An Efficiency Study of the Australian Superannuation Industry

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Final Report

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The Australian Superannuation Industry

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Contents

List of Figures

List of Tables

Abstract

This research analyses the efficiency of Australian superannuation industry between 2004 and 2012. A review of the Australia's superannuation industry and the surrounding literature is undertaken, as is a discussion of the techniques of efficiency measurement. In this respect, the first part of this study provides an introduction into superannuation fund efficiency measurements.

The empirical analysis was conducted using a two-stage procedure. In the first stage Data Envelopment Analysis (DEA) is used to construct an efficient frontier based on annual fund level data from the Australia Prudential Regulatory Authority (APRA). The second stage calibrates a non-linear Frational Response Model (FRM) under the GLM regression framework.

Our analysis contributes to the broader literature in three ways. First, a comprehensive frontier efficiency study incorporating all fund types is unique in the context of Australia's superannuation industry. Second, we incorporate age profiles of members in our key performance indicator; this is an innovative technique that has not been adopted in the broader pension fund efficiency literature. Lastly, we calibrate more vigorous second stage techniques in estimating the relative impacts of structural variables, which is somewhat lacking in the existing study of super fund efficiency in Australia.

Finally, our results indicate that overall, the Australian superannuation industry is relatively efficient. However, there are significant caveats in the structural features of the industry which prevents the full benefit of economies of scale from being utilised. These result have significant implications for future industry structural reforms and competition regulation.

Chapter 1

Introduction

1.1 Background

'Pension policy has become one of the more volatile areas of economic reform in recent years. The onset of demographic transition, in developing and developed economies alike, has combined with concerns about the efficiency effects of a large public sector, to generate a search for pension reform options which reduce the legal responsibility of governments to provide financial support for the retired. Many countries around the world have recently undertaken reform, are in the middle of the reform process, or are actively debating reform options.' - Bateman et al. (2001)

The need for pension policy reform goes beyond fiscal sustainability and economic stability, as the quality of life for the retied is partly determined by their level of income and wealth. Australia's current taxpayer funded and means tested age pension system has been designed to target low income populations and support a basic, acceptable standard of living, accounting for prevailing community standards. The general desire for higher standards of retirement living along with the pursuit of fiscal sustainability of public pension scheme has led to wide spread legislative reforms in Australia's retirement income provision policies. The current policy emphasis on publicly mandated and privately managed superannuation savings is the core legacy of this reform.

Since the inception of the superannuation guarantee (SG) in 1992, the superannuation system has undergone significant changes. Today the industry manages over \$1.6 trillion in assets, more than Australia's annual national GDP, and is projected to rise to \$6.1 trillion by 2035.[1] A recent ABS survey[2] shows 43%

[1] Treasury Forecast 2012

[2] ABS Australian Social Trends 4102.0 (2009)

of retired Australians have somewhat benefited from superannuation, of which 20% solely depend on their superannuation balance for retirement. This figure is expected to increase exponentially over the next decade. The issue is further exacerbated by the transition of investment risk, as the industry has moved away from Defined Benefit (DB) to Defined Contribution (DC) schemes in recent years. As of 2012, over 82.6% of superannuation assets held in large super funds[3] have been allocated to accumulation plans, representing retirement savings of more than 93.1% of members.[4] The rapid transition from the reliance on public pensions to privately managed savings coupled with the shift in investment risk from employers to members has placed greater responsibility on the superannuation fund custodians to provides best value for money investment management that promotes the financial adequacy and stability of its members in retirement.

1.2 Motivation and Contributions

The primary motivation for this research derives from the 2012 *Cooper Review* of the superannuation industry also known as the Super System Review. The *Cooper Review* highlighted the importance of examining the operating efficiency of the industry. In particular, whether the full benefit of economies of scale is being harnessed and whether processes and procedures are still appropriate given the changes that have occurred in the industry over the last decade. This research aims to contribute to this debate by analysing the industry's production efficiency and the relative impact of key structural and design features. Given the diversity of fund structures and plan features that operate concurrently in the Australian market, the potential findings of systematic inefficiencies within the industry will better inform future policy formulation.

Furthermore, previous research has shown that the level of administrative fees prevalent in the APRA regulated superannuation funds[5] have been very persistent

[3] Funds with more than four members

[4] APRA Annual Superannuation Bulletin 2013

[5] Australian Prudential Regulatory Authority (APRA) is the main regulator in Australian

while returns have not improved, despite rapid consolidation of funds occurring within the superannuation industry (Bateman, 2002). This is in contradiction with conventional economic wisdom which suggests that increases in economies of scale would likely result in the lowering of administrative fees due to greater dispersion of fixed costs. Existing literature has been inadequate in addressing this contradiction, with much of the studies focusing partially or entirely on investment performance indicators such as return, risk and expenses. Our research seeks to provide some insights to this research gap by examining the overall production efficiency of super funds in delivering its core services to members.

A review of international pension fund efficiency literature revealed that these studies are mostly conservative, which rarely departs from traditional banking and mutual fund output/input specifications. This study argues that such practice is inadequate in capturing the unique features of retirement income provision, in particular, the fixed statutory holding period faced by members.[6] Our research seeks to incorporate the age profile of members in the key performance indicator of super funds. This technique is innovative and more accurately depicts the distinction between super funds and other investment services.

Previous study of super fund efficiency in Australia (Sathye, 2011) has adopted a similar two-stage DEA approach. However, we argue that the study was inadequate in addressing the prevailing concerns regarding the misspecification of conventional linear models in the second stage. This research seeks to address this issue by calibrating non-linear models that is increasingly prevalent in the broader DEA literature.

superannuation industry, it's regulatory jurisdiction include all super funds with more than four members. The rest of the industry composed of exempted public sector funds and Self Managed Super Funds (SMSF) which are regulated by the Australian Taxation Office (ATO)

[6] In the Australian context, members are forbidden from accessing their retirement saving before the age of 60 by law.

1.3 Research Questions

This paper aims to answer the following questions:

- What is the appropriate technique to measure the efficiency of the Australian superannuation industry? How should these models be calibrated to accurately reflect the industry's unique functionalities?
- What are the impacts of key structural and design features on the efficiency of super funds?
- What are the implications of future retirement policy reform?

1.4 Structure

This research is organised in the following manner:

Chapter 2 provides an overview of the superannuation industry in Australia, including its structural characteristics, design features and industry trends. This chapter serves as a background to our current research.

Chapter 3 presents a summary of literature surrounding this research. This includes the broader international literature on the efficiency of financial service sectors and existing superannuation performance studies in Australia. The chapter will seeks to identify key research gaps and provides some basis for our empirical model calibration.

Chapter 4 briefly discusses the theoretical framework behind efficiency measurements and the DEA technique. More importantly, the chapter outlines the key consideration one must take in implementing an efficiency study.

Chapter 5 is concerned with the DEA input/output calibration. A brief discussion of the underlying theory of variable selection is also provided.

Chapter 6 discusses aspects of data handling, including sample selection, the construction of output/input measures and the potential contextual variables.

Chapter 7 present the results of this research. First, we investigate the implications of first stage results, especially in terms of average efficiency and scale efficiency. Next, the chapter provides an overview of popular second stage regression models and calibrate these to our analysis. The implications of our second stage results are also discussed.

Chapter 8 concludes the study, where key results and policy implications are summarised.

Chapter 2

Institutional Setting

In contrast to the private pension industry in comparable countries, the Australian pension environment permits considerable diversity of plan design, structure and size. These unique features of Australian superannuation (pension) funds [1] are inextricably linked the history of pension policy reforms in Australia. Section 2.1 briefly discusses the history of pension policy reforms in Australia. Section 2.2 describes the current institutional framework that governs superannuation funds in Australia. Section 2.3 outlines some puzzling empirical observations that motivate this research.

2.1 A Brief History

Private pension schemes first emerged in Australia in the mid 19^{th} century. Since then, their key functionality and coverage evolved markedly up to the time of the introduction of mandatory superannuation in 1992. The development of pension policy in Australia can be broadly divided into three periods. During the first era, until the 1940s, occupational superannuation provided a selected group of salaried employees with an independent source of retirement income. The second era, from 1950s to 1970s saw the relaxation of the means testing of the age pension, and superannuation acted as supplement the age pension for mostly white-collar workers. From the 1970s until the introduction of award superannuation in 1986 and subsequently mandatory occupational superannuation in 1992, superannuation was an employment fringe benefit which, although more generally available, was still concentrated among professional, managers and administrators, public sector employees, and workers in the financial sector (Kewley (1973)).

[1] Superannuation is the Australian term for private pensions and that the two term are used interchangeably

Policy reforms initiated by government inquiries and industry movements have helped shaped the current structure of the Australian superannuation industry today. Notably, the Royal Commission established by the Bruce government in 1923 was the first to consider extending the limited coverage of the existing contributory retirement benefit schemes. However, it was the minority findings of the Hancock review commissioned by the Whitlam government in 1973 which sparked a shift in the emphasis of retirement income policy away from poverty alleviation through the minimalist age pension towards income maintenance via contributory superannuation. The impetus for universal contributory superannuation came primarily through the industrial relations arena in the 1970s and 1980s. For the union movement, the existing occupational superannuation available to middle to senior management provided a platforms upon which workers could obtain deferred wage increases in the form of retirement savings without going outside the bounds of Australia's then centralised wage fixing system (Kewley (1973)).

Then, in the mid 1980s the Hawke labor government included superannuation in its contract (or The Accord) with the union movement. This saw the introduction of award superannuation arrangements that constituted the first working version of a mandatory private saving framework in Australia. Ultimately, this led to the introduction of the Superannuation Guarantee (SG) in 1992, which is the basis of the current superannuation landscape in Australia.

In its first phase, the SG increased from 4% to 9% between 1992 and 2002. Under more recent reforms, employers must now contribute at least 9.25% of payroll on behalf of their employees to a funded pension program, increasing to 12% by 2019(Bateman and Mitchell (2001)).

2.2 Current Landscape

Current retirement income provision in Australia is a three pillar construct, comprising a public pension (the Age Pension), mandatory private saving (the Superannuation Guarantee) and voluntary long-term savings including voluntary superannuation. Given the reality of the ageing population in Australia, the efficacy of the second pillar has become increasingly important in ensuring the long term viability of the means tested Age Pension due to increasing upward pressure on future pension liabilities. This section will summarise the current characteristics of the mandatory superannuation environment in Australia.

2.2.1 Industry Composition

The diversity of funds in the current Australian Superannuation Industry is a legacy of its development process prior to the introduction of the Superannuation Guarantee. Australian superannuation funds (super funds) are privately managed trusts with different benefit designs, profit orientations and operational structures.

The industry can be broadly categorised into two regulatory jurisdictions: (1) Institutional superannuation funds that are governed by trustees on behalf of members and are under the jurisdiction of the Australian Prudential Regulatory Authority (APRA). These account for 59.5% of industry assets; and (2) Self-Managed Superannuation Funds (SMSF)[2] are regulated by the Australian Taxation Office (ATO). These account for 31.5% of industry assets; The rest of the industry comprises of public sector funds and life office statutory funds which are exempt from regulations, accounting for 9% of total superannuation assets in Australia.

Institutional superannuation funds can be further categorised by their functional

[2]SMSF are funds with less than five members, all of which are trustees of the fund. Reporting obligations of SMSF are to the ATO, these informations are not publicly available.

classification. That is, (1) Corporate funds ; (2) Industry funds; (3) Public Sector funds; (4) Retail funds. Superannuation funds in categories (1)-(3) are typically 'not for profit' funds that cater only to members in their respective sector or entity. Traditionally the majority of such funds were not available to the general public (i.e, non-public offer), but this mix is changing. They charge members for services at cost and fees, charges and insurance benefits are often subsidised by the sponsors or through the fund surplus (APRA (2005)). In contrast, retail funds are public offer funds that provide superannuation products to the general public on a commercial 'for-profit' basis.

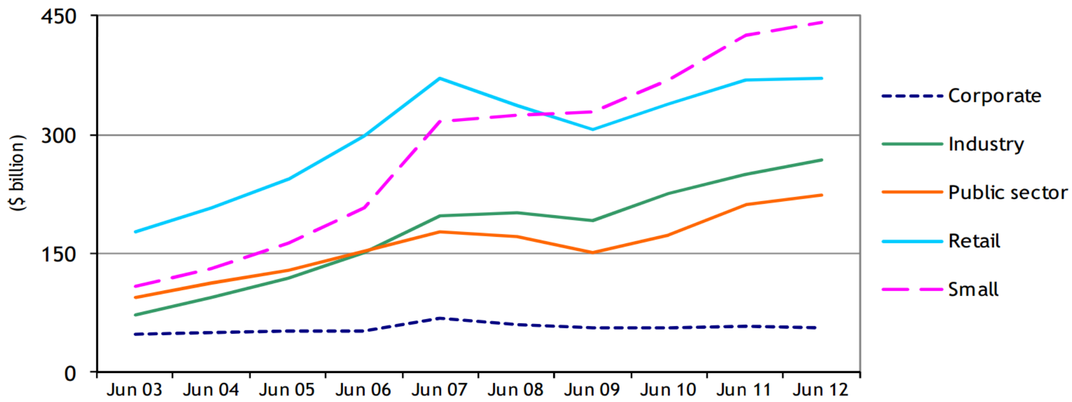
The most recent annual superannuation fund data for June 2012 is presented in *Table 2.1.* This shows that SMSFs are the largest sector by total assets under managements, with 31.5% of all superannuation assets in the Australian market. Retail funds lead the institutional super fund market with 26.4% of market share, while industry and corporate super funds trails at 19.1% and 4% respectively.

Table 2.1: Composition of the Australian Superannuation Industry 2012

Fund Type	No. of Funds	No. of Accounts (AU$'000)	Total Assets (AU$ Billion)	Average Balance (AU$'000)
Corporate	122	551	56.1	101.8
Industry	56	11,664	267.3	22.9
Public Sector	39	3,371	222.7	66.1
Retail	135	15,408	371.4	24.1
SMSF (Small)	481,538	918	440.9	480.4
Other			42.2	
Total	481,957	31,912	1,400.6	695.3

The dynamics of asset growth by the different fund types over the past decade is illustrated in *Figure 2.1.*

Figure 2.1: Assets Under Management: Fund Type



Source: APRA Annual Superannuation Bulletin 2012

Despite the rapid growth of assets held in SMSFs, it remains a relatively small part of the Australian Market in terms of members.[3] The vast majority of Australian workers (97.5%) still belong to the large institutional funds. Thus, the rest of this section and subsequently the remainder of this research will only focu on the institutional funds.

2.2.2 Coverage

The introduction of the mandatory Superannuation Guarantee saw rapid growth in the coverage of superannuation schemes. *Table 2.2* shows the decomposition of superannuation coverage before and after the introduction of SG in 1992.

[3]Members of SMSFs are typically higher income earners and their families,

Table 2.2: Superannuation Coverage (1982 - 2012)

Year	Full-time Coverage (%)	Part-time Coverage(%)	Total Coverage(%)
1986	46.5	7.0	39.4
1989	55.1	17.8	48.1
1992	88.0	54.1	80.3
2010	94.4	79.2	89.8
2012	94.1	80.2	89.9

Source: ABS No. 6310.0

Today, 89.9% of the Australian workforce are covered under the superannuation system, which is the highest participation rate in private retirement saving among comparable economies (OECD (2007)). The retirement and retirement intentions survey conducted by the ABS indicate that in 2012 more than 43% of retired Australians have benefited from superannuation at some time, of which 20% rely solely on their superannuation lump sum payment to support their retirement. Further, projections based on current trends also indicate that by 2050, only 28.3% of retirees will entirely depend on the Age Pension to fund their retirement, private savings in the form of superannuation are expected to partially or entirely fund the rest of the retired population.[4]

2.2.3 Benefit Design

Traditionally, the majority of superannuation funds operate under a Defined Benefit (DB) framework, where the retirement benefit of an individual is a function of certain employment factors; benefit typically depends on the employee's earning history, age, tenure of service etc. In such schemes, the investment risk falls on the fund sponsors; if the fund has inadequate assets to meet its obligations, the sponsor is required to make up the shortfall. However, most DB plans suffer from poor portability, so changes in employment would significantly reduce value of retirement benefit. The

[4] ABS Survey of Employment Arrangements, Retirement and Superannuation 2012.

limited portability of DB benefits creates a major disincentive against moving jobs. This feature coupled with concerns about the ability of employers to maintain the benefit structure during periods of market downturn (such as the GFC) saw Defined Contribution (DC) plans rise in popularity. In the DC arrangement, investment risks is borne entirely by fund members as well as the risk that inadequate contributions are made into the plan. Under a DC scheme, the final benefit received by the member is directly related to their SG contributions, their choice of investment strategy, the performance of the chosen portfolio and the fees and cost charged by the fund.

Today, most DB schemes have completely or partially transitioned into DC structures. That is, most DB schemes have now closed to new members *Table 2.2* shows that the membership of DC plans has increased from 18.2% in 1983 to 94% in 2008.

Table 2.3: Membership Distribution: Benefit Type

Year	Members in DB funds (%)	Members in DC funds (%)
1982-83	81.8	18.2
1991-92	24.3	73.2
1999-00	13.9	86.1
2007-08	6.0	94.0

Source: Australian Social Trends, March 2009, ABS No. 4102.0

The increasing prevalence of DC schemes represents one of the most significant changes in the Australian superannuation system. While mandatory superannuation helps alleviate some of the fiscal responsibly of the government for retirement incomes, the structural shift from DB to DC schemes places greater emphasis on member's choice of investment portfolios and the management of these portfolios by superannuation funds, as their performance directly impacts the level of benefit received and the ability of these private savings to deliver retirement income requirements.

2.2.4 Regulatory Framework

With the exception of a small number of selected public sector funds which are 'constitutionally protected', all institutional funds in the Australian superannuation industry fall under the jurisdiction of the Australian Prudential Regulation Authority's (APRA). APRA plays a key role in the industry as the administrator of *The Superannuation Industry (Supervision) Act 1993* (Cth) *(SIS Act)*. The *SIS Act* provides the authority with extensive supervisory and regulatory powers.

APRA's regulatory approach is 'principle-based' rather than 'rule-driven'. This means it focuses on promoting prudent behaviour by superannuation trustees and on ensuring the trustees comply with prudential requirements and operational standards. The aim of prudential regulation is to promote best practices and soundness within the funds, and reduce the likelihood that regulated funds will fail and be unable to meet their commitments (Liu (2013)).

In practice, APRA relies on arm-twisting and moral persuasion to ensure compliance (APRA (1998)). This passive regulatory stance typically translates to non-binding guidance in the form of circulars and guidance notes to regulated superannuation funds. However, the installation of a new prudential standard making power to APRA in 2012 is likely to see potential regulatory reforms in the superannuation sector, including stricter prudential standards, and more active regulatory involvement as seen in other APRA regulated sectors such as Banking.

2.3 Industry Trends

The superannuation industry in Australia has undergone a tremendous and rapid change over the past decade. This section will examine some key industry trends that motivate this study of the efficiency of the superannuation industry.

2.3.1 Decreasing Levels of Competition

Over the past decade there has been a substantial consolidation of the number of superannuation funds within the industry. *Figure 2.2* illustrates the decrease in the number of funds by 57.6% from 469 funds in 2004 to 199 funds in 2012.[5] Over this period, the Herfindahl Hirshman Index increased from 1.5% in 2004 to 2.8% in 2012, suggesting greater market concentration and decreasing level of competition in the industry. Although, this figure remains relatively low compared to HHI benchmarks,[6] there is still a need to examine how this market rationalisation has affected the efficiency of the industry and the welfare of members.

Figure 2.2: Market Concentration

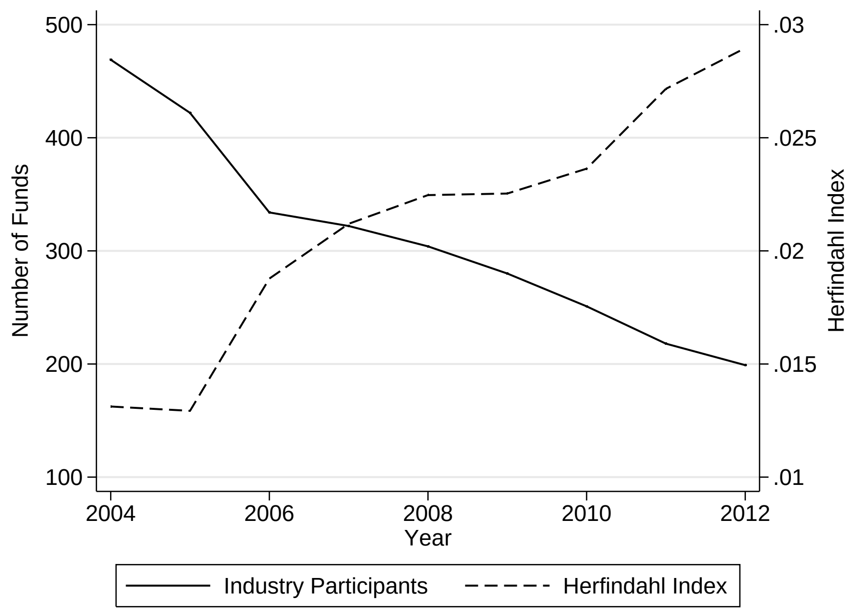
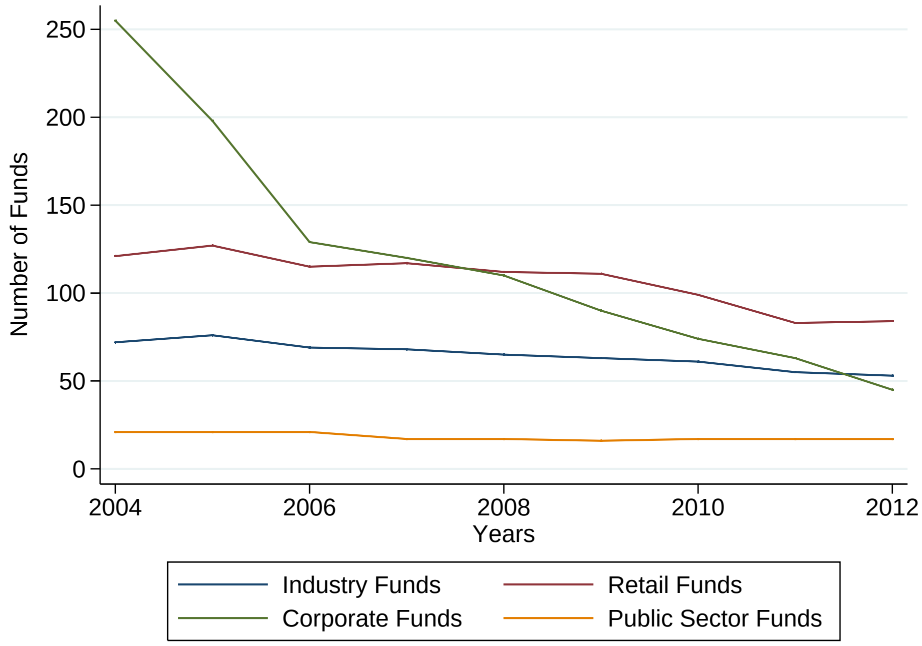


Figure 2.3 shows that industry consolidation has not been uniform across public offer and non-public offer superannuation funds: the number of public offer funds decreased by 12.7% and non-public offer funds decreased by 80.1%.

