Doctoral Dissertation

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Essays on the decisions of investors and fund managers

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Thesis abstract

This thesis studies aspects of equity market outcomes that may arise from the existence of fundamental differences in the optimisation problems of private investors and institutional investors.

The first essay reviews what is known and unknown about the differences in the incentives of private investors and fund managers, and examines the significance of those differences for market outcomes. The growth of delegated portfolio management in the UK and the US is firstly documented. Then, the results of empirical studies of incentives faced by fund managers, and resultant fund manager trading behaviour, is surveyed. Next, the optimisation problems faced by private investors and fund managers are contrasted. Finally, the essay presents conjectures on the effect of differences in the incentives of private and institutional fund managers on unexplained stock market phenomena.

In the second essay a dataset of the portfolio holdings of 268 UK equity mutual fund managers is employed to test for herding among UK unit trust managers and at the same time test the accuracy of the herding measures of Lakonishok, Shleifer and Vishny (LSV 1992b) and Wermers (1995, 1999). Invalid assumptions in the LSV and Wermers measures, which may be expected to bias the measures, are identified and analysed.

A bootstrap re-sampling technique is developed to create replicated datasets which exhibit approximately zero systematic herding but are drawn from populations in which the invalid assumptions are relaxed. The results show that the LSV assumption, that all managers short sell, biases the measure towards finding herding in the smallest stocks, the largest stocks and stocks in which a small number of managers trade during a period. Nonetheless, a significant amount of herding among UK unit trust managers is found particularly in the smallest and largest market capitalisation stocks. The Wermers measure is biased toward finding herding in all subsets of the data which are formed on the basis of stock size or the number of managers trading the stock during a period.

The final essay models the relationship between a fund manager's portfolio performance figures and an investor's decision, each period, to either retain or fire the fund manager. The investor must decide on the basis of evolving information whether to abandon the current manager, and at cost K, engage the best alternative manager. The model highlights the value of the real option to delay the decision by one or more periods, after which some uncertainty about the quality of the manager is resolved. In addition, the model partially explains why some investors wait a seemingly irrational length of time before changing manager and shows the effect of uncertainty over manager skill on the value of that real option. A closed form solution is presented for the case of an investor deciding *n* periods after hiring the manager and 2 periods from the investment horizon. Then simulation results are provided for the case of an investor deciding *n* periods after hiring and 10 periods from the investment horizon.

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Chapter 1 Introduction

1.1 Theme and purpose of the thesis

The past three decades have seen the rise of funds management to a central position in UK and US financial markets. In the equity markets of both countries the assets managed by institutional investors now amount to over one half of the value of the market.[1] The consequences of the large scale delegation of portfolio decision making by private investors to their chosen institutional investors, are not well understood. They may be substantial; private investors and institutional investors face profoundly different optimisation problems and can therefore be expected to undertake different trades even if their information sets and initial conditions are identical.

An example can illustrate the differences in the incentives (objective function) faced by private investors and fund managers. Suppose a private investor and an institutional investor each hold 4 percent of their respective portfolios in a particular stock which realises a return of 150 percent over the following period. For the private investor the stock generates a 6 percent increase in end of period wealth, in direct proportion to the initial weight of the stock in the portfolio. The effect of the stock return on the fund manager's end of period wealth is more complicated. Among many differences, the two principal differences are, firstly, that end of period wealth will be a non-linear function of the excess-to-benchmark return of the stock rather than a linear function of total return. Empirical studies have revealed that even though management fees generally increase linearly with the size of the fund, there is a non-linear relationship between a fund's excess-to-benchmark portfolio return and the flow of new money to the fund. Secondly, the scale of a large fund can make the manager's end of period wealth (or investment management firm value) highly sensitive to returns achieved.

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[1] The terms *money manager*, *fund manager* and *institutional investor* are used interchangeably in the finance literature and that practice is continued here.

The point of this example is that private investors and fund managers face fundamentally different incentives and can therefore be expected to behave differently. The incentives of fund managers are shaped by the way that private investors choose fund managers. The effect of these differences on market outcomes is not well understood. The research reported in this dissertation seeks to understand aspects of how financial market outcomes are related to decisions that arise from the relationship between investors and their fund managers.

The first essay assesses the significance of the rise of delegated portfolio management. The astonishing growth of managed funds is firstly documented. The state of knowledge of fund manager incentives is then reviewed and the importance of differences between the incentives of private and institutional investors are analysed in the context of several unexplained equity market phenomena.

To better comprehend the market equilibrium and to decide whether differences in incentives are important, we need to know whether investors can be clustered into groups (in particular, private investors and institutional investors) which are delineated by their trading behaviour. Empirical measures of herding are important because a test for herding by a group of investors constitutes a test of whether the group's trading behaviour marks it as separate from the rest of the market.[2] **The second essay** develops and implements bootstrap methodology for testing the accuracy of herding measures. The herding measures, suitably adjusted for inaccuracies, are then used to test for the presence of herding among UK equity fund managers.

The rise of institutional investment is the story of millions of individual investors choosing between thousands of fund managers. But how investors make decisions on hiring and firing fund managers has received surprisingly little attention in the finance literature. **The third essay** models this decision process with the aim of better understanding the down-side of fund managers' incentive schedules and

[2] Brown and Goetzmann (1997) form US mutual fund managers into 'style' groups by a method which is analogous to k-means cluster analysis.

explaining seemingly curious aspects of investor behaviour in hiring and firing managers.

1.2 Financial markets and the rise of delegated portfolio management

The initial studies of fund manager incentives focused on the principal-agent problem faced by investors. The tools of agency theory were applied and developed within the framework of delegated portfolio management. However, it was found that the optimal contract design, as predicted by agency theory was not reflected in actual contracts between private investors and institutional investors.[3] The great majority of contracts between investors and mutual fund or pension fund managers are ‘boilerplates’ with no explicit performance related component.

Empirical studies of fund manager incentives followed which sought, among other things, to characterise and parameterise the implicit incentives faced by fund managers. There is now a body of work which in aggregate can help to define the incentive structure faced by mutual funds. Chapter 2, the first essay, meets the need for a paper that brings together the results of the empirical studies of fund manager incentives studies. Further, it analyses the consequences for market outcomes of the difference between the incentives of private investors and institutional investors.

The empirical studies of fund manager incentives can be formed into three categories: fee structures in mutual and pension funds; the flow of funds to mutual and pension funds; and strategic behaviour and hedging by fund managers. The essay includes a detailed literature review which consolidates results from the several strands of the literature and includes observations from the many discussions with fund managers on this topic conducted in the course of the research that is presented in this thesis.

The most significant element in shaping the incentives of a fund manager is the manner in which portfolio performance modulates the volume of money managed by

[3] Hedge funds, private banking services and limited partnerships are clear exceptions.

an investment management firm. New funds flow disproportionately to managers who have performed strongly in recent periods. Consequently, the capitalised value of future fees is highly dependent upon performance relative to the fund manager's peers. The relationship between performance and funds flow is non-linear with some curious aspects, such as, the seemingly high tolerance of some investors for poor performance and the preference of investors for fund managers with shorter track records. These particular phenomena are partially explained in the Hiring and Firing essay of chapters 5 and 6.

After consolidating the evidence on the nature of fund manager incentives, it is examined in the framework of the optimisation problems faced by private investors and institutional investors. The equivalent components of the optimisation problems faced by members of these two groups are compared; including, objective function (in which the incentives are embedded), opportunity set, constraints, choice variables and initial conditions. The comparison allows a critical assessment of the findings of the empirical studies and clarification of the differences between the incentives of private investors and institutional investors.

Having established what empirical studies in aggregate can say about the differences in incentives, the thesis examines aspects of how a market in which institutional investors have a substantial role should be expected to differ from a market comprised principally of private investors. The discussion focuses on evaluation of managers against the performance of their peers, which ensures that private investors and institutional investors have fundamentally different perceptions of risk. In turn they may have different dynamic hedging demands, different perceptions of corporate governance and different perceptions of optimal risk management by firms. Further, in aggregate, private investors and institutional investors may choose significantly different portfolios, which implies net trade between the groups.

The paper concludes with conjectures about how several unexplained phenomena in equity markets may be partially explained by the differences in the incentives of private investors and institutional investors. These conjectures are intended to form a blueprint for ongoing research in this area.

1.3 Herding

In the finance literature ‘herding’ is taken to mean a group of investors trading the same assets in the same direction at the same time. That is, trading correlated across members of the group, in excess of that which arises simply from artefacts of the market such as a rights issue. Previous empirical studies of herding have sought to determine whether herding by institutional investors moves asset prices away from ‘fundamental’ values. However, a separate motivation for studying herding is that empirical findings of herding are evidence that the market can be clustered into groups of investors which are delineated by their different trading behaviour. If private investors and institutional investors face significantly different incentive schedules and solve correspondingly different portfolio choice problems, then we should expect that in their trading behaviour the members of each group will on average be more akin to each other than to members of the other group. Empirical tests of herding by fund managers represent a test of that conjecture.

The objectives of the second essay (chapters 3 and 4) are fourfold. Firstly, to develop a methodology for testing the accuracy of metrics which are based on portfolio holdings data. Currently, portfolio holdings based measures of: herding; portfolio performance; and window dressing; are simply assumed to return a value of zero in the absence of the phenomenon being measured. The bootstrapping methodology developed here allows an approximate calibration of such measures to zero. Secondly, to apply the bootstrapping methodology to test the accuracy of existing herding measures. Studies employing those measures have found significant levels of herding by US pension fund and mutual fund managers. However, as demonstrated in the essay there is reason to believe that the measures return positive values even in the absence of herding. Thirdly, to apply the herding measures, suitably adjusted for estimated bias, to data drawn from a country which has an investment management industry comparable to that of the US; thereby, extending the generality of empirical herding results. Finally, to provide a mathematical formulation of herding that encompasses each of the several theoretical explanations of fund manager herding. Further, to show that all of the theories have the same fundamental explanation – the optimisation problems of individual fund managers are related – but each theory simply concentrates on a different aspect of the optimisation problem. In meeting these four objectives the essay makes methodological, empirical and conceptual contributions to the literature on the empirical study of herding.

The methodology of the accuracy tests is designed to overcome an obvious problem in testing the accuracy of a measure in which the input is the whole dataset; we do not have a large number of datasets which were drawn independently from the same group of managers over the same period. Instead, a large number of independent datasets are created by conditional bootstrap re-sampling. The re-sampling technique is designed to ensure that: each re-sampled dataset exhibits zero systematic herding; the invalid assumption that is being tested does not hold but other assumptions do; and essential dataset characteristics that are not associated with herding are preserved.

Applying a herding measure to each of the bootstrapped datasets builds up an estimate of the sampling distribution of the measure under the null conditions of zero herding. The mean of that empirical sampling distribution gives an estimate of the degree of mis-calibration (the bias in the absence of herding) of the measure. In turn, the mis-calibration is an estimate of the bias at the actual level of herding. Once an estimate of the bias in the measure at the actual level of herding is available, then the level of herding in the actual dataset can be measured and adjusted for the estimated inaccuracy of the measure.

The dataset is comprised of the portfolio holdings of 268 UK equity unit trusts over the period January 1986 to December 1993. It was compiled by Johnson Fry Pension Fund Consulting from the biannual reports of unit trust managers to investors.[4] There is a survivorship issue in that only unit trusts that were 'alive' in December 1992 are included. On the basis of results of previous empirical herding studies survivorship bias is not considered a significant problem. Two major advantages of the dataset are, firstly, that it contains UK data which allows the first test of herding among UK fund managers. Secondly, UK data is ideal for testing the effect of a

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[4] Johnson Fry Pension Fund Consulting is now a part of John Morrell Pty Ltd.

short selling constraint because all UK unit trust managers are prohibited from undertaking short sales.

The LSV measure is found to be biased toward a finding of herding as a result of its dependence on the invalid LSV assumption that all managers short sell all stocks. About one half of the herding found in stocks other than the very largest or very smallest is explained by this bias. About one third of the herding found in the smallest group of stocks, those outside the one thousand largest, is explained by the bias induced by the short selling assumption.

The accuracy tests demonstrate significant problems with the Wermers (1995) measure of herding. The likelihood of incorrect inference with the Wermers measure is severe. In each subset of the data, formed on the basis of the market capitalisation of stocks and the number of managers trading during the period, the estimated probability of the measure returning a significant level of herding on a dataset where no herding exists is 0.25 or more. When the unadjusted Wermers measure is applied to the UK dataset, approximately one half of the level of herding found is accounted for by the estimated bias of the measure.

The accuracy tests reported here are general rather than specific tests which have three potential problems. Firstly, some herding may survive the re-sampling process that is intended to replicate datasets drawn from managers which do not exhibit systematic herding. Secondly, the replicated datasets may differ in some essential characteristic from the actual dataset, so that the estimated sampling distributions are not representative of the choices of the managers under conditions of no herding. Finally, some error is introduced because the number of re-sampled datasets is finite. As discussed in chapter 4, the accuracy tests are designed to mitigate these problems; nonetheless, they must be born in mind when considering the results of the tests.

When the LSV and Wermers herding measures are suitably adjusted for their estimated mis-calibration on the UK dataset, a significant degree of herding remains. For example, where 20 managers trade a stock in a particular period the level of herding is commensurate with an average of 14 of the managers buying or 12 of the managers selling the stock.[5] The results from both the adjusted LSV and adjusted Wermers measures reveal that herding is increasing in the size of the stock and the number of managers trading; as predicted by herding theory. A large amount of herding is found among stocks with the smallest market capitalisation and most of that herding appears as herding in buying of stocks rather than herding in selling of stocks.

The herding essay tests the accuracy of the existing measures of herding and seeks to adjust them for demonstrated mis-calibration. Ideally, the essay would propose an improved measure of herding. However, in the finance literature herding is not a precisely defined concept; which is a problem that is addressed in the essay. Rather than propose another measure that seeks to catch all forms of herding, future herding research should identify predictions of the principal theoretical explanations of herding, and separate and test them. The objective of those tests being to illuminate the causes of the herding and separate the competing theoretical explanations of the existence of herding.

Other herding research might test for a link between herding and serial correlation in stock returns. There is evidence in the empirical herding literature that fund managers herding into stocks cause the price of the stocks to rise. It is conceivable that a large increase in the price of a stock causes institutional investors to herd into that stock, as a result of asymmetric dynamic hedging by fund managers. If a rise in a stock price causes herding which in turn causes a rise in the stock price, then a causal link between herding and stock price momentum will have been established.

1.4 Hiring and firing

The relationship between a fund manager's portfolio performance and the flow of funds to that manager, which is central to understanding fund manager incentives, has been illuminated by recent empirical studies. Those studies take the macro approach of modelling the effect of portfolio performance, and other variables, on

[5] The asymmetry exists because there are more occurrences of manager buys than manager sells in the dataset, as a result of the positive flow of funds to UK unit trusts during the dataset period.

aggregate fund flows. In contrast, at a micro level the flow of funds to and from managers is determined by the decisions of individual investors. Those individual agent level decisions, on which new managers to hire and which existing managers to retain, in aggregate determine the flow of funds in the investment management industry.

It is surprising then that the finance literature is so silent on how investors rationally decide which managers to hire or when to fire a poor performing manager. There is an extensive principal-agent literature which analyses the nature of optimal contracts between investors and fund managers. But those studies seek to design optimal contracts rather than model the investor's decision problem.

The third essay (chapters 5 and 6) models the fund manager hiring and firing decisions of individual investors, with three primary objectives. Firstly, to model at the decision-theoretic level the relationship between fund manager portfolio performance and investor hiring and firing decisions. Such a model may provide a deeper understanding of how investors rank fund managers and how that ranking is related to the moments of fund managers' portfolio performance distributions. Secondly, to better understand the downside of the incentive schedule faced by fund managers. Empirical studies of mutual funds find that fund managers face tournament-like incentive schedules where the new money goes to managers with recent high performance but other managers may have relatively poor performance and still retain the bulk of funds under management. The retention of poor performing managers seems to go beyond what can be explained by transaction cost or tax realisation explanations.

The model of investor hiring and firing decisions proceeds from two basic precepts. The first is that investors view each manager within a universe of managers as a separate project. The period by period portfolio return that a manager achieves, in excess of the benchmark return, is the payoff to the project of choosing that manager. There is a fixed per pound cost of initially choosing any manager or changing managers (projects). Investors are assumed to simply choose the manager with the highest initial value and then change managers when the value of the best alternative manager exceeds the value of the current manager by more than the cost of changing managers. Investment in the benchmark portfolio is a project which returns zero excess return in every period. Therefore, the benchmark is a natural reference project with zero value and active management is only chosen if it is a positive net present value project.

The second basic precept is that investors have initial information on the moments of the excess return distribution of the managers, upon which they base the choice of manager. As the portfolio returns of the chosen manager are revealed over time they are combined with the prior information and the perceived value of the manager (project) is updated. If performance is a significant factor in determining whether to retain the manager, the investor's decision is naturally a Bayesian decision problem. Naturally, because it is hard to imagine how investors could rationally choose between active portfolio managers without some initial information on excess return moments.

The Bayesian decision model is developed in a gamma-normal framework. The excess return distributions of managers are assumed to be normal with unknown mean and precision. The investor has a gamma-normal prior distribution over the unknown parameters of the normally distributed excess return. It is shown that the value of each manager (project) is the solution of a dynamic programming problem.

The investor's decision is then modelled in two periods. N periods after the initial choice of the manager, the investor is two periods from the investment horizon. At that point the investor must decide whether to retain the manager or alternatively choose another manager at cost K, whilst realising that the same decision must be made one period from the horizon. A closed form solution for the value of the existing manager (project) is found. The value function is decomposed into four parts that have clear and intuitive meaning. An important, separable component of the value function is the option to decide whether to retain or change the manager after the next period's excess return information is received. The option to decide whether to change managers (projects) next period, after some uncertainty over the manager's ability has been resolved, has positive value which is formulated in the two period model.

Several propositions are then presented which represent the contribution of the model. It is shown that the value of the embedded real option to delay the decision on changing managers partially explains why some investors hold on to poor performing managers for so long. Next, the relation between the posterior precision of the expected excess return and the option value is analysed. It is shown that this relation partially explains the empirical observation that after controlling for size and performance, more new money flows to managers with shorter investment records.

The model is then used to characterise the priors of investors who choose active management over passive management. A further contribution of the essay is to move discussion of the choice of fund managers beyond the notion that '100 quarters of data are required to be 95 percent certain that a manager has positive excess return.' The model demonstrates that in hiring and firing decisions the degree of certainty that a manager can 'beat the index' is determined endogenously. Finally, a number of comparative statics results are presented.

A simulation study of the comparative static results from the two period model is then presented for an investor who has a 10 period investment horizon. The real option effects are shown to be of a magnitude that is significant economically.

1.5 Overview of the funds management industry

1.5.1 Delegation of portfolio management

Investors have many good reasons for delegating management of their investment portfolios to professional portfolio managers. By pooling their funds, investors can share the fixed costs of trading assets and administering their portfolios, and reduce the marginal costs of transaction and administration by employing specialised labour and capital.[6] Moreover, certain financial assets are traded in units of such high value

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[6] Some investors may choose to delegate portfolio management because by pooling with other investors they can share the cost of entering and exiting the market with those other investors. In funds that have no explicit entry or exit costs, investors who seek to 'time' their entry and exit from the market can unload some of their transaction costs onto the fund's other investors who trade less often.

or require such trading expertise that ordinary investors are forced to pool funds and delegate management if they wish to invest in those asset classes. Real estate investment trusts, bond funds and country funds are examples of both unit size and requisite trading expertise.

Investors may also delegate management for reasons that are not closely related to investment management. Financial service companies induce investors to delegate their portfolio management by bundling that service with other financial products, such as insurance, chequeing facilities, cash withdrawal or other consumer transaction services. In addition, the tax code in both the US and the UK confers tax advantages on investment in certain qualifying funds.[7] In both countries the accrued pension fund assets of many employees are placed with pension fund managers as a matter of course.

Investors may also choose to delegate portfolio management because they believe that their chosen manager has private information which will generate a superior portfolio return. There are a multitude of studies of the investment performance of fund managers. Whilst the results are somewhat mixed, the preponderance of studies conclude that portfolios managed by institutional investors do not earn higher risk adjusted returns, after expenses, than benchmark portfolios that replicate the return of the market portfolio. Unfortunately, we are still unsure whether fund managers 'add value' because none of these studies has comprehensively demonstrated that their performance measure returns zero in the absence of fund manager trading based upon private information.

However, in terms of returns relative to the market portfolio, performance measurement is a zero sum game and some aggregate conclusions can be drawn from the simple arithmetic of the market.[8] Say that institutional investors as a group outperform the market portfolio after adjustment for risk and expenses. Then the

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[7] For instance 401(k) pension plans and Individual Retirement Accounts (IRAs) in the US, and Personal Equity Plans (PEPs) and personal pensions in the UK.

[8] See Wylie (1997) for a discussion of the measurement of fund manager performance and further references.

return to the group of non-institutional (private) investors must fall short of the market portfolio return by: the amount of the fund manager out-performance; plus all trading execution costs of active managers and private investors; plus the expenses of all the actively managed portfolios. The higher the proportion of the market's value which is managed by active managers, the more profound is this effect.

This simple idea helps to explain why some investors choose to pay the higher fees of active management in markets where low fee, market replicating funds are available. Investors who choose active portfolio management over passive portfolio management must believe at least one of three things. Either, that the market exhibits semi–strong informational inefficiency and the average fund manager out-performs the market portfolio after risk and expense adjustment.[9] Or, that the market exhibits strong informational inefficiency where only some managers can form private information sets and the investor can at least partially identify that subset of managers. Or, that there is a dynamic interaction between private investors and institutional investors; such as, provision of dynamic insurance between the groups, which supports an efficient market equilibrium in which the two groups have different average risk adjusted returns.

For many asset classes, the choice of active over passive management does not arise because there are no passively managed portfolios that track the market return. Moreover, for many investors the principal service of investment managers is the informed allocation of funds to different asset classes which is by definition an active exercise. Nonetheless, it remains a mystery why more money is delegated to active rather than passive management in the UK and US equity markets.

1.5.2 Investment vehicles and investment products

The different types of investment vehicles available to investors reflect the different purposes of those investments. Unit trusts and their US analogue mutual funds are designed to pool the capital of small investors, such as households and small self administered pension funds. Unit trusts and mutual funds are also known as open-ended funds because the managers of the fund, with the agreement of the Trustees,

[9] Where the average of fund manager performance is weighted by portfolio size.

can issue new units and redeem units to meet the demand of investors. In this way cash flows into and out of mutual funds but the change in the price of units simply reflects the change in market value of the underlying assets. The market value of the trust's assets, divided by the number of units on issue, plus brokerage costs, gives the price at which units can be redeemed. The price at which units can be purchased is the redemption price, plus stamp duty, plus the entry fee. In contrast, closed-end trusts, also known as investment trusts, are listed on stock exchanges and the shares are traded as with ordinary stocks.

Many investors work for companies that offer or mandate an employee pension plan. The defining characteristic of corporate pension plans is whether the plan defines a benefit that is a percentage of final salary, to be paid to the employee on an ongoing basis upon retirement; or alternatively, defines a contribution that is a percentage of the employee's current salary and is paid into the employee's retirement savings account. Management of large defined benefit funds are typically delegated to institutional investors who manage the fund as a separate (segregated) portfolio. The fund may be divided among several institutional investors who specialise in different investment approaches or asset classes. Institutional investors manage pension money for multiple corporate clients. Smaller defined benefit plans generally delegate the management of their pension assets to managers who pool the plan with other small plans to achieve the administrative savings discussed previously. The pooled fund will typically invest in unit trusts offered by the same investment management firms.

Companies offering or mandating defined contribution pension plans usually invite a small number of investment management firms to offer their unit trusts to the employees as the pension investment vehicle. The firm then pays the defined contribution into the unit trusts chosen by the employee. In the US this type of pension investing, in 401(k) plans, is partially responsible for the massive expansion of the volume of money invested in mutual funds. In the UK and US many individuals who are not part of corporate pension plans have private pension plans which again are usually invested in unit trusts and receive special tax treatment.

This thesis is concerned with the decisions of investors and fund managers. Unless otherwise specified *investors* refers to private individuals, who are saving for future consumption, and corporations which are providing pension plans for employees. Unless otherwise specified, *fund manager* or *institutional investor* or *investment management firm* refers to the principal to whom private individuals and corporations delegate their savings and pension assets respectively. There are, nonetheless, a number of other organisations in which portfolios are managed. Insurance firms have very large portfolios of financial assets and managing those portfolios professionally is one of the core competencies of insurance firms. However, households and corporations do not usually choose between insurance products on the basis of portfolio performance – if they do it is because of bundling of insurance and investment products.[10] Consequently, the management of portfolios in insurance firms does not generate the decisions that are the focus of this thesis.

Hedge funds provide specialist and highly active management of funds, which is essentially a private service to wealthy individuals. They are usually very active in terms of volume of assets traded and may take highly leveraged, high risk positions to maximise the return to private information or arbitrage opportunities identified by the hedge fund manager. Unlike unit trust or pension fund managers, the contracts of hedge fund managers' with investors contain explicit performance related components. Master limited partnerships are US based investment vehicles which confer preferential tax treatment on up to 499 partners in a portfolio. The General Partner is essentially the manager of the assets and receives incentive based fees for that service. Master limited partnerships mostly invest in high risk portfolios of private equity, such as, leverage buy out stakes and venture capital positions. Whilst of interest in terms of manager incentives and investor decisions, hedge funds and master limited partnerships operate essentially in a private market and are not a large part of overall delegated portfolio management.

There are now a huge number of fund managers vying for the funds of investors. Between 1985 and 1995 the number of US mutual fund investment management firms increased from 252 to 558 and the number of funds increased from 1528 to

[10] The portfolio performance of insurance fund managers is not readily available to households.

5761.[11] That compares to 2907 companies listed on the New York Stock Exchange (NYSE) at the end of 1996.[12] Corporate pension plan trustees also face a large field of institutional investors eager to manage their money.

From an investor's perspective fund managers are differentiated by several characteristics. Firstly, the asset class in which the manager invests. Investors can choose unit trusts or pension managers that invest in equities, bonds, real estate or commodities in most every major market or region of the world. Within these asset classes fund managers are further differentiated by the investment style of their portfolio. These styles are numerous, loosely defined and overlap considerably. They include growth, aggressive growth, value, general, high market capitalisation, small market capitalisation, contrarian, recovery, special situations and many others. Funds are also classified by their investment objective which may include the degree of income versus capital growth that is sought, or the balance between equities, bonds and other asset classes. Other funds are simply defined by the industry sector in which they invest, such as, high tech or health care.

The terms investor and fund manager do not nearly describe all the roles fulfilled within the unit trust and pension fund industries. The diversity of roles and the depth of agency within the investment industry is best illustrated by example. Take, for instance, the decision path in a defined benefit pension fund. The company makes monthly contributions to fund the corporate pension plan. The trustee board is required to represent the interests of the beneficiaries of the fund, who are current and previous employees of the firm. The trustee board chooses an investment management firm to manage the pension fund. Therefore, the trustee board is the agent of the beneficiaries and the principal of the investment management firm. Within the investment management firm an employee is assigned the role of portfolio manager. So the investment management firm is the agent of the trustee board and principal of the employee fund manager. Of course, the portfolio manager then chooses financial assets, which are issued by companies and institutions which themselves have management who ultimately choose real projects in which to invest

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[11] Mutual Fund Fact Book 1996.

[12] NYSE Fact Book 1996.

the pension money. Between the trustee board and the investment management firm stand consultants who advise trustee boards on the choice of investment management firms. Further, the portfolio return is independently measured and reported by a performance measurement agency.

These relationships are mirrored in the unit trust industry. Many investors employ independent financial advisors to assist with, among other things, the choice of unit trust. The chosen investment management firm determines which of its employees manages that trust. Independent measurement agencies report the performance of the unit trust. The investment management industry is characterised by a series of choices: investors choosing investment management firms, who choose portfolio managers, who choose financial assets. In this context it is natural to study the industry in terms of decisions and incentives.

1.5.3 How portfolios are managed

Active portfolio managers can add value in three ways: by asset allocation; market timing; or stock selection. Asset allocation is a decision that no investor can avoid. However, many investors delegate this decision to a fund manager, as is the case with many UK pension funds or investors that choose ‘balanced’ unit trusts. Or the investor makes an allocation of funds between asset classes and then chooses one or more specialist managers in each class, as do many US pension plans. Within an investment class an investment manager can add value by timing the market. This involves holding less cash and increasing the portfolio’s exposure to market risk when the manager believes the market return in the next period will be above its long run average, and the converse when the market return is expected to be historically low. Market timers are concerned with factors that affect the market as a whole. Stock selectors, in contrast, seek to identify individual assets or sectors of the market that will exhibit returns in the next period that exceed the return commensurate with their exposure to priced risk factors.[13] In this case the manager is searching for information that is idiosyncratic to the stock or sector.

An optimal asset allocation is an investor specific exercise. It depends upon, firstly, the relationship between the investor's expected utility of wealth (or firm value) and the moments of the portfolio return distribution. Secondly, upon the investor's time discount rate and the loss function associated with being unable to meet anticipated consumption requirements (or firm liabilities) in the future. Asset allocation is essentially the solution of an investor specific dynamic optimal control problem. Market timing is also an essentially quantitative problem. The manager must model a relation between measurable economic variables and the market return, to obtain an expected market return for the next period which is conditioned on those variables.

Stock selection can also be purely quantitative. Managers taking this approach must have (or give the impression of having) either new quantitative techniques or a proprietary dataset in order to delineate themselves from other managers and sustain a competitive advantage. However, most stock selecting managers undertake 'fundamental' analysis to arrive at estimates of the future returns on individual stocks. The inputs to this analysis are publicly available information and semi-private information derived from private briefings, company visits and the like. Another conceivable approach to asset management is to ignore information on specific assets or economic variables and instead act strategically in the asset management 'game' by trading only on the basis of an understanding of the position and behaviour of other institutional and private investors. However, this approach is not common.

The 1996 Fund Management Survey of the UK Institutional Fund Managers Association, reports that 77 of its 79 members managed a total of over £1,500

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[13] Managers are also looking for stocks that will *under-perform*. But managers can only directly benefit from that information if they already hold the stock or the fund's trust deed allows them to hold derivative securities or short positions.

billion.[14] These funds are heavily concentrated in the largest investment management firms: the top quartile manages 66 percent of the funds and the bottom quartile manages 4 percent. The investment management firms manage £423 billion on behalf of UK corporate pension clients and £103 billion in unit trust funds. The ownership structure of the investment management firms is quite diverse. Most of the largest investment management firms are the investment management arms of other financial services companies such as investment banks, commercial banks and insurance companies. Others are separately listed or privately owned companies.

Investment management firms are the employers of portfolio managers. On average the investment management firms of the IFMA survey employed 62 investment staff; a category which includes analysts, portfolio managers and trading desk staff. The investment management firms managed an average of 48 separate pension fund portfolios and 18 unit trust portfolios each. Pension fund portfolios averaged £114 million and unit trust portfolios £50 million.

1.5.4 A comparison of the UK and US investment management industries

The investment management industries in the two countries are similar in most respects, so it is easier to describe their differences. Both the UK and the US have large corporate pension fund sectors. In both countries there is a trend for corporations to wind up their defined benefit plans, or more commonly close them to new members, in favour of defined contribution plans. This trend is more advanced in the US where nearly one half of pension funds by investment volume are in defined contribution plans. UK pension funds are more heavily invested in equities and have a greater proportion of the fund invested in foreign assets.

In the US, the accrued pension benefits of beneficiaries are guaranteed up to a limit set by a Federal Government agency called the Pension Benefits Guarantee Corporation (PBGC). There is no analogue to the PBGC in the UK. This may

[14] (Wylie 1996b) The author advised on the construction of the survey, compiled and analysed the data and wrote the report in its entirety. The IFMA survey was sent to the 79 members of the IFMA which constituted the largest investment management firms based in London in March 1996.

partially explain the profound asset allocation herding of UK pension funds.[15] US pension funds are highly varied in their asset allocation. Another stark difference in pension fund management in the two countries is that many UK trustee boards choose a single investment management firm which makes asset allocation decisions within constraints and manages the fund as a single portfolio. US corporations, in contrast, almost always make their own asset allocation choices and then choose one or more managers for each asset class and perhaps even one manager for each desired investment style within an asset class. US pension fund management is correspondingly more specialised and management is less concentrated than in the UK where five investment management firms manage over one half of all pension fund assets.

The most striking difference between the unit trust industry in the UK and the mutual fund industry in the US is scale. In 1996, US mutual funds managed $1,346 billion of equities listed on the NYSE, whereas UK unit trusts in total managed less than one eighth of that figure. The difference is partially explained by the larger role of defined contribution plans in the US which use mutual funds as their investment vehicles. Another striking difference is the near absence of actively managed UK unit trusts that charge no entry fee or exit fee. In the US approximately one half of all domestic equity funds are no load. Whereas few UK domestic equity unit trusts charge an entry fee of less than 4 percent. Finally, index funds – funds that replicate market portfolio weights or track the market return – form a larger proportion by volume of US managed funds.

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[15] The WM Company's 1995 study of asset allocation herding found that among UK pension plans managed as single balanced portfolios, the interquartile range of portfolio weights allocated to UK equities was only 4 percent. This herding is not just a curiosity. Defined benefit pension fund assets amount to over one half of UK GDP. Asset allocation herding may serve the interests of: investment managers, through mitigation of the risk of comparative performance evaluation; company security holders, through reduced risks that a company will face contribution increases which competitors do not face; and beneficiaries because if many funds become insolvent simultaneously the UK Government may be forced to act in the beneficiaries' favour which represents an implicit guarantee. However, from the point of view of the nation, asset allocation herding looks rather like putting too many eggs in one basket.

1.6 Market efficiency assumptions

As discussed previously, the choice of active management by some investors appears to indicate that those investors believe that the market is sufficiently inefficient that fund managers can earn risk adjusted returns that exceed the management fees and expenses. Grossman and Stiglitz (1980) formulate the intuitive notion that as a market approaches efficiency, the magnitude of the force moving it toward efficiency approaches zero. Hence a perfectly efficient market even in the weak form is never attained. Fama (1991) argues that the interesting question is not whether the market is perfectly efficient but rather how close to efficiency it is. However, none of the research presented in this thesis is directed toward determining the degree of efficiency of financial markets.

In the following chapters it is nowhere assumed that financial markets deviate substantially from efficiency. At several points it is argued or assumed that the actions of some agents are consistent with *those* agents believing that the equity market is substantially inefficient. It is reasonable when studying outcomes in the market to make assumptions about the beliefs of agents that are consistent with their behaviour even if there is no objective reason to believe that those beliefs are correct.

This approach is consistent with the view of optimal contracting taken here. The thesis is not concerned with the question of whether investors are acting sub-optimally, by ignoring the recommendations of the optimal contracting literature and entering into contracts which have no explicit performance related components. It is simply taken as an empirical fact that pension fund and unit trust contracts do not typically contain these provisions and no further consideration is given to the matter because it is not the focus of the research. Likewise, the thesis attempts to explain decisions of investors and fund managers, in optimisation frameworks in which their beliefs about market efficiency are taken as given.

1.7 The remainder of the thesis

The remainder of the thesis is set out as follows.

Chapter 2 contains the first essay on financial markets and the rise of delegated portfolio management. This chapter: documents the rise of delegated portfolio management in the UK and US; reviews the empirical literature on fund manager incentives; contrasts the optimisation problems faced by private and institutional investors; and presents conjectures on the relationship between differences in private investor and institutional investor incentives and unexplained equity market phenomena.

Chapter 3 contains the first part of the second essay which studies the accuracy of measures of herding. The theoretical and empirical herding literature is first reviewed. Then the nature of herding theories and herding measures is analysed.

Chapter 4 presents the dataset employed in the study of herding and discusses the strengths and weaknesses of the data. The methodology of the accuracy tests is discussed. The herding measures are applied to a UK portfolio holdings dataset. Finally, the results of the accuracy tests are presented and discussed at length.

Chapter 5 contains the first part of the third essay which studies the hiring and firing of pension fund managers. To begin, a detailed discussion of the UK pension fund industry is presented.

Chapter 6 presents the model of investors hiring and firing decisions. The model is developed as a dynamic programming problem. Then a two period model is developed and a closed form solution attained. Propositions which summarise the significant results of the model are presented. Finally, results of a simulation study of the comparative statics results are presented for an investor who has an investment horizon of 10 years.

Chapter 7 summarises the contribution and meaning of the thesis. It concludes with a discussion of studies that follow from the research presented here.

Chapter 2 Financial Markets and the Rise of Delegated Portfolio Management

2.1 Introduction

In several branches of finance it is assumed that investors can be differentiated in some fundamental way. For example, many models assume that there are informed and uninformed traders in the market. Other studies assume that investors differ by their investment horizons, tax status, location, trading costs, risk preferences or endowments. It is accepted that the portfolio choices of investors, and hence the dynamic market equilibrium, reflect this diversity.

However, there are few studies of the market equilibrium which recognise that two investors can hold the same stock, in the same weight in their respective portfolios, and yet face radically different relationships between price changes in the stock and their end of period wealth.[16] Nonetheless, there is now a body of empirical studies which, in totality, demonstrate that the portfolio pay-offs to private investors and institutional investors differ in this way. Cohen (1998) directly addresses the question of differences in the incentives faced by private and institutional investors. He uses the US Federal Reserve *Federal Flow of Funds* data to examine the aggregate holdings of US equities by private investors and institutional investors and how they relate through time. The main finding is that institutional investors reduce their holdings of US equities and private investors correspondingly increase their holdings after rises in the market.

The difference in the incentives of private and institutional investors might have little impact on market outcomes if not for two facts. Firstly, because they face different state contingent pay-offs, private and institutional investors can be expected, all other things equal, to choose different portfolios and have different hedging demands. Consequently, every time a private investor delegates the management of a portfolio to an institutional investor the market equilibrium is altered.

Secondly, neither group has an insignificant role in the market. Since the mid 1960s, financial markets in the UK and US have witnessed a massive transit of the control of portfolios of financial assets from households to investment management firms. The purpose of this essay is to argue that the transfer of the control of portfolios of equities represents a significant structural change in the markets for those securities because of the fundamental differences in the incentives faced by private investors and institutional investors. Moreover, this diversity in the incentives faced by portfolio decision makers may be the key to understanding certain aspects of the dynamic market equilibrium.

The tables and figures at the end of this chapter illustrate the rise of delegated management of equity portfolios in the UK and US. The purpose is to collate data that documents the transition of control of equities in the UK and US; then to review what is known about the differences in incentives faced by institutional and private investors and then discuss why those differences should be expected to impact equity market equilibrium. The data does not explain why so many households have chosen to delegate management of all or part of their investment in equities. Nor does the data show whether the forces driving this transfer are the same in the UK and the US. Those questions are obviously of interest in their own right but are not central to the questions of this chapter.

In this context, a prime motivation for studying the history of the transfer of control of equities, even without studying the cause of that transfer, is to do with the effect of the rise of delegated portfolio management on long term studies of the equity market equilibrium. If the level of ownership of equities by institutional investors versus private investors significantly affects the market equilibrium, then tests of equity market equilibrium phenomena that do not account for the changing level of ownership may be mis-specified.

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[16] Brennan (1993) addresses the differences in the incentives faced by fund managers and private investors in a general equilibrium framework similar to that of the CAPM.

2.2 The rise of delegated portfolio management

In this section a series of tables and charts illustrate the rise of delegated portfolio management to a prominent position in the financial markets of the US and UK. For ease of exposition, all tables and figures referred to in the text are presented at the end of this chapter.

2.2.1 The UK experience

Table 2.1 and figure 2.3 show the level of UK financial assets held by various types of financial intermediaries in the UK economy. Those intermediaries can be grouped into three principal sectors. *Investment management* encompasses pension funds, unit trusts and insurance companies. The *banking sector* comprehends UK banks and building societies. *Other sectors* are the household sector and the foreign sector.

Since 1967 the assets of financial intermediaries in the UK have expanded a great deal. Table 2.2 and the corresponding figure 2.4 show the level of financial assets of UK financial sectors since 1967 as percentages of UK GDP. The investment management sector has grown from 47 percent of GDP in 1967 to 202 percent at the end of 1997. The annualised geometric mean growth rate of the investment management sector in the period 1969 to 1997 was 15.7 percent versus 10.6 percent for nominal GDP.

Assets in the banking sector have grown at a marginally faster rate than those in the investment management sector. They grew from 64 percent of GDP at the end of 1967 to 264 percent in 1997 at an annualised rate of 15.8 percent. The assets of the banking sector include non-sterling denominated assets, and likewise for bank sector liabilities. These figures record the growth of London as a centre for international banking in the period.

The total market capitalisation of listed UK equities grew at 15.4 percent per annum in the period 1967 to 1997. Table 2.3 shows the level of UK equity holdings in the investment management, foreign and household sectors in the period 1967 to 1997. The equity holdings of the investment management sector grew at 17.6 percent per annum versus a growth rate of only 11.8 percent for the UK equity holdings of the UK household sector in the period December 1975 to December 1997.

Table 2.4 shows that if the UK equity holdings of the investment management, foreign and household sectors are summed, then the proportion of that sum held by the household sector fell from 49 percent at the end of 1979 to 20 percent in 1997. The corresponding figures for the investment management sector are a rise from 41 to 57 percent.[17] The proportion of equities in pension funds rose from 23 to 27 percent from 1979 to 1997. The corresponding figures for unit trusts are 4 percent to 7 percent, and for insurance companies (long term funds) the rise is from 14 percent to 23 percent. Figure 2.5 illustrates the changing proportions of UK equities held by the components of the investment management sector and the foreign and household sectors.[18]

Table 2.5 and figure 2.6 show the UK equity holdings of UK financial sectors as a percentage of their total financial assets. UK pension funds have not much changed

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[17] Ideally the changes in the relative equity holdings of institutional versus private investors would be illustrated in terms of the percentage of the market capitalisation of the UK equity market held by each group over time, as is done when describing the rise of delegated portfolio management in the US in the next section. However, because of double counting in the Office for National Statistics equity levels series, the sum of equity holdings of the investment management, foreign and household sectors exceeds the total market capitalisation of UK listed equities in several years between 1967 and 1997. There is no straight forward way of undoing the double counting.

[18] The investment management sector as defined here includes insurance companies. As shown in table 2.3 insurance companies, long term funds in particular, in aggregate hold a large portion of the UK equity market. Equity portfolio management is a core competency for many insurance companies. Insurance companies are included in the investment management sector because a large part of the equities managed by insurance companies are part of the assets of pooled pension schemes managed by insurance companies or personal pension products. Other equity portfolios of insurance companies principally support the savings function of products that bundle savings and insurance services. The pension and savings related equity portfolios of insurance companies are substitutes for portfolio management that households could otherwise undertake on their own behalf without any delegation of portfolio management, which is the central interest of this section. However, it should be noted that a part of the equity holdings of insurance companies relates to risk sharing rather than savings and those equity holdings do not represent portfolios that individual households could manage on their own behalf.

the allocation of their assets to UK equities over the period of interest. In 1968 their allocation was 52 percent and at year end 1997 it was 52 percent. The increase in the proportion of equities held by pension funds reflects their increase in total assets managed rather than asset allocation change. In contrast insurance companies have increased the percentage of their assets held in UK equities from 17 percent in 1967 to 42 percent in 1997. The increased allocation of insurance companies is consistent with their increased role as managers of pooled pension funds and products for personal pensions.

Table 2.6 shows the net acquisition of UK equity holdings of UK financial sectors on an annual basis from 1966 to 1997. Figure 2.7 presents the annual net flow of equities, averaged over eight year periods, to UK financial sectors as a percentage of the total year end market capitalisation of listed UK equities. Households have been net sellers of equities in all but three years in the period 1966 to 1997. Figure 2.7 highlights the massive flow of equities to pension funds from the mid 1960s through to the late 1980s. In the periods 1966-73, 1974-81 and 1982-89 the annual net purchases of UK equities by pension funds as a percentage of end of year total UK equity market value was 1.5 percent, 3.1 percent and 1.8 percent respectively. The flow equities to insurance companies has been on a smaller scale but more consistent in time, averaging between 0.9 and 1.0 percent of total market value per annum over the periods 1974-81, 1982-89 and 1990-1997.

Flows to unit trusts have been consistent and positive in each period but at a lower level than pension funds and insurance companies. Nonetheless, unit trust holdings have grown at 17.3 percent per annum from a low base. Table 2.7 records the number of unit trust holdings of households, pension funds and other investors. The number of holdings increased by 80 percent from 5 million to 9 million in the four years from year end 1993.

2.2.2 The US experience

Table 2.8, and its corresponding figure 2.8, show the financial asset levels of the various US financial sectors at year end in the period 1967 to end of year 1998. These sectors are a subset of the financial sectors defined in the US Federal Reserve's *Flow of Funds* publication. They are the sectors which hold a large volume of financial assets; other than, households, non-profit organisations, and federal government agencies. For the purpose of this section the sectors can be grouped as follows. Pension funds of both public and private organisations, plus mutual funds and money market funds, plus bank personal trusts and estates make up the *investment management sector*. Commercial banks and the savings institutions combined constitute the *bank sector*. The *insurance* and *foreign* sectors remain separate sectors. Figure 2.9 depicts the level of financial assets of the different sectors in nominal terms.

There is a degree of double counting in tables 2.8 and 2.9. At the end of 1998, private pension funds held $564 billion in mutual fund shares, $58 billion in money market funds and $31 billion in deposits with the bank sector. Insurance companies held $31 billion in mutual fund shares and $112 billion in money market fund shares. For simplicity this double counting is only considered in what follows where its effect is material to the discussion.

Between December 1969 and December 1998 the total financial assets in the sectors reported in table 2.8 grew at a geometric average rate of 11.0 percent per annum. In the same period nominal US GDP grew at 7.7 percent per annum. The 11.0 percent growth rate of financial sector assets is not simply the result of high asset returns in this period. To see this consider the following factors. The percentage growth figure is derived from holdings of assets with high and low historical returns and periods of high returns to financial assets and periods of low returns. Moreover, a 31 year period must be a significant portion of the investment horizon of many investors, meaning that funds flow out to meet the savings objectives of investors as well as flowing in.[19]

The growth of total assets masks the disparity in growth of the different financial sectors. The growth rates of the investment management sector and foreign sector, at

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[19] Poterba (1998) looks at the question of whether de-cumulation of financial assets by ‘baby they grow older and leave the workforce will lead to a reduction in asset returns. He finds little support for large scale de-cumulation in the foreseeable future.

13.3 and 15.0 percent respectively in the period 1969 to 1998, are much higher than those of the bank sector and insurance sectors at 8.2 percent and 9.9 percent.

The structural change in financial intermediation that has occurred in the US is also apparent in figure 2.9. In 1969 the combined financial assets of private pension funds, state and local government pension funds, mutual funds, money market funds and bank personal trusts and estates, amounted to only 35 percent of the GDP of the US.[20] By the end of 1998 that figure was 152 percent of GDP.[21] In contrast, the combined financial assets of commercial banks, savings and loans institutions, mutual savings banks and credit unions increased only modestly as a percentage of GDP, going from 73 percent in 1967 to 83 percent at the end of 1998. In 1969, the market value of financial assets held by the US investment management sector was less than one half that of the bank sector. At the end of 1998, assets under investment management exceeded bank sectors assets by 82 percent. This change in the ratio of value of assets controlled by investment managers versus banks represents a fundamental change in the flow of savings to productive projects and the governance and oversight of capital in the US economy.

From nominal growth rates it is difficult to assess the real magnitude of the growth of assets under institutional management. Table 2.9 shows the level of assets in the Federal Reserve defined sectors as a percentage of US gross domestic product (GDP). Figure 2.9 is a comparative depiction of the same data. It is clear from this figure that delegated portfolio management in the US (the bottom five series in figure 2.9) has grown rapidly as a proportion of GDP only since the early 1980s, and that growth has continued through 1998. The growth in assets under management

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[20] 1969 is the beginning date for this comparison because that is the year in which Federal Flow of Funds reports the assets of bank personal trusts and estates as a separate series rather than including them in the assets of the personal sector.

[21] These figures are adjusted for the double counting discussed previously in section 2.2.2.

reflects, and at the same time may have been a cause of, the high returns to US financial assets since 1980.[22]

2.2.2.1 US retirement savings

Pension reserves, which are financial claims of US households, have risen from $195 billion (23 percent of GDP) at the end of 1967 to $8,770 billion (103 percent of GDP) at the end of 1998. Those 1998 household claims are the liabilities of private pension funds ($4,355 billion), state and local government pension funds ($2,371 billion), life insurance companies ($1,401 billion) and the US Federal Government ($643 billion).[23]

Of the $3,233 billion invested in mutual funds and money market funds at the end of 1996, $334 billion was from the 401(k) plans of private pension funds (counted here as part of private pension fund assets), and a further $620 billion was invested by households in mutual funds through Individual Retirement Accounts (IRAs). The volume of funds invested under Keogh plans (for self employed persons) is tax data that is not readily available. Therefore, putting the Federal Government and insurance company liabilities to one side, the percentage of financial assets held by the investment management sector, that arise from corporate, government or household, tax preferred pension schemes, was at least 74 percent at the end of 1996.

2.2.2.2 US equity holdings by sector

Table 2.10 presents the holdings of US equities by US financial sectors, including households. Table 2.11 presents the percentage of direct ownership of the US equity market by private versus institutional owners. Figures 2.10 and 2.11 depict this data graphically. In 1969, 69 percent of the US equity market was directly held by households, 26 percent by US institutional investors and 3 percent by foreigners. By the end of 1998 those figures were 41 percent, 51 percent and 7 percent

[22] Warther (1995), Edwards and Zhang (1998) and Edelen and Warner (1999) find a strong relationship between flows to US mutual funds and returns to US financial assets.

[23] Source is the Federal Reserve *Flow of Funds*, Fourth Quarter 1998.

respectively.[24] Figure 2.10 shows that the migration of equities from household portfolios to institutional portfolios shows little sign of abating. Figure 2.11 shows the change since 1969 in the percentage of the US equity market held by the different components of the investment management sector. In particular, the figure highlights the decline in the importance of bank personal trusts and estates as equity managers and the rise of mutual funds and SLGE retirement funds.

This trend is not just the inevitable result of institutional investors having more money under management. Table 2.12 displays the US equity holdings of US financial sectors as a percentage of their total financial assets. The table shows that the increased demand of institutional management for US equities reflects three major trends. Firstly, state and local government employee funds have increased their aggregate portfolio weight in equities from just 7 percent in 1967 to 62 percent in 1998 as depicted in figure 2.12. Consequently, the percentage of the US equity market held in these funds has risen from 0.5 percent in 1967 to 10.3 percent in 1997. The asset allocation change in state and local government employee funds represents a major change in risk borne by the tax payers who ultimately insure those funds.[25]

Secondly, the percentage of the US equity market held by private pension funds increased from 6.1 percent in 1967 to 14.5 percent at the end of 1998. The increase occurred despite the fact that asset allocation to US equities of private pension funds increased only slightly over the period. Such is the scale of the increase in assets of private pension funds.

