines that indicate ranges. This can be interpreted as saying '*there is a 95 per cent chance that the true parameter value lies in this range*'.

How are Bayesian models estimated?

The Commission used the statistical package Stan (Carpenter et al. 2017) through an interface to the R programming language to estimate its Bayesian economies of scale model.

For all but the simplest cases there is no mathematical equation that defines the posterior distribution — it needs to be estimated empirically. This estimation can be computationally difficult, indeed it has only been possible to estimate complicated models in recent years, as computing power has increased. Stan uses an algorithm called Markov Chain Monte Carlo (MCMC) to explore and sample from the posterior probability distribution. Statistical inference about the posterior distribution is conducted using these samples.

Much of the work associated with Bayesian analysis involves ensuring that the MCMC algorithm is drawing sensible samples from the posterior distribution, such that valid inferences can be drawn.

Annex B: Modelling strategy

This annex outlines the model variables and equations used in the Commission's analysis. The model estimated by the Commission jointly estimates the cost functions of funds and the pass-through of economies of scale to members via lower fees.

A hierarchical structure

The model is hierarchical — that is, the model is specified from the top and is broken down into its smaller constituents in a tree-like structure (figure B.1). On the top level of the model, administration and investment expenses are jointly modelled (in logarithmic form) using a multivariate normal distribution (this allows for the estimated error terms for administration and investment expenses to be correlated at the fund level).

On the next level are equations that estimate administration and investment expenses. These cost functions are allowed to vary from fund to fund — taking account of heterogeneity in the relationship between size and expenses between funds that was observed in the raw data. Feeding into the two cost equations are also estimates of survival (to account for sample selection) and the number of investment options (which are imputed for funds where data are missing).

Predictions of economies of scale (taken from the administration and investment expenses equations) are fed into the pass-through model, to estimate the degree to which funds have passed economies of scale through to members via lower fees.

There is an additional — and uniquely Bayesian — hierarchical characteristic of the model. The priors of some model parameters are functions of the parameters themselves (hyperparameters) and are estimated within the model. These hyperparameters then have their own priors called hyperpriors. So for example, the mean administration/investment expense is a hyperparameter for the fund-specific cost parameters (the average expense is assumed to be the mean of the prior for fund expenses), and their hyperpriors are a normal distribution with mean of zero.

Figure B.1   **Hierarchical structure of cost model**
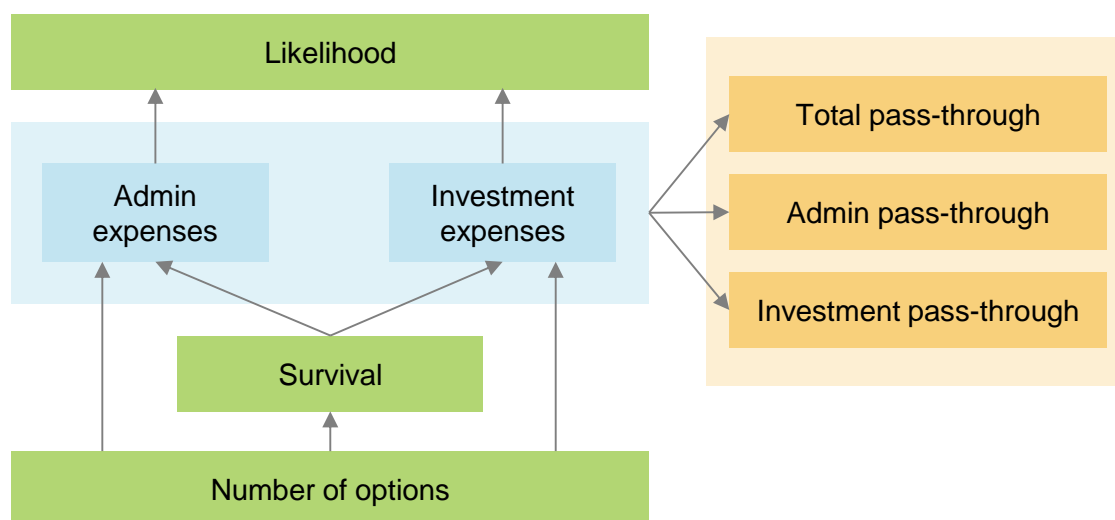
Simulation procedure

The simulation was conducted in Stan with 4 chains, 1000 warm-up iterations, and 1000 draws from the posterior density. The Commission used Hamiltonian Monte Carlo with a No-U-Turn sampler (NUTS) (Stan's default MCMC algorithm).

Model equations

This section presents the equations and priors used in the Commission's modelling of economies of scale. This exposition covers the Commission's preferred model, alternative specifications have been considered and are outlined in annex C.

Notation and key variables

A variety of notations and abbreviations are used in this section:

- $\alpha_{[i]}$ is the fund varying intercept for fund i
- $\beta_{[i]}$ are the fund-varying slope coefficients for fund i
- γ are the coefficients that do not vary by fund
- $\hat{p}$ is the fitted survival probability
- X, Z, and $\delta(\hat{p})$ are covariate matrices

Superscripts on variables or coefficients indicate the outcome variable (the variables being estimated) they are associated with. The following abbreviations are used for outcome variables:

- A: administration expenses (so for example, γ^A indicate the non-varying coefficients relate to administration expenses)
- I: investment expenses
- N: number of investment options
- S: survival indicator (whether a fund is in operation at the end of the financial year)

The following distributions abbreviations are used:

- MVN: multivariate normal
- N: normal
- IG: inverse gamma.
- LKJ: the LKJ distribution[30]

To aid estimation, all continuous variables have:

- either been log standardised or standardised (divided by their standard deviation) (table B.1)
- been centred on their mean values.

Table B.2 is a list of model variables with the equations that they are used to estimate.

Table B.1   **Variables used in the preferred model**

Log-standardised variables $(log(x)/sd(log(x)))$	Standardised variables $(x/sd(x))$	Indicator variables
Admin expenses	Net contributions	Fund type
Investment expenses	Net rollovers	Stronger super
Total assets	Net insurance flows	Post reporting change
Member accounts	Number of investment options	Survival
Sum of other fund's assets in same the period	Annual return	
Sum of other fund's member accounts in the same period	Proportions in each asset class	
Sum of other fund's net annual returns in the same period		

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30 Note that the LKJ distribution is named after the initials of the authors of the paper that derived the distribution (Lewandowksi, Kurowicka and Joe 2009).

Table B.2   **Covariates for preferred estimation**

	Admin	Investment	Number of investment options	Selection equation	Pass-through model
Intercept					
Varying	✓	✓			✓
Non-varying			✓	✓	
Varying slope coefficients					
Assets	✓	✓			
Member accounts	✓				
Other (proportion held in asset class)		✓			
Change in expenses due to size					✓
Non-varying coefficients					
Assets			✓	✓	
Member accounts			✓	✓	
Number of investment options	✓	✓		✓	
Net contributions	✓		✓	✓	
Net rollovers	✓		✓	✓	
Net insurance flows	✓				
Stronger super (indicator)	✓	✓	✓	✓	
Post reporting change (indicator)	✓	✓	✓	✓	
Asset classes (proportions)		✓			
Asset classes × Post reporting change		✓			
Fund type (indicator)	✓	✓			✓
Fund type × Assets	✓	✓			
Fund type × Member accounts	✓				
Fund type × Other		✓			
Annual net return			✓	✓	
Sum of other fund's assets in same period				✓	
Sum of other fund's member accounts in same period				✓	
Sum of other fund's annual net returns in same period				✓	
Fund type × Change in expenses due to size					✓

Likelihood

The likelihood function (the probability distribution for outcome variables as a function of model parameters and conditional on the data) for the joint estimation of administration and investment expenses is modelled as a multivariate normal distribution:

$$\begin{bmatrix} Admin \\ Investment \end{bmatrix} \sim MVN \left(\begin{bmatrix} \mu^{Admin} \\ \mu^{Invest} \end{bmatrix}, \Sigma \right)$$

With the following priors assumptions for the covariance matrix:

$$\Sigma = \begin{bmatrix} \sigma^A & 0 \\ 0 & \sigma^I \end{bmatrix} L \begin{bmatrix} \sigma^A & 0 \\ 0 & \sigma^I \end{bmatrix}$$

$$L \sim LKJ(50)$$

$$\sigma^A, \sigma^I \sim IG(2,1)$$

The priors and their corresponding hyperparameters for μ^{Admin} and μ^{Invest} are detailed in the sections below.

Administration expenses

Mean administration expenses are modelled as being dependent on a fund-specific intercept, fund-specific slope effects, non-fund specific slope effects and a survival prediction variable:

$$\mu^{Admin} = \alpha^A_{[i]} + X^A \beta^A_{[i]} + Z^A \gamma^A + \delta^A(\hat{p})\gamma^A_{CF}$$

The fund-specific coefficients are modelled as a multivariate normal distribution:

$$\begin{bmatrix} \alpha^A_{[i]} \\ \beta^A_{[i]} \end{bmatrix} \sim MVN \left(\begin{bmatrix} \alpha^A \\ \beta^A \end{bmatrix}, \Sigma^A \right)$$

With the following prior assumptions:

$$\alpha^A, \beta^A \sim N(0,1)$$

$$\Sigma^A = \begin{bmatrix} \sigma^A_{[i]} & 0 \\ 0 & \sigma^A_{[i]} \end{bmatrix} L^A \begin{bmatrix} \sigma^A_{[i]} & 0 \\ 0 & \sigma^A_{[i]} \end{bmatrix}$$

$$\sigma^A_{[i]} \sim IG(2,1)$$

$$L^A \sim LKJ(50)$$

The coefficients that do not vary by fund have the following priors:

$$\gamma^A, \gamma^A_{CF} \sim N(0, 0.5)$$

The survival prediction equations are presented below.