[5]Figures are post sample selection, where erroneous observations and missing data are dropped.

[6]Herfindahl Hirschman Index (HHI) indicates the level of concentration, and distribution of market share, within an industry. An industry is typically considered low concentration when HHI is less than 15%.

Figure 2.3: Sector Decomposition



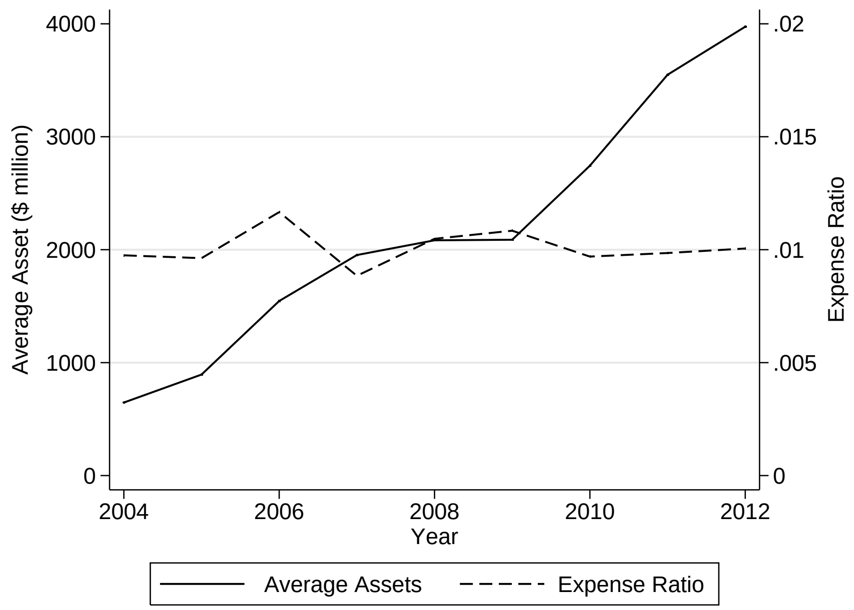
The rationalisation within the non-public offer sector is primarily driven by market exits of corporate super funds, while the number of Industry funds and Public Sector funds have remained relatively stable. The number of corporate funds has significantly decreased by 91.3% over the past decade. This is in line with the observation that an increasing number of small corporate funds wind up and merged their managed assets into retail master trust funds due to high cost associated with onerous regulatory compliance and licensing requirements (from 2002). The number of retail funds have also moderately decreased.

Current literature surrounding the superannuation industry in Australia has been inadequate in assessing the impact of the rapid consolidation and asymmetric rationalisation on overall industry efficiency. This research seeks to provide some empirical evidence to inform such debates.

2.3.2 Stagnant Expenses

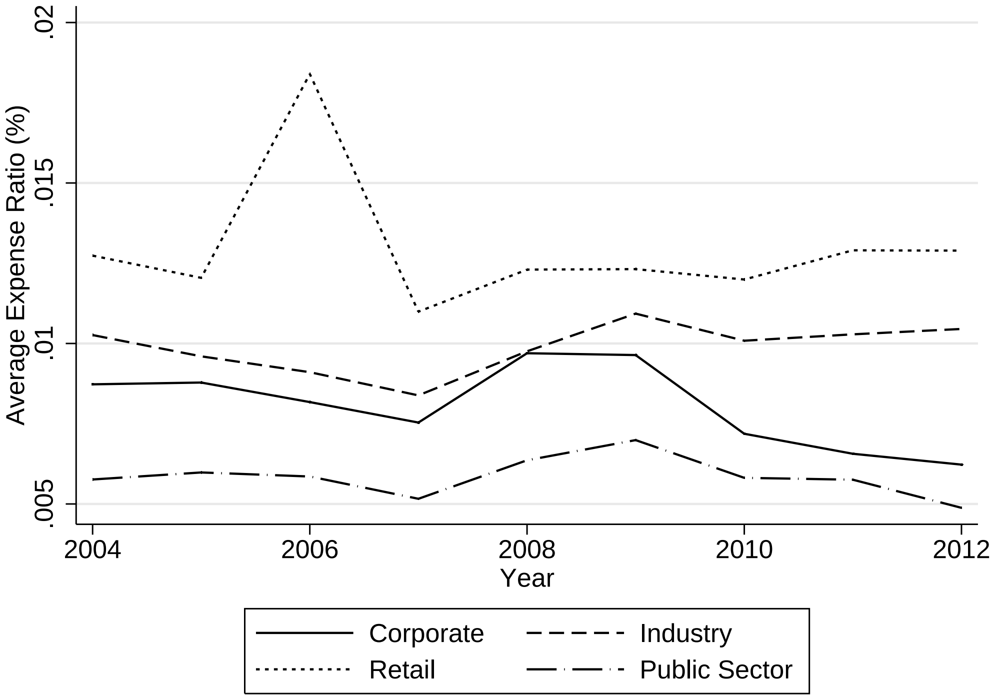
As discussed earlier, the industry has grown considerably in scale over the past decade, and in conjunction with market consolidation, this has in effect resulted in fewer and larger funds. Economies of scale imply that larger funds are more efficient than smaller funds because they can distribute fixed costs across more members and assets. However, *Figure 2.4* illustrates that the superannuation industry has been stagnant in improving average fees and charges imposed on members, with the expense to assets ratio remaining at the 1% level.

Figure 2.4: Average Fund Asset and Expense Ratio



This observation is somewhat consistent across the four institutional fund types. Further, *Figure 2.5* shows that public sector funds have the lowest reported fees, immediately followed by corporate funds, industry and retail funds. This is consistent with the prior assertion that these funds are likely to be subsidised by their respective sponsors. Retail funds have the highest average expense ratio, again not surprising as these funds are mostly 'for profit' public offer funds.

Figure 2.5: Average Expense Ratio by Fund Type



Chapter 3

Literature Review

A comprehensive literature review of efficiency studies on financial institutions is a fairly daunting task. There is no consensus among researchers as to the best technique to measure efficiency (that is, should one use parametric approaches, non-parametric approaches or semi parametric approaches), nor is there agreement on the precise inputs and outputs to be calibrated in the analysis (in particular, should one take intermediation approach or the production approach).

Further, the quantum of the efficiency and productivity literature is large. Therefore, rather than canvassing every relevant study, this chapter will focus on the key considerations one must make when undertaking a study of superannuation efficiency, and illustrate them by citing relevant studies.

The literature review is organised as follows: Section 3.1 will briefly discuss the key policies consideration presented by the *Cooper Review* and the motivations in undertaking an efficiency study of the Australian superannuation industry. Section 3.2 canvas the most prominent area of efficiency study in financial services, that is the U.S. banking market and mutual funds, and examine how these literatures have helped to inform government policies and research interests. These studies deviate from traditional productivity literature as the industry does not have conventional production process, the sights from this stream of literature provides guidance to calibrate our efficiency model for the superannuation industry. Section 3.3 extends our review of literature to more recent international studies on pension fund efficiencies. And lastly, Section 3.4 discusses the exiting performance and efficiency studies of the Australian superannuation industry, this section will also existing identify research gaps and the potential contributions of this research.

3.1 The Cooper Review

In 2009, the Australian Government announced a comprehensive review of Australia's superannuation system: the Super System Review (*the Cooper Review*). The review was chaired by *Jeremy Cooper* and was charged with '*examining and analysing the governance, efficiency, structure and operation of Australia's superannuation system. The Review is focused on achieving an outcome that is in the best financial interests of members and which maximises retirement incomes for Australians*' (super system review, p5). The *Cooper Review* was conducted in three phases. In particular, phase two of the review sought to address whether the superannuation system is operating as efficiently as it could be, whether the full benefit of economies of scale are being harnessed and whether processes and procedures that worked when the system was smaller are still appropriate.[1]

This section of the thesis give an overview of the *Cooper Review* and its key findings as it applies to an assessment of superannuation fund efficiency in Australia. The purpose is not to critique the review or its findings, but rather to identify the potential sources inefficiencies in the Australian superannuation system as these characteristics form the basis for our efficiency analysis.

The *Cooper Review* took the view that wholesale investment markets are competitive and efficient, therefore only marginal potential gains in efficiency can be realised by increasing gross investment outcomes. However, there appears to be scope for improvement in the overall system efficiency by refining and streamlining operation processes and reducing costs and leakages (including agency costs). In this respect, the *Cooper Review* has identified several key areas of potential efficiency gains.

[1]Australian Superannuation System Review, Phase Two: Operation and Efficiency 2009

3.1.1 Reducing Costs

The first key area of efficiency gain is to reduce the universal fixed costs associated with the industry so that service providers can reduce price of service, while still retaining their current profit margin. The review noted that by removing redundant regulatory requirements and promoting greater utilisation of new technologies in super fund, one can reduce the relatively large fixed costs borne by current market participants due to system design and external factors. Efficiency gains under this regime is likely to occur if the market is highly competitive and that any potential gains for super funds is likely to be fully passed on to consumer in the form of reduced service fees.

The *Cooper Review* also recognised cost transparency as a major impediment to achieving greater efficiency in this respect. In particular, the emphasis on lowering prices would likely result in too much focus on services such as administration and insurance where fees are more transparent, and insufficient attention on achieving efficiencies from areas such as investment management and distribution, where the costs imposed on members are less visible.

3.1.2 Lower profit margins

The second key area of efficiency gain is to promote vigorous price competition in the market where it is insufficient, particularly in areas where price competition between service providers are less than optimal. The *Cooper Review* argued that in selecting professional service providers, super fund trustees should be more aware of the profitability of their service providers. The current lack of such information limits the extend of competition between service providers and inhibits the ability of trustees to make fully informed decisions in pursuing the best financial interest of their members.

The findings of the Wallis inquiry (1997) into the Australian banking sector are also relevant. The final report suggested that an increase in competition for (profitable) aspects of the financial services market by specialist providers may result in a reduction of inefficient product pricing (cross-subsidisation) by existing firms. For example, the administrators of superannuation funds could be inclined to provide transaction services at a discounted price in order to obtain patronage of customers (super fund members), the loss of revenue from transaction services could be then made up in other aspects of service such as investment and insurance charges. An increase in competition due to greater profitability transparency in the superannuation investment service market could reduce the service provider's ability to recover the foregone revenue from their transaction discounts. As a result, one might expect the cross-subsidisation between services to be removed, hence the overall result of increases in competition may not be optimal.

3.1.3 Technology

Coupled with changing demographics is the way in which members use technology to interact with their superannuation funds. Information is now increasingly susceptible to transmission, storage and interrogation because of advances in technology and reduced cost barriers. While members have increasing access to information to make decisions, super funds also have an increasing responsibly to use and interrogate the information they possess. Super funds which operates in an competitive environment would have to justify their value where customers have, because of technology, direct access to markets.

The *Cooper Review* argued that the range of technologies employed by different participants in the super system, the existence of multiple legacy technologies within some organisations and the retention of manual and paper based processes in other areas, seem to present challenges to the efficient operation of the system.

3.1.4 Default Portfolios

The *Cooper Review* cited as at June 2008, 46% of total assets in APRA-regulated funds were in default investment options, ranging from 23.4% of assets in retail funds to 74.8% in industry funds (the APRA data for June 2012 suggests a slight reduction since then). This proportion of assets translates to a higher proportion of members, as members with lower account balances are over represented in default investment options.

Further, most default investment options in super funds are not age based, and typically use a 'balanced' asset allocation.[2]It is then important that super funds have default investment options that appropriately accommodate a variety of members and that members' best financial interests are served.[3]

3.1.5 Regulation

The *Cooper Review* posed the question of whether the cost effectiveness and usefulness of regulation in superannuation can be assessed? That is, how can regulation be frequently reviewed?

Shared administration of the same provisions by different regulators, with their distinctive approaches to fulfilling their statutory mandates, may lead to particular problems as industry sectors diverge in different directions. It is then imperative that the regulators coordinate efficiently and do not impose excess compliance and reporting obligations on the industry. Further, there is a need to ensure that regulatory standards are sensible and promote efficiency in delivering best outcomes for members.

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[2]In Australia, 'balanced' most commonly refers to an approximately 70/30 growth/defensive asset allocation. By contrast, some other countries typically use far more conservative default investment options for their default fund.

[3]The new legislation setting of the new MySuper product endorsed age based defaults.

3.2 International Literature

3.2.1 Efficiency Studies: General Applications

Berger and Humphrey (1997) surveyed 130 efficiency studies, the majority in the banking sector. This survey revealed that the literature has primarily contributed to three principal areas: informing government policy; addressing research issues; and improving managerial performance. This classification and its subcategories are useful in defining the key focus of this study and assessing its potential contributions. The classification by Berger and Humphrey (1997) is reproduced in *Table 3.1.* This section will briefly discuss each research area and particularly where it relates to the core analysis and contributions of this research.

Table 3.1: Research Areas - Berger and Humphrey (1997)

Rsearch Areas	Subcategories
Inform government policy	Deregulation, financial disruption
	Institutional failure, risk, problem loans
	Market structure and concentration
	Mergers and acquisitions
Address research issues	Profit, revenue
	Confidence intervals
	Comparing different efficiency techniques
	Different output measures
	Organisational form, corporate control issues
	Cross-country comparisons
	Methodology issues
	Opportunity cost, output diversification
Improve managerial performance	Credit unions
	Bank branch
	Savings and loans branch

Informing Government Policy

Deregulation - One of the main sources of potential efficiency gain, identified by the *Cooper Review*, was the deregulation of the superannuation market in Australia. Indeed, financial deregulation has often been characteristically undertaken to improve the efficient performance of an industry, whereby a reduction in redundant regulatory requirements could promote better resource allocation and greater competition in the industry. This could then lead to a reduction in prices and the delivery of better services to consumers.

Of the studies canvassed by Berger and Humphrey (1997), there was no clear evidence that deregulation results in increased efficiency. For example, in the U.S., measured efficiency fell following deregulation. Bank productivity declined largely due to interest rate deregulation which resulted in higher interest rates being paid on consumer deposits, with no accompanying reduction in the services provided to those account holders and no increase in account fees. While some jurisdictions shared similar experiences to that of the U.S., selected studies did show evidence of increases in efficiency following financial deregulation of the sector. Berger and Humphrey (1997) concluded that the effects of deregulation depends, in part, on the initial industry conditions and therefore 'the conventional wisdom which holds that deregulation always improves efficiency and productivity may be incorrect'.

Market structure and concentration - Berger and Humphrey (1997) noted that many studies of financial institutions and other firms have found a positive statistical relationship between market concentration and profitability. This observation has often been attributed to market powers, in which firms can earn supernormal profits. Alternatively, due to more efficient firms gaining increased market share, when combined with low production costs result in increased industry profits. These competing arguments of profitability, market power vs. efficiency, have opposing implications for the government's anti-competition policy. If high profits are fashioned by market power, anti-competitive actions are likely to be socially beneficial. If high relative efficiency is the grounds for greater profitability, then breaking up efficient firms, which have gained large market shares, or by blocking mergers and acquisition of firms, are likely to be less favourable to consumers.

The reality of the superannuation industry in Australia, is an industry undergoing rapid consolidation and increase in market concentration. This is particularly so for the public offer funds, where corporate super funds commonly merge into retail master trust funds, and the consolidation in the retail superannuation market itself. It is then imperative to understand the fundamental underpinning of the competition policy proposed by the Cooper review.

Addressing Research Issues

Organisational Form and Corporate Control - Berger et al. (1993) identified several possible determinants of inefficiency, including agency problems between owners and managers, regulation, organisational and legal structures. In theory, firms owned by shareholders are expected to be more efficient due to the incentives asserted onto management to control costs and enhance profits. Berger and Mester (1997) provide empirical evidence for this proposition, where publicly listed banks as well as those owned by a parent entity are confirmed to be more efficient.

Parallels can be drawn between the governance structure of the banking sector and the Australian superannuation industry, where each fund type (Industry, Retail, Public Sector, Corporate) have distinctive governance features. For example, 'for-profit' super funds operate under similar management incentive schemes to those of the publicly listed banks, and corporate funds are typically governed by its sponsoring entity. Additional board features could also contribute to the efficiency of the fund.

Methodological Issues - Literature in this category focuses on improving the technique by which efficiency is estimated. Advances has been made in areas associated with semi-parametric and semi-nonparametric techniques which depart from traditional DEA/SFA analysis. However, these more advanced techniques are out of the scope of this thesis.

An interesting technique considered in selected studies using data with time dimensions is the Malmquist Index. The technique allows researchers to account for technological change in analysing the efficiency of firms.[4]. This is outside the scope of this research, and could be pursued in future studies.

Wheelock and Wilson (1999) studied changes in cost productivity for over 11,387 U.S. banks between 1984 and 1993 using DEA constructed Malmquist indices. To analyse the sources of change in productivity, the researchers decomposed the decline in productivity into four components: changes in pure technical efficiency, changes in scale efficiency, changes in pure technology and finally, changes in the scale of technology, as follows.

$$\begin{aligned}\text{Productivity} =& \Delta\text{Efficiency} \times (\Delta\text{Technology})^{\frac{1}{2}} \\ =& (\Delta\text{Pure Technical Efficiency} \times \text{Scale Efficiency}) \\ & \times \Delta\text{Pure Technology}^{\frac{1}{2}} \times \text{Scale Technology}^{\frac{1}{2}}\end{aligned}$$

The change in pure technology is the geometric mean of a ratio that measures the shift in variable returns to scale (VRS) frontier relative to the firms' position at time t+1, and a second ratio, which measure the shift in the VRS frontier relative to the firms position at time t. Change in the scale of technology describes the change in returns to scale resulting from technological changes.

Using U.S. bank data from 1984 to 1993, Wheelock and Wilson (1999) found large increases in the change of pure technology, which indicates that the efficiency frontier shifted heavily outward during the period. The paper also found overall cost efficiency declined between 11.43% to 17.28%, depending on the bank size (smaller banks have larger declines than larger banks). This suggest that despite

[4] Recall that the ability of super funds to adapt to technological shifts in the market was identified as a key efficiency metric by the Cooper review

large advances in technology during the period, average technical and scale efficiency has declined more than the opposing movements of the frontier. The overall effect is a decline in productivity, which is less for large banks than for small banks.

3.2.2 Efficiency Studies: Pension Funds

The application of efficiency analysis to pension or superannuation funds is limited, and is somewhat concentrated to a few South American countries. To our benefit, a number of these countries followed Chile in privatising their pension systems, and the resulting pension fund landscape is somewhat similar to that in Australia. Therefore, it is useful in canvassing some of the literature in this space and their experiences in assessing the efficiency of pension funds.

Earlier work of Braberman et al. (1999) studied Argentinian pension fund management institutions using a Cobb-Douglas cost frontier model,[5] where the researchers regressed operating cost again three independent variables: the number of members; the positive turnovers; and the profitability of the fund. The study also included two dummy variables to account for changes in regulation after November 1997. They found that regulation increased total costs but did not significantly affect relative efficiency, although the study was criticised for its misspecification of the Cobb-Douglas production function due to the lack of factor prices.

Barrientos and Boussofiane (2005) analysed Chilean pension fund management companies with the use of a two-stage procedure. The researchers first computed efficiency scores for the pension funds using the non-parametric frontier approach Data Envelopment Analysis (DEA), and then regressed the scores against contextual variables using OLS regression. The study was conservative in defining the output factors of pension funds. Similar definitions as those used in the banking sector were followed, including total revenue and the number of contributors as outputs;

[5] This is one possible specification of Stochastic Frontier Analysis (SFA), which will be discussed later in this thesis in conjunction with Data Envelopment Analysis.

marketing costs, office personnel costs and administration costs as inputs. The study found no continuous trend toward an improvement in technical efficiency. Analysis of the determinants of efficiency showed that an increase in market share contributes positively to technical efficiency. Barros and Garcia (2006) noted that the second stage analysis was the caveat of this paper, where the regression model did not fully account for the unique nature of the efficiency scores (continuous on the unit interval). Further, studies by Simar and Wilson (1999, 2000) showed the efficiency scores obtained in the first stage are correlated with the explanatory variables used in the second stage, therefore any regression output is likely to be inconsistent and biased. Barros and Garcia (2006) suggested that a bootstrap procedure is necessary to overcome this problem.

Using the same data, Barros and Garcia (2006) studied the sample with four DEA models and concluded that traditional DEA models are unable to discriminate adequately between Portuguese pension funds with most funds on the VRS frontier. The study also found significant statistical correlations between efficiency and selected contextual variables, this include private/public status, mergers/acquisition and scale. However, the study did not conduct any second stage regression analyses. Further work by Barros et al. (2008) analysed the sample using Stochastic Frontier Analysis (SFA) and found that market share is negatively related to cost efficiencies, while mergers and acquisitions appear to increase cost efficiencies.