Finally, a huge volume of money has flowed into US equity mutual funds in the 1990s. In the period 1991 to 1998 the value weighting of US equities in the aggregate portfolio of US mutual funds has increased from 38 percent to 68 percent. Further, the percentage of the US equity market held by these funds has increased from 6.4 percent to 16.3 percent. In just seven years in the 1990s, an additional 10 percent of the US equity market came under the control of mutual fund managers.

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[24] Where *institutional investors* means the investment management sector plus the insurance sector.

[25] State and local government employee (SLGE) funds are not insured by the US Pension Benefits Guarantee Corporation (PBGC).

Tables 2.13 and 2.14 and the corresponding figures 2.13 and 2.14 illustrate the dynamic process by which equities have been transferred year by year from the household sector to institutional investors. Table 2.13 shows that in every year since 1977 US households have been net sellers of US equities.

Figure 2.13 captures the flows of equity ownership between the different categories of owners in five periods since 1949. For each category of stock ownership, the annual net flow of equities, as a percentage of the total capitalisation of the equity market, is averaged over 10 year periods and presented in figure 2.13. In the period 1949-58 listed corporations were the only net sellers of stocks, all other categories including households were net buyers. Listed corporations were net sellers in each 10 year period except 1979-88; a period when US corporations undertook massive share repurchase programs. In each of the four periods after 1958 households were net sellers of US equities. In the period 1979-88 the average annual sale of equities by US households was 2.8 percent of the end of year total market capitalisation of US listed equities.[26]

Table 2.13 shows the transit of equities from household portfolios to mutual funds accelerating through the 1990s. Table 2.14 however, shows that the reduction in exposure of US households to US equity market risk is in part offset by the ownership of US mutual funds by US households. In 1996 direct purchases of US equities by US households was -$281 billion but after accounting for household ownership of mutual funds the reduction was only -$67 billion.

The flow of money to US mutual funds accelerated through the 1990s to 1997. Table 2.15 and the accompanying figure 2.15 record the astonishing increase in the volume of funds managed by US mutual funds and the number of mutual fund

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[26] Figures 2.10 and 2.13 taken together pose an interesting question. The percentage of US listed equities, by market capitalisation, owned by US households was 58.2 percent at year end 1979 falling to 40.7 percent at the end of 1998. In the first 10 years of that period households were net sellers of 2.8 percent of the market to other parties. In the next 10 years the figure averages to 1.9 percent. This result is made possible in part by the volume of IPOs in this period. In an IPO, an entrepreneur may be counted as a household which is selling a newly listed equity. The part of the IPO retained by the entrepreneur increases the recorded equity ownership of households.

accounts. US households had 119 million mutual fund accounts (nearly one for each of the 126 million full time workers in the US labour force) and 32 million money market fund accounts at the end of 1997.

There is no readily available breakdown of foreign investment in US financial assets into investments of foreign private investors and foreign institutional investment. However, given the large fixed cost associated with active overseas investment it is reasonable to assume that a high percentage of foreign held US financial assets are controlled by foreign institutional investors. In fact, because of the now substantial position of foreign investors in US financial assets, the proportion of the US financial markets controlled by institutional investors may be understated here.

2.2.3 Implications of UK and US data

The UK and US data suggest that the observed large scale delegation of the management of equities portfolios is driven by some aspect of saving for retirement. In both countries the growth of portfolios managed for the provision of retirement income is a large part of the total growth of institutional equity portfolios.

A natural question is why private investors have chosen to save for retirement income through institutionally managed portfolios rather than just manage their own portfolio. Asymmetric information, taxes, transactions costs and administrative costs explain much of the demand for financial intermediation in general and each of those factors may be important here. It may be possible to estimate the relative effects of changes in information asymmetry, the tax code and costs on the transfer of the control of equity portfolios. Although, identifying and separating changes in information asymmetry and transactions cost, and establishing their causality in relation to the volume of institutional management of equities would be difficult. The question of why investors choose to delegate portfolio management is intrinsically interesting but not central to the question addressed in this essay; which is, how has the equity market equilibrium been affected by the transfer of control of equities from private investors to institutional investors?

The UK and the US data discussed above shows that since 1967 there has been a substantial transfer of control of equities from private investors to institutional investors in both the UK and the US. Figure 2.16 shows the ratio of household sector domestic equity holdings to institutional domestic equity holdings in both the UK and the US from 1975 to 1996. At the beginning of that period the UK ratio was 1.55 and the US ratio 1.66.

The UK ratio of private to institutional equity holdings fell rapidly in the next four years, principally as a result of pension fund buying of domestic equities in the UK, as depicted in figure 2.7. The UK ratio continued downward to 0.35 by year end 1997. The US ratio fell to 0.8 at the end of 1998. However, during the period year end 1985 to year end 1992 the US ratio rose from 1.10 to 1.36. It has been in steep decline since then.

Whilst the UK ratio of private to institutional domestic equity holdings was only slightly below that of the US ratio in 1975, in 1996 it was less than one half that of the US and has been little changed since 1991. The decline in the US ratio shows no sign of abating. In both 1997 and 1998 the net sales of equities by US households exceeded $500bn.

A comparison of figures 2.4 and 2.9 shows that in both the US and the UK the rapid rise of investment management assets as a percentage of GDP began in the early 1980s. The future path of the ratio of private to institutional equity holdings in the US and UK is not clear. We should anticipate that corporate and government pension plans will become more mature in their liability structure over time. In which case the net contribution to these funds will fall as beneficiary payments increase. Moreover, as the structure of their liabilities matures, pension plans can be expected to hold a greater portfolio weight in bonds and credit market instruments, to match asset income to a more precisely estimated liability stream.

2.3 A review of literature on fund manager incentives

The term *incentives* means the relationship between outcomes, over which an economic agent has some control, and the associated reward which accrues to that agent as a result of the outcome. This thesis is concerned with the difference between the incentives faced by private investors and institutional investors and the decisions and concomitant market outcomes that arise from those differences.

For private investors managing a portfolio on their own behalf, incentives are straight forward. Under reasonable assumptions, the investor can be expected to choose a portfolio that maximises the sum (integral) of discounted expected utilities over the agent's lifetime; with the maximum attained under the assumption that at all future decision points an optimal portfolio is chosen, whatever the future time or state. This dynamic programming problem is addressed in many studies, the most important of which are the Intertemporal Capital Asset Pricing Model (ICAPM) of Merton (1973) and the Consumption CAPM of Breeden (1979).

A simplifying aspect of the private investor's portfolio choice problem is the one-to-one relationship between changes in the market value of the portfolio held and changes in the investor's end of period wealth. Under reasonable assumptions about consumption or dis-saving, the value of the private investor's portfolio at any future date is an uncomplicated function of the interim total returns on the portfolio. In this sense the incentives of the private investor are very simple. Moreover, the same basic incentive structure applies whether the investor is a corporation, which seeks to maximise firm wealth, or a government authority, which seeks to minimise future tax collection.

2.3.1 Investment management fees

The incentives of fund managers are more complicated. The first component of an investment manager's incentives are the management fees received each period. Fees are related to portfolio outcomes by the explicit clauses of the investment management contract between the investor and fund manager.

2.3.1.1 Description of management fees

There are a variety of fees levied on private investors by mutual fund and pension fund managers. Virtually every contract includes a flat fee which is a percentage of the value of the portfolio managed in a period. Lakonishok, Shleifer and Vishny (1992a) studied US equity pension fund managers and found that one half of all contracts have flat fees of between 43 and 56 basis points. Halpern and Fowler

(1991) surveyed 133 of the largest state and local government schemes. They observed fees of 25 to 40 basis points for active equity management of portfolios of $250 million or more. The fees they observed were: higher for management of portfolios of international assets; lower for fixed income management (5-10 basis points); and as low as zero basis points for passive management of large US equity portfolios. They also found that managers have concave fee schedules, with lower fees for larger portfolios.

A November 1994 survey by Pensions Management Magazine, found that UK pension fund managers on average charge 21 basis points for managing funds above 200 million pounds. Fees are higher for management of smaller amounts, with an average fee of 51 basis points for management of 10 million pounds. Fees for managing overseas equity portfolios in developed markets averaged 57 basis points and for emerging markets the figure was 67 basis points. Fees for passive management of large UK equity portfolios were as low as 3 basis points.

Investors in mutual funds choose between managers who charge a variety of fees, including, management, advisory, entry, redemption, exchange and 12b-1 fees. Investment management firms may levy exchange fees when investors transfer funds between mutual fund products offered by that house. Since 1980 the US Securities Exchange Commission has allowed mutual fund managers to deduct 12b-1 fees for marketing of the fund. Kihn (1996) finds that nearly 50 percent of US mutual funds levy this annual fee and the median non-zero fee charged is 20 basis points. Further, 50 percent of US mutual funds charge a front end load (entry fee). Kihn found a median non-zero entry fee of 330 basis points. The majority of actively managed UK unit trust managers charge an entry fee of between 400 and 600 basis points.

Kihn argues that the division of the mutual fund industry into managers who charge entry fees and those who do not is explained by the higher quality service provided by mutual funds with entry fees. A more convincing explanation is provided by Chordia (1996) who argues that mutual funds provide investors with insurance against unexpected liquidity shocks. Redemptions are netted against purchases in a mutual fund. But even if assets must be sold to meet the liquidity shock, the transaction cost is shared amongst the investors. As a result, funds which have lower entry fees are forced to hold higher cash reserves to prevent buy and hold investors bearing the cost of market timers entering and leaving the market. Then, because they are not fully invested, zero load funds have lower expected returns.

2.3.1.2 Boilerplate nature of fees

Some of the most interesting aspects of empirical studies of investment management fees relate to what is not found. Since 1985 the Securities Exchange Commission has permitted investment advisors registered under the Investment Advisers Act of 1940 to charge fees which are a fraction of the capital gain of the client assets.[27] However, most institutional managers of mutual fund or pension fund money are employed on fixed fee contracts (Ippolito 1992, Lakonishok, Shleifer and Vishny 1992a, Golec 1992, Goode 1993). In a study of mutual fund contracts, Golec found that only 29 of 476 mutual fund managerial contracts contain performance based fee components. Ippolito found that of 373 funds checked in 1988 only 18 used incentive fees.

Another surprising finding is the uniformity of fees charged by fund managers. We might expect managers to vary their fees to match market demand for their service, or that managers might discriminate between investors in charging fees to capture the maximum amount of investors' economic surplus. But instead LSV (1992a) and Golec find little variation in fees levied by pension managers and mutual funds (except the entry fee).

2.3.1.3 Conclusions from studies of fees

Taken together these studies portray a mutual fund and pension fund investment management industry in which the fees charged by managers over a period (fund manager revenue), is a fixed fraction of the funds under management. Moreover, fees vary little across managers and typically do not have significant performance related components. Under these circumstances the future stream of income to managers is directly determined by the future value of funds under management at

[27] US registered mutual funds are authorised to use incentive compensation fees under section 205 of the Investment Advisers Act (1990). Compensation must rise or fall symmetrically about the benchmark. The benchmark must be a recognised market index.

each date. Therefore, if the per pound cost of management is constant or falling in the value of funds managed, then increases in fund manager wealth or firm value arise principally from flow of new funds to managers. The incentives of fund managers are thus characterised. The variables that determine the flow of funds to managers are the variables that the manager will wish to control. Important exceptions to this characterisation of the investment management industry are hedge funds (Goetzmann, Ingersoll and Ross, 1997), private banking services and private equity partnerships (Gompers and Lerner, 1997) in which incentive fees are charged.

2.3.2 The flow of money to mutual funds

2.3.2.1 The funds flow – portfolio performance relationship

Fund managers face implicit incentives, in addition to the explicit incentives of the investment management contract, because existing contracts may be terminated, or new contracts may be initiated, on the basis of portfolio outcomes. As a result of these implicit incentives the relationship between the wealth of a fund manager (or investment management firm value) at a future date, and the interim portfolio returns, *cannot* be assumed to have the same simple structure found in the private investor's problem. The empirical studies of fund manager incentives seek to model the relationship between portfolio outcomes and the flow of funds to institutional investors. That performance –flow relationship is a crucial input to understanding fund manager incentives; although, most of the performance-flow studies do not make a connection between their results and fund manager incentives. Those studies are reviewed in this section.

2.3.2.2 Early studies of the performance-flow relationship

Despite the positive flow of cash from investors to the mutual fund industry in every year since 1940, few rigorous studies of the determinants of mutual fund flows were conducted in the fifty years before 1990. A study prepared by the Wharton School in 1962 created contingency tables to determine whether the top half of the universe of funds, ranked by total return in one period, received more new money in the next period than the bottom half. The Wharton study found no evidence of performance determining the flow of money to balanced funds and only a weak relationship in equity funds. Williamson (1970) found no significant relationship between funds flow and portfolio performance in a sample of 15 funds. In contrast, Friend, Blume and Crockett (1970) found a significant positive correlation between mutual fund returns in one period and net sales of shares by the mutual fund in the next period.

The Sharpe (1964), Lintner (1965) and Treynor (1961) development of the Capital Asset Pricing Model (CAPM) promised the technology to adjust the performance of portfolios for market risk. This new technology was employed in Jensen's (1968) study of the risk adjusted performance of US equity mutual fund managers. The Jensen measure of performance is the intercept in the ordinary least squares regression of portfolio return less the risk free rate, on the market return less the risk free rate.

Surprisingly, another ten years elapsed between the development of risk adjustment techniques and their use in the study of the performance-flow relationship. Smith (1978) ranked 74 US equity mutual funds by their performance in one period and then the growth of funds managed in the next period; where portfolio performance was measured by both the Jensen measure and the Forbes annual rating of the fund. Rank correlations provided no statistically significant evidence of a positive correlation between portfolio performance in one period and growth of funds under management in the next period. Woerheide (1982) found negative parameter values in a regression of the growth rate of mutual funds on fund portfolio returns lagged up to four years. However, the portfolio returns are not adjusted for risk.

The papers discussed to this point are the first generation of funds flow – portfolio performance studies. These early studies found either no connection or only a weak connection between portfolio performance and the flow of new money to funds, which may explain the subsequent hiatus in funds flow research. With the exception of Smith (1978), the importance of these early studies is reduced by the small number of funds in the datasets and the inadequate adjustment of returns for risk.

2.3.2.3 Modern studies of the performance-flow relationship

The next generation of funds flow – performance studies began with the Zeckhauser, Patel, Hendricks (ZPH 1991) study of the growth of funds managed by 96 no load, growth mutual funds in the period 1976 to 1987. They seek to characterise and explain irrational behaviour by economic agents in financial markets, and flows to mutual funds are taken to be one manifestation of irrational behaviour. The following equation is estimated.

Equation 2.1

$$Flow_{it} = \alpha_t + \beta_1 Flow_{it-1} + \beta_2 Size_{it-1} + \beta_3 Return_{it-1} + \beta_4 Rank_{it-1} + \varepsilon_{it}$$

Where	Flow	=	the net dollar inflow after accounting for growth in existing assets
	Return	=	the total return net of expenses and fees
	Size	=	the dollar value of the fund
	Rank	=	the order of the fund in a ranking of funds by Return
	i, t	=	subscripts to represent the identity of the fund and the time period respectively.

The specification of equation 2.1 is flawed; an obvious problem is that $Flow_{it-1}$ is a function of $Return_{it-1}$. Another shortcoming is the pooling of panels of data without any provision for variation in funds flow by year. Nonetheless, some of the results are interesting. The coefficient on lagged flow, in a univariate regression, is 0.75 and is highly significant. This result, with an R^2 of 0.73, suggests that important variables are missing from equation 2.1. When both Return and Rank are included in the regression, β_3 is significantly negative and β_4 is significantly positive. If not for the model mis-specification, this result might indicate that Rank is a more important determinant of funds flows than absolute Return.

Santini and Aber (1996) find that rankings in Forbes' magazine have greater explanatory power than performance measures in predicting fund flows. In addition, they argue that due to higher advertising levels and perceptions of reliability, large funds should grow more quickly, other things equal.

The motivation for the Ippolito (1992) study of the flow of investors' money to US mutual funds is to better understand how consumers react to less-than-promised quality in a purchased product. The flows to 143 US equity mutual funds over the period 1965-1984 are studied in the following fixed effects model.

Equation 2.2

$$G_{it} = C_1 V_{i,t-1} + C_2 V_{i,t-2} + C_3 V_{i,t-3} + dF + eY + \alpha_{it}$$

Where G_{it} = The ratio of net sales to beginning of period assets for fund i in period t

$V_{i,t-1}$ = Jensen's α for fund i in period t-1

F = Dummy variable for fund specific effects

Y = Dummy variable for year specific effects.

The results show that risk adjusted portfolio returns, lagged up to three years, are significant in explaining fund flows. A fund that achieved a return of 2 percent in excess of that commensurate with market risk, over each of three years, on average grows 1.4 percent faster than a fund with a Jensen's α of zero. The finding by Ippolito that risk adjusted returns from several years before the current period are significant determinants of funds flow, differs from the findings of previous studies that only the portfolio return in the immediately previous period is significant.

Two results from Ippolito's study have a bearing on the down-side risks faced by fund managers. Firstly, Ippolito divides the data into observations for which the fund has a positive Jensen α measured over five years and those for which the fund has a negative α over five years. Then separate regressions are run on the two sets of observations. In the first dataset the coefficient on the five year alpha (measured in percent) is 0.90 and on the second group it is 0.35. The results reveal an asymmetry in the response of fund flows to positive and negative portfolio performance.

Secondly, in Ippolito's dataset 31 funds were merged with other funds over the 20 year dataset period. A logistic examination of the relation between mergers and poor performance estimates that a fund with a Jensen α of –5.0 percent, measured over five years, has a 50 percent higher probability of merger in the next year than a fund with the population average α.

Goetzmann, Greenwald and Huberman (GGH 1992) undertake the first large scale estimation of the funds flow – portfolio performance relationship, with a study of 230 ‘seasoned’ funds that survived the period 1976 to1989. The net dollar inflow in each fund, after accounting for growth of existing assets, is regressed on the total return of the fund in the current and each of the previous three years, and the dependent variable lagged by one, two and three years. GGH argue that the flow of funds should be measured as dollar growth rates, rather than a percentage of assets managed, because otherwise the results will be dominated by small fund growth rates which are either unsustainably high or omitted due to survivorship bias. A consequence of studying flows in dollar terms is that the parameters of the regression are dependent upon the total flow of money to mutual funds in a year. Therefore cross-sectional regressions cannot be pooled across years. GGH estimate an equation for each year in the dataset. They find that flows in the current period are significantly dependent upon the total return lagged by one year (but not the current year or longer lags), and the flow of funds in each of the previous three years.

Lakonishok, Shleifer and Vishny (LSV 1992a) focus on the pension fund industry. They study the relationship between the relative performance of US equity pension fund managers and the number of new pension fund management mandates captured by those managers. The dataset covers 359 investment management firms in the period 1985 to1989. For each 1 percent that the return of a manager exceeded the value weighted return to the universe of managers over the previous three years, the number of new mandates signed the next year increases by 1.3 percent.

Berkowitz and Kotowitz (1993) study the flow of money to Canadian mutual funds. They estimate the parameters in the following equation on observations of an unbalanced panel of about 40 mutual funds in the period 1977 to 1986.

Equation 2.3

$$\ln P_{it+1} = const + \beta_1 \ln P_{it} + \beta_2 R_{it} + \beta_3 R_{it-1} + \beta_3 R_{it-2} + \{Dummies\} + \varepsilon_{it}$$

Where P_{it+1} = the value of assets held by fund i at the end of period t+1

R_{it} = is the risk adjusted return of fund i in period t

Dummies = represents dummy variables for large funds, load funds, and each of the years in the dataset.

This specification reflects the benefits of using levels rather than returns, and separating out the effects of individual years, that are noted by Goetzmann, Greenwald and Huberman (1992). The results show a stronger relationship between flows and portfolio returns than previous studies. A fund that achieved a Jensen α of 2 percent in each of the previous three years would expect a net flow of new funds of 4.8 percent of the current value of the fund in the current year.

Rockinger (1995) studies the flow of money to US mutual funds in a dynamic panel data model which nests previous models of Zeckhauser, Patel and Hendricks (1991), Ippolito (1992) and Sirri and Tufano (1998). The model has the following structure.

Equation 2.4

$$g_{it} = \alpha + g_{i,t-1}\gamma + x'_{it}\beta + z'_{i}\delta + u_{it}$$

$$u_{it} = u_i + \lambda_t + \xi_J + v_{it}$$

$$v_{it} = \rho v_{it-t} + w_{it}$$

Where g_{it} = the growth rate of the assets of mutual fund i during period t attributable to net sale of fund shares

x'_{it} = factors that vary across funds and through time, including measures of the performance of the fund in previous periods

z'_{I} = variables characteristic of individual mutual funds, such as fees, expense ratio, turnover ratio

u_I = a fund specific residual effect

λ_t = time specific residual effect

ξ_J = investment style specific residual effect.

The Ippolito (1992) measure is obtained if the dynamics of the residual effect and the investment style effects are eliminated ($\rho = 0$ and $\xi_J = 0$) and x'_{it} is set to $[p_{i,t-1}, p_{i,t-2}, p_{i,t-3}]'$ where $p_{i,t-1}$ is the portfolio performance in the previous period. Rockinger shows that these restrictions introduce inconsistency in parameter estimates.

Rockinger finds that a 1 percent higher alpha (Jensen's 1968 measure) in one period, on average causes a 6.6 percent increase in the growth rate of the fund next period. This is a substantially higher sensitivity to fund performance than found in most previous studies. However, the results also show that the rank of the mutual fund within its investment objective group is the most important determinant of increased flow of money to mutual funds (Zeckhauser, Patel and Hendricks, 1991, Rockinger, 1995, Santini and Aber, 1996). Rockinger finds that larger funds, other things equal, grow less quickly, however this effect is only important for the largest funds.

2.3.2.4 Non-linear studies of the performance-flow relationship

Sirri and Tufano (1998) study 690 US equity mutual funds in the period 1971 to 1990. They find that investors base their choice of mutual fund upon historical investment performance, fees charged and services provided. However, the main contribution of their paper is to demonstrate that the relationship between funds flow and risk adjusted returns is non-linear and should be estimated as such.

Sirri and Tufano look at the performance sensitivity of fund flows for funds with recent extreme performance. The very highest performers enjoy growth rates many times those of other funds. Funds are ranked each year by portfolio return and then formed into twenty groups, with funds in group twenty having the highest returns. The growth of the funds in each group in the following year is then examined. Groups 1-18 show little variation, but group 19, and especially group 20, have huge growth (55 percent in group 20). For all other groups there is almost no relationship between performance and flow of funds. This is a powerful result which surely demonstrates that an assumption of linearity in the flow – performance relationship leads to an underestimation of the sensitivity of funds flow to portfolio performance for the highest ranked funds.

Sirri and Tufano then conduct the following piecewise linear regression to explain the flow of money to funds in the bottom 20 percent, middle 60 percent and top 20 percent by portfolio performance.

Equation 2.5

$$FLOW_{i,t} = \alpha + \beta_1 TNA_{i,t-1} + \beta_2 OBJFLOW_t + \beta_3 Rank_{i,t-1} + \gamma_1 LOWPERF_{i,t-1} + \gamma_2 MIDPERF_{i,t-1} + \gamma_3 HIGHPERF_{i,t-1} + \varepsilon_{it}$$

Where $FLOW_{i,t}$ = percentage growth of fund i in period t after accounting for growth of existing funds

$TNA_{i,t-1}$ = asset value of fund i at the end of period t-1

$OBJFLOW_t$ = aggregate flow of funds the investment management category of fund i in period t

$RANK_{i,t-1}$ = portfolio performance rank of fund i [0,1] amongst all funds in period t-1

$LOWPERF_{i,t-1}$ = Min ($Rank_{i,t-1}$, 0.2)

$MIDPERF_{i,t-1}$ = Min (0.6 , $RANK_{i,t-1} – LOWPERF_{i,t-1}$)

$HIGHPERF_{I,t-1}$ = $RANK_{i,t-1} – (LOWPERF_{i,t-1} + MIDPERF_{i,t-1})$.

Sirri and Tufano report the regression results for five different measures of return upon which the ranks are formed: total return over 1 year; total return over 3 years; excess to index return over 1 year; Jensen’s alpha over 1 year; and Jensen’s alpha over 5 years. In each of the five regressions the parameters on HIGHPERF and MIDPERF are highly significant and the parameters on LOWPERF are insignificant. The parameter values on HIGHPERF are much the largest. The parameters indicate that the flow of money to mutual funds is convex in the performance rank of the fund in the previous year. When the funds are ranked by total portfolio return over one year, then for the top 20 percent of funds a 5 percentile increase in rank leads on average to a 9 percent increase in the flow of funds in the next year. The regressions also indicate that, other things equal, smaller funds grow at a faster rate.

Chevalier and Ellison's (1997a) study of mutual fund flows seeks to estimate the functional form of the relationship between the portfolio performance of a mutual fund and the flow of investors' money to that mutual fund. Most other studies of mutual fund flows assume a linear relationship between the growth rate of funds and the explanatory variables. The exceptions being Ippolito and Sirri and Tufano who assume piecewise linear models with two and three segments respectively. With data on 839 US equity funds, Chevalier and Ellison (1997a) firstly reject a piecewise linear model and then fit the following semi-parametric model.

Equation 2.6

$$Flow_{it+1} = (1 + \Sigma_k \gamma_k\, Age\_k_{it})\, f(r_{it} - r_{mt}) + \Sigma_k \delta_k\, Age\_k_{it} + \alpha' X_{it} + \varepsilon_{it}$$

Where	$Flow_{it+1}$	=	the percentage growth in assets attributable to net purchase of shares
	Age_k_{it}	=	a dummy variable for the age of the fund
	$r_{it} - r_{mt}$	=	the excess return of the mutual fund portfolio over the market portfolio
	$f(\ )$	=	non-linear function which is to be estimated
	X_{it}	=	a vector of additional explanatory variables which includes r_{it-1}-r_{mt-1}, $r_{it-2} - r_{mt-2}$, growth in mutual fund industry assets and the log of fund size.

A three step kernel estimation process is implemented to estimate the value of α coefficients, then δ and γ coefficients, and finally the function f. The result is an estimate of a functional relationship between growth of funds managed by a fund and the excess market return in the previous year $r_{it} - r_{mt}$; whilst holding constant the excess return in previous years, the flow of funds to all mutual funds and the mutual fund size. The results indicate that the flow of new funds is a convex function in positive values of the excess return $r_{it} - r_{mt}$ and a concave function in negative values of $r_{it} - r_{mt}$. A mutual fund which: is two years old; had an excess-to-benchmark return of 10 percent this year; had zero excess returns in the past two years; and matched the geometric mean of fund sizes; would be expected to grow by 55 percent next year if the industry growth were zero. This result corroborates the finding of Sirri and Tufano that the growth of the highest ranked funds is very large.

Chevalier and Ellison also estimate a linear model of funds flow. The results show that for a two year old fund, each percent of excess return increases the growth of funds under management by 3.3 percent. This result shows that the linear model understates the sensitivity of funds flow to performance for the highest ranked funds. A curious result is that, other things equal, the flow of money to mutual funds with shorter histories is greater. This result matches a similar finding by Ippolito. A partial explanation of this phenomena is provided by the Hiring and Firing model in chapter 6.

2.3.2.5 Causality in the portfolio performance – funds flow relationship

Implicit in the results of studies of the portfolio performance – funds flow relationship that are reviewed here is the assumption that variation in portfolio performance causes variation in the volume of funds that flow to those portfolios. The relationship may be more complicated because we might expect fund managers with large cash flows to earn higher returns for several reasons. Managers with large positive cash flows can hold smaller cash balances than other managers and hence have a higher expected return for their portfolio. The new funds must be invested and hence incur transactions costs, however, in the US, a fund that is growing quickly typically has less unrealised capital gains tax which is attractive to new investors in high tax brackets.

Spitz (1970) looked at whether investors choose funds that subsequently perform well. A significant link was not established. More recently Gruber (1996) finds that new money on average earns a higher return than money already invested in mutual funds. Gruber postulates the existence of clienteles of sophisticated investors who change funds from time to time and unsophisticated investors who earn lower returns. Zheng (1999) finds that mutual fund investment strategies that follow the flow of money earn significantly positive risk adjusted excess returns.

The findings of Gruber and Zheng support to some extent the notion that the flow of funds to portfolios influences the subsequent returns of those portfolios. The findings of Sirri and Tufano (1998) and Chevalier and Ellison (1997a) regarding the flow of money to the best performed managers is so strong that it is difficult to argue that flows causing returns is the full story. However, feedback from flows to returns is plausible and appears to have some empirical support. If this feedback is substantial then all the tests reported here have endogeneity on both sides and are therefore not correctly specified tests.

2.3.2.6 Other econometric issues in funds flow studies

The studies reviewed to this point are essentially the same in that they seek to determine the relationship between the flow of money to mutual funds by the application of regression techniques to panel datasets. Econometric issues are crucial in assessing the veracity of these studies. As always, the first issue is model specification. The most obvious inadequacy of most of the studies is the assumption of a linear relationship between flows and portfolio performance.

There seems to be no reason to assume a linear relationship. Ippolito (1992), Sirri and Tufano (1998), and Chevalier and Ellison (1997a) comprehensively reject the assumption of linearity. Their combined results indicate that flow of money to mutual funds is convex in positive risk adjusted returns of the fund. In this case, linear models will overestimate the sensitivity of flows to small positive portfolio returns and underestimate the sensitivity of flows to large returns. Further, rank correlation tests, such as that by Smith (1978) have less power if the performance-flow relationship is non-linear.

Sirri and Tufano find that only the top 10 percent of funds, ranked by portfolio returns, exhibit a strong correlation between performance and growth. This finding is consistent with investors' mutual fund choices being influenced by the rank of a mutual fund versus a peer group. However, the implication is that all the 'action' is in the few funds with the highest performance in each investment category. If that is true then an estimation procedure that equally weights all observations is inappropriate. It is difficult to say why the studies do not simply include the square and cube of excess-to-benchmark returns. It may be better to guess the form of non-linearity and proceed on that basis than just assume linearity.

Another specification issue is the inclusion of fixed effects. The panels of data employed in performance-flow studies present difficult econometric problems which are glossed over for the most part. Studies that simply pool the cross-sectional fund data and do not include fund, investment management objective and year effects are not properly specified. That includes all of the studies before 1990. But there are other problems, such as, omitted variables. The omitted variables problem can be mitigated by the inclusion of lagged variables, but then there is no standard way to evaluate the significance of the lag coefficients in panel data.

It is difficult to assess the importance of survivorship bias in these studies. If the funds missing from a dataset are those that experienced low growth of assets and low returns then the estimated regression parameters will understate the magnitude of the correlation between funds flows and portfolio returns. Grinblatt and Titman (1988) find that survivorship bias in mutual fund datasets is not large in absolute terms; the total return of surviving funds exceeds the total return of all funds by one percent. But one percent is important in terms of the rank of funds. Moreover that average of one percent may represent large under-performance by a few funds.

Survivorship bias may at least partially explain the asymmetry of the funds flow – portfolio performance relationship, where the best performed funds receive most of the new money but the poor performing funds lose little. Goetzmann, Greenwald and Huberman argue that if funds with low returns and consequent large outflow of money are absent from a dataset then a spurious asymmetry in the relationship will arise. The magnitude of survivorship bias in regression studies of the funds flow – performance relationship is unknown but it seems reasonable to assume that survivorship bias leads to an understatement of the strength of the relationship between under-performance by a manager and the flow of money out of that manager's fund.

Whether the dependent variable is a percentage change in funds managed or a dollar change, it is measured with considerable inaccuracy. This measurement error does not bias parameter estimates but does lead to overstatement of t values. However, if lagged dependent variables are included then parameter values are biased towards zero, causing an understatement of the strength of the funds flow – portfolio performance relationship.

Ideally we want to estimate the relationship between the performance over several previous periods and the growth in fund manager wealth or firm value in this period. This objective poses several problems which have not yet been solved. Chevalier and Ellison estimate the increase in funds under management as a function of r_{it} - r_{mt}, but to characterise fund manager incentives we really need the capitalised value of future fees as a function of r_{it}-r_{mt}, r_{it-1}-r_{mt-1}, r_{it-2}-r_{mt-2} and longer lags. This requires the estimation of a multivariate function rather than a univariate function as in Chevalier and Ellison.

A problem faced by all of these estimation attempts is that we want to accurately estimate the function over a wide range of returns but there are only a few funds that achieve very high excess returns and very low excess returns. A great deal of data is required to accurately estimate the relationship between very high or very low performance.

There is a more fundamental problem in empirically estimating the incentives faced by fund managers. The required relationship is between performance in the next period and the wealth of the fund manager. To estimate that relationship we need to know how excess return this period affects changes in funds managed next period *and* all future periods; assuming that fund managers choose wealth maximising portfolios at each future date. The point here is that the return this period affects fund manager wealth not only because funds under management increase but because the choice set faced by the manager changes.

Another way to explain this point is as follows. Chevalier and Ellison estimate a relationship between performance this period and fund growth last period. The expected growth in total funds next period is therefore estimated. If the value of an investment management firm is directly proportional to size, then the increase in wealth associated with the excess return achieved (the incentive schedule) has been estimated. However, a mutual fund with $100 million in assets which has a history of high performance may have a higher value than a fund with a poor performance history. In that way the return this period affects the value not only through the size of the fund but through future options for the fund manager.

Chevalier and Ellison estimate that a mutual fund which: is two years old; achieved zero excess returns in the past two years; matched the geometric mean of fund sizes; and achieved an excess return of 10 percent; would be expected to grow by 55 percent next year if the industry growth were zero. This example illustrates a problem with the approach taken by all the studies mentioned here. In solving their optimisation problems fund managers give greater weight to low probability events (high and low excess portfolio returns) because of the non-linearity in their incentive schedule. However, these are the points that are estimated with the least accuracy. With the current estimation techniques it will always be difficult to estimate the degree of convexity of the fund manager’s incentive schedule simply because extreme returns are unusual.

2.3.2.7 Studies of fund manager employment termination

Two studies apply limited dependent variable techniques to study the relationship between the portfolio performance of mutual funds and change of manager of the fund. Khorana (1996) studies portfolio managers and the investment management firms that employ them. In particular, 339 observations of the replacement of the portfolio manager of a US mutual fund is created and a logit analysis is undertaken to identify the variables that determine the probability that a mutual fund will experience a change of manager in a particular period. The following equation is estimated.

Equation 2.7

$$P(\text{Replacement}) = a_0 + \sum_{i=0}^{3} b_i \text{PCASSET}_{t-1} + \text{AR}_{t-1} + e_i$$

Where: P(replacement) = the probability that the portfolio manager is replaced in the current period

$PCASSET_{\tau-1}$ = the percentage growth in the portfolio asset value, adjusted for growth of existing assets and the growth of funds with the same investment objective

$AR_{\tau-1}$ = adjusted portfolio return where the adjustment is for either market risk or the return of the universe of peer managers.

In regressions where asset growth and portfolio performance are both included, Khorana finds that the parameters on both are negative and significant. Each percent of asset growth, above that of the weighted average of peer funds, in either of the past two periods, is estimated to decrease the probability of dismissal by about 14 percent. One percent of risk adjusted excess portfolio returns in the previous year decreases dismissal probability by 8 percent and for one year further back the reduction is 3 percent. The results indicate that only recent performance is important in these decisions.

Results from logit studies which use panel datasets are problematic at best. Ordinary least squares parameters are not biased if the missing regressors are orthogonal to included regressors. However, in logit studies, parameter estimates are not consistent if there are missing variables, which seems very plausible in this simple model which has a pseudo R^2 of about only 0.16. Another questionable aspect of Khorana's results is the large negative intercept values. If a fund experiences zero asset growth and zero adjusted return over the previous and lagged periods, which would presumably represent a fairly typical observation, then the probability of the manager being dismissed is estimated as –1.8.

Chevalier and Ellison (1997b) undertake a probit analysis of the turnover of mutual fund portfolio managers which is very similar to that of Khorana (1996). From the Morningstar *Mutual Funds on Disc* CD ROMs they identify 348 manager turnover events in the years 1992 to 1994. Like Khorana they find that risk adjusted returns are highly significant in explaining the probability of turnover of a manager in a period and that the performance of the manager in the past year is much more important than other years in this decision.

To estimate the importance of the length of a manager's service in the industry, the product of risk adjusted return and age less median age of peer managers is included as an explanatory variable. The probit analysis suggests that, a manager of average age, whose portfolio return lags the mean return of investment category peers by 10 percent, is 6 percent more likely to turn over than the average manager. However, a manager with the same performance who is 10 years younger is 12 percent more likely to turnover than the average manager.

2.3.3 What is known about the incentives faced by fund managers?

The purpose of studying fund manager incentives in this essay is to better understand how the trading behaviour of institutional investors differs from that of private investors as a result of differences in their incentives. Moreover, to understand what those differences mean for market outcomes. The previous sections of this essay reviewed studies of the relationship between the portfolio performance of a fund manager and the flow of money into that manager's fund. What then do these performance-flow studies tell us about the incentives faced by fund managers?

To understand fund manager maximising behaviour, what is needed is an objective function that relates a manager's choice variables to the quantity that the manager wishes to maximise. For instance, the manager's expected lifetime utility of consumption (or the value of the investment management firm) as a function of: the asset weights of the chosen portfolio; or the estimated moments of the total return of the chosen portfolio; or the estimated moments about the excess-to-benchmark return. The results of the performance-flow studies take us part of the way toward understanding those relationships.

Consider, equation 2.8, which shows the maximisation problem of a manager that chooses portfolio weights to maximise expected lifetime utility of consumption (see Ingersoll 1987). The solution to this dynamic programming problem is a function which relates optimal portfolio weights to state variables of the problem.

Equation 2.8

$$J_0 = \underset{\{\omega_{pt},\, \Omega_t\}}{\text{Max}} \; E_0 \left\{ \Sigma_{t=0}^{T-1} \left[\frac{U\left[C_t\left(W_t(.)\right)\right]}{\left(1 + r_{adj}\right)^t} \right] + \frac{B\left[W_T(.)\right]}{\left(1 + r_{adj}\right)^T} \right\}$$

Where	J_t	=	expected utility of lifetime consumption at time t
	ω_{pt}	=	the optimal portfolio weight vector at time t
	Ω_t	=	all control variables other than portfolio choice; such as, expenditure on research or expenditure on advertising
	E_t	=	expectation conditioned on the time t information set
	T	=	number of periods to the investment horizon
	U	=	the manager's utility of consumption as a function of wealth
	C_t	=	the manager's consumption in the period beginning at time t
	W_t	=	manager's wealth at time t
	$1+r_{adj}$	=	the risk adjusted discount factor
	B	=	the manager's utility of bequeathing wealth.

The significance of the performance-flow studies for the maximisation problem is in understanding the functional form of end of period wealth W(.). In the private investor's optimal portfolio choice problem, wealth at time t is a simple function of the time 0 wealth, consumption to time t and portfolio returns to time t. Equation 2.9 shows the simple law of motion followed by the state variable wealth in the private investor's dynamic optimisation problem. It is typically assumed that consumption is a simple monotonic function of beginning of period wealth.

Equation 2.9

$$W_t = \left[W_{t-1} - C_{t-1}\left(W_{t-1}\right)\right]\left[1 + r_{t-1}\right]$$

Where	r_{t-1}	=	total return on the investors personal wealth portfolio in the period beginning at time t-1

at time t-1.

The performance-flow studies show that the relationship between portfolio return and wealth is more complicated for the fund manager. The law of motion of the state variable wealth in the manager's dynamic optimisation problem is correspondingly more complex. To simplify, it might be assumed that the wealth of a manager (or alternatively the value of an investment management firm) is a linear function of the value of money managed.[28] In that case, the net flow of money into a manager's fund is directly proportional to increases in end of period wealth. The law of motion governing fund manager wealth is then as shown in equation 2.10.

Equation 2.10

$$W_t = \left[W_{t-1} - C_{t-1}\left(W_{t-1}\right)\right]\left[1 + r_{t-1}\right] + W_{t-1}F\left(r_{pt-1}, \Delta_{t-1}\right)$$

Where F = percentage growth of the manager's portfolio which results from the net flow of new money to the portfolio

r_{pt-1} = return to the managed portfolio (as opposed to the fund managers personal wealth portfolio) in the period starting at time t-1

Δ_{t-1} = all variables determining the flow of funds in the period beginning at t-1 other than r_{t-1}.

To determine the existence of, and form of, a solution to the fund manager's problem, and then compare it to the solution of the private investor's problem, a functional form must be assumed for the performance-flow relationship $F(r_{t-1}, \Delta)$. This task is left to follow up research. It is assumed here that a unique solution to the manager's problem exists and has the property that the expected lifetime utility of the

[28] This assumption implies that there is no finite optimum size of the fund – the manager simply seeks to maximise the volume of funds under management. The assumption ensures that the manager portfolio choice problem does not include a simultaneous consideration of costs and revenues. If the precision of a manager's estimates of asset return moments is related to the amount spent on research, then the portfolio choice and research costs will be determined simultaneously. The problem is not considered here.

manager at time t is concave in the W_t. The solution is a function which solves the functional equation.

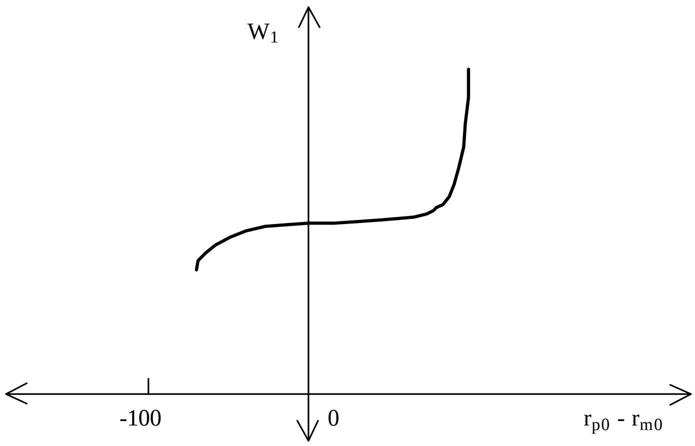
Equation 2.11

$$J_0(W_0) = U\left[C_0(W_0)\right] + \frac{E_0\left[J_1(W_1)\right]}{1 + r_{adj}}$$

Where $W_1 = \left[W_0 - C_0(W_0)\right]\left[1 + r_0\right] + W_0\, F(r_{p0}, \Delta_0)$

The performance-flow studies model F(.), the percentage increase in the value of a manager's portfolio from net flow of new money, as a function of r_{t-1}, which is the portfolio performance in the previous period, and other variables Δ_{t-1}; which include lags of portfolio performance. Figure 2.1 depicts a relationship between portfolio performance in the current period and the manager's wealth (or the firm value) at the end of the current period. This relationship can be thought of as the incentive schedule that the manager faces in choosing the optimal portfolio. It relates an outcome over which the manager has some control, the portfolio performance, to the reward to the manager, namely, the manager's end of period wealth. The figure summarises the contribution of performance-flow studies to the understanding of fund manager incentives.

Figure 2.1 Fund manager incentive schedule



Various measures of portfolio performance are employed in the empirical mutual fund flow studies. The measure with the most explanatory power over the flow of funds is the rank of the manager within the group of managers which have the same investment management objective (aggressive growth, growth, income, small cap etc.), where rank is formed on the basis of total return over the previous period. This result is intuitive in that much of the fund performance information presented to investors by investment journals and investment advisors is in the form of rankings; such as, '#1 fund', 'top decile performance', 'top quartile performance in every three year rolling window since 1986' etc. The performance-flow studies indicate that whether the rank is formed on the basis of risk adjusted returns, or alternatively unadjusted total returns, makes little difference. In the pension fund industry, performance results are usually presented in terms of the rank of the manager's performance within the universe of peer managers. Again results are typically not adjusted for risk.

The performance-flow studies show that the excess-to-benchmark return of the portfolio also has significant explanatory power over the flow of funds. It is not clear to what degree the excess-to-benchmark return is a signal of manager quality which is considered by investors, rather than a proxy for the rank of the manager's return within a peer group. Ideally, in modelling the incentive schedule of a fund manager, portfolio performance would be represented by the rank of the manager's performance. However, in this essay the excess-to-benchmark return is chosen instead because of its far greater analytical tractability.

The shape of the incentive schedule has the following features which are drawn from the results of the studies of Ippolito (1992), Sirri and Tufano (1998), and Chevalier and Ellison (1997a). The schedule is convex in positive portfolio performance and concave in negative portfolio performance. Only the best performed funds over the last period have a substantial flow of funds to the manager's portfolio. The degree of concavity in under-performed funds is muted compared to the convexity of flows in highly performed funds. This result may be explained by the cost of changing managers, cognitive dissonance and survivorship bias.[29] Unfortunately, the results of the performance-flow studies do not provide any functional characterisation of the manager's incentive schedule.[30] Further study is required to estimate a functional form for the fund manager incentive schedule that is amenable to analysis.

The schedule depicted in figure 2.1 is drawn with several important variables held constant including, lagged portfolio performance values and the level of marketing effort. The estimation procedure of Chevalier and Ellison shows that the schedule is steeper for younger funds, meaning that for the same excess return the growth of the fund is greater. The performance-flow studies show that mutual fund investors consider the returns in at least the three previous years when choosing mutual funds in which to invest. This means that the manager's incentive schedule is drawn for a particular performance history and if that history is changed, then the schedule will be altered; certainly in location and perhaps in shape.

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[29] The cost of changing managers includes the extra taxes arising from early realisation of capital gains. Further, the loss of the real option to delay a decision about whether to withdraw funds from the manager until some uncertainty about the manager's capacity to add value has been resolved; as discussed in chapter 6.

[30] Simple polynomial, exponential or trigonometric functions have the form depicted in figure 2.1 over appropriate ranges. For instance, a polynomial such as $W_1 = W_0(1+r_{pt}) + (r_{t-1})^3$; an exponential function such as $W_1 = W_0(1+r_{pt}) + \exp(r_{t-1}) - \exp(-r_{t-1})$; or a trigonometric function $W_1 = W_0(1+r_{pt}) + \tan^{-1}(r_{t-1})$.

In studying the dynamic hedging behaviour of fund managers it is precisely the changes in the performance history of the manager's portfolio that are of interest. Consider the following example. Assume that the percentage growth in a manager's portfolio is proportional to the cube of the sum of excess-to-benchmark returns in the previous three years, where growth can take the percentage values $(-100\ ,\ \infty)$. Further, that the fund manager's wealth is directly proportional to the value of the fund's assets and the manager's consumption in each period is zero. Fund manager wealth at t and t+1 is as shown in equation 2.12.

Equation 2.12

$$W_t = W_{t-1}\left(1 + r_{pt-1}\right) + W_{t-1}K\left(r_{pt-1} - r_{mt-1} + r_{pt-2} - r_{mt-2} + r_{pt-3} - r_{mt-3}\right)^3$$

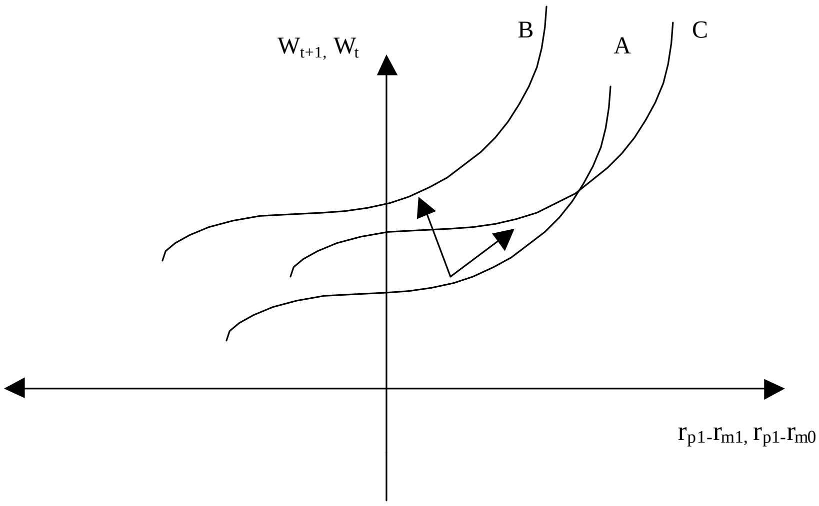
$$W_{t+1} = W_t\left(1 + r_{pt}\right) + W_tK\left(r_{pt} - r_{mt} + r_{pt-1} - r_{mt-1} + r_{pt-2} - r_{mt-2}\right)^3$$

Where $F(r_{t-1}, .\ ) = K(r_{pt-1} - r_{mt-1} + r_{pt-2} - r_{mt-2} + r_{pt-3} - r_{mt-3})^3$

In going from the incentive schedule at time t-1 to that at time t, there are two effects. Firstly, the schedule is moved 'up' by the positive values of r_{pt} which increase the value of the portfolio assets and, in proportion, the manager's wealth. The second effect is that the schedule is moved to the left if r_{pt}-$r_{mt} > r_{pt-3}$-r_{mt-3}. That is, when the window moves forward one year, if the performance figures that drop out are exceeded by those that come into the window, then the schedule moves to the left. Conversely, if r_{pt}-$r_{mt} < r_{pt-3}$-r_{mt-3} then the schedule moves to the right in the incentive schedule diagram. Another way to conceptualise the shift in the incentive schedule is to note that the point of inflexion of the curve moves from $\{W_{t-1}(1+r_{pt-1})\ ,\ -(r_{pt-2}-r_{mt-2} + r_{pt-3}-r_{mt-3})\}$ at time t-1 to $\{W_t(1+r_{pt})\ ,\ -(r_{pt-1}-r_{mt-1} + r_{pt-2}-r_{mt-2})\}$ at time t. This dynamic response of the incentive schedule provides a framework in which to analyse the dynamic hedging of fund managers. Figure 2.2 depicts two cases of shifts in the incentive schedule. Curve A is the schedule at time t. Curve B is the schedule at time t+1 where $W_t > W_{t-1}$ and $r_{pt}-r_{mt} > r_{pt-3}-r_{mt-3}$. Curve C is the schedule at time t+1 where $W_t > W_{t-1}$ and $r_{pt}-r_{mt} < r_{pt-3}-r_{mt-3}$.[31]

The shape of the manager's incentive schedule and the shifting of the schedule through time lead to two important conclusions. The first arises from the asymmetry

Figure 2.2 Shifts in the fund manager incentive schedule



of the schedule, which is concave in negative portfolio performance and convex in positive portfolio performance. This ensures that, other things equal, risk averse managers will place a higher value than private investors on securities that have return distributions which are skewed to the right. The significance for market outcomes of this preference heterogeneity across investors is discussed in section 2.5

The second conclusion relates to the reaction of fund managers after high portfolio performance. It is often postulated in the finance literature that if a manager, who is remunerated on the basis of calendar year portfolio return, experiences high returns early in the year, then the manager will reduce risk as the year end approaches to 'lock in' portfolio returns. Conversely managers with poor performance are postulated to increase portfolio risk.