Investment expenses

Mean investment expenses are also modelled as being dependent on a fund-specific intercept, fund-specific slope effects, non-fund specific slope effects and a survival prediction variable:

$$\mu^{Invest} = \alpha^I_{[i]} + X^I \beta^I_{[i]} + Z^I \gamma^I + \delta^I(\hat{p}) \gamma^I_{CF}$$

For the coefficients that vary by fund:

$$\begin{bmatrix} \alpha^I_{[i]} \\ \beta^I_{[i]} \end{bmatrix} \sim MVN \left(\begin{bmatrix} \alpha^I \\ \beta^I \end{bmatrix}, \Sigma^I \right)$$

$$\alpha^I, \beta^I \sim N(0, 1)$$

$$\Sigma^I = \begin{bmatrix} \sigma^I_{[i]} & 0 \\ 0 & \sigma^I_{[i]} \end{bmatrix} L^I \begin{bmatrix} \sigma^I_{[i]} & 0 \\ 0 & \sigma^I_{[i]} \end{bmatrix}$$

$$\sigma^I_{[i]} \sim IG(2, 1)$$

$$L^I \sim LKJ(50)$$

The coefficients that do not vary by fund have the following priors:

$$\gamma^I, \gamma^I_{CF} \sim N(0, 0.5)$$

Selection equation

Survivorship bias is addressed using a control function approach. First, a logit regression is estimated using data on whether a fund is still in operation at the end of the financial year as the indicator of survival. All coefficients are assumed to not vary by fund. Variables included in the selection equations are presented in table B.2.

$$SurvivalIndicator \sim logit(\mu^{Survival})$$

With the following assumed priors and hyperparameters:

$$logit(\mu^{Survival}) = Z^S \gamma^S$$

$$\gamma^S \sim N(0, 0.5)$$

The fitted values from the logit regression — $\hat{p}$ (interpreted as the probability of a fund exiting in a given year) — are then used to construct a control function matrix, $\delta(\hat{p})$, which is included in the administration and investment equations. The control function matrix is a five-degree polynomial.

$$\delta(\hat{p}) = \begin{bmatrix} \hat{p}_1 & \hat{p}_1^2 & \cdots & \hat{p}_1^5 \\ \hat{p}_2 & \hat{p}_2^2 & \cdots & \hat{p}_2^5 \\ \vdots & \vdots & \ddots & \vdots \\ \hat{p}_N & \hat{p}_N^2 & \cdots & \hat{p}_N^5 \end{bmatrix}$$

For example, $\hat{p}_1$ is the fitted value for fund 1, $\hat{p}_2^2$ is the fitted value for fund 2 raised to the power of 2, and $\hat{p}_N^5$ is the fitted value for fund N raised to the power of 5.

Number of investment options

The number of investment options (an input into the administration, investment and selection equations) is modelled using a normal distribution:

$$NumOptions \sim N(\mu^{NumOptions}, \sigma^{NumOptions})$$

With the following assumed priors and hyperparameters:

$$\mu^{NumOptions} = Z^N \gamma^N$$

$$\sigma^{NumOptions} \sim Truncated\ Student's\ t(4, 0, 0.5)$$

$$\gamma^N \sim N(0, 0.5)$$

The estimated values are used for funds did not report data on the number of investment options in APRA data.

Pass-through

The pass-through module takes predicted values for the yearly change in costs attributable to changes in scale and compares it to actual yearly changes in fees.

The dependent variable is the change in (log) fees for a fund over one time period. Pass-through is estimated for administration, investment, and total fees, and is modelled using normal distributions:

$$TotalPassthrough \sim N(\mu^{TotalPassthrough}, \sigma^{TotalPassthrough})$$

$$AdminPassthrough \sim N(\mu^{AdminPassthrough}, \sigma^{AdminPassthrough})$$

$$InvestPassthrough \sim N(\mu^{InvestPassthrough}, \sigma^{InvestPassthrough})$$

$$\mu^{TotalPassthrough} = \alpha_{[i]}^{TP} + \beta_{[i]}^{TP} \Delta Total + Z^{TP} \gamma^{TP}$$

$$\mu^{AdminPassthrough} = \alpha_{[i]}^{AP} + \beta_{[i]}^{AP} \Delta Admin + Z^{AP} \gamma^{AP}$$

$$\mu^{InvestPassthrough} = \alpha_{[i]}^{IP} + \beta_{[i]}^{IP}\Delta Invest + Z^{IP}\gamma^{IP}$$

$\Delta Total$, $\Delta Admin$, and $\Delta Invest$ refer to the predicted change in expenses only due to a change in size. They are calculated by taking the difference between the predicted costs for a fund in the current time period (μ_{Base}) and the predicted costs if the total assets and members accounts are shifted forward one period but other information is held constant (μ_{Size}).

To calculate total expenses, the above expressions for administration and investment expenses are unstandardised and summed up.

$$M_{Base}^{Admin} \propto \exp(\mu_{Base}^{Admin})$$

$$M_{Size}^{Admin} \propto \exp(\mu_{Size}^{Admin})$$

$$M_{Base}^{Invest} \propto \exp(\mu_{Base}^{Invest})$$

$$M_{Size}^{Invest} \propto \exp(\mu_{Size}^{Invest})$$

$$M_{Base}^{Total} = M_{Base}^{Admin} + M_{Base}^{Invest}$$

$$M_{Size}^{Total} = M_{Size}^{Admin} + M_{Size}^{Invest}$$

Log differences are taken for total, administration, and investment expenses to calculate the change in expenses only due to a change in size.

$$\Delta Total = \log\left(M_{Size}^{Total}\right) - \log\left(M_{Base}^{Total}\right)$$

$$\Delta Admin = \log\left(M_{Size}^{Admin}\right) - \log\left(M_{Base}^{Admin}\right)$$

$$\Delta Invest = \log(M_{Size}^{Invest}) - \log(M_{Base}^{Invest})$$

The priors for the pass-through model are:

$$\begin{bmatrix} \alpha_{[i]}^{TP} \\ \beta_{[i]}^{TP} \end{bmatrix} \sim MVN\left(\begin{bmatrix} \alpha^{TP} \\ \beta^{TP} \end{bmatrix}, \Sigma^{TP}\right)$$

$$\begin{bmatrix} \alpha_{[i]}^{AP} \\ \beta_{[i]}^{AP} \end{bmatrix} \sim MVN\left(\begin{bmatrix} \alpha^{AP} \\ \beta^{AP} \end{bmatrix}, \Sigma^{AP}\right)$$

$$\begin{bmatrix} \alpha_{[i]}^{IP} \\ \beta_{[i]}^{IP} \end{bmatrix} \sim MVN\left(\begin{bmatrix} \alpha^{IP} \\ \beta^{IP} \end{bmatrix}, \Sigma^{IP}\right)$$

$$\alpha^{TP}, \beta^{TP}, \alpha^{AP}, \beta^{AP}, \alpha^{IP}, \beta^{IP} \sim N(0,1)$$

$$\Sigma^{TP} = \begin{bmatrix} \sigma_{[i]}^{TP} & 0 \\ 0 & \sigma_{[i]}^{TP} \end{bmatrix} L^{TP} \begin{bmatrix} \sigma_{[i]}^{TP} & 0 \\ 0 & \sigma_{[i]}^{TP} \end{bmatrix}$$

$$\Sigma^{AP} = \begin{bmatrix} \sigma_{[i]}^{AP} & 0 \\ 0 & \sigma_{[i]}^{AP} \end{bmatrix} L^{AP} \begin{bmatrix} \sigma_{[i]}^{AP} & 0 \\ 0 & \sigma_{[i]}^{AP} \end{bmatrix}$$

$$\Sigma^{IP} = \begin{bmatrix} \sigma_{[i]}^{IP} & 0 \\ 0 & \sigma_{[i]}^{IP} \end{bmatrix} L^{IP} \begin{bmatrix} \sigma_{[i]}^{IP} & 0 \\ 0 & \sigma_{[i]}^{IP} \end{bmatrix}$$

$$\sigma_{[i]}^{TP}, \sigma_{[i]}^{AP}, \sigma_{[i]}^{IP} \sim IG(2,1)$$

$$L^{TP}, L^{AP}, L^{IP} \sim LKJ(50)$$

$$\gamma^{TP}, \gamma^{AP}, \gamma^{IP} \sim N(0, 0.5)$$

$$\sigma^{TotalPassthrough}, \sigma^{AdminPassthrough}, \sigma^{InvestPassthrough} \sim IG(2,1)$$

Interpretation of parameters — calculation of power coefficients

Reversing the log standardisation of the size and cost variables leads to the following equation (using admin expenses as an example):

$$AdminExpense \propto Assets^{\beta_{1,[i]}^{A} + \gamma_1^A FundType} \times MemberAccounts^{\beta_{2,[i]}^{A} + \gamma_2^A FundType}$$

This implies that the curvature of the cost function depends on:

- a component which varies by fund type (γ_1^A, γ_2^A), i.e., it takes on the same value for all funds of the same type
- a component which varies by fund $(\beta_{1,[i]}, \beta_{2,[i]})$.