In addition to the above attempts at analysing of pension funds, there is also some evidence in the mutual fund context. Basso and Funari (2001) constructed a generalised performance index for Italian mutual funds using DEA, where the researchers defined an innovative output measure which reflects the matching of the investor's preference structure and the time occurrence of the returns. This study departs from traditional efficiency analysis in focusing on either cost or profit definitions of outputs, and was among the first to include variables that directly capture specialised functionality of the industry studied. Further studies by Basso and Funari (2003) builds upon this aspect by introducing ethical indicators as a key output for mutual funds, the measure not only allows mutual funds to compete on financial performance but also on their ethical standards, such as investment in renewable energy and community projects.

Galagedera and Silvapulle (2002) used DEA to analyse the relative efficiency of 257 Australian mutual funds, while secondary regression explored the relationship between fund attributes and their respective efficiency measures. The study found that technical efficiency of mutual funds in Australia appear to be dominated by the effects of scale efficiency compared to pure technical efficiency. The study found no significant relationship between the mutual funds' relative efficiency score and its structure, classification, size and age.

3.3 Australian Literature

Efficiency studies of the Australian superannuation industry are sparse with only one relevant frontier efficiency analysis conducted. Sathye (2011) examined the efficiency of retail superannuation funds in Australia for the period 2005 - 2009 using DEA. The study found a positive relationship between fund size and production efficiency, and suggested that M&A within the industry should be encouraged to achieve higher overall efficiency through rationalisation. The caveats of this study is in two fold. First, the study did not consider other fund types (Industry, Corporate, Public Sector) which accounts for a significant proportion of the Australian market. Further, output variables defined in the study were poor in reflecting the features of the superannuation industry in Australia. Second, The study was inadequate in accounting for the prevalence of alternative second stage techniques popularised in the recent DEA literature. TOBIT regression employed in this study was widely recognised as a misspecification of the DEA efficiency scores.

Other industry studies in Australia have been focused on particular elements of super funds' performance indicators, including investment returns, risk, administrative fees and fund designs. This research aims to extend these studies by adopting efficiency analysis techniques used extensively in other financial services industries. The study is valuable in that it takes a broader view of super fund operations and assesses its performance based on a combination of its key functions other than investment outcomes.

3.4 Investment Performances and Risk

Earlier studies often employed traditional financial indicators commonly used in the analysis of other professionally managed funds. Bird et al. (1983) examined the performance of Australia superannuation funds from 1973 to 1981 using the Sharpe ratio, the Treynor ratio and Jensen's alpha. The study compared funds' investment performance with three standardised benchmark market portfolios. They found no consistency in funds performance but did note that funds with larger asset pools performed relatively better than smaller funds. This was first amongst an extensive body of inquiry that examine the performance of asset managers using risk-adjusted returns.

Jacob (1998) argues that, because a benchmark portfolio is intended to represent a passive alternative to the investment manager's style, then if there are costs associated with replicating this passive portfolio, those should be reflected in the benchmark's return, or the comparison is not fair. Drew and Stanford (2001) took this into account by constructing a customised indexed portfolio for trustees, based on the notion of relative market efficiency. The portfolio bears the properties of an open end retail fund, and the management fees are proxied from US mutual funds. The study found that low cost passive asset selection provides superior risk adjusted returns to fund members than the returns achieved through a high cost active asset selection strategy. The study is further extended in Drew and Stanford (2003), where the authors used a multi factor model to analyse the performance of retail superannuation funds in Australia. The study found active investment strategies did not add any value for members, instead active portfolio management consistently under performs passive portfolios. Due to the limitation of data, only the retail segment of the industry was analysed. In addition, the analysis relied heavily on benchmark portfolios; this meant the studies were highly sensitive to assumptions made in regards to portfolio asset allocation and management fees.

Coleman et al. (2006) conducted a broader industry study using two sets of proprietary APRA data. The study examined the relationship between risk, returns and expenses over the period 1995 to 2002 for large APRA funds, with a particular focus on how performance varies by total assets, by fund type and over time. By comparing net return on assets and volatilities across fund types, the study found that retail and industry funds have the lowest returns and volatilities whereas public sector and corporate funds have the highest returns and volatilities. On both a net return and risk adjusted return basis, not-for-profit funds significantly outperformed for-profit funds. The differences are attributed to the greater agency costs of for-profit funds (due to non-representative trustee board structure and potential board member conflicts of interest). Furthermore, the study also found a positive relationship between returns and fund size.

Ellis et al. (2008) recognised that prior studies of fund performances were limited in terms of comparability between funds, due to active portfolio choice of members; thereby implicitly incorporating asset preferences of its members in its performance. To focus on comparable returns, the study focuses on the default option only and uses the asset allocation information to construct a benchmark for the default option in each fund. Comparisons of performance are then made relative to this benchmark. This technique is superior to prior studies as it isolates the net performance that a fund member would earn using the trustee's asset allocation and management approach. The data used in this paper is a customized quarterly survey of 197 large superannuation funds between 2001 and 2006. The result showed significantly lower average net return relative to the benchmark for balanced and growth retail default investment options, compared with other fund types. This implies both higher expenses and taxes, explicit and embedded, for the retail fund options. However, the study is limited in that it only considered the risk element in relation to the benchmark portfolio but not the fund's portfolio. This shortcoming could be attributed to the limited time series of the dataset.

So far, the literature that assesses Superannuation fund performance has been based on risk to reward comparisons, though they differ in procedure. The definitions of risk often rely on theoretical assumptions and may be open to manipulation. Sy and Liu (2009) took a different approach to the risk measures. This study argues that traditional ratios such as the Sharpe ratio is inappropriate in situations where the manager has control over the volatility or is encourage to assume different levels of risk from the benchmark. To illustrate, the paper proposed the following example:

Table 3.2: Negative Sharpe Ratio Example - Sy and Liu (2009)

$r_f = 5\%$	Return (%)	Volatility (%)	Sharpe Ratio (%)
Benchmark	-2	10	-0.7
Manager A	-5	20	-0.5
Manager B	1	5	-0.8

Even though Manager A underperformed its benchmark index and assumed considerably more risk, it still out-performed both the benchmark and manager B in terms of the Sharpe ratio. Scholz and Wilkens (2008) described this phenomenon as 'market climate bias' where a fund with constant fund specific characteristics that outperforms the Sharpe ratio of the market index in a declining market will not necessarily have a superior Sharpe ratio in a normal market period. This paradox originates from the fact that the Sharpe ratio is a mere measure of efficiency of risk taking: how much excess return per unit of risk taken. It does not reward or measure the decision of the manager to select the appropriate level of risk.

Given the issues with existing risk to reward ratio measures, Scholz and Wilkens (2008) proposes an alternative approach called risk-adjusted value added (RAVA) metric.

$$\rho = \frac{R_A - R_B}{\sigma_B}$$

Where R_A is the total fund return of the firm, R_B is the benchmark return, $_B$ is the benchmark volatility. The measure is advantageous as it departs from the over emphasis on return volatility and avoids the contradiction experienced by the Sharpe Ratio. Further the metric can also be computed with relative ease, as data availability for the benchmark is much more abundant. Using this index and total fund level accounting data, the study found a statistically significant inverse correlation between the net performance metric values and management expenses of the firms. That is, on average, value adding from active management appears statistically to be unable to overcome higher costs associated with attempts to exploit market inefficiencies.

3.5 Administrative Expenses

Another key area of interest revolves around the effectiveness of funds' operations, particular in regards to the administrative fees charged by superannuation funds. The importance of administrative fees is highlighted by Bateman (2002), which noted that costs arising from custodianship of funds could have a profound impact on the financial well-being of retirees. Individual retirement accumulations could be reduced by as much as 22% for a 1% per annum management fee. In conjunction with contribution and superannuation taxes, a 1% p.a administrative fee could reduce the then statutory contribution rate of 9% to an effective rate of 5.1%.

Bateman et al. (2001) reported that the costs within the Australia superannuation industry for the financial year 1998-1999 averaged 1.72%. This paper also raised concerns in regards to the considerable variation of fees between types and characteristics of superannuation funds. Most notably, retail funds exhibits 50% higher administrative charges than industry average.

Other studies, including Drew and Stanford (2003) recognise the persistent high level of administration costs of superannuation funds in Australia. The authors attributed these costs and other member benefit issues to the agency issues resulting from constraints on market competition. The study advocates unrestricted member choice of fund and portability of superannuation entitlements, and argues that funds can be disciplined by increasing market competition; provide incentives to improve operating efficiency.

In contrast, Vidler (2004) examined optimal market structure and makes the observation that such an approach ignores cost issues inherent in personal account based pension systems, especially with non-centralised account administration. It also ignores the added costs associated with competition. The paper supports the argument for achieving a reasonable level of fees within the superannuation industry, however asserts that free choice would compound rather than alleviate current problems related to fees. The paper alternatively advocates for an institutional market structure, similar to that of the Swedish pension system. Account administration in that market is public and centralised, preventing account proliferation and maximising administrative economies of scale. Consumers choose from a relatively limited range of funds and investment options. Fund management is conducted by private firms which periodically tender for licenses at auctions run by the government. This competition 'for the market' rather than 'within the market' provides more effective discipline on providers.

Bateman and Mitchell (2001) took a more structural approach. The studies focuses on the design features of superannuation fund structure and how it could best deliver value for its members. In this respect, the paper examined the linkage between fund designs and their respective administration costs. Using data from 1998-1999, the study reported that DC plans would likely to bear the least amount of administration cost; this is followed by DB plans and retail funds. There also appears to be a significant negative relationship between the fund's scale and its respective costs.

Chapter 4

Theoretical Framework

This chapter is concerned with the theory underpinning efficiency and productivity measurement. Section 4.1 briefly summarises the underlying theory of frontier efficiency analysis. Section 4.2 discusses two popular techniques in estimating frontier efficiency and investigates the considerations in selecting the correct approach within the context of this research.

4.1 Efficiency Analysis

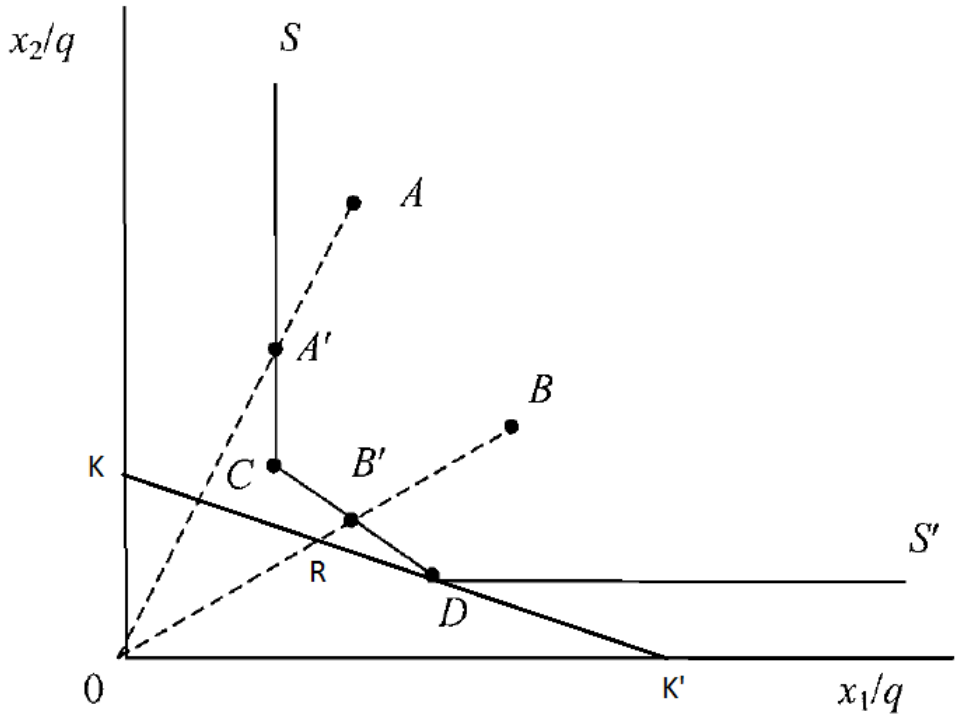
4.1.1 Farrell Efficiency

Frontier analysis is essentially a sophisticated way to 'benchmark' the relative performance of firms (super funds). Farrell (1957) was among the first to conceptualise this framework, by developing a technique that could measure the productivity and efficiency of firms using multiple input and output factors. Farrel's research departed from previous literature, which utilised simple labour productivity as a measurement of firm efficiency, by incorporating other essential inputs including capitals. The technique also accommodates and avoids the index number problems. Through the analysis of frontier dynamics, Farrell was able to isolate the two components of firm efficiency measures, technical and allocative efficiency. Technical Efficiency (TE) measures the ability of a firm to achieve maximum output given the set of input parameters, and Allocative Efficiency (AE), reflects the ability of a firm to use inputs in optimal proportions, given their respective prices. The firm's Total Overall Efficiency (TOE) is then the product of the two elements.

$$q = F(x_1, x_2)$$

Where Q is the feasible vector of outputs given input vector x_1 and x_2. By assuming constant return to scale, or homogeneous of degree zero; we are able to present all the relevant information in a simple 'isoquant' diagram in two dimensional space.

Figure 4.1: Input-oriented efficiency measurement and the isoquant



Source: Coelli et al. (2005), p165

The 'isoquant' SS' represents the various combinations of the two factors that a perfectly efficient firm might use to produce unit output. It is also the frontier that represents the minimal amount of inputs required to produce one unit of output; now the point B' represents efficiency firm using the two factors in the same ratio as B. It can be seen that it produces the same output as B using only a fraction OB'/OB as much of each factor. Farrell defined this ratio as Technical Efficiency of firm P, and it could also be expressed in terms of input distance function $d_i(x, y)$

$$TE = \frac{1}{d_i(x, y)}$$

The firm under consideration is technically efficient if it is on the frontier, in which case TE=1 and $d_i(x, y)$ also equals to 1.

By the same token, if we observe price information w of the firm's production factors, we are able to construct an 'isocost' line of the firm. The slope of such line KK' is simply the price ratio of the two inputs. This then allows us to measure the extent to which a firm uses the various factors of production in the best proportions or the allocative efficiency of the firm. Such measure allows one to further distinguish performance among technically efficient firms, for example, of all the technically efficient firms operating on the line SS', firms operating at point C have the optimal method of production rather than at B'. The costs of product at C will only be a fraction OC/OB' of those at B', this also represent the possible reduction of costs in its factors of production (Bhagavath, 2006).

Formally, if the observed firm B were perfectly efficient, both technically and in its allocation of production factors, its costs would be a fraction OR/OB of what they are. This Total Operating Efficiency of the firm could also be expressed as the product of its technical and allocative efficiency. As can be seen below.

$$TOE = \frac{OR}{OB} = \frac{OB\prime}{OB} \times \frac{OR}{OB\prime}$$

Two central problems to Farrell's analysis of firm efficiency revolve around the assumptions of constant returns to scale and the convexity of the isoquant line. The latter is common among other economic theories; the assumption of convexity ensures that the weighted average of any two attainable points is also attainable. This then allows the construction of a hypothetical firm as a weighted average of two observed firms, in the sense that each of its inputs and outputs is the same weighted average of those of the observed firms; the weights being chosen so as to give desired factor proportions (Farrell, 1957).

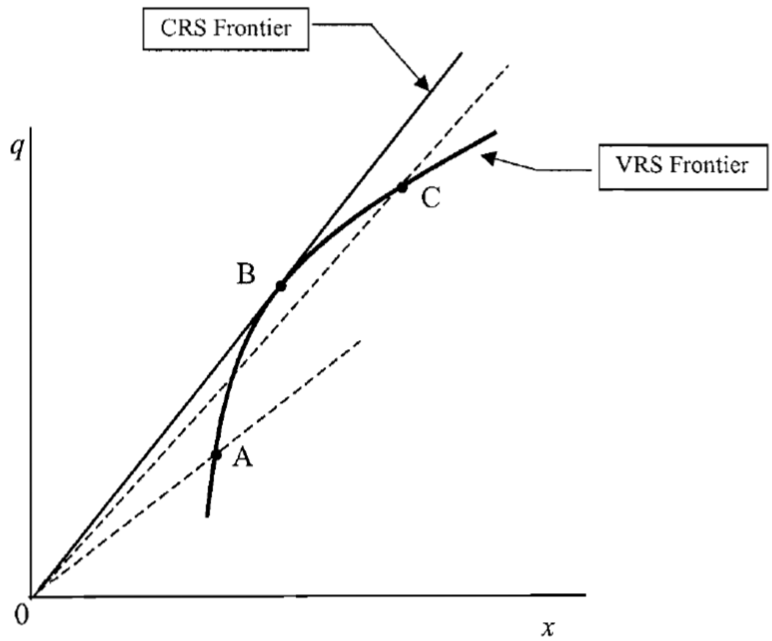
4.1.2 Scale Efficiency

The assumption of Constant Return to Scale (CRS) allows for computational simplicity of the efficient set but imposes global scale efficiency on all firms. This is unlikely to hold in practice. It is possible that a firm is both technically and allocative efficient but the scale of operation of the firm may not be optimal. Possible sources of scale inefficiency could be attributed to imperfect competition, government regulations, constraints on finance etc. Suppose the firm involved may be too small in its scale of operations, which might fall within the increasing returns to scale (IRS) part of the production. Similarly, a firm may be too large and it may operate within the decreasing returns to scale (DRS) part of the production function. In both of these cases, efficiency of the firms might be improved by changing their scale of operations . Farrell (1957) devised a methodology that divide firms in a discrete output interval, the assumption being that returns are constant within a group to a sufficient degree of approximation. However a key shortfall of this method is that it does not isolate the effects of scale efficiency and also requires a sufficient number of observations in each output interval which is not readily available. As a result comparability between firms across output intervals is limited.

Given the radical shifts in the scale of the superannuation industry in Australia, isolating the effect of scale efficiency could be the key to facilitate the explanation of productivity changes of the industry over time.

Balk (2001) provides a formal framework to define scale efficiency and to study the role of scale efficiency in productivity change. Consider the following one input and single output case:

Figure 4.2: The effect of Scale Efficiency



Source: Coelli et al. (2005), p59

Where A,B,C are all technically efficient firms since they lie on the production frontier. However, because the productivity of each of these firms is equal to the ratio of their observed output and input quantities (i.e y/x), and this is equivalent to the gradient of a line drawn from the origin through the data point (x,y), we can see that firm B is more productive than others (highest gradient). Firm A is operating in the increasing returns to scale portion of the production frontier. That is, it could become more productive by increasing its scale of operation towards point B. By the same token, firm C is in the decreasing return to scale portion and can improve productivity by reducing its scales towards B.

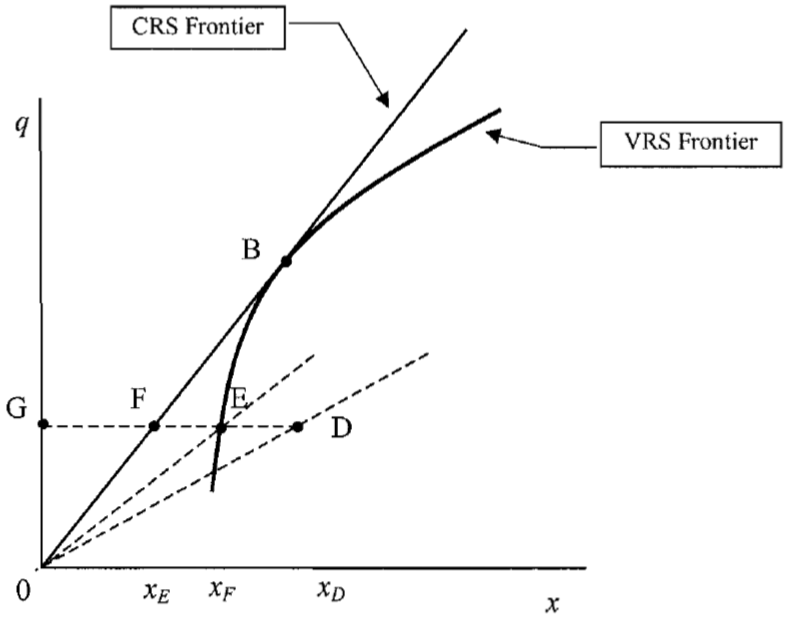
The line representing firm B is tangential to the VRS production frontier, which implies that it is operating at the highest feasible productivity. Most literature refers to this point as the technically optimal productive scale (TOPS). The point can be formalised as:

$$TOPS = \max\left\{\frac{y}{x} \;\middle|\; (x, y) \in S\right\}$$

Recall that under the assumption of CRS, all firms operates under perfect scale efficiency, therefore the line through TOPS is also the CRS production frontier.

Under this simple model, one can decompose scale efficiency as the ratio of technical efficiencies under CRS and VRS.

Figure 4.3: Scale Efficiency



Source: Coelli et al. (2005), p61

The technical efficiency of firm D relates to the distance from observed data point to the VRS technology and is equal to the ratio:

$$TE_{VRS} = \frac{GE}{GD}$$

Similarly, technical efficiency under CRS could be expressed as:

$$TE_{CRS} = \frac{GF}{GD}$$

The requires scale efficiency of firm D relates to the distance from the technically efficiency data point,E, to the CRS technology:

$$SE = \frac{GF}{GE}$$

Simple manipulation reveals that this ratio could also be represented as the ratio between the two technical efficiency measures:

$$SE = \frac{TE_{CRS}}{TE_{VRS}} = \frac{GF}{GD} \cdot \frac{GD}{GE} = \frac{GF}{GE}$$

Fare et al. (1998) has generalised this approach to multiple output/input factors to the following form.

$$SE\left(x, q\right) = \frac{d_i\left(x, q \mid VRS\right)}{d_i\left(x, q \mid CRS\right)} = \frac{TE_{CRS}}{TE_{VRS}}$$

This thesis will following this framework in isolating the scale efficiency effects.

4.2 Efficiency Score Estimation

4.2.1 Model Selection

Theoretical best practice firms typically cannot be calculated from observed data, which makes the efficiency concepts difficult to operationalise. Early attempts used OLS regression technique that fits an average curve through the sample and compares firms with the average performance in the industry. This technique is not satisfactory as it does not produce the required efficiency measurements. This has led to attempts to approximate best practice firms in the sample by estimating frontiers.

Two most prominent frontier approaches are Data Envelopment Analysis and (DEA) and Stochastic Frontier Analysis (SFA). DEA is a deterministic means of constructing a 'piece-wise linear' approximation of the efficiency frontier, where the resulting frontier is 'kinked' curve that 'envelops' the sample, each observation is optimised individual in reference to the frontier (Charnes et al., 1978).