[31] Changes in the shape of the incentive schedule arising from an increase in fund size, for instance, are being ignored here.

To analyse this question assume that the manager has a subjective probability distribution over r_{pt-1} - r_{mt-1} which is unchanged by the manager's evolving portfolio performance history. Further, assume that the manager's utility function exhibits constant relative risk aversion, so that changes in the manager's wealth does not affect portfolio choice. Under these conditions, consider a manager whose incentive schedule relates end of period wealth to the arithmetic average of excess-to-benchmark return over the four quarters of a calendar year. If after three quarters the average is large and positive then the fund manager's incentive schedule will have moved to the left. This shift moves the convex portion of the incentive schedule toward the centre of the probability distribution of r_{pt-1} - r_{mt-1} in which case the manager will *increase* the variance of the portfolio. We might then expect managers with high performance up to the third quarter to take on more risk and managers with poor performance to reduce risk.

2.3.4 Strategic behaviour and hedging by fund managers

The results of the performance-flow studies, in aggregate, can be used to characterise incentive schedules for fund managers. The incentive schedules of fund managers determine how they modify the risk of the managed portfolio; that is, how they hedge their exposure. Several studies examine how managers react to changes in their evolving portfolio performance histories.

Orphanides (1996) studies risk taking behaviour of US mutual fund portfolio managers that results from the agency relationship between a portfolio manager and the investment management firm that employs that manager. In each quarter of the periods 1976 to 1993 the variation of a manager's portfolio return, about the median return of the universe of peer managers, is estimated from daily returns as the portfolio 'risk'. Then the quarterly risk is regressed on: the calendar-year-to-date excess return of the portfolio multiplied by dummies for each quarter; plus the square and cube of those excess returns with multiplicative dummies; plus other fund-specific terms.

The study finds the following patterns in the risk taking behaviour of US equity mutual fund managers. There is substantial seasonal variation of the risk in managers' portfolios with the level of risk highest in the first quarter. Fund managers with high excess returns early in the calendar year reduce their portfolio risk as the year goes on, but this effect is only significant in the later years of the period covered by the dataset. In contrast, managers with negative excess returns early in the year on average increase the risk of their portfolios but this pattern is only observed in the early years of the dataset period.

Orphanides argues that for many portfolio managers the annual bonus is capped at some multiple of their salary and therefore managers with high performance early in the year face an effective incentive schedule which is concave in their excess returns for the rest of the year. An alternative explanation is that high performance leads to increased wealth and in turn greater risk aversion, which counteracts the effect shifting the incentive schedule to the left.

In an attempt to explain the ‘January effect’, Cuny, Fedenia and Haugen (1995) examine the year-end trading behaviour of fund managers and find that some managers of mutual funds and pension funds track the S&P 500 index towards the end of the year and then re-establish their ‘bets’ in the new year.

In the study of manager turnover, Khorana (1996) finds that mutual funds which experience a change of fund manager exhibit significantly higher levels of market and total risk in the periods leading up to the departure than a sample of funds matched by investment objective in which managers do not depart. The causality of fund manager departure and increased portfolio volatility is not precisely determined in the study. Nonetheless, it appears that managers act as though their tenure represents an option with limited downside risk. A finding in the Khorana study that impacts on the Hiring and Firing essay in chapters 5 and 6 is that, other things equal, a manager is less likely to depart, the higher the volatility of the assets managed.

Chevalier and Ellison (1997b) use the portfolio holdings of 839 mutual funds in September and December to study how fund managers modulate the risk of their portfolio in the face of changing incentives. They find that between September and December mutual fund managers change the risk of their portfolios in a way that is consistent with the incentives faced in September.

In each of these studies of the reaction of fund managers to an evolving performance history, the risk faced by the fund manager is characterised in terms of the managed portfolio's total variance or the variance of the excess-to-benchmark return. Yet the asymmetry of the manager's incentive schedule, with convexity on one side and concavity on the other, may induce the most interesting aspects of dynamic hedging by fund managers. We should expect the effects of asymmetry to result from the third moment of managers' portfolio returns rather than the second.

Ross (1998) looks at how the concavity of an investors utility function is altered when the incentive schedule is convex. He finds the surprising result that the risk aversion of an investor is not necessarily increased when the incentive schedule goes from linear to convex.

2.4 A comparison of optimisation problems

In this section the optimisation problems of private investors and institutional investors are compared with a view to identifying differences that may lead to different trading behaviour. The discussion proceeds through all of the components of the basic portfolio choice problems faced by these economic agents. This exercise helps to separate differences in the behaviour of the two types of investor that arise from heterogeneous incentives, which is the focus of this dissertation, from the trading differences that arise from other factors. The discussion also serves as background to the chapter 3 analysis of the theoretical explanations of fund manager herding.

2.4.1 Decision making

Private investors can be assumed to choose their own portfolios. A great deal of advice is proffered by brokers and other intermediaries but essentially the private investors take asset choice and timing decisions for their own portfolios.

As discussed in chapter 1, delegated portfolio management typically involves two levels of agency and therefore two levels of decision making. The first level is the investment management firm and the second is the individual fund managers who are the employees of that firm. The allocation of decision making rights to each level varies widely across fund management firms. Often the investment management firm will set asset allocation guidelines, if that is an issue, and be active in market timing decisions. In addition, the firm may form lists that define the set of assets that can or cannot be held.

A more important distinction between the decisions taken by individual fund managers and the investment management firm is that the firm must take decisions across a set of funds which, from the firm's perspective, form a portfolio of options.[32] A tractable approach to studying the effects of delegated portfolio management is to recognise only one level of decision making in the investment management firm. Then, consider the decision maker to be the investment management firm when studying the interaction between funds within the firm, and to consider the decision maker to be an individual fund manager when studying the effect of the choice of individual assets at the portfolio level.

2.4.1.1 Objective function

The assumption that private investors maximise expected utility arises directly from the theory of choice under uncertainty which is founded on a remarkably modest set of axioms over how individuals rank payoff distributions.[33] If the fund manager is taken to be an individual, then the objective is again the maximisation of expected utility. However, if the fund manager is taken to be an investment management firm and the assumptions of the Fisher Separation Theorem are valid, then the objective function is the maximisation of firm value. In a problem in which maximisation of the value of the firm is the objective, all of the portfolios managed by the firm must

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[32] The mutual funds form an option for the investment management firm because a poor performing fund can be merged into other funds, with another fund started in its place. Other managed portfolios are less option like but nonetheless represent a degree of freedom in the investment management firm's optimisation problem. For instance, if the firm has information which is correlated with the future price of a particular stock, and it is known that the firm's intended buying will move the price up, then the information must be budgeted across the funds.

[33] See Kreps (1990), Huang and Litzenberger (1988), or Ingersoll (1987) for comprehensive discussions of the theory of choice under uncertainty.

be considered jointly. For instance, if a firm has two funds, one of which holds none of stock A and the other fund holds twice the index weighting in stock A, then what is the firm's exposure to stock A?

The performance-flow studies reviewed in section 2.3 showed that the incentives faced by fund managers differ fundamentally from those faced by private investors in at least four respects. Firstly, fund manager payoffs are dependent upon relative rather than absolute returns. Secondly, the relationship between the return on an individual stock and end of period wealth is linear for a private investor, but highly non-linear for an institutional investor, with convex and concave components. Thirdly, there is a one-to-one relation between the end of period wealth of a private investor and the increases in the value of the portfolio held. The fund manager's wealth will typically be much more sensitive to portfolio returns because the portfolio is typically a large multiple of the fund manager's wealth. But also because small increases in portfolio returns can move the manager a long way up the ranking against peers. Finally, private investors will typically have considerably longer term investment horizons than institutional investors.[34] The empirical performance-flow studies suggested that the importance of performance results in determining the flow of funds to a manager decreases rapidly with the age of the performance.

2.4.1.2 Components of the maximisation problem

The major components of the portfolio choice problem are the estimated moments of the return on assets, the state variables, the asset choice set and constraints on the choice set. Investors undertake research with the intention of increasing the precision of estimates of asset return moments. The amount of resources deployed in uncovering mispriced securities is an outcome of the maximisation problem. However, because of their relatively short investment horizons, when choosing assets to research, fund managers must be cognisant of the speed of price discovery in assets. Consequently, fund managers may have a tendency to research the same assets (Brennan 1990). This effect is an example of how the maximisation problems

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[34] When the Author explained to a fund manager that a proposed programme of doctoral research would take up to 3 years, the fund manager replied that he could quite conceivably be sacked, hired elsewhere and become a rising star all within that time frame.

of fund managers are linked in a way that the maximisation problems of private investors are not. Chapter 3 discusses the causes of fund manager herding in a maximisation framework.

The important state variables for both groups are asset prices and investor wealth. The fund manager's problem is slightly different in that the portfolio performance history enters the problem as a state variable which is a function of past asset prices and past portfolio weight choices. The private investor's problem does not have this dimension of portfolio return history entering the problem, except through wealth.

The asset choice set in the portfolio choice problem of many fund managers is constrained by a prohibition on holding derivative securities or selling assets short. Fund managers who have an incentive schedule which is convex in positive excess-to-benchmark returns and concave in negative excess-to-benchmark returns, will value securities with convex payoff schedules such as stock options. Of course such managers can synthesise the returns to stock options by dynamic trading strategies. The constraint on short selling may affect a manager's search for mispriced securities since information that a stock's price will fall is of little value to a manager if short sales are prohibited and the stock is not already held.

In both the US and UK, courts hold fund managers to a 'prudent person rule'. By this rule fund managers must be able to demonstrate ex-poste that their portfolio choices were consistent with the choices of a prudent person. Many investment professionals believe that fund managers would deploy more resources on researching the returns of smaller stocks, which are less efficiently priced, were it not for the prudent person rule.

2.5 Conjectures about unexplained market phenomena

The rise of delegated portfolio management represents a major change in the composition of decision makers in the market. How might we expect a market in which institutional investors have a dominant role to differ from that in which institutional investors are absent? In considering outcomes in financial markets, such as asset price dynamics or the pricing of assets, the finance literature gives little consideration to who controls the ownership of the assets.

In this section several equity market anomalies are considered in the light of the findings and considerations of the previous sections of this essay. The ideas expressed here are intended to form the basis for ongoing research. Future research will flow from an understanding of the rise of delegated portfolio management. However, when reviewing the results of existing research the rise of delegated portfolio management should also be carefully considered. Many of the most influential empirical studies in finance span a part or all of the period (1967-1998) in which the control of 28 percent of the US equity market has passed from private investors to institutional investors and foreign investors. If the trading behaviour of fund managers is fundamentally different from that of private investors then these studies span a period in which the structure of the market is changing, but make no allowance for that change.

2.5.1 Dynamic hedging by fund managers

The performance-flow studies reviewed in section 2.3 indicate that investors evaluate fund managers on the basis of portfolio performance. The best measure of performance appears to be the rank of the manager's total return within the universe of peer managers, but excess-to-benchmark returns are an adequate proxy for the analytically intractable rank variable. Where performance is measured relative to an investable benchmark portfolio, the manager may reduce the variance of the excess return to zero by holding the benchmark portfolio.[35] However, we should expect managers to trade even if they have zero information simply because a buy and hold strategy would reveal that the manager has no information (Dow and Gorton 1997).

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[35] If the manager is measured relative to a universe of peers then the manager can reduce performance risk to nearly zero by holding the value weighted portfolio of the universe of managers. Some managers who work for large investment management firms consider their effective remuneration benchmark to be the 'house return'. In that case the manager can hedge by holding the weighted average portfolio of the all firm's managers within the relevant asset class.

In solving the portfolio choice problem in continuous time fund managers will choose portfolio weight vectors that differ from the index and reflect the precision of the manager's private information in each asset and the incentive schedule faced. The difference between the benchmark vector of asset weights and the manager's vector is the vector of manager 'bets' against the index. As the price vector evolves and the manager's portfolio performance history evolves, the manager will dynamically hedge by trading to a new portfolio weight vector.

To simplify, consider the following situation. Assume that a manager knows with certainty that if the portfolio return is more than x percent below the benchmark return then the manager will be dismissed, which entails a fall in end of period wealth to zero. In this stylised scenario, the manager has a classic discrete portfolio insurance problem.[36] The difference between portfolio insurance for fund managers and for private investors is that for fund managers the risk free asset is the benchmark portfolio (Brennan 1993).

The manager will choose a vector of bets at the beginning of the period and then alter those bets to maximise end of period expected utility conditional upon the excess-to-benchmark return not falling below –x. Now consider a stock Y which has a market capitalisation that is 2 percent of the index. Then consider two managers that face the incentive schedule described above and are identical in every respect except their heterogeneous information signals for stock Y. Assume that the managers have risk preferences that exhibit constant absolute risk aversion. Manager A initially holds none of stock Y and therefore has a 2 percent bet against stock Y. Manager B's initial portfolio initially holds 4 percent in stock Y. The managers have zero information on all other stocks. The rest of their portfolio is held in index proportions and is not traded except for liquidity purposes.

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[36] See Grossman and Zhou (1996) for an equilibrium analysis of the market outcomes that arise from the market being divided into portfolio insurers and non-insurers. However, they are not examining the effect of delegated portfolio management. Their portfolio insurers are insuring against low total returns rather than low excess-to-benchmark returns.

The price vector evolves over the period and the return of stock Y exceeds the index return by 200 percent. Then, assuming that managers' expectations over future stock returns are unchanged, how will the managers react? To dynamically hedge, manager A will sell all other stocks in index proportion and buy stock Y. Likewise, manager B will sell the riskless asset, the market index, and take a larger bet in Y to dynamically replicate the option on stock Y.

The profound result of this 'thought experiment' is that when stock prices rise significantly, then to dynamically hedge, all managers are induced to buy the stock, whether they bet for or against the stock. Moreover, there is an asymmetry to this dynamic hedging. If the price of stock Y was to fall sharply rather than rise sharply, then manager B would be induced to buy the stock but manager A cannot sell the stock because of the short sales constraint that most managers face.

What market phenomena could this manager dynamic hedging effect explain? Firstly, if large changes in a stock's price induce fund managers to trade in the same direction then we should expect to see fund manager herding in those stocks. The testable implication is that more herding should be found in larger stocks. That hypothesis is tested in detail in the herding essay of chapters 3 and 4 and is shown to be correct for UK unit trust managers. A second testable prediction is that after controlling for size, herding should be greater in those stocks in which fund managers have the largest bets. That implication will be tested in ongoing research.

Secondly, if the fund managers herding into stocks that have changed significantly in price creates price pressure, then we should expect to see serial correlation in stock prices. This effect has been widely observed.[37] The testable implication is that the effect should be greater in large stocks and stocks in which fund managers take the largest bets. Sias and Starks (1997) find that, after conditioning for size, daily serial correlation in stock prices is monotonically increasing in the proportion of a stock that is held by institutional investors.

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[37] See, for instance, Jagadeesh and Titman (1993) or Lo and MacKinlay (1990).

Finally, consider who is on the other side of these dynamic hedging trades. We should expect the dynamic hedging demand for stocks to be met by private investors who are concerned with total returns and not excess-to-benchmark returns. If private investors provide this dynamic insurance to fund managers, then when we measure the performance of fund managers versus index benchmarks we should not be surprised to see that fund managers under-perform the benchmark even after accounting for fees, expenses and traditional risk factors.

2.6 Concluding remarks

The purpose of this essay is to highlight the importance of the rise of delegated portfolio management. In the first section the massive transfer of the control of financial assets in the UK and US is documented in a series of tables and figures.

The essay then brings together results from a large number of empirical studies of the flow of funds to managers who have achieved high relative performance in previous periods. It is shown that these fund flows characterise the incentives that are faced by fund managers. Those incentives are significantly different from the incentives faced by private investors.

Finally, the effect of the differences in incentives for unexplained market phenomena are discussed. The most important observation results from a thought experiment on dynamic herding, namely, that when large changes in prices occur, fund managers are all induced to trade in the same direction. Of course, the subsequent shift in price arising from price pressure undoes the hedging effect for managers who had small bets against the index and those managers meet some of the hedging demand. Nonetheless, we should expect to see fund manager herding arising from dynamic hedging of pay-offs that are different to those faced by private investors.

Two other interesting results then follow. Firstly, dynamic hedging may be a cause of serial correlation in stock prices. Secondly, the provision of dynamic insurance by private investors to institutional investors may partially explain the under-performance of fund managers. These three concepts will be the subject of hopefully fruitful further research.

Table 2.1 Level of financial assets held by UK financial sectors (£bns)

	Pension funds	Unit trusts	Insurance companies – long-term funds	Insurance companies – other than long-term funds	Building societies	Banks
1967	7	1	11	1	8	19
1968	8	1	12	1	8	22
1969	8	1	13	1	9	28
1970	9	1	14	2	12	34
1971	12	2	15	2	13	40
1972	14	2	17	3	15	53
1973	12	2	20	3	18	75
1974	10	1	21	4	20	88
1975	16	3	23	5	24	108
1976	21	3	24	5	28	136
1977	30	3	34	7	35	145
1978	35	4	38	8	40	167
1979	42	4	43	10	46	200
1980	54	5	54	12	54	233
1981	63	6	61	13	62	332
1982	84	8	80	16	75	411
1983	111	12	96	19	87	480
1984	139	15	114	21	103	604
1985	168	20	130	21	122	590
1986	211	32	159	34	142	704
1987	228	36	173	35	162	729
1988	267	42	198	40	193	817
1989	339	58	246	48	190	1014
1990	303	46	232	44	222	1031
1991	344	55	276	48	247	1011
1992	382	64	328	54	265	1153
1993	481	96	434	63	280	1211
1994	443	92	404	62	297	1286
1995	509	113	495	75	297	1481
1996	544	132	550	96	301	1536
1997	657	158	678	97	138	1943

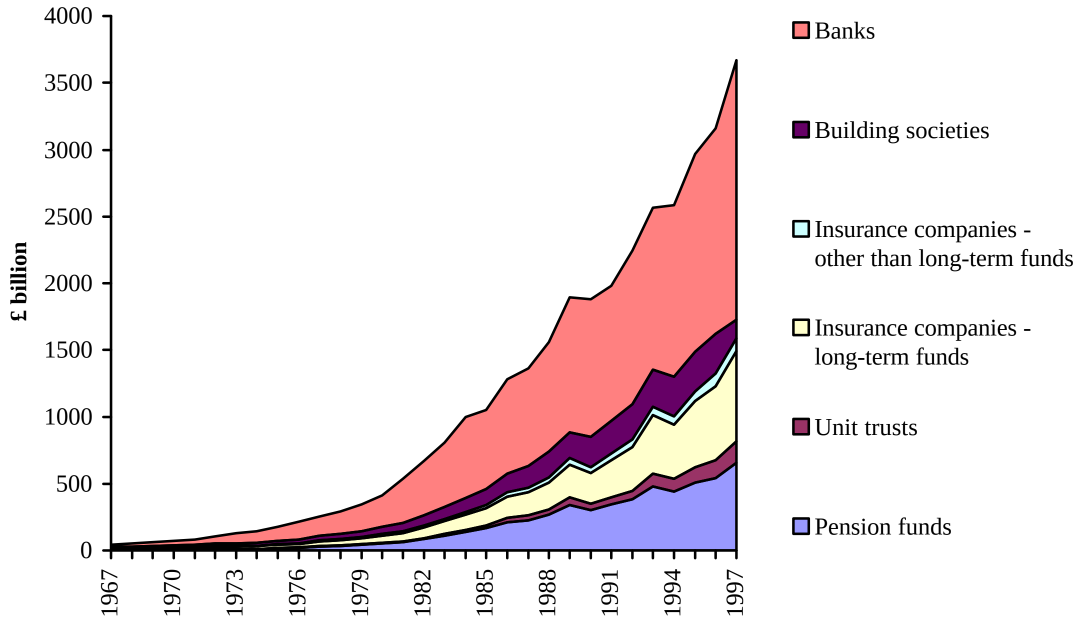
Source: Office for National Statistics – Financial Statistics

Table 2.2 Level of financial assets held by UK financial sectors (% of UK GDP)

	Pension funds	Unit trusts	Insurance companies – long-term funds	Insurance companies – other than long-term funds	Building societies	Banks
1967	16	2	26	3	19	46
1968	18	3	27	3	19	51
1969	17	3	27	3	20	58
1970	17	2	27	3	22	65
1971	20	3	26	4	23	69
1972	21	4	26	4	24	82
1973	17	2	27	4	24	101
1974	12	1	25	4	24	105
1975	15	2	22	4	23	102
1976	16	2	20	4	22	109
1977	20	2	23	5	24	99
1978	21	2	23	5	24	99
1979	21	2	22	5	23	101
1980	23	2	23	5	23	101
1981	25	2	24	5	24	130
1982	30	3	29	6	27	147
1983	36	4	31	6	29	158
1984	43	5	35	6	32	185
1985	47	6	36	6	34	165
1986	55	8	41	9	37	183
1987	54	9	41	8	38	172
1988	57	9	42	9	41	173
1989	66	11	48	9	37	197
1990	55	8	42	8	40	187
1991	60	10	48	8	43	176
1992	64	11	55	9	44	193
1993	76	15	69	10	44	192
1994	66	14	60	9	44	192
1995	72	16	70	11	42	210
1996	73	18	74	13	41	207
1997	83	20	86	12	18	247

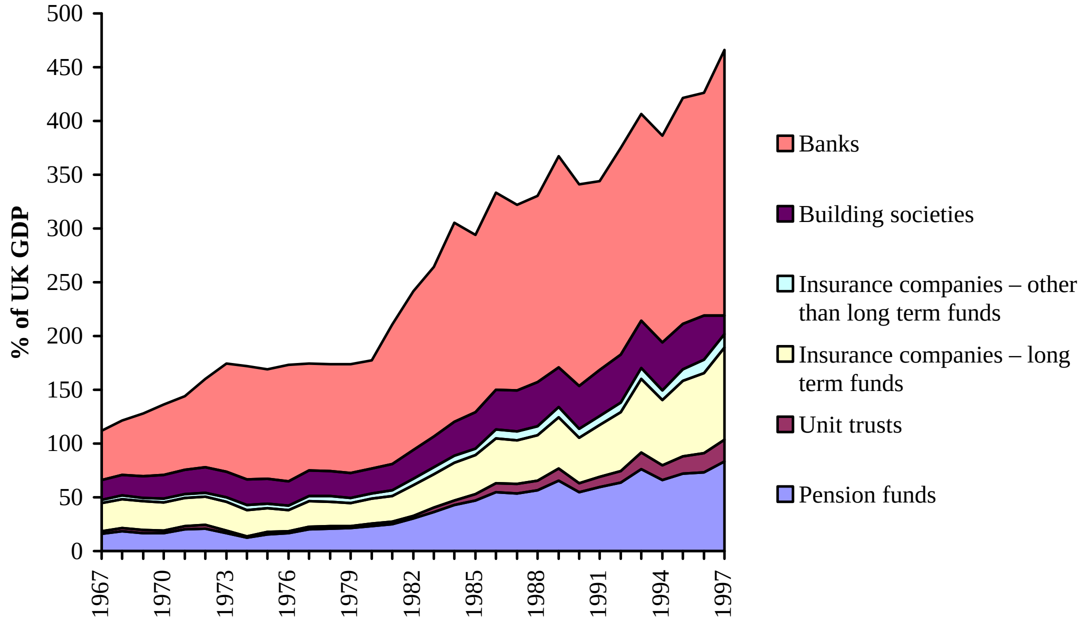
Source: Office for National Statistics – Financial Statistics

Figure 2.3 Level of financial assets held by UK financial sectors (£bns)



Source: Office for National Statistics – Financial Statistics

Figure 2.4 Level of financial assets held by UK financial sectors (% of UK GDP)



Source: Office for National Statistics – Financial Statistics

Table 2.3 UK equity holdings of UK financial sectors (£bns)

	Pension funds	Unit trusts	Insurance companies – long-term funds	Foreign[1]	Household sector[2]
1967	3	1	2	na	na
1968	4	1	2	na	na
1969	4	1	3	na	na
1970	4	1	3	na	na
1971	6	2	3	na	na
1972	8	2	4	na	na
1973	6	1	4	na	na
1974	3	1	4	na	na
1975	7	2	4	na	21
1976	9	2	6	na	25
1977	13	3	9	na	30
1978	15	3	10	na	31
1979	18	3	11	8	38
1980	24	3	15	6	38
1981	28	4	17	7	45
1982	36	4	22	8	54
1983	48	6	28	8	61
1984	65	8	36	15	68
1985	82	11	43	25	96
1986	106	16	56	45	122
1987	117	21	59	40	129
1988	126	22	67	32	118
1989	158	29	88	40	146
1990	142	26	81	55	124
1991	174	30	102	66	114
1992	202	33	122	88	125
1993	251	50	167	128	151
1994	219	43	159	119	156
1995	257	59	199	145	169
1996	276	68	223	165	190
1997	340	87	283	295	246

Sources: Office for National Statistics – Financial Statistics

[1] *The ONS series on the equity holdings of the foreign sector begins in 1979*

[2] *The ONS series on the equity holdings of the household sector begins in 1975*

Table 2.4 Proportional ownership of UK equity market, private versus institutional investors (proportions sum to 100)

	Pension funds	Unit trusts	Insurance companies - - long-term funds	Total of UK institutional investors	Foreign	Household sector
1974	10	2	12	na	na	76
1975	21	5	13	39	na	61
1976	21	4	14	39	na	61
1977	24	5	17	45	na	55
1978	26	5	17	48	na	52
1979	23	4	14	41	10	49
1980	28	4	17	49	7	44
1981	28	4	17	48	7	45
1982	29	4	18	51	6	43
1983	32	4	18	54	6	40
1984	34	4	19	57	8	35
1985	32	4	17	53	10	37
1986	31	5	16	52	13	35
1987	32	6	16	54	11	35
1988	35	6	18	59	9	32
1989	34	6	19	60	9	32
1990	33	6	19	58	13	29
1991	36	6	21	63	14	23
1992	35	6	21	63	15	22
1993	34	7	22	63	17	20
1994	31	6	23	61	17	22
1995	31	7	24	62	17	20
1996	30	7	24	61	18	21
1997	27	7	23	57	24	20

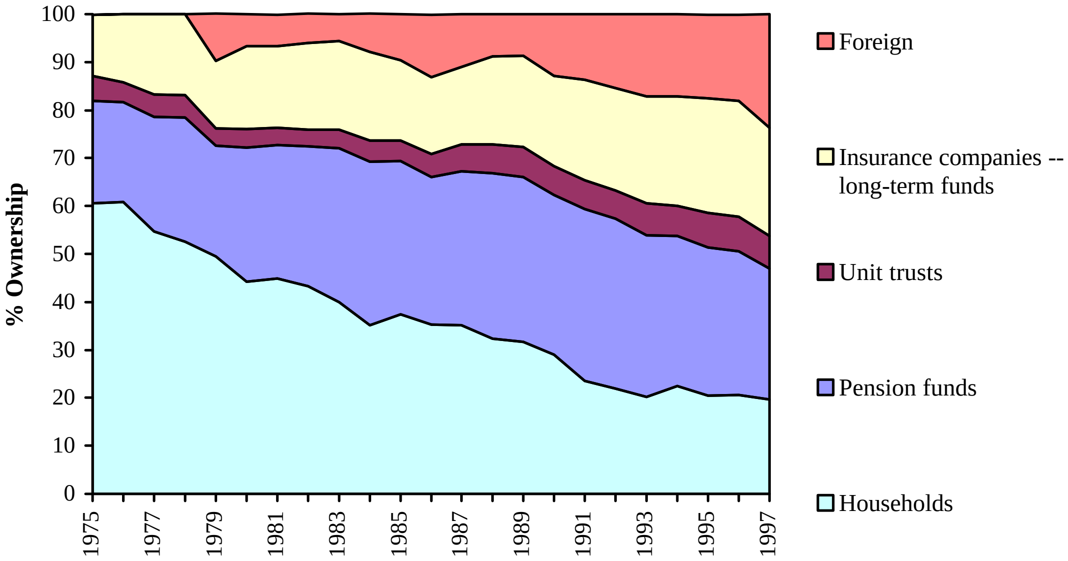
Source: Office for National Statistics – Financial Statistics

Table 2.5 UK equity holdings of UK financial sectors as a % of their total UK financial assets

	Pension funds	Unit trusts	Insurance companies -- long-term funds
1967	44	86	17
1968	52	88	19
1969	49	84	20
1970	47	83	21
1971	54	87	21
1972	56	81	23
1973	46	79	21
1974	31	70	18
1975	46	72	19
1976	42	67	24
1977	44	74	27
1978	44	71	26
1979	42	70	25
1980	44	68	27
1981	44	60	28
1982	43	57	28
1983	44	51	29
1984	47	54	31
1985	49	54	33
1986	50	51	35
1987	52	56	34
1988	47	53	34
1989	47	50	36
1990	47	55	35
1991	50	54	37
1992	53	52	37
1993	52	52	38
1994	49	47	39
1995	50	52	40
1996	51	51	41
1997	52	55	42

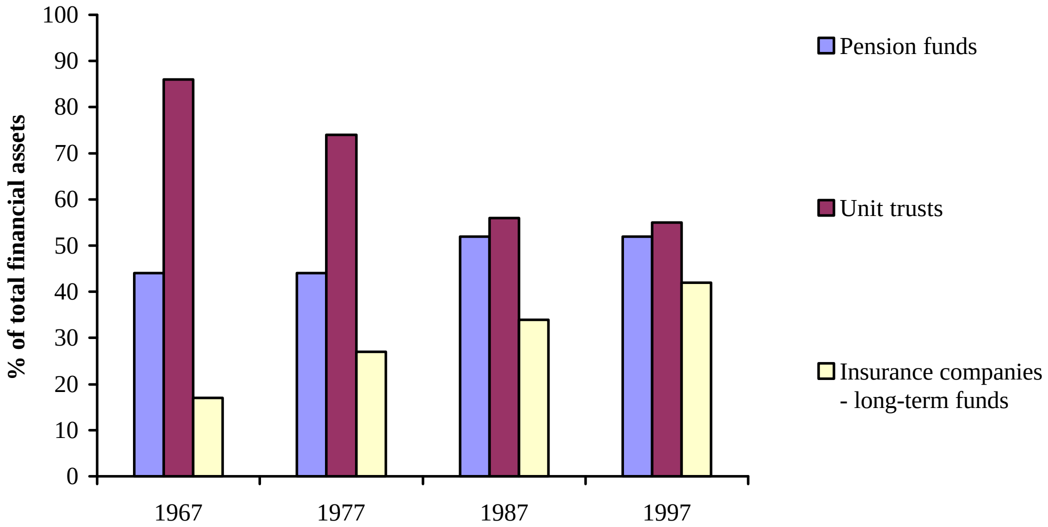
Source: Office for National Statistics – Financial Statistics

Figure 2.5 Proportion of ownership of UK equity market, private versus institutional investors



Note: The ONS series on the equity holdings of the foreign sector begins in 1979.
Source: Office for National Statistics – Financial Statistics

Figure 2.6 UK equity holdings of UK financial sectors as a % of their total UK financial assets



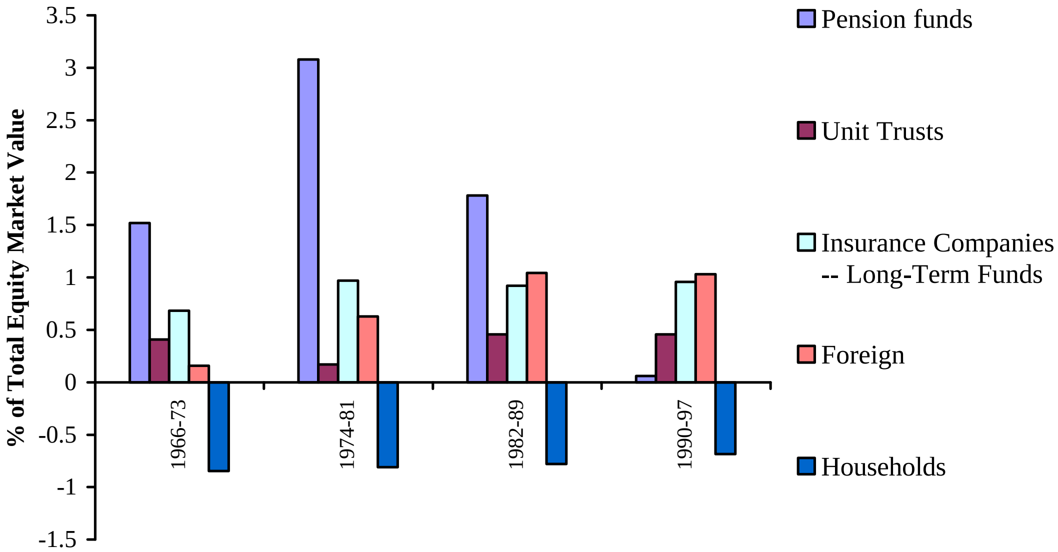
Source: Office for National Statistics – Financial Statistics

Table 2.6 Net acquisition of UK equities by UK financial sectors (£bns)

	Pension funds	Unit trusts	Insurance companies – long-term funds	Foreign	Household sector
1966	0.20	0.08	0.08	-0.05	-0.08
1967	0.26	0.08	0.15	-0.02	-0.12
1968	0.38	0.19	0.05	0.03	-0.03
1969	0.25	0.13	0.11	0.11	-0.15
1970	0.43	0.05	0.09	0.02	-0.21
1971	0.56	0.07	0.38	0.07	-0.35
1972	0.66	0.08	0.39	0.11	-0.23
1973	0.26	0.06	0.16	0.14	-0.55
1974	0.06	0.01	0.06	0.15	0.07
1975	1.33	0.24	0.19	0.18	-0.33
1976	1.15	0.04	0.18	0.23	-0.46
1977	1.59	0.12	0.42	0.53	-0.54
1978	1.48	0.02	0.62	-0.08	-0.40
1979	1.57	0.01	0.75	0.51	-0.68
1980	2.32	-0.03	0.81	-0.06	-0.61
1981	2.01	0.03	0.95	0.37	-0.04
1982	2.57	0.16	1.36	0.75	-0.35
1983	1.88	0.25	0.89	0.06	-0.03
1984	3.88	0.51	1.26	1.18	-1.37
1985	4.41	1.11	2.26	3.44	-2.56
1986	4.16	1.74	2.27	3.58	-0.74
1987	8.38	3.57	2.78	3.39	-3.90
1988	2.27	1.41	2.68	6.32	-5.59
1989	0.94	0.72	3.26	3.46	-2.30
1990	7.91	0.88	5.64	2.70	-10.33
1991	7.86	1.88	8.48	3.44	-3.54
1992	0.57	0.62	3.39	10.46	2.42
1993	-3.21	5.81	11.14	17.27	-6.17
1994	0.37	5.73	8.92	3.73	2.24
1995	-6.88	3.43	4.03	8.10	-7.70
1996	-7.14	4.94	6.73	9.43	-6.37
1997	-14.93	7.96	6.17	9.15	-9.98

Source: Office for National Statics – Financial Statistics; Datastream

Figure 2.7 Net acquisition of UK equities by UK financial sectors – 8 year average annual flows as a percentage of total equity market value



Source: Office for National Statics – Financial Statistics; Datastream

Table 2.7 UK unit trust holdings

Year	Number of unit trust holdings (mns)	Net purchases of units trust shares (£bns)	Total Funds (£bns)
1968	2.2	na	0.8
1969	2.4	na	1.3
1970	2.4	na	1.3
1971	2.3	na	1.2
1972	2.3	na	1.9
1973	2.2	na	2.3
1974	2.2	na	1.8
1975	2.2	0.2	1.0
1976	2.1	0.2	2.5
1977	2	0.1	3.5
1978	2	0.2	3.9
1979	1.8	0.1	3.9
1980	1.7	0.1	5.0
1981	1.8	0.5	5.9
1982	1.8	0.6	7.8
1983	2	1.5	11.7
1984	2.2	1.4	15.1
1985	2.6	2.5	20.3
1986	3.4	5.2	32.1
1987	5	6.3	36.3
1988	4.9	1.8	41.6
1989	4.8	3.9	58.2
1990	4.6	0.4	46.3
1991	4.5	2.8	55.1
1992	4.4	0.6	63.9
1993	5	9.1	95.6
1994	6.1	8.3	91.8
1995	6.6	6.9	112.6
1996	8	10.0	131.9
1997	9	10.2	157.7

Source: Office for National Statistics – Financial Statistics

Table 2.8 Level of US financial assets held by US financial sectors ($bns)

	Private pension funds[1]	SLGE retirement funds[2]	Mutual funds	Money market funds[3]	Bank personal trusts and estates[4]	Insurance companies - life & other	Banks and depository institutions[5]	Foreign
1967	98	43	44	na	na	214	625	78
1968	111	48	51	na	na	228	685	88
1969	114	53	48	na	130	237	721	94
1970	124	60	47	na	132	252	788	99
1971	147	69	55	na	156	274	892	127
1972	182	81	59	na	179	301	1028	152
1973	180	85	47	na	166	316	1162	159
1974	178	88	35	2	138	325	1266	206
1975	244	104	43	4	159	358	1374	220
1976	275	119	47	4	185	409	1522	268
1977	297	131	46	4	182	458	1716	319
1978	351	152	46	11	193	518	1951	390
1979	413	168	52	45	215	581	2151	437
1980	504	197	62	76	245	646	2342	516
1981	530	223	60	186	248	702	2519	541
1982	658	261	77	220	264	780	2682	596
1983	801	305	112	180	293	868	2995	702
1984	861	350	136	232	306	948	3412	816
1985	1207	399	246	242	358	1095	3779	974
1986	1262	477	427	291	404	1260	4150	1178
1987	1328	524	480	314	414	1410	4448	1355
1988	1375	609	501	335	444	1587	4773	1576
1989	1584	767	590	425	515	1763	4929	1885
1990	1572	920	608	493	522	1901	4856	2009
1991	1860	1032	770	535	608	2076	4799	2163
1992	1959	1168	993	540	630	2208	4955	2336
1993	2193	1256	1375	560	661	2423	5178	2705
1994	2352	1294	1477	603	670	2563	5453	2905
1995	2755	1518	1853	745	775	2828	5812	3466
1996	3155	1715	2342	891	842	3052	6067	4152
1997	3705	2094	2989	1049	1055	3418	6553	4660
1998	4331	2344	3626	1334	1263	3672	7073	5410

Source: The US Federal Reserve Flow of Funds

[1] *Note that at the end of 1998 private pension plans held $58bn in money market funds; $31bn with savings institutions; and $564bn in mutual fund shares. Insurance companies held $112bn in money market funds and $31bn in mutual funds. Foreign investors held $343bn in US currency and deposits at US banks.*

[2] *SLGE is 'State and Local Government Employee.'*

[3] *Money market funds came into existence in 1973.*

[4] *Before 1969, 'Bank Personal Trust & Estate' is not separated from 'Bank & Depository Institutions.'*

[5] *Includes commercial banks, savings and loan associations, mutual savings banks and credit unions.*

Table 2.9 Level of US financial assets held by US financial sectors (% of US GDP)

	Private pension funds [1]	SLGE retirement funds [2]	Mutual funds	Money market funds [3]	Bank personal trusts and estates [4]	Insurance companies - life & other	Total of institutional investors	Banks and depository institutions [5]	Foreign
1967	12	5	5	na	na	26	22	75	9
1968	12	5	6	na	na	25	23	75	10
1969	12	5	5	na	13	24	35	73	10
1970	12	6	5	na	13	24	35	76	10
1971	13	6	5	na	14	24	38	79	11
1972	15	7	5	na	14	24	41	83	12
1973	13	6	3	na	12	23	35	84	11
1974	12	6	2	0	9	22	29	85	14
1975	15	6	3	0	10	22	34	84	13
1976	15	7	3	0	10	22	35	84	15
1977	15	6	2	0	9	23	33	85	16
1978	15	7	2	0	8	23	33	85	17
1979	16	7	2	2	8	23	35	84	17
1980	18	7	2	3	9	23	39	84	19
1981	17	7	2	6	8	23	40	81	17
1982	20	8	2	7	8	24	46	83	18
1983	23	9	3	5	8	25	48	85	20
1984	22	9	3	6	8	24	48	87	21
1985	29	10	6	6	9	26	59	90	23
1986	29	11	10	7	9	28	65	94	27
1987	28	11	10	7	9	30	65	95	29
1988	27	12	10	7	9	31	65	95	31
1989	29	14	11	8	9	32	71	91	35
1990	27	16	11	9	9	33	72	85	35
1991	31	17	13	9	10	35	81	81	37
1992	31	19	16	9	10	35	85	79	37
1993	33	19	21	9	10	37	92	79	41
1994	34	19	21	9	10	37	92	78	42
1995	38	21	26	10	11	39	105	80	48
1996	41	22	31	12	11	40	117	79	54
1997	46	26	37	13	13	42	135	81	58
1998	51	28	43	16	15	43	152	83	64

Source: The US Federal Reserve Flow of Funds

[1] *Note that at the end of 1998 private pension plans held $58bn in money market funds; $31bn with savings institutions; and $564bn in mutual fund shares. Insurance companies held $112bn in money market funds and $31bn in mutual funds. Foreign investors held $343bn in US currency and deposits at US banks.*

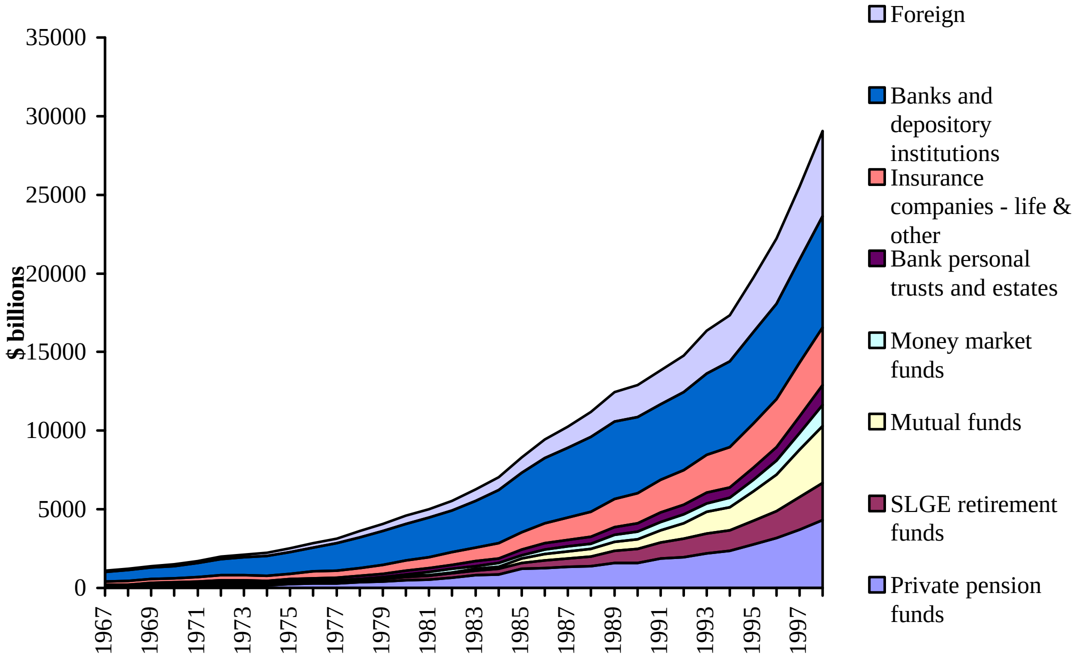
[2] *SLGE is 'State and Local Government Employee.'*

[3] *Money market funds came into existence in 1973.*

[4] *Before 1969, 'Bank Personal Trust & Estate' is not separated from 'Bank & Depository Institutions.'*

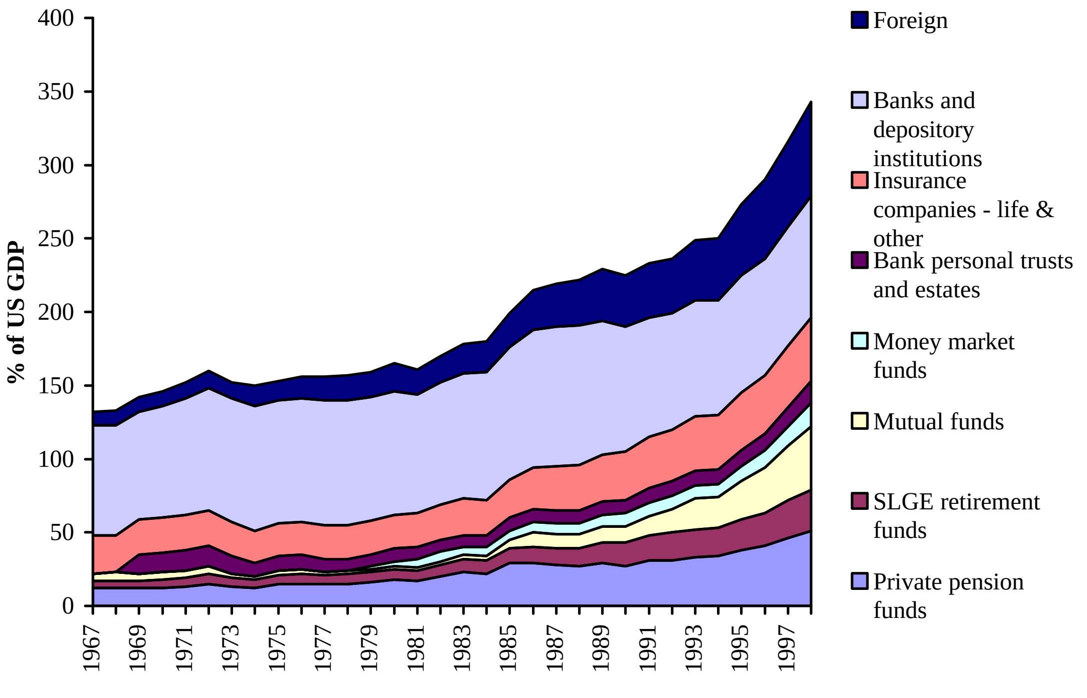
[5] *Includes commercial banks, savings and loan associations, mutual savings banks and credit unions.*

Figure 2.8 Level of US financial assets held by US financial sectors ($bns)



Source: The US Federal Reserve Flow of Funds

Figure 2.9 Level of US financial assets held by US financial sectors (% of US GDP)



Source: The US Federal Reserve Flow of Funds

Table 2.10 US equity holdings of US financial sectors ($bns)

	Private pension funds	SLGE retirement funds [1]	Mutual funds	Bank personal trusts and estates [2]	Insurance companies - life & other	Households	Foreign	Market value of US listed equities
1967	51	4	40	na	24	682	26	835
1968	61	6	46	na	28	815	30	996
1969	61	7	41	89	26	587	27	850
1970	67	10	40	88	28	573	27	841
1971	89	15	49	106	37	651	31	988
1972	108	22	52	124	55	814	39	1220
1973	94	20	38	107	45	598	34	949
1974	75	16	26	76	34	373	24	637
1975	108	24	34	92	42	499	35	846
1976	125	30	37	109	55	637	43	1042
1977	124	30	32	100	49	543	40	929
1978	150	33	32	104	54	550	42	978
1979	175	37	35	113	64	675	48	1160
1980	234	44	42	135	78	903	65	1514
1981	218	48	37	125	78	810	64	1403
1982	283	60	49	134	92	870	76	1588
1983	350	90	74	152	110	984	96	1889
1984	359	97	81	146	105	914	96	1825
1985	494	120	114	171	131	1128	126	2319
1986	499	150	161	164	137	1418	170	2746
1987	507	170	182	156	145	1382	176	2763
1988	485	220	188	172	160	1640	198	3115
1989	593	300	251	207	190	1964	276	3832
1990	562	296	233	190	178	1795	251	3537
1991	748	392	309	234	250	2578	299	4866
1992	808	447	401	217	271	2920	329	5458
1993	938	534	607	181	329	3221	373	6258
1994	996	543	710	167	358	2990	398	6240
1995	1238	754	1025	225	450	3995	528	8331
1996	1491	956	1470	249	559	4528	657	10061
1997	1864	1306	2019	401	746	5333	916	12959
1998	2232	1592	2523	538	950	6280	1110	15438

Source: US Federal Reserve Flow of Funds

[1] *SLGE is 'State and Local Government Employee'.*

[2] *Before 1969, 'Bank Personal Trust & Estate' is not separated from 'Bank & Depository Institutions'.*

Table 2.11 Percentage ownership of US equity market, private versus institutional investors

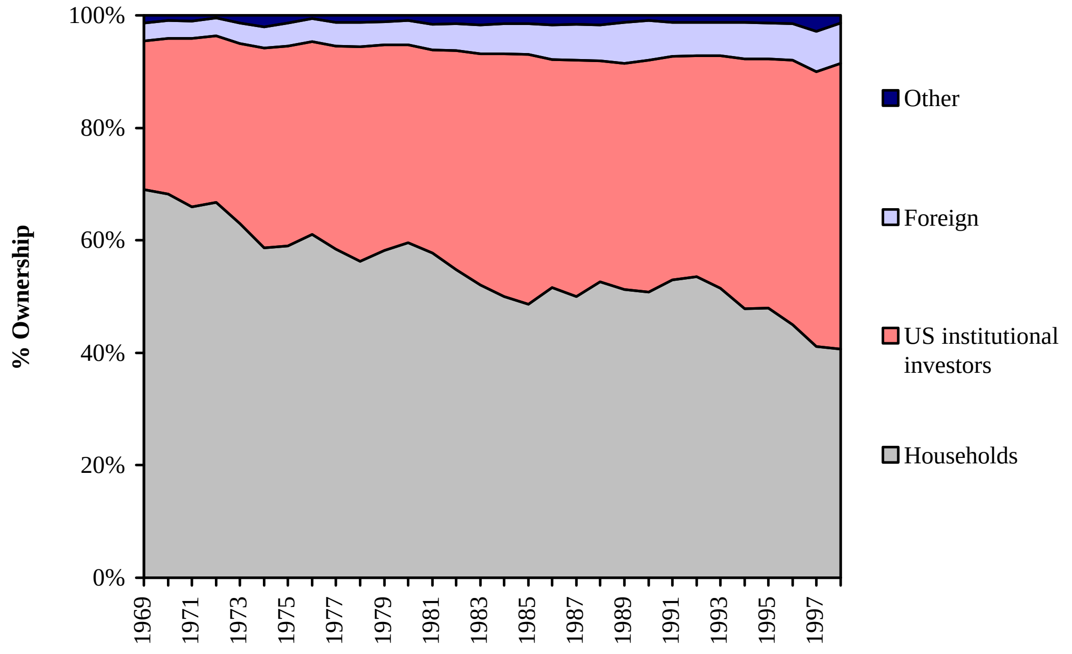
	Private pension funds	SLGE retirement funds [1]	Mutual funds	Bank personal trusts and estates [2]	Insurance companies - life & other	Total of US institutional investors	Households	Foreign
1967	6	0	5	0	3	14	82	3
1968	6	1	5	0	3	14	82	3
1969	7	1	5	10	3	26	69	3
1970	8	1	5	10	3	28	68	3
1971	9	2	5	11	4	30	66	3
1972	9	2	4	10	5	30	67	3
1973	10	2	4	11	5	32	63	4
1974	12	3	4	12	5	36	59	4
1975	13	3	4	11	5	35	59	4
1976	12	3	4	10	5	34	61	4
1977	13	3	3	11	5	36	58	4
1978	15	3	3	11	6	38	56	4
1979	15	3	3	10	6	37	58	4
1980	15	3	3	9	5	35	60	4
1981	16	3	3	9	6	36	58	5
1982	18	4	3	8	6	39	55	5
1983	19	5	4	8	6	41	52	5
1984	20	5	4	8	6	43	50	5
1985	21	5	5	7	6	44	49	5
1986	18	5	6	6	5	40	52	6
1987	18	6	7	6	5	42	50	6
1988	16	7	6	6	5	39	53	6
1989	15	8	7	5	5	40	51	7
1990	16	8	7	5	5	41	51	7
1991	15	8	6	5	5	40	53	6
1992	15	8	7	4	5	39	53	6
1993	15	9	10	3	5	41	51	6
1994	16	9	11	3	6	44	48	6
1995	15	9	12	3	5	44	48	6
1996	15	10	15	2	6	47	45	7
1997	14	10	16	3	6	49	41	7
1998	14	10	16	3	6	51	41	7

Source: US Federal Reserve Flow of Funds data.