The sum of the two components is defined as the power coefficient for a fund. If the power coefficient for assets is larger than 1, the cost function for fund i is convex with respect to assets (that is, experiences diseconomies of scale or increasing average costs). If the sum is less than 1, this implies a concave cost function which corresponds to economies of scale (decreasing average costs). The same logic can be applied to see if there are economies of scale with respect to the number of member accounts.

An important caveat is that this model imposes the restriction that an individual fund can only experience economies of scale or diseconomies of scale (with respect to total assets or number of member accounts).

Priors

Broadly speaking, the Commission has adopted informative priors. While the Commission did consult with participants on potential economies of scale present in the superannuation industry, this did not directly lead to information that could be included in priors. Rather, the Commission chose priors centered on zero with relatively diffuse variances. To ensure that the priors chosen were not driving results, a specification with more diffuse priors was tested (annex C).

Priors have been presented alongside their respective parameters in the previous sections. A summary of the priors used in the model is presented in table B.3.

Table B.3   **Priors on model parameters[a]**

Parameters	Admin	Investment	Number of options	Selection model	Pass-through model
Non-varying coefficients	N(0, 0.5)	N(0, 0.5)	N(0, .5)	N(0, 0.5)	N(0, 0.5)
Temporary intercept	N(1, 0.5)	N(1, 0.5)	N(1, 0.5)	N(1, 0.5)	N(1, 0.5)
Control function coefficients	N(0, 0.5)	N(0, 0.5)			
SD of residual	IG(2, 1)	IG(2, 1)	Truncated positive t with 4 degrees of freedom and 0.5 standard deviation[b]		IG(2, 1)
SD of varying coefficients	IG(2, 1)	IG(2, 1)			IG(2, 1)
Varying coefficients	N(0, 1)	N(0, 1)			N(0, 1)
Cholesky factor for varying coefficients	LKJ(50)	LKJ(50)			LKJ(50)
Cholesky factor for joint estimation of admin/investment expenses	LKJ(50)	LKJ(50)			

a *N* denotes a normal distribution. *IG* denotes an inverse gamma distribution. *LKJ* denotes the LKJ distribution.
b The Commission discovered this inconsistency prior to publication. However the Commission tested a specification with consistent and tighter priors with minimal differences (annex C).

Annex C: Tests of assumptions and specifications

To check the robustness of the Commission's cost model, some underlying assumptions and alternative specifications were tested. Almost all do not materially alter results, although how fees data are treated may matter.

Weighted average fees

Participants at the Commission's technical workshop suggested using a weighted average of a fund's products to calculate average fees rather than a simple average. Another change was to remove a handful of observations where fees were equal to zero for every one of a fund's products.

In the earlier years covered by the data, product coverage for funds was quite limited therefore using weighted averages on the available data may not necessarily yield fees more representative of the fund as a whole than using simple averages.

Analysis of model results that incorporated both these changes (for which coefficients are presented in annex E), showed no material changes to the results presented in the body of the supplement. The only notable change was that the median estimate of the power coefficient for industry funds shifted above one (from 0.89 to 1.06), reinforcing the conclusion that it is difficult to find evidence for economies of scale in investment for industry funds based on the available data. Given that the two approaches to calculating fees do not change the key findings, and the risks inherent in changing presented figures and tables close to publication, the Commission opted to publish the model results that calculate fees using a simple average and include a small number of zero-fee observations.

Other tests

Random-effects assumption

Random effects models assume that fund-specific effects are uncorrelated with the independent variables. If they are not, the parameters estimates may be biased. This can be corrected by including the average of the independent variables for each fund as a fund-level independent variable when estimating the varying slope and varying intercepts. The parameter estimates with the corrected model do not differ significantly from the original estimates, suggesting that the random effects assumption is not violated.

Yearly effects (including inflation)

To test for the potential effects of inflation and other time-varying factors that may drive costs, yearly fixed effects were included. The estimated median effects for these parameters

were all close to zero. For this reason, and to maintain parsimony in the modelling strategy, the Commission's preferred specification does not include yearly fixed effects.[31]

Insourcing versus outsourcing of investment management

Stakeholder consultation highlighted that the investment expenses associated with in-house management investment, particularly by large industry funds are more likely to be captured in the APRA reporting framework. Therefore, the increased in-house management of investments by some large industry funds could present as increased investment management costs in APRA data because it results in costs being more accurately reported, even though costs are actually likely to have decreased. This could lead the model to conclude a weaker economies of scale relationship for industry funds relative to other fund types than there actually is.

To better understand these issues, the Commission sought data on the proportion of in-house managed investments from ten large funds that are known to manage investments in-house.

When these data are included in the cost model (all other funds are assumed to have zero in-house investment management), there do not appear to be any material differences in the economies of scale relationship for industry funds. However, with so little in-house management in the system as a whole, this should not be interpreted as a zero effect, rather it indicates that no effect could be found based on the limited data available.

Priors

To check that the priors adopted were not too tight and were not driving estimates, the Commission estimated the model with a more diffuse set of priors as specified in table C.1. There were no significant differences to model estimates.

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[31] Including yearly fixed effects would require a significant change to the analysis, which uses predictions for 2017. Refer to the footnotes in box 8.2.

Table C.1   **Priors on model parameters**[a]

Parameters	Admin	Investment	Number of options	Selection model	Pass-through model
Non-varying coefficients	N(0, 1)	N(0, 1)	N(0, 1)	N(0, 1)	N(0, 1)
Temporary intercept	N(1, 1)	N(1, 1)	N(1, 1)	N(1, 1)	N(1, 1)
Control function coefficients	N(0, 1)	N(0, 1)			
SD of residual	IG(2, 1)	IG(2, 1)	IG(2, 1)		IG(2, 1)
SD of varying coefficients	IG(2, 1)	IG(2, 1)			IG(2, 1)
Varying coefficients	N(0, 1)	N(0, 1)			N(0, 1)
Cholesky factor for varying coefficients	LKJ(50)	LKJ(50)			LKJ(50)
Cholesky factor for joint estimation of admin/investment expenses	LKJ(50)	LKJ(50)			

a N denotes a normal distribution. *IG* denotes an inverse gamma distribution. LKJ denotes the LKJ distribution.

Different imputation thresholds for expenses

In the Commission's preferred specification, only zero investment and administration expenses are imputed but, as previously noted, the data are likely to exhibit substantial underreporting of expenses. It therefore made sense to test the impact of treating assumed under-reported expenses as missing and imputing those too.

The Commission estimated a model where average administration expenses of less than 10 basis points and average investment expenses of less than 25 basis points were considered implausible and imputed[32]. This model was also estimated using weighted fees and with identified fee outliers removed. Relative to the model with only changes in weighted fees and identified fee outliers, the estimated coefficients resulted in less economies of scale in administration and corporate, industry and retail funds exhibiting weak diseconomies of scale on average in investment (power coefficients just above 1). Imputations avoid throwing away important information for estimating costs, but are not a panacea for poor quality data on the expenses-size relationship. Imputing more expenses effectively means that less data are used to estimate the size and expense coefficients, much of which are from smaller funds. This may lead the model to underestimate the extent of economies of scale. On balance from consultations, the Commission considers these estimates to be less plausible than those in the preferred specification.

Different asset allocation specification

In the Commission's preferred specification multiple asset allocation categories are allowed for in the investment expense model. These include cash, Australian fixed income,

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[32] A large number of fund-year observations – 1852 of 4138 fell into this bucket.

international fixed income, listed Australian equities, listed international equities, listed property, unlisted property and 'other' assets. Some participants in the technical workshop suggested that, for parsimony, these could be aggregated into categories because the unit costs of subsets of these asset classes do not differ significantly.

The Commission considered a specification of the investment expense model with only cash, fixed income, listed equities, listed property and other asset classes, as before the model was also estimated using weighted fees and with identified fee outliers removed. Relative to the model with only changes in weighted fees and identified fee outliers, the model appears sensitive to the choice of asset allocation categories, with many of the asset allocation coefficients changing significantly under the simpler specification. However, the estimated coefficients associated with total assets and number of member accounts are stable.

The relative merit of this specification is unclear. It is not clear that unit costs of the aggregated asset classes are all that similar. While ETFs are not easy to compare, Stockspot (2018) shows significant variation in listed Australian equity ETFs and listed international equity ETFs. A similar result can be seen in the Commission's analysis of funds survey data in its supplementary paper on investment performance.

Annex D: Preferred model fit

This annex presents histograms of estimation errors when median estimates are used. Two panels are presented in each case so that different bin sizes can be used (figure D.1 and D.2).