SFA is an alternative approach to the traditional regression technique, where a secondary error term is introduced to capture the impact of inefficiencies on the production function while the traditional error captures the disturbances. This technique could account for outliers which either are very atypical or appear to be exceptional performers as a result of data measurement error. It is also useful in capturing abnormal disturbances in firm performance, especially in sectors that have highly volatile outputs and are prone to heterogeneous shocks. In contrast, the inability of DEA to accommodate for these disturbances is constantly criticised in the relevant literature, where the efficiency estimates could potentially be biased by idiosyncratic shocks to its outputs.

However, SFA implicitly requires underlying assumptions regarding the production function; the production process defines the deterministic component in the SFA regression. This characteristic makes the application of SFA in non-traditional productive industry such as the superannuation or pension industry extremely difficult. This is because the true production function is not readily observable, thus SFA application in such a scenario is likely to be vulnerable to specification error without further modifications to the model (Grosskopt, 1993). In contrast, DEA does make such assumptions, thus are more superior to SFA in this respect.

A clear advantage of DEA is the ability to readily incorporate multiple inputs and outputs; whereas SFA is somewhat limited to singular output. In the context of this thesis, our a priori knowledge of the superannuation industry in Australia is that it is a crucial part of our social infrastructure and thus serves several key functions. As a result the ability to accommodate for multiple vectors of output measures would be more appropriate in capturing the entirety of the industry's operations. Further, DEA only requires information on the output and input quantities instead of its prices (as required under SFA). This makes DEA particularly suitable for analysing the efficiency of financial service providers, where it is difficult assign prices to many of the outputs and input factors.

It is also possible to determine the underlying sources of inefficiency under DEA, as the technique provides a means of decomposing economic inefficiency into technical and allocative inefficiencies. Furthermore, DEA also allows technical inefficiencies to be decomposed into scale effects, the effects of undisposable inputs, and a residual pure inefficiency component. The decomposition of technical inefficiencies could provide valuable insights for individual case studies of decision units (i.e. superannuation funds) and could allow the industry regulator (i.e. APRA) to readily identify sources of inefficiency in the market.

4.2.2 Limitations of DEA

Standard DEA models typically impose monotonicity (i.e. free decomposability of all inputs and outputs) and convexity assumption. These assumption can sometimes be overly restrictive and easily violated in practice. Congestion of production factors and increasing marginal product of inputs are common examples of violations in these assumptions. This will discuss further within the context of our analysis later in this paper.

Due to the deterministic nature of DEA, one must also be cautiously aware of the sensitivity of DEA to measurement errors in the data. Outliers in output and input factors can significantly distort the shape of the frontier and reduce the efficiency scores of nearby decision units. Therefore a vigorous outlier detection and sample selection process is undertaken in constructing the sample used in this thesis.

In addition, sample size also has a significant impact on DEA results. Increasing the sample size will tend to reduce the average efficiency score, because including more firms provides greater scope for DEA to find similar comparison partners, and thus reducing the dimension in which a firm could be relatively unique. Relevant literature that investigate the required sample size for valid DEA analysis is explored in later sections.

Further, DEA scores are also extremely sensitive to the selection of output and input vectors. Previous studies have shown that subtle changes in parameter specifications of DEA can drastically alter the efficiency estimates. The majority of the DEA studies define output/input parameters in accordance with the assumptions about the key functionalities of the entities being studied. In this research we adopt this approach and discuss the merits of various output and input measures analysed by existing industry literatures.

It is also important to note that DEA results are very limited in their comparability outside the sample. Efficiency scores are only relative to the best practice firm within the particular sample. Thus, it is not meaningful to compare the scores between two different studies because differences in best practice between the samples are unknown. Similarly, a DEA study that only includes observations from within the nation cannot tell us how those observations compare with international best practice firms. Although it is not the aim of this thesis to draw international comparisons, this does limit our ability to draw parallels from similar studies in other industries or countries.

Furthermore, the 'piece-wise' comparison approach used in DEA enables peer to peer comparison. This provides a powerful benchmarking capability where efficient role models could be separately identified in different operating environments. Such benchmark could be useful in guiding improvement of operations for inefficient entities.

The focus of this research is to assess the performance the Australian superannuation industry and to inform regulatory reforms. In this respect, DEA is the most appropriate technique on account of its ability to capture the multiple service functions that the industry provide to its members, as well as its ability to yield valuable benchmarks and efficiency decompositions.

The comparison between the two models in relation to their ability to accommodate stochastic shocks is less clear. Intuitively, SFA is superior in the sense that it does not punish firms as much for performance shocks that are beyond the firm's control. However given the environment in which superannuation fund operate in, it is unlikely that subgroups of funds will experience heterogeneous shocks. As a result it is relatively benign to make the assumption that individual participants in the industry faces fairly uniform changes in market conditions and economic disturbances. That being said, it is possible that super funds experience fund level externalities, therefore we check the robustness of our result using aggregated performance over the sampling period.

4.2.3 Data Envelopment Analysis

Data Envelopment Analysis is the term first introduced in the operations research literature by Charnes et al. (1978) (CCR) to measure the technical efficiency of a given observed decision making unit. The technique is a non-parametric approach that places relatively little structure on the specification of the production frontier. The original model by CCR was restrictive as it assumes constant return to scale. Their linear programming formulation adopted the piece wise linear convex hull approach to frontier estimation, proposed by Farrell (1957). The technique also accommodated for multiple inputs and multiple outputs. Banker et al. (1984) (BCC) extended the CCR model to allow variable returns to scale and showed that solutions to both CCR and BCC allowed a decomposition of CCR efficiency into technical and scale components.

This section will explain the theoretical foundations of the CCR efficiency estimation under constant return to scale and its VRS extension under BCC.

Constant Return to Scale (CRS)

Coelli et al. (2005) introduced DEA via the ratio form. For each firm, we would like to obtain a measure of the ratio of all outputs over all inputs, such as $\frac{u'y_i}{v'x_i}$, where u is an $M \times 1$ vector of outputs weights and v is a $N \times 1$ vector of input weights. Q and X are matrices of output and inputs respectively. The optimal weights are obtained by solving the mathematical programming problem:

$$\max_{u,v} \frac{u'y_i}{v'x_i}$$

$$s.t \quad \frac{u'y_j}{v'x_j} \leq 1, \quad j = 1, 2, \ldots, I,$$

$$u, v \geq 0$$

The system of equations will calibrate the value of global weights on inputs (v) and outputs (u) that maximises the efficiency score of sample firms, subject to the efficiency scores being less than 1 and weights are greater than 0. However, this ratio formulation has an infinite number of solutions, since any linear combination between the weights and a common scalar is also a solution to the system of equations. To avoid this, one can impose the constraint $v'x_i = 1$, which provides the following linear programming system of equations:

$$h_j = \max_{u,v} \mu' y_i,$$

$$st \quad v'x_i = 1$$

$$u'y_j - v'x_j \leq 0, \quad j = 1, 2, \ldots, I,$$

$$u, v \geq 0$$

This form of linear programming problem of DEA is known as the multiplier form. This model gives a value based measure of efficiency of DMU j. The weighting variable u can be seen as an imputed marginal value of output y. Similarly, v can be seen as the imputed marginal value of input x. The efficiency measure h_j of DMU measured under this model is the ratio of the total imputed value of its output levels to the total imputed value of its input level. The total imputed input value is normalized to some arbitrary level (i.e 1) (Thanassoulis, 1997).

If we consider the multiplier form as the Primal DEA Model, then we can use the duality in linear programming to compute the equivalent envelopment form of this problem.

$$\min_{\theta,\lambda} \theta,$$

$$s.t \;\; Y\lambda \geq y_i$$

$$\theta x_i - X\lambda \geq 0$$

$$\lambda \geq 0$$

Where θ is a scalar and λ is a $I \times 1$ vector of constants. This envelopment form involves fewer constraints than the multiplier form ($N + M < I + 1$), and hence is generally the preferred form to solve (Coelli et al., 2005).

The efficiency of a DMU is measured by θ with reference to a Production Possibility Set (PPS) which contains all correspondences of input and output levels feasible in the context of the technology operated by the DMU. The PPS is constructed from observed input-output correspondences at DMUs using a set of postulates (Banker et al., 1984), hence the inner boundary of this set is a piece wise linear isoquant. The efficiency measure gives a nice intuitive interpretation, as it measures in effect the minimum proportion of the observed input levels of the i-th firm which would be sufficient, under efficient operation, to secure at least its observed output levels.

The practical value of duality in DEA is dependent in the context of its application.

The primal model has less intuitive appeal in a value free production context such as the Superannuation Industry, where its output vectors may not have quantifiable monetary value. The envelopment form of DEA is therefore more appropriate as it reflects the extent to which the company can lower its operating expenditure, given the amount of output it delivers, the number of properties it serves and so on (Thanassoulis, 1997).

Variable Return to Scale (VRS)

Previous descriptions of DEA linear programming assumes Constant Return to Scale, earlier discussion in this thesis has revealed that technical efficiency measures under this assumption is confounded by scale efficiencies (SE) when not all firms are operating at the optimal scale. Therefore, we need to adapt the existing DEA model to account for the scale effects. This is accomplished through the addition of the convexity constraint: $I1'\lambda = 1$.

The modified system of linear programming equations is then:

$$\min_{\theta,\lambda} \theta,$$

$$st. \qquad Y\lambda \geq y_i$$

$$\theta x_i - X\lambda \geq 0$$

$$I1'\lambda = 1$$

$$\lambda \geq 0,$$

Where $I1$ is an $I \times 1$ vector of ones, this constraint essentially ensures that an inefficient firm is only benchmarked against firms of a similar size. This approach forms a convex hull of intersecting facets that envelope the data points more tightly than the CRS conical hull and thus provides technical efficiency scores that are greater than or equal to those obtained using the CRS model.

Scale inefficiencies can be easily isolated using the previously devised formula.

$$SE\left(x,q\right)=\frac{d_i\left(x,q\mid VRS\right)}{d_i\left(x,q\mid CRS\right)}=\frac{TE_{CRS}}{TE_{VRS}}$$

Chapter 5

Empirical Specifications

The specification of output and input variables in production efficiency analysis are of the utmost importance. This is especially true in DEA analyses, where efficiency estimates are highly sensitive to the definition and measurement of these variables. Economic theory suggests that these variables should reflect the entity's production process and its key functionalities Ferrier and Lovell (1990).

Two popular conceptualizations of the production process in financial services industries such as banking, managed funds, and pension funds are: the intermediation approach and the production approach. The intermediation approach views firms in these industries as mediators between two parties, their purpose can be seen as those of an agent that intermediate between investors and prospective investment projects Humphrey (1985). While the central belief surrounding the production approach is that firms are services providers, they are seen as fee taking institutions that provide specialised financial services to its members Kolari and Zardkoohi (1987). Empirically, the conceptualization of the production process should guide our definition of output and input factors. The question is then, which production process is deemed to be more appropriate in the context of this study?

The underlying belief of this study is that superannuation is a crucial part of Australia's social infrastructure. Its purpose and objective goes beyond the intermediation between retirement assets and potential investment opportunities. Instead, the creation and preservation of asset value should be core to the Industry's functionalities. In this sense, the production approach is more appropriate, as it aligns with the notion that the superannuation industry is a specialised financial service provider (retirement asset investment) using a variety of input factors (fees and commissions). This approach is also consistent with international pension fund studies (Basso and Funari, 2003, 2001; Barrientos and Boussofiane, 2005; Barros and Garcia, 2006).

5.1 Output Specification

Appropriate measures of output factors under the production approach should closely reflect the key services that the industry provides to its members. Although the empirical specifications of output variables in the context of pension and superannuation funds are typically constrained by the availability of data and adapted to the particular market environment in which the industry operate. Most studies recognize that the industry performs three key duties: *Administration of accounts*, *Investments of asset* and *preservation of value*. In the Australian context, these functionality are in line with the statutory duties of super fund trustees, therefore they are appropriate for the purposes of this research.

5.1.1 Administration

Administration of accounts typically involves addressing member inquiries, record keeping, transaction services, reporting duties, and compliance to regulators. The majority of these functions are incorporated into superannuation licensing agreements, however additional services such as financial advices, insurance add-ons and consulting services are also available from some superannuation funds. The APRA superannuation fund data does not report any information on these services or their related pricing information. In previous research this deficiency has been addressed using proxy variables. Mitchell and Andrews (1981) argued that total number of members could reflect the aggregate service function provided by the institution since some essential services provided are identical to all accounts. This was supported by similar studies in the Australian context, where Bateman and Mitchell (2001) argued the technique is applicable in Australia since the superannuation market provides near identical products. Indeed, the total number of members could serve as proxy to the essential account services provided by superannuation funds. However the technique does not reward funds for providing additional account services that are not common across the industry and is incapable of capturing the quality of the essential services provided. This limits one ability to draw inferences on the efficiency scores rankings, since funds that spend additional resources to provide premium services will be unjustly punished because those high quality services are not fully captured in the output specifications. The impact of these limitations is dependent on the extent of heterogeneity of services provided by the participants of the industry, since these characteristics are not directly observable in our database, we have decided not to include this output measure in this research.

5.1.2 Investment

Investment services provided by superannuation funds includes portfolio asset allocations, asset class selections, investment evaluations and executing trades. To evaluate the fund's performance in delivering these services, one can take the perspective of fund members, where the accumulation and creation of wealth is of the utmost importance. Prior investment performance studies in the broader financial services literature often adopt index measures such as rate of return, Sharpe ratio and Jensen's alpha. Although these measure provide valuable insights into the relatively performance of the fund, it is not appropriate for the purposes of this research. In particular, the index measure neglect any scale factors of production, essentially the model assumes constant return to scale. This restriction limits one's ability to isolate the scale efficiency component from technical efficiencies of the super funds. In this research we shall measure investment performance using *net investment income*, which have simple intuitive interpretation; it is the net amount of wealth the fund has generated for its members in addition to their existing assets. Net investment income within the APRA superannuation database comprises of two main components, direct investment income and unrealised capital gains. These two measures provide a sufficient description of a superannuation fund's investment output.

5.1.3 Risk Management

Risk management is a common feature for most investment service providers; funds often make investment choices based on a trade-off between the returns and the amount of risk involved. Management of risk provides certainty and predictability to members; assist them in planning and formulating retirement options. Existing literature has measured risk in terms of variability in returns and also its correlation with volatilities in the market. This study argues that this is inadequate in captivating the key features of superannuation funds in Australia. In particular, the statutory holding period require that distinguishes superannuation funds and other investment vehicles. As an integral part of our social infrastructure, superannuation funds have a significant social responsibility in preserving individual's wealth for a prolonged period of time until their retirement. A person in Australia can not access their superannuation saving under age 60. This translates to a fixed long term investment horizon as opposed to the more flexible investment periods in other financial service sectors. A comparison of return volatility is somewhat inadequate in capturing the fund's performances in reference to its membership characteristics and their respective investment horizons.

The core objective here is to capture risk exposure of funds in conjunction with the value of the investment assets and the duration of the risk exposure. One plausible approach is the Value at Risk measure. The metric incorporate the three key investment characteristics: expected return, volatility and holding period to produce a meaningful value measure of losses due to normal market movements. The application of VaR in other financial institutions has gained tremendous impetus in growth since the 1990s. Its intuitive interpretation and computational ease are favoured by private institutions and regulators alike. The application of VaR in relation to the pension market is especially useful as it measure the potential loss in portfolio value of members at retirement. Further, age distribution records of members in the APRA data base allows us to approximate the expected holding periods of assets.

Empirically, this thesis follows the long term Value at Risk framework outlined in Dowd et al. (2004). Formally the model can be expressed as follows:

$$VaR\,(t) = P - exp\left(\mu t + \phi_{cl}\sigma\sqrt{t} + ln\,(P)\right)$$

Where:

P is the portfolio's present value.

μ,σ is the mean and standard deviation of the funds' historical returns.

t is the holding period or investment horizon faces by members.

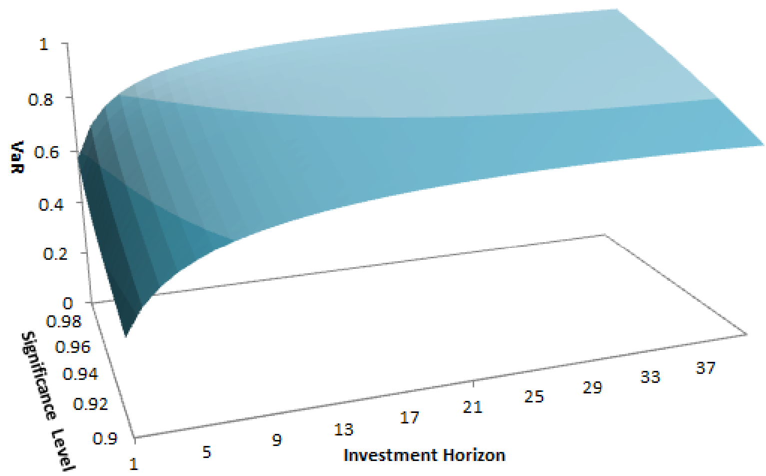
ϕ_{cl} is the index value of the normal distribution at given probability thresholds.

Figure 5.1 illustrate the VaR measurement of two simulated portfolios at 5% significance. Subfigure (a) shows a \$1 portfolio with low return and high risk, its terminal value with holding period of 40 years is close to \$1. This result suggest that long term investment under such portfolio is likely to result in the portfolio value reducing to 0. In contrast, subfigure (b) demonstrate that a similar portfolio under high return and low risk is likely to have a negative terminal VaR value. This translates to an overall profit.

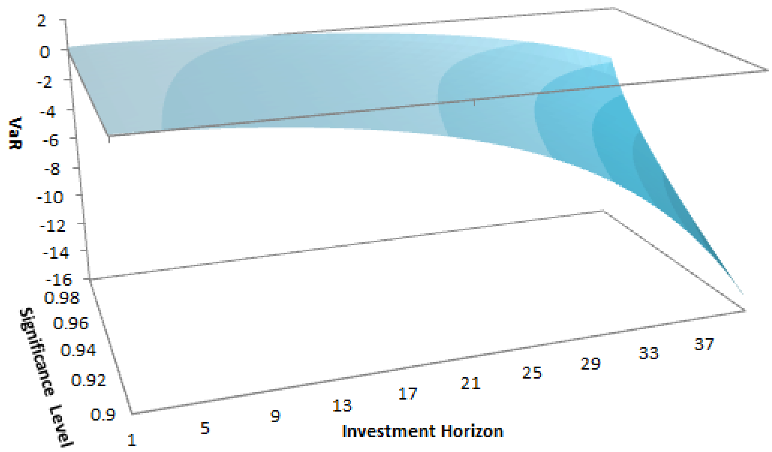
As discussed earlier, DEA requires positive and monotonic output measure. To accommodate this requirement, we perform the following transformation.

$$VaR' = (-1) \times VaR + 1$$

Figure 5.1: Value at Risk Comparisons



(a) Low Return (4%) and High Risk (0.35)



(b) High Return (10%) and Low Risk (0.15)

The measurement of holding period is especially troublesome, as APRA report age distribution in discrete intervals. This makes determining the accurate holding period difficult. However if one assume that members are distributed normally within the age interval, one can approximate the investment duration using the median age in the group. A possible criticism of this technique is the violation of normality in age distributions. For example, it is plausible that in the lower spectrum of the age categories, age distribution is likely to be skewed to the left, since membership of superannuation fund is directly linked to work force participation, therefore we would expected a higher density of older workers in the lower spectrum of age categories.

Another consideration in computing VaR is the measure of return volatility. Given the granularity of our data (annual observation) and the limited time series (9 years or less) any standard deviation estimate is likely to be biased. To account for this caveat in our data, we adopt a similar approach to Ellis et al. (2008), where we approximate the volatility in return of super funds using a benchmark portfolio. The benchmark portfolios are constructed by combining the asset allocation information in our data and their respective market portfolio[1]. Although this measure is not accurately reflect the portfolio risk of the fund, we argue it is representative. Large super fund typically holds extremely diversified portfolio within each asset categories, asset allocation information are sufficient in determining the return volatility of such super funds. The caveat of this technique lies with smaller funds where the market portfolio is not a good proxy for risk.

It must also be noted that some superannuation funds outsource their investment services to an administrator. It can be argued under these circumstances funds are no longer producing the entirety of its outputs. Therefore, any analysis of fund efficiency will also endogenously incorporate those of its administrator. Here we argue that even in such scenarios,a fund does not simply proliferate itself from its duties; rather, this represents a shift from 'in house' to a 'proxy' production process, where funds are responsible for the selection of investment agents (administrators) as well as instructing their investment philosophies. Efficiency analysis of funds are thus still valid despite a slight change in its intuitive interpretation.

5.2 Input Specification

Similar to that of the output production factor definitions, input factors are selected based on the hypothesized production process of superannuation funds, in which

[1]See appendix for a table of volatility measures for the market portfolios

input factors should be directly utilised for the provision of services to members. This paper has defined the input factors using *total assets under management* and *total expenses*.

5.2.1 Total Assets

In line with the production approach, firms requires the input of capital and labour. In our institutional setting, capital input could be captured using the total value of assets under a fund's management. Funds invest existing assets in a variety of classes including fixed incomes, equities, properties and other assets to generate investment income. To some degree, the variable is also capable of capturing the scale effect of market access; for example, funds with a greater asset pool is believed to have access to a greater spectrum of investment options than smaller funds. One would expect that this effect is insignificant once a certain threshold of asset holding is achieved.

5.2.2 Administrative Expenses

Labour inputs are typically measured by wage expenses in traditional economic literature. In the financial services sector, these most closely translate to account administrative expenses, and investment related expenses. These figures are directly available from the APRA's fund-level superannuation database, however one should be cautiously aware of how these expenses are incurred and reported to the regulator. Administrative expenses are typically incurred from staffing of 'in house' service functions such as record keeping, regulation compliance, transactions and other day to day operations. The reported administrative expenses to APRA are believed to be fairly accurate. A potential source of complication arise in relation to marketing costs; for example, non-public offer funds such as those in the public sector and corporate fund require relatively low marketing activity, while public offer funds in the retail sector need to spend substantially more on advertising and other publicity campaigns. The difference stems from a range of factors including fund type, corporate governance and other circumstances that are not under direct control of the fund. Since the available data does not allow us to isolate marketing expenses, this represents a potential sources of endogeneity. where funds that require intensive marketing activity are punished for something for which they have no direct control. Robustness checks will be performed on efficiency scores to assess the sensitivity of our results to these issues.