[1] *SLGE is 'State and Local Government Employee'.*

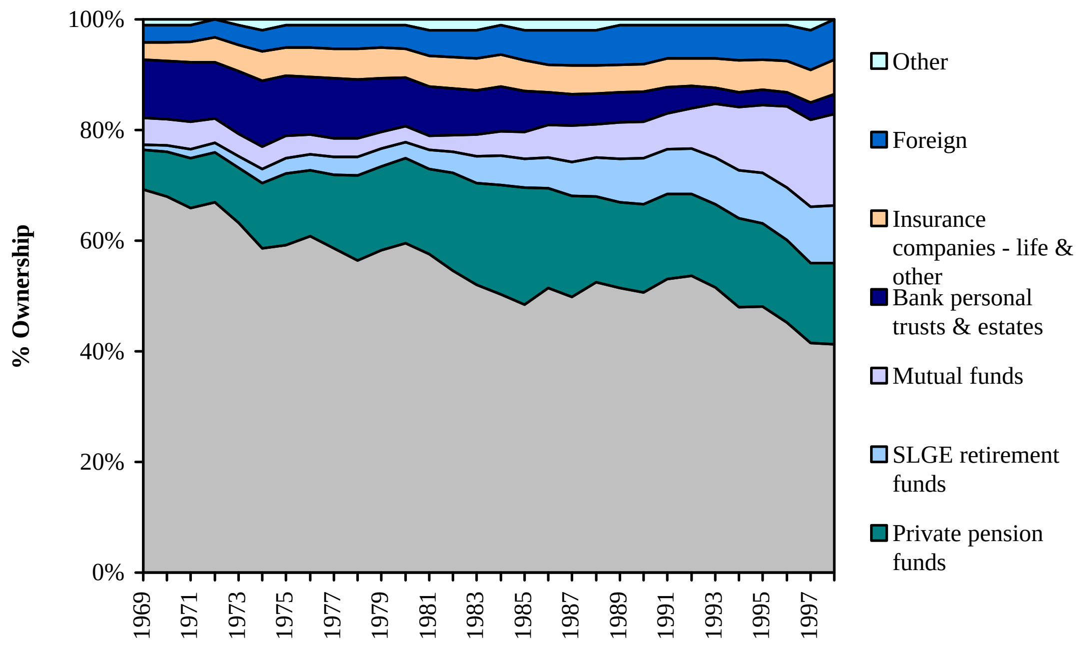
[2] *Before 1969, 'Bank Personal Trust & Estate' is not separated from 'Bank & Deposi*

Figure 2.10 % Ownership of US equity market, private versus institutional



Source: The US Federal Reserve Flow of Funds

Figure 2.11 % Ownership of US equity market, private versus institutional, by institutional type



Source: The US Federal Reserve Flow of Funds

Table 2.12 US equity holdings of financial sectors as a % of their total US financial assets

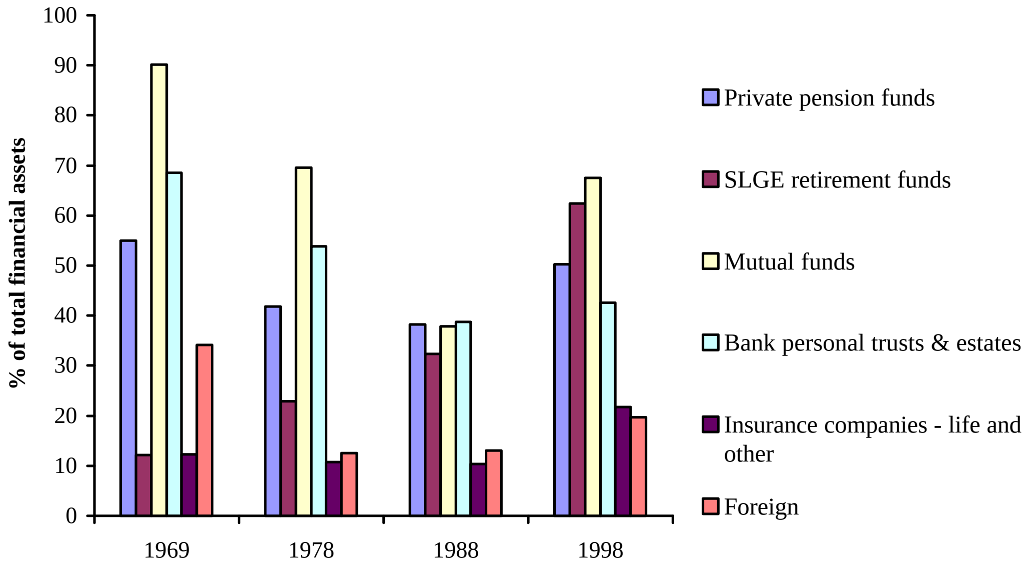
	Private pension funds	SLGE retirement funds [1]	Mutual funds	Bank personal trusts & estates [2]	Insurance companies - life and other	Foreign
1967	47	7	83	na	10	22
1968	52	9	91	na	11	33
1969	55	12	90	68	12	34
1970	54	14	85	67	11	29
1971	54	17	85	68	11	27
1972	61	22	89	69	14	24
1973	59	27	88	64	18	26
1974	52	24	81	55	14	21
1975	42	18	74	58	10	12
1976	44	23	79	59	12	16
1977	45	25	79	55	13	16
1978	42	23	70	54	11	13
1979	43	22	70	53	10	11
1980	42	22	67	55	11	11
1981	46	22	68	50	12	13
1982	41	22	62	51	11	12
1983	43	23	64	52	12	13
1984	44	30	66	48	13	14
1985	42	28	60	48	11	12
1986	41	30	46	41	12	13
1987	40	31	38	38	11	14
1988	38	32	38	39	10	13
1989	35	36	38	40	10	13
1990	37	39	43	36	11	15
1991	36	32	38	38	9	12
1992	40	38	40	34	12	14
1993	41	38	40	27	12	14
1994	43	43	44	25	14	14
1995	42	42	48	29	14	14
1996	45	50	55	30	16	15
1997	47	56	63	38	18	16
1998	50	62	68	43	22	20

Source: The US Federal Reserve Flow of Funds

[1] *SLGE is 'State and Local Government Employee'.*

[2] *Before 1969, 'Bank Personal Trust & Estate' is not separated from 'Bank & Depository Institutions'.*

Figure 2.12 US equity holdings of financial sectors as a % of their total US financial assets



Source: The US Federal Reserve Flow of Funds

Table 2.13 Net acquisition of US equities by US financial sectors ($bns)

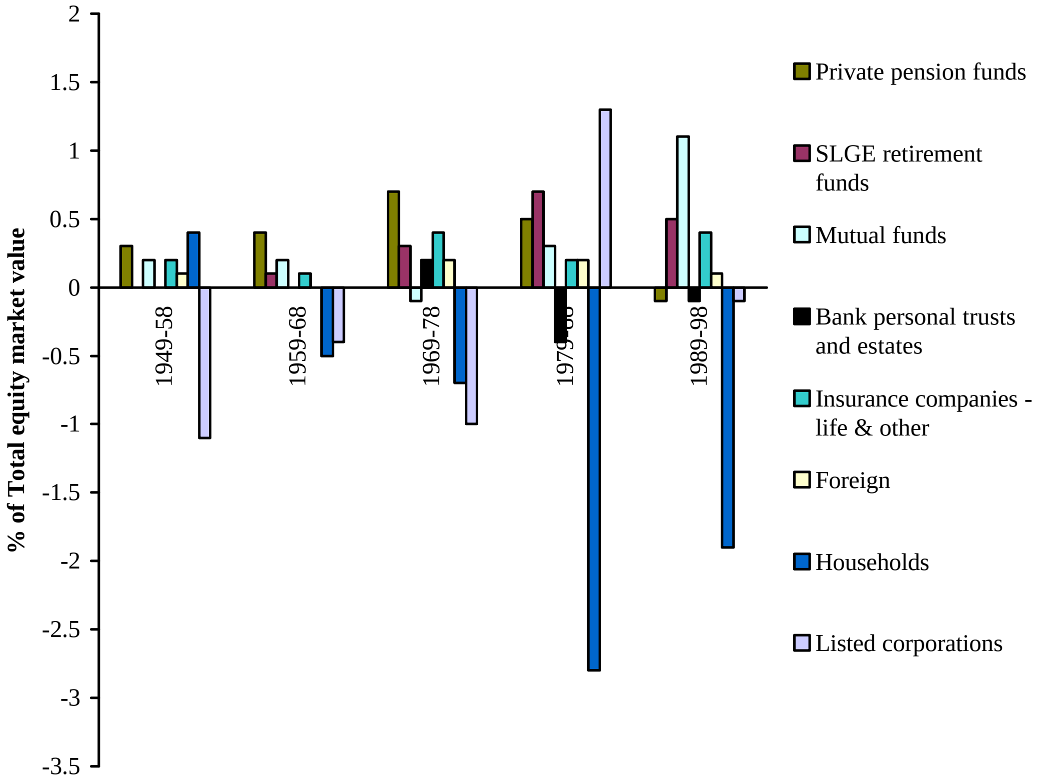
	Private pension funds	SLGE retirement funds [1]	Mutual funds	Bank personal trusts & estates [2]	Insurance companies – life & other	Foreign	Households	Listed corporations
1967	4.6	0.7	1.8	0	1.3	0.7	-5.5	-2.9
1968	4.8	1.3	2.5	0	2.1	2.1	-10.6	-2.5
1969	5.4	1.8	1.8	8.1	2.3	1.6	-15.7	-6.5
1970	4.6	2.1	1.2	0.8	2.6	0.7	-4.4	-6.3
1971	8.9	3.2	0.4	6.6	6.5	0.8	-11.7	-15.7
1972	12.1	3.7	-1.8	4.4	6.8	2.4	-13.8	-14.2
1973	4.1	3.4	-2.2	7.4	5.7	2.8	-10.5	-13.7
1974	1.8	2.6	-0.4	1.8	1.4	0.2	-3.5	-5.2
1975	7.5	2.4	-0.9	-9.6	1.4	3.1	5	-7.8
1976	6.3	3.1	-2.4	0.4	4	0.9	3.6	-12.6
1977	8.1	3.7	-3.7	0.2	2.3	1.3	-7	-5
1978	9.8	2.6	-1.6	0.9	1.9	1.3	-12.1	-3
1979	13.3	4.1	-2.8	-6	3.6	1	-17.3	4.4
1980	16.4	5.3	-1.8	-7.2	3.5	4.2	-4.3	-14.5
1981	17.3	7.1	-0.6	2.2	4.4	4.8	-45.1	10.4
1982	21.9	6	3.5	-8.2	5.1	3.7	-24.1	-7.6
1983	7.1	20	13.7	-5.9	5.5	5	-22.6	-26.7
1984	-4.8	7.3	5.9	-4.9	-4	-3.4	-66.6	72.6
1985	10.6	28.6	10.3	-12.8	2.8	4.4	-111.2	65
1986	-12.6	24	20.2	-31.7	-2.4	17.9	-87.9	65.9
1987	-0.2	31.8	26.9	-4.8	8.4	15	-132.5	57.2
1988	5.6	21	-16	-5.2	0.2	-2.9	-111.2	102.6
1989	-38.9	2.9	1.2	-5.2	17.6	9	-84.3	98
1990	-4.4	13.2	14.4	0.5	-12.7	-16	-26	37.7
1991	6.9	31.2	48.5	-8.6	15.8	10.4	-33.3	-76.9
1992	30.8	21	59.8	-37	12	-5.6	23.6	-105.4
1993	14.9	44.3	115.3	-55.2	37.1	20.9	-55.6	-137.7
1994	-1.7	29.3	100.8	-8.8	62.9	0.9	-159.8	-24.6
1995	5.9	41.3	87.4	1.6	18	16.6	-192	3.5
1996	-9.6	52.2	193	-17.3	35.3	11	-281.5	7
1997	-16.1	53.5	166.8	72.3	95.2	64.2	-513.9	79
1998	-52.7	65.7	143.5	45.9	87	42.5	-500	178.4

Source: The US Federal Reserve Flow of Funds

[1] *SLGE is 'State and Local Government Employee'.*

[2] *Before 1969, 'Bank Personal Trust & Estate' is not separated from 'Bank & Depository Institutions'.*

Figure 2.13 Net acquisition of US equities by US financial sectors – 10 year average annual flows as a percentage of total equity market value



Source: The US Federal Reserve Flow of Funds

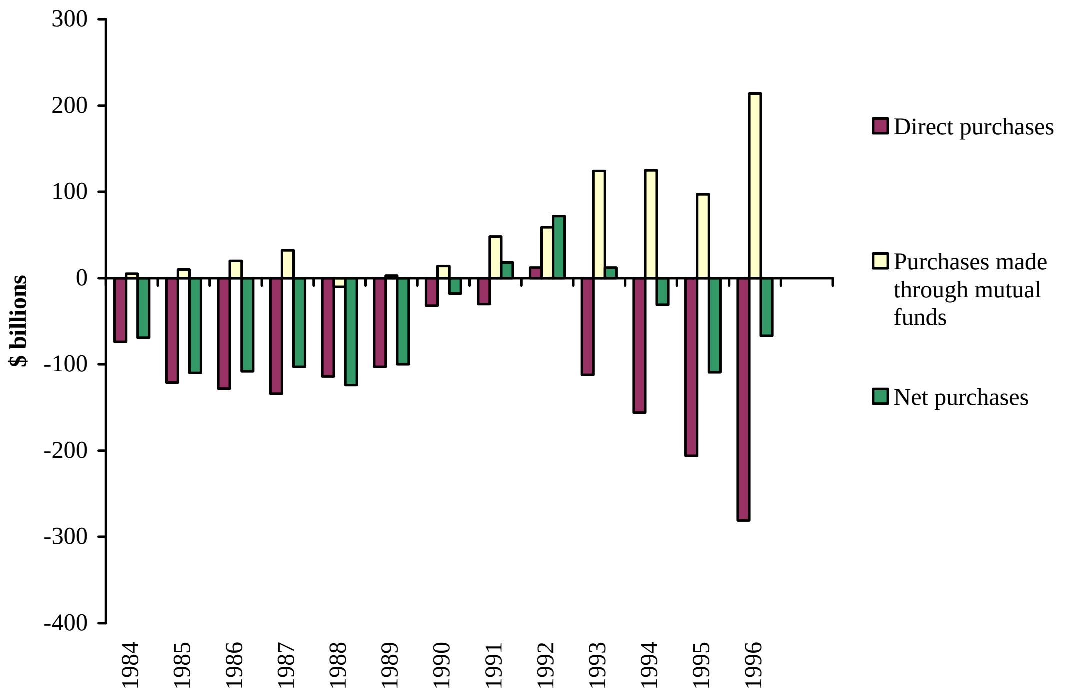
Table 2.14 Acquisition of US equities by US households ($bns)

Year	Direct purchases	Purchases made through mutual funds	Net purchases
1984	-74	5	-69
1985	-121	10	-110
1986	-128	20	-108
1987	-134	32	-103
1988	-114	-10	-124
1989	-103	3	-100
1990	-32	14	-18
1991	-30	48	18
1992	12	59	72
1993	-112	124	12
1994	-156	125	-31
1995	-206	97	-109
1996	-281	214	-67

Source: Investment Company Institute, Mutual Fund Fact Book 1996

Note: The data series of the net purchase of equities by US households in this table does not precisely match that of table 2.13 which is derived from the more authoritative US Federal Reserve Flow of Funds data.

Figure 2.14 Acquisition of US equities by US households ($ bns)



Source: Investment Company Institute, Mutual Fund Fact Book 1996

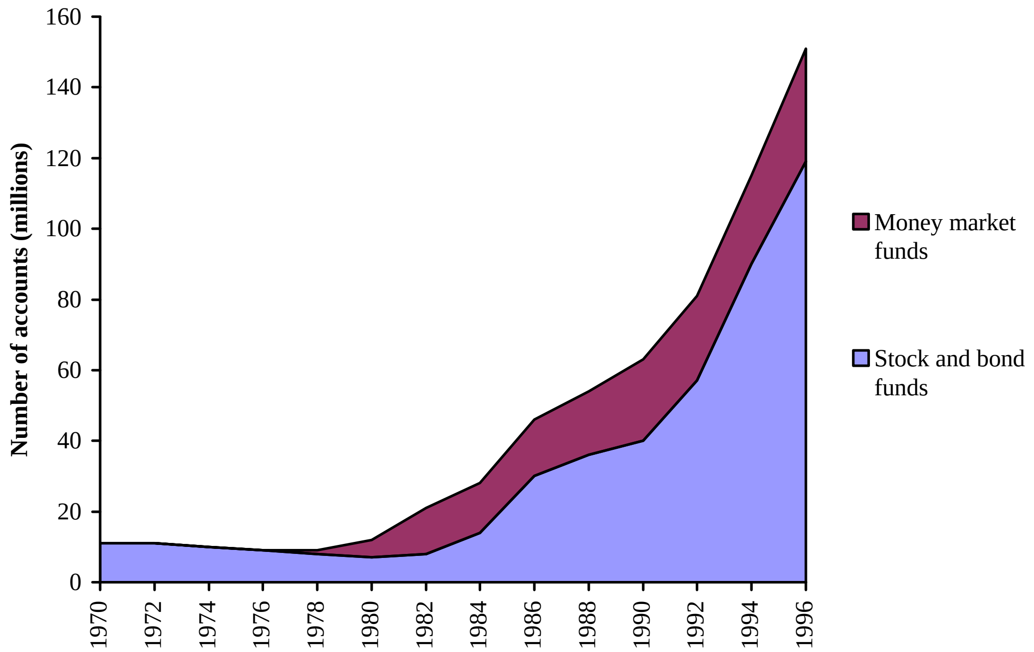
Table 2.15 Number of US mutual fund shareholder accounts (millions)

Year	Stock and bond funds	Money market funds[1]
1970	11	n/a
1972	11	n/a
1974	10	0
1976	9	0
1978	8	1
1980	7	5
1982	8	13
1984	14	14
1986	30	16
1988	36	18
1990	40	23
1992	57	24
1994	90	25
1996	119	32

Source: Investment Company Institute, Mutual Fund Fact Book 1996

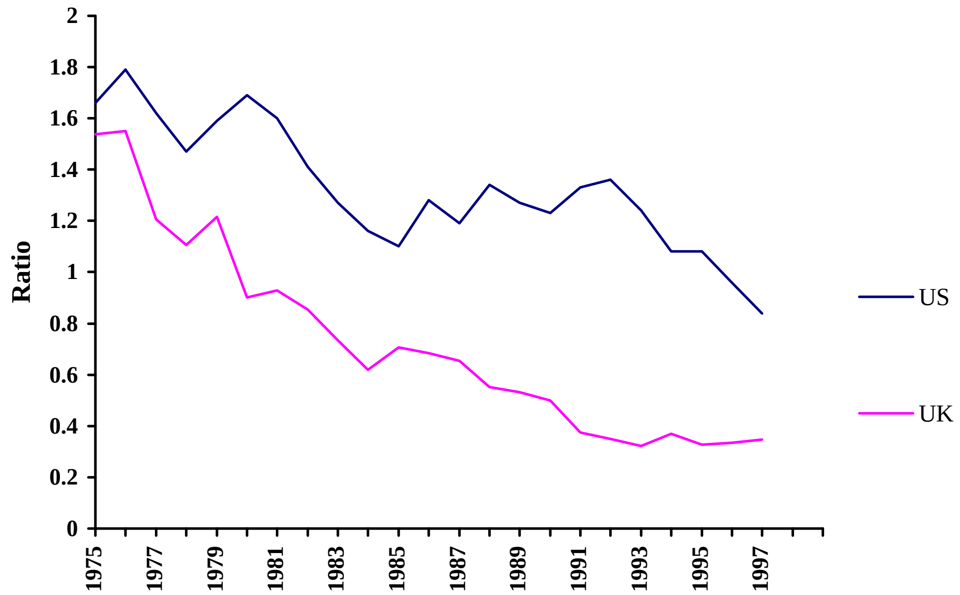
[1] *Money market funds came into existence in 1973.*

Figure 2.15 US mutual fund shareholder accounts



Source: Investment Company Institute, Mutual Fund Fact Book 1996

Figure 2.16 Ratio of household domestic equity holdings to institutional domestic equity holdings in the UK and the US



Source: Office for National Statistics – Financial Statistics
The US Federal Reserve Flow of Funds

Chapter 3 Fund Manager Herding

3.1 Introduction

Why do we care whether fund managers ‘herd’ in their purchases and sales of financial assets? A principal reason is that herding is evidence that institutional investors behave differently from private investors. Previous empirical studies of herding have sought to determine whether institutional investors, by trading in the same direction at the same time, move asset prices away from ‘fundamental’ values.[38] However, a separate motivation is that empirical findings of herding are evidence that the market can be clustered into groups of investors which are delineated by their different trading behaviour.[39]

Private investors and institutional investors seem to be two such distinct groups. A simple example can illustrate one major difference between them - incentives. Suppose a private investor and a fund manager each hold 4 percent of their respective portfolios in a particular stock which realises a return of 150 percent over a period. For the private investor the stock contributes a 6 percent increase to end of period wealth, in direct proportion to the initial weight of the stock in the portfolio. The effect of the stock return on the fund manager’s end of period wealth is more complicated. Firstly, it will be non-linear in the excess-to-benchmark return of the stock; because even though management fees generally increase linearly with the size of the fund, there is a non-linear relationship between a fund’s excess-to-benchmark return and the flow of new money to the fund.[40] Secondly, the scale of a large fund can make the manager’s end of period wealth (or investment firm value) highly sensitive to returns achieved.

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[38] See Lakonishok, Shleifer and Vishny (1992b), Grinblatt, Titman and Wermers (1995), Wermers (1995, 1999), Kodres and Pritsker (1995).

[39] A condensed version of this essay exists as a working paper Wylie (1996b).

[40] See Orphanides (1996), Chevalier and Ellison (1997a), Khorana (1996), Rockinger (1995), Sirri and Tufano (1992), Zeckhauser, Patel and Hendricks (1991).

The point of this example is that since institutional investors face fundamentally different incentives from those of private investors they can be expected to behave differently. It is surprising then that finance theory does not put more emphasis on the existence of groups of investors that differ in their investment and trading behaviour. Most portfolio management and investment theory assumes that the gain to the representative investor is simply the increase in value of the portfolio held - which implicitly assumes that the representative investor is not an institutional investor. Consider, for example, the investor in the CAPM or the informed trader in the Kyle model of market microstructure. Clearly neither are institutional investors because their end of period wealth changes in direct proportion to the total return on the financial assets held.[41]

To better comprehend the market equilibrium we need to know whether investors can be clustered into groups (such as private investors and institutional investors) by their trading behaviour. The manner in which such groups interact with each other may be central to understanding phenomena such as: overshooting in asset prices; net trade between groups arising from dynamic insurance of the different risks they face; and differences in investment performance of the groups as a result of net trade and aggregate provision of insurance. In this context the importance of herding studies is that a test for herding by a group of investors constitutes a test of whether the group's trading behaviour is significantly different from that of the rest of the market[42].

Herding by a group of investors is generally taken to mean that individual investors do not act solely on the basis of their private information, but instead, give some precedence in their decision-making to the decisions of other members of the group, and consequently the members of the group act in concert. Empirical studies have focused on herding among fund managers, rather than other groups of investors. The characteristics of a group of investors that are identified by herding theory as causes of herding, such as correlated information signals or relative performance evaluation, are assumed in the existing literature to be found predominantly in institutional

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[41] Brennan (1993) addresses this issue in the CAPM framework.

[42] Brown and Goetzmann (1997) form US mutual fund managers into 'style' groups by a method which is analogous to k-means cluster analysis.

investors rather than private investors. Moreover, as a practical matter little data is available on the trading behaviour of other groups of investors.

The Lakonishok, Shleifer and Vishny (LSV 1992b) measure of herding is based on the degree to which investors in the group trade on the same side of the market, as compared to that which would be expected by pure chance. LSV find weak evidence of herding among US equity pension fund managers, with more herding in small market capitalisation stocks[43]. Using the LSV measure, Grinblatt, Titman and Wermers (GTW 1995) find stronger evidence of herding by US mutual fund managers in stocks that are traded by large numbers of managers in a period. Wermers (1999), using 20 years of US mutual fund data finds evidence of herding by US mutual funds, but little variation in the herding level with the number of managers trading the stock in a period. Choe, Kho and Stulz (1999) use the LSV measure to study herding by foreign investors in the Korean equity market in 1997. They find very large levels of herding for some subsets of the data.

Wermers (1995) develops a different measure of herding based on the correlation between the portfolio weight changes of two randomly formed sub-groups of the investors. The Wermers measure applied to the GTW mutual fund data also measures substantial levels of herding, which increases with the number of funds trading. Kodres and Pritsker (1995) examine herding in the futures market and find that institutions herd in their holdings of futures contracts, but the herding does not explain a large part of the changes in their positions.

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[43] Empirical studies of the existence of fund manager herding began with the Friend, Blume and Crockett (1970) study of mutual funds which found, for the brief period studied, that managers buy stocks that were previously bought by successful managers. Kraus and Stoll (1972) examined the monthly trades of 229 institutional investors between January 1968 and September 1969. They reported large monthly net trade, in some stocks, between the group of institutional investors and the rest of the market. Klemkosky (1977) examined the relationship between the net trades of a group of large institutional investors and the returns of securities before and after the measured period. He found evidence of herding by institutional investors that was consistent with ‘overshooting’ of stock prices; the herding was manifested in net buying of stocks that had recently risen in price and net selling of stocks that had recently peaked in price.

The studies of LSV, GTW and Wermers suggest that herding measures can identify: groups of investors whose trades are significantly correlated; the types of stocks in which this herding occurs; and intertemporal effects such as feedback trading (positive serial correlations in the portfolio weight changes of a single group) and cascades (positive serial cross-correlations in portfolio weight changes between two groups). Measures of herding appear to have a broad application in studies of the dynamic equilibrium of the market. A clear finding of the empirical studies is that groups of fund managers, particularly mutual fund managers, can be separated from the rest of the market by their trading behaviour.

In order to obtain an expected value of zero in the absence of herding the LSV and Wermers measures are constructed with strong implicit assumptions. However, as shown in the next section some of these assumptions are not sustained in real datasets. It is counterfactually assumed that all managers may short sell all stocks. Further it is assumed that when a manager trades a certain stock in a period, the ex ante probability of the manager buying rather than selling that stock is not dependent on either the manager's initial weight in the stock or the amount of new money that the manager must invest during the period.

The primary purpose of this study is to determine whether the empirical herding literature is well founded by testing whether the principal measures of herding are accurate. That is, whether those measures find a statistically and economically significant level of herding where no herding exists. Or if herding does exist, whether the measures substantially overstate the level of herding present.

Ideal data for a test of the accuracy of herding measures would be a large number of independent datasets of trading decisions, drawn from a group of investors, that is known to exhibit no herding. Applying the herding measure to each such dataset would create an estimate of the sampling distribution of the herding measure under conditions of zero herding. The herding measurements on the independent datasets would allow estimates of, firstly, the probability of a false positive finding of herding, and secondly, the expected value of the herding measure in the absence of herding. A feasible alternative approach is to start with an actual dataset of the net trades of a group of investors, and from it, randomly create independent datasets which exhibit approximately zero systematic herding.

In this study a dataset of the portfolio holdings of 268 UK equity unit trusts, in the period January 1986 to December 1993, is employed to test the accuracy of the herding measures of LSV and Wermers (1995). The required zero herding datasets are formed by re-sampling from the actual dataset. The re-sampling techniques, principally bootstrapping, are designed with the objective of maintaining in the new datasets as much of the essential characteristics of the actual dataset as possible, whilst still eliminating all systematic herding. To separate the effect of different invalid assumptions on the accuracy of the herding measures, various re-sampling techniques are implemented to produce datasets in which the different invalid assumptions are relaxed.

The LSV measure is first applied to the actual dataset, *without adjustment for inaccuracy*. A significant amount of herding is found which is increasing in the number of funds that trade the stock during the period. The measured level of herding is higher for the smallest and the largest market capitalisation stocks. For the subset of the data where 20 or more managers traded the stock over the particular period, the level of herding is commensurate with an average of between 13 and 14 of 20 managers trading on one side of the market.

The first accuracy test examines the effect of the invalid short sales assumption which is implicit in the LSV measure. On 1,000 datasets, constructed to exhibit no short selling and approximately zero systematic herding, the LSV measure finds an average level of herding which is positive and large in certain categories of stocks. That is, when short selling is ruled out the LSV measure is not calibrated to zero.

For stocks that lie, in market capitalisation, between the largest and smallest stocks, much of the herding found can be attributed to the false LSV assumption that all fund managers can sell stocks short. Moreover, about a third of the herding found in the smallest market capitalisation stocks is attributable to the LSV short selling assumption. Nonetheless, the herding levels found in the UK dataset exceed the 95th percentile of the sampling distribution in every major subset of the dataset.

The Wermers measure, when applied to the actual trading decisions of UK equity mutual fund managers finds a surprisingly strong level of herding in some subsets of the data. For example, when the funds are randomly divided into two groups and formed into two value weighted portfolios, in the subset of the dataset where 15 or more managers trade a stock during a period, the sample ‘correlation’ between weight changes in the portfolios is 0.24.

The accuracy of the Wermers measure is similarly tested by transforming the data to eliminate systematic herding. To test for the effect of mis-specification of the test for correlation, bootstrap re-sampling of the portfolio weight changes in each observation is undertaken. Results from 200 replications show that, for large stocks and where more than 10 managers trade a stock in a period, the Wermers measure is substantially biased towards finding herding and severely overstates the level of herding in the actual dataset. Nonetheless, when the results of applying the Wermers measure to the actual dataset are compared to the estimated zero herding sampling distribution, the hypothesis of no herding among the UK equity unit trust managers is again rejected.

With this study of herding among equity mutual fund managers in a large market outside the US, the results of the empirical herding literature are made more general. Herding is found where a large proportion of the managers trade a stock, and in their trading of largest and smallest stocks. The foundation of the empirical herding literature is strengthened because in this study the distribution of the herding measures under the null assumption of no herding is estimated empirically rather than simply assumed. Finally, the techniques developed here for re-sampling datasets of trading decisions can easily be adapted to empirically estimate the sampling distribution of other measures based upon portfolio holdings data, such as, measures of fund manager performance, window dressing or performance persistence.

3.2 Types of herding

A natural approach to the analysis of herding is to begin with the individual investors’ decisions to trade and then search for forces that align or polarise their actions to create the aggregate effect of herding. Fund managers face a stochastic dynamic optimisation problem which we can assume for simplicity is solved once every period. The manager seeks to maximise an objective function, such as expected utility of end of period wealth or the value of the investment management firm, by choosing stocks from the choice set, subject to constraints such as no short sales. The information set of the manager is processed to estimate the moments of stock returns, which along with initial conditions are the input to the objective function.

There are several explanations for the existence of fund manager herding, each of which derive from a part of the manager's optimisation problem.[44] Firstly, relative performance evaluation of managers causes the portfolio holdings of one manager to enter the objective function of another manager, which in turn may lead to positive correlation between the trades of managers. Scharfstein and Stein (1990) argue that when the quality of managers' decisions are assessed, then for the same payoff to the principals, a consensus decision is taken to be a stronger signal of quality than a contrarian decision. Maug and Naik (1996) show that a manager whose payoffs depend on returns which are measured relative to the return on assets held by other managers, may choose to ignore some private information and herd with the other managers.

Secondly, positive correlation of the trading decisions of managers can arise from overlap in their information sets. Models by Brennan (1990), Froot, Scharfstein, Stein (1992) and Hirshleifer, Subrahmanyam and Titman (1994) recognise that when valuing private information investors consider the probability that the information will be incorporated into the price of the asset within their investment horizon. This effect may lead managers to research the same stocks and therefore derive their estimates of stock return moments from partially correlated private information sets.

Thirdly, managers may augment their information sets with inferences from the trades of those other managers who are perceived to be informed. Bikhchandani, Hirshleifer and Welch (1992) provide the seminal ideas for herding theories based on

[44] Devenow and Welch (1996) comprehensively review herding theory and provide a similar categorisation of herding theory.

local conformity. Banerjee (1992) applies these ideas to explain herding as an informational cascade. In addition, fund managers may take decisions on the basis of the same public information. In particular, they may follow the same strategies based on public information, such as momentum, contrarian or earnings surprise strategies.

Mathematical definitions of herding implied by the herding theories are set out in equations 3.1, 3.2 and 3.3 below. If herding arises from relative performance evaluation then the portfolio weight changes of individual managers should be positively correlated with the changes of the other managers after conditioning on overlapping information sets. In contrast, if herding arises from informational cascade then positive conditional correlation should be found only between individual managers and other managers that are perceived to be informed. If correlated information sets are the sole explanation of herding, then the portfolio weight changes of individual managers should be unconditionally correlated with the aggregate changes of the remaining managers but, after conditioning on the shared information, the correlation should be zero.

Equation 3.1

Relative performance evaluation

$$\operatorname{corr}\left[\Delta w_{it}^{j}, \Delta w_{it}^{u} \middle| I_t\right] > 0$$

Equation 3.2

Informational cascade

$$\operatorname{corr}\left[\Delta w_{it}^{j}, \Delta w_{it}^{u'} \middle| I_t, \Delta w_{it}^{u''}\right] > 0 \qquad (3.2a)$$

$$\operatorname{corr}\left[\Delta w_{it}^{j}, \Delta w_{it}^{u''} \middle| I_t, \Delta w_{it}^{u'}\right] \leq 0 \qquad (3.2b)$$

Equation 3.3

Correlated information

$$\operatorname{corr}\left[\Delta w_{it}^{j}, \Delta w_{it}^{u}\right] > 0 \qquad (3.3a)$$

$$\operatorname{corr}\left[\Delta w_{it}^{j}, \Delta w_{it}^{u} \middle| I_t\right] = 0 \qquad (3.3b)$$

Where Δw_{it}^{j} = the change in portfolio weight of manager j, in stock i, in period t

Δw_{it}^{u} = the change in portfolio weight of the full group of managers (excluding manager *j*), in stock *i*, in period *t*

$\Delta w_{it}^{u'}$ = the change in portfolio weight of the sub group of managers perceived to be informed (excluding manager *j*), in stock *i*, in period *t*

$\Delta w_{it}^{u''}$ = the change in portfolio weight of the sub group of managers perceived to be uninformed (excluding manager *j*), in stock *i*, in period *t*

I_t = the union of managers' information sets for stock *i* to the end of period t (other than portfolio change information).

There are, however, other means by which the trading of fund managers may become correlated, which are apparent when herding is considered in a framework of the portfolio choice problem of individual managers, but are not generally considered to be herding. Firstly, changes in the opportunity set faced by managers can induce them to trade in the same direction. Consider for example small stocks. Because fund managers on average hold more than the market weight in larger stocks, as small stocks get larger there is a net flow of these stocks from private investors to institutional investors.[45] These trades are clearly correlated across managers. Another example is dividend yield. When the yield of a previously low yielding stock rises sufficiently, the stock moves into the domain of income managers who may then buy the stock in concert. Secondly, changes in the scale of the optimisation problem faced by individual managers may lead to correlated trading. Fund managers who hold those stocks which realised high abnormal positive returns in the previous period receive more of the new money in the current period, and therefore have a liquidity need to buy. If these managers maintain their existing portfolio weights by investing the new money in stocks that they already hold, then they will on average trade in the same direction.[46]

Changes in the issued capital of a stock are another form of variation in the managers' opportunity set. IPOs, seasoned equity issues, stock repurchases,

[45] See Lakonishok, Shleifer, Thaler and Vishny (1991)

[46] Wermers calls this a scale effect.

delistings etc., generate positively correlated trading which is an illusion of herding. Fortunately, in portfolio holdings data observations surrounding equity issues, stock buy-backs, capital payouts and birth and death of stocks can be ignored, and the effects of other capital changes can be routinely undone.

To summarise, correlated trading arising from the polarisation of the trading decisions of individual managers may be of three types. Firstly, managers making their decisions on the basis of other managers' decisions because of relative performance evaluation or informational cascade. Secondly, positive correlation between managers' decisions as a result of overlapping private or public information sets. These sources of correlated trading are considered to be herding because they result from managers' cognisance of the actions of other managers when making their trading decisions. Finally, correlated trading arises from the market artefacts of changes in the characteristics of stocks and changes of scale in the holdings of some managers. These effects are not considered to be herding and must be controlled for in accurate measures of herding.

From an experimenter's perspective, a manager's portfolio choice decision for each stock, in each period, is the realisation of a stochastic process, the exact form of which is unknown. Portfolio holdings datasets record these realisations in panels of data, one for each date, which show how many shares in each stock were held by each fund at that date. The task in measuring herding is to test for independence of the trading decisions of managers whilst controlling for effects that are not herding, and if independence is rejected, then to summarise the degree of joint dependence between the trades of the managers in the group. The herding measure of LSV and Wermers employ non parametric methods for this purpose.

3.3 The LSV herding measure

LSV simplify the task by transforming the managers' portfolio choice decision for a stock to an ordered categorical variable, which takes one of three outcomes; either *buy, hold* or *sell*. The basic unit of data is a stock-period-manager observation, denoted here by x_{it}^{j}, which records whether stock *i*, in period *t*, was either bought, held or sold by manager *j*. From the experimenter's perspective, the probability distribution of this trichotomous variable may be conditioned by several other variables, including: the manager's information set; the observed trading decisions of other managers; the manager's initial holding in the stock; and the amount of new money that the manager must invest.

LSV consider only those observations where the outcome is a buy or a sell. This conditioning on the occurrence of a trade reduces the observed trading direction to the outcome of a Bernoulli trial. LSV further assume that Prob(X_{it}^{j} = buy | X_{it}^{j} = buy or X_{it}^{j} = sell), denoted here by p_{it}^{j}, is a constant, p_t, for any random variable x_{it}^{j} in period t. That is, conditional on a trade occurring, the probability that the outcome is a buy (the propensity to buy) is the same for the trading of all managers, in all stocks, in any one period. It is further assumed that, in the absence of herding, each of the Bernoulli trials is independent of all other trials. Under these assumptions, if n_{it} is the number of managers who trade stock *i* in period *t*, and b_{it} is the number of managers who buy the stock, then b_{it} is the outcome of a random draw from a binomial distribution with probability parameter p_t and dimension n_{it}.

The LSV test of herding rests upon the following proposition. In the absence of herding the expected number of managers who buy a stock in a period, as a proportion of those who trade that stock, has the same value, p_t, for all stocks. If significant cross sectional variation in this proportion is found, then the null of no herding can be rejected. The herding in stock *i*, in period *t*, is measured as follows.

Equation 3.4

$$H_{it}^{lsv} = \left| \frac{b_{it}}{n_{it}} - r_t \right| - E\left[\left| \frac{b_{it}}{n_{it}} - r_t \right| \right]$$

Where E is the expectation operator

ρ_t is the sample estimate of the probability parameter p_t, where $\rho_t = \Sigma_i b_{it} / \Sigma_i n_{it}$.

The value $| b_{it}/n_{it} - \rho_t |$ is the magnitude of the difference between the observed ratio of buys to trades and the expected value of that ratio under the null of no herding. This magnitude will be large if the trading of managers is polarised in the direction of either buying or selling. The estimated variance of the herding statistic in one stock-period, $VarH_{it}$, is easily calculated from the values of b_{it} , n_{it} and ρ_t. The overall herding statistic H^{lsv} is simply the average of the herding statistic over all stock-periods of interest.

Equation 3.5

$$H^{lsv} = \frac{1}{T}\sum_{t=1}^{T}\sum_{i=1}^{N_t}\frac{H_{it}}{N_t}$$

Where N_t is the number of stocks considered in the period t

T is the number of periods.

Under the LSV null, this statistic is approximately normally distributed (by the Lindberg-Feller version of the Central Limit Theorem) with variance as per equation 3.6. Hypothesis testing is therefore straightforward.

Equation 3.6

$$VarH^{lsv} = \frac{1}{T^2}\sum_{t=1}^{T}\sum_{i=1}^{N_t}\frac{VarH_{it}}{N_t^2}$$

The several different sources of herding predicted by herding theory are captured by this measure. If relative performance evaluation or informational cascade induce positive correlation between the trades of the managers, then the variance of b_{it} is greater than the null condition variance of $n_{it}\, p_t\, (1-p_t)$. Otherwise, if the information sets of individual managers are correlated, then the expected value of b_{it} is conditioned on that information.[47] In each case unexpectedly large numbers of managers trading in one direction will be found.

However, the LSV measure should be expected to find herding where none exists for two reasons. Firstly, H_{it} is calculated using the sample quantity ρ_t rather than its population counterpart p_t. Therefore, $E[H_{it}]$ is not zero, which means that the CLT is not applicable. Moreover, because of the absolute value operation, both positive and negative values of $(\rho_t - p_t)$ can lead to positive bias in H_{it}; meaning that the estimation error need not go to zero as we average H_{it} across stocks and dates.

Secondly, the LSV measure starts with the observations where a trade is known to have occurred and the random outcome of interest is whether the manager bought or alternatively sold the stock in the period. But the beginning of period holding in the stock is also known. Therefore, it is implicitly assumed that all managers can short sell all stocks because otherwise in those observations where the initial holding is zero, the manager's decision is not a random outcome   it must be a buy.[48]

The short sales constraint restricts the number of 'sell' occurrences in a stock-period to be no more than the number of managers who initially hold the stock. In terms of the distribution of $b_{it,}$ the short sales constraint imposes a left truncation. In contrast, the LSV measure is calculated assuming a binomial distribution of b_{it}. Therefore, on real datasets drawn from groups of managers, few if any of whom can undertake short sales, the expected value of the LSV measure need no longer be zero. If none of the managers who trade in a stock-period initially hold the stock then all the trades must be buys, so the measure must return a non-negative value. However, in other cases where some managers have positive initial holdings, the short sales constraint can lead to an expected value of the LSV measure which is negative in the absence of herding, because the truncation reduces the overall probability mass in the tails of the distribution of b_{it}.

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[47] Changes in the characteristics of stocks, such as the transition of small stocks to large stocks are likewise manifested as changes in the expected value of b_{it}.

[48] UK unit trust managers are prohibited from undertaking short sales. US mutual fund managers may only undertake short sales if such trades are foreshadowed in the fund prospectus.

Two other reasons that the distribution of b_{it} does not have the assumed binomial distribution, even in the absence of herding, are apparent. Managers whose weight in a stock is already comparatively large at the beginning of the period are more likely to sell than other managers, because of mean reversion in portfolio weights. Further, empirical studies show that mutual fund managers who have recent high performance relative to their peers receive more of the new money to manage, as discussed at length in section 2.3. They therefore have a higher propensity to buy stocks than poor performing managers. We might therefore expect that p_{it}^{j}, the probability that manager *j* buys rather than sells stock *i* in period *t*, is conditioned by both the size of the manager's initial holding in the stock and the manager's liquidity need to buy stocks. Tests of the dataset strongly reject a hypothesis of no variation in p_{it}^{j} by manager or initial holding.[49]

When the propensity to buy varies by initial holding and/or across managers, b_{it} is no longer binomially distributed. The distribution of b_{it} is not centred on p_t, making extreme values more likely, but the variance of the distribution may be larger or smaller than in the assumed binomial distribution. The direction and size of a bias, induced by the assumptions on short selling and the variation in p_{it}^{j} by manager and initial holding, is an empirical question. The question can be addressed by estimating the sampling distribution of H^{lsv} under the null hypothesis of no herding with the invalid assumptions relaxed.

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[49] To test for variation in p_t across managers, the value of p_t is estimated for each manager in each period covered by the dataset (the dataset is described in chapter 4). The null hypothesis that p_t is the same for all managers at any particular date is rejected at the 95 percent significance level in all but two of 90 periods. To test for variation in p_t by the initial holding of managers, stock-period-manager observations for which the initial holding of the stock is positive are grouped by stock-periods. For each such group, the observations are formed into quintiles by the initial weight of the stock in the manager's portfolio. Retaining the quintile marker, the full set of observations are regrouped into the 90 reporting periods and the value of p_t is calculated for each quintile in each period. The null hypothesis of no variation in p_t by initial holding in the stock is rejected at the 95 percent significance level in all 90 periods.

3.4 Wermers herding measure

Wermers (1995) develops a herding measure which is based on the following idea. If a group of investors are randomly divided into two subgroups, then in the absence of herding the aggregate changes in portfolio weights of the two subgroups have zero correlation in each period. Wermers randomly divides the fund managers in the dataset into two groups, A and B.[50] The value-weighted vector of portfolio weights of each group is formed for each of the T+1 reporting dates. These vectors are then differenced to give T vectors of portfolio weight change for each group. The Wermers measure of herding is the average over the T periods of the sample correlation of portfolio weight changes of the two groups.

There is a powerful geometric intuition for the measure. Starting with group A, the vector of portfolio weights at any time t is a point in the n dimensional asset space, on the unit simplex. There are T such points mapping out the path taken by group A over time. The vector between any two sequential points is the portfolio change vector for that period. The same is true for group B. Under the null of no herding the direction of the portfolio change vectors of groups A and B should be unrelated. It follows that the cosine of the angle between the portfolio change vectors of the two groups in any period should have an expected value of zero. Essentially, Wermers estimates the cosine of these angles and compares their average to zero. This idea is expressed in equation 3.7, where the change in stock *i's* weight in group *j*, in period *t*, is Δw_{it}^{j}. T is the number of periods.[51] It is assumed by Wermers that the unconditional expectation of all portfolio weight changes is zero.

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[50] Wermers uses stratified random sampling to divide the two groups, controlling for families of funds and the investment objective.

[51] I simply average the cosines as in equation 4. Wermers, however, prefers to average the denominator terms and then apply this average as the scaling factor for all periods (with the stated intention of reducing the standard error of the estimate), as shown in equation 4a.

$$H^{w} = \frac{1}{T}\Sigma_t \frac{\Sigma_i\left((\Delta w_{it}^{A})(\Delta w_{it}^{B})\right)}{\frac{1}{T}\Sigma_t\left(\Sigma_i\left(\Delta w_{it}^{A}\right)^2 \ \Sigma_i\left(\Delta w_{it}^{B}\right)^2\right)^{\frac{1}{2}}} \qquad (4a)$$

Equation 3.7

$$H^W = \frac{1}{T}\sum_t \frac{\sum_i\left((\Delta w_{it}^A)(\Delta w_{it}^B)\right)}{\left(\sum_i\left(\Delta w_{it}^A\right)^2 \sum_i\left(\Delta w_{it}^B\right)^2\right)^{\frac{1}{2}}}$$

Wermers shows the conditions under which this measure is equivalent to the LSV measure. Consequently, as with the LSV measure, the accuracy of the Wermers measure may rely upon assumptions that are not sustained in real datasets. A study of the accuracy of the measure by analytical derivation of the mean of the sampling distribution under various assumptions is infeasible for several reasons. Most importantly, the portfolio weight change observations (Δw_{it}^A,Δw_{it}^B) are drawn from probability distributions the form of which are unknown and not easily modelled. However, it is clear that these distributions are conditioned by characteristics of the stock, including size, and by the beginning of period holding of each group in the stock.[52] The distributions also exhibit data truncation because of the omission of observations where one or both of the groups do not trade the stock during the period. If short sales are prohibited then the distribution from which the portfolio weight changes are drawn are left censored. Geometrically, the short sales constraint confines the portfolio weight vectors to the first quadrant of the asset space.

It is standard practice to average ratios in empirical work to reduce the effect of outliers. However, in this case the cosine terms which are averaged in equation 4 can only range from -1 to +1. There are good reasons for choosing equation 4 rather than equation 4a as the measure. Firstly, equation 4 retains the useful intuition of a null where the cosine of the angle between the portfolio changes is on average zero. Secondly, in equation 4a the terms in the time series average are clearly not independent because they share the same denominator, so straight-forward hypothesis testing based on t-values calculated from time series standard errors is not appropriate. Therefore, in this paper the Wermers measure is calculated as per equation 4.

[52] Tests for cross-sectional heteroscedasticity in the portfolio weight changes rejected the null of homoscedasticity in all periods for both groups A and B. Further, in regressions of the portfolio weight changes of group A on the portfolio weight changes of group B and the initial holding of group A, the co-efficient on the initial holding of group A is significant at the 1 percent level.

Another potential problem is the use of average prices in calculating portfolio weights. Portfolio weight changes over a period result from both changes in the number of shares held in each stock, as desired, but also from changes in prices. Changes in the price vector shift the portfolio weight vectors of groups A and B and also the market portfolio in related directions; which may create an illusion of herding. To mitigate this problem Wermers uses the same price vector to calculate both the beginning and end of period portfolio weight vectors. Mid-prices, the simple average of beginning and end of period prices, are chosen for this purpose – but other choices would be equally valid. However, it is not possible to cleanly separate quantity and price effects in weight changes derived from portfolio holdings that are recorded at discrete time points. Changes in the price vector will induce changes in portfolio holdings vectors of both groups, which may be correlated. Therefore, the use of mid-prices may lead to a positive mean for the Wermers measure in the absence of herding.