Figure D.1   **Prediction errors for administration expenses**

Bin-size = $1m

Differences in estimated and actual administration expenses ($m)

Bin-size = $10,000

Differences in estimated and actual administration expenses ($'000)
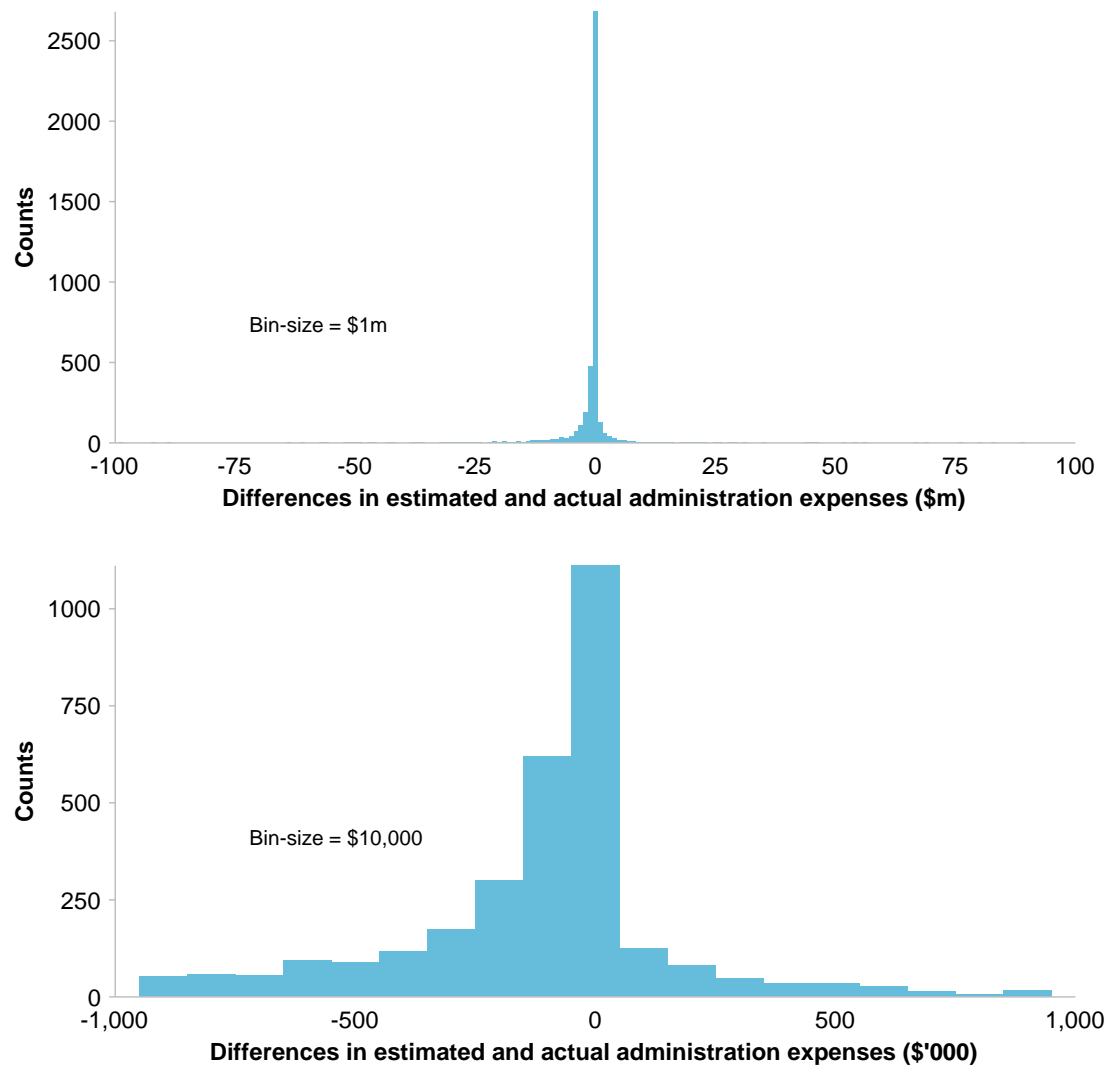
Source: PC analysis of unpublished APRA data.

Figure D.2　**Prediction errors for investment expenses**
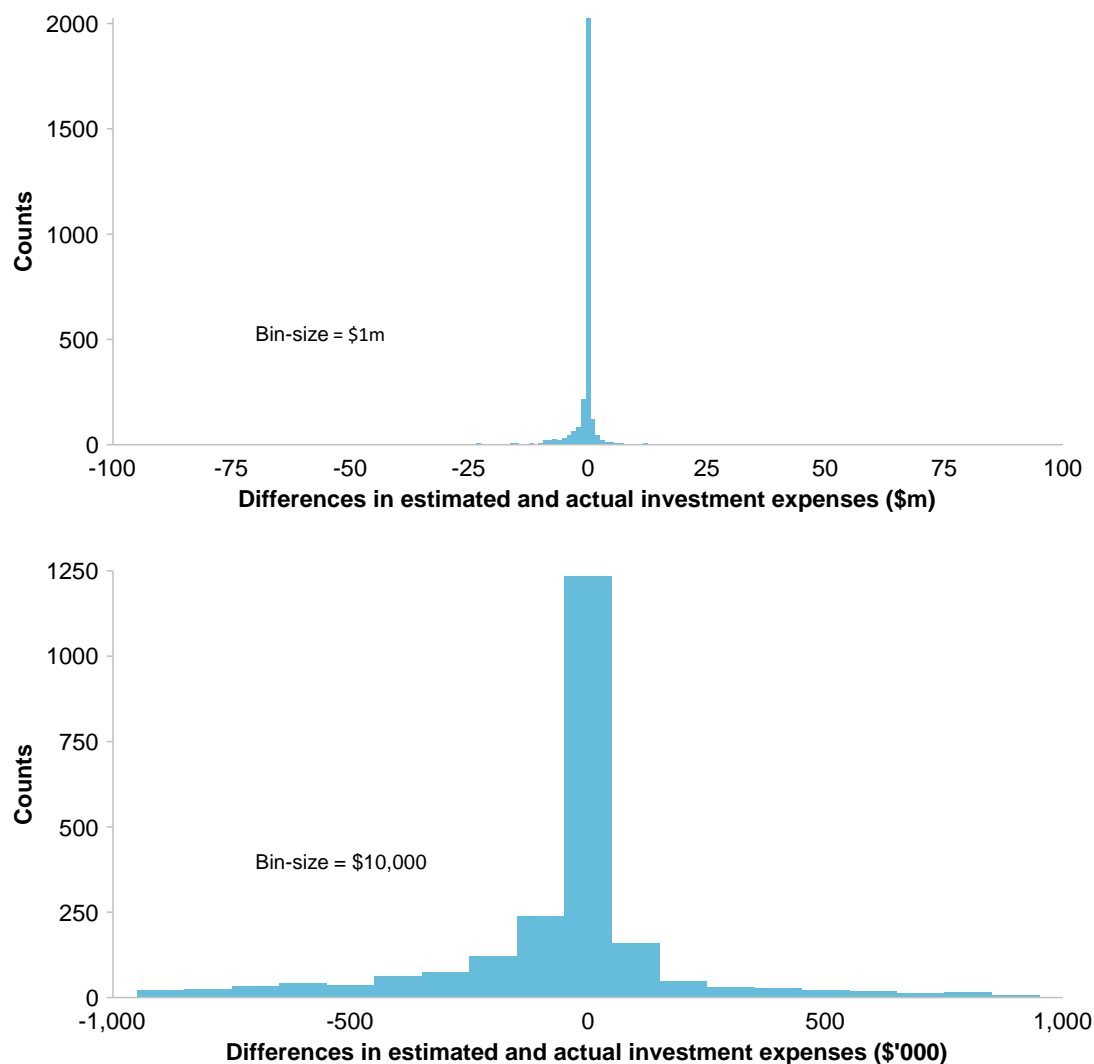
Source: PC analysis of unpublished APRA data.

One concern may be that the errors may compound over time which may be problematic given that some analysis is at the fund level. The following histograms show this is unlikely to be the case for the vast majority of funds (figures D.3 and D.4).

Figure D.3   **Prediction errors for changes in administration expenses over a fund's lifetime**

Bin-size = $1m

Counts

Differences in estimated and actual changes in administration expenses ($m)