Investment related expenses accounts for a broader category of costs associated with the investment process. These costs could arise from labour costs in strategy formulation, evaluation of securities, consultancy as well as transaction costs. However due to outsourcing, the reported investment expenses in the APRA data is highly unreliable (Coleman et al., 2003).For example, when funds outsource investment activities to a third party, they often report the net investment return to the regulator and report nil investment expenses. This presents similar interpretation issues due to outsourcing to those from the previous discussion on the output definition. In addition, the reported nil investment expenses presents statistical challenges to the linear programming of DEA, where efficiency of these firms are likely to be skewed upwards due to the program's inability to find comparable peers. One plausible solution is to use *total expenses*, where we aggregate investment and administrative expenses. The measure ensures that the input factors are strictly positive and provides a simple intuitive interpretation. However, this aggregation does limit one's ability to isolate the specific slacks in input factors which restrict inferences from results.

Chapter 6

Data

The primary source of data used in this study is the annual superannuation fund level publication released by the Australia Prudential Regulatory Authority (APRA) for the financial years 2004 to 2012 inclusive. This data is compiled from annual surveys for regulatory purposes and is publicly available on the APRA's website. Funds under APRA's oversight recorded in the database represent a substantial portion of the current retirement assets under management, with the exclusion of small Self Managed Superannuation Funds (SMSF), Pooled Superannuation Trusts, Approved Deposit Funds and Exempted Public Sector Funds. The sample remains highly representative of the industry, with more that 59.5% of assets captured in 2012 and higher percentages in earlier periods. This section will discuss the issues related to the data, especially the sample selection process and the limitations in the measurement accuracy.

6.1 Variables

The reported information in the data set can be broadly divided into two categories: financials and characteristic data. This conveniently aligns with the objective of this research, where financial information is used to construct efficiency scores; we then investigate the impact of a variety of fund characteristics on the operating efficiencies.

6.1.1 Financials Information

There is a substantial amount of financial information in the data set. However for the purposes of this study, variables relating to investment returns, expenses and asset holdings are of particular interest.

Total Assets

Assets is mainly used as the portfolio value in Value at Risk calculated, the desired variable is asset holding by account type, which was categorized by gender as well as age groups. The age group intervals are: (1) Less than 35 years old, (2) Between 35 to 49 years old, (3) Between 50 to 59 years old , (4) Between 60 to 65 years old and (5) Above 65 years old. These decompositions of asset holding allows us to compute more accurate Value at Risk measures as the vested exposure is specific to the particular age group.

A particular issue associated with the asset variable is the reconciliation between vested assets and the net asset measure. In some instances, the total vested asset is lower than the new asset reported; this is likely due to legacy Defined Benefit (DB) asset holdings, which is not accounted for in the vested asset measure. In some cases, this difference is substantial, and could bias the results as the assets under exposure is understated. To account for this difference, we assume that the DB asset is distributed evenly across all age groups; this allows us to simply rescale the vested asset figures for each age group using their current proportion of asset. The validity of the uniform distribution assumption is weak, however due to the lack of further information and its limited implications, we would argue that the assumption is innocuous.

Investment Outcomes

Net Investment Income is another key variable that is central to the efficiency analysis. This variable is directly available from the APRA data set and it is typically composed of direct investment income and unrealised capital gains. Direct investment income includes dividends, rents, trust distributions and interests. Bad debt expenses are also deducted from this measure. Note that the proceeds of insurance policies proceed does not contribute to this figure.

Fees

For reasons outlined in the Empirical Specification Section, Total Expenditure is used instead of its individual components of administrative and investment expenses.

6.1.2 Structural Characteristics

The data set captures several structural dimensions of the superannuation industry in Australia. This include fund type, benefit structure, membership and public offer status.

Fund Type

Fund type in the superannuation industry typically reflects its governance structure as well as the sector in which it operates in. There are typically 5 main fund types: (1) Corporate Funds, (2) Industry Funds, (3) Public Sector Funds, (4) Retail Funds and (5) Others. Also note that first three categories of super fund are also 'not for profit', which means that they charge members for services at cost. Of the funds categorised as 'others', majority belongs to lost and inactive superannuation accounts, these accounts are unclaimed and are set aside by funds in passive management; due to it's relative menial market share and the nature of the accounts, funds categorised as 'others' have been excluded from this study.

Benefit Structure

Benefit structure is another categorical variable that includes: (1) Defined Contribution (DC) Funds, (2) Defined Benefit (DB) Funds and (3) Hybrid Funds. Hybrid funds are typically legacy DB funds that have closed their DB options to new members and offers only DC options. For the purposes of this study, hybrid funds are relabelled as DC funds. This is in line with their close resemblance to that of the DC funds and their diminishing functions as DB fund provider.

Membership

The data offers several membership related information with variables which includes age and gender distributions of accounts; and the concentration of assets in the default investment strategy.

Age and gender distribution of accounts is reported in identical format and intervals as that of the asset distribution.

Asset concentration in default measures the percentage of asset in the super fund's default strategy. This measure could be used to proxy the level of member engagement in the funds. This is in no way a perfect proxy, as default strategy selection could be attributed to both inactive and active selection. Where members elect the default option because it's the best option can't be isolated from those who fail to chose investment options. Further, funds without default options report the investment option with the highest assets as their default strategy, so the measure is misleading in such circumstances.

Other variables also include: number of active members and the number of investment choices available.

Public Offer Status

Public offer is a binary variable that describes whether a fund is open to members of the general public. For example, public sector and corporate funds are typically non public offer funds, since members who are not part of the Australia public service or the corporation in which the fund belongs to will not be able to join these funds. Unlike other structure characteristics of the funds, public offer status is less persistent; recent trend suggest that many funds are opening up to the public.

6.2 Sample Selection

Due to DEA's sensitivity to the sample being analysed, a vigorous sample selection process is conducted. where unreliable and erroneous observations are dropped from the sample.

6.2.1 Erroneous Data

Erroneous data are observations that are empty or those that does not make logical sense. These observations serves little purpose and may potentially bias the results, therefore they are dropped from the analysis.

Where key variables including, investment return, expenses and assets are missing the observations are dropped.

Observations with negative expenses and assets are also dropped from the sample as these measurement are not possible.

In 2004, APRA made changes the reporting unit of some key measures, including total assets, contributions etc (from \$ to \$'000). Correction are made for selected observations in the 2005 sample which did not take into account of this change.

6.3 Final data

Table 6.1 provides the summary statistics of the final data set used in this study.

Table 6.1: Summary Statistics

	Category	Observations	Units	Mean	Std. Dev	Min	Max
Investment Income	Output	2807	$ m	76.71	453.71	-5694.29	5351.33
Value at Risk	Output	2807	$ m	-9484.06	40700.00	-947000.00	26000.00
Total Expenses	Input	2807	$ m	13.96	34.69	0.00	370.41
Total Assets	Input	2807	$ m	1887.62	4949.27	0.06	51900.00
Investment Choices	Enviromental	2807	choices	55.10	239.13	1.00	2829.00
% Asset in Default	Enviromental	2807	%	56.65	36.66	0.00	100.00

Value at Risk are raw, pre transformation measures.

Chapter 7

Results

The efficiency analysis in this research can be broadly categorised into two stages. First, a set of technical efficiency scores are constructed using DEA and initial observations and comparative studies are conducted on the estimated efficiencies. The second stage analysis aims to examine key drivers of industry inefficiency under the regression framework, where several popular second stage models from the literature are assessed to ensure consistency and robustness of our results.

7.1 Limitation of Inference

Prior to any analysis, it should be noted that any statistical inference based on DEA analysis should only be interpreted subject to the underlying assumptions. In this research, we analyse superannuation funds in Australia using two output factors: Investment Earnings and Value at Risk, and two related input factors: Administrative Expenses and Total Assets. This specification reflects the quantifiable financial performance of super funds from the member's perspective. However this interpretation does not necessarily resemble the true performance of the super funds as there are other dimensions of success that are incorporated in this model, including customer satisfaction, the diversity and quality of other services offered, as well as the other unique core objectives of the entities in the market. Therefore our results of super funds' efficiency performance are limited to our particular empirical specification.

Further, all outputs and inputs are normalised relative to the mean for a given period t. In the context of DEA analyses, this manipulation rebalances the scale and hence the relative weighting assigned to funds' output variables and input variable are identical. However, in reality this does not necessarily reflect the true weighting of various factors in a super funds' production process (that is, the relative importance of factor inputs/outputs). Unfortunately due to the atypical nature of the production process and the granularity of our data, the true production factor weight is difficult to determine. Given these limitations, it is reasonable to assume equal production factor weight, so inferences based on efficiency should also take this under consideration.

A reminder is also necessary in relation to the interpretation of results. This thesis took an input orientated DEA approach, therefore an efficiency score of say 0.80 can be interpreted as meaning that this super fund could reduce weighted input factors by 25% $\left(\frac{1-0.8}{0.8} = 0.25\right)$ without altering output levels. Also recall that overall technical efficiency (OTE) is a product of its constituent components: pure technical efficiency (PTE) and scale efficiency (SE). The decomposition allows insights into the sources of inefficiencies. It also helps determine whether super funds have been operating at their most productive scale size(MPSS), increasing returns to scale (IRS) or decreasing returns to scale (DRS).

7.2 First Stage: Efficiency Scores Analysis

The linear programming program described in previous chapters is applied to the data and the technique is iterated for each year to account for the movements in the frontier and market conditions. From this, a series of efficiency scores are generated for each super fund. In presenting these results, we first turn to the industry averages, as this measure is a good reflection of the overall performance of the super funds in the market.

Table 7.1: Average Efficiency Scores

	OTE		PTE		SE		Funds
Year	Average	St. dev	Average	St. dev	Average	St. dev	
2004	0.82	0.06	0.94	0.07	0.88	0.06	472
2005	0.84	0.05	0.93	0.07	0.91	0.05	425
2006	0.83	0.07	0.93	0.08	0.90	0.07	336
2007	0.84	0.05	0.94	0.06	0.89	0.06	322
2008	0.77	0.26	0.78	0.26	0.98	0.06	304
2009	0.76	0.26	0.77	0.26	0.97	0.06	280
2010	0.88	0.09	0.92	0.10	0.95	0.04	251
2011	0.90	0.12	0.95	0.07	0.95	0.08	218
2012	0.79	0.24	0.83	0.21	0.94	0.13	199

Perhaps the most striking result from **Table 7.1**[1] is that industry average OTE has been relatively high throughout the period, but there is a noticeable decrease during the GFC period between 2008 and 2009. This appears to be primarily driven by a substantial decrease in the PTE; the opposite movement in scale efficiency has somewhat reduced the impact of PTE movements on overall technical efficiency. Further, downward movements in the PTE average is coupled with greater dispersion of scores across the industry. A plausible explanation for these observations is related to the Global Financial Crisis (2008-2009), where the majority of superannuation funds in the Australian market reported significant investment losses, whilst their input vector such as fees remains relatively unchanged. In these circumstances, the super funds that did generate positive returns or slightly less portfolio loss during this period will appear significantly more efficient than the rest of the industry, which results in larger dispersion of efficiency scores towards the lower spectrum. This chapter will focus on the movements in the PTE and the impact of environmental variables including super fund governance structure, regulatory framework, benefit design and investment choices.

[1]OTE : Overall Technical Efficiency (CRS efficiency); PTE : Pure Technical Efficiency (VRS efficiency); SE : Scale Efficiency.

The survey of the Australian literature revealed only one study that had previously measured technical efficiency of superannuation funds during this period. In contrast to our results, Sathye (2011)'s analysis of retail funds from 2005 to 2009 found that the decrease in average OTE occurred in 2009, with scores averaging 0.16 from 2005 - 2008 and 0.07 in 2009. This is an interesting result and its difference to the results presented here may partly be explained by the differing specification of inputs and outputs factors. In his study, Sathye (2011) has specified 'value of the fund' as one of two outputs. This variable is likely to be related to our investment income variable in a one period lag structure, where large investment losses are realised in the 'fund value' measure in the subsequent period. This helps explain why Sathye (2011) has found decreases in efficiency from 2009 instead of 2008 as per our results. Further, Sathye (2011) has only examined the efficiencies of retail superannuation funds, whereas we have examined all super fund types except for self managed super funds (SMSFs). Since DEA analysis is extremely sensitive to reference units in the sample, this difference is likely the primary source of differences between our results.

Recall that pure technical efficiency (PTE) measures how well the super fund manages its resources to deliver its vector of outputs. Our results show that Australian super funds perform relatively well on average, with a 9 year average of 0.89. The higher average does not necessarily imply that Australian super funds on average are highly efficient. However this clustering around the production frontier does show that on average Australian super funds perform very closely to the best performing entity in the market. Given the unique production process of the superannuation sector and the lack of comparable benchmarks, it is reasonable to use the best performing units in the market as the reference points to infer results. Regardless, under input orientation DEA, our result translates to a potential reduction of 12.2% in input factors if the industry operates at its maximum production efficiency. Further, since super fund are limited in manipulating their input factor 'Total assets', potential input oriented efficiency gain is most likely achieved from cost reductions (i.e decreasing input 'administrative costs'). The exact quantifiable benefit is dependent on the unique input slacks of each super funds analysed in our sample. This will be explored in a case study context later in this chapter.

Our results also show that there are limited scale efficiency gains; with a 9 year average of 0.93, this suggests that on average, Australian super funds appears to operate very close to their most productive scale size. Despite this, our results show that in 2012, 59.3% of Australian super funds are operating at increasing scale to return, that is these funds could somewhat improve their efficiency by increasing their scale. It is comforting to see that the majority of these super funds are industry funds(35.59%) and retail funds(34.75%), as other fund types are somewhat limited in growth due to their restrictive membership base. Our previous discussion showed that an increasing number of corporate funds are merging into retail trust funds or industry funds, and under these circumstances we would expect the super industry to somewhat benefit from scale efficiency improvements in industry and retail funds.

7.2.1 Efficiency Rankings

Efficiency analysis in its essence is a form of benchmarking technique, and allows us to identify how super funds perform relative to one another. As such, it is natural that we rank industry participants using their efficiency performance.In this research, we have defined industry leaders as those funds that systematically obtained top scores in terms of their productive pure technical efficiencies. The results are presented in **Table 7.2**. An initial review of market leaders did not reveal any prevalence by a particular superannuation fund type; that is, there appears to be a mixture of Corporate, Industry, Public Sector and Retail funds.

Fund Name	Average Efficiency	Type	Frontier
Betros Bros Super	0.9992	Corporate	5
Commonwealth Life Personal	0.9328	Retail	5
MLC Superannuation	0.7793	Retail	5
Australia Post Super	0.8644	Public Sector	4
UniSuper	0.7714	Industry	4
BT Superannuation	0.9978	Retail	3
Construction & Building Union	0.7561	Industry	3

Perhaps the more striking result *Table 7.2* reveals is that all three retail funds that frequently appeared on the production frontier are staff superannuation funds associated with the large commercial banks in Australia - that is, Commonwealth Life Personal, MLC and BT super are affiliated with the Commonwealth Bank (CBA) National Australia Bank (NAB) and Westpac respectively. This result is consistent with our a priori that large financial service entities have the ability to leverage their expertise and overheads from their core financial services activities into the superannuation management service of their own staff super funds. In essence, this translate to a lower operating cost base, making these funds highly competitive and very efficient.

Our results also show that while some funds have frequently appeared on the frontier, they have a relatively lower average efficiency score than similar frontier super funds. This result can be primarily attributed to the poor performance during the 2008 - 2009 GFC period, when these funds significantly under-performed their benchmark reference units.

As an example, we conduct the following case study. UniSuper, the superannuation fund for employees of the tertiary education sector, is one of the largest industry funds in Australia; in 2012, UniSuper managed over 470,000 accounts and approximately A$32.5 billion in assets. This gives UniSuper 4.13% of the total market share in Australia's superannuation sector by assets. Our DEA analysis shows that UniSuper has consistently performed well in 7 year period, excluding 2008 and 2009, appearing on the production frontier in 4 out 7 years and scoring an average efficiency of 0.96. However, UniSuper's efficiency significantly decreased during the GFC period, averaging only 0.11. This can be primarily attributed to its large investment losses during this period (-AU$1.50 billion in 2008 and -AU$2.13 billion in 2009). A set of reference funds around the target fund from which the hypothetical efficient unit on the frontier is constructed is provided by the DEA program for each year. **Table 7.3** shows the reference funds for years 2008 and 2009.

Table 7.2: Reference Decision Making Units for Unisuper

2008 Reference Units	**2009 Reference Units**
Towers Watson	Towers Watson
BMA Personal	Tower Australia
	Standard Communications

A common feature among the funds in the frontier reference set during this period is that either they have managed to generate positive investment income during the GFC period, or recorded relative small losses with low expenses. As an example, BMA Personal recorded a 5.7% net return and an expense ratio of 0.7% in 2008; whilst UniSuper recorded a 6.2% net loss and an expense ratio of 0.5%. Similar comparisons can also be made with the second reference point (Towers Watson). From these figures it is clear that a notable source of inefficiency is from investment income outputs. Indeed, DEA's administrative expenses input slack estimate for UniSuper is around 19.5%; that is, if UniSuper employed strategies or performed similarly to the two reference funds, the fund could reduce its operating cost in this period from 0.7% to approximately 0.56%.

Further, our DEA analysis also shows large inefficiencies derived from the Risk Management Output (VaR). This is could be attributed to both investment return and differences in portfolio volatility between UniSuper and the reference funds. In 2008, the super fund BMA Personal had 100% of its asset holdings in cash; while the Towers Watson super fund held 53.6% of its assets in domestic fixed interest securities and cash.[2] In comparison, UniSuper has substantially higher exposure in the equities market and relatively low holdings in bonds. These portfolio allocation differences combined with the volatile financial climate during the GFC period contributed greatly to the substantially higher portfolio value at risk figure estimated for UniSuper in comparison to the reference super funds.

Another interesting feature of super funds in the reference set is the limited number of investment options offered. Both funds in the 2008 reference set only offered one investment option to their members; this correspond to extremely high levels of asset concentration in the default strategy (BMA (100%), Towers Watson (93%)). Since our a prior information suggests that fund managers have significantly greater control over their default strategy, it can be argued that this characteristic allowed these funds to more easily manage their various asset exposures and more effectively adjust to any unexpected market movements. In the case of the Towers Watson super fund in 2008, the fund had adjusted its combined domestic fixed interest security and cash holding up from 38.3% in 2007 to 53.6% in 2008, international equity holdings have also decreased by 3.2%. These asset allocations movements are not uncommon during this period. However the high level of portfolio management concentration grants fund managers with greater flexibility and allows any changes to propagate through all the member accounts at a faster rate. In contrast, UniSuper is fairly decentralised in their portfolio management, with 9 available investment options

[2] Asset holdings categorised as 'others' are assumed to be some kind of cash holdings, this is consistent with assumptions made in Ellis et al. (2008).

and only 26.1% of assets in its default strategy. Similar to the two reference funds, Unisuper has also increased its fixed income and cash holding during the GFC period, however it's reaction was much more subtle, with a modest 2.8% increase from 30.4% in 2007 to 33.2% in 2008 (compared to 15.3% increase in the Towers Watson super fund). This is consistent with our a priori that decentralised super funds' reaction to market movements are dependent on the active management of members to some extent. While these super funds are able to offer more conservative investment options during market downturns, it is ultimately up to the members to divert their portfolios into these investment strategies. Given the low level of membership engagement evident in the Australian superannuation enviroment, this feature of the portfolio management chain is likely to result in lagged response of some super funds to shocks in the financial markets.

While this evidence seems to support our previous assertion that greater portfolio concentration enables super funds to more effectively reaction to market shocks during periods of financial distress, the implication of this is less clear in relatively modest periods. The issue here is then the trade-off between super funds' ability to effectively manage assets, and the utility different members derive from their portfolios. Increasing Academic literature analysing the Australia superannuation market has concluded there is a need for more tailored investment choices, accommodating for individual's risk preference structures, age, and other characteristics. Greater investment choice could facilitate such demand, however this is likely to decreases the fund manager's ability to effectively control the asset composition of the fund itself. More sophisticated analysis is required to determine the optimum level of portfolio choices, however this is out of the scope of this research.

The identification of efficiency leaders could potentially be very useful to market participants and regulators alike. Careful study of consistently efficient firms could provide valuable guidelines for further regulatory reform, informing policy decisions and to promote "yardstick" competition between market participants. Moreover, previous industry studies have recognised the importance of a single performance measure in reducing the complexity of the information presented to consumers through its role in promoting consumer engagement and market competition.[3] Efficiency scores are an intuitive method to facilitate such discussion; the technique is also advantageous as its input/output vectors could be altered to accommodate different research objectives. While this research has focused extensively on the efficiency of super funds in delivering benefit for members, one could easily alter the output variables to examine how efficient the superannuation industry is operating in alleviating public pension liabilities.

7.2.2 Public Offering

The analysis thus far has considered average efficiency across the industry as a whole, however this research also has particular interest in examining the differences in efficiency performance across sectors and fund types. *Table 7.4* summarises the efficiency trends between public offer funds and non public offer funds. Recall that funds on public offer are available to the general public while non public offer funds are closed funds are only available to employees of a particular firm or industry.[4]

[3] Coleman et al. (2003)

[4] The majority of public offer funds are retail funds while closed funds are mainly comprised of industry, corporate and public sector funds.