The inaccuracy in the Wermers measure arising from mis-specification of the measure of correlation, and from the use of mid-prices can be determined empirically by estimating the sampling distribution of the measure on datasets that are constructed to exhibit zero systematic herding.

3.5 Concluding remarks

A test for herding by a group of investors amounts to a test of whether that group can be differentiated from the rest of the market by it's trading behaviour. The herding measures of LSV and Wermers can capture the correlated trading of fund managers that is postulated by the three principal theoretical explanations of the existence of herding; which are, relative performance evaluation, informational cascade; and correlated information theories.

It is argued in this chapter that invalid assumptions in LSV and Wermers measures may significantly bias the measures toward finding herding where no herding exists. The LSV and Wermers measures may also record correlated trading that is not considered herding, such as, fund managers with new money scaling up their portfolios, or correlated trading arising from changing characteristics of stocks (small stocks becoming large stocks, for instance).

The next chapter employs the LSV and Wermers measures to test for herding among a group of UK unit trust managers and conducts tests of the effects of the invalid assumptions on the accuracy of these measures.

Chapter 4 Tests of the Accuracy of Herding Measures

4.1 Introduction

This is the second of two chapters which comprise the essay on tests of the accuracy of herding measures using UK data. Chapter 3 motivated the study of herding among UK unit trust managers as a test of whether those managers can be delineated from the rest of the UK equity market on the basis of their behaviour in trading UK equities.

This chapter fulfils three of the four purposes of this study. Firstly, to develop a methodology for testing the accuracy of metrics which are based on portfolio holdings data. Secondly, to apply the bootstrapping methodology to test the accuracy of existing herding measures. Thirdly, to apply the herding measures, suitably adjusted for estimated bias, to data drawn from a country which has an investment management industry comparable to that of the US; thereby, extending the generality of empirical herding results.

4.2 Data

The primary data for this study is a record of the portfolio holdings of 268 UK equity mutual funds, as contained in semi-annual reports to investors over the period January 31, 1986 to December 31, 1993.[53] For a fund to be classified as an UK equity mutual fund it must have more than 90 percent of its holdings in stocks listed on the London Stock Exchange. All other data required for the study, including prices, market-values and capital changes are taken from the London Business School's London Share Price Database (LSPD). Dimson and Marsh (1983) provides a detailed description of the LSPD.

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[53] The portfolio holdings data for this study was provided by John Morrell and Associates of London.

The dataset contains semester data, meaning that for each full year during which a fund appears in the dataset, two snapshots of portfolio holdings are recorded. UK fund managers choose the two calendar months in which they report to their investors each year, and so they declare their portfolio holdings on either a January - July cycle or a February - August cycle, etc. Each fund manager falls into one of six reporting cycles and these cycles overlap. The 268 funds (that is, 268 managers) are managed by 99 separate investment management firms. The average size of each fund is £93 million. Tables 4.1 to 4.6, at the end of this section, provide a further description of the data.

The basic unit of variation in this study is a manager's holding in a particular stock on a particular date. The dataset is composed of 96 panels of data, being one for each month between January 1986 and December 1993 inclusive. These panels record 237,185 non-zero portfolio entries across all stocks, periods and managers. Of those records, 685 could not be matched to the LSPD dataset and were consequently excluded. There were 3,469 'cash' records which were deleted. The 95 records of stocks holdings of less than 100 shares were deleted because they were unlikely to help extend our understanding of herding by UK fund managers. Then 2,151 occurrences, of a single stock appearing more than once in a single portfolio, were consolidated into a single holding.

Next, the portfolios of each manager at sequential dates were differenced to determine whether a particular stock was *bought* (from an initial holding of zero), *increased* (from a positive initial holding), *held*, *decreased* or *sold* (leaving a holding of zero). In this process of determining the direction of trades, the dataset has been adjusted to ensure that basic changes to the opportunity set of fund managers, resulting from capital changes of stocks, are not measured as herding. The effects of stock splits and scrip issues on prices and number of shares held are reversed using weights that are calculated for this purpose in the LSPD. Stock-periods that coincide with equity issues, stock buy-backs or capital payouts are deleted. There were 14,741 such occurrences. Finally, stock-periods that cover a period that begins or ends within six months of the birth or death of a stock are also removed. There were 10,708 such occurrences. What remains are 234,689 records comprised of 41,774 buys, 42,774 increases, 78,369 holds, 32,982 decreases, and 39,287 sells. These figures do not include the observations of a manager beginning and ending a period with a zero holding in a stock – the vast majority of observations.

The dataset includes UK equity mutual funds that existed in December 1992. It is conceivable that studying only the survivors creates an illusion of herding because the survivors are more likely to have avoided strategies that led to termination or merger of other funds. With a dataset of portfolio holdings of 274 US equity mutual funds over a 10 year period, Wermers finds that the herding results are much the same whether or not the dataset includes only funds that survived the entire period. It therefore appears that survivorship bias is not an important issue in studies of herding by mutual fund managers.

Empirical tests of herding require data on the purchases and sales of financial assets by fund managers. Unfortunately, large datasets on the transactions of fund managers are not readily available. Instead the beginning and end of period holdings of mutual fund managers are differenced to reveal the net transactions over each period. The net transactions proxy for the actual transactions. Obviously if a trade is partially or wholly reversed within the reporting period then the complete transaction is not captured.

Table 4.1 Number of trusts reporting at each date

Beginning date of period	Reporting cycles						Total
	Jan-July	Feb-Aug	Mar-Sep	Apr-Oct	May-Nov	Jun-Dec	
31-Jan-86	15	21	27	33	21	16	133
31-Jul-86	17	22	34	34	24	18	149
31-Jan-87	18	26	40	39	30	20	173
31-Jul-87	20	31	42	40	31	23	187
31-Jan-88	22	30	47	44	37	26	206
31-Jul-88	25	33	49	47	37	29	220
31-Jan-89	27	37	52	48	39	31	234
31-Jul-89	30	39	53	50	40	34	246
31-Jan-90	31	40	56	49	42	35	253
31-Jul-90	32	44	56	49	41	36	258
31-Jan-91	33	43	56	49	42	36	259
31-Jul-91	32	44	57	49	40	36	258
31-Jan-92	32	44	57	49	40	36	258
31-Jul-92	32	44	56	47	36	38	253
31-Jan-93	33	43	54	48	37	38	253
31-Jul-93	34	43	54	47	35	35	248
Average	27	37	49	45	36	30	224

Table 4.1 shows the number of trusts reporting in each of the 96 overlapping six month periods of the dataset. The dataset contains more portfolio reports in the later years of the dataset. Moreover, there is variation in the number of funds reporting across reporting cycles with the largest number of trusts in the Mar-Sep cycle and the Apr-Oct cycle.

Table 4.2 Aggregate number of stocks held and average size of trusts

Beginning date of period	Total number of stocks held by trusts	Total assets of trusts (£mn)	Number of trusts reporting	Average assets of trusts (£mn)
31-Jan-86	924	6,521	133	49
31-Jul-86	927	7,953	149	53
31-Jan-87	952	11,902	173	69
31-Jul-87	992	13,673	187	73
31-Jan-88	1,068	13,468	206	65
31-Jul-88	1,137	14,681	220	67
31-Jan-89	1,161	17,469	234	75
31-Jul-89	1,210	18,850	246	77
31-Jan-90	1,207	18,299	253	72
31-Jul-90	1,201	16,699	258	65
31-Jan-91	1,234	19,982	259	77
31-Jul-91	1,220	21,636	258	84
31-Jan-92	1,210	21,484	258	83
31-Jul-92	1,223	20,731	253	82
31-Jan-93	1,279	24,715	253	98
31-Jul-93	1,294	28,175	248	114
Average	1,140	17,265	224	75

Table 4.2 shows that the total value of the stocks held by the unit trusts recorded in the dataset increased by over a factor of four from the first to the last date. Table 2.3 of chapter 2 shows the total market value of UK equities held by all UK unit trusts at year end in the period 1967 to 1997. At year end 1985 the UK unit trusts held £11 billion pounds in UK equities and at year end 1993 the figure was £50 billion. The corresponding figures for the dataset are £6.5 billion and £28 billion. Hence the dataset is representative of UK equity unit trusts in that it records more than half of the UK equities held by UK unit trusts in the period January 1986 to Dec 1993. Moreover, there are unit trusts that hold UK equities but have less than 90 percent of their assets in UK equities and are therefore not classified as UK equity unit trusts.

Table 4.3 Average asset levels of trusts by sector

Beginning date of period	General (£mn)	Growth (£mn)	Income (£mn)	Small Companies
31-Jan-86	69	35	48	16
31-Jul-86	77	36	53	18
31-Jan-87	112	46	61	24
31-Jul-87	122	50	63	30
31-Jan-88	113	41	60	30
31-Jul-88	121	39	60	33
31-Jan-89	141	42	66	35
31-Jul-89	147	45	67	31
31-Jan-90	147	43	63	22
31-Jul-90	130	39	55	19
31-Jan-91	160	46	63	23
31-Jul-91	172	51	67	29
31-Jan-92	168	52	67	30
31-Jul-92	167	51	67	27
31-Jan-93	199	60	83	34
31-Jul-93	230	70	100	41
Average	142	47	65	28

Table reports trust asset values for the main trust sectors in the dataset. The average portfolio size of each of the sectors increases over the period covered by the dataset, but at different rates. The General sector portfolios are much the largest and increase the most in size over the period.

Table 4.4 Average number of stocks held in trusts of different sectors

Beginning date of period	General	Growth	Income	Small Companies
31-Jan-86	72	49	63	51
31-Jul-86	72	49	61	57
31-Jan-87	80	53	61	60
31-Jul-87	81	53	62	70
31-Jan-88	83	51	63	68
31-Jul-88	81	51	60	71
31-Jan-89	79	51	57	68
31-Jul-89	79	54	57	61
31-Jan-90	79	54	58	54
31-Jul-90	77	54	58	53
31-Jan-91	78	58	60	58
31-Jul-91	80	59	61	60
31-Jan-92	80	58	60	61
31-Jul-92	81	58	61	63
31-Jan-93	83	63	64	75
31-Jul-93	87	65	65	77
Average	80	55	61	63

Table 4.4 shows the average number of stocks held in the portfolios of trusts in the different investment sectors over the period covered by the dataset. With the exception of income trusts the average number of stocks in the portfolios increased over the period covered by the dataset. The average number of stocks held is suggestive of heavily diversified portfolios.

Table 4.5 Average number of buys and sells in representative periods

Beginning date of period	Trade direction	General	Growth	Income	Small Companies
31-Jan-86	Buy	29	20	26	23
	Sell	18	17	17	18
31-Jul-86	Buy	32	24	27	29
	Sell	25	18	19	25
31-Jan-88	Buy	29	20	25	27
	Sell	25	20	21	21
31-Jul-88	Buy	32	21	23	29
	Sell	28	20	23	25
31-Jan-90	Buy	26	22	23	15
	Sell	25	18	19	20
31-Jul-90	Buy	27	23	24	22
	Sell	23	20	20	19
31-Jan-92	Buy	31	23	28	20
	Sell	28	23	22	16
31-Jul-92	Buy	29	25	28	22
	Sell	31	24	25	24

Table 4.5 shows the average number of buy and sell occurrences for portfolios in the different sectors for the even years in the dataset. There is not much variation year to year in the total number of trades. However, the tables show more trades in the second half of each of the years than in the first half. There is also some variation across the sectors with more trades in the General sector portfolios, which may reflect the larger size of those portfolios and the larger number of stocks held by them.

Table 4.6 Number and total market value of stocks in each log decile*

Stock size decile	31-Jan-86		31-Jan-88		31-Jan-90		31-Jan-92	
	# of stocks	(£mn)	# of stocks	(£mn)	# of stocks	(£mn)	# of stocks	(£mn)
1	10	58,287	10	82,642	10	103,628	10	137,965
2	8	21,391	8	31,046	8	38,068	8	61,705
3	15	26,697	15	38,905	15	47,271	14	69,732
4	26	29,485	26	45,819	27	52,045	27	70,282
5	48	33,510	49	53,291	50	56,549	46	67,662
6	87	28,926	87	46,985	90	45,500	85	63,236
7	157	23,986	158	38,314	165	36,021	152	47,449
8	284	17,646	286	29,657	300	25,536	275	31,736
9	514	10,829	518	19,841	545	15,164	495	16,369
10	930	4,550	939	8,967	994	6,772	892	5,944

**The first decile contains the 10 largest stocks. Otherwise the cut off for decile n is calculated as* $10(S/10)^{(n-1)/9}$ *where S is the total number of stocks listed at that date.*

Table 4.6 reports descriptive statistics for the size deciles that are employed in the accuracy tests of the LSV herding measure. The table entries demonstrate that the market value of UK listed stocks is heavily concentrated in the very largest stocks. For this reason the deciles are formed on the basis of the log of the size rank rather than a more conventional division into 10 groups with an equal number of stocks. The number of stocks in each of the log deciles is fairly stable over the period of the dataset.

4.3 Methodology

4.3.1 Test of the short selling assumption in the LSV measure

It is argued in chapter 3 that the LSV measure of herding may be significantly biased in measuring herding among managers that face a short selling constraint; returning positive herding values where no herding exists. Moreover, the sampling distribution of the herding measure under the null condition of no herding is not analytically tractable. An alternative is to empirically estimate a sampling distribution of the LSV herding measure on the trading of the managers of interest under the null condition.

The required sampling distribution, under the null of no herding, can be approximated by a re-sampling approach. An ideal re-sampling method would have the following properties. Firstly, it would deduce the exact trinomial distribution from which each stock-period-manager observation was drawn, under conditions of no herding. Then zero herding datasets would be re-sampled and measured by the LSV measure to form a sampling distribution which is arbitrarily close to its asymptotic form.

There are three impediments to obtaining this ideal. Firstly, and most importantly, we cannot be sure that the re-sampled datasets are completely free of systematic herding. Some systematic herding may survive the process of estimating the trinomial distributions and re-sampling from them. Secondly, with a finite dataset the estimated trinomials will not capture all of the distinguishing characteristics of the managers and stocks of interest. Therefore, when comparing the LSV results on the actual dataset to the estimated zero herding sampling distribution, to some (unknown) extent, we are not comparing apples with apples. Finally, there is re-sampling error which is decreasing in the number of re-sampled datasets (1,000 in this case).

What is proposed here is a general test of the LSV measure, using an approximation of the zero herding sampling distribution. When comparing the LSV test results to the estimated sampling distribution, the shortcomings of the process by which the sampling distribution was estimated must be considered. Nonetheless, there are specific reasons to think that the LSV measure is biased and the re-sampling procedure that is presented here is designed to highlight the effects of those problems. The problems relate to specific assumptions; that managers can short sell and that the propensity to buy is not conditioned by a manager's initial holding of the stock. To highlight the effect of those invalid assumptions the zero herding re-sampling distribution is estimated with and without those assumptions in place. In this way some control is imposed to arrive at an estimate of the effect of the invalid assumptions.

The two principal requirements of the re-sampling procedure are, firstly, that herding is eliminated, and secondly, that the re-sampling preserves the essential characteristics of the actual dataset that are not associated with herding. Starting with the herding elimination requirement, there are two sources of herding to eliminate – unconditional correlation between managers' trades and conditional correlation.

Managers' trades may be correlated because of correlated signals regarding future stock values, or because of a scale effect (managers with new money replicating existing portfolios) or because of changing stock characteristics (small stocks getting bigger) or other information that conditions the trinomials from which the managers' trade directions are drawn. This correlation is unconditional because after conditioning on this information (the correlated signals about future returns, or the identity of the managers with new money, or the identity of stocks with changing characteristics) the correlation is zero. Conditional correlation exists even after conditioning on those three sources of conditioning information. Conditional correlation may arise from comparative performance evaluation or informational cascade.

Both sources of correlation must be eliminated by the re-sampling procedure. We can be confident that conditional correlation will be eliminated by the independence of the draws in the re-sampling. Unconditional correlation is more problematic.

The basic unit of data to be re-sampled is the trade direction, $X_{it}^{j} \in \{buy, sell, hold\}$, of a stock *i*, during period *t*, by manager *j*. Each such stock-period-manager observation is replaced by a draw from an estimate of the probability distribution, $P_{it}^{j}(x_{it}^{j})$ that would prevail in the absence of herding. The trinomial distributions are estimated by forming the buy/hold/sell observations of the actual dataset into groups and taking the proportion of buy observations as the probability of a buy, and likewise for hold and sell probabilities. This process will only eliminate unconditional correlation if the conditioning information averages (integrates) to an expected value of zero over all observations in the group. It is therefore crucial that criteria used to form groups (dates, stock size, initial holding levels) not be correlated with conditioning information that is associated with herding. This concept is revisited in the results section.

The purpose of grouping the observations before estimating the trinomials is to preserve essential characteristics and to relax the invalid assumptions. In the test of the short selling assumption three levels of grouping are imposed. Firstly, the data is divided into the 15 six month periods within which each trust reports its holdings once. The first period is 31 January 1986 to 30 June 1986, the next is 31 July 1986 to 31 December 1986, and so on. The next criteria is size. In each period the stocks are divided into size deciles. The market value of UK stocks is heavily concentrated in the largest stocks and the number of trades is commensurately larger in those stocks. To even out the number of observations across groups, the size deciles are formed by the log of the size rank of the stock, with the requirement that the first decile include the 10 largest stocks. The cut-off for the other nine deciles is $10(S/10)^{(n-1)/9}$ where n is the decile and S is the total number of stocks listed at that date.

The period and size criteria generate 150 groups. These criteria are intended to preserve characteristics of the actual dataset that are not associated with herding. The third criteria is that all stocks that have an initial holding of zero are placed in a separate group. The trinomials estimated from the zero-initial-holding groups have an estimated probability of ‘sell’ observations that is zero by construction. Thus relaxing the invalid assumption that all managers undertake short selling. The zero herding sampling distribution is estimated with and without this third grouping into positive and zero initial holdings. This control of the presence of the assumption permits an estimate of the effect of the short selling assumption on the accuracy of the LSV herding measure.

4.3.2 Test of the invariance assumption in the LSV measure

It is explicitly assumed in the construction of the LSV measure that in the absence of herding the propensity of managers to buy rather than sell, denoted p_{it}^{j}, is invariant across stocks and managers in any one period. The propensity to buy is defined as $p_{it}^{j} = P_{it}^{j}(X_{it}^{j} = \mathit{buy})/[P_{it}^{j}(X_{it}^{j} = \mathit{buy}) + P_{it}^{j}(X_{it}^{j} = \mathit{sell})]$. Chi square tests of invariance of the propensity to buy strongly reject the assumptions that p_{it}^{j} does not vary with a manager’s initial holding in a stock or, separately, the identity of the manager.

The effect of variation in p_{it}^{j} with a manager’s initial holding in a stock is tested here. It is reasonable to assume that there is mean reversion in the portfolio holdings weights of managers. We might expect that managers with high initial holdings have lower propensities to buy than managers with lower initial holdings of the stock. When the propensity to buy varies by initial holding, b_{it} is no longer binomially distributed. The mean and the variance of the distribution of b_{it} is affected by the variation in propensity to buy. Whether extreme values of b_{it}/n_{it} are made more rather than less likely by variation in managers’ initial holdings in a stock is an empirical question.

The effect of the invariance assumption is tested by imposing another level of grouping to include the initial holding level. In each stock-period the non-zero initial holdings of the stock are ranked and formed into quintiles. If the number of initial holdings that is positive is less than 5 then all non-zero holdings in that stock period are assigned to the middle quintile. Each period/size group is then divided into six groups. One for zero initial holdings and five for the initial holding quintiles. As before, trinomials are estimated for each group and the trade direction of the stock-period-manager combinations that comprise the group are redrawn from that group’s estimated trinomial.

The effect of variation in p_{it}^{j} by manager identity is not measured here. The effect could be incorporated by estimating a trinomial distribution for each individual observation within a group. This can be achieved by fitting a probit estimation to the categorical observations of buys, holds and sells within the group. When this was done, the dummy variables for many of the managers were found to be highly insignificant, thus calling into question the validity of the estimation. Omitting some but not all of the managers is unsatisfactorily arbitrary. The effect of variation in p_{it}^{j} by manager is likely to be qualitatively similar to the effect of variation by initial holding. Therefore, variation by manager was not tested, and grouping rather than probit estimation was employed to estimate the effect of variation in p_{it}^{j} by initial holding.

4.3.3 Bootstrapping test of the Wermers measure

The probability distribution of a manager's change in a stock's portfolio weight during a period is conditional on the manager's initial holding in the stock. The most extreme case is where the manager has no initial holding in a particular stock and short sales are prohibited; in which case negative changes in portfolio weight have zero probability. However, the Wermers measure of correlation between the portfolio weight changes of two groups of managers has no sample mean term. Therefore, the measure need not have an expected value of zero in the absence of herding. To determine whether the short sales constraint results in a significant bias in the Wermers measure we require an estimate of the sampling distribution of the measure on a dataset which is constructed to have no systematic herding, which maintains the essential characteristics of the actual dataset, and for which the short sales constraint prevails. Again, the sampling distribution is created by a cycle of transforming the dataset by bootstrap re-sampling and then applying the herding measure, in this case the Wermers measure.

In the Wermers measure the basic unit of data, denoted Δw_{it}^{j}, is the change in portfolio weight in stock *i* of manager *j* during a period *t* (a stock-period-manager observation). To transform the dataset, the portfolio weight change of each observation is replaced by a random draw from an empirical estimate of its probability distribution $P_{it}^{j}(\Delta w_{it}^{j})$. To estimate $P_{it}^{j}(\Delta w_{it}^{j})$ the set of stock-period-manager observations which contain a stock among the 2,000 largest stocks at the beginning of the period, is first divided into 146 groups by the market capitalisation of the stock. Firstly, each observation is allocated a rank on the basis of the size of the stock at the beginning to the period, with the largest stock allocated a rank of 1 and the smallest of the stocks considered, a rank of 2,000. The observations which at the beginning of the period contained one of the 20 largest stocks are formed into 20 groups by their rank. The next 180 largest stocks are divided into 36 groups - five ranks per group. The next 1,800 largest stocks are divided into 90 groups - 20 ranks per group. Each of these 146 groups are then divided into two groups by whether the holding of the stock is positive or zero at the beginning of the period.

To randomly transform the dataset, the portfolio weight change in each observation is replaced by the portfolio weight change of an observation drawn randomly, with replacement, from the same group of observations. This replacement procedure constitutes a draw from the estimate of the probability distribution of the portfolio weight change after conditioning on stock size and whether the initial holding is positive.

As discussed in the previous section, the conditional correlation between the portfolio weight changes of managers is eliminated by the independence of the draws. The unconditional correlation is eliminated in estimating $P_{it}^{j}(\Delta w_{it}^{j})$ if the conditioning information regarding correlated signals on future stock returns, stock characteristic changes and manager performance is averaged to zero across the observations in each group. In that case any measured correlation arises either from chance or from features of the herding measure itself; in particular, mis-specification of the test and/or use of average prices to calculate portfolio weights.

The empirical estimate of the sampling distribution of the Wermers herding measure is constructed by undertaking 200 repetitions of the cycle of transformation and measurement. The bootstrapping literature provides little guidance on the minimum number of replications for adequate estimates of the sampling distribution. However, 200 or more replications is generally considered adequate for an estimate of the standard error of the sampling distribution.[54] Because the Wermers measure is the average of 90 sample correlations we can rely on the central limit theorem to ensure that the sampling distribution is approximately normal.

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[54] See Efron and Tibshirani (1993)

4.3.4 Re-ordering test of the Wermers measure

The bootstrapping test of the Wermers measure does not tell us whether any bias that is found results from mis-specification, as opposed to the use of mid-prices, in calculating portfolio weights. To separate the effects, a transformation is undertaken which accentuates the effect of using mid-prices and attenuates other sources of bias. In each stock-period-manager observation the stock identity is replaced with that of another stock which is drawn, without replacement, from a stock in the same size group of 10 stocks, where size is the market capitalisation of the stock at the beginning of the particular period. This transformation involves rearrangement of the data rather than re-sampling. Thinking of the data in terms of stock-periods, the transformation takes 10 stocks in one period where the stocks are adjacent in size ranking, and then for any one manager the 10 observations in those stocks are transformed by randomly swapping the stock identities between the observations.

This transformation is an averaging process which reduces the occurrence of highly polarised trading by the managers in those stock-periods. In that way any effect from conditioning of the probability distribution of portfolio changes is attenuated and the effect of changes in prices (rather than weights) is accentuated. Again, an estimate of the sampling distribution of the measure under these conditions is created by repeated re-ordering and application of the Wermers measure to the re-ordered dataset.

4.4 LSV measure applied to the UK dataset

Table 4.7 reports the results of applying the LSV herding measure to the dataset of 268 UK equity mutual fund managers. Results are reported for the entire dataset, and subsets of the observations formed on the basis of the number of managers who trade in a stock-period and the market capitalisation rank of the stock (where the largest stock at the beginning of the period has a rank equal to 1). For comparison, results are also reproduced from the LSV (1992b) and Wermers (1999) studies of US pension funds and US mutual funds respectively.

For the entire UK dataset the level of herding is 2.6 percent. The herding figure rises with the number of managers trading to 6.9 percent when 20 or more managers trade demand can be equilibrated by trade with the rest of the market and/or price changes that reduce the managers' net trading demand. If the funds managed by the group of managers is a small part of the total market then prices may change little. Otherwise, if the group of managers forms a large component of the total market then the polarised demand of fund managers may be resolved largely by price changes.

Price changes resulting from the aggregate demand of managers reduce the forces that polarise the managers' demand, creating a negative feedback effect.[56] For this reason it would be surprising if we were to find a large degree of fund manager herding where fund managers are a large part of the market (as is the case in the UK). Given a negative feedback effect of price changes, the herding figure of 6.9

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[55] The comparison between the UK and US results is not direct. The number of managers reporting per period is greater in the studies on US data, the reporting by US fund managers is quarterly and the UK stock market is more concentrated in the largest stocks.

[56] If herding arises because one manager undertakes a large trade and other managers are counter parties to it, then herding could exist with no net trade between the managers and the rest of the market. However, in the UK dataset there are few occurrences of managers herding in one direction and their net trade being in the other direction.

percent is surprisingly large. Moreover, since it may be impossible to separate price changes resulting from the polarising forces acting on managers from other causes of price changes, the importance of studying these forces in terms of correlated trading is apparent.

Table 4.7 shows that the highest levels of herding are found in the largest stocks and the smallest stocks. Amongst the five largest stocks by market capitalisation the level of herding is 4.1 percent. Amongst stocks outside the 1,000 largest, the level of herding found is 6.2 percent. LSV in studying US pension fund managers' trades find a level of herding of 6.1 percent among the quintile of smallest stocks. Wermers finds a figure of 6.2 percent for the quintile of smallest stocks amongst stocks that are traded by 5 or more US fund managers in a period. LSV and Wermers do not find that herding is increasing with market capitalisation of stocks. However, they do not break down the largest quintile of US listed equities to see whether the herding is increasing among the very largest stocks.

If herding results from relative performance evaluation, then managers should be mostly concerned about the trades of other managers in large stocks which have the most weight in the performance benchmark (unless they are small cap managers). Further, if herding is explained by managers acting on shared information then we might again expect more herding in larger stocks, because large stocks are followed by more analysts and there is more information on large stocks in the public domain. However, there is little in the theoretical explanations of herding that predicts high levels of herding among the smallest stocks by market capitalisation.

Table 4.8 reports the results of testing for herding among managers with the same investment management objective. Herding is low in these categories for stock-periods where a small number of funds trade. In the UK data, when the number of managers trading is 10 or more, the herding in the investment categories is higher than the overall level of herding. The UK results are consistent with the hypothesis that relative performance evaluation causes herding, so that managers who are measured against the same investment category benchmarks herd more strongly with each other than with other managers. However, an alternative explanation is that the managers with the same investment management objective are simply reacting at the same time to changing characteristics of stocks, such as price earnings ratio or book to market ratio.

The stock-periods can be divided on the basis of buy or sell herding. Buy herding stock-periods are those where $(b/n-p_t)>0$, and likewise sell stock-periods are those where $(b/n-p_t)<0$. These results indicate that over the whole dataset, most of herding is on the buy side. That is, most of the herding is managers herding into stocks rather than out of them. Moreover, this is particularly true of smaller stocks. For stocks outside the 100 largest, the aggregate level of herding is 2.7 percent, which is much the same as the 2.6 percent level of the whole dataset. However, that 2.7 percent breaks down as 5.2 percent on the buy side and only 0.7 percent on the sell side. This dichotomy is even more acute amongst the smallest stocks. For stocks outside the 1,000 largest the buy side herding is 12.1 percent and sell side is 1.2 percent. For the largest stocks and stocks where a large number of managers trade in a period the difference between buy-side and sell-side herding levels is much smaller.

These results suggest that managers herd when buying into small stocks or increasing their holdings of these stocks but then reduce their holdings with less conformity. It is also consistent with a spurious finding of herding arising from the scale effect, although it seems unlikely that a scale effect creates the stark difference in buy and sell herding among the smallest stocks. Amongst the smallest stocks Wermers finds a different result. His finding of 6.2 percent herding among the smallest quintile of stocks breaks down to 3.7 percent on the buy side and 8.1 percent on the sell side.

The results of tables 4.7, 4.8 and 4.9 indicate that herding is episodic in that it is strongly increasing in the number of managers trading. This suggests that herding is caused by shared information since the arrival of information is also intermittent. In contrast, comparative performance appraisal is ever present. Herding by UK unit trust managers is higher in the extremes of market capitalisation, but relatively constant otherwise.

When interpreting results of the LSV measure across subsets where different numbers of managers trade we should note that the measure is intrinsically dependent on the number of managers trading. To illustrate, consider a dataset containing 100 managers who always trade in the same direction. If $p_t = 0.5$, then in a stock-period where all 100 managers trade the LSV measure is 46 percent. If only 10 of the 100 managers trade then the figure is 37 percent, and if only 2 trade then the figure is 25 percent.[57] So for a given level of correlation among the trades of managers, some increase in the level of herding with the number of managers trading is expected. By comparing the level of herding found in the actual dataset to an estimate of the empirical sampling distribution, this effect can be accounted for.

4.5 Results of the accuracy tests of the LSV measure

4.5.1 The effect of the short selling assumption

The purpose of the tests reported in this section is to estimate a sampling distribution of the LSV measure under the null conditions of no herding, firstly with, and then, without, the short sales assumption relaxed.

4.5.1.1 Eliminating the 'buy from zero holding' records

First consider another, specific, test of the effect of the short selling constraint. Since the short selling problem is associated with observations where the manager is known to have traded a stock in the period but the initial holding was zero, we could simply eliminate those data points. We would then start with a dataset that included only observations where the manager bought from an initially positive position, left the initially positive holding unchanged or sold the stock in the period.

The results of applying the LSV measure to the UK dataset with the 'buy from zero holding' observations removed are reported in table 4.10. The results are substantially different to those in table 4.7 which report the LSV measure on the whole dataset. The results seem to indicate much higher levels of herding in trades that exclude buys from a zero holding. However, examination of the herding at the

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[57] The LSV measure for one stock period is $H_{it}^{lsv} = \left|\frac{b_{it}}{n_{it}} - r_t\right| - E\left|\frac{b_{it}}{n_{it}} - r_t\right|$. For a given value of b_{it}/n_{it}, the second term in this equation is decreasing in n_{it}.

individual stock-period level rather than averages shows that these results are spurious.

The problem is as follows. For the largest stocks many managers hold a position in the stock over long periods of time; decreasing or increasing their holding but seldomly buying from an initial holding of zero. So for the largest stocks, elimination of the buy from zero holding records does not greatly change the observations of buying and selling but it does greatly change p_t which is reduced from an average across periods of 0.58 to an average of 0.39. This reduction creates the illusion of high levels of herding among the largest stocks. For example, table 4.9 shows that of the 25 stock-periods in which 30 or more managers trade, 18 are on the buy side and 7 on the sell side. Table 4.10 shows that after eliminating the buy from zero holding records there are 11 stock-periods in which 30 or more managers trade. Of those 11 stock-periods, 9 are buy-side herding and 2 are sell-side. The observations where managers buy are still numerous enough to increase the number of stock-periods that are buy-side.

Because the omission of buy from zero holding records has a different effect on different stock periods, it is not a suitable means of estimating the effect of the invalid short sales assumption. There are two other good reasons for pursuing a re-sampling approach rather than just eliminating the buy from zero holding records. Firstly, in addition to estimating bias caused by problems with the LSV measure, we want to know whether zero herding can be rejected at the 95 percent level. For that purpose we need a sampling distribution rather than just a measure on a reduced dataset. Secondly, the most important results might be in the buy from zero holding observations. So a means of estimating the bias and compensating for that bias, in a measure on the entire dataset is desirable.

4.5.1.2 Re-sampling from the basic binomial distribution

The first step is to estimate the sampling distribution of the LSV measure by simply redrawing from an estimate of the binomial distribution for each stock-period. For each date the value of p_t was estimated as $\rho_t = \Sigma_i b_{it}/\Sigma_i n_{it}$. Re-sampled datasets are then constructed by replacing each observation, in which a trade occurs in the actual dataset with a draw from a Bernoulli distribution with parameter ρ_t, being the estimated probability of a buy in that period. The results of applying the LSV measure to 1,000 replicated datasets are reported in table 4.11.

The expected value of the LSV measure is not zero, even in this simple binomial set-up for the following reason. The value of ρ_t in equation 3.4 is an estimate of p_t. That estimate is unbiased but contains errors. The effect of those errors is systematic because of the absolute value operations in equation 3.4. We might expect that this effect will be small in large datasets and that expectation is born out in the table 4.11 results. The bias caused by systematic errors in estimating p_t is small for all subsets of the stock-periods. For the stock-periods where a large number of managers trade, and for the smallest stocks, the 95th percentile of the sampling distribution exceeds 1 percent.

4.5.1.3 Re-sampling from one trinomial for each period

The next step is to estimate the trinomial distributions which are the probability distributions of the trade directions of the managers under conditions of no systematic herding. For this purpose all observations in the dataset were formed into 15 separate groups. One group for each six month period in the dataset, with the first period being January 31, 1986 to June 30, 1986. Each manager reports their portfolio holdings no more than once in each period. Observations where a manager's initial holding was zero and no trade was made during the period are included.

In each group the proportion of buy/hold/sell observations give the estimated trinomial of those events. Each observation is then randomly redrawn from the trinomial of its group. The LSV is applied and the process is repeated 1,000 times. Summary statistics of the sampling distribution that is estimated in this way are reported in tables 4.12 and 4.13. For table 4.13 each of the 15 period groups was divided into one group for observations where the initial holding was zero and those where it was positive. Therefore, the results in tables 4.12 and 4.13 give a comparison of the estimated sampling distribution of the LSV measure under null conditions of no herding, with and without short selling in the replicated datasets.

Table 4.12 reports sampling distributions with means of approximately zero. The 95th percentile values are all small except for the largest stocks. The ‘size rank of stock’ panel shows that a finding of 2.7 percent herding in the five largest stocks has a 5 percent probability even if the managers do not systematically herd. What causes these spurious results among the largest stocks is not clear. It may be the systematic effect of errors in estimating p_t or it may be another effect that has been overlooked.

The results of table 4.13 suggest that the invalid short selling assumption is important. The sampling distribution of the average level of herding in stock periods where 20 or more managers trade has a mean of 7.8 percent and the 95th percentile is 9.4 percent. The corresponding mean and 95th percentile of the sampling distribution for the stocks outside the 1,000 largest is 7.7 percent and 8.2 percent.

4.5.1.4 Grouping by size

However, in the datasets replicated for the table 4.13 sampling distributions, important characteristics of the managers and stocks of the actual dataset are not preserved. In particular differences in the probability of ‘hold’ occurrences between large and small stocks.

A further level of grouping is introduced to capture the effect of size on the probability distributions from which trade directions are drawn. In each period the stocks are divided into deciles by their market capitalisation rank. The market capitalisation of stocks on the London Stock Exchange is highly concentrated in the largest stocks (see table 4.6). Consequently, if groups were formed on the basis of size deciles, then the first decile would encompass roughly the 200 largest stocks, most of the aggregate market capitalisation of stocks and most of the trades in the dataset. Instead, deciles are formed from the log of the size rank of stocks with the constraint that the first decile (of largest stocks) contains 10 stocks as described in the methodology section.

Tables 4.14 and 4.15 show summary statistics of the sampling distribution created from applying the LSV measure to 1,000 datasets which were re-sampled from the period/size/initial holding groups. Table 4.14 shows the results where short selling is assumed and table 4.15 shows results where that assumption is relaxed. With the short selling assumption in place the average level of herding found is small. Where more than 25 managers trade, the mean of the sampling distribution is 1.1 percent and the 95th percentile is 3.0 percent. As with table 4.12 results, the origin of these biases is not clear, but the systematic effect of errors in estimating p_t is one source.

Another possibility is that there is significant migration of stocks from low deciles to high deciles, and vice versa, over time. The illusion of herding that can result from small cap managers selling in unison stocks that become too large for their portfolios is not eliminated when stock-periods are grouped by size. However, that effect is not considered to be herding, so in a test like this it is desirable that it be captured in the mean of the sampling distribution in the absence of herding.

Table 4.15 shows the effect of relaxing the short selling assumption. Comparing tables 4.13 and 4.15 we can see the need for size grouping. The mean and 95th percentile values of the sampling distributions are substantially reduced. They are nonetheless significant. Comparing tables 4.7 and 4.15 it appears that a significant amount of the herding found in certain subsets of the stock-periods is a result of the LSV assumption that managers can short sell. In particular, for stocks outside the largest and smallest stocks, where rank is between 20 and 100, the mean of the sampling distribution is more than one half of the herding found on actual datasets. Further, the 95th percentile of the sampling distribution is high for some subsets of the stock-periods. Where the number of managers trading exceeds 30, the 95th percentile is 4.8 percent. For stocks with a market capitalisation rank of more than 1,000 (that is, the smallest stocks), the mean of the sampling distribution under simulated conditions of zero herding is more than one third of the herding measured in the actual dataset.

Nonetheless, in each subset the level of herding found on the actual dataset exceeds the 95th percentile of the sampling distribution under conditions of zero herding.

4.5.2 The effect of the invariance assumption

It is assumed in the LSV measure that the propensity to trade, p_t , has the same value for all stock-period-manager observations in the same period. However, in the dataset there is significant variation in p_t by the relative size of the initial holding of the stock. To test the effect on the LSV measure of relaxing this assumption, an estimate of the sampling distribution of the LSV measure is created under the conditions of: no systematic herding; no short sales; and variation in p_t by initial holding. The 1,000 replicated datasets are created by re-sampling from the probability distribution of the trade direction for each observation, which is estimated by grouping all observations by the four criteria of period, size, initial holding quintile and whether the initial holding is positive or alternatively zero. The summary statistics of the sampling distribution of subsets of the stock-periods of 1,000 re-sampled datasets are reported in table 4.16. The grouping and re-sampling was conducted for the five log deciles of largest stocks, which equates roughly to the 100 largest stocks. Comparing table 4.16 to 4.15 in the subsets where size rank is less than 100, the main result is that the effect of variation in the propensity to buy across observations in a period is small. When variation in p_{it}^j is included in the trinomials from which the observations are redrawn, the effect is to slightly reduce the mean and 95th percentile values of the re-sampling distribution under conditions of zero herding.

4.6 Wermers measure applied to the UK dataset

Tables 4.17 and 4.18 report the results of applying the Wermers herding measure to the dataset of 268 UK equity mutual fund managers. The Wermers results are shown for different subsets of the data which are formed on the basis of the number of managers trading and the market capitalisation rank of the stocks. Results are also reproduced, for comparison, from the Wermers (1995) study of US mutual funds. In the Wermers measure the managers are randomly divided into two groups and the correlation between the aggregate portfolio weights changes of the groups is measured. In this study, to reduce the variation in the results which arises from the essentially arbitrary division of the managers, the reported results, including the t-values, are the average from measuring 10 separate divisions of the managers.

For the entire dataset the level of herding is 0.10. This is an estimate of the correlation in the portfolio weight changes of the two groups of managers.[58] This figure rises steeply with the number of managers trading the stock in a period, to 0.24 when 15 or more managers trade the stock.[59] Wermers also finds large correlations when measuring US mutual funds. The herding levels found in the subsets formed by the number of managers trading are in every case significant at the 95 percent level.

The measured herding is increasing in the market capitalisation rank of the stock, from 0.06 with a t-value of 4.9 for stocks below the 100 largest, to 0.15 with a t-value of 5.6 for stocks in the 50 largest. However, within the largest 50 stocks (over half the market by value) the herding results do not vary with stock size. The measured level of herding is more pronounced in subsets of the data where many managers trade during a period than subsets where the stocks are very large.

Table 4.18 reports the Wermers measure of herding in the subsets of the data classified by the investment objective of the managers. The results are mixed. The Growth-Income and Income managers appear to herd strongly with the level of herding increasing to 0.25, in both cases, in stock-periods where 10 or more managers trade. This figure is larger than the corresponding subset of all managers.

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[58] The UK managers report their portfolio holdings on a cycle of either January-July, February-August etc. There are 90 overlapping six month periods between January 1986 and December 1993 inclusive. On average 40 managers report in each of the 90 periods. The Wermers measure is calculated for each period and then averaged. The t values are the average divided by the standard error of the 90 values. Under the Wermers assumption of no correlation between managers' trades, the 90 values are uncorrelated. So the t tests are valid under their null conditions, but the overlapping nature of the data should be considered in interpreting the results.

[59] If the data exhibits heteroscedasticity, then the square of the correlation is *not* the R^2 value in an equivalent regression of portfolio weight changes in group A on the changes in group B. We might expect heteroscedasticity because the stocks vary in size, the explanatory power of the regression varies across observations and the data is aggregated. Unreported results showed that there is significant heteroscedasticity in the portfolio weight changes across stocks in each group in a single period. For this reason we should only interpret the square of the Wermers measure as an R^2 in the tightly defined subsets, such as the stock quarters in which the stock is among the 20 largest.

The Growth managers do not exhibit this pattern. When more than 10 Growth managers trade the level of herding is insignificant.

In the geometric interpretation of the Wermers measure the finding of strong herding among managers in large stocks means that in the asset space of large stocks the portfolio weight vectors of the two groups of managers track each other through time. We might think that this effect arises simply because both groups track the index over time (buying stocks that become larger over time for instance). However, unreported tests show that when the group A portfolio weight changes are regressed on the Group B changes there is no difference in the regression results whether or not the portfolio weight changes of the market index are included in the regression.

4.7 Results of accuracy tests of the Wermers measure

4.7.1 The effect of mis-specification

The Wermers measure assumes that the unconditional expected value of the portfolio weight changes in a stock is zero. Therefore no sample average term is included in the measure of correlation. This means that the expected sample correlation between the portfolio weight changes in two stocks can be non-zero, even when no systematic herding exists, if the expected value of the weight change is a function of the initial holding in the stock. The most extreme case is where neither group initially holds the stock but they both buy - the cross product of their portfolio changes must be positive.

An estimate of the sampling distribution of the Wermers measure on a dataset which is constructed to exhibit no herding and in which no short selling is present, is created by measuring each of 200 replicated datasets with the Wermers measure. Table 4.19 reports the summary statistics of the estimated sample distribution for the subsets of the stock-periods which are formed on the basis of the number of managers trading and the market capitalisation rank of the stock.

For each of the 200 replicated datasets the level of herding and associated t-value, is calculated by the Wermers method. The second row of each panel reports the percentage of the measurements of the 200 replications that yield a t-value of two or more. The results show that incorrect inference of the existence of herding, when no systematic herding exists is a real danger with the Wermers measure. In only one of the subsets (where the number of managers trading is greater than 20) is the proportion of incorrect inferences less than 50 percent.

A comparison of tables 4.18 and 4.19 indicates that the miscalibration of the Wermers measure is severe. For all but one of the subsets of the stock-periods reported in table 4.19, the average level of herding found in the 200 re-sampled datasets, is at least one half of the herding found by the Wermers measure in the actual dataset.

We can, however, say from the simulation results that the Wermers measure finds a significant level of herding in the UK fund manager dataset. For all but the n=20 subset of the stock-periods, the level of herding measured in the actual data is more than two (estimated) standard deviations above the mean in the corresponding estimated sampling distribution of the dataset transformed to eliminate herding. Hypothesis tests with the estimated sampling distribution are in this case undertaken with t-values because the 200 bootstrapping replications are not sufficient for tests against the estimated 95th percentile. The Wermers measure of each replication is the average of the sample correlation in 90 independent samples so we can appeal to the Central Limit Theorem to justify the use of t-values. The estimates of the skewness and kurtosis of the sampling distribution for each stock-period subset are reported in table 4.19 and do not invalidate the use of t-values.

4.7.2 The effect of calculating weights with average prices

The miscalibration in the Wermers measure found in the bootstrapping test may arise from mis-specification, the use of the average of beginning and end of period prices in calculating portfolio weights, or some other factor. To separate the effects, the dataset is transformed to eliminate herding and accentuate changes in weights arising from price changes as opposed to changes in the number of stocks held. To transform the dataset, in each stock-period-manager observation the stock identity is replaced with that of another stock which is drawn, without replacement, from a stock in the same size group of 10 stocks. Table 4.20 reports the summary statistics of the estimated sample distribution for the subsets of the stock-periods which are formed on the basis of the number of managers trading and the market capitalisation rank of the stock.

The results in table 4.6 show that on the transformed dataset the Wermers measure does not find any significant herding. However, for some subsets of the dataset, the estimated standard deviation of the sampling distribution is quite large. Where the number of managers trading is at least 20 the estimated mean of the sampling distribution is 0.05 and the estimated standard deviation is 0.09. On this subset of the actual dataset the Wermers measure records a level of herding of 0.24. So we can still reject the null hypothesis of no herding at the 5 percent level. For most of the other subsets the mean and standard deviation are not large compared to those in table 4.19.

We can conclude from this re-ordering test that there is some bias in the Wermers measure other than that caused by the short sales assumption. That bias may be induced by the use of average prices but in any case it is not large for most subsets of the UK unit trust dataset.

4.8 Concluding remarks and future research

This chapter meets three of the four aims of the essay on tests of the accuracy of herding measures using UK data. Firstly, to determine whether the empirical herding literature is well founded. This is done by testing whether the principal measures of herding of LSV and Wermers are accurate. That is, whether those measures find herding where no herding exists. Or if herding does exist, whether the measures overstate the level of herding present.

Secondly, to extend the empirical herding literature to an economy, outside the US, which has a comparable investment management industry - in this case the UK. Thirdly, to develop and demonstrate techniques for empirically estimating the sampling distribution of a metric that is derived from portfolio holdings. In this case the measure is of herding but it could just as easily be a measure of fund manager performance or performance persistence or any other measure derived from portfolio holdings data.

It is common in the finance literature for researchers to develop a metric to measure some phenomenon and then simply assume that in its absence the expected value of the metric is zero. In the investment management literature this is the standard approach for measures of herding, fund manager performance, performance persistence and the like. When computing power was limited this was the necessary approach. But now, for most measures in investment management, researchers should be able to estimate the distribution of their measures under simulated null conditions to better determine whether the measure is properly calibrated.

Chapters 3 and 4 seek to analyse measures of herding from the perspective that herding by fund managers arises because all fund managers face basically the same portfolio choice problem. It is argued in chapter 3 that the existing explanations of herding are each derived from one part of the manager's portfolio choice problem. Relative performance appraisal may cause the asset holdings of other managers to enter a manager's objective function, resulting in positive correlation of managers' trades. Shared information may lead to positive correlation if managers collect and process information in the same way, or the information is simply the trades undertaken by other managers. Changes in the characteristics of stocks affect the opportunity set of all managers causing positive correlation in trades. Finally, managers with new money replicating their portfolios represents a change of scale in the portfolio choice problem which may also cause positive correlation.

When herding is viewed from this perspective it is clear that there are assumptions in the LSV and Wermers measures that are not only counterfactual for some datasets but potentially the source of significant bias. The tests reported here seek to isolate the effects of invalid assumptions in the LSV measure that all managers can short sell all stocks and that there is no variation in p_{it}^{j} with the initial holding of the stock. The results indicate that for certain subsets of the dataset the short sales assumption leads to an overstatement of the level of herding. Further, that the effect of the variation in p_{it}^{j} due to different initial holdings is to understate the level of herding, though this effect is small enough to be ignored.

The bootstrapping tests reveal the high probability of finding herding, where none exists, when using the Wermers measure. The severe miscalibration of the measure for the dataset results from the mis-specification of the test, a part of which is caused by the assumption that all managers can sell all stocks short.

In interpreting the results of the tests of short selling and variance of p_{it}^{j} the shortcomings of these tests must be born in mind. Firstly, we cannot be certain that the grouping and re-sampling technique eliminates all systematic herding from the re-sampled datasets. Thus part of the mean of the herding measure applied to the replicated datasets may be systematic herding that has survived the grouping and re-sampling. The LSV tests are built up a step at a time in an attempt to ensure that systematic herding is not surviving and to isolate the effect of the invalid assumptions that are being tested.

Secondly, are we comparing apples with apples? Not all the essential characteristics of the actual dataset that are not associated with herding survive the grouping and re-sampling. Because the re-sampled data is a stylised version of the actual dataset the effect of invalid assumptions on the herding measurement in those datasets is only an approximation of the effect on the actual dataset.

Finally, only 1,000 new datasets are created in each LSV test and 200 in the Wermers test. The 200 replications of the test of the Wermers measure only support estimates of the standard deviation of the sampling distribution rather than estimates of the 95th percentile. However, these results are compelling in their portrayal of mis-specification of the Wermers measure; so, an increase in the number of replications appears unlikely to change the nature of the accuracy test results.

This study of UK fund managers reinforces the findings of existing studies that fund managers herd in their trading of stocks. Further, that a significant amount of herding is found in the smallest stocks. This study looks at herding in the very largest stocks and finds that it is increasing in market capitalisation. By testing the accuracy of the measures upon which these studies are based, the foundation of empirical herding literature is strengthened by the results reported here.

The finance literature does not contain a precise definition of herding. The implicit assumption in both the LSV and Wermers herding measures is that herding is a positive contemporaneous cross sectional correlation in the trading of pairs of investors in the group, which arises for any reason other than changes to the issued capital of stocks. The broadness of this definition affects the usefulness of the results of the LSV and Wermers measures. There is substantial evidence that herding exists among certain groups of fund managers in subsets of the data but little can be said about the causes of herding. To understand the consequences of herding a better empirical understanding of the causes is needed. Future tests of the causes of herding should be against more specific null hypotheses.