Bin-size = $10,000

Counts

Differences in estimated and actual changes in administration expenses ($'000)
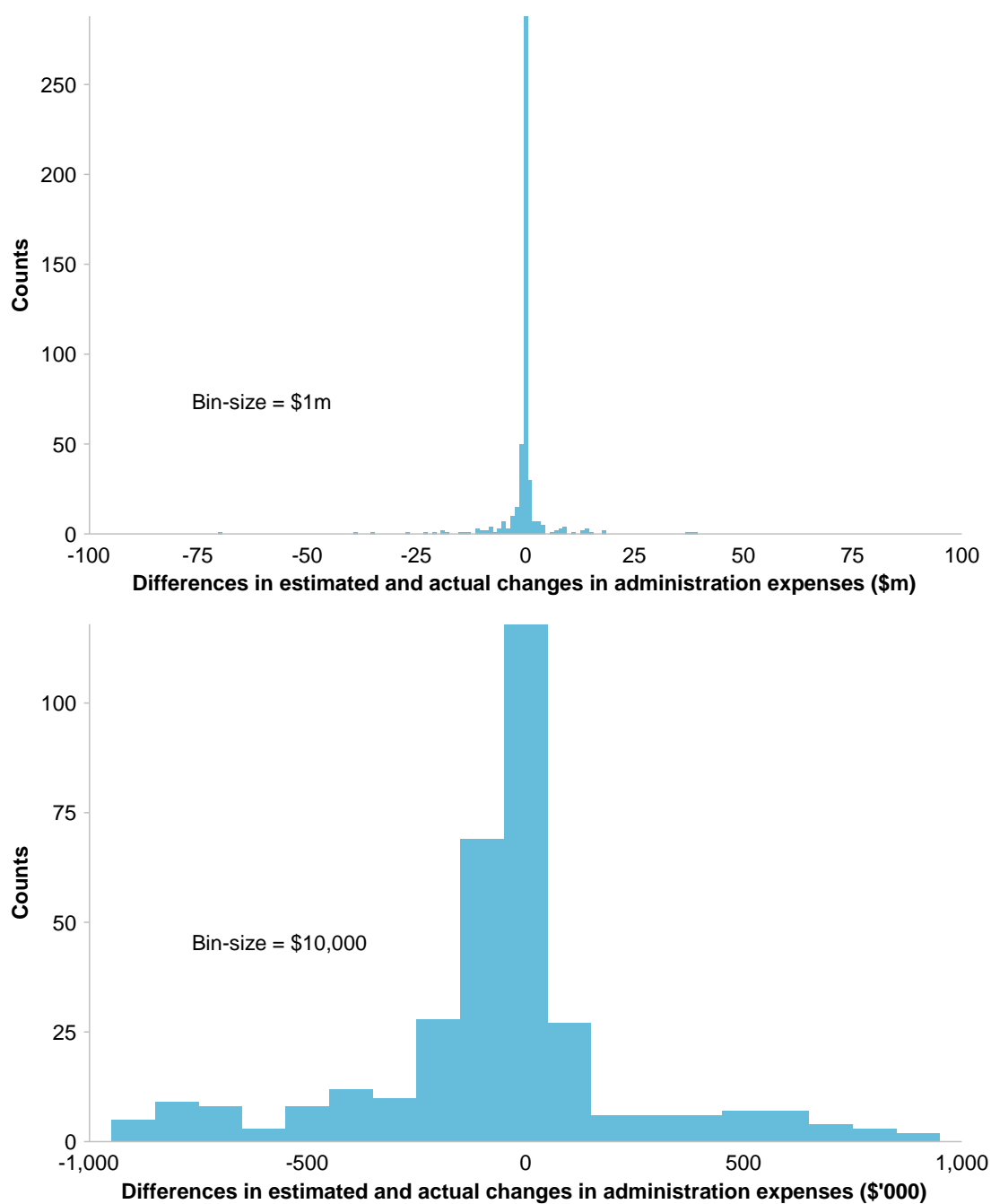
Source: PC analysis of unpublished APRA data.

Figure D.4 **Prediction errors for changes in investment expenses over a fund's lifetime**

Bin-size = $1m

Differences in estimated and actual changes in investment expenses ($m)

Bin-size = $10,000

Differences in estimated and actual changes in investment expenses ($'000)
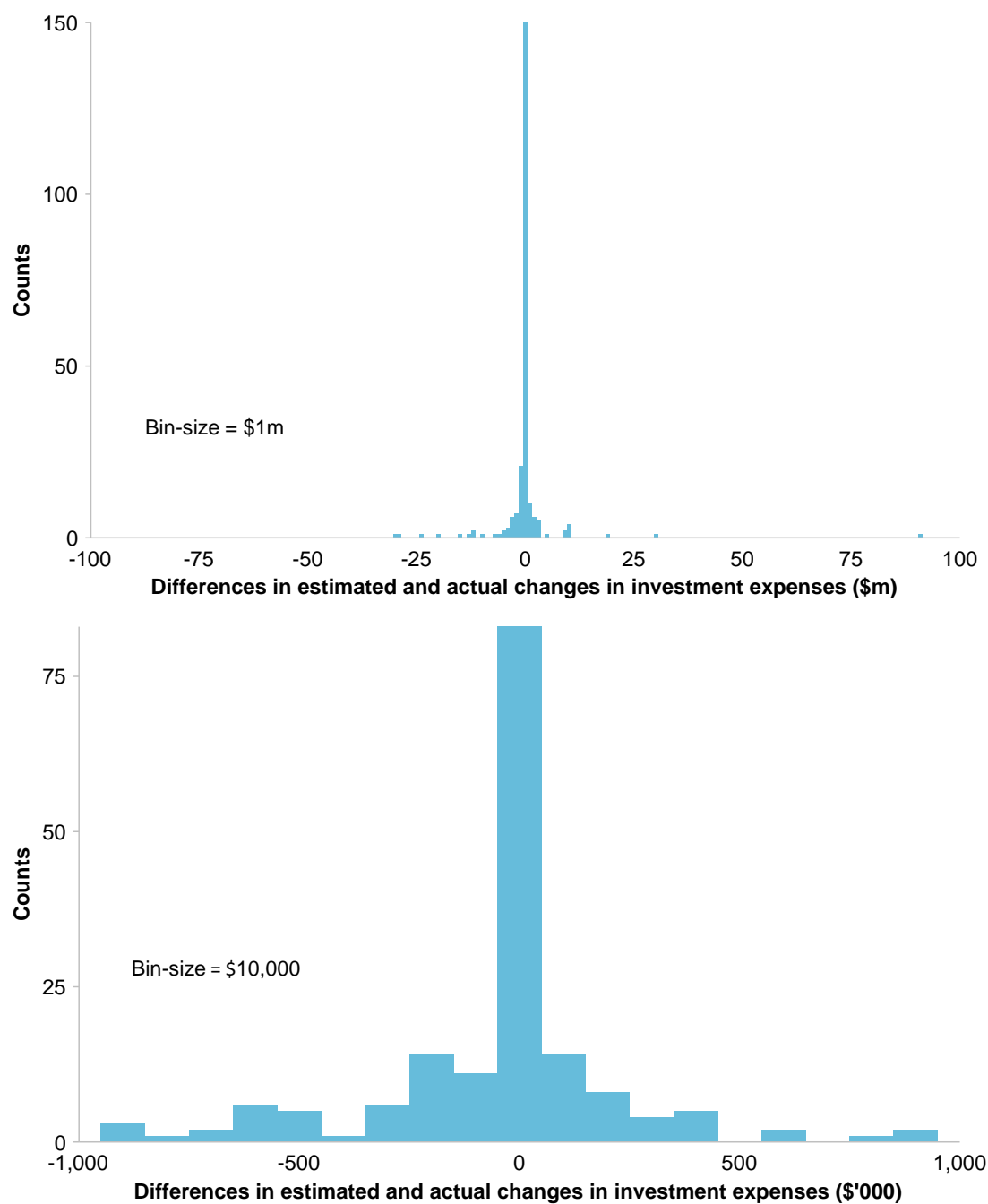
Source: PC analysis of unpublished APRA data.

Annex E: Selection and cost model parameter estimates

This annex presents parameter estimates for the following models:

- the primary joint module (cost function and pass-through) with unweighted fees and the identified outlier cases of products reporting zero fees for both administration and investment (table E.1)

- a joint model (table E.2) with weighted fees and the identified outlier cases removed.

How should parameter estimates be interpreted?

The posterior distributions that flow out from a Bayesian-estimated model are often simplified for presentation using summary statistics. In this supplement, medians of the parameter posterior distributions are presented to give an indication of an average effect. The uncertainty associated with parameter values is reported using the 2.5 and 97.5 percentiles of the posterior distribution — sometimes as a shaded area, sometimes as lines that indicate ranges. This can be interpreted as saying '*there is a 95 per cent chance that the true parameter value lies in this range*'.

Table E.1   **Parameter estimates**

Parameter	Mean	Standard deviation	2.5 percentile	Median	97.5 percentile
Likelihood					
SD of admin expenses	0.175	0.003	0.170	0.175	0.181
SD of investment expenses	0.308	0.005	0.298	0.308	0.317
Admin					
Assets	0.511	0.044	0.432	0.510	0.597
Member accounts	0.445	0.053	0.341	0.445	0.544
Number of investment options	0.059	0.011	0.035	0.060	0.082
Net contributions	0.006	0.007	-0.008	0.006	0.019
Net rollovers	-0.010	0.004	-0.018	-0.010	-0.004
Net insurance flows	-0.009	0.006	-0.021	-0.009	0.004
Stronger super	0.035	0.013	0.010	0.035	0.060
Post reporting change (PRC)	-0.037	0.015	-0.067	-0.037	-0.008
Industry	-0.389	0.243	-0.914	-0.384	0.056
Public	0.044	0.368	-0.673	0.041	0.725
Retail	-0.322	0.132	-0.592	-0.316	-0.077
Industry x Assets	0.161	0.063	0.045	0.160	0.289
Public x Assets	0.076	0.102	-0.132	0.074	0.274
Retail x Assets	0.228	0.048	0.136	0.228	0.325
Industry x Member accounts	-0.150	0.093	-0.343	-0.147	0.027
Public x Member accounts	-0.179	0.155	-0.462	-0.185	0.132
Retail x Member accounts	-0.286	0.049	-0.380	-0.285	-0.193
Intercept	-0.876	0.127	-1.115	-0.876	-0.628
SD of varying Intercept	0.979	0.132	0.735	0.976	1.243
SD of varying slope: Assets	0.208	0.036	0.142	0.207	0.277
SD of varying slope: Member accounts	0.205	0.031	0.151	0.202	0.272

Table E.1　(continued)