Table 7.3: Average Pure Technical Efficiency: Public Offering

	Non Public Offer Super Funds		Public Offer Super Funds	
Year	Efficiency (PTE)	Scale Efficiency	Efficiency (PTE)	Scale Efficiency
2004	0.96	0.87	0.91	0.90
	(0.05)	(0.06)	(0.10)	(0.07)
2005	0.95	0.89	0.91	0.92
	(0.05)	(0.05)	(0.08)	(0.06)
2006	0.96	0.88	0.90	0.91
	(0.04)	(0.06)	(0.09)	(0.07)
2007	0.95	0.88	0.93	0.90
	(0.05)	(0.05)	(0.06)	(0.06)
2008	0.86	0.99	0.71	0.97
	(0.18)	(0.05)	(0.29)	(0.07)
2009	0.86	0.98	0.71	0.97
	(0.18)	(0.04)	(0.28)	(0.07)
2010	0.95	0.95	0.91	0.95
	(0.07)	(0.03)	(0.11)	(0.04)
2011	0.97	0.97	0.93	0.94
	(0.05)	(0.06)	(0.08)	(0.08)
2012	0.93	0.96	0.79	0.93
	(0.09)	(0.12)	(0.24)	(0.13)

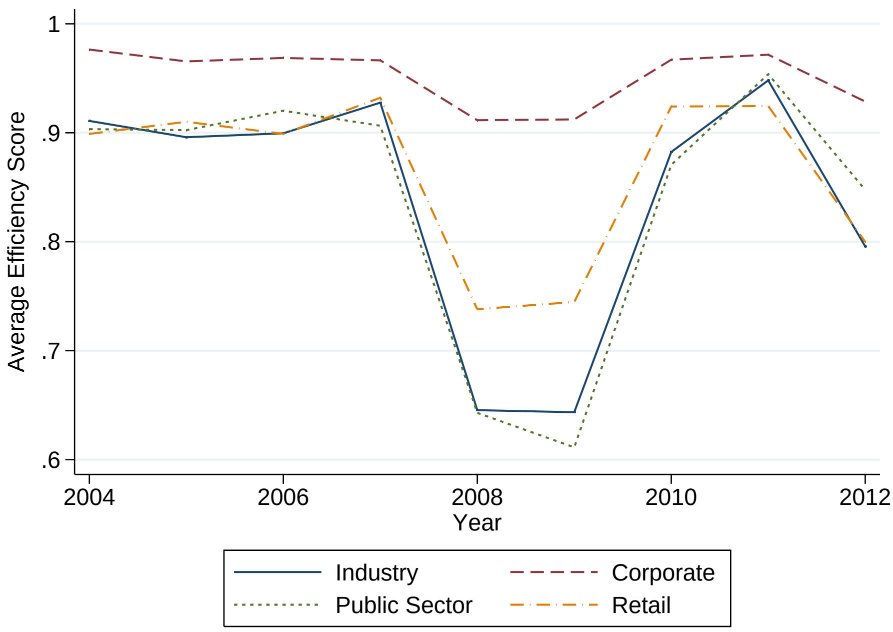
Standard deviations in parentheses

On average, closed super funds appear to be more technically efficient than funds on public offer. This is in line with our prior, where public offer funds are believed to be less productive than their counterpart due to additional expenses arising from marketing, distribution and other related costs. A more striking result is the relatively low scale efficiency of the non-public offer (closed) super funds. These super funds by their nature are constrained to the members in their constituent industry or corporation. For example, an industry fund such as UniSuper is only available to university employees. This underlying structural feature could prevent super funds from reaching their maximum productive scale size, hence operate at a lower scale efficiency. Our results show that average scale efficiency of non-public offer funds converge with their industry counterpart over time. This result is also consistent with the observation that an increasing number of industry funds are becoming public offer funds in order to expand their membership base. Further analysis reveals that the majority of these industry funds previously operated at increasing scale of return, which suggests offering their membership to the general public is likely to improve their overall efficiency. These results are somewhat supported by the relevant literature; Bateman (2001) showed that public offer retail funds exhibit the highest level of administrative fees.

7.2.3 Fund Types

This research is also concerned with the efficiency performance of the four fund types currently available in the market - that is corporate, public sector, industry and retail super funds. Our results are presented in *Figure 7.1*, which shows that corporate funds consistently outperform the market in pure technical efficiency (PTE).

Figure 7.1: Average Pure Technical Efficiency: Fund Type



Perhaps the more interesting result from this exercise is the dynamic of technical efficiency movement during the financial crisis (2008 - 2009). Here we observe a substantial decrease in average efficiency across the industry, with the effect much more severe among public sector and industry funds. Again corporate funds outperformed other funds types, followed by retail funds. This result somewhat reflects the ability of funds to manage market externalities, in particular shocks in the financial markets. Higher efficiency during this period can be generally attributed to good performance in delivering outputs (Investment Income and Portfolio exposure) and/or the reduction in inputs (Administrative costs). Further analysis revealed that in general, more efficient super funds during this period typically have relatively higher holdings in fixed income assets and cash. By passively investing in these securities, some super funds were able to limit their portfolio losses while maintaining relatively low levels of administrative costs. Also, one should keep in mind that super funds such as industry and corporate funds generally have a greater proportion of members in their respective default portfolios, where default portfolios in Australia are typically balanced investment options, with 30% invested in bonds and 70% in shares. In contrast, retail super funds typically experience a relatively higher degree of member engagement and prior to the introduction of MySuper[5] were less likely to offer default options, whereby members are more actively involved in the asset allocation process. Higher level of membership engagement coupled with the flexibility offered by decentralised portfolios could explain why retail funds are more efficient during periods of financial crisis.

During the non GFC periods (2004 - 2007, 2010 - 2012), the three remaining sectors of the industry are generally indistinguishable in their efficiency performance, with public sectors funds slightly outperforming others in 2006 and 2012.

7.2.4 Efficient Market

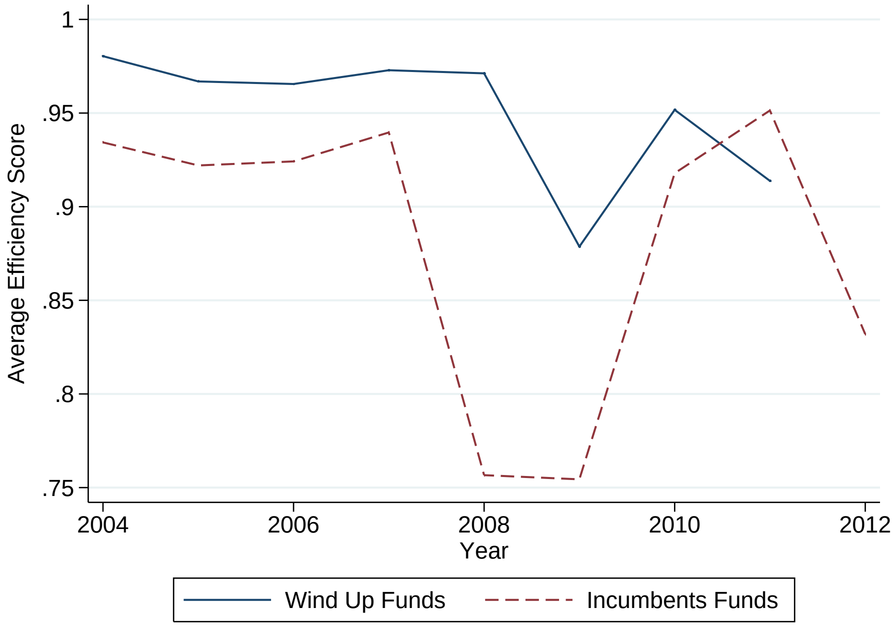
Goddard et al. (1993) argued that more efficient firms display superior performance and are more viable in a competitive environment. In a rational and efficient market setting, one would expect more efficient super funds to generate higher output and increase their market share at the expense of less efficient funds, thereby increasing

[5] MySuper is an industry reform initiated by the Australian federal government in 2010, one of its key policy is the introduction of compulsory default option.

industry concentration. The literature has conceptualised this idea as the "Efficient Structure Hypothesis"; an implication is that efficient and inefficient firms cannot coexist in the long run. The hypothesis that technical inefficiency increases the probability of firm exits has been well documented in the literature (Kumbhakar et al., 2009; Tisonas and Papadogonas, 2006; Wheelock and Wilson, 2000). The causal link between inefficiency and market exit remains an open research question.

We conduct a preliminary testing of the efficient structure hypothesis by computing the average efficiency scores of super funds that are leaving the market[6] and super funds that remained at least for another year. Our results are presented in *Figure 7.2*.

Figure 7.2: Average Pure Technical Efficiency: Market Exits



Contrary to our priori beliefs, our results show that average pure technical efficiency of wind up super funds are consistently higher than incumbent funds, except in 2011. This is not a surprising result given the market structure and features of the Australian superannuation industry. In particular, these results have identified two

[6]Market exits in the superannuation context means that the super fund cease to exit as a separate entity, but its assets and members are merged into another existing super fund.

key areas where the efficient structure hypothesis may fail.

First, the hypothesis implicitly assumes that all firms within the industry compete for market share, and that more efficient firms are able to leverage their efficiency to be more price competitive than less efficient firms, hence expanding output through acquisition of market share. However, the Australia superannuation environment presents a different reality. For example, our results have shown corporate funds to be much more efficient than the rest of the industry. However these super funds are almost always restricted to the employees of the sponsoring firms. This feature essentially constrains the potential membership base of the super funds to a small sub population, significantly limiting its ability to gain any substantial market share from less efficient incumbent super funds. Further, corporate funds are commonly not-for-profit. This indicates that the funds operate at cost, therefore there is limited incentive for the funds to expand its membership base. This conclusion is consistent for all not for profit, non public offer funds. This is a powerful result as it indicates that the Australian superannuation industry suffers from structural limitations where market allocative productivity gains are somewhat limited to public offer super funds.

The second caveat of the hypothesis arises from cost subsidization. Selected super funds in Australia (mostly corporate) are heavily subsidized by their respective sponsors. This then gives rise to the question whether our productive efficiency measure truly reflects the productivity of the super funds' operations. This question has significant implications. In particular, as *Figure 2.3* illustrates, over the past decade, the majority of market exits in the industry has been corporate funds. Previous research has attributed these exits to increasing operational costs associated with regulatory requirements, and the reduction of employer's willingness to subsidize the costs of their corporate superannuation funds.[7] If this is the case,

[7]Cost subsidization can be in the form of monetary donations to the fund, as well as donation of personnel, executive time and resources

then it can be argued that some of the efficiency of these super funds can be attributed to the amount of cost subsidization, and the true productive efficiency may well lie below the industry average. However, the analysis here is not concerned with the true productive efficiency of the super funds, but rather their efficiency in delivering outputs for members. Therefore, we proceed our analysis by assuming cost subsidization to be part of the super funds production process, where it can be thought of as a discount in factor prices available to selected number of funds.

7.3 Second Stage: Regression Analysis

Two stage analysis efficiency scores is popular in the existing DEA literature. Indeed the procedure is very appealing both in terms of its simplicity and the way efficiency is described and interpreted. We are interested in the effect that exogenous environmental variables including fund structure, consumer engagement and market share have on the pure technical efficiency (PTE) of superannuation funds.[8]

7.3.1 Regressors

The exogenous environmental variables used in this study are a combination of extracted APRA fund characteristic data and generated variables.

Fund Type

APRA categorise funds into four main types: (1) Industry Funds; (2) Corporate Funds; (3) Public Sector Funds; (4) Retail Funds. The categorical string variable in the APRA data is converted to three binary dummies, setting retail funds as the base dummy.

Regulatory Type

The binary dummy variable describing the regulatory environment in which the fund operates in: = 1 if fund membership is open to the general public (i.e, a public offer super fund); The alternative = 0 are funds that have restricted

[8] The dependent variable PTE is continuous and confined to the unit interval (excluding 0).

membership to particular sub populations such as corporate employees or public servants (i.e, a non-public offer super fund).A key difference between public offer and non-public offer is the system of governance. Public offer funds are governed by corporate trustees, where the trustee board comprises employees of the managing financial institution. A non-public offer fund trustee board has equal representation of employer and employees representatives (although two can be supplemented by independent trustees).For example, the UniSuper board of trustees has 4 employee representatives, 4 employee representatives and 3 independent trustees.

In recent years many not-for-profit industry super funds which have become public offer funds, but retained equal representation on the trustee board. Therefore we would expect some degree of heterogeneous effect of this variable on industry funds, interaction term between public offer and fund types are also included in the regression framework.

Benefit Type

A binary dummy variable that describes funds' benefit type; = 1 if the super fund is a pure Defined Benefit (DB) fund; that is, members accrue retirement benefits using a prescribed formula involving final salary, years of service and some multiplier. The base alternative are funds that have pure Defined Contribution (DC) or Hybrid DB/DC structure, DC members accumulate wealth based on their life time contribution and funds' investment performance. Hybrid funds are difficult to classify, however the majority are legacy DB funds that have closed to new members and are phasing into a DC structure. Therefore it is reasonable to assume that they associate more closely with DC funds.

Members in the Default Investment Option

A continuous variable in [0,100] describes the percentage of assets who in the default portfolio provided by the super fund. Funds that did not nominate a default portfolio reports the percentage of members in their largest portfolio by asset. In essence, this variable measures the degree of concentration in the fund's portfolio management.

Market Share

A continuous variable in [0,100] describing the market share of the fund by assets in a particular year.

Our a priori knowledge suggest that market power could have a heterogeneous effect across different fund types. Therefore we also include interaction terms between this variable and the fund type dummies.

Number of Members

A continuous variable describing the logarithm of the number of members in the fund at a particular year.

Number of Investment Choices

A continuous variable that describes the logarithm of the number of investment choices offered by the fund in a particular year.

Market Exit

A binary dummy that =1 if the fund no longer exist in the subsequent year. =0 for all funds in 2012 since this is the last year of our data.

Recall that our previous result have attributed corporate exit to the inability of the employers to further subsidize their super funds. We then would expect some level of heterogeneity between corporate fund exits and other market leavers. Interaction between exit dummy and corporate fund dummy is also included in the regression.

Herfindahl Index

A continuous variable in [0,100] describing the level of market concentration in a given year. The variable is measured as the squared sum of market shares of all super funds in the market.

7.3.2 Model Selection

Second Stage DEA efficiency score regression is challenging due to the unique nature of the dependent variable (PTE efficiency scores) being continuous in]0,1]. Standard linear models are generally not appropriate for such analysis due to their unboundedness. A popular approach among the DEA empirical literature is the two limit TOBIT (2LT) model bounded at zero and unity. Recent developments in the literature saw Fractional Response Models (FRM) rise to popularity, these models are difficult to implement but are more flexible and accurate in accommodating the underlying features of the data. The correct modelling approach remains controversial, and this section of the paper will discuss the merits of three most popular models employed in the literature.

Before we start, it is useful to note the key selection criteria in assessing available models. The DEA technique measures efficiency relative to a non-parametric, maximum likelihood estimate of an unobserved true frontier, conditional on observed data resulting from an underlying data-generating process (DGP). A trend in the previous literature was to regress the efficiency estimates on environmental variables in a two stage framework. This procedures allows researchers to account for exogenous factors that might affect firms' performance, however most studies lack proper consideration to the functional form of the DGP implicitly assumed by their models. A coherent DGP description is essential to the correct specification of the regression model in the second stage and to ensure that the estimates are consistent. Further, statistical inference is complicated by the unknown serial correlations between estimated efficiencies. This section of this thesis will draw upon the experience of the current two stage DEA literature and debate the appropriate model for our context.

Let y be the variable of interest (PTE efficiency scores), $0 < y \leq 1$, and let x be a vector of k environmental factors. Further, let $f(y|x, \theta)$ denote the conditional distribution of y, which is unknown, where θ is a vector of parameters to be estimated.

Linear Probability Model (LPM)

Typical LPM models are characterised by the conditional mean, in which:

$$E[y|x] = x\theta,$$

However, these models employ OLS estimators and are often criticised for two reasons. First the conceptual requirement that the predicted values of y lie in the interval]0,1] is not satisfied. Second, in a linear model, the marginal effect on the DEA score of a unitary change in covariate x_j is constant over the entire range of y, which is not compatible with either the bounded nature of DEA scores or the existence of a mass point at unity in their distribution (Ramalho et al., 2010).

$$\frac{\partial E(y|x)}{\partial x_j} = \theta_j,$$

Despite these shortfalls, OLS could still be implemented if it's appropriate for the underlying DGP. McDonald (2009) showed that under the unit interval linear DGP model, OLS estimates of parameters are consistent and asymptotically normal under general linear assumptions. However such assumptions are strong and is unlikely to hold.

A common variant of the LPM for the fractional dependent variable (]0,1[) is the logistic transformation $y^* = log\left(\frac{y}{1-y}\right)$. However this variable is undefined for observations at $y = 1$, and therefore not a viable approach.

TOBIT

The most common approach implemented in the current DEA literature is the two-limit TOBIT regression framework. The two-limit model assumes that there is a latent variable of interest y^* where $-\infty < y^* < \infty$. The observable variable y is the result of a censoring Data Generating Process (DGP) of y^*, where $y = 0$ if $y^* \leq 0$ and $y = 1$ if $y^* \geq 1$. More formally we describe the model using the following set of equations:

$$
\begin{aligned}
y_i^* &= \sum_{k=1}^{n} \beta_k x_k + \varepsilon_i, \\
y_i &= \left[\frac{1 + sign(y_i^*)}{2}\right] \min\{1, y_i^*\}, \\
sign\,(y_i^*) &= \begin{cases} 1; & y_i^* \geq 0 \\ -1; & y_i^* < 0 \end{cases}
\end{aligned}
$$

where $\varepsilon_i \sim N(0, \sigma)$ are independent and identically normally distributed (iid.) residual of the observations. The structural assumption of the error term allows one to compute the densities of the TOBIT model.
The probability that a recorded y is equal to 0 is given by

$$
\begin{aligned}
P(y = 0) &= F(y^* \leq 0) \\
&= F(\sum \beta_k x_k + \varepsilon \leq 0) \\
&= F(\leq -\sum \beta_k x_k) \\
&= F(\frac{\varepsilon - 0}{\sigma} \leq -\frac{\sum \beta_k x_k - 0}{\sigma}) \\
&= \Phi(\frac{-\sum \beta_k x_k}{\sigma})
\end{aligned} \tag{7.1}
$$

Under this framework, the estimated parameters $\frac{\beta_k}{\sigma}$ are the effect of the exogenous environmental variables on the index function inside the normal CDF (Φ). Also note that β_k is indirectly identified; the identification of this true parameter requires positive density at the upper bound. In this case, the probability of $y = 1$

$$\begin{aligned} P(y = 1) &= F(y^* \geq 1) \\ &= 1 - \Phi(\frac{1 - \sum \beta_k x_k}{\sigma}) \end{aligned} \tag{7.2}$$

The estimation of $\frac{1}{\sigma}$ allows one to compute the underlying value of σ which can then be utilised in identifying β_k. Finally, the probability of y when it is between the unit interval is given by:

$$\begin{aligned} P(y_i|0 < y_i < 1) &= f(y_i - \beta_k x_k) \\ &= \phi(y_i - \sum \beta_k x_k) \end{aligned} \tag{7.3}$$

where ϕ denotes the probability density function of the underlying normal distribution of the error term. The joint likelihood function for the recorded censored dataset is then given by:

$$L = \prod_{y_i=0} P(y_i = 0) \cdot \prod_{y_i=1} P(y_i = 1) \cdot \prod_{0<y_i<1} P(y_i|0 < y_i < 1) \tag{7.4}$$

The joint likelihood function is a major source of criticism of the two limit TOBIT model, because the inherent nature of DEA efficiency prohibits a 0 efficiency score. The absence of observations at 0 essentially eliminate the $y = 0$ component of the joint likelihood function. The estimation is therefore based on a one limit TOBIT model for $y \in [-\infty, 1]$. Despite this, the said TOBIT model is still valid in identification of the underlying parameters (i.e. β, σ) from the remaining components of the likelihood. As such, Maddala (1986) has shown TOBIT to be an sensible estimate of the conditional mean $E(y|x)$.[9]

[9]See Appendix for full derivation

$$
\begin{aligned}
E(y|x) = \sum \beta_k x_k & \left[\Phi\left(\frac{1-\sum \beta_k x_k}{\sigma}\right) - \Phi\left(\frac{-\sum \beta_k x_k}{\sigma}\right)\right] \\
& + \sigma \left[\phi\left(\frac{-\sum \beta_k x_k}{\sigma}\right) - \phi\left(\frac{1-\sum \beta_k x_k}{\sigma}\right)\right] \\
& + \left[1 - \Phi\left(\frac{1-\sum \beta_k x_k}{\sigma}\right)\right]
\end{aligned}
$$

The expression reveals a complex relationship between the conditional mean and the index function. The corresponding marginal effects of the TOBIT model can then be derived by taking the first order derivative of the above expression.

$$
\frac{\partial E(y|x)}{\partial x_i} = \beta_i \left[\Phi\left(\frac{1-\sum \beta_k x_k}{\sigma}\right) - \Phi\left(\frac{-\sum \beta_k x_k}{\sigma}\right)\right]
$$

The marginal effect of covariate x_i is a function of the coefficient estimateβ_i as well as the other covariates and their respective coefficient estimates. More simply, the marginal effect is the estimated coefficient β_i scaled by the probability that the conditional mean is within the bounds of [0,1]. This is an important result as it indicates that if there are only handful observations that lie on the limiting values of y, then the marginal effect will be very close to the estimated coefficient or the LPM marginal effect.