Table 4.7 Herding levels in UK unit trusts by LSV measure of herding

H^{lsv} is the level of herding as measured by the LSV measure

number is the number of stock-period combinations over which herding is measured and then averaged

Number of managers trading in the period

	n>2	**n>5**	**n>10**	**n>15**	**n>20**	**n>25**	**n>30**
H^{lsv}	0.026*	0.025	0.033	0.043	0.069	0.090	0.080
number	27,014	10,522	3,342	1,007	302	101	25

Number of managers trading in the period

	2<n<5	**5<n<10**	**10<n<15**	**15<n<20**	**20<n<25**
H^{lsv}	0.026	0.021	0.028	0.032	0.059
number	16,492	7,180	2,335	705	201

Size rank of stock

	r≤5	**r≤10**	**r≤20**	**r≤50**	**r≤100**
H^{lsv}	0.041	0.028	0.023	0.020	0.021
number	466	890	1,690	3,991	7,682

Size rank of stock

	r>100	**r>200**	**r>500**	**r>1000**
H^{lsv}	0.027	0.032	0.044	0.062
number	19,332	14,031	6,004	1,247

Comparative results from US studies

	US Pension Funds**			**US Mutual Funds*****			
	n≥1	**n>10**	**n>20**	**n≥5**	**n≥10**	**n≥20**	**n≥30**
H^{lsv}	0.027	0.020	0.021	0.034	0.036	0.034	0.033
number	na	na	na	109,486	67,252	34,704	21,571

** t values are not reported because all of the results are highly significant*

*** US pension fund data is from Lakonishok, Shleifer and Vishny (1992a)*

**** US mutual fund data is from Wermers (1999)*

Table 4.8 Herding levels in UK unit trust sectors by LSV measure of herding

H^{lsv} is the level of herding as measured by the LSV measure

number is the number of stock-period combinations over which herding is measured and then averaged

Number of managers trading in the period				Size rank of stock			
	n≥2	**n≥5**	**n≥10**	**r≤20**	**r≤100**	**r>100**	**r>1000**
Funds in the 'general' sector							
H^{lsv}	0.013*	0.022	0.076	0.017	0.012	0.027	0.077
number	10,704	2,055	55	1,496	5,877	4,827	49
Funds in the 'growth' sector							
H^{lsv}	0.013	0.018	0.045	0.009	0.010	0.016	0.032
number	10,776	1,719	62	1,462	5,473	5,303	136
Funds in the 'income' sector							
H^{lsv}	0.033	0.043	0.059	0.043	0.034	0.033	0.060
number	9,852	2,137	166	984	4,173	5,679	133

** t values are not reported because all of the results are highly significant*

Table 4.9 Buy and sell herding levels by LSV measure of herding

H^{lsv}(buy) = $|b/n\text{-}p|$ - E$|b/n\text{-}p|$ averaged over stock periods of interest, where $(b/n\text{-}p_t) \geq 0$
H^{lsv}(sell) = $|b/n\text{-}p|$ - E$|b/n\text{-}p|$ averaged over stock periods of interest, where $(b/n\text{-}p_t) \leq 0$
number is the number of stock-period combinations over which herding is measured and then averaged

Number of managers trading in the period

	n≥2	**n≥5**	**n≥10**	**n≥15**	**n≥20**	**n≥25**	**n≥30**
H^{lsv}(buy)	0.044	0.022	0.038	0.048	0.068	0.095	0.084
number	12,566	5,486	1,840	591	191	66	18
H^{lsv}(sell)	0.010	0.027	0.026	0.036	0.072	0.080	0.071
number	14,448	5,036	1,502	416	111	35	7

Number of managers trading in the period

	2≤n<5	**5≤n<10**	**10≤n<15**	**15≤n<20**	**20≤n<25**
H^{lsv}(buy)	0.060	0.014	0.033	0.039	0.053
number	7,080	3,646	1,249	400	125
H^{lsv}(sell)	0.001	0.028	0.023	0.023	0.068
number	9,412	3,534	1,086	305	76

Size rank of stock

	r≤5	**r≤10**	**r≤20**	**r≤50**	**r≤100**
H^{lsv}(buy)	0.045	0.035	0.030	0.027	0.025
number	267	496	953	2,081	3,899
H^{lsv}(sell)	0.036	0.020	0.015	0.011	0.017
number	199	394	737	1,910	3,783

Size rank of stock

	r>100	**r>200**	**r>500**	**r>1000**
H^{lsv}(buy)	0.052	0.063	0.087	0.121
number	8,667	6,203	2,695	570
H^{lsv}(sell)	0.007	0.007	0.009	0.012
number	10,665	7,828	3,309	677

Table 4.10 Herding levels by LSV measure of herding with 'buy from zero holding' occurrences omitted

H^{lsv} is the level of herding as measured by the LSV measure

number is the number of stock-period combinations over which herding is measured and then averaged

Number of managers trading in the period

	n≥2	**n≥5**	**n≥10**	**n≥15**	**n≥20**	**n≥25**	**n≥30**
H^{lsv}	0.018	0.029	0.045	0.082	0.106	0.12	0.172
number	21,440	7,275	1,796	469	146	43	11

Number of managers trading in the period

	2≤n<5	**5≤n<10**	**10≤n<15**	**15≤n<20**	**20≤n<25**
H^{lsv}	0.013	0.024	0.032	0.071	0.101
number	14,165	5,479	1,327	323	103

Size rank of stock

	r≤5	**r≤10**	**r≤20**	**r≤50**	**r≤100**
H^{lsv}	0.062	0.051	0.041	0.027	0.023
number	458	874	1,641	3,808	7,232

Size rank of stock

	r>100	**r>200**	**r>500**	**r>1000**
H^{lsv}	0.016	0.017	0.020	0.019
number	14,208	9,740	3,750	679

Table 4.11 Results of bootstrap replication from basic LSV binomial distribution

Number of managers trading in the period

	$n \geq 2$	**$n \geq 5$**	**$n \geq 10$**	**$n \geq 15$**	**$n \geq 20$**	**$n \geq 25$**	**$n \geq 30$**
H^{lsv}	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.001
t value	-5.2	-7.3	-6.9	-5.3	-2.6	-1.3	-1.6
number	27,014	10,522	3,342	1,007	302	101	25
95 pct	0.002	0.002	0.002	0.003	0.006	0.0100	0.017

Number of managers trading in the period

	$2 \leq n < 5$	**$5 \leq n < 10$**	**$10 \leq n < 15$**	**$15 \leq n < 20$**	**$20 \leq n < 25$**	**$25 \leq n < 30$**
H^{lsv}	-0.000	0.000	0.000	0.000	0.000	0.000
t value	-2.6	-4.7	-5.3	-4.6	-2.3	-0.7
number	16,492	7,180	2,335	705	201	76
95 pct	0.002	0.002	0.003	0.004	0.007	0.011

Size rank of stock

	$r \leq 5$	**$r \leq 10$**	**$r \leq 20$**	**$r \leq 50$**	**$r \leq 100$**
H^{lsv}	-0.000	-0.000	-0.000	-0.000	-0.000
t value	-3.2	-4.6	-4.3	-4.7	-5.4
number	444	868	1,668	3,969	7,660
95 pct	0.006	0.005	0.004	0.003	0.002

Size rank of stock

	$r > 100$	**$r > 200$**	**$r > 500$**	**$r > 1000$**
H^{lsv}	-0.000	-0.000	-0.000	-0.000
t value	-3.4	-2.5	-1.5	-2.0
number	19,332	14,031	6004	1,247
95 pct	0.002	0.003	0.004	0.010

Table 4.12 Results of bootstrap replication from single buy/hold/sell trinomial for each period

	Number of managers trading in the period						
	$n \geq 2$	**$n \geq 5$**	**$n \geq 10$**	**$n \geq 15$**	**$n \geq 20$**	**$n \geq 25$**	**$n \geq 30$**
H^{lsv}	-0.000	-0.000	0.002				
t value	-4.9	-2.3	0.7				
number	28,826	9,632	2,626				
95 pct	0.001	0.005					

	Number of managers trading in the period					
	$2 \leq n < 5$	**$5 \leq n < 10$**	**$10 \leq n < 15$**	**$15 \leq n < 20$**	**$20 \leq n < 25$**	**$25 \leq n < 30$**
H^{lsv}	-0.000	-0.000	0.002			
t value	-4.7	-2.3	0.7			
number	19,194	7,006	1,962			
95 pct	0.001	0.005				

	Size rank of stock				
	$r \leq 5$	**$r \leq 10$**	**$r \leq 20$**	**$r \leq 50$**	**$r \leq 100$**
H^{lsv}	0.001	0.001	-0.000	-0.000	-0.000
t value	-1.7	-1.5	-0.1	-0.7	-1.2
number	443	871	1,703	4,137	8,071
95 pct	0.027	0.019	0.014	0.009	0.006

	Size rank of stock			
	$r > 100$	**$r > 200$**	**$r > 500$**	**$r > 1000$**
H^{lsv}	-0.000	-0.000	-0.000	-0.000
t value	-4.9	-4.6	-4.7	-3.9
number	20,753	14,266	5,340	1,046
95 pct	0.002	0.002	0.002	0.002

Table 4.13 Results of bootstrap replication from single buy/hold/sell trinomial, for each period, with no short selling

Number of managers trading in the period							
	n≥2	**n≥5**	**n≥10**	**n≥15**	**n≥20**	**n≥25**	**n≥30**
H^{lsv}	0.030	0.036	0.056	0.071	0.078	0.081	
t value	951.8	848.3	670.7	429.0	252.2	122.9	
number	32,250	7,823	1,573	350	85	18	
95 pct	0.031	0.039	0.061	0.080	0.094	0.115	

Number of managers trading in the period						
	2≤n<5	**5≤n<10**	**10≤n<15**	**15≤n<20**	**20≤n<25**	**25≤n<30**
H^{lsv}	0.028	0.031	0.052	0.068	0.077	0.080
t value	713.5	602.4	528.1	347.1	217.7	116.0
number	24,427	6,250	1,224	265	67	16
95 pct	0.030	0.034	0.057	0.078	0.095	0.116

Size rank of stock					
	r≤5	**r≤10**	**r≤20**	**r≤50**	**r≤100**
H^{lsv}	0.059	0.057	0.050	0.041	0.036
t value	318.0	421.8	464.8	557.3	654.1
number	443	859	1,633	3,824	7,295
95 pct	0.069	0.064	0.055	0.045	0.039

Size rank of stock				
	r>100	**r>200**	**r>500**	**r>1000**
H^{lsv}	0.028	0.030	0.042	0.077
t value	736.0	675.7	742.1	877.7
number	24,930	20,020	11,653	4,675
95 pct	0.030	0.032	0.045	0.082

Table 4.14 Results of bootstrap replication from trinomial formed each period from size ranked groups

Number of managers trading in the period							
	n≥2	**n≥5**	**n≥10**	**n≥15**	**n≥20**	**n≥25**	**n≥30**
H^{lsv}	0.001	0.002	0.003	0.006	0.010	0.011	
t value	37.6	50.7	59.5	70.6	58.6	29.0	
number	28,826	9,632	2,626	664	169	31	
95 pct	0.003	0.004	0.006	0.011	0.018	0.030	

Number of managers trading in the period						
	2≤n<5	**5≤n<10**	**10≤n<15**	**15≤n<20**	**20≤n<25**	**25≤n<30**
H^{lsv}	0.001	0.001	0.002	0.005	0.009	0.011
t value	20.5	28.3	33.6	47.9	49.4	28.7
number	19,194	7,006	1,962	494	139	28
95 pct	0.003	0.003	0.006	0.011	0.019	0.032

Size rank of stock					
	r≤5	**r≤10**	**r≤20**	**r≤50**	**r≤100**
H^{lsv}	0.006	0.005	0.006	0.003	0.002
t value	41.9	55.0	76.3	59.1	46.7
number	443	871	1,703	4,137	8,071
95 pct	0.013	0.010	0.010	0.006	0.004

Size rank of stock				
	r>100	**r>200**	**r>500**	**r>1000**
H^{lsv}	0.001	0.001	0.001	0.001
t value	21.1	19.3	9.9	6.2
number	20,753	14,266	5,340	1,046
95 pct	0.003	0.004	0.006	0.012

Table 4.15 Bootstrap replication from trinomials formed each period from size ranked groups with no short selling

Number of managers trading in the period							
	n≥2	**n≥5**	**n≥10**	**n≥15**	**n≥20**	**n≥25**	**n≥30**
H^{lsv}	0.015	0.013	0.010	0.010	0.011	0.013	0.017
t value	476.6	356.7	197.9	121.9	76.3	56.3	30.3
number	27,741	9,937	3,011	854	249	73	15
95 pct	0.017	0.015	0.013	0.015	0.018	0.025	0.048

Number of managers trading in the period						
	2≤n<5	**5≤n<10**	**10≤n<15**	**15≤n<20**	**20≤n<25**	**25≤n<30**
H^{lsv}	0.017	0.014	0.010	0.010	0.010	0.012
t value	366.9	304.3	156.4	96.6	54.7	45.5
number	17,804	6,926	2156	605	176	59
95 pct	0.019	0.016	0.013	0.016	0.020	0.026

Size rank of stock					
	r≤5	**r≤10**	**r≤20**	**r≤50**	**r≤100**
H^{lsv}	0.008	0.010	0.013	0.014	0.013
t value	62.1	100.1	157.9	242.1	295.3
number	444	869	1,687	4,072	7,919
95 pct	0.015	0.016	0.017	0.016	0.015

Size rank of stock				
	r>100	**r>200**	**r>500**	**r>1000**
H^{lsv}	0.016	0.015	0.015	0.022
t value	393.6	283.2	161.4	98.4
number	19,812	13,904	5,543	998
95 pct	0.019	0.018	0.019	0.033

Table 4.16 Bootstrap replication from trinomials formed from period, size and initial holding quintile groups with no short selling

	Number of managers trading in the period						
	$n \geq 2$	**$n \geq 5$**	**$n \geq 10$**	**$n \geq 15$**	**$n \geq 20$**	**$n \geq 25$**	**$n \geq 30$**
H^{lsv}	0.013	0.010	0.008	0.008	0.008	0.010	0.013
t value	10.5	8.0	4.9	3.4	2.1	1.4	0.8
number	8,610	6,857	2,986	933	273	80	17
95 pct	0.015	0.012	0.011	0.012	0.015	0.021	0.039

	Number of managers trading in the period					
	$2 \leq n < 5$	**$5 \leq n < 10$**	**$10 \leq n < 15$**	**$15 \leq n < 20$**	**$20 \leq n < 25$**	**$25 \leq n < 30$**
H^{lsv}	0.024	0.012	0.008	0.008	0.008	0.009
t value	6.5	6.2	3.7	2.6	1.6	1.1
number	1,752	3,871	2,053	660	193	64
95 pct	0.030	0.015	0.011	0.013	0.016	0.022

	Size rank of stock				
	$r \leq 5$	**$r \leq 10$**	**$r \leq 20$**	**$r \leq 50$**	**$r \leq 100$**
H^{lsv}	0.004	0.006	0.010	0.012	0.012
t value	1.0	2.0	4.2	7.1	9.4
number	444	870	1,695	4,112	8,027
95 pct	0.011	0.011	0.014	0.015	0.014

Table 4.17 Herding levels in UK unit trusts by Wermers measure of herding

H^W is the level of herding as measured by the Wermers measure

number is the number of stock-periods in each calculation of the Wermers correlation

Number of managers trading in the period

	$n \geq 2$	**$n \geq 5$**	**$n \geq 10$**	**$n \geq 15$**	**$n \geq 20$**
H^W	0.10	0.12	0.17	0.24	0.24
t value	6.0	5.9	4.5	4.4	2.6
number	251	114	37	14	5

Number of managers trading in the period

	$2 \leq n<5$	**$5 \leq n<10$**	**$10 \leq n<15$**	**$15 \leq n<20$**
H^W	0.03	0.07	0.12	0.21
t value	2.4	5.0	3.6	3.7
number	182	78	26	10

Size rank of stock

	$r \leq 5$	**$r \leq 20$**	**$r \leq 50$**	**$r \leq 100$**	**$r>100$**
H^W	0.15	0.15	0.15	0.12	0.06
t value	2.7	4.3	5.6	5.6	4.9
number	229	84	44	18	5

US mutual funds*

	$n \geq 2$	**$n \geq 5$**	**$n \geq 10$**	**$n \geq 15$**	**$n \geq 20$**
H^W	0.19	0.17	0.20	0.24	0.27
t value	3.2	3.8	4.7	4.8	3.7
number	971	419	168	78	43

* *US mutual fund data is from Wermers (1995)*

Table 4.18 Herding levels in UK unit trust sectors by Wermers measure of herding

H^W is the level of herding as measured by the Wermers measure

number is the number of stock-periods in each calculation of the Wermers correlation

UK Unit trusts

	Growth		**Growth-income**		**Income**	
	n≥2	**n≥10**	**n≥2**	**n≥10**	**n≥2**	**n≥10**
H^W	0.05	0.03	0.07	0.25	0.16	0.25
t value	3.4	1.1	4.0	3.7	7.9	7.2
number	119	33	124	35	110	31

US Mutual funds*

	Growth		**Growth-income**		**Income**	
	n≥2	**n≥10**	**n≥2**	**n≥10**	**n≥2**	**n≥10**
H^W	0.16	-	0.08	-	0.11	-
t value	3.04	-	2.93	-	2.26	-
number	-	-	-	-	-	-

* *US mutual fund data is from Wermers (1995)*

Table 4.19 Estimated sampling distribution of Wermers measure under null conditions

H^W is the level of herding as measured by the Wermers measure

percent significant is the percentage of the 200 simulated datasets on which the Wermers measure finds a level of herding that is significant at the 95% level

stdev is the sample standard deviation of the Wermers measure on the 200 replicated datasets. *Skewness* and *kurtosis* are corresponding higher sample moments

Number of managers trading in the period

	n≥2	**n≥5**	**n≥10**	**n≥15**	**n≥20**
H^W	0.05	0.06	0.09	0.12	0.14
percent significant	100	100	78	58	26
stdev	0.01	0.01	0.02	0.04	0.07
skewness	-0.16	-0.11	0.25	-0.14	-0.03
kurtosis	-0.09	-0.03	0.06	-0.46	-0.54

Number of managers trading in the period

	2≤n<5	**5≤n<10**	**10≤n<15**	**15≤n<20**
H^W	0.03	0.05	0.08	0.12
percent significant	100	99	66	50
stdev	0.01	0.01	0.02	0.04
skewness	0.22	-0.05	0.28	-0.12
kurtosis	-0.17	0.22	-0.03	-0.53

Size rank of stock

	r≤5	**r≤20**	**r≤100**	**r>1000**
H^W	0.04	0.06	0.07	0.08
percent significant	100	100	99	94
stdev	0.01	0.01	0.01	0.02
skewness	-0.07	-0.08	0.30	0.24
kurtosis	-0.35	0.37	0.06	-0.26

Table 4.20 Wermers measure on datasets replicated by randomly re-allocating the identity of stocks

H^W is the level of herding as measured by the Wermers measure

percent significant is the percentage of the 200 simulated datasets on which the Wermers measure finds a level of herding that is significant at the 95% level

stdev is the sample standard deviation of the Wermers measure on the 200 replicated datasets. *Skewness* and *kurtosis* are corresponding higher sample moments

	Number of managers trading in the period				
	n≥2	**n≥5**	**n≥10**	**n≥15**	**n≥20**
H^W	0.00	0.01	0.01	0.02	0.05
percent significant	8	5	2	2	1
stdev	0.01	0.01	0.03	0.05	0.09
skewness	-0.38	0.17	0.35	0.22	-0.08
kurtosis	0.63	0.68	1.78	0.23	0.42

	Number of managers trading in the period			
	2≤n<5	**5≤n<10**	**10≤n<15**	**15≤n<20**
H^W	0.01	0.01	0.00	0.02
percent significant	10	3	0	2
stdev	0.01	0.01	0.03	0.05
skewness	0.06	0.11	-0.43	0.29
kurtosis	-0.35	0.04	0.70	0.14

	Size rank of stock			
	r≤5	**r≤20**	**r≤100**	**r>1000**
H^W	0.01	0.01	0.01	0.01
percent significant	16	6	3	3
stdev	0.01	0.01	0.01	0.02
skewness	0.20	0.10	-0.09	0.00
kurtosis	-0.42	0.20	0.02	0.14

Chapter 5 The Pension Fund Industry

5.1 Introduction

The current level of delegated portfolio management has arisen from investors choosing fund managers. It is the story of millions of individual investors delegating the management of their portfolios by choosing one or more fund managers from among the many institutional fund managers that offer their services. The dynamic re-structuring of the investment management industry is characterised by: the concentration of funds in the hands of a relatively few very large investment management firms, the winners; the diminution and exit of losers; and the continuous entry of new investment portfolios offered by new and existing investment management firms. These dynamics result from the aggregation of the myriad individual decisions of individual investors regarding which fund managers to invest with, and then the period by period decision whether to retain those managers.

This essay, encompassing this chapter and the next, studies how investors choose fund managers and how investors decide each period whether to retain a fund manager for at least one more period, or alternatively, dismiss the fund manager and choose another. The study proceeds by modelling the rational decision process of investors in hiring and firing fund managers.

The motivation for studying these decisions is twofold. Firstly, to gain a better understanding of the downside of the incentive schedule faced by fund managers. In this essay the relationship between poor performance and the decision of investors to withdraw their funds from a manager is modelled in an attempt to better understand the downside of the fund manager incentive schedule.

The second objective is to better understand the aggregate effects of the decisions of individual investors. The aggregate effects of interest to this study include: the concentration of fund management in the hands of fewer managers; the equilibrium level of passive investment management in the market; and the entry and exit of managed portfolio products.

g and firing is a discrete, observable decision with no complicating portfolio effects.

Secondly, the information structure is particularly simple in this case. It can be reasonably assumed that the investor receives portfolio performance information at discrete points in time; usually quarterly. In this case a discrete model can be realistically constructed, which facilitates the employment of Bayesian techniques. Moreover, the investor can observe aggregate statistics on the universe of fund managers, but cannot readily observe the performance of individual fund managers other than their own. This property of the UK pension environment allows the vastly simplifying assumption that investors consider only the performance of their own fund manager in deciding whether to retain the manager each period.

The remainder of this chapter provides institutional detail on the UK pension fund industry to aid the reader in understanding the context in which the crucial assumptions of the model are made.

5.2 An overview of the UK pension fund industry

5.2.1 Pension funds and the economy

In the UK, occupational pension funds play a major role in private provision for retirement income. In 1991, 57 percent of working men and 37 percent of working women were members of occupational pension schemes (Goode 1993, p581). In December 1996 the assets of UK segregated UK pension funds was £544bn (Office for National Statistics, Financial Statistics). In 1996, segregated pension funds (excluding pooled funds managed by insurance companies) owned £276 billion in UK equities. The sheer size of pension fund assets ensures that the decisions of the managers of these funds collectively affect financial asset markets. The UK Inland

Revenue statistics 1992 show that in 1988 the pension rights of occupational pension scheme members were equal to 31 percent of marketable wealth.[60]

The 1995 Annual Survey of the National Association of Pension Funds (NAPF) reported an average pension scheme size of slightly less than £500 million, with 70 percent of the 800 survey respondents in the range of £10 million to £500 million.

The UK Government has provided tax incentives to encourage personal sector saving for retirement through occupational pension schemes. Contributions to the pension fund are made before tax for both firms and individuals. Benefits received are generally taxable except for a lump sum.

Occupational pension funds are organised at the level of the firm. Pension schemes benefit firms by: maintaining their competitiveness in the labour market; helping to match the marginal productivity of workers to their remuneration; encouraging junior workers to remain with the firm as their skills develop; and encouraging senior workers to retire when their marginal productivity falls.

5.2.2 Defined benefit and defined contribution schemes

Pension funds fall into the two broad categories of defined benefit schemes (also known as final salary schemes) and defined contribution schemes (also known as money purchase schemes). In defined benefit schemes the firm promises to pay a pension which is a fraction of the employee's final salary. Typically the fraction increases by an increment of 1/60th or 1/80th with each year of service. The scheme may also pay a lump sum on retirement. Many schemes have some indexation of pensions for price inflation.

The promised pension benefits are a liability of the firm. The firm makes regular contributions to the assets of the pension fund as provision for meeting the liabilities when they become due. The assets are held in trust and are therefore separate from the assets of the firm. In most cases the firm makes a monthly contribution to the pension fund which is a fixed percentage of total superannuated salaries/wages for

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[60] Marketable assets do not include pension rights.

the month. The firm contributes a fixed percentage of each employee's salary; however, the firm reviews its contribution rate annually to ensure that the funding rate is adequate. The firm's shareholders bear the risk that the growth in asset values may not be sufficient to meet the growth in liabilities, in which case the firm must meet the deficiency. This division of risk is considered economically efficient because shareholders can diversify the pension risk across firms and therefore can bear the risk at lower cost than the beneficiaries of the pension fund.

In defined contribution schemes the firm and the employee each pay a fixed percentage of the salary into the pension scheme. On retirement the employee receives a pension which is commensurate with the growth of the value of assets in the scheme and the employee's share of those assets. This paper focuses exclusively upon defined benefit schemes. In 1993, defined contribution schemes covered less than 9 percent of UK employees in pension schemes (Goode 1993, p 583 table 6).

5.2.3 Control of the fund

The firm controls the existence of the pension fund. The trust deed sets out the general features of the pension scheme and the power to appoint trustees. A schedule to the deed contains the rules of the trust; including eligibility, benefits, and contributions. The trust deed is drawn up by the firm.

There is no compulsion for the firm to have a pension fund. Moreover, the firm may wind up the scheme, close it to new members, or freeze the scheme. UK firms provide little information to shareholders regarding the pension fund. The annual accounts typically contain a brief statement of the actuarial method of valuation, the last date of valuation, and perhaps the current contribution rate. More detailed information is usually provided in rights issue and take-over documentation.

The accounts of the pension fund are separate from those of the firm. However, in most cases, the firm's auditors also audit the pension fund. Moreover, much of the administration of the pension fund may be undertaken by the firm. So the firm and the pension fund are intricately linked at all levels. In the US pension funds often invest significant fractions of their funds in the securities of the firm itself and pension funds may be simply run by the treasury department of the firm. Self investing by pension funds is not permitted in the UK.

5.2.4 Role of the trustee board

The trustee board of the pension fund is separate from the firm. The trustees have a duty to act in the interests of the trust's beneficiaries, and to treat them equally. The duties of the trustee board are to: oversight the funds of the trust to ensure their safe keeping; decide upon allocation of the funds to asset classes; choose a manager or managers for the funds; keep the beneficiaries informed of the status of the trust; administer the pension fund; decide upon benefits levels; and act for the beneficiaries in winding up the trust.

UK trustee boards usually have less than eight members and often four or less (Brown, Davies, Draper 1992a). Most trustee boards include an elected or nominated representative of the beneficiaries. In practice senior executives or directors of the firm often form a majority of the trustee board members.

The interests of shareholders and pension fund beneficiaries are largely coincident; however, where these interests diverge the trustee board must decide whose interests to promote. Most of the literature on the US pension fund industry assumes that the trustee board acts in the interests of shareholders. Trustees are legally obliged to represent beneficiaries, but the actual objectives and incentives of pension fund trustees are not well understood.

5.2.5 Agency structure of the pension fund industry

An interesting facet of delegated portfolio management in the pension fund industry is that there are several levels of agency. The beneficiaries of the pension fund are the ultimate principals in the relationship. They are represented by the trustees of the pension fund who are required by law to act in the interests of beneficiaries. Nonetheless, the trustee board is often dominated by the management of the firm - who must represent the interests of shareholders in other matters. The trustee board chooses an investment management firm to manage the assets of the fund. Finally the investment management firm tasks one of its fund managers to manage the particular account.

The trustee board acts as agent to the beneficiaries and principal to the investment management firm. The investment management firm acts as agent to the trustee board and principal to the individual fund manager. The investment management firm has an explicit contract with the trustee board and an implicit contract with its fund managers; the investment management firm's employee.

The delegated portfolio management literature for the most part ignores this additional level of agency that exists between investors and fund managers. Yet in optimal contracting, performance persistence, and other areas, this extra level of agency is of crucial importance. The UK pension fund management industry has become highly concentrated in the last 10 years with the result that the largest investment management firms now employ large numbers of fund managers. Merrill Lynch Mercury Asset Management, the market leader, employs over 140 fund managers Mercury Asset Management alone.

5.2.6 Funding levels

UK firms generally pay a constant fraction of their salary bill into the pension fund on a monthly basis. This fraction, called the contribution rate, is usually set every three years at the time of the actuarial review of the pension fund but is reviewed annually to ensure that the minimum funding requirements of the Pensions Act 1996 are met.

Most schemes are currently well funded, with solvency at or near 100 percent. This means that the actuarial value of the pension fund's assets are 100 percent or more of the actuarially estimated present value of the pension fund's liabilities. The tax exempt nature of pension schemes is a powerful incentive for the firm to maintain a high level of funding. The Finance Act 1986 introduced a 105 percent solvency ceiling to prevent firms using the pension fund as a vehicle for tax minimisation. Regulations stipulate the calculation of solvency for tax purposes. If the fund is more than 105 percent solvent for tax purposes, then 5 years are allowed for a run down in the solvency, otherwise tax is applied.

Assets in the pension fund in excess of those required for 100 percent solvency represent a surplus. Since the late 1980s many schemes have accrued large surpluses due to high investment returns and previously high funding levels. Surpluses can be run down by: benefit improvements; contribution ‘holidays’ for the employer and occasionally the employees; a reduction in asset values; or a transfer of surplus to the firm. Transfer of surplus is uncommon and difficult for the firm to achieve. If the solvency of the fund falls markedly below 100 percent, then the firm must inject additional funds into the scheme.

“Under current legislation, any deficit of the pension scheme where the employer becomes insolvent, is a debt of the employer. The debt created does not have preferential treatment under the insolvency rules” (Goode 1993). Certain unpaid contributions are preferential in insolvency. Deductions from earnings in the four months preceding appointment of an insolvency practitioner are treated preferentially. Further, deductions in the previous twelve months for employers contracting out of the State Earnings Related Pension Scheme (SERPS) can be reclaimed from the National Insurance Fund. These amounts are typically small compared to total pension fund liabilities. In respect to any shortfall in the pension fund due from the firm, the pension fund is not a priority creditor.

5.2.7 Fund management

Most trustee boards appoint external investment managers for the assets of the pension fund. Generally only pension funds with over £1 billion in assets find it economical to conduct in-house management. Firms with less than 200 employees generally find the risk of a self administered pension fund and the level of administration unacceptable (Goode, p 586 table 10). They consequently purchase administration services and insurance or annuity contracts, from insurance companies.

Larger firms usually choose to be self administered and uninsured. Firms with less than £50 million in pension fund assets usually choose a single fund manager to manage a balanced fund. This means the single balanced fund manager (SBFM) then chooses the allocation of funds among asset classes. The trustee board often sets allocation limits of approximately +/- 5 percent for the major asset classes of UK equities, overseas equities, bonds, etc. The trustee board may preclude some asset classes such as property. The balanced fund manager then chooses specific assets within each class.

Above £50 million in pension fund assets, trustee boards often choose to diversify the fund manager specific risk by employing more than one balanced fund manager. Funds that are larger still may choose specialist managers for different asset classes. Since the late 1980s there has been a trend toward specialist management in the UK pension fund industry.

The different types of institutions offering fund management services include: financial conglomerates; investment banks; the investment arms of retail banks; specialist fund managers; insurance companies; and boutiques (offering niche products in investment management). In this essay any firm offering investment management services to pension funds is generically referred to as an investment management firm. The term ‘fund manager’ is reserved for the individuals who are employed by investment management firms to manage pension fund accounts. The pension fund engages an investment management firm to manage part or all of its assets. The investment management firm chooses a fund manager, who is a member of its staff, to manage the account. Investment management firms vary in size from those that employ 3 or 4 fund managers to the largest which employ over 100 fund managers.

The trustee board and the investment management firm have a contract which can be terminated at short notice. These contracts usually stipulate flat rate fees and performance based incentives are rare.[61] The relationship between trustee boards and investment management firms is highly fluid. Brown, Davies, Draper (1992a) report the following figures from a survey of trustee boards. Last change to investment management arrangements: current year 18.7 percent; last year 11.7 percent; two or three years ago 25.7 percent; 4 or more years ago 28.3 percent; no recent changes 15.7 percent.

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[61] The level fees charged by UK and US pension fund managers are discussed in section 2.3.1.1

5.2.8 Consultants and performance measurement

Most trustee boards engage consultants to advise them on management of the pension fund. Consultants are particularly important in accumulating independent sources of information on the performance of investment management firms. They assist trustee boards with the choice of investment management firm, appraisal of fund manager performance, and asset allocation.

Trustee boards and investment management firms employ performance measurement service companies to provide independent measurement of the investment performance of fund managers. Performance measurement in the UK is dominated by the WM Company and CAPS which each measure the investment results of over 1,000 pension funds. From these results WM and CAPS each create a 'universe' of pension funds. The critical descriptive figures of the CAPS and WM universes, such as, median return, weighted average return, quartile returns, interquartile range, etc. are widely quoted. Many trustee boards base fund manager performance benchmarks on one of these universes. For instance, a trustee board might stipulate the WM weighted average plus 200 basis points as the performance that is expected from the fund manager.

5.2.9 Information available to trustee boards

Trustee boards need performance data in order to make reasonable decisions about which investment management firm to choose initially, and then to decide whether to retain the investment management firm as time goes by. Investment management firms employ a number of fund managers. In the selection process the investment management firm usually presents to the trustee board a fund manager who has achieved relatively high recent portfolio returns, as the manager who will manage the trustee board's funds. The trustee board will often ask the investment management firm for data on the average performance of the investment management firm's fund managers, and the interquartile range of their performance. The measurement services, WM Company and CAPS, will not release detailed information on the breakdown of investment management firm performance by fund manager to the trustee boards. However, since a large consulting firm may share many clients with a large investment management firm, a more detailed picture of the distribution of fund manager performances within the investment management firm can be gleaned from the records of the consultant.

5.2.10 Role of the actuary

Consulting actuarial firms provide advice to both the firm and the trustee board on the status of liabilities and the sufficiency of pension fund assets to meet those liabilities. Actuarial reports are also required to meet certain regulatory requirements. An actuarial review of the pension fund is usually undertaken every three years.

The actuary estimates the present value of the liabilities of the pension fund. To do this, economic assumptions about the growth of nominal wages and the growth of asset income levels are made, followed by demographic assumptions about mortality rates and retirement ages. Then the present value of liabilities is estimated, either on the basis of accrued liabilities or, alternatively, the liabilities that are projected to accrue over the employees' service lives.

The actuary then looks at the earnings power of the pension fund assets. Simple assumptions are made about the stream of earnings that will arise from the pension fund assets. These earnings are then discounted back to the present using the same discount factor as in the liability present value calculation.

The actuary estimates the contribution necessary to meet liabilities as they accumulate over the next three years. This contribution rate might be 8 percent of salaries for instance. If the actuarially estimated present value of assets exceeds the actuarially estimated present value of liabilities, then the fund is in surplus. The actuary will then calculate a reduction in the contribution rate that will run the surplus down to zero over a certain interval.

5.2.11 The US pension fund industry

The Employee Retirement Income Security Act (ERISA 1974) has a dominant regulatory influence in the US pension fund industry and leads to industry outcomes that are in many ways different from the UK industry. ERISA created the Pensions

Benefit Guarantee Corporation (PBGC). US firms with defined benefit schemes pay a yearly premium to the PBGC for each employee covered.

The PBGC sets limits on maximum and minimum contribution levels, solvency levels and asset allocation choices. The PBGC can wind up a pension fund that does not meet its requirements. In return the PBGC insures the pension benefits of each employee up to a maximum sum. The firm essentially has a put option which is written by the PBGC. The firm can put its pension liabilities to the PBGC at an exercise price of the assets of the fund plus 30 percent of the net value of the firm. If the firm exercises the option then the PBGC may prevent the firm from creating another defined benefit scheme. The PBGC insurance means that beneficiaries do not bear default risk. Therefore, PBGC insurance removes the main source of conflicting interest between shareholders and beneficiaries.

The accounting of US pension funds is largely dictated by FASB 87. Firms cannot include pension fund surpluses in their balance sheet but must include deficits. As in the UK, the US actuarial practices permit a great deal of flexibility for the firms pension fund accounts. US firms must lodge a Form 5500 with the Department of Labour each year. The form includes: asset and liability figures; asset allocations; and income and expense data.

Defined contribution schemes are more popular in the US where they comprise nearly 50 percent of schemes. Unlike the UK industry, asset allocation is heterogeneous across US pension schemes (Papke 1991). Moreover, the pension fund management industry is not as concentrated in the US as it is in the UK (Lakonishok, Shleifer and Vishny 1992b). Finally, US firms choose more pension fund managers than their UK counterparts and the management firms chosen are more specialised by the asset class managed.

5.3 A review of the finance literature on pension funds

The literature on occupational pension funds spans the topics of labour economics, welfare economics, public finance, management accounting and finance. The main body of the literature focuses on the US pension fund industry. However, the results can often be adapted to UK circumstances.

Empirical work in pension funds has been restricted by a dearth of good data resulting from the proprietary nature of major data sources. There has been a great deal of research undertaken by performance measurement agencies, industry organisations, regulatory bodies and committees of enquiry. This research is of mixed quality - but is a valuable source of data.

5.3.1 Trustee board objectives

Much of the behaviour of pension funds is not well understood. Several immediate examples are choice of asset allocation, asset allocation herding, choice of funding levels, decisions on retaining or dismissing fund managers or choices of active versus passive management. To understand decisions taken by pension funds we need an understanding of the objectives of the pension fund trustees. Of particular importance is, firstly, the question of how the trustee board views risk; including, total risk, market risk, and the correlation between firm value and pension fund value. Secondly, how the trustee board acts in situations where the interests of shareholders and beneficiaries conflict.

Brown, Davies, Draper (1992a) and the National Association of Pension Funds Committee of Enquiry into Performance Measurement (1991) report survey evidence on: how trustees view their decision-making; the composition of trustee boards; who trustee boards represent; and the importance of risk. UK trustee boards state their main objective as that of protecting the pension rights of beneficiaries. This answer is not surprising in light of UK trust law and trustee board liability, but does not always accord with the decisions of trustee boards.

As stated in the background section, the major difference in how shareholders and the beneficiaries view the pension fund is the meaning and the significance of risk. Papers relating to trustee board's perception of risk in the UK include Nobles (1985, 1992) and Schuller and Hyman (1983). Nobles (1985) discusses the UK law relating to trustees of pensions funds and how the UK courts have interpreted the law in specific cases. Nobles discusses the ownership of surplus pension fund assets. The trustee board's view of the treatment of surpluses is important for framing their view of the potential payoffs to risks taken. Bulow and Scholes (1983) look at ownership of surpluses in a US framework. Nobles (1992) examines the scope that trustees have for decision-making in the pension fund. Schuller and Hyman (1983) examine employee representation in UK pension schemes and the actual influence that beneficiaries have over pension fund decisions.

Most papers on the US pension fund industry assume that decisions on the running of the firm's pension scheme(s) are taken in the interests of shareholders - even where these interests conflict with beneficiaries. Bodie, Light, Morck and Taggart (1987) call this the corporate financial perspective of pension schemes. They point out that in the US insurance of benefits by the PBGC eliminates much of the shareholder/beneficiary conflict of interest. In contrast, the UK has no explicit government backed insurance of occupational pension benefits. Lakonishok, Shleifer and Vishny (1992b) give a detailed description of decision-making in US pension funds. Petersen (1994) describes how firms adjust funding of pension schemes to control operating leverage - an example of decisions on the pension scheme being taken purely in the interests of shareholders.

5.3.2 Defined benefit versus defined contribution

The firm's most fundamental decision regarding its pension fund is whether to have a defined benefit or alternatively a defined contribution scheme. Blake (1996) shows that the value of a pension scheme to the firm as a defined benefit scheme versus a defined contribution scheme can be compared with simple option mathematics. Bodie, Marcus and Merton (1987) examines this choice in terms of: differences in risks faced by the firm and beneficiaries; inflation; funding flexibility; and the importance of PBGC insurance of defined benefit schemes. Petersen (1994) concentrates on the influence of operating leverage on the choice. In the US, ERISA legislation defines minimum and maximum contribution limits for defined benefit schemes, whereas defined contribution schemes are not encumbered by these limits. Petersen's empirical research shows that firms with variable cashflows and a high cost of financial distress are more likely to choose defined contribution plans.

5.3.3 Funding asset allocation

On a period by period basis the trustee board or plan sponsors must decide the funding level and asset allocation of the pension fund. Much of the finance literature on pension funds develops theories of the choice of funding and asset allocation in a US setting.

Sharpe (1976) and Treynor (1977) use simple contingent claims pay-off diagrams to examine the effects of ERISA (1974) legislation. Sharpe shows the perverse incentive effects created by PBGC insurance. In Sharpe's model, if all agents (firm, beneficiaries, PBGC) react rationally to the risk of pension fund default by the firm, then neither funding nor asset allocation decisions should matter. But if the PBGC does not demand compensation commensurate with the risk of default (the generally accepted view) then the optimal shareholder strategy is to minimise the funding level and maximise the risk of the portfolio (in practical terms - hold more equity) to maximise the value of the put. The PBGC insurance guarantee takes the form of a put option in a one period model.

By assuming there is no default risk and considering tax aspects of the decision, Black (1980) and Tepper (1981) arrive at the conclusion that firms should both maximise funding and choose to hold only bonds: which is the exact opposite of the Sharpe and Treynor prescription. Black and Tepper look at funding and asset allocation from the corporate financial perspective where the balance sheets of the firm and the pension fund are considered as one.

Black argues that, in the absence of taxes, Modigliani-Miller (1958) considerations dictate that the firm is indifferent to the funding and asset allocation policies. In the presence of taxes, and ignoring default risk, firms can make a tax arbitrage gain as follows. Pension fund stocks are all sold and are replaced in the fund by bonds of equal value. Then (1-T)B of corporate bonds are issued by the firm to fund the repurchase of the same amount of the firm's equity (where T is the corporate tax rate and B is the value of pension fund stocks sold). This rearrangement does not affect firm leverage but does reduce tax paid by BT/r per year. Funding is maximised to reap full benefits of the pension fund tax shield.

Tepper's justification for the same strategy is that because of the special tax status of the pension fund, the stream of income from bonds in the fund are received by shareholders with tax applied at the lower equity rate. Harrison and Sharpe (1983) and Bulow (1982) show that if the PBGC insurance effects and tax shield effects are considered together then firms will choose one of the extreme solutions (minimum funding and maximum volatility or vice versa). There is no interior solution for funding and asset allocation. Marcus (1983) analyses the value of PBGC insurance in a model in which termination of the plan is endogenously determined - rather than just imposed at the end of period. Under two separate regimes, voluntary termination and alternatively, termination at bankruptcy, it is again found that an extreme funding position is optimal.

Bicksler, Chen and Babcock (1985) show that if pension termination costs and an asymmetric corporate income tax regime are included, then interior funding and asset allocation solutions can be optimal - which accords with empirical findings of interior solutions. Francis and Reiter (1987) find that high levels of funding are driven by tax incentives, creation of financial slack and financial statement incentives relating to relationship costs. Low levels are driven by PBGC insurance effects, capture of pension fund surplus by beneficiaries and debt contracting costs.

There are surprisingly few empirical papers on pension funding and asset allocation given the importance of these decisions to asset markets. Friedman (1983) collects the asset allocations, income and expenses, and accrued liabilities of 20,000 defined benefit plans in 1977. The 1974 ERISA legislation requires that US corporations annually lodge a Form 5500 with the IRS and Department of Labour. Friedman uses 5500 data and Compustat data to examine the pension fund strategy of US firms. He finds that firms with volatile earnings hold less equity and more debt in their pension fund. The same result is found for highly leveraged firms but the opposite result of low debt high equity characterises firms which have experienced high rates of return on assets.

Bodie, Light, Morck and Taggart (BLMT 1987) use data from the US FASB 36 filings for 1980, and asset allocation data from a commercial source, to examine funding and asset allocation decisions. They report the following findings. Discount rates chosen by firms to calculate the present value of liabilities is inversely related to profitability. There is a positive relation between profitability and funding level. There is evidence that firms facing higher risk and lower tax choose lower funding levels. The percentage invested in bonds is negatively related to plan size and underfunding. Finally, the distribution across funds of the percentage invested in bonds is bimodal but not clustered around extreme distributions.

Papke (1991) uses Form 5500 data from 1981 to 1987 to present a wealth of data on asset allocation of US plans in this period. He shows that US funds are quite heterogeneous in their choice of asset allocation weightings. His frequency distribution diagram of the percentage invested in bonds has one mode at 45 percent and another at 100 percent. Nearly 10 percent of funds held only fixed income securities.

Papke points out that there are aspects of plans' funding which are not captured in this asset allocation data. Derivative securities (which could change the actual asset allocation) are <u>not</u> reported. Moreover, plans may have strategies such as a stop loss order where if equities fall to a certain level then equities are sold and bonds with a duration equal to the duration of the plans' liabilities are purchased.

The WM Company is a major UK based performance measurement service. WM (1995) shows how the asset allocation of UK pension funds became increasingly homogeneous in the period 1979 to 1993. Nonetheless, WM believe that claims of asset allocation herding by pension fund managers are exaggerated, while their results show that the interquartile range of weightings in UK equities in 1993 was only 4 percent when the median weighting exceeded 50 percent. The 5-95 percentile range is only 21 percent. Compared to the US pension fund asset allocation data, the WM results actually seem to demonstrate a high level of asset allocation herding. Blake, Lehmann and Timmermann (1999) study the asset allocations and returns of a large set of UK pension funds and find little variation in fund performance due to asset allocation herding. They attribute the existence of asset allocation herding to the incentive structure faced by UK pension fund managers.

Blake (1992) has a stochastic dynamic programming model of portfolio choice by UK pension funds. He uses data on UK pension fund portfolio holdings from 1963 to 1978 (a period during which ownership of foreign assets was heavily disadvantaged by capital/exchange controls). Blake looks at whether pension fund portfolio choices were consistent with models of dynamic portfolio choice. His most interesting finding, for this essay, is that “...private sector pension funds are only moderately risk averse (indeed their portfolio behaviour could be described as close to risk neutrality.)” (Blake 1992, page 161)

Michel and Shaked (1986) find that critical pension fund ratios, which relate unfunded pension liabilities to the number of employees, total annual pension cost, net worth, etc, vary across industries. Industry rankings for these measures remain remarkably stable from year to year.

Feldstein and Seligman (1981), Feldstein and Morck (1983) and Bulow, Morck and Summers (1987) look at whether share prices accurately reflect the unfunded pension liabilities of firms. They create datasets that permit adjustments for the different discount rates that firms use in calculating pension fund liabilities. They unanimously find that shareholders do adjust share prices for unfunded liabilities. Moreover, that firms choose discount rates strategically: underfunded firms choose high discount rates and overfunded firms (the majority) choose low discount rates.

5.3.4 Investment management decisions of trustee boards

In addition to decisions on: defined benefit versus defined contribution; funding level; and asset allocation; the trustee board faces decisions on the choice of fund manager. Initially three fundamental choices must be made between: internal or external fund management; active or passive management; and balanced or specialist management. Then a manager or managers must be chosen and each period a decision must be taken on whether the manager is retained or, alternatively, dismissed.

The academic literature does not much discuss these decisions. Lakonishok, Shleifer and Vishny (1992a) discuss these matters but provide no model and little evidence. Brown, Davies and Draper (1992a) report survey data on the frequency with which

UK trustee boards alter their fund management arrangements, and the performance measures that are considered important by trustee boards. Brealey and Hodges (1972) undertake a simulation study of portfolio performance and find that even for highly informed managers, 100 or more quarters of data is required to reject the null hypothesis of no information at the 95 percent level. Ashton (1996) arrives at a similar result by creating an econometric lower bound for the number of observations required to identify informed managers.

The literature is remarkably silent on the decision process by which investors decide to retain or dismiss their fund manager. There appears to be no literature on this question in a pension fund framework. The literature on the explicit and implicit forms of fund manager incentives is reviewed at length in chapter 2.

5.3.5 Survivorship bias

Survivorship bias refers to the bias in results that arises from omitting firms that do not survive the entire sample period. One effect is the increase in the cross sectional average of fund returns if survival is related to relatively good performance. Grinblatt and Titman (1989b) results indicate that this effect is fairly small, between 10 and 40 basis points per year.

A separate form of survivorship bias arises if fund managers differ cross sectionally in the variance of their portfolios and survival is related to performance. Brown, Goetzmann, Ibbotson and Ross (1992) have shown that under these circumstances, the truncation of the cross sectional distribution of portfolio returns can induce the illusion of performance persistence. Their simulations show that modest truncation can substantially bias the inferences of performance persistence tests.

An attrition rule (dismissal rule) relates survival in a period to the history of fund performance. The form of the attrition rule determines, firstly, whether the bias is toward or, alternatively, against finding persistence and, secondly, the magnitude of the inferential bias. A dismissal rule is a form of attrition rule. Therefore if the retention/dismissal process can be modelled and a dismissal rule estimated then it may be possible to reassess the results of previous studies of pension fund performance persistence and illuminate the design of future studies. LSV (1992a) and Brown, Draper and McKenzie (1997) have found persistence in pension fund performance in the US and UK respectively.

Chapter 6 Hiring and Firing Fund Managers

6.1 Introduction

Investors who opt for delegated portfolio management have a large number of professional fund managers to choose from, including active managers and passive managers. Investors use information available at the time that funds are invested to choose one or more fund managers. Over time new information arrives. At a cost, the investor can enact some combination of the following actions: dismissal of one or more of the fund managers and employment of new managers; re-balancing of the investment across the existing managers; and/or re-negotiation of the contractual terms with one or more managers.

In deciding which managers to choose, investors may have preferences over several characteristics of fund managers, including: size of funds under management; range of services provided; administrative support; and location of offices. However, a major consideration for all investors who choose active management is the ability of the fund manager to add value by attaining positive risk adjusted excess-to-benchmark returns.

Investors receive performance results at regular intervals. If the fund manager performs poorly, other things equal, the investor must decide whether to change for the next period the value of assets delegated to that manager.[62] In this chapter the following simple case is modelled. An investor chooses a single fund manager on the basis of the information available at time t_0. Performance results then arrive at the end of each period, at which time the investor decides whether to continue with the manager, or alternatively, incur cost K and choose a new manager. The investor's optimal manager dismissal policy is derived here for a two period model.