Parameter	Mean	Standard deviation	2.5 percentile	Median	97.5 percentile
Investment					
Assets	0.667	0.045	0.584	0.665	0.758
Number of investment options	-0.014	0.020	-0.052	-0.014	0.024
Net contributions	-0.009	0.014	-0.038	-0.008	0.019
Net rollovers	-0.013	0.009	-0.031	-0.013	0.004
Industry	-0.333	0.324	-0.977	-0.321	0.299
Public	1.401	0.421	0.537	1.413	2.202
Retail	0.427	0.214	0.005	0.426	0.872
Aus fixed income	-0.017	0.012	-0.039	-0.017	0.007
International fixed income	-0.005	0.010	-0.024	-0.005	0.015
Aus equity	0.009	0.013	-0.018	0.009	0.033
International equity	-0.012	0.016	-0.041	-0.012	0.019
Listed Property	0.013	0.008	-0.002	0.013	0.029
Unlisted property	0.054	0.013	0.029	0.054	0.080
Other	-0.067	0.090	-0.240	-0.069	0.116
Post reporting change (PRC)	0.295	0.156	-0.023	0.302	0.581
Industry x Assets	0.110	0.066	-0.012	0.108	0.243
Public x Assets	-0.208	0.076	-0.352	-0.211	-0.052
Retail x Assets	-0.151	0.048	-0.246	-0.152	-0.055
Industry x Other	0.079	0.108	-0.133	0.080	0.282
Public x Other	-0.069	0.138	-0.355	-0.071	0.210
Retail x Other	0.106	0.105	-0.092	0.107	0.310
PRC x Aus fixed income	-0.065	0.040	-0.140	-0.064	0.010
PRC x International fixed income	0.073	0.037	-0.003	0.072	0.148
PRC x Aus equity	0.014	0.037	-0.057	0.014	0.088
PRC x International equity	-0.111	0.034	-0.181	-0.112	-0.045
PRC x Listed Property	0.075	0.045	-0.012	0.075	0.163
PRC x Unlisted property	-0.120	0.040	-0.199	-0.121	-0.039
PRC x Other	-0.033	0.054	-0.136	-0.034	0.074
Intercept	-1.488	0.194	-1.871	-1.485	-1.128
SD of varying Intercept	0.494	0.073	0.353	0.489	0.640
SD of varying slope: Assets	0.115	0.011	0.094	0.115	0.140
SD of varying slope: Other	0.430	0.048	0.341	0.427	0.530

Table E.1   (continued)

Parameter	Mean	Standard deviation	2.5 percentile	Median	97.5 percentile
Number of investment options					
Assets	0.034	0.084	-0.127	0.036	0.199
Member accounts	0.277	0.101	0.073	0.279	0.474
Net contributions	0.009	0.016	-0.022	0.009	0.039
Net rollovers	0.044	0.012	0.022	0.044	0.067
Annual net return	-0.030	0.018	-0.066	-0.030	0.005
Stronger super	0.032	0.040	-0.042	0.031	0.108
Post reporting change	0.205	0.049	0.109	0.204	0.299
Industry	-0.475	0.290	-1.030	-0.479	0.072
Public	0.137	0.418	-0.673	0.138	1.000
Retail	-1.944	0.208	-2.349	-1.935	-1.546
Industry x Assets	0.248	0.106	0.053	0.240	0.462
Public x Assets	0.082	0.136	-0.211	0.089	0.353
Retail x Assets	0.730	0.088	0.560	0.729	0.896
Industry x Member accounts	-0.252	0.131	-0.509	-0.249	0.000
Public x Member accounts	-0.221	0.161	-0.533	-0.226	0.094
Retail x Member accounts	-0.314	0.106	-0.514	-0.317	-0.101
Intercept	-0.008	0.194	-0.387	-0.010	0.357
SD of number of options	0.746	0.009	0.729	0.746	0.764
Survival equation					
Assets	0.797	0.140	0.529	0.791	1.074
Member accounts	-0.166	0.121	-0.411	-0.168	0.076
Number of investment options	0.115	0.081	-0.035	0.114	0.292
Net contributions	0.290	0.184	-0.040	0.275	0.682
Net rollovers	0.264	0.164	0.027	0.211	0.579
Annual net return	0.029	0.047	-0.052	0.029	0.124
Stronger super	0.433	0.148	0.152	0.439	0.727
Post reporting change	0.290	0.206	-0.120	0.293	0.706
Sum of other fund's assets in same period	-0.649	0.156	-0.981	-0.653	-0.356
Sum of other fund's member accounts in same period	-0.432	0.106	-0.644	-0.429	-0.246
Sum of other fund's annual net returns in same period	0.374	0.086	0.215	0.372	0.572
Intercept	128.692	20.805	92.346	127.392	175.367

Table E.1 (continued)

Parameter	Mean	Standard deviation	2.5 percentile	Median	97.5 percentile
Pass-through: Admin fees					
Industry	0.023	0.024	-0.025	0.024	0.071
Public	0.020	0.028	-0.035	0.020	0.074
Retail	0.000	0.024	-0.044	0.001	0.045
Change in admin expenses due to size	0.096	0.199	-0.301	0.097	0.494
Industry x Change in admin expenses due to size	-0.087	0.211	-0.511	-0.088	0.320
Public x Change in admin expenses due to size	-0.039	0.239	-0.513	-0.041	0.436
Retail x Change in admin expenses due to size	-0.107	0.206	-0.507	-0.108	0.313
Intercept	-0.016	0.021	-0.057	-0.016	0.025
SD of admin pass-through	0.164	0.003	0.158	0.164	0.171
SD of varying intercept	0.039	0.005	0.030	0.039	0.048
SD of varying slope: Change in admin expenses due to size	0.165	0.047	0.093	0.157	0.274
Pass-through: Investment fees					
Industry	-0.020	0.052	-0.121	-0.019	0.080
Public	-0.009	0.064	-0.135	-0.010	0.123
Retail	-0.028	0.048	-0.119	-0.028	0.065
Change in investment expenses due to size	-0.177	0.253	-0.670	-0.175	0.318
Industry x Change in investment expenses due to size	0.120	0.320	-0.494	0.125	0.757
Public x Change in investment expenses due to size	-0.021	0.418	-0.843	-0.011	0.779
Retail x Change in investment expenses due to size	-0.313	0.317	-0.936	-0.317	0.285
Intercept	0.027	0.044	-0.059	0.027	0.114
SD of investment pass-through	0.378	0.008	0.362	0.378	0.393
SD of varying intercept	0.064	0.010	0.045	0.063	0.087
SD of varying slope: Change in investment expenses due to size	1.544	0.171	1.229	1.531	1.907

(continued next page)

Table E.1   (continued)

Parameter	Mean	Standard deviation	2.5 percentile	Median	97.5 percentile
Pass-through: total fees					
Industry	-0.011	0.025	-0.057	-0.012	0.041
Public	0.015	0.031	-0.043	0.014	0.076
Retail	-0.023	0.025	-0.069	-0.023	0.025
Change in total expenses due to size	0.086	0.206	-0.321	0.094	0.488
Industry x Change in total expenses due to size	0.189	0.232	-0.260	0.185	0.665
Public x Change in total expenses due to size	-0.043	0.276	-0.584	-0.036	0.498
Retail x Change in total expenses due to size	-0.141	0.222	-0.554	-0.145	0.288
Intercept	0.017	0.022	-0.027	0.018	0.059
SD of total pass-through	0.172	0.004	0.165	0.172	0.180
SD of varying intercept	0.043	0.005	0.032	0.042	0.055
SD of varying slope: Change in total expenses due to size	0.552	0.066	0.435	0.550	0.689

Table E.2 **Parameter estimates**

Weighted product fees

Parameter	Mean	Standard deviation	2.5 percentile	Median	97.5 percentile
Likelihood					
SD of admin expenses	0.175	0.003	0.169	0.175	0.181
SD of investment expenses	0.309	0.005	0.299	0.309	0.319
Admin					
Assets	0.511	0.046	0.418	0.513	0.601
Member accounts	0.443	0.051	0.344	0.443	0.543
Number of investment options	0.059	0.011	0.038	0.059	0.082
Net contributions	0.006	0.007	-0.008	0.006	0.019
Net rollovers	-0.010	0.004	-0.018	-0.010	-0.003
Net insurance flows	-0.010	0.006	-0.022	-0.010	0.001
Stronger super	0.035	0.012	0.012	0.035	0.059
Post reporting change (PRC)	-0.038	0.015	-0.068	-0.038	-0.006
Industry	-0.335	0.231	-0.782	-0.342	0.113
Public	0.071	0.343	-0.596	0.054	0.749
Retail	-0.329	0.123	-0.573	-0.325	-0.095
Industry x Assets	0.160	0.063	0.034	0.163	0.277
Public x Assets	0.076	0.103	-0.127	0.077	0.274
Retail x Assets	0.227	0.044	0.147	0.227	0.316
Industry x Member accounts	-0.161	0.089	-0.335	-0.161	0.015
Public x Member accounts	-0.185	0.153	-0.491	-0.186	0.129
Retail x Member accounts	-0.281	0.047	-0.378	-0.279	-0.196
Intercept	-0.872	0.131	-1.130	-0.868	-0.599
SD of varying Intercept	0.996	0.146	0.689	1.005	1.245
SD of varying slope: Assets	0.218	0.042	0.129	0.221	0.297
SD of varying slope: Member accounts	0.209	0.039	0.139	0.209	0.286

Table E.2 (continued)