A summary of the result using LPM and TOBIT specifications with robust standard error and fixed year effect are presented below. Interactions between key explanatory variables are also included to account for heterogeneous effects.[10]

[10] Only informative estimates are reported, for full regression output see appendix

Table 7.4: Efficiency Regression: LPM & TOBIT

	(1) LPM	(2) TOBIT
Corporate Fund Dummy	−0.0179	−0.0211
	(0.0111)	(0.0180)
Industry Fund Dummy	−0.0470***	−0.0565**
	(0.0172)	(0.0240)
Public Sector Fund Dummy	−0.0607***	−0.0641**
	(0.0202)	(0.0257)
Public Offer Dummy	−0.0308***	−0.0293***
	(0.00781)	(0.0104)
Defined Benefit Dummy	−0.00396	0.00640
	(0.0149)	(0.0220)
Corporate × Exit	−0.0323**	−0.0354**
	(0.0136)	(0.0147)
Corporate × Choice	0.0198***	0.0199***
	(0.00367)	(0.00613)
Public Sector × Choice	−0.0341***	−0.0379***
	(0.0101)	(0.0141)
Corporate × Share	−0.120***	−0.119***
	(0.0395)	(0.0318)
Public Sector × Share	0.0782***	0.0899***
	(0.0199)	(0.0318)
Exiting Market Dummy	0.0278**	0.0326**
	(0.0126)	(0.0133)
Market Share	−0.0830***	−0.0817***
	(0.0129)	(0.0186)
Assets in Default Option	0.0000870	0.000107
	(0.0000782)	(0.000113)
Herfindahl Index	−0.0321***	−0.0315***
	(0.00694)	(0.00694)
Investment Choices (log)	−0.0180***	−0.0201***
	(0.00299)	(0.00501)
Constant	1.053***	1.062***
	(0.0162)	(0.0209)
σ		0.124***
		(0.00589)
Adjusted R^2	0.472	
Right Censored		7.3%

Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Our results appears to be sensible and consistent with our hypotheses. Perhaps the more striking result here is that after controlling for covariates, corporate funds appears to be very similar to retail funds in their efficiency performance. Industry and public sector super funds appear to be less efficient than retail and corporate super funds. Further, our results show that market share has a significant and negative impact on super fund efficiency. This is not a surprising result as our previous results in this chapter suggested that structural features of the industry could prevent highly efficient funds from expanding and allowing less efficient funds to populate significant portions of the market. As expected, our result also shows some heterogeneous effects of covariates among different fund types, where corporate super funds are more susceptible to changes in market share when compared to industry and retail funds. This is consistent with our a priori that the willingness of employers to subsidise the cost borne by corporate funds is a decreasing function of scale. Our estimates for the coefficients of other environmental variables are also sensible.

Statistical inferences from both the TOBIT and LPM model rely heavily on normality and the homoskedasticity assumption of the error term. McDonald (2009) and Ramalho et al. (2010) argued against the implementation of TOBIT models because the error term assumption is unlikely to hold due to its misspecification of the underlying DGP for the variable of interest (i.e. efficiency scores are not results of censoring or corner solutions). Similar criticism of LPM is also true. Pagan and Vella (1989) conditional moment test and the Andrews (1988) Chi - square test provides useful frameworks to assess the validity of these assumptions.

The misspecification under conventional linear models imply that the LPM/TOBIT coefficients are likely to be inconsistent and thus biased. We then turn to more sophisticated technique such as Fractional Response Models to produce more reliable results.

Fractional Response Model

McDonald (2009) argued that the efficiency score data can be better described as a normalisation process. In input oriented analyses, a production unit's efficiency score is determined as its actual inputs divided by the frontier inputs corresponding to its output values. This normalises the maximum efficiency to 1 and all efficiency scores to lie on or within the unit interval. To fully reflect this characteristic of the underlying DGP we turn to the Fractional Response Model (FRM) proposed by Papke and Wooldridge (1996).

The core assumption under the FRM is that the conditional mean of the response variable is related to the linear index through a link function.

$$E(y|x) = G(x\theta)$$

Where $G(\cdot)$ is a non linear function satisfying the constraints $(0 \leq G(\cdot) \leq 1)$. The partial effect then follows

$$\frac{E(y|x)}{\partial x_j} = \theta_j g(x\theta)$$

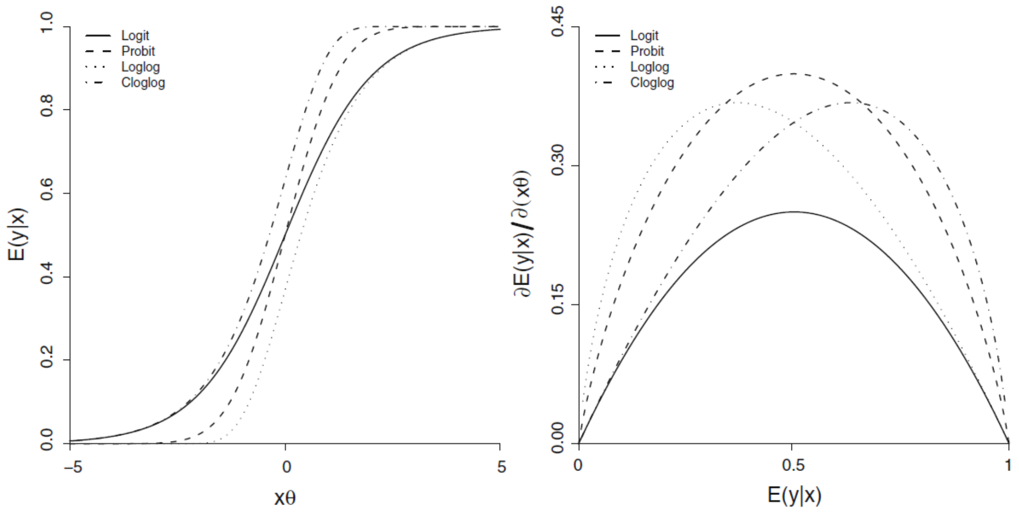
Here we examine, four standard FRM GLM link functions under binomial dispersion:

$$G(x\theta) = \begin{cases} \frac{e^{x\theta}}{1+e^{x\theta}} & \textit{Logit} \\ \Phi(x\theta) & \textit{Probit} \\ e^{e^{-x\theta}} & \textit{Loglog} \\ 1 - e^{e^{-x\theta}} & \textit{Cloglog} \end{cases}$$

Papke and Wooldridge (1996) have shown that regardless of the true distribution of y conditional on x, as long as the link function is correctly specified, the estimator $\hat{\theta}$ is consistent and asymptotically normal. *Figure 7.2* describes the cumulative density $G(x\theta)$ and the pdf $g(x\theta)$ of the alternative models. An important observation is that the maximum partial effect for the symmetric probit and logit models are achieved at $E(y|x) = 0.5$ and are identical for values of x that yield values of $E(y|x)$ that are symmetric around that point (Ramalho et al., 2010) That is, the effect of x on $E(y|x)$ is the same for $E(y|x) = 0.05$ and $E(y|x) = 0.95$.

While asymmetric loglog and cloglog yields a varying partial effect of x at different values of $E(y|x)$ it can be observed that the models are equivalent to each other at $E(y|x) = 0.5$. Further, under asymmetric models, x achieves the highest partial

Figure 7.3: Standard Fractional Regression Models



Source:* *Ramalho et al. (2010)

effect at values $E(y|x) < 0.5, E(y|x) > 0.5$. These features of the alternative specifications should reflect the observed characteristics in the data, and thus a misspecification test is conducted to assess the underlying specification of the model.

The Quasi Maximum Likelihood Estimation (QMLE) procedure in Papke and Wooldridge (1996) follows the Bernoulli log-likelihood function

$$\mathscr{L}_i(\theta) = y_i log\left[G(x_i\theta)\right] + (1 - y_i) log\left[1 - G(x_i\theta)\right]$$

A summary of the results are presented in *Table 7.6*, where we also apply fixed year effect and clustered standard errors.[11]

[11]For full regression output see appendix

Table 7.5: FRM Results with Four Link Function Specifications

	(1) Logit	(2) Probit	(3) Loglog	(4) Cloglog
Corporate Fund Dummy	0.438***	0.165**	0.459***	0.0824*
	(0.145)	(0.0696)	(0.137)	(0.0487)
Industry Fund Dummy	−0.596***	−0.288***	−0.569***	−0.203***
	(0.177)	(0.0911)	(0.165)	(0.0668)
Public Sector Fund Dummy	−0.674***	−0.330***	−0.629***	−0.239***
	(0.240)	(0.123)	(0.214)	(0.0926)
Public Offer Dummy	−0.314***	−0.151***	−0.286***	−0.104***
	(0.0764)	(0.0388)	(0.0714)	(0.0286)
Public Sector × Choice	−0.243**	−0.144**	−0.194**	−0.131***
	(0.108)	(0.0567)	(0.0916)	(0.0444)
Corporate × Share	−1.477***	−0.796***	−1.335***	−0.634***
	(0.218)	(0.131)	(0.139)	(0.147)
Public Sector × Share	0.423***	0.258***	0.297***	0.291***
	(0.119)	(0.0699)	(0.0890)	(0.0726)
Exiting Market Dummy	0.643**	0.272**	0.647***	0.163**
	(0.257)	(0.119)	(0.243)	(0.0795)
Market Share	−0.467***	−0.276***	−0.351***	−0.297***
	(0.0676)	(0.0383)	(0.0333)	(0.0488)
Herfindahl Index	−0.365***	−0.185***	−0.345***	−0.133***
	(0.0670)	(0.0342)	(0.0622)	(0.0255)
Investment Choices (log)	−0.182***	−0.0952***	−0.173***	−0.0690***
	(0.0272)	(0.0139)	(0.0238)	(0.0104)
Constant	3.891***	2.139***	3.825***	1.472***
	(0.184)	(0.0897)	(0.173)	(0.0634)
Log-likelihood	−524.8	−527.4	−523.3	−530.9
AIC	1099.7	1104.9	1096.5	1111.9
BIC	1245.4	1250.6	1242.3	1257.6

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Our estimated coefficients represent the expected contribution of the covariates on the index function instead of the dependent variable of interest. The effects are also dependent on the levels of other covariates, therefore before any meaningful interpretation can be made, we must assess the model specification for each of the link functions considered and compute the corresponding marginal effects under that specification.

Misspecification

As previously stated, the FRM only yields a consistent estimator $\hat{\theta}$ when the functional form of the link is correctly specified. One way to assess the general specification errors of the alternative models is the Ramsey RESET test. Pagan and Vella (1989) showed that any index model of the form $E(y|x) = G(x\theta)$ can be approximated by $S(x\theta + \sum_{j=1}^{J} \gamma_j (x\theta)^{j+1})$ for sufficiently large J. We follow this logic and adopt a two stage process, the first stage procedure regresses the efficiency scores against all covariates using FRMs; the second stage adopt identical procedure but also incorporate the quadratic and cubic terms of the predicted values in first stage. We then assess the significant of the quadratic and cubic term. The RESET test results are presented in *Table 7.7*.

Table 7.6: RESET Test Results

	(1) OLS	(2) TOBIT	(3) Logit	(4) Probit	(5) Loglog	(6) Cloglog
$\hat{y}^2$ t-test	29.62*	15.78	0.381	−0.379	−0.291	−1.203
	(16.52)	(18.40)	(6.372)	(4.079)	(4.664)	(4.006)
$\hat{y}^3$ t-test	−12.95**	−7.614	1.613	2.142	1.730	3.195
	(6.171)	(6.786)	(5.757)	(3.593)	(4.372)	(3.450)
$\hat{y}^2$ & $\hat{y}^3$ f-test	17.83***	17.10***	4.30	10.14**	3.08	15.82***
$(p - value)$	(0.00)	(0.00)	(0.12)	(0.01)	(0.21)	(0.00)

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

All models except for Logit and Loglog are rejected at a 10% significance level for the joint significance test. That is, the predicted terms are not significantly different from 0, and thus provide no explanatory power to the conditional mean. To further inform model selection, we examine the relative fit of the two models.

Model Fit

A further analyses of model fit is conducted using Akaike Information Criterion (AIC) and Baysian Information Criterion (BIC). These measures provide a means to test the statistical quality of the models through their likelihood.

Table 7.7: Information Criterion

	Logit	Probit	Loglog	Cloglog
AIC	1099.7	1104.9	1096.5	1111.9
BIC	1245.4	1250.6	1242.3	1257.6

AIC is theoretically motivated and assesses statistical fit of the model using the likelihood estimates, BIC employs a similar framework but punishes less parsimonious models. However, in this case, all four link functions have the same number of estimated parameters, therefore the AIC is sufficient for making model selection. According to AIC measures, loglog has the best relative fit, while logit ranked second.[12]

These test result suggest that loglog link is the sensible model selection. Future results discussed in the rest of this chapter will reflect this model selection.

Partial Effects

The partial effect of the FRM with loglog Link can be seen from the previous generalisation

$$\frac{E(y|x)}{\partial x_j} = \theta_j g(x\theta) = \theta_j e^{x\theta - e^{x\theta}}$$

It is dependent on the coefficient estimate of x_j as well as the value of the index function, that is, the magnitude of the partial effect is dependent on the value of other covariates. To generalise inference of the partial effects, two measures are computed: (1) Partial effect At the Means (PAM); (2) Average Partial Effect (APE). Results are presented in *Table 7.9.*

[12] The less the better

Table 7.8: FRM (loglog) Partial Effects

	(1) Partial Effect At Mean	(2) Average Partial Effect
Corporate Fund Dummy	0.0286***	0.0407***
	(0.00866)	(0.0123)
Industry Fund Dummy	−0.0355***	−0.0505***
	(0.0102)	(0.0146)
Public Sector Fund Dummy	−0.0392***	−0.0557***
	(0.0132)	(0.0189)
Public Offer Dummy	−0.0178***	−0.0254***
	(0.00442)	(0.00631)
Corporate × Share	−0.0832***	−0.118***
	(0.00893)	(0.0126)
Public Sector × Share	0.0185***	0.0263***
	(0.00558)	(0.00786)
Industry × Share	0.00652*	0.00927*
	(0.00388)	(0.00549)
Public Sector × Choice	−0.0121**	−0.0172**
	(0.00572)	(0.00810)
Corporate × Exit	−0.0185	−0.0263
	(0.0175)	(0.0250)
Exiting Market Dummy	0.0403***	0.0573***
	(0.0149)	(0.0215)
Market Share	−0.0219***	−0.0311***
	(0.00220)	(0.00296)
Assets in Default Option	0.000108*	0.000153*
	(0.0000561)	(0.0000798)
Herfindahl Index	−0.0215***	−0.0306***
	(0.00394)	(0.00560)
Investment Choices (log)	−0.0108***	−0.0154***
	(0.00145)	(0.00209)
Observations	2512	2512

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Our result shows that PAM estimates are consistently smaller in scale than that of APE. This is consistent with the concave curvature of partial effect $g(x\theta)$, where the APE is the average of $g(x\theta)$ and PAM is a line representing the linear combination of two points on the curve, concavity ensures that $APE \geq PAM$. While both measures are valid and their interpretations are slightly different. PAM is an estimate of the partial effect at the mean value of the covariates, generalised inference using PAM is valid if majority of covariates are continuous. In our research, most exogenous contextual variables are binary dummies, the mean values of these variable are not achievable in reality, this then limits our ability to inference based on these results. APE represent the mean of the partial effect over the entire sample. It has a simple intuitive interpretation as the expected value of the partial effect. Inference based on APE is consistent if the sample covariate distribution is representative of the population. This is true in our case since the data set captures all regulated funds under APRA's regulatory jurisdiction, with only small sample truncations based on erroneous data. Due to these considerations, interpretation of our regression result is based on the APE of the FRM using loglog link.

FRM partial effects closely resembles those results under conventional linear models. This is not surprising as conventional linear models are often good approximations of partial effects averages or at the mean value of the index function. The true advantage of these FRM consistent estimators is in computing the partial effects at the end points, where linear model prediction introduce significant bias due to poor specification of the underlying data structure. The result is analogous to that of McDonald (2009), where the paper recognised model misspecification under LPM/TOBIT but argued that for the purposes of most studies, OLS is sufficient in approximating the true APE. Regardless, this section of this research serves to ensure that our result is robust under the various model specifications, and that any inference based on these results are valid.

7.3.3 Discussion of Results

Our second stage DEA regression results presents a number of implication for the efficiency and productivity of Australian superannuation funds. In particular, our results presents quantifiable evidence of the influence of the various structural and design features in the Australian superannuation environment.

Fund Type

Our second stage result is consistent with our previous result which showed that corporate super fund appear to be the most technically efficient fund type in the market. Relative to retail fund, corporate funds on average outperform by a PTE score of 0.0407. Again, this result is not surprising, as our analysis incorporates cost subsidization of the corporate funds as input discounts. This allows corporate funds to operate at a relatively lower cost base, which could explain how super funds in this sector is able to systematically outperform the industry in technical productive efficiency.

Perhaps the more interesting result here is that, after controlling for other environmental factors, we found that retail funds are more efficient than public sector and industry funds. This result is at odds with recent Australian literature on superannuation fund investment performance and administrative fees, which have generally concluded that retail funds appear to charge members higher fees but offer very little difference in investment outcomes (Bateman and Mitchell, 2001; Coleman et al., 2003; Ellis et al., 2008). The difference in our results can be explained in two ways.

First, previous studies have focused on financial metrics such as investment outcomes and administrative expenses. In additional to these traditional measures of performance, our analysis has also accounted for the membership characteristics of the funds by adopting the VaR output measure. This measure punishes super funds for excessive risk exposure for shorter term asset holdings (i.e. those members nearing retirement), which could help explain why retail super funds appear to be superior in their technical efficiency to deliver this output. Retail super funds by their nature are a client winning business and typically experience greater membership engagement. We can then hypothesise that portfolio holdings in retail funds are much more tailored to the needs of members when compared to other fund types. This could be a result of active management by the fund managers, or deliberate life cycle choice by the members. Unfortunately the limitations of our data does not allow the separate identification of these two dynamic movements in portfolio composition. To the best of our knowledge, this research is among the first to incorporate membership characteristics in the assessment of superannuation fund performance in Australia. In particular, the incorporation of member age profiles and the corresponding fixed statutory asset holding period they face in our performance metric provides a better description of the industry's core functionality in the provision of retirement incomes.

Second, literature that studies the performance differentials between different fund types have rarely controlled for other structural characteristics of the super funds, including features such as market share, investment choice, market concentration, public offer etc. Our results are more robust in that technical efficiency comparisons between super fund types are conducted under a regression framework, where we have controlled for environmental variables that could potentially contribute to the technical efficiency of the super funds. This could also contribute to the difference between previous results and our results.

Public Offer

Recall that the public offer dummy captures whether the super fund offers its services to the general public. It is also a proxy variable that characterises the trustee board structure. Our results shows that public offer status has a negative effect on the technical efficiency of super funds; on average a public offer super fund is likely to be 0.0178 less efficient than its counterpart.

Again, this result is consistent with our a priori that public offer funds are likely to incur higher administrative expenses due to expenditure in areas including marketing, distribution and other related areas.

The findings of the Australian literature in this respect is mixed. Drew and Stanford (2003) argue that public offering allows for more vigorous price competition and promotes market discipline of funds, so under such assumption we would likely to see public offer funds outperforming industry counter parts in efficiency. However Vidler (2004) argued that such an approach ignores cost issues inherent in personal account based pension systems, and costs associated with competition observed both in Australia and overseas. The evidence presented in our research seems to support the latter, where competition in the general superannuation market appears to have a negative impact on the super funds' technical productive efficiency.

Market Power

Our results showed that on average, a 1% increase in market share will result in a 0.0311 decrease in technical efficiency for industry and retail funds. Inclusion of interaction terms also revealed significant heterogeneous effects, where corporate fund suffer an additional 0.118 efficiency loss from gains in market share; while public sector funds suffer slightly less than industry and retail funds by 0.0263. The net effects are presented in *Table 7.10*

Table 7.9: Net APE of 1% change in market share

	Corporate	Retail	Industry	Public Sector
1% Δ Market Share	-0.1491	-0.0311	-0.0311	-0.0048

Overall, our results show that increases in market share systematically decrease productive efficiency across all sectors of the industry. However, this is does not necessarily mean that there are no efficiency gains from economies of scale. Rather, we observe the overall effect of the trade-off between costs arising from market power and production economies of scale benefits. The negative effect of market power would simply suggest that the cost is greater than the benefit gained.

The results illustrate that corporate super funds suffer the most from changes in market share. This is consistent with our a priori; recall that corporate funds enjoys significant input factor discounts as a result of cost subsidisation from the sponsoring employer. This is also a caveat that limits the growth of corporate super funds, as the real cost of borne by the employer to subsidise the operations of the corporate fund is directly related to the relative scale of the fund. Increasing market share, or fund scale is likely to decrease the employers' ability and willingness to continue supporting the super fund's operations. In essence the loss of employer subsidies removes any competitive cost advantage of corporate super funds, and is likely to result in large decreases in technical efficiency.

Both public offer super funds, industry[13] and retail sectors appears to suffer similar efficiency losses from increases in market power. This could be attributed to the costs arising from significant gains in market share. Vidler (2004) suggested that in order to gain significant market power in a competitive environment, super funds have to offer a greater range of products to accommodate greater number of members, invest in new IT systems to cope with increasing level of member interaction, and most importantly, develop and maintain marketing exposure to compete against industry counterparts.

As expected, public sector funds suffer from neither caveats (cost subsidies, or competition) and therefore remain relatively immune to market share movements.

Investment Options

Our results suggest that more investment choices offered by the fund decreases fund efficiency: a 1% increase in investment choices on average decreases super fund

[13]Not all industry funds are public offer, but increasing number of industry funds are undergoing such reform.

efficiency by 0.0154. This effect is also heterogeneous for public sector funds, where the sector experiences an additional 0.0172 efficiency loss from increased investment choices.

Our result is intuitive and consistent with the majority of recent industry studies. Bateman and Thorp (2007) argued that inefficiency in decentralized portfolio management can arise from incomplete information transfer between the central manager and delegated manager. This is difficult, and inefficiency is likely to arise from unsuccessfully combining delegated portfolio subsets into an efficiency centralized portfolio. Further, increasing investment options offered to members is also likely to increase fixed portfolio management costs, hence decrease overall productive efficiency.

It is unclear why public sector super funds experience heterogeneous effects from this characteristic. One plausible explanation is perhaps that these funds have significantly higher cost base in administering additional investment options. There is a lack of evidence that is able to provide any explanation to this effect. Perhaps this could be resolved in future research.

Market Concentration

Recall that the Herfindahl index measures the level of competition and market concentration in each year of our sample. Our result illustrate that this variable is negatively related to the fund efficiency scores. A 0.01 movements in the index correspond to a universal efficiency loss of 0.0306 across the industry. This is a sensible result given our previous analysis of market shares, where increasing fund scale decreases its productive efficiency. Although the Herfindahl index is somewhat collinear to the market share variable, they are separately identifiable.

One should also note that the current Herfindahl index of the Australian superannuation market is relatively low, with market share largely decentralised. Therefore it is unlikely we would see significant changes in the index over the next few years. This implies that the variable is unlikely to have a significant impact in the short term.