In this essay the investor's problem is placed in the specific context of a pension fund trustee board's relationship with its single balanced fund manager. There are

[62] Contractual terms between investors and institutional or retail investment managers are rarely renegotiated (Lakonishok, Shleifer and Vishny 1992a, Golec 1992, Goode 1993).

advantages to choosing a pension fund context. Firstly, assumptions about risk, contractual form and costs can be made simple and reasonable. Secondly, the descriptive results of the modelling can be compared to known institutional arrangements in the pension fund industry.

Most of the performance measurement literature analyses problems associated with measures of asset selection or market timing abilities. Brealey and Hodges (1972) and Ashton (1996) take a different tack. They discuss the practical difficulty of getting enough observations to make inferences about measures of fund manager ability. Brealey and Hodges simulate optimal portfolio formation by managers who have various levels of stock selection and market timing ability. They show that for a manager who has a correlation between predicted stock return residuals and realised residuals of 0.15 (a high figure), approximately 100 quarters of data would be required to attain 95 percent confidence that the correlation is not zero. Ashton seeks an econometric lower bound for the number of observations required to discern plausible levels of manager forecasting ability. He similarly finds that over 100 periods of data are required.

But we know that trustee boards do not wait 100 periods before making decisions. In fact the relationship between pension fund trustee boards and fund managers is quite fluid. Brown, Davies and Draper (1992a) report that 56.1 percent of their trustee board survey respondents indicated that they changed their relationship with one or more of their fund managers in the previous 3 years.

The Brealey and Hodges, and Ashton approaches ignore two crucial aspects of trustee board behaviour. Firstly, levels of statistical certainty are incidental to the investor's decision. Rather, the investor has an objective, such as minimisation of the cost of a pension scheme, in which the choice of manager is a decision variable. The critical level of certainty about fund manager ability, at which the decision to change managers is made, is determined endogenously and varies with the circumstances of the problem - such as the cost of changing manager. Secondly, the investor has prior information about the manager's ability to add value. It is hard to imagine how an investor could choose a manager from a completely uninformed position.

The investor's decision process involves the combination of prior information with evolving sample information to choose optimally between mutually exclusive decisions (to retain or dismiss) which have stochastic payoff states. This is naturally a Bayesian updating decision problem. Naturally - because it seems indisputable that investors update their information through time and then choose optimally from a set of managers.

A two period model of the optimal manager dismissal policy is developed here. Heinkel and Stoughton (1994) develop a two period Bayesian updating model of manager performance. Their purpose, however, is to explain observed features of investor/fund manager contracts, such as flat rate fees, boiler plate contracts and independent performance measurement.

A model of an investor's rational fund manager dismissal policy has a number of potential applications. Firstly, in understanding incentives faced by fund managers. A better understanding of the structure of incentives faced by fund managers may help to explain features of the individual and collective behaviour of fund managers; such as, momentum investing, herding, index tracking and mean reversion of returns in 'universes' of fund managers. As discussed in Chapter 2, most fund managers in the mutual fund and pension fund industries are employed on fixed fee contracts (Lakonishok, Shleifer and Vishny 1992a, Golec 1992, Goode 1993). Poor performance does not usually result in lower fees but it may lead to termination of the contract. The investor's dismissal policy relates fund manager performance to dismissal, which in turn characterises the downside risk faced by that investor's fund manager.

In addition, a manager dismissal model can illuminate dynamics in the overall relationship between pension fund trustees and pension fund managers. Brown, Harlow and Starks (1996) view the fund management industry as a tournament. The tournament 'winners' get the new funds flowing into the industry each year. The others gain no new investment money but also lose little. Sirri and Tufano (1998), Goetzmann, Greenwald and Huberman (1992), Capon, Fitzsimmons and Prince (1996) provide results which support this theory. Ippolito (1992) looks at how investors react to poor performance. Goetzmann and Peles (1997) seek to explain the seemingly unnatural length of time that investors retain poor performing managers, in a cognitive dissonance framework.[63] A manager dismissal policy provides an additional framework in which to examine these industry dynamics.

6.2 A model of investors' hiring and firing decisions

6.2.1 The structure and assumptions of the model

This model of optimal fund manager dismissal policy is developed in the context of a pension fund trustee board which delegates management of its assets to a single fund manager. At time t_0, which is the beginning of period 1, the investor chooses a manager from among a 'universe' of a large number of managers. At the end of each period the investor receives the portfolio performance figures for the period which include the benchmark return and the excess-to-benchmark return, as described below. The investor then decides whether to retain the manager for at least one more period, or alternatively, dismiss the manager and choose the best alternative manager from the universe of managers. The assumptions of the model are as follows.

A.1 The trustee board's sole objective in choosing a fund manager is the minimisation of the cost of meeting pension fund liabilities.

A.2 The return on the pension fund's portfolio in period n has two components; a benchmark return and an excess-to-benchmark return. The excess-to-benchmark returns are assumed to be normally distributed about mean m with precision t, and the values of those parameters vary across fund managers.

Equation 6.1

$$r_{pn} = r_{bn} + x_n$$

$$x_n \sim N(\mu,\tau), \quad n \in \{1, 2, \ldots\}$$

[63] See also Shefrin and Statman (1985) and Odean (1998a) for discussion of the disposition of private investors to hold on to poor performing investments for too long.

Where r_{pn} = return on the portfolio in period n (the period beginning at time t_{n-1})

r_{bn} = return on the benchmark portfolio in period n

x_n = the excess-to-benchmark return in period n

μ = the mean of the excess-to-benchmark return distribution of the incumbent manager

τ = the precision of the excess-to-benchmark return distribution of the incumbent manager.

All returns are after fees, expenses and turnover costs.

A.3 *The portfolio benchmark is chosen such that the excess-to-benchmark returns are independent of the factors that determine asset returns.*

A.4 *The stochastic process generating each manager's excess-to-benchmark returns is assumed to have time invariant parameters.*

By assumption A.1, the trustee board seeks to minimise the present value of the cashflows from the firm to the pension fund. There is a one-to-one correspondence between increases in the excess-to-benchmark return and reduction in the cashflows to the pension fund.[64]

The excess-to-benchmark return is a metric for value added by the manager, and therefore should not reflect exposure to priced factors. The benchmark portfolio return can be formed as the fitted or explained return in a factor model that includes all priced factors. The excess-to-benchmark return is then simply the residual of the factor model estimation. Therefore, the average of excess-to-benchmark returns can be interpreted as a multi-factor version of Jensen's alpha (Jensen 1968). In which case, the excess-to-benchmark return is seeking to measure value added by stock

[64] How pension fund decisions are actually taken, and exactly whose interests are represented by the decision makers, is not well understood. Legally, the trustees are required to act exclusively in the interest of the beneficiaries. However, trustee boards are often dominated by the management of the firm. Here I assume that the trustee board considers only market risk of the firm's free cash flows, thereby representing the interests of shareholders. This isn't an unreasonable assumption: trustee boards must balance the interests of shareholders and beneficiaries where they conflict. Beneficiaries can be compensated by higher solvency levels or higher benefits.

selection rather than factor or market timing by the manager.[65] The importance of the assumption that the excess-to-benchmark return is independent of priced risk factors is that it allows the considerable simplification of discounting of expected excess-to-benchmark returns at the risk free rate.

The probability distribution of the benchmark return is chosen by the trustee board. The distribution of the excess-to-benchmark return is specific to fund managers. Each manager is fully characterised by a stochastic process for the manager's excess-to-benchmark portfolio conditioned by the benchmark set by the trustee board. Each realisation of that process is a draw from a normal distribution which has time invariant parameters.

Let $\theta^{\mathbf{i}} = (\mu^i,\tau^i)$ be the mean and precision of the distribution of excess-to-benchmark returns for manager *i*. There is a large group of fund managers from which the trustee board may choose. From the trustee board's perspective the managers vary only in the mean and precision of their excess-to-benchmark returns over the benchmark portfolio; reflecting the managers' different investment abilities, incentives and risk preferences. The trustee board aims to appoint the manager that is expected, over time, to add the most value to the funds under management.

Implicit to assumption A.4, of time invariance of the manager's excess-to-benchmark return distribution, is an assumption that managers are not strategically varying the distribution parameters μ and τ through time as their realised performance changes their incentives. This assumption also means that the dilution of fund manager's r invested', resulting from new funds flowing to well performed fund managers, has no effect upon the mean of the excess-to-benchmark return distribution.

The trustee board uses all the initially available information to form a prior probability distribution over $\theta^{\mathbf{i}} = (\mu^i, \tau^i)$ for each manager *i* at time t_0. The available information includes the investment performance history of the manager, but might

[65] Until recently there was little evidence of market timing ability among institutional investors. Studies by Ferson and Schadt (1996) and Chance and Hemler (1998) find evidence of timing ability.

also include other information, such as recent personnel changes or investment in new technologies. In this Bayesian view, $\theta^{\mathbf{i}}$ is a random vector.

From the trustee board's perspective the universe of managers represents a set of projects, where each manager's excess-to-benchmark return in a period is the cash flow from the project which is that manager. At the end of any period the trustee board can switch from one project (manager) to another at a known cost of K per £ invested. From the prior distribution on $\theta^{\mathbf{i}}$, denoted $\varsigma(\theta)$, the trustee board is able to value the anticipated stream of excess-to-benchmark returns, and manager change costs, which follow the choice of manager *i* to manage the pension fund portfolio from time t_0. This value, denoted V_0^i is the value of active management to the trustee board at time t_0 conditional upon the initial choice of manager *i*. It is determined in equation 6.2 under the following assumptions.

A.5 The market value of the pension fund portfolio is re-balanced to £1 at the beginning of each period.

A.6 The income and assets of the pension fund are not taxed.

A.7 The interest rate on risk free assets is constant through time.

Equation 6.2

$$V_0^i = \sum_{n=1}^{\infty} \frac{E\left[x_n^j \middle| \Im_0, I_0 = i\right] - K \ \mathrm{Prob}\left[D_n = 1 \middle| \Im_0, I_0 = i\right]}{(1 + r)^n}$$

Where V_0^i = the value of portfolio management to the trustee board at time t_0, conditional on the choice of manager *i* at t_0

E = expectation operator applied at time t_0

x_n^j = excess-to-benchmark return of the incumbent manager j in the period beginning at time t_{n-1} (until manager *i* is dismissed *j=i*).

$\Im_0$ = the trustee board's information set at time t_0

I_0 = the identity of the chosen manager at time t_0

K = the cost of changing manager per £ in portfolio value

D_n = the indicator function which takes value 1 if the trustee board changes manager at time t_n

r = the risk free interest rate.

Equation 6.2 characterises the valuation of each manager as a net present value problem. V_0^i is the value to the trustee board of active management conditioned by the trustee board's information set at time t_0 and the choice of manager *i* at time t_0. It is the discounted sum of the value added to the portfolio by active management in each period. That value added is the excess-to-benchmark return of the incumbent manager less any cost incurred in changing manager at the end of the period. The equation recognises that the identity of the incumbent manager may change.

The trustee board can associate a value V_0^i with each manager *i* in the universe of managers under consideration. After ranking the available managers, the trustee board chooses the manager which maximises the value of active management of the trustee board's portfolio.[66]

A.8 The expected value of the best alternative manager at the end of any future period is only infinitesimally below that of the highest valued manager at time t_0.

Equation 6.3

$$V_0 = \underset{\{i \in I\}}{\mathrm{Max}}\, V_0^i = E\left[V_{n+m}^a \middle| \Im_n\right] \qquad n, m \in \{1, 2, \ldots\}$$

Where V_0 = the value of portfolio management to the trustee board at time t_0

[66] Passive management can be approximately characterised by an excess-to-benchmark return which has a known mean of zero and variance of zero. The manager's problem is trivial in this case - the value of index management is simply zero. If the trustee board does not assign a positive value to the management of any of the active portfolio managers then passive management is chosen and there is no reason to change manager in any future period.

V_0^i = the value of portfolio management to the trustee board at time t_0, conditional on the choice of manager *i*

V^a_{n+m} = the value of active management to the trustee board, at time t_{n+m}, if the best alternative manager is appointed at that time

$\mathfrak{I}_n$ = the trustee board's information set at time t_n

I = the set (universe) of all managers under consideration.

Assumption A.8 ensures that the trustee board makes decisions on the basis of the mathematical expectation that, in any period, if the current manager is dismissed, then after reassessing the universe of other managers the value of the chosen manager will be V^a.

The chosen manager is offered and accepts a flat fee contract. The terms of the contract are not renegotiated at any point. Having chosen a manager, the trustee board receives performance results at the end of each period.

If after n periods there has been no change of manager then the trustee board has observed a vector of excess-to-benchmark returns $\mathbf{x} = (x_1,....,x_n)$. Let V_n^r denote the value of active management at time t_n conditional upon retention of the manager for at least one more period. The value of active management at time t_n if the manager is dismissed is V^a-K. The value of active management at time t_n is then the maximum of V_n^r and V^a-K.

A.9 The only changes in the trustee board's information set are the performance figures of the chosen manager.

Equation 6.4

$$V_n = \text{Max}\,[V_n^r, V^a\text{-}K\,]$$

Where V_n = the value of portfolio management to the trustee board at time t_n

V_n^r = the value of portfolio management to the trustee board conditioned upon the existing manager being retained for at least one more period existing manager being retained for at least one more period

V^a = the value of portfolio management conditioned on the dismissal of the existing manager and appointment of the best alternative manager.

6.2.2 Illustration of the value of active management

6.2.2.1 Manager with permanent tenure

Much of this essay is concerned with modelling the determinants of the value of active management to the investor. To begin, consider a trustee board that is choosing a manager who after appointment will then have permanent tenure. In this case the choice of manager is a simple net present value problem.

Equation 6.5

$$V_0 = E\left[\frac{x_1}{1+r}\Big|\Im_0\right] + E\left[\frac{x_2}{(1+r)^2}\Big|\Im_0\right] + \ldots..$$

After n periods, during which **x** = (x_1, x_2, ,x_n) is observed, the posterior probability distribution over θ = (μ,τ), denoted $\xi_n(\theta)$, can be determined. Let m_n denote the trustee board's expected value of μ at time t_n.[67]

Equation 6.6

$$E\left[x_{n+1}|\Im_n\right] = \int_{-1}^{\infty}\int_{0}^{\infty} E\left[x_{n+1}\,|\,m,t\right]x_n(m,t)\,dt\,dm$$

$$= \int_{-1}^{\infty}\int_{0}^{\infty} m\,x_n(m,t)\,dt\,dm$$

$$= E\left[m\,|\,\Im_n\right]$$

$$= m_n$$

[67] The subscript *i* has been dropped to simplify notation.

The expected value of the excess-to-benchmark return, in the period beginning at t_n, is the expected value of μ over its posterior distribution at time t_n.

Equation 6.7

$$
\begin{aligned}
E\left[x_{n+2} \mid \Im_n\right] &= E\left[E\left[x_{n+2} \mid \Im_{n+1}\right] \mid \Im_n\right] \\
&= E\left[m_{n+1} \mid \Im_n\right] \\
&= E\left[\int_{\theta} \mu\, \xi_{n+1}(\theta)\, d\theta \mid \Im_n\right] \\
&= \int_{-\infty}^{\infty} \int_{\theta} \mu\, \xi_{n+1}(\theta)\, d\theta\, f(x_{n+1})\, dx_{n+1} \\
&= \int_{-\infty}^{\infty} \int_{\theta} \mu \frac{\xi_n(\theta)\, f\{x_{n+1} \mid \theta\}}{f(x_{n+1})}\, d\theta\, f(x_{n+1})\, dx_{n+1} \\
&= \int_{\theta} \mu\, \xi_n(\theta) \int_{-\infty}^{\infty} f\{x_{n+1} \mid \theta\}\, dx_{n+1}\, d\theta \\
&= E\left[\mu \mid \Im_n\right] \\
&= m_n
\end{aligned}
$$

Therefore from equations 6.6 and 6.7 and mathematical induction we have:

Equation 6.8

$$E\left[x_1 \mid \Im_0\right] = E\left[x_2 \mid \Im_0\right] = \ldots. = m_0$$

$$V_0 = \sum_{n=1}^{\infty} E\left\{\frac{x_n}{(1+r)^n} \mid \Im_0\right\}$$

$$= \frac{m_0}{r}$$

where $\{x_1, \Im_0\}, \{x_2, \Im_1\}, \ldots$ forms a martingale

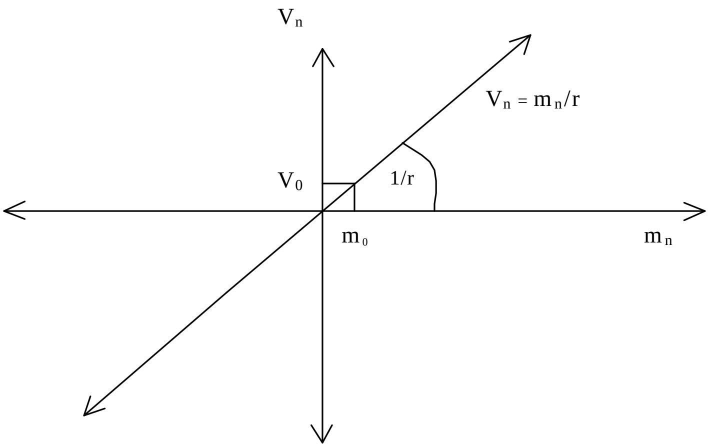
similarly, $V_n = \dfrac{m_n}{r}$

Under the assumption of permanent tenure for the chosen fund manager the value of portfolio management can be depicted in a two dimensional diagram. Figure 6.1 shows that the initial value is V_0 and a trustee board will only choose active management over passive management if $m_0 > 0$. That is, active management is chosen over passive management if the expected value of the mean of the excess-to-benchmark return distribution of the chosen manager is greater than zero. After the manager is chosen the vector of excess-to-benchmark returns evolves period by period. V_0 and V_n are related by the equation 6.9.

Equation 6.9

$$\text{If } \sum_{k=1}^{n} \frac{x_k}{n} \begin{matrix} < \\ = \\ > \end{matrix} m_0 \quad \text{then} \quad V_n \begin{matrix} < \\ = \\ > \end{matrix} V_0$$

Figure 6.1 Manager with permanent tenure



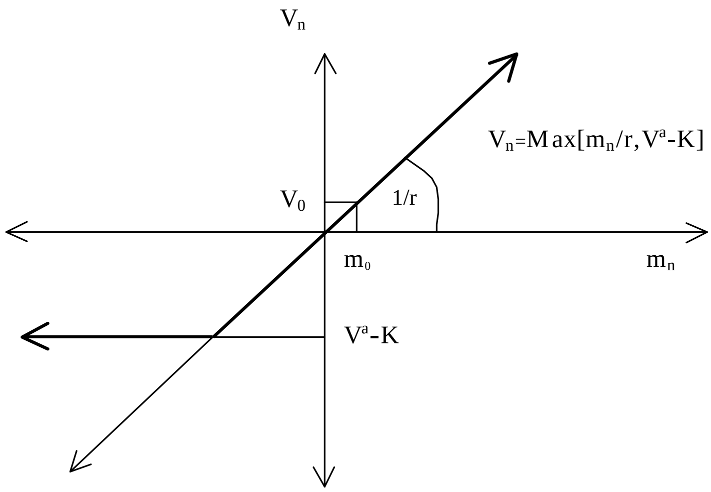
6.2.2.2 Option to change manager

Now assume that the trustee board has a one-off option to dismiss the manager at time t_n and choose a new manager, and then the new manager or retained manager has permanent tenure. The value of delegated portfolio management at time t_n is then the maximum of either the value conditioned on retaining the existing manager, denoted V_n^r, or the value conditioned on dismissing the existing manager which is the value of the best alternative manager, denoted V^a, less the cost K of switching to the best alternative manager.

Equation 6.10

$$V_n = \mathrm{Max}\left[V_n^r\ ,\ V^a - K\right] = \mathrm{Max}\left\{\frac{m_n}{r}\ ,\ V^a - K\right\}$$

Figure 6.2 Option to change manager in current period only



6.2.2.3 Option to change the manager at any time

The option at t_n, to dismiss the incumbent manager and employ the best alternative manager, puts a floor under the value of active management at that time. Now consider the conditions that trustee boards actually face – the option to change manager at the end of any period. Now V_n^r denotes the value of delegated portfolio management conditional on retaining the manager for *one or more* periods.

Where the trustee board can dismiss the manager at any point in time, the decision at the end of each period is between two actions. Firstly, to choose a new manager at cost K. Or alternatively, to postpone the decision to change manager to the end of the next period at which time another observation from the fund manager's excess-to-benchmark return is available. This decision is analogous to that of an investor deciding whether to pay a known cost to abandon one project and commence another project. The 'real' option, to delay the abandonment decision, by one or more periods, has value. The value derives from the resolution, during the period of delay, of some uncertainty over a variable that affects the value of the project.

As with options on financial assets, insight can be obtained by considering limiting cases. Here the limiting case is that of the sample mean of the excess-to-benchmark return approaching positive infinity or approaching –1. In either case the value of the option to decide in future periods approaches zero.

Equation 6.11

$$V_n^r = \frac{E\left[x_{n+1} + V_{n+1} \mid \Im_n\right]}{1+r}$$

$$= \frac{E\left[x_{n+1} \mid \Im_n\right]}{1+r} + \frac{E\left[\mathrm{Max}\left[V_{n+1}^r, V^a - K\right] \mid \Im_n\right]}{1+r}$$

$$= \frac{m_n}{1+r} + \frac{E\left[\mathrm{Max}\left[V_{n+1}^r, V^a - K\right] \mid \Im_n\right]}{1+r}$$

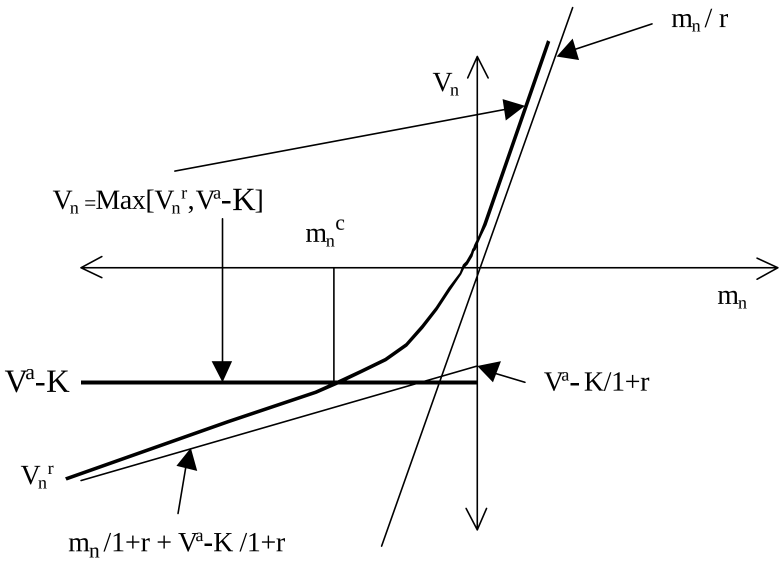
Equation 6.11 shows that, conditional on the retention of the existing manager for at least one more period, the value of delegated portfolio management is the sum of two quantities. The first is the discounted value of the expected excess-to-benchmark return in the next period. The second is the expected value of delegated portfolio management at the end of the next period discounted to the present. For V_n^r as a function of m_n, the asymptotes as m_n goes to $+\infty$ or -1 are easily deduced.

Equation 6.12

$$\lim_{m_n \to \infty} V_n^r = \frac{m_n}{r}$$

$$\lim_{\substack{m_n \to -1 \\ n \to \infty}} V_n^r = \frac{m_n}{1+r} + \frac{V^a - K}{1+r}$$

Figure 6.3 Option to change the manager at any time



As m_n goes to $+\infty$ investor sample information dominates any prior information. The investor's subjective probability of observing a sequence of excess-to-benchmark returns that would lead to dismissal of the existing manager goes to zero. This implies that the value of the option to dismiss the manager in any future period goes to zero, and the manager effectively has permanent tenure. Therefore, $V_n^r \rightarrow m_n/r$ from above (because the option goes to zero from above).

As m_n goes to -1 and n goes to ∞ the probability that the excess-to-benchmark return in the next period will be sufficient to prevent dismissal of the manager at time t_{n+1} approaches zero. Therefore the value of the option, to retain the manager for one more period after the next period, goes to zero. For finite n, the probability that the manager is dismissed next period is finite. For finite n we have a lower bound rather than a lower asymptote for V_n^r.

Figure 6.3 depicts the upper asymptote and lower bound of V_n^r. A curve is fitted to the asymptotes for illustrative purposes.[68] The vertical distance between the asymptotes and the V_n^r curve represents the option value of delegated portfolio management. The value of m_n below which the manager is dismissed at time t_n is m_n^c. As in the classic investment under uncertainty problem, the required rate of return on the project before the trustee board acts is higher when value of the option to delay the decision is included. The result is $m_n^c < r\,(V^a - K)$.

6.2.2.4 The Bellman functional equation

Continuing the expansion of the expression for the value of delegated portfolio management we have the following equation.

Equation 6.13

$$V_n = \mathrm{Max}\left[V_n^r, V^a - K\right]$$

$$V_n^r = \frac{E\left[x_{n+1} + V_{n+1} \mid \Im_n\right]}{1+r}$$

$$= \frac{m_n}{1+r} + \frac{E\left[\mathrm{Max}\left[V_{n+1}^r, V^a - K\right] \mid \Im_n\right]}{1+r}$$

$$= \frac{m_n}{1+r} + \frac{E\left\{\mathrm{Max}\left\{\dfrac{E\left[x_{n+2} + V_{n+2} \mid \Im_{n+1}\right]}{1+r}, V^a - K\right\} \mid \Im_n\right\}}{1+r}$$

This expression is a recursive Bellman equation which can be expanded indefinitely. The trustee board faces a dynamic programming problem. They can choose to retain the manager or acquire more information. The option to delay now is an option on all the future options to delay and hence the expression has an infinite expansion.

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[68] Note that figure 6.3 is drawn with all variables that affect V_n, other than m_n, held constant. In particular parameters of the posterior distribution of θ that characterize the uncertainty

V_n^r and V_{n+1}^r are functions which are related by the functional equation 6.13. The trustee board wishes to compare V^a - K, which is known, to V_n^r which is a function of **x** the vector of observed excess-to-benchmark returns. From equation 6.11 we can see that to solve for V_n^r we need to know the functional form of V_{n+1}^r. We can proceed to a solution by guessing V_{n+1}^r and then solving for V_n^r, then using this form as the next guess for V_{n+1}^r. Convergence is guaranteed, under modest regularity conditions, by the Contraction Mapping Theorem of functional equations.[69] An equivalent solution can be obtained by assuming a termination time when the fund is wound up and working backwards recursively.

6.3 A two period model

To solve the functional equation which determines the value of delegated portfolio management, a functional form of the prior distribution over θ must be specified. It is assumed here that the parameters of the manager's excess-to-benchmark return, $\theta = (\mu,\tau)$ have a gamma-normal distribution. The normal distribution of the excess-to-benchmark return, $x \sim N[\mu,\tau]$, and the gamma-normal distribution of the parameters of that normal distribution, $\theta = (\mu,\tau)$, form a Bayesian conjugate pair. This means that when the sample data drawn from the normal distribution is combined with the gamma-normal prior, the resulting posterior distribution is also gamma-normal.

In the course of this analysis several Bayesian conjugate pairs were considered for the modelling of the return distribution and the prior, including, the binomial--beta conjugate pair; the exponential--gamma conjugate pair; the Poisson--gamma conjugate pair; and the normal--gamma-normal conjugate pair. None of the available conjugate pairs leads to a closed form solution for V_n where the trustee board's investment horizon is infinite. If assumptions are made about the parameters of prior distribution, the interest rate r and the cost of changing managers K, then a

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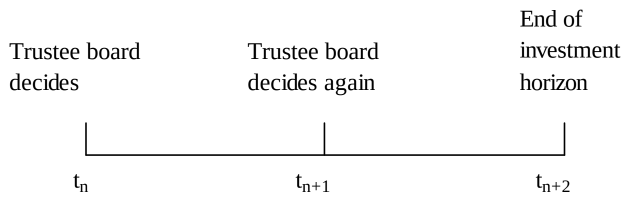
over μ are held constant.

[69] See Dixit and Pindyck, (1994, p102), or Stokey and Lucas (1993, p50).

numerical solution for V_n can be obtained. The next section presents the simulation results.

In this section, to pursue an understanding of the relationship between variables in the trustee board's problem, a closed form solution is obtained by reducing the trustee board's investment horizon to two periods from the decision date t_n. In the two period model, the trustee board is making the dismissal decision n periods after the incumbent manager was initially appointed. Therefore $\mathbf{x}_n=(x_1,x_2,..,x_n)$ has been observed at the decision point. Further, the investment horizon time is t_{n+2}. Meaning that the trustee board must decide at time t_n whether to retain or dismiss the manager, then make the equivalent decision at time t_{n+1}, and then the fund is wound up at time t_{n+2}. Figure 6.4 depicts the decision timing.

Figure 6.4 Decision times



To proceed we need to assume a form for the prior distribution over the mean and precision of the excess-to-benchmark return distribution. Assume that θ has a gamma-normal distribution. Also known as the gamma inverse normal distribution, where variance takes the place of precision. See DeGroot (1989, p402) for the standard gamma-normal distribution results given here.

Where ξo(θ) in the prior distribution are over θ.

Equation 6.14

$$x_0(q) = x_0(m,t) = x_0(t)x_0(m|t)$$

The parameters of the gamma-normal prior distribution are α_0, β_0, λ_0 and m_0.

Equation 6.15

$$x_0(q) = \frac{b_0^{a_o} t^{a_0-1} e^{-b_o t}}{\Gamma(a_0)} \sqrt{\frac{l_0 t}{2p}}\, e^{\frac{-l_0 t}{2}(m-m_0)^2}$$

The marginal distribution of τ is a gamma function with parameters α_0 and β_0.

Equation 6.16

$$\xi(\tau) = \frac{\beta_0^{\alpha_0} \; \tau^{\alpha_0 - 1} \; e^{-\beta_0 \tau}}{\Gamma(\alpha_0)}$$

The conditional distribution of μ is a normal distribution with mean m_0 and precision $\lambda_0\tau$.

Equation 6.17

$$\xi(\mu | \tau) = \sqrt{\frac{\lambda_0 \tau}{2\pi}} \; e^{\frac{-\lambda_0 \tau}{2}(\mu - m_0)^2}$$

The marginal distribution of μ can be obtained from a student t distribution with $2\alpha_0$ degrees of freedom. It is the student t distribution shifted to have a mean of m_0 and scaled by $\left(\frac{b_0}{l_0 a_0}\right)^{\frac{1}{2}}$

Equation 6.18

$$\frac{m - m_0}{\left(\frac{b_0}{l_0 a_0}\right)^{\frac{1}{2}}} \sim t_{2a_0}$$

Where dof $= 2\alpha_0$

$E[\mu | \Im_0] = m_0$

$\mathrm{Var}\,[\mu | \Im_0] = \frac{b_0}{l_0 a_0}$

$\beta_o > 0, \alpha_o \geq 1, \lambda_o > 0$

The gamma-normal Bayesian conjugate pair is suitable for this analysis for several reasons. Firstly, in the gamma-normal distribution the information is combined in an intuitively appealing way, as shown below in the explanation of how the parameters update. Another appealing property of the gamma normal distribution is the relationship between the precision of the excess-to-benchmark return x_n and the precision with which μ is known. For a given τ the precision of μ is $\lambda_o\tau$. This means that if $\lambda_0>1$, then the less noise there is in observations of the manager's excess-to-benchmark returns (higher τ), the more precise will be the prior over μ (higher $\lambda_0\tau$).

Finally, the gamma normal distribution has a flexible shape which can accommodate a wide range of plausible prior beliefs.

To establish the prior distribution, the trustee board chooses α_0, β_0, λ_0 and m_0 such that:

The mean of the marginal μ distribution $= m_0$

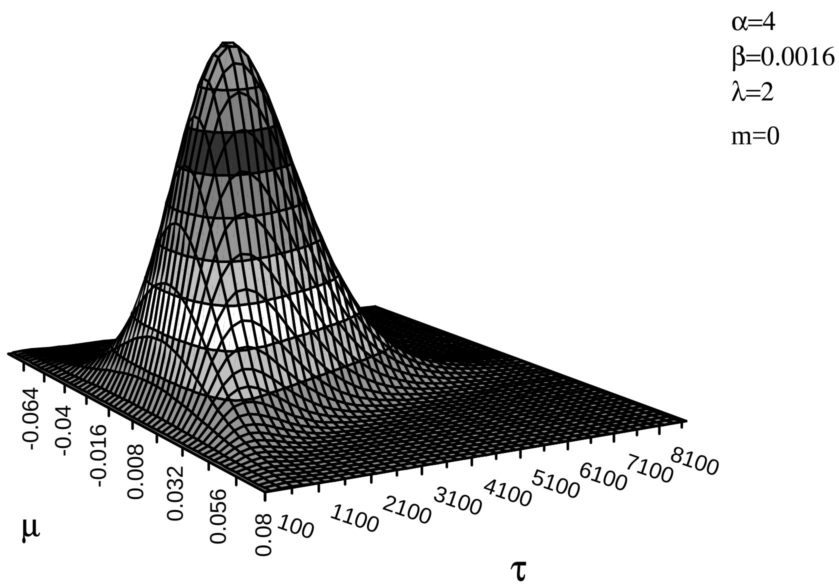
The variance of the marginal μ distribution $= \frac{b_0}{l_0 a_0}$

The mean of the marginal τ distribution $= \frac{\alpha_0}{\beta_0}$

The variance of the marginal τ distribution $= \frac{\alpha_0}{\beta_0^2}$

The gamma normal prior is graphed in figure 6.5. The parameter values of the depicted distribution are α=4, β=0.0016, λ=2 and m=0. These are the parameters used in the base case for the simulation study of the next section.

Figure 6.5 The gamma normal prior distribution



6.3.1 The gamma-normal posterior distribution

As noted previously the posterior is also a gamma normal distribution.

Equation 6.19

$$\xi_n(\theta \mid \mathbf{x}) = \frac{\beta_n^{\alpha_n}\,\tau^{\alpha_n - 1}\,e^{-\beta_n \tau}}{\Gamma(\alpha_n)} \sqrt{\frac{\lambda_n \tau}{2\pi}}\; e^{\frac{-\lambda_n \tau}{2}(\mu - m_n)^2}$$

Where $\bar{x}_n = \dfrac{\sum_{i=1}^{n} x_i}{n}$

$$s_n^2 = \frac{\sum_{i=1}^{n}(x_i - \bar{x}_n)^2}{n-1}$$

$$m_n = \frac{n\bar{x}_n + \lambda_0 m_0}{\lambda_0 + n}$$

$$\lambda_n = \lambda_0 + n$$

$$\alpha_n = \alpha_0 + \frac{n}{2}$$

$$\beta_n = \beta_0 + \frac{n-1}{2} s_n^{\ 2} + \frac{n\lambda_0(\overline{x}_n - m_0)^2}{2(\lambda_0 + n)}$$

The process of updating parameters is highly intuitive. The expected value of μ after excess-to-benchmark returns have been observed, denoted m_n, is a weighted average of the sample and prior information. Each weight reflects the amount of information contributed by that source. The parameter λ_0 controls the balance between the prior and sample information in determining m_n.

The Bayesian predictive distribution of the unknown x_{n+1} can be obtained as follows.

Equation 6.20

$$f(x_{n+1} \mid \mathbf{x}) = \int_\theta f(x_{n+1} \mid \theta, \mathbf{x})\, \xi_n(\theta \mid \mathbf{x})\, d\theta$$

$$= \int_{-\infty}^{\infty}\int_0^{\infty} \sqrt{\frac{\tau}{2\pi}}\, e^{-\frac{\tau}{2}(x_{n+1}-\mu)^2}\, \frac{\beta_n^{\alpha_n}\, \tau^{\alpha_n - 1}\, e^{-\beta_n \tau}}{\Gamma(\alpha_n)} \sqrt{\frac{\lambda_n \tau}{2\pi}}\, e^{\frac{-\lambda_n \tau}{2}(\mu - m_n)^2}\, d\tau\ d\mu$$

Gathering the τ terms and integrating yields the following expression.

$$f(x_{n+1} \mid \mathbf{x}) = \int_{-\infty}^{\infty} \frac{\sqrt{\lambda_n}\ \beta_n^{\alpha_n}\ \Gamma(\alpha_n + 1)}{2\pi\ \Gamma(\alpha_n)} \frac{2^{\alpha_n + 1}}{\left[2\beta_n + (x_{n+1} - \mu)^2 + \lambda_n(\mu - m_n)^2\right]^{\alpha_n + 1}}\, d\mu$$

A useful substitution is:

$$\left(x_{n+1}-\mu\right)^2+\lambda_n\left(\mu-m_n\right)^2=\frac{\lambda_n\left(x_{n+1}-m_n\right)^2}{\lambda_{n+1}}+\lambda_{n+1}\left(\mu-m_{n+1}\right)^2$$

$$\text{Where } m_{n+1}=\frac{x_{n+1}+\lambda_n\mu_n}{\lambda_{n+1}}$$

By making the substitution and then grouping the τ terms into a student t form and integrating them out, the following expression is found.

Equation 6.21

$$f\left(x_{n+1}\,|\,\mathbf{x}\right)=\frac{\Gamma\left(\alpha_n+\frac{1}{2}\right)}{\Gamma\left(\alpha_n\right)}\frac{\left[1+\dfrac{\left(x_{n+1}-m_n\right)^2}{2\alpha_n\left(\dfrac{\lambda_{n+1}\beta_n}{\lambda_n\alpha_n}\right)}\right]^{-\left(\alpha_n+\frac{1}{2}\right)}}{\sqrt{2\alpha_n\pi}\sqrt{\dfrac{\lambda_{n+1}\beta_n}{\lambda_n\alpha_n}}}$$

Equation 6.21 shows that x_{n+1} has the distribution of a student t with $2\alpha_n$ degrees of freedom, which has been shifted by m_n and scaled by $\left(\frac{\lambda_{n+1}\beta_n}{\lambda_n\alpha_n}\right)^{\frac{1}{2}}$. The predicted excess-to-benchmark return in the next period has a variance which is λ_{n+1} times that of the variance of μ.

$$\frac{x_{n+1}-m_n}{\sqrt{\dfrac{\lambda_{n+1}\beta_n}{\lambda_n\alpha_n}}}\sim t_{2\alpha_n}$$

Where: dof $= 2\alpha_n$; $E[x_{n+1} \mid \Im_n] = m_n$, $\mathrm{Var}\,[x_{n+1} \mid \Im_n] = \dfrac{\lambda_{n+1}\beta_n}{\lambda_n \alpha_n}$

6.3.2 Decomposition of the value of delegated portfolio management

Returning to the trustee board's decision process, if $V_n^r > V^a - K$ then the manager is retained. Otherwise the alternative manager is contracted at cost K.

Equation 6.22

$$V_n^r = E\left\{ \frac{x_{n+1} + V_{n+1}}{1+r} \mid \Im_n \right\}$$

$$= E\left\{ \frac{x_{n+1}}{1+r} + \frac{\max\left[V_{n+1}^r \,,\, V_{n+1}^a - K\right]}{1+r} \mid \Im_n \right\}$$

$$= \frac{m_n}{1+r} + \frac{\int_{-\infty}^{\infty} \max\left[V_{n+1}^r \,,\, V_{n+1}^a - K\right] f\left(x_{n+1}\right) dx_{n+1}}{1+r}$$

$$= \frac{m_n}{1+r} + \frac{V_{n+1}^a - K}{1+r} + \frac{\int_{x_{n+1}^c}^{\infty} \left[V_{n+1}^r - \left(V_{n+1}^a - K\right)\right] f\left(x_{n+1}\right) dx_{n+1}}{1+r}$$

V_n^r is a function of x_{n+1}. The integration limit x^c_{n+1} is the critical value of x_{n+1} below which the manager is dismissed at time t_{n+1}, if the manager is retained at time t_n. If $x_{n+1} < x^c_{n+1}$ then the manager will be dismissed at the end of period n+1. Otherwise the manager is retained at that time. In this two period model x^c_{n+1} is a function of m_n. A value for x^c_{n+1} is found as follows.

At x^{c}_{n+1}

$$V^{r}_{n+1} = V^{a}_{n+1} - K$$

$$\frac{E\left[x_{n+2} \mid \Im_{n+1}\right]}{1+r} = \frac{m^{a}_{0}}{1+r} - K$$

$$\frac{m_{n+1}}{1+r} = \frac{m^{a}_{0} - K(1+r)}{1+r}$$

$$\frac{x^{c}_{n+1} + \lambda_{n} m_{n}}{\lambda_{n+1}} = m^{a}_{0} - K(1+r)$$

$$x^{c}_{n+1} = m_{n} + \lambda_{n+1}\left(m^{a}_{0} - K(1+r) - m_{n}\right)$$

Where m^{a}_{0} = the mean of μ^{a} in the prior distribution of the best alternative manager.

Equation 6.23 can be rearranged to give the components of the value of delegated portfolio management.

Equation 6.23

$$V^{r}_{n} = \frac{m_{n}}{1+r} + \frac{V^{a}_{n+1} - K}{1+r} + \frac{\int_{x^{c}_{n+1}}^{\infty}\left[V^{r}_{n+1} - \left(V^{a}_{n+1} - K\right)\right] f(x_{n+1})\, dx_{n+1}}{1+r}$$

$$= \frac{m_{n}}{1+r} + \frac{V^{a}_{n+1} - K}{1+r} + \frac{\int_{x^{c}_{n+1}}^{\infty}\left[\frac{m_{n+1}}{1+r} - \left(V^{a}_{n+1} - K\right)\right] f(x_{n+1})\, dx_{n+1}}{1+r}$$

$$= \frac{m_{n}}{1+r} + \frac{V^{a}_{n+1} - K}{1+r} + \int_{x^{c}_{n+1}}^{\infty}\left[\frac{x_{n+1} + \lambda_{n} m_{n}}{\lambda_{n+1}(1+r)^{2}} - \frac{V^{a}_{n+1} - K}{1+r}\right] f(x_{n+1})\, dx_{n+1}$$

$$= \frac{m_{n}}{1+r} + \frac{V^{a}_{n+1} - K}{1+r} F\left(x^{c}_{n+1}\right) - \frac{m_{n}}{(1+r)^{2}}\left[1 - F\left(x^{c}_{n+1}\right)\right] + \int_{x^{c}_{n+1}}^{\infty}\left[\frac{x_{n+1} - m_{n}}{\lambda_{n+1}(1+r)^{2}}\right] f(x_{n+1})\, dx_{n+1}$$

$$= \frac{m_n}{1+r} + \frac{m_0^a - K(1+r)}{(1+r)^2} F\left(x_{n+1}^c\right) + \frac{m_n}{(1+r)^2}\left[1 - F\left(x_{n+1}^c\right)\right]$$

$$+ \frac{1}{\lambda_{n+1}(1+r)^2} \int_{x_{n+1}^c}^{\infty} (x_{n+1} - m_n) \frac{\Gamma(\alpha_n + 0.5)}{\Gamma(\alpha_n)} \frac{1}{\sqrt{2\pi\alpha_n}\sqrt{\frac{\lambda_{n+1}\beta_n}{\lambda_n\alpha_n}}} \left[1 + \frac{(x_{n+1} - m_n)^2}{2\alpha_n\left(\frac{\lambda_{n+1}\beta_n}{\lambda_n\alpha_n}\right)}\right]^{-(\alpha_n + 0.5)} dx_{n+1}$$

The integral is the value of an European option with and a strike price of x^c_{n+1}-m_n. In this option the probability distribution of the underlying asset is a student t shifted to have a mean of m_n and scaled to have a variance $\left(\frac{\lambda_{n+1}\beta_n}{\lambda_n\alpha_n}\right)$. Integrating and rearranging yields the following decomposition of the value of delegated portfolio management conditional on the incumbent being retained for at least one more period.

Equation 6.24

$$V_n^r\left(\bar{x}_n, s_n^2, n\right) = \frac{m_n}{1+r} + \frac{\left(m_0^a - K(1+r)\right)}{(1+r)^2} F\left(x_{n+1}^c\right) + \frac{m_n}{(1+r)^2}\left[1 - F\left(x_{n+1}^c\right)\right]$$

$$+ \frac{1}{(1+r)^2 \lambda_{n+1}} \left(\frac{\lambda_{n+1}\beta_n}{\lambda_n(\alpha_n - 1)}\right) t_{2\alpha_n - 2}\left[x_{n+1}^c\right]$$

Where $F(\ )$ = the distribution function of xn+1

$\bar{x}_n$ = the sample mean of observed excess-to-benchmark returns

s_n^2 = sample variance of excess-to-benchmark returns

n = the number of periods since appointment of incumbent manager

To determine whether to retain the manager the trustee board calculates V_n^r and compares this value to V^a-K. Where V^a is calculated using the μ_0^a, λ_0^a, β_o^a and α_0^a parameters of the best alternative manager, with $\bar{x}_n = s_n^2 = n = 0$. Equation 6.24 can be interpreted as follows. At time t_n the value of active management conditional upon retention of the manager for at least another period has four components:

i. The discounted expected excess return next period.

$$\frac{\mu_n}{1+r}$$

ii. The discounted expected excess return in the second period conditional upon changing manager at the end of next period, times the probability of that event.

$$\frac{\mu_0^a - K(1+r)}{(1+r)^2} F\left(x_{n+1}^c\right)$$

iii. The discounted expected excess return in the second period conditional upon retaining the manager at the end of the next period, times the probability of that event.

$$\frac{\mu_n}{(1+r)^2}\left[1 - F\left(x_{n+1}^c\right)\right]$$

iv. The value of the option to decide whether to retain or change after the next period's excess return information is received.

$$\frac{1}{\lambda_{n+1}(1+r)^2}\left(\frac{\lambda_{n+1}\beta_n}{\lambda_n(\alpha_n - 1)}\right) t_{2\alpha_n - 2}\left[x_{n+1}^c\right]$$

V_n^r is a function of : $\bar{x}_n$ the sample mean of the observed excess-to-benchmark returns; s_n^2 the sample variance; n the number of observations. Only the first two sample moments are important - as might be expected from a prior distribution based upon normal and gamma functions.

6.3.2.1 Alternative model specification

The two period model of investors' hiring and firing decisions has the investor deciding at time t_n, two periods from the investment horizon, whether to retain or alternatively dismiss the manager. One period later at time t_{n+1} the investor must again decide whether to retain the (possibly new) manager or choose another manager for the last period. As shown in equation 6.24 , at t_n the value of active management conditional upon retaining a manager that has been employed for n periods is given by equation 6.24.

An alternative set up is for the investor to have a different choice at t_{n+1}, between granting the then incumbent manager permanent tenure or alternatively choosing the best alternative manager who will have permanent tenure. In this model the value of active management at t_n, conditional on retaining the existing manager is:

Equation 6.25

$$V_n^r\left(\bar{x}_n, s_n^2, n\right) = \frac{m_n}{1+r} + \frac{\left(m_0^a - K r\right)}{r\left(1+r\right)} F\left(x_{n+1}^c\right) + \frac{m_n}{r\left(1+r\right)}\left[1 - F\left(x_{n+1}^c\right)\right] + \frac{1}{r\left(1+r\right)\lambda_{n+1}}\left\{\frac{\lambda_{n+1}\beta_n}{\lambda_n\left(\alpha_n - 1\right)}\right\} t_{2\alpha_n - 2}\left[x_{n+1}^c\right]$$

The value of x_{n+1} at which the investor is indifferent between retention or dismissal of the manager at time t_n, denoted x^c_{n+1} is higher in equation 6.24 than 6.25 by $\lambda_{n+1}K$. Nonetheless, the models are qualitatively alike. In section 6.5 results of a simulation of the hiring and firing model are presented. The simulations are for an investor's decision on whether to dismiss the manager where the investment horizon is 10 years hence. The longer the horizon, the less important are the terminal conditions to the decision today. Since equations 6.24 and 6.25 are so similar in form, the simulation study is conducted only for the model where, at the end of the investment horizon, there is no further investment.

6.4 Implications of a dismissal policy

The trustee board's valuation of portfolio management after n periods is a function of parameters, constants and state variables.

α_0, β_0, λ_0, m_0	The parameters of the prior distribution over θ.
k, r	The constants which are exogenous to the trustee board's decision making.
$\bar{x}_n$, s_n^2, n	The state variables of the dynamic programming problem faced by the trustee board.

The comparative statics of these variables can provide insight into various influences upon fund manager dismissal decisions. The two period gamma-normal model of fund manager dismissal supports the following propositions.

6.4.1 Proposition 1:

If the vector of reported excess-to-benchmark returns is $\mathbf{x}_n = (x_1, ...,x_n)$, then $\bar{x}_n$, s_n^2 and n are sufficient to determine V_n .

This follows directly from equation 6.24 and the value rule V_n = Max [V_n^r , V^a-K] . The result implies that, conditional upon a gamma-normal prior, trustee boards need only know the number of performance observations and the first two moments of those observations to attain the value of active management after n periods. It also implies that the value process is Markovian rather than path dependent, because of the Bayesian nature of the decision process.

6.4.2 Proposition 2:

The value of active management is non decreasing in uncertainty over the expected value of the manager's excess return.

$$\frac{dV_n}{d\sigma_\mu^2} \geq 0 \quad \text{where} \quad \sigma_\mu^2 = \frac{\beta_n}{\lambda_n \alpha_n} \quad \text{is the variance of the expected excess-to-}$$

benchmark return after observing $\mathbf{x_n} = (x_1, \ldots\ldots, x_n)$

If the investor retains the manager for period n+1, then there is a unique value of x_{n+1}, denoted x^c_{n+1}, for which the investor is indifferent between retaining or dismissing the manager at the end of that period. Equation 6.24 can be rearranged to express V_n^r in an option form.

Equation 6.26

If $x^c_{n+1} > m_n$ then

$$V_n^r = \frac{m_n}{1+r} + \frac{V^a - K}{(1+r)} + \frac{1}{\lambda_{n+1}(1+r)^2}\int_{x^c_{n+1}}^{\infty}\left(x_{n+1} - x^c_{n+1}\right) f(x_{n+1})\,dx_{n+1}$$

If $x^c_{n+1} < m_n$ then

$$V_n^r = \frac{m_n}{1+r} + \frac{m_n}{(1+r)^2} + \frac{1}{\lambda_{n+1}(1+r)^2}\int_{-\infty}^{x^c_{n+1}}\left(x^c_{n+1} - x_{n+1}\right) f(x_{n+1})\,dx_{n+1}$$

In the first expression the integral term represents the value of a European call option with a strike price at x^c_{n+1}, over an asset, the value of which has a t distribution with mean m_n and variance $\lambda_{n+1}\sigma_u^2$ at the strike date, which is one period hence. In the second expression the integral term represents the value of the corresponding put option. Since it is well known that these option terms are strictly increasing in the variance of the value of the underlying asset and since none of the other terms are functions of that variance we know that:

V_n^r is increasing in $l_{n+1} s_m^2$, the variance of x_{n+1}

$$\frac{d\,V_n}{d\,s_m^2} \geq 0 \quad \text{since} \quad V_n = \mathrm{Max}\left[V_n^r, V^a - K\right]$$

The uncertainty over the expectation of the excess-to-benchmark returns is measured by the variance of m which is a function of β_n, α_n and λ_n. These parameters therefore combine to represent the uncertainty over the value that the manager can add to the delegated portfolio. The value of active management is increasing in this uncertainty.