Parameter	Mean	Standard deviation	2.5 percentile	Median	97.5 percentile
Investment					
Assets	0.714	0.043	0.628	0.716	0.798
Number of investment options	-0.019	0.020	-0.060	-0.018	0.018
Net contributions	-0.013	0.014	-0.041	-0.013	0.015
Net rollovers	-0.013	0.008	-0.030	-0.014	0.004
Industry	-0.881	0.317	-1.496	-0.872	-0.294
Public	1.078	0.411	0.347	1.076	1.875
Retail	0.616	0.196	0.226	0.619	0.993
Aus fixed income	-0.019	0.012	-0.041	-0.019	0.006
International fixed income	-0.006	0.010	-0.025	-0.006	0.013
Aus equity	0.010	0.013	-0.014	0.010	0.036
International equity	-0.022	0.015	-0.050	-0.021	0.006
Listed Property	0.013	0.008	-0.003	0.013	0.028
Unlisted property	0.053	0.013	0.026	0.053	0.077
Other	-0.064	0.082	-0.224	-0.067	0.090
Post reporting change (PRC)	0.306	0.158	-0.003	0.305	0.608
Industry x Assets	0.211	0.066	0.088	0.210	0.338
Public x Assets	-0.155	0.075	-0.296	-0.154	-0.020
Retail x Assets	-0.191	0.044	-0.279	-0.191	-0.101
Industry x Other	0.062	0.108	-0.149	0.059	0.270
Public x Other	-0.038	0.138	-0.308	-0.039	0.233
Retail x Other	0.115	0.103	-0.090	0.116	0.315
PRC x Aus fixed income	-0.065	0.040	-0.143	-0.066	0.013
PRC x International fixed income	0.068	0.038	-0.003	0.067	0.148
PRC x Aus equity	0.010	0.038	-0.062	0.011	0.086
PRC x International equity	-0.114	0.035	-0.180	-0.113	-0.043
PRC x Listed Property	0.076	0.042	-0.008	0.076	0.159
PRC x Unlisted property	-0.129	0.041	-0.207	-0.129	-0.050
PRC x Other	-0.049	0.055	-0.156	-0.052	0.063
Intercept	-1.682	0.190	-2.052	-1.688	-1.296
SD of varying Intercept	0.270	0.065	0.148	0.268	0.393
SD of varying slope: Assets	0.101	0.008	0.084	0.101	0.115
SD of varying slope: Other	0.430	0.047	0.340	0.430	0.528

(continued next page)

Table E.2 (continued)

Parameter	Mean	Standard deviation	2.5 percentile	Median	97.5 percentile
Number of investment options					
Assets	0.036	0.078	-0.118	0.034	0.191
Member accounts	0.275	0.094	0.091	0.275	0.459
Net contributions	0.009	0.015	-0.019	0.008	0.037
Net rollovers	0.044	0.013	0.020	0.043	0.070
Annual net return	-0.030	0.018	-0.066	-0.029	0.006
Stronger super	0.032	0.037	-0.043	0.032	0.103
Post reporting change	0.206	0.045	0.121	0.207	0.293
Industry	-0.483	0.275	-1.026	-0.483	0.069
Public	0.155	0.378	-0.564	0.161	0.887
Retail	-1.948	0.207	-2.329	-1.953	-1.546
Industry x Assets	0.251	0.098	0.048	0.251	0.456
Public x Assets	0.076	0.130	-0.189	0.071	0.336
Retail x Assets	0.732	0.085	0.562	0.730	0.903
Industry x Member accounts	-0.255	0.126	-0.507	-0.253	-0.010
Public x Member accounts	-0.217	0.159	-0.529	-0.211	0.098
Retail x Member accounts	-0.315	0.100	-0.514	-0.316	-0.110
Intercept	-0.011	0.184	-0.379	-0.014	0.328
SD of number of options	0.746	0.009	0.730	0.747	0.764
Survival equation					
Assets	0.815	0.138	0.562	0.814	1.099
Member accounts	-0.161	0.123	-0.416	-0.157	0.078
Number of investment options	0.106	0.079	-0.049	0.103	0.270
Net contributions	0.277	0.184	-0.054	0.269	0.676
Net rollovers	0.254	0.167	0.021	0.193	0.582
Annual net return	0.030	0.049	-0.055	0.028	0.128
Stronger super	0.430	0.146	0.148	0.427	0.712
Post reporting change	0.277	0.211	-0.111	0.273	0.699
Sum of other fund's assets in same period	-0.648	0.153	-0.953	-0.645	-0.356
Sum of other fund's member accounts in same period	-0.427	0.111	-0.643	-0.425	-0.217
Sum of other fund's annual net returns in same period	0.374	0.082	0.220	0.370	0.532
Intercept	127.521	21.607	87.913	127.473	171.615

Table E.2 (continued)

Parameter	Mean	Standard deviation	2.5 percentile	Median	97.5 percentile
Pass-through: Admin fees					
Industry	0.023	0.026	-0.028	0.023	0.073
Public	0.029	0.035	-0.041	0.030	0.094
Retail	0.009	0.026	-0.041	0.009	0.060
Change in admin expenses due to size	0.117	0.224	-0.343	0.116	0.521
Industry x Change in admin expenses due to size	-0.129	0.242	-0.601	-0.126	0.356
Public x Change in admin expenses due to size	-0.139	0.291	-0.690	-0.123	0.435
Retail x Change in admin expenses due to size	-0.221	0.229	-0.645	-0.218	0.244
Intercept	-0.014	0.024	-0.060	-0.013	0.034
SD of admin pass-through	0.147	0.004	0.140	0.146	0.154
SD of varying intercept	0.042	0.005	0.033	0.041	0.052
SD of varying slope: Change in admin expenses due to size	0.262	0.077	0.125	0.259	0.412
Pass-through: Investment fees					
Industry	-0.016	0.029	-0.072	-0.016	0.038
Public	0.006	0.036	-0.065	0.005	0.073
Retail	-0.027	0.028	-0.084	-0.027	0.027
Change in investment expenses due to size	-0.137	0.191	-0.480	-0.146	0.273
Industry x Change in investment expenses due to size	0.063	0.206	-0.362	0.066	0.435
Public x Change in investment expenses due to size	-0.079	0.243	-0.557	-0.075	0.357
Retail x Change in investment expenses due to size	0.034	0.204	-0.377	0.037	0.406
Intercept	0.027	0.026	-0.023	0.028	0.076
SD of investment pass-through	0.166	0.004	0.159	0.166	0.174
SD of varying intercept	0.043	0.005	0.033	0.042	0.054
SD of varying slope: Change in investment expenses due to size	0.147	0.035	0.089	0.143	0.224

Table E.2   (continued)

Parameter	Mean	Standard deviation	2.5 percentile	Median	97.5 percentile
Pass-through: total fees					
Industry	-0.005	0.034	-0.076	-0.005	0.058
Public	0.034	0.048	-0.064	0.036	0.123
Retail	-0.026	0.033	-0.092	-0.027	0.038
Change in total expenses due to size	-0.034	0.224	-0.481	-0.034	0.391
Industry x Change in total expenses due to size	0.006	0.243	-0.461	-0.005	0.516
Public x Change in total expenses due to size	-0.213	0.319	-0.829	-0.213	0.374
Retail x Change in total expenses due to size	-0.053	0.230	-0.484	-0.056	0.422
Intercept	0.021	0.031	-0.037	0.021	0.083
SD of total pass-through	0.226	0.005	0.217	0.226	0.237
SD of varying intercept	0.044	0.006	0.034	0.044	0.058
SD of varying slope: Change in total expenses due to size	0.161	0.042	0.094	0.156	0.261

Annex F: Additional figures

As previously discussed, inspection of the log transformations of the size and expenses variables data revealed linear relationships (figure F.1) — suggesting that a linear model is appropriate once logs are taken.

Figure F.1   **A linear model is appropriate**
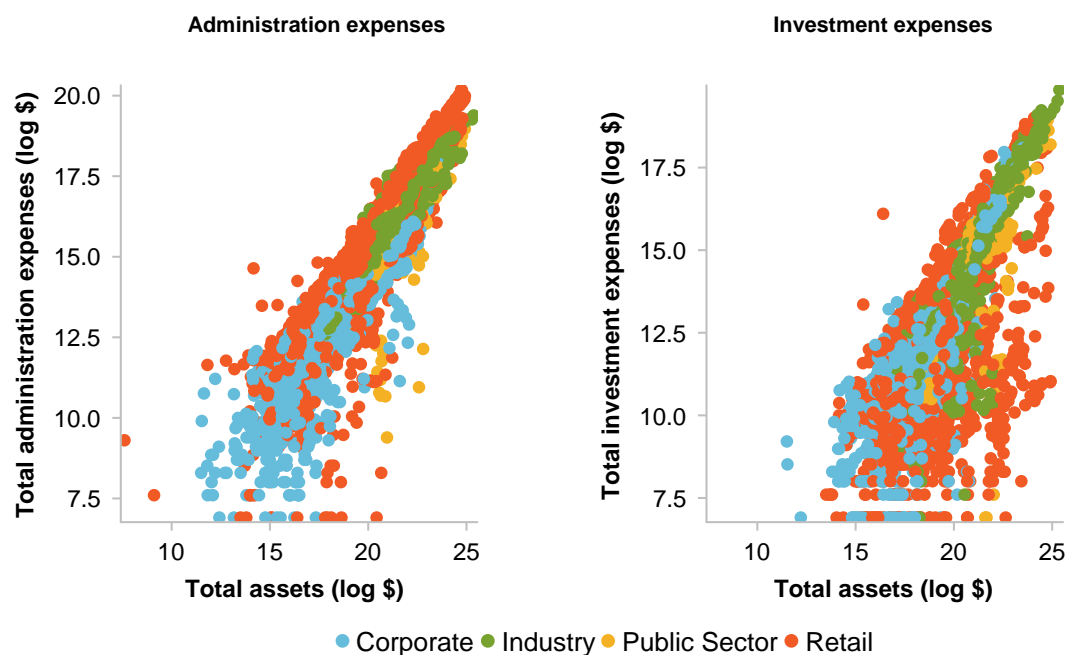
Source: PC analysis of unpublished APRA data.