Wind Up Funds (Exits)

Our previous analysis in the first stage revealed that market leavers in the industry appears to be more efficient than incumbent funds. This holds true in our second stage results, where market leavers are 0.0573 more efficient on average. Corporate funds exits also appears to be heterogeneous, where the effect is reduced by 0.0263 to 0.0310.

Similar to our first stage analysis, these results clearly violate the efficient market hypothesis. We have attributed this effect to two structural failures in the market. First, the market structure is restrictive and segregated where some super funds only compete on a sub population level. This limits the ability of efficient fund to expand their outputs and increase their market power. Second, some super funds derive their efficiency from competitive cost advantage due to subsidies from fund sponsors. These subsidies are not sustainable in the long run as funds increase in scale. These factors remains valid in our second stage interpretation of results.

Recall, one of the key motivations of this research was to better understand the persistence of the average expense to asset ratio of the industry over the past decade. This could be partly be explained by our result relating to market exits. Where super funds that exit the market appear to be more efficient than their incumbent counterparts, this could be interpreted as a downward shift in the frontier or the efficiency cluster below the frontier. In practice, less efficient funds require more inputs to produce the same level of output, therefore asset flows from more efficient funds to less efficient funds within the industry are likely to counteract any cost reductions arising from increases in economies of scale due to consolidation and growth.

7.4 Policy Implication

These results have significant implications for future policy formulation and regulatory reforms.

We find that corporate funds are systematically more efficient than the rest of the industry. Although these efficiencies can be partially attributed to discounted inputs factors due employer subsidies, they benefit the members nonetheless. Therefore, future superannuation policies should encourage the continuum of corporate fund in the market. This can be achieved by reducing excess fixed regulatory costs associated with licensing and compliance for smaller funds.

Our result also shows that the costs associated with public offer is likely to outweigh any benefit derived from the reduction in prices. This is consistent with the finding of the *Cooper Review*, which suggested cost transparency as a major impediment to reducing costs. The limited visibility is likely to hinder any vigorous pricing competition among competitors, hence offering little incentive for super fund to reduce the underlying cost to deliver services.

This research also find that increasing market power is likely to decrease efficiency. This seems to provide some empirical evidence to Vidler (2004), which argued that in order to gain significant market power in a competitive environment, super funds must allocate significant resources in improving their market profile and accommodate more members. This results calls for more restrictive anti-competitive regulation, where super fund mergers and acquisitions should be discouraged.

We also find that large number of investment options decrease super fund efficiency.

This provides empirical support to the recent policy reforms to mandate default options and consolidate the dispersion of portfolio choices.[14]

7.4.1 Extension: Aggregate Performance

Efficiency measurements under the Data Envelopment Analysis framework are computed using a piece wise comparison mechanism. A common criticism of this technique is its inability to account for standard errors. For example, an inefficient super fund could be considered efficient for period t if their particular portfolio worked well with the unexpected financial shocks during that period. Indeed, our first stage analysis revealed that selected funds significantly outperformed the rest of the industry during the period of the GFC. The superior performance of these super funds could reflect their true productive efficiency or could be attributed a degree of luck. Relatively better performance of super funds such as BMA Personal in 2008/2009 could be traced to their significant holding of defensive assets such as domestic bonds and cash. These asset categories are less risky during periods of market downturn, hence assist in limiting losses incurred by the super funds during these periods. However, these portfolios are not necessarily the best investment strategies in other periods as they offer relatively lower levels of return. The objective of this extension is to ensure that our results are robust under the aggregate performance framework. This section will briefly discuss the data generating process underpinning this analysis and compare the results with our previous findings. The interpretation is brief and is analogous to that of the previous section.

Data

To compute aggregate performance, we take the average of super funds input/output measures over the sample period from 2004-2012. DEA analysis is then computed based on these observations.

The unbalanced nature of our data presents a unique problem. Super funds that

[14] MySuper reform 2012

exit the market before the financial crisis are likely to have higher output measures, which would give them an unfair advantage in the DEA process. Therefore we also check the robustness of our results using a sample comprising super funds which was present in the data for at least 5 years.[15] However, analysis under the restrictive sample could also cause sample selection issues, as attrition is asymmetric and biased towards corporate and retail funds.

Results

Table 7.10: Average Efficiency Scores: Aggregate Performance

	Full Sample			Restricted Sample		
	Average PTE	Std. Dev	Obs	Average PTE	Std. Dev	Obs
Corporate	0.957	0.079	296	0.966	0.039	103
Industry	0.748	0.196	78	0.870	0.095	67
Public Sector	0.747	0.216	25	0.859	0.097	18
Retail	0.822	0.221	183	0.843	0.179	108
Overall	0.878	0.181	574	0.892	0.134	288

The first stage results presented in *Table 7.11* are similar to our previous findings. Corporate super funds lead the industry in average productive efficiency, followed by retail super funds. An interesting result here is that under the restricted sample, retail funds did not appear to be significantly different from industry and public sector super funds. In fact, we observe a systematic increase in average efficiency across all four sectors. This could be partly explained by our sample selection strategy. By restricting the sample to super funds that lasted for more than 5 years, we reduce the amount of distortion created by market leavers. This has resulted in a lower dispersion of efficiency score (lower Std.Dev); particularly in the lower spectrum, hence boosting efficiency averages.

[15] Due to lack of new market entrants, only super fund that exits before 2009 are dropped

We employ a similar FRM estimation technique in our previous second stage analysis. Specification tests and model fit suggests that Cloglog would be the correct link function in this instance. A summary of our results are presented in *Table 7.12*

Table 7.11: FRM (cloglog) Partial Effects: Aggregate Performance

	(1) Full Sample	(2) Restricted Sample
Corporate Fund Dummy	0.00166	0.0184
	(0.0197)	(0.0257)
Industry Fund Dummy	−0.0483*	−0.0184
	(0.0289)	(0.0351)
Public Sector Fund Dummy	−0.0613	0.00761
	(0.0394)	(0.0372)
Public Offer Dummy	−0.0269**	−0.0306***
	(0.0108)	(0.0109)
Corporate × Share	−0.134*	−0.0259
	(0.0745)	(0.0401)
Public Sector × Share	0.175***	0.0507*
	(0.0413)	(0.0283)
Industry × Share	0.110***	0.0707**
	(0.0415)	(0.0293)
Public Sector × Choice	−0.0365	−0.0343*
	(0.0245)	(0.0203)
Corporate × Exit	0.00253	0.0109
	(0.0164)	(0.0233)
Exiting Market Dummy	0.0598***	0.0121
	(0.0130)	(0.0191)
Market Share	−0.161***	−0.0714***
	(0.0334)	(0.0248)
Assets in Default Option	0.000192	0.000149
	(0.000135)	(0.000225)
Investment Choices (log)	−0.0146***	−0.0148**
	(0.00424)	(0.00616)

Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Under the full sample analysis, we find that there is little difference in efficiency performance between fund types except for industry funds, which slightly under performs the other three fund types after controlling for other covariates. Although this result differs from our previous findings, this is not entirely unexpected. Our previous analysis has shown that retail funds are only relatively more productive than other fund types during market downturns, so it is plausible that this identification is no longer viable under the aggregate performance framework.

Consistent with our previous findings, public offering appear to have a negative relationship with super fund efficiency. Our estimated effects of public offering are fairly robust, with the effect under the two aggregate samples (-0.0269 and -0.0306 respectively) only slightly higher than the original APE estimates (-0.0254). This result confirms that public offer super funds are generally less efficient than their non-public offer counterparts. Similar findings also extend to investment choices, with the estimated effect fairly similar under the three sample specifications (-0.0154, -0.146 and -0.148).

The results in *Table 7.12* confirms our previous finding in relation to the effect of market power on super fund efficiency. We find a consistent negative relationship across the two aggregate samples (-0.161, -0.0714). The difference in the estimated effect between the two samples could be attributed to the attrition of small market exit super fund[16] in the restricted sample. Regardless, these estimates appear to be significantly higher than our original estimate of -0.0311. However, one should keep in mind that the market share variable regressed here is the average measure over the entire period that the super fund appeared in the sample. Therefore, this estimate differs from our original results as the dynamic movements in market power are no longer captured under the aggregate samples. In addition, we find similar heterogeneous effect across fund types, with corporate super funds experiencing the higher marginal effect, followed by industry and retail funds.

Perhaps the more interesting result here is our estimated effect for market exits. Under the full sample specification, the effect of a market exit is 0.0598. This is nearly identical to our previous APE estimate of 0.0573. In contrast, we find

[16]Market exits before 2009 are comprised of mainly small corporate funds

no significant differences between market exits and incumbent players under the restricted sample analysis. This a surprising result, as the restricted sample only captures market exits from 2010-2012, and suggest that market exits are randomized in terms of productive efficiency. However, it is important to note that there is a very limited number of market exits between 2010-2012, therefore there may be a small sample bias for the estimator due insufficient observations.

Overall, our results are robust under the aggregate performance measures. This implies that inferences based on our results are valid despite the possible 'luck' element under the DEA framework.

7.4.2 Key Results

This section will provide a summary of the key results presented in this chapter. In general, we find that:

- The Australian superannuation industry appears to have relatively high technical and scale efficiency. However, the industry could benefit from improvements in scale efficiency of public offer super funds.
- Corporate super funds consistently appear to be more efficient than their industry counterparts. As well, the majority of the highly efficient retail funds are affiliated to commercial banks.
- On average, industry, public sector and retail super funds appear to be equally efficient. However, retail funds appear to perform slightly better during market downturns.
- Conventional linear regression frameworks are inadequate for specifying the underlying data generating process of the efficiency scores. Fractional response models using binomial dispersion and a loglog link function appear to provide consistent estimates of environmental variables.

- After controlling for contextual variables, we find that corporate funds are the most efficient fund type, followed by retail and industry super funds. Public sector super funds appears to be the least efficient.

- Super funds that offer their membership to the general public are less efficient than their not-for-profit counterparts.

- Market Power is negatively related to the technical efficiency of super funds. A heterogeneous treatment effect is also present for different fund types, with corporate funds suffering highest declines with market share gains.

- The number of investment options decreases technical efficiency of super funds.

- Centralisation of portfolio assets in the default option increase technical efficiency of super fund, although the effect is not economically significant.

- Defined Benefit design did not have an impact on super fund efficiency.

The above results are also robust under an aggregated performance framework, where efficiency is computed using average measures across the sampling period.

Chapter 8

Conclusion

The aim of this research was to investigate the production efficiency of the Australian superannuation industry, and discover the relative impact of key industry structural and design features. The efficiency analysis was conducted using a two stage construct. In the first stage a non-parametric frontier technique - Data Envelopment Analysis (DEA) - was calibrated to measure the production efficiency for a sample of APRA regulated large Australian superannuation funds between 2004 and 2013. In the second stage, technical efficiency of super funds are analysed under a regression framework, where the impact of key industry structural characteristics and design features were assessed.

A review of the international literature revealed significant insights from efficiency studies on the banking sector and mutual funds. These research have helped to inform government policy formulation and regulatory reforms. By contrast, studies of superannuation fund efficiency in the Australian literature is very limited. The core contribution of this research is to bridge this literature gap, and then inform policy and regulatory development and industry practice.

In comparison to other parametric efficiency analysis, DEA is superior within the confines of our research as it does not require the input factor prices that are not available for the current study. Further, the technique allows for multiple output/input definitions of the production process. This is advantageous as it enables us to capture the multiple functionality of the superannuation industry and produce an aggregate measure of production efficiency based on their respective outcomes. A key contribution of this research is to assess super fund performance using a innovative Value at Risk framework, which readily incorporates membership characteristics in evaluating super funds' performance in risk management.

The majority of previous two stage efficiency studies have employed conventional linear models in their analysis. These models are heavily criticised for their misspecification of the underlying data structure and generally yield inconsistent results. This research has assessed the validity of these models against the more sophisticated non-linear modelling techniques. We found that the fractional response model with binomial dispersion and loglog link function is the most accurate model for correctly specifying the underlying data.

Our results show that the Australian superannuation industry has relatively high technical and scale efficiency, with most super funds operating at or close to the production frontier. We found that corporate super funds consistent outperform their industry counterparts in technical efficiency, which is likely driven by the discounted input factors resulting from heavy cost subsidization by corporate sponsors.

This research also found that super funds that offer their membership to the general public are less efficient than closed funds (i.e. non-public offer). This result has significant policy implications, as it seems to discourage recent regulatory movements to promote greater consumer choice in the selection super funds. Our results provide some empirical basis for previous studies such as Vidler (2004), which argues there are significant costs associated with increasing levels of competition and the cost would outweigh any benefit derived from market discipline.

Another key finding of this research is the negative relationship between a super funds efficiency and their corresponding market share. This result suggests that any efficiency gains from increasing economies of scale is likely to be offset by the increasing costs arising from gains in market power. The effect also varies in severity across the different fund types, with corporate fund experiencing the greatest efficiency loss, followed by retail and industry funds. The implications are complex, and our findings suggest that the superannuation fund market is highly inefficient, with less efficient entities occupying larger portions of the market. That being said, we found that the more efficient super funds often derive their efficiency from subsidies and are restricted to sub populations of the market, this essentially limits their ability to expand. Such market restriction prevents any allocative gains from reallocation of output between more efficient and less efficient super funds.

Finally, our results have shown that the majority market exits in the past decade are highly efficient super funds. Previous studies have attributed corporate super fund exits to the increasing cost of regulation and compliance. Our finding imply that the current regulatory framework is inadequate in promoting efficiencies within the market. In particular, fixed regulatory expenditures such as licensing costs and the recent MySuper reforms serves to discourage small and highly efficient corporate funds from participating in the market.

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Appendix

Average Efficiency by Fund Type

Table 8.1: Average Efficiency by Fund Type

year	Corporate	Industry	Public Sector	Retail
2004	0.80	0.74	0.79	0.71
2005	0.63	0.69	0.74	0.69
2006	0.64	0.65	0.78	0.65
2007	0.67	0.75	0.78	0.76
2008	0.19	0.03	0.07	0.14
2009	0.27	0.03	0.01	0.11
2010	0.65	0.59	0.68	0.66
2011	0.60	0.76	0.85	0.72
2012	0.32	0.30	0.51	0.29

TOBIT Proof

$$
\begin{aligned}
E(y|x) =& 0 \cdot P\left(\sum \beta_k x_k + \mu < 0\right) \\
&+ E(y|x, 0 < y < 1) \cdot P\left(0 < \sum \beta_k x_k + \mu < 1\right) \\
&+ 1 \cdot P\left(1 < \sum \beta_k x_k + \mu\right)
\end{aligned}
$$

$$
\begin{aligned}
E(y|x) =& 0 + \left[\sum \beta_k x_k + \sigma \frac{\phi\left(\frac{-\sum \beta_k x_k}{\sigma}\right) - \phi\left(\frac{1-\sum \beta_k x_k}{\sigma}\right)}{\Phi\left(\frac{1-\sum \beta_k x_k}{\sigma}\right) - \Phi\left(\frac{-\sum \beta_k x_k}{\sigma}\right)}\right] \\
&\cdot P\left(-\sum \beta_k x_k < \mu < 1 - \sum \beta_k x_k\right) + 1 \cdot P\left(1 - \sum \beta_k x_k < \mu\right)
\end{aligned}
$$

VaR Benchmarks

Table 8.2: Return Volatility Benchmark Index

Abreviation	Asset Class	Benchmark Index	Source
AS	Australian Listed Equities	S&P/ASX 200 Merged Accumulation Index	Bloomberg
OSH	International Listed Equities	MSCI TR NetWorld Ex-Australia Local	Bloomberg
P	Australian Listed Property	S&P/ASX 200 Propoerty Merged Accumulation Index	Bloomberg
PD	Australian Direct Property	Australian Mercer Unlisted Property Funds Index Pre-Tax	Mercer Investment Consulting
AFI	Australian Fixed Interst	UBS Composite Bond Index All Maturities	Bloomberg
OFI	International Fixed Interest	JP Morgan World ex-Aust $A	Bloomberg
C	Cash	UBS Bank Bill Index	Bloomberg
O	Other	UBS Bank Bill Index	Bloomberg

VaR Benchmark Volatilities

Table 8.3: Benchmark Return Volatilities (Std.Dev)

	Equity(AU)	Equity(Int)	Bonds(AU)	Bonds(Int)	Property	Cash
2003	0.00457	0.00765	0.00984	0.00581	0.00677	0.00168
2004	0.00425	0.00902	0.00674	0.00576	0.00767	0.00011
2005	0.00619	0.00671	0.00604	0.00414	0.01003	0.00024
2006	0.00843	0.00915	0.00485	0.00428	0.00978	0.00031
2007	0.01073	0.01251	0.00509	0.00860	0.01528	0.00030
2008	0.02152	0.02823	0.01041	0.01825	0.03003	0.00079
2009	0.01325	0.01878	0.00835	0.01082	0.02504	0.00042
2010	0.00991	0.01473	0.00904	0.00872	0.01158	0.00034
2011	0.01238	0.01801	0.00700	0.00863	0.02115	0.00017
2012	0.00736	0.01153	0.00944	0.00548	0.01114	0.00048
2013	0.00850	0.00892	0.00852	0.00520	0.01070	0.00016

Table 8.4: OLS & TOBIT estimates

	(1) LPM	(2) TOBIT
Corporate Fund Dummy	-0.0179	-0.0211^{*}
	(0.0111)	(0.0121)
Industry Fund Dummy	-0.0470^{***}	-0.0565^{***}
	(0.0172)	(0.0180)
Public Sector Fund Dummy	-0.0607^{***}	-0.0641^{***}
	(0.0202)	(0.0227)
Public Offer Dummy	-0.0308^{***}	-0.0293^{***}
	(0.00781)	(0.00820)
Defined Benefit Dummy	-0.00396	0.00640
	(0.0149)	(0.0181)
Corporate × Share	-0.120^{***}	-0.119^{***}
	(0.0395)	(0.0402)
Public Sector × Share	0.0782^{***}	0.0899^{***}
	(0.0199)	(0.0228)
Industry × Share	0.0325	0.0349^{*}
	(0.0199)	(0.0207)
Corporate × Choice	0.0198^{***}	0.0199^{***}
	(0.00367)	(0.00404)
Public Sector × Choice	-0.0341^{***}	-0.0379^{***}
	(0.0101)	(0.0117)
Industry × Choice	-0.0184^{*}	-0.0177^{*}
	(0.00972)	(0.0100)
Corporate × Exit	-0.0323^{**}	-0.0354^{**}
	(0.0136)	(0.0151)
Exiting Market Dummy	0.0278^{**}	0.0326^{**}
	(0.0126)	(0.0139)
Market Share	-0.0830^{***}	-0.0817^{***}
	(0.0129)	(0.0132)
Members in Default Option	0.0000870	0.000107
	(0.0000782)	(0.0000849)
Herfindahl Index	-0.0321^{***}	-0.0315^{***}
	(0.00694)	(0.00735)
Investment Choices (log)	-0.0180^{***}	-0.0201^{***}
Constant	1.053^{***}	1.062^{***}
	(0.0162)	(0.0172)
σ		0.124^{***}
		(0.00320)
Year Fixed Effect	*Yes*	*Yes*
Adjusted R^2	0.472	

Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Fractional Response Model Results

Table 8.5: Generalised Linear Model Results

	(1) Efficiency Score (VRS)	(2) Efficiency Score (VRS)	(3) Efficiency Score (VRS)	(4) Efficiency Score (VRS)
Corporate Fund Dummy	0.438***	0.165**	0.459***	0.0824*
	(0.145)	(0.0696)	(0.137)	(0.0487)
Industry Fund Dummy	−0.596***	−0.288***	−0.569***	−0.203***
	(0.177)	(0.0911)	(0.165)	(0.0668)
Public Sector Fund Dummy	−0.674***	−0.330***	−0.629***	−0.239***
	(0.240)	(0.123)	(0.214)	(0.0926)
Public Offer Dummy	−0.314***	−0.151***	−0.286***	−0.104***
	(0.0764)	(0.0388)	(0.0714)	(0.0286)
Defined Benefit Dummy	−0.0582	−0.0176	−0.0763	−0.00630
	(0.192)	(0.0961)	(0.181)	(0.0684)
Corporate × Share	−1.477***	−0.796***	−1.335***	−0.634***
	(0.218)	(0.131)	(0.139)	(0.147)
Public Sector × Share	0.423***	0.258***	0.297***	0.291***
	(0.119)	(0.0699)	(0.0890)	(0.0726)
Industry × Share	0.178*	0.112*	0.105*	0.149**
	(0.0968)	(0.0576)	(0.0621)	(0.0676)
Corporate × Choice	0.0910*	0.0667***	0.0718	0.0590***
	(0.0548)	(0.0256)	(0.0514)	(0.0175)
Public Sector × Choice	−0.243**	−0.144**	−0.194**	−0.131***
	(0.108)	(0.0567)	(0.0916)	(0.0444)
Industry × Choice	−0.122	−0.0777*	−0.0928	−0.0756**
	(0.0783)	(0.0426)	(0.0698)	(0.0340)
Corporate × Exit	−0.321	−0.177	−0.297	−0.127
	(0.297)	(0.136)	(0.282)	(0.0899)
Exiting Market Dummy	0.643**	0.272**	0.647***	0.163**
	(0.257)	(0.119)	(0.243)	(0.0795)
Market Share	−0.467***	−0.276***	−0.351***	−0.297***
	(0.0676)	(0.0383)	(0.0333)	(0.0488)
Members in Default Option	0.00202**	0.00107**	0.00173*	0.000841**
	(0.000968)	(0.000484)	(0.000902)	(0.000348)
Herfindahl Index	−0.365***	−0.185***	−0.345***	−0.133***
	(0.0670)	(0.0342)	(0.0622)	(0.0255)
Investment Choices (log)	−0.182***	−0.0952***	−0.173***	−0.0690***
	(0.0272)	(0.0139)	(0.0238)	(0.0104)
Constant	3.891***	2.139***	3.825***	1.472***
	(0.184)	(0.0897)	(0.173)	(0.0634)
Fixed Year Effect	*Yes*	*Yes*	*Yes*	*Yes*

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$