This proposition partially explains two questions arising from empirical research into the flow of investors' funds to and from investment management groups. Firstly, it is found by Ippolito (1992), Brown, Harlow, Starks (1996), Goetzmann and Peles (1997), Sirri and Tufano (1998) and others, that fund managers can return persistently poor performance relative to their peers without experiencing large outflows of money. These results have been explained in terms of high switching costs, including the tax costs of realising capital gains. Nonetheless, relative to perceived costs of changing manager, the poor performance that some investors tolerate has no obvious full explanation in the literature.

The framework for analysing investors hiring and firing decisions presented here recognises that a delay in the decision to switch managers may allow resolution of some uncertainty over the manager's quality. As in a real options framework, the more uncertainty that can be resolved by delay the higher is the required return to the new project (the worse the manager's performance) before the new project is initiated.

Secondly, this proposition partially explains an observation of Chevalier and Ellison (1997a). They found that after controlling for size and for the performance of managers, the growth rate of the funds managed by managers with shorter performance histories is greater than equivalent managers with longer histories. A shorter history equates to less prior information, which in this model is captured by a lower value for λ_0. The greater uncertainty of the expected value of the excess-to-benchmark returns of the managers with shorter performance records makes them more valuable to investors who discount excess-to-benchmark returns at the risk free rate.

A final point relates to the entry of fund managers to the industry. The number of fund managers entering (and exiting) the fund management industry is large - particularly in the mutual fund industry. This observation may be partially explained by the uncertainty about μ, the expected excess return for managers new to the industry. Because investors are more uncertain about the new fund managers, and since investors have the option to sack the manager at low cost and choose another, relatively unknown managers may have a comparative advantage.

6.4.3 Proposition 3:

The value of active management is non decreasing in the shape parameter β_0 of the gamma-normal prior distribution or the sample variance of the excess return observations.

$$\frac{d\,V_n}{d\,\beta_0} \geq 0 \quad , \quad \frac{d\,V_n}{d\,s_n^2} \geq 0$$

This is true because $\frac{d\,V_n}{\sigma_m^2} \geq 0$, β_0 and s_n^2 enter V_n only through the expression

$$\sigma_u^2 = \frac{\beta_0 + \left(\frac{n-1}{2}\right) s_n^2 + \frac{\lambda_0 n_0 \left(\bar{x} - \mu_0\right)^2}{\lambda_0 + n}}{\left(\lambda_0 + n\right)\left(\alpha_0 + \frac{n}{2}\right)}$$

The value of active management is non decreasing in the sample variance. This result has significance for active managers who deliberately track the market index. Index tracking can assure that the sample mean of excess-to-benchmark returns is close to zero but it also reduces the sample variance which in turn reduces V_n^r. A manager that replicates the benchmark portfolio may be more likely to exceed x^c_{n+1}; however, index tracking decreases the variance of their excess-to-benchmark returns, which decreases V_n^r and in turn increases x^c_{n+1} .

In this framework managers have an incentive to inject noise into their return to increase the trustee board's valuation. This idea is closely related to the Dow and Gorton (1997) noise and volume argument. They argue that managers with no information will undertake noise trading so that their lack of information is not revealed in the short term.

6.4.4 Proposition 4:

The value of active management is decreasing in K, the cost of changing managers, and not increasing in r the risk free interest rate.

$$\frac{\partial V_n}{\partial k} < 0 \quad , \quad \frac{\partial V_n}{\partial r} \leq 0$$

From equation 6.226 the value of active management conditional on retaining the manager can be expressed as:

$$V_n^r = \frac{\mu_n}{1+r} + \frac{\mu_n}{(1+r)^2} + \frac{1}{\lambda_{n+1}(1+r)^2}\int_{-\infty}^{x_{n+1}^c}\left[x_{n+1}^c - x_{n+1}\right]\phi(x_{n+1})\,dx_{n+1}$$

$$\text{Since } \frac{d\left[V_{n+1}^a - K\right]}{dK} < 0 \ , \quad \frac{dx_{n+1}^c}{dK} = -(\lambda_{n+1})(1+r) < 0$$

$$\frac{dV_n^r}{dK} < 0 \quad \text{and therefore } \frac{dV_n}{dK} < 0$$

$$\text{Similarly, } \frac{dx_{n+1}^c}{dr} = -K(\lambda_{n+1}) < 0$$

$$\frac{dV_n^r}{dr} < 0 \quad \text{and therefore } \frac{dV_n}{dr} \leq 0$$

A consequence of this result is that active investment managers may create externalities for their industry if they increase costs of changing manager. The active investment management industry competes with passive investment management for funds. If investors can only estimate an industry value of K, rather than a manager specific value, then the externality may lead to higher costs of changing manager and thereby the value of active management to investors is decreased relative to passive management.

For example, when a portfolio is passed from a dismissed manager to a newly appointed manager, the costs of trading to the new manager's preferred portfolio holdings is typically not attributed to either the old or new manager. For large pension funds this unattributed cost may be the largest component of the cost of changing manager. Because of the lack of attribution managers have little incentive to minimise this cost, but the value of active management to an investor is strictly decreasing in the investor's estimate of this cost.

The relationship between the value of active management and the riskless rate simply presents a testable implication of this model. In a large universe of managers, the number of investors switching managers, over any short period, should be increasing in r.

6.4.5 Proposition 5:

There is not a simple monotonic relationship between the value of active management and either the volume of prior information, measured by λ_0, or the volume of sample information, measured by n.

$$\textit{If} \quad \bar{x} > \mu_0 \ \text{ and } \ \sigma_n^2 > \frac{\beta_0}{\alpha_0 \lambda_0} \ \text{ then } \ \frac{\partial V_n^r}{\partial n} > 0$$

$$\textit{If} \quad \bar{x} < \mu_0 \ \text{ and } \ \sigma_n^2 < \frac{\beta_0}{\alpha_0 \lambda_0} \ \text{ then } \ \frac{\partial V_n^r}{\partial n} < 0$$

$$\textit{Otherwise} \quad \frac{\partial V_n^r}{\partial n} \ \frac{\leq}{\geq} \ 0$$

V_n is a function of μ_n and σ_n^2. μ_n is a weighted average of $\bar{x}_n$ the sample mean and μ_0 the prior mean. The weights are $\frac{n}{\lambda_n}$ and $\frac{\lambda_0}{\lambda_n}$ respectively. If $\bar{x}_n > m_0$ then an increase in n puts greater weight on the sample data. The same reasoning applies to s_n^2 and $\frac{\beta_0}{\alpha_0 \lambda_0}$. If the sample mean and variance are consistent with high value then shifting weight to sample information increases V_n^r. Both the sample mean and variance are important.

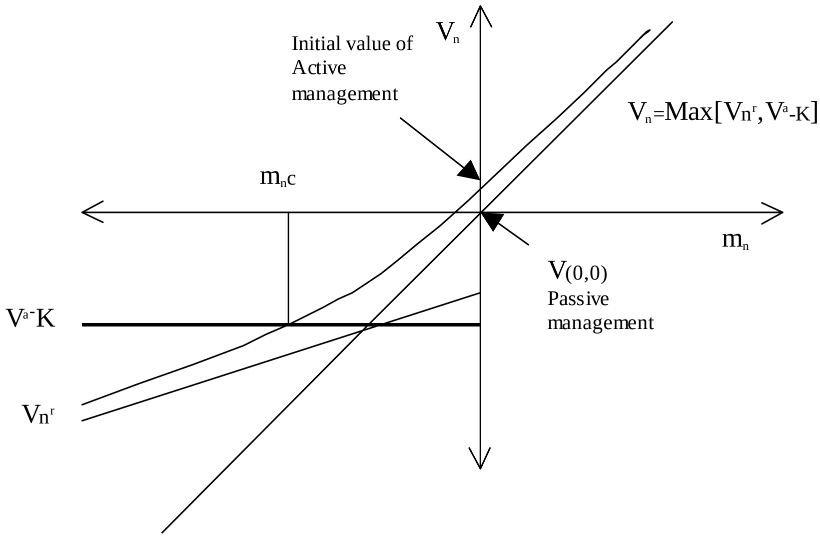
This result characterises the simple idea that a larger number of observations of performance is good news for managers whose performance has exceeded the investor's prior expectation of the manager's average excess-to-benchmark return. However, uncertainty over the mean of the manager's excess-to-benchmark distribution is also an important determinant of the manager's value to the investor. If more sample information increases the posterior expected value of μ, but decreases the uncertainty over μ then the effect of n on V_n is ambiguous. Note that the same reasoning applies to λ_0 because λ_0 and n enter the expression for V_n^r symmetrically.

6.4.6 Stationarity and equilibrium

It is assumed here that the processes that generate the fund manager's excess-to-benchmark returns are stationary. However, the assumption implies that the fund manager does not react strategically as the vector of performance results evolves. The fund manager will learn about the trustee board's prior over the fund manager's excess return through: the initial fund manager selection process; the benchmarks that are set; and the ongoing contact with the trustee board. Presumably the fund manager will use an informed assumption about the trustee board's prior to formulate a strategic response.

A manager's estimate of x^c_{n+1} represents the size of the 'bets' that the manager can afford to take. If a manager has a given level of information on the future realisation of an asset price, then the quantity of that asset held will be a function of x^c_{n+1}. A manager can take bets on specific assets and at the same time insure against a portfolio return of less than x^c_{n+1}. Many pension fund management mandates

Figure 6.6 Active versus passive management



preclude the purchase of derivative securities. Instead, the manager can hedge by dynamically adjusting the holding of the benchmark portfolio and individual assets - as discussed in chapter 2.

The parameter stability assumption implies the existence of performance persistence. There is not much evidence of performance persistence in the pension fund industry (Lakonishok, Shleifer and Vishny 1992a, Brown, Draper and M^{c}Kenzie 1997 and Brown, Goetzmann, Ibbotson and Ross 1992). Performance persistence studies face severe methodological problems in handling survivorship bias and risk adjustment.

If the excess return distributions of managers are stationary, then we might expect to see a migration of pension funds from poor managers to good managers over time. In the UK pension fund industry over the last 15 years, pension fund investment mandates have become concentrated in the hands of the most successful investment management firms. This observation is consistent with a degree of stationarity.

6.4.7 Passive and active management

In the framework of this paper a passive manager can be characterised by

$$\theta^{index} = (\mu , \tau) = (0,0). \quad \Rightarrow \quad V_0^{index} = 0$$

Passive management provides a calibration of the value of active management. This sets a lower bound on V^a-K of $-K^{index}$. Each trustee board's assessment of V^a-K determines their choice between active and passive management.

The trustee board depicted in figure 6.6 initially chooses active management even though $m_0 < 0$. This illustrates the point that a trustee board may choose active management even if they do not expect on average to choose a manager with positive μ. Under the conditions of this model trustee boards which choose active management do not rationally have to believe that they will on average choose a manager who will beat the market - they just have to believe that they can hold on to managers who do beat the market for longer. If the trustee board has a rational view of the market then they must believe that they have higher than average ability to choose a manager with a high μ. This is because over time active fund managers on average have lower returns than passive managers (Lakonishok, Shleifer and Vishny 1992b, Brown, Draper and McKenzie 1996).

Little is known about the factors that determine the fraction of the total capitalisation of a financial asset market that is under passive management. The figure must be less than 100 percent to permit the rational formation of prices (Grossman and Stiglitz 1980). However, the literature says little else. The framework presented here partially characterises the equilibrium between passive and active management (institutional or private). Trustee boards which believe that V^a-K > $-K^{index}$ will see another active manager as the best alternative to their current manager; otherwise they will go to passive management when they change manager. As the volume of passively managed funds rises, V^a increases (in a Grossman Stiglitz world) - giving rise to the equilibrium. Since 1986 the pension fund industry in the UK has seen both a slow drift of pension fund mandates to passive management and a narrowing of the average returns of the active management and passive management sectors.

6.5 A simulation study

6.5.1.1 Purpose of the simulation

The two period model developed in section 6.3 yields a closed form solution for the value of active management which in turn yields the propositions of section 6.4. However, investors typically have horizons longer than two years. In the case of trustee boards the investment horizon is often the duration of the liabilities: which for a young workforce may be several decades.

The model cannot be extended by increasing the horizon without giving up either the closed form nature of solutions or the gamma – normal Bayesian structure of the model. A simpler Bayesian model may have a closed form, but such a model may be too abstract to be of interest. The alternative to a closed form solution is a numerical solution. In this section the results of numerical solution of the value of active management for a trustee board with an investment horizon of 10 years are presented.[70]

There are three objectives in this study. Firstly, to estimate the size of the option effects for investors with longer horizons. The two period model indicates that option effects exist but does not demonstrate that they have economic significance. Secondly, to confirm the direction of the comparative static results set out in the propositions of section 6.4. Thirdly, to determine the economic significance of each of these comparative static results.

The numerical solution of the model of hiring and firing for differing parameter values amounts to a simulation study of the model. That is not a substitute for confronting the testable implications of the model with data. However, simulation is

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[70] My discussions with pension fund consultants indicated that 10 years is often chosen as the time to the investment horizon in their simulation studies.

useful and necessary to guide the formation of interesting testable implications before proceeding with the task of collecting data for empirical testing.

6.5.1.2 Nature of simulation

The simulation proceeds by numerically solving the following equation.

Equation 6.27

$$V(\bar{x}, s^2, n \mid \alpha_0, \beta_0, \lambda_0, m_0, r, K)$$

$$= \frac{m_n}{1+r} + \int_{-\infty}^{+\infty} \frac{\text{Max}\left[V(\bar{x}(x_{n+1}), s^2(x_{n+1}), n+1 \mid \alpha_0, \beta_0, \lambda_0, m_0, r, K), V(0,0,0) - K\right]}{1+r}$$

This is a discrete functional equation in V(.). The chosen values of α_0, β_0, λ_0, m_0, k, r specify the prior distribution and the exogenous economic variables. The value of the best alternative manager is calculated as V(0, 0 ,0), the initial value of the existing manager. Recall that it is assumed here that the value of the best alternative manager is invariant with time. A solution is a value of V(.) at each point in the state space of points ($\bar{x}$, s_n^2, n). In this simulation the approximation to the full solution is the values of V(.) at the points:

n = 1, 2, 3, ……., 20

$\bar{x}$ = -0.100, -0.099, ……, 0,…….0.098, 0.099

s_n^2 = 0.0000, 0.0002,…...,0.0098

Therefore, the value of active management at 20 x 200 x 50 = 200,000 points are estimated in each simulation. Those values are the source of data for the graphs and tables presented in this section. The simulations compute the value of V($\bar{x}$, s_n^2, n) for an investor who has an investment horizon of 10 years. For some situations a longer horizon might be appropriate. However, the number of computations in the simulation increases as the square of the number of periods to the horizon. In any case we know from the Bayesian structure of the model that the results will be qualitatively similar for larger horizons.[71]

6.5.2 Simulation methodology

The simulation can proceed to a solution by solving for $V(\bar{x}, s_n^2, n)$ where the horizon is one period. In that case $V(\bar{x}, s_n^2, n) = \text{Max}\,[m_n/(1+r),(m_0^a-K(1+r))/(1+r)]$ where m_0^a is the expected return from the best alternative manager over the one period. Having solved for the one period values, the simulation can step back a period and use the 200,000 values from the one period problem to calculate the values for the two period horizon. Then the simulation iterates back another eight times to reach the ten year horizon solution.

In each iteration for each of the 200,000 cells, the integral in equation 6.27 must be evaluated. In this study, Montecarlo estimation of the integral was employed. For each cell calculation a large number of independent draws are made from the student t distribution of x_{n+1} that relates to that cell. The value in the next period that corresponds to the draw is found and the values are averaged. This method appeals to the law of large numbers to estimate the expectation of V(.) over the possible values of the excess-to-benchmark return in the next period.

6.5.2.1 Calibration of the Montecarlo simulation

Two elements of the Montecarlo simulation are central to its accuracy. Firstly, the range of the points calculated and the distance between those points.[72] Secondly, the number of draws in evaluation of the integral. To determine suitable values for these quantities the Montecarlo simulation values can be calibrated against the closed form solution from the two period model.

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[71] The number of computations required in the simulation if the reporting periods are quarters instead of years is 16 times greater.

[72] Outside the range the value is estimated by the upper asymptote for high sample mean values which are outside the range of cells and V^a-K for the low sample mean values which are outside the range of cells.

For the two period horizon case, the value of $V(\bar{x}, s_n^2, n)$ was calculated by both the closed form equation of 6.24 and the Montecarlo method. The results of this calibration are depicted in figures 6.7 and 6.8. Figure 6.7 shows that the closed form and Montecarlo values are co-incident. In the legend to that figure hor=2 means that these results are for the two period horizon model. Draw = 5000 records that 5000 draws were made in the Montecarlo estimation.

Figure 6.8 depicts the value of the option component of V_n^r (part 4 in equation 6.24), as it varies with the sample mean. The different lines show the effect of increasing the number of draws in the Montecarlo estimation technique. The results suggest that the number of cells (200,000) is large enough and 1,000 draws is sufficient for the Montecarlo method.[73]

6.5.3 Representative investor case

6.5.3.1 Parameter choices

The values of α_0, β_0, λ_0 and m_0 determine the slope and location of the prior distribution. In this simulation the parameters were chosen on the following basis.

$\frac{a_0}{b_0} = E(\tau)$	Values of $\alpha_0 = 4$ and $\beta_0=0.0016$ were chosen to give an expected value of τ of 2500 in the prior.
α_0 = dof	A prior degree of freedom in the t distribution of x_{n+1} of 4 was chosen. The choice of α_0 also determines the variance of τ which is α_0/β_0^2.
λ_0	Determines the weight that is given to prior information versus sample information in forming the posterior distribution. The choice of $\lambda_0 = 2$ corresponds to a representative investor whose prior information is equivalent to two observations (years) of sample information.
m_0	In this simulation the representative investor is given a prior expected value of μ of 0.

[73] This calibration also permits very accurate de-bugging of the simulation program which provides a non trivial improvement in confidence in the simulation results.

Figures 6.9 – 6.12 depict the value of active management to the representative trustee board when the investment horizon is 10 years and the investment manager has been employed for 3 years. Figure 6.9 shows the value of active management for the representative trustee board for different values of the sample variance of excess-to-benchmark returns. It shows that $V(\bar{x}, s_n^2, n)$ is increasing in the sample variance. In particular the figure demonstrates that the value of $\bar{x}$ at which the manager is dismissed is decreasing in the sample variance.

Figure 6.9 shows the low and high asymptotes which V_n^r approaches when the sample mean of excess-to-benchmark returns is low or high respectively. Figure 6.10 shows the difference between V_n^r and the asymptotes. This difference represents a part of the value of the option to delay the decision to dismiss the manager by one or more periods. Figure 6.10 shows that part of the option value is an increasing function of s_n^2. Much of the option value is captured by V^a because the option to change managers stills exists after a new manager is chosen.

Figure 6.11 exhibits the relationship between V_n^r and the number of observations of the excess-to-benchmark return. Clearly there is not a single monotonic relationship between the volume of sample information and the value of active management. The position of the asymptotes is dependent upon n. Nonetheless, figure 6.12 shows that the height of V_n^r above the asymptotes (the option value not captured in V^a) is a decreasing function of n. That option value is increasing in the level of uncertainty over μ, which is decreasing in n.

6.5.4 Uncertainty over the expected value of excess-to-benchmark returns

Tables 6.1 and 6.2 and figures 6.13 and 6.14 depict the effect of the level of uncertainty over μ on the value of active management. The variance of μ is $s_m^2 = \frac{b_n}{l_n a_n}$. In the simulations for this sub-section the effect of varying σ_μ^2 was studied by varying β_0 and keeping the initial degrees of freedom (α_0) and the weight on prior information (λ_0) constant.

The middle row of each of the following cases presents data for the representative investor, as discussed in the previous section. Table 6.1 shows that for the representative investor the minimum value of $\bar{x}$ at which the manager is dismissed at the decision date is decreasing in s_n^2. The value falls 50 basis points between s_n^2 = 0.0002 and s_n^2 = 0.0050.

For higher and lower values of uncertainty over μ, this range is much the same. However, table 6.1 shows that the critical value of $\bar{x}$ at which the investor is indifferent between retention or dismissal is decreasing in β_0. Investors with high values of β_0, that is, high uncertainty over the value of μ, will accept a lower sample mean of excess-to-benchmark returns before dismissing the manager. Another important effect of varying σ_μ^2 is to shift the value of the alternative manager and hence the value of active management. This is particularly apparent in table 6.2 which shows the value of active management for different values of β_0 and s_n^2 when $\bar{x}$ = 0.

Table 6.1 Effect of uncertainty over μ on dismissal level of $\bar{x}$

	Sample variance			
	s_n^2=0.0002	s_n^2=0.0010	s_n^2=0.0024	s_n^2=0.0050
β_0 = 0.0064	0.005	0.005	0.002	0.000
β_0 = 0.0016	-0.003	-0.004	-0.005	-0.008
β_0 = 0.0004	-0.006	-0.008	-0.010	-0.012

Table 6.2 Effect of uncertainty over μ on value of active management at $\bar{x}$=0

	Sample variance			
	s_n^2=0.0002	s_n^2=0.0010	s_n^2=0.0024	s_n^2=0.0050
β_0 = 0.0064	0.0426	0.0425	0.0456	0.0483
β_0 = 0.0016	0.0101	0.0125	0.0154	0.0204
β_0 = 0.0004	-0.0134	0.0022	0.0036	0.0132

6.5.5 Level of prior information

Simulation results are presented in tables 6.3 and 6.4 and figures 6.15 and 6.16 where weight on the prior information versus sample information is varied, with other parameters held constant. Higher values of λ_0 are consonant with giving more weight to the prior information in the formation of the posterior distribution. The critical value of $\bar{x}$ for which the investor is indifferent between retention and dismissal is decreasing in the weight placed on prior information. Moreover at $\bar{x}$=0 the value of active management is strongly decreasing in the weight put on prior information.

Table 6.3 Effect of level of prior information on dismissal level of $\bar{x}$

	Sample variance			
	s_n^2=0.0002	s_n^2=0.0010	s_n^2=0.0024	s_n^2=0.0050
λ_0 = 4	-0.008	-0.009	-0.011	-0.014
λ_0 = 2	-0.003	-0.004	-0.005	-0.008
λ_0 = 1	0.004	0.002	0.000	-0.002

Table 6.4 Effect of level of prior information on value of active management at $\bar{x}$=0

	Sample variance			
	s_n^2=0.0002	s_n^2=0.0010	s_n^2=0.0024	s_n^2=0.0050
$\lambda_0 = 4$	0.0040	0.0043	0.0075	0.0106
$\lambda_0 = 2$	0.0101	0.0125	0.0154	0.0204
$\lambda_0 = 1$	0.0271	0.0283	0.0327	0.0377

6.5.6 Effect of the cost of changing manager

Tables 6.5 and 6.6 and figures 6.17 and 6.18 depict the effect of the cost of changing fund manager on the value of active management. It is clear from table 6.6 that the value of active management is falling in the cost of changing manager. However, the reduction in value is less than the increase in cost. Comparing the columns of table 6.6, the results suggest that the ratio of decrease in value of active management to increase in cost of changing is increasing with the sample variance. Thus, the more likely it is that a change is required, the larger the effect of K on V(.).

Table 6.5 suggests, as expected, that investors will accept a lower value of $\bar{x}$ before changing manager when the cost of changing manager is higher.

Table 6.5 Effect of K on dismissal level of $\bar{x}$

	Sample variance			
	s_n^2=0.0002	s_n^2=0.0010	s_n^2=0.0024	s_n^2=0.0050
K=0.04	-0.010	-0.012	-0.013	-0.015
K=0.02	-0.003	-0.004	-0.005	-0.008
K=0.01	0.001	0.000	-0.001	-0.004

Table 6.6 Effect of K on value of active management at $\bar{x}$=0

	Sample variance			
	s_n^2=0.0002	s_n^2=0.0010	s_n^2=0.0024	s_n^2=0.0050
K=0.04	0.0029	0.0031	0.0067	0.0099
K=0.02	0.0101	0.0125	0.0154	0.0204
K=0.01	0.0217	0.0228	0.0266	0.0308

6.5.7 Effect of the risk free rate

Tables 6.7 and 6.8 and figures 6.19 and 6.20 depict the effect of the cost of changing fund manager on the value of active management. Table 6.7 indicates that investors will accept lower values of $\bar{x}$ before dismissing a manager when interest rates are high. The future payoffs to switching managers is lower when interests rates are higher. However, the value of active management is strongly decreasing with increased interest rates at a sample mean of 0. In this framework active management is less valuable when interest rates are high but nonetheless investors have less incentive to change managers.

Table 6.7 Effect of risk free rate on dismissal level of $\bar{x}$

	Sample variance			
	s_n^2=0.0002	s_n^2=0.0010	s_n^2=0.0024	s_n^2=0.0050
r=0.20	-0.008	-0.009	-0.010	-0.012
r=0.08	-0.003	-0.004	-0.005	-0.008
r=0.02	-0.001	-0.001	-0.003	-0.007

Table 6.8 Effect of risk free rate on value of active management at $\bar{x}$=0

	Sample variance			
	s_n^2=0.0002	s_n^2=0.0010	s_n^2=0.0024	s_n^2=0.0050
r=0.20	0.0029	0.0032	0.0056	0.0078
r=0.08	0.0101	0.0125	0.0154	0.0204
r=0.02	0.0210	0.0227	0.0288	0.0350

Figure 6.7 Closed form values versus Montecarlo values

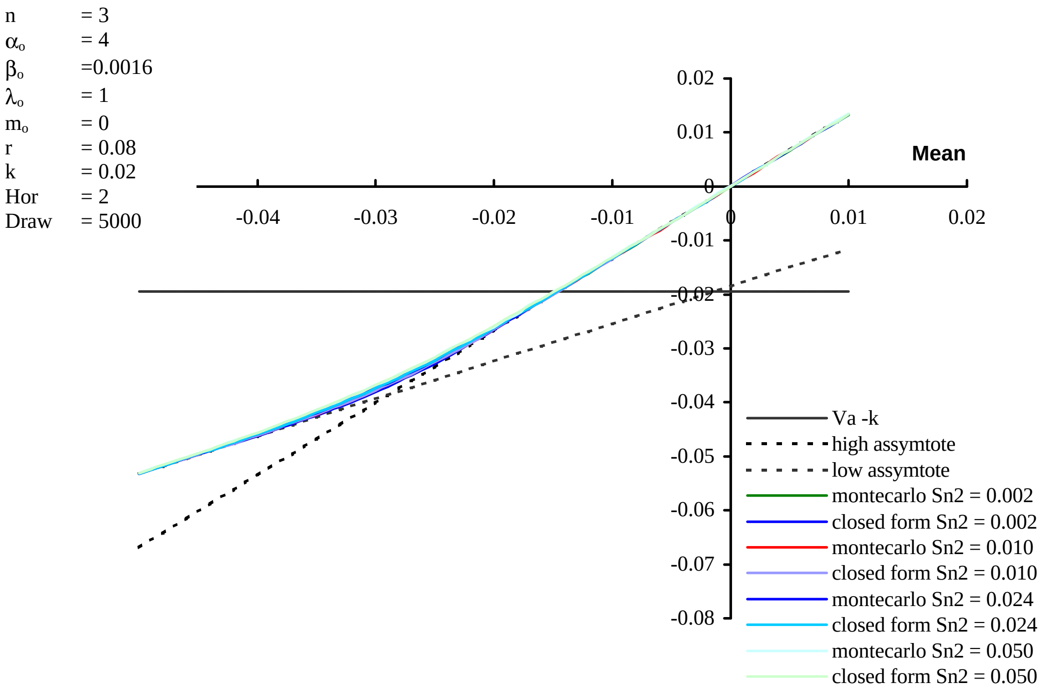


Figure 6.8 Montecarlo accuracy with varying numbers of draws

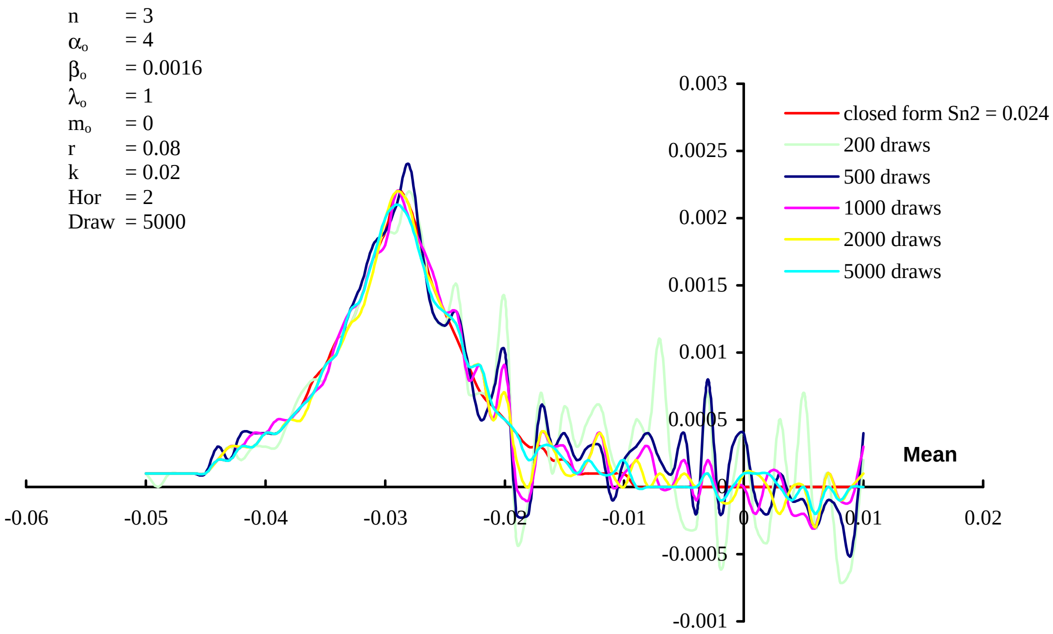


Figure 6.9 Value of active management for representative investor

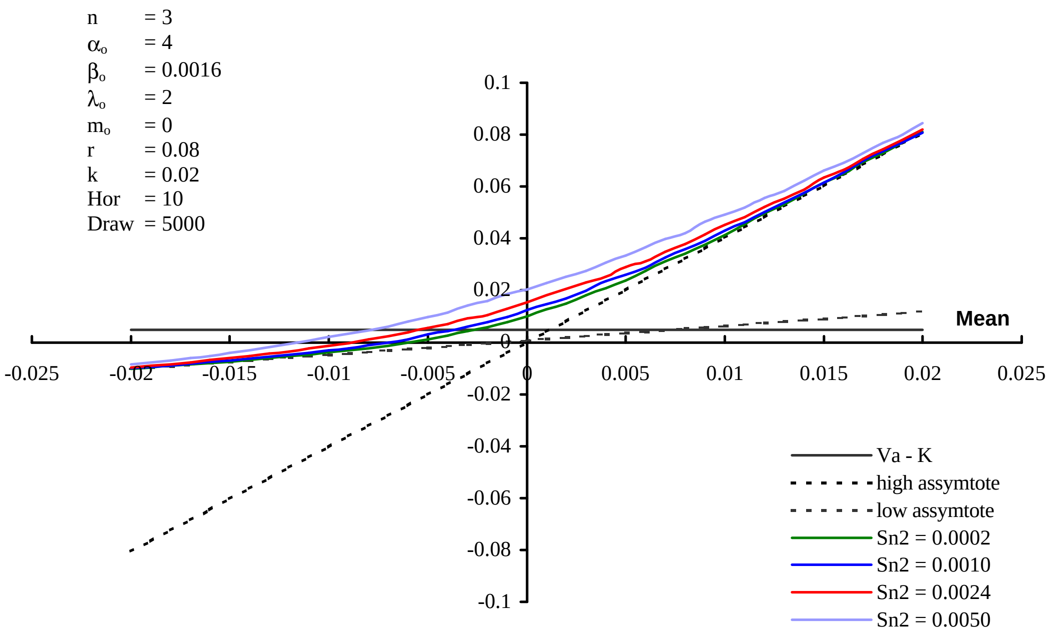


Figure 6.10 Variation of option value of active management

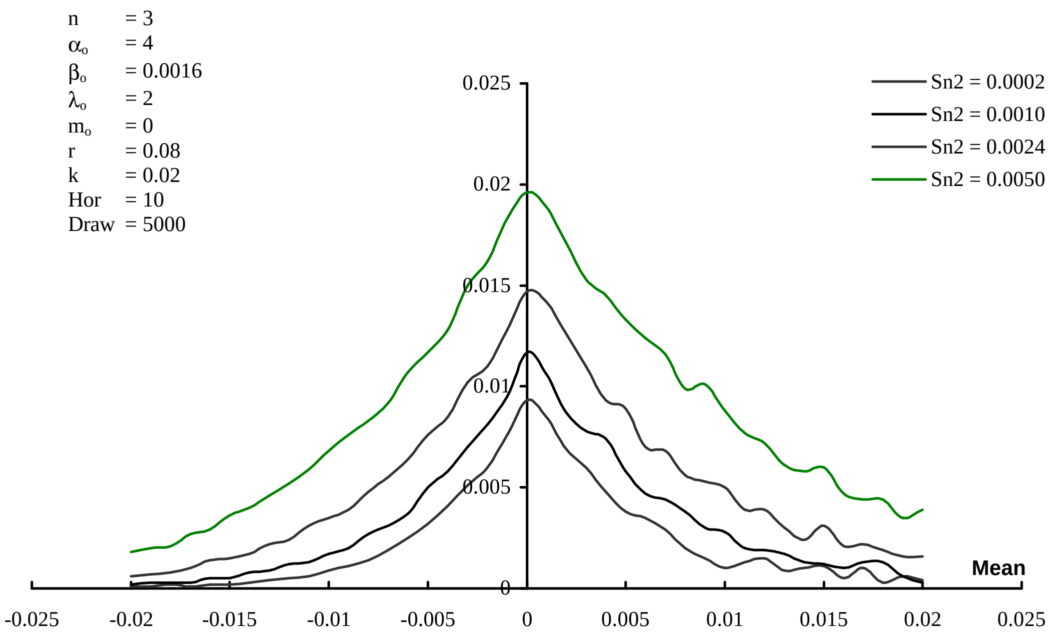


Figure 6.11 Variation of value with level of sample information

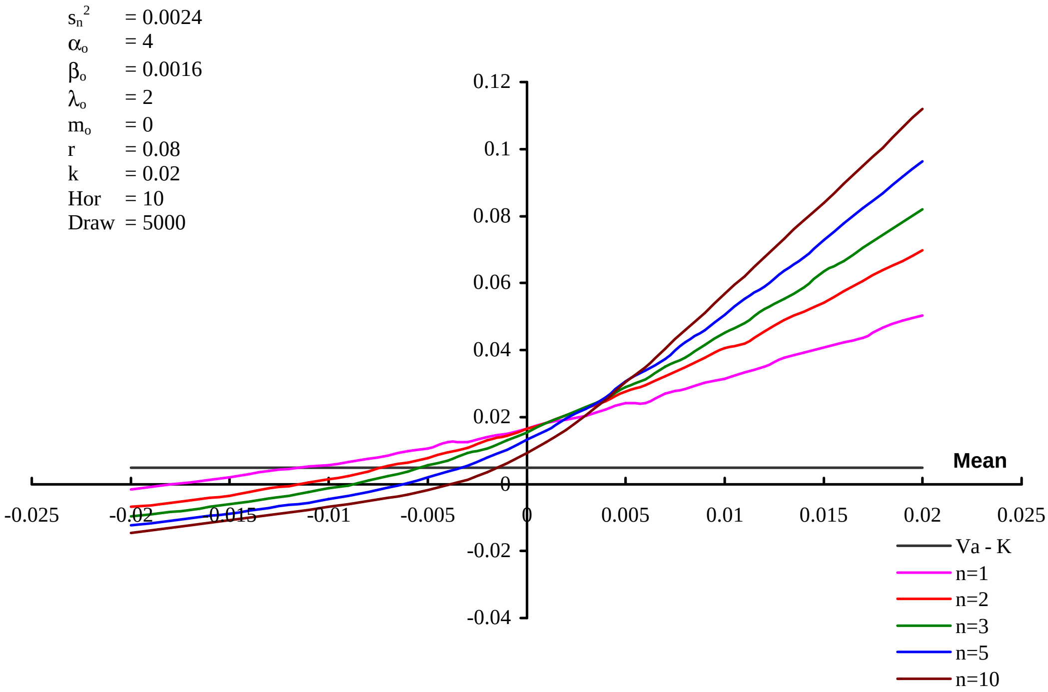


Figure 6.12 Option value versus level of sample information

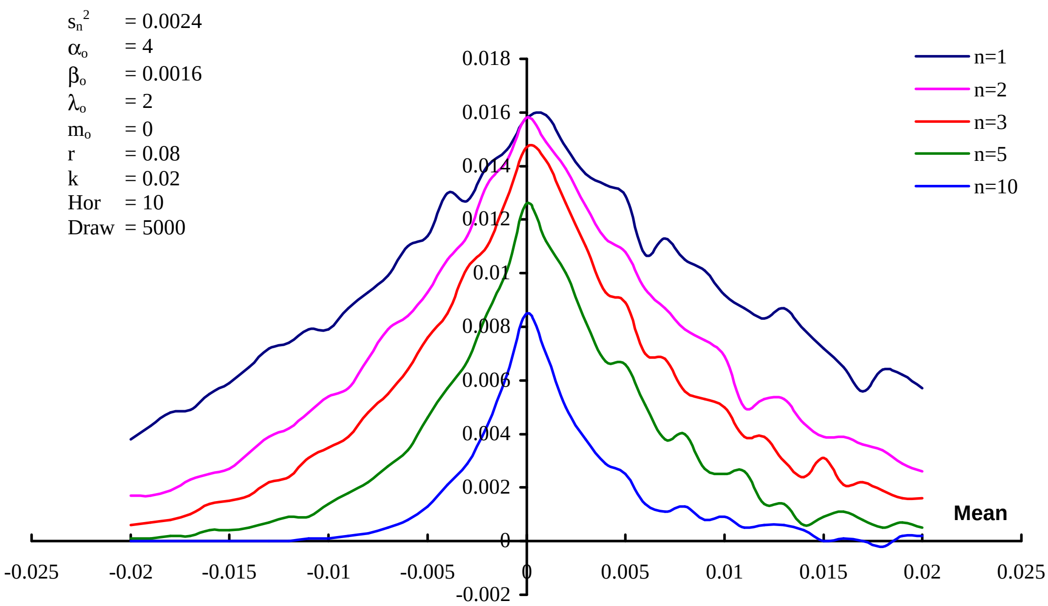


Figure 6.13 High uncertainty over value of μ

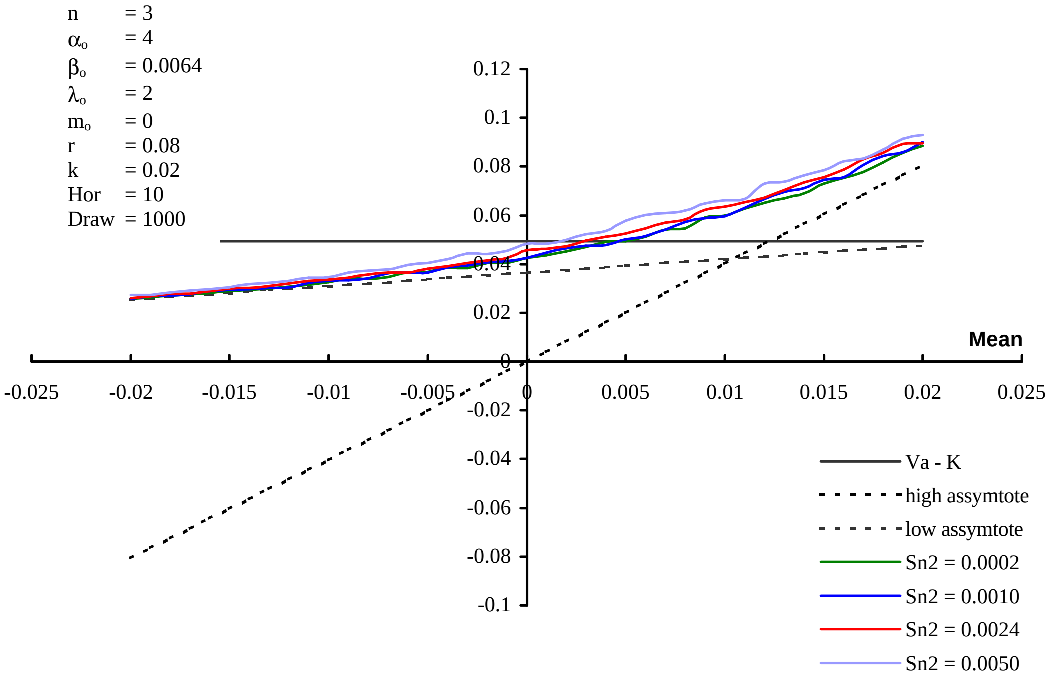


Figure 6.14 Low uncertainty over the value of μ

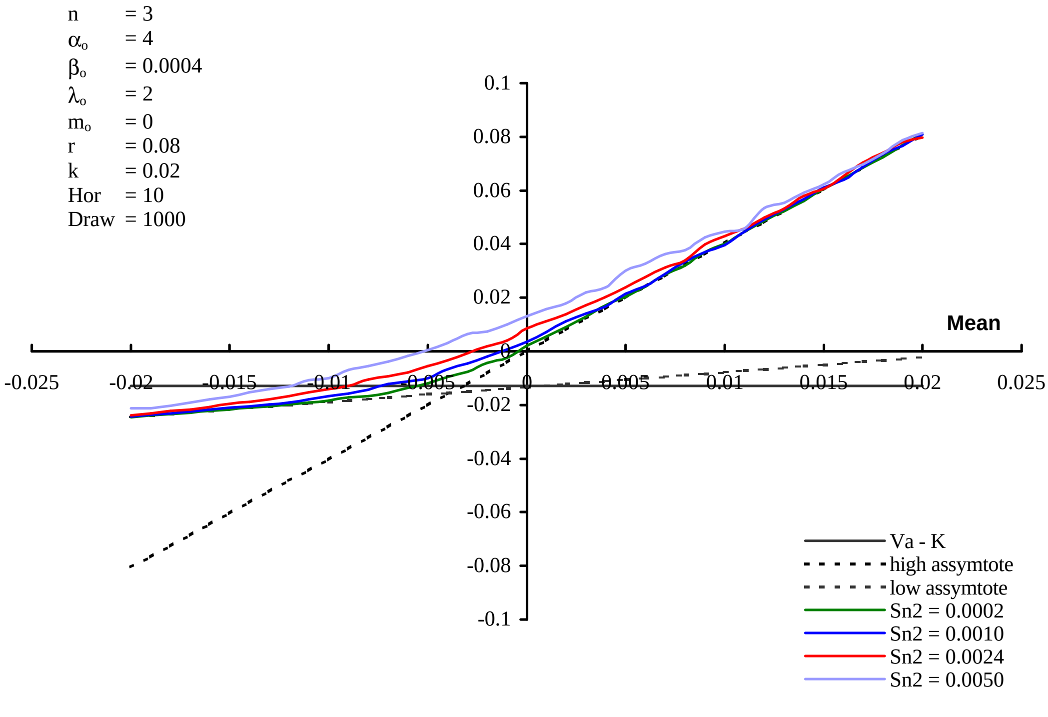


Figure 6.15 Strong prior information

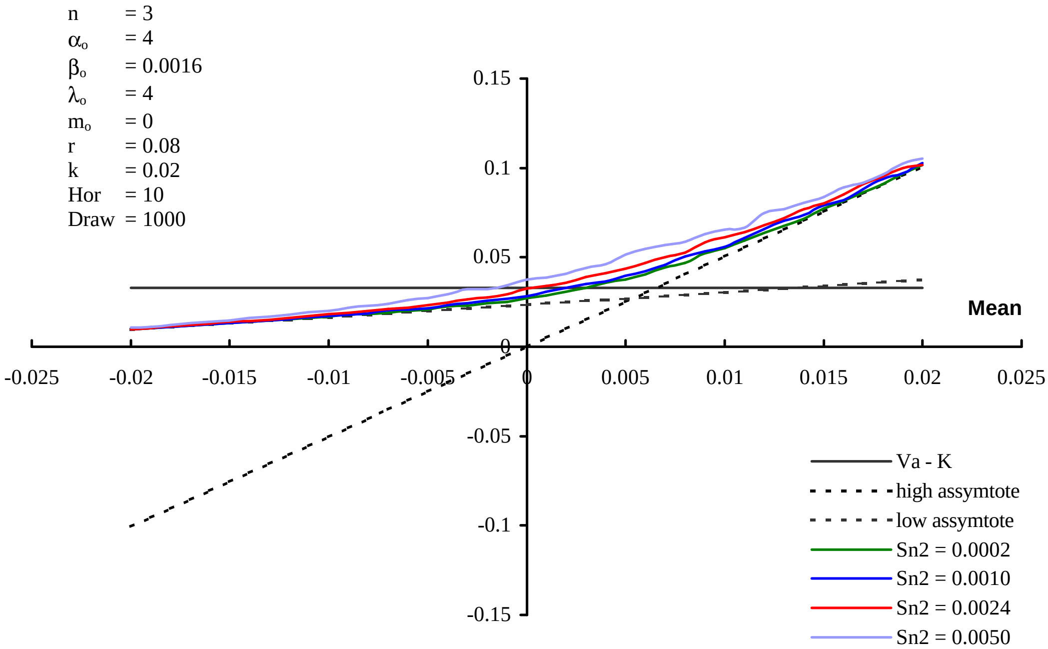


Figure 6.16 Weak prior information

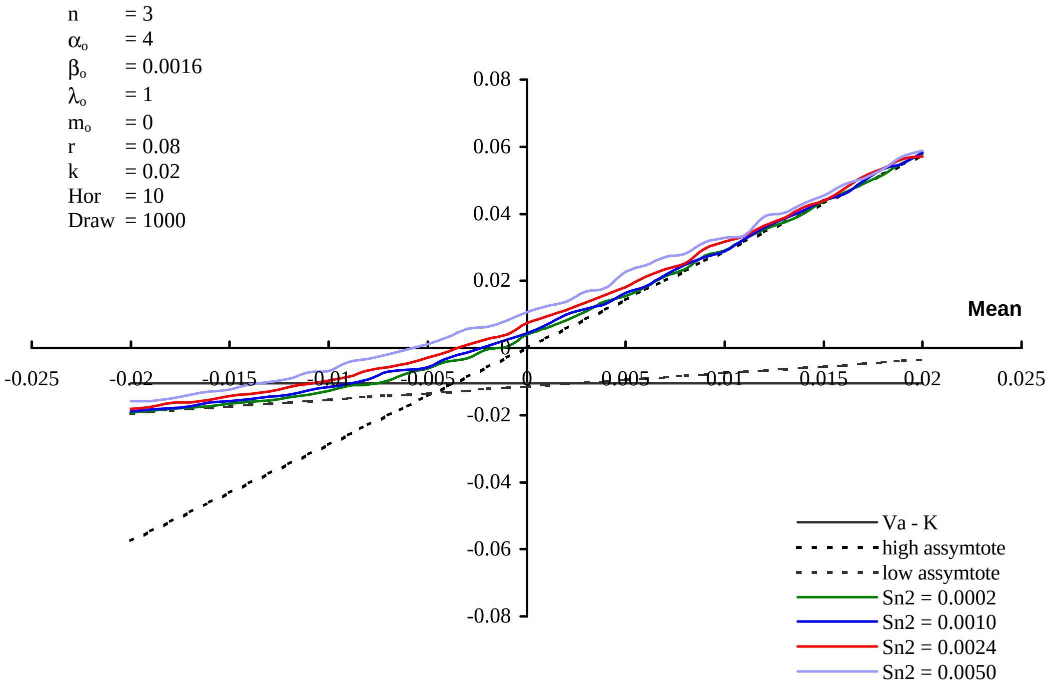


Figure 6.17 High cost of changing manager

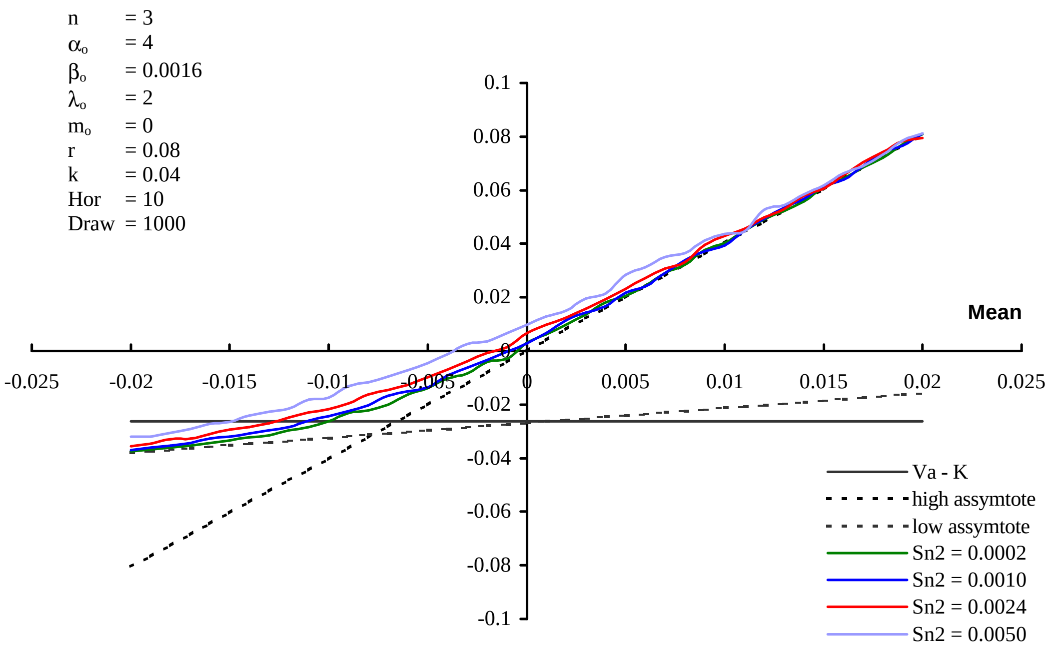


Figure 6.18 Low cost of changing manager