The relationship between size and expenses varied markedly between funds, prompting the use of more flexible functional forms (figure F.2).

Figure F.2   **Heterogeneity supports multilevel modelling approach**[a,b]
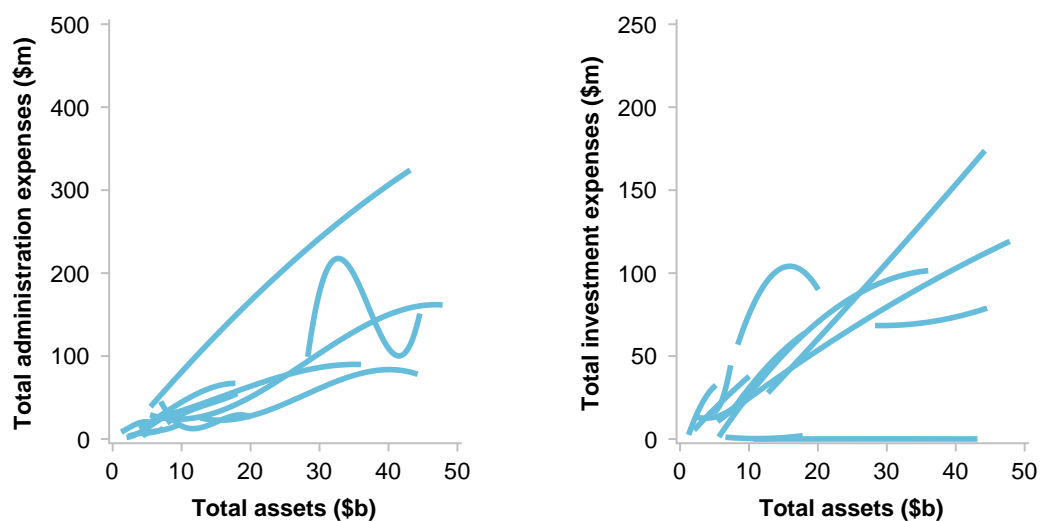
[a] Each line represents a cubic spline curve (machine learning technique) fitted to a fund's expense and assets for a selection of medium to large funds. [b] Shows there is likely to be heterogeneity in slopes and to a lesser extent intercepts. Many curves look log-like.

Source: PC analysis of unpublished APRA data.

Annex G: Regression results

Table G.1   **Mean regression: average percentage of assets in unlisted asset classes**[a]
2014 to 2017

	Percentage in all unlisted asset classes	Percentage in unlisted infrastructure	Percentage in unlisted property	Percentage in private equity
Net assets	0.907	0.557***	-0.223	0.573
	(0.838)	(0.200)	(0.381)	(0.651)
Industry	21.901	4.319	0.156	17.425
	(18.898)	(4.516)	(8.595)	(14.686)
Public sector	21.378	-0.209	0.635	20.952
	(29.976)	(7.163)	(13.634)	(23.295)
Retail	-2.753	4.473	-5.327	-1.900
	(11.969)	(2.860)	(5.444)	(9.301)
Net assets x Industry	-0.943	-0.130	0.175	-0.987
	(1.311)	(0.313)	(0.596)	(1.018)
Net assets x Public sector	-1.008	-0.031	0.112	-1.088
	(1.941)	(0.464)	(0.883)	(1.508)
Net assets x Retail	-0.284	-0.450**	0.119	0.048
	(0.914)	(0.219)	(0.416)	(0.711)
Intercept	-0.503	-5.414**	8.484*	-3.573
	(10.946)	(2.616)	(4.979)	(8.507)
N	178	178	178	178
R^2	0.409	0.509	0.331	0.148
Adjusted R^2	0.384	0.489	0.304	0.113
F	16.795***	25.203***	12.040***	4.225***

a Net assets for each fund are averaged over the time period and logged. The reference fund type is 'Corporate'. Standard errors in parentheses. *** Significant at the 1 per cent level. ** Significant at the 5 per cent level. * Significant at the 10 per cent level.

Source: PC analysis of unpublished APRA data (2014–17).

Table G.2   Mean regression: annualised net returns and annualised benchmark adjusted returns[a]

2014 to 2017

	Annualised net return		Annualised benchmark adjusted return
Net assets	0.095**	0.126	0.268**
	(0.044)	(0.101)	(0.131)
Defensive assets (proportion)	-2.768***	-2.421***	
	(0.942)	(0.841)	
Unlisted infrastructure (proportion)	11.456***	1.982	
	(3.744)	(3.836)	
Unlisted property (proportion)	5.451**	-0.722	
	(2.408)	(2.372)	
Private equity (proportion)	-0.194	-0.309	
	(1.296)	(1.158)	
Industry		-2.725	-0.312
		(2.216)	(2.824)
Public sector		-5.178	-2.036
		(3.501)	(4.393)
Retail		-0.316	1.995
		(1.449)	(1.886)
Net assets x Industry		0.172	0.003
		(0.153)	(0.196)
Net assets x Public sector		0.288	0.094
		(0.226)	(0.285)
Net assets x Retail		-0.094	-0.249*
		(0.110)	(0.143)
Intercept	6.540***	7.364***	-3.898**
	(0.724)	(1.375)	(1.735)
N	168	168	174
R^2	0.312	0.488	0.291
Adjusted R^2	0.291	0.452	0.261
F	14.692***	13.520***	9.735***

a Net assets for each fund are averaged over the time period and logged. The reference fund type is 'Corporate'. Defensive assets include cash and fixed income. Outlier observations have been excluded from this analysis (where outliers are defined to be at least 2 standard deviations away from the mean). Standard errors in parentheses. *** Significant at the 1 per cent level. ** Significant at the 5 per cent level. * Significant at the 10 per cent level.

Source: PC analysis of unpublished APRA data (2014–17).

Table G.3   Panel regression: percentage of assets in unlisted asset classes[a]

2014 to 2017

	Percentage in all unlisted asset classes	*Percentage in unlisted infrastructure*	*Percentage in unlisted property*	*Percentage in private equity*
Net assets	0.931	0.598***	-0.197	0.530
	(0.855)	(0.143)	(0.669)	(0.467)
Industry	26.655	3.911	1.513	21.232
	(18.386)	(5.334)	(10.793)	(13.400)
Public sector	24.111	-1.972	4.777	21.306
	(33.876)	(8.981)	(15.111)	(29.665)
Retail	0.386	4.732***	-3.993	-0.353
	(11.460)	(1.506)	(9.616)	(5.295)
Net assets x Industry	-1.259	-0.103	0.089	-1.244
	(1.222)	(0.358)	(0.732)	(0.873)
Net assets x Public sector	-1.197	0.084	-0.153	-1.128
	(2.040)	(0.587)	(0.978)	(1.771)
Net assets x Retail	-0.488	-0.467***	0.034	-0.055
	(0.847)	(0.140)	(0.676)	(0.455)
Lambda	-8.591	1.269	-2.498	-7.362
	(12.127)	(1.576)	(3.609)	(11.171)
N	712	712	712	712
R^2	0.303	0.461	0.273	0.090
Adjusted R^2	0.292	0.453	0.261	0.075
F	19.686***	20.587***	24.36***	8.186***

a Time fixed effects are used and standard errors are clustered by fund. The reference fund type is 'Corporate'. Lambda is the coefficient for the survival correction term. Standard errors in parentheses. *** Significant at the 1 per cent level. ** Significant at the 5 per cent level. * Significant at the 10 per cent level.

Source: PC analysis of APRA unpublished data (2014–17).

Table G.4   **Panel regression: annual net returns and benchmark adjusted returns**[a]

2014 to 2017

	Annual net return		Benchmark adjusted return
Net assets	0.200**	0.071	0.062
	(0.084)	(0.170)	(0.299)
Defensive assets (proportion)	-6.345***	-5.883***	
	(1.089)	(0.990)	
Unlisted infrastructure (proportion)	12.069***	4.082*	
	(3.462)	(2.390)	
Unlisted property (proportion)	-0.889	-5.538	
	(4.152)	(3.392)	
Private equity (proportion)	0.669	0.534	
	(1.091)	(1.171)	
Industry		-4.578**	-6.170
		(2.279)	(3.861)
Public sector		-5.039**	-6.161
		(2.494)	(4.207)
Retail		-3.583	-6.019
		(2.483)	(4.319)
Net assets x Industry		0.286*	0.412
		(0.163)	(0.275)
Net assets x Public sector		0.292*	0.394
		(0.173)	(0.295)
Net assets x Retail		0.122	0.311
		(0.175)	(0.307)
Lambda	1.449	1.931	5.260*
	(1.962)	(1.703)	(2.901)
N	712	712	712
R^2	0.257	0.322	0.078
Adjusted R^2	0.247	0.307	0.064
F	27.135***	36.700***	13.995***

a Time fixed effects are used and standard errors are clustered by fund. The reference fund type is 'Corporate'. Defensive assets include cash and fixed income. Standard errors in parentheses. Lambda is the coefficient for the survival correction term. *** Significant at the 1 per cent level. ** Significant at the 5 per cent level. * Significant at the 10 per cent level.

Source: PC analysis of unpublished APRA data (2014–17).

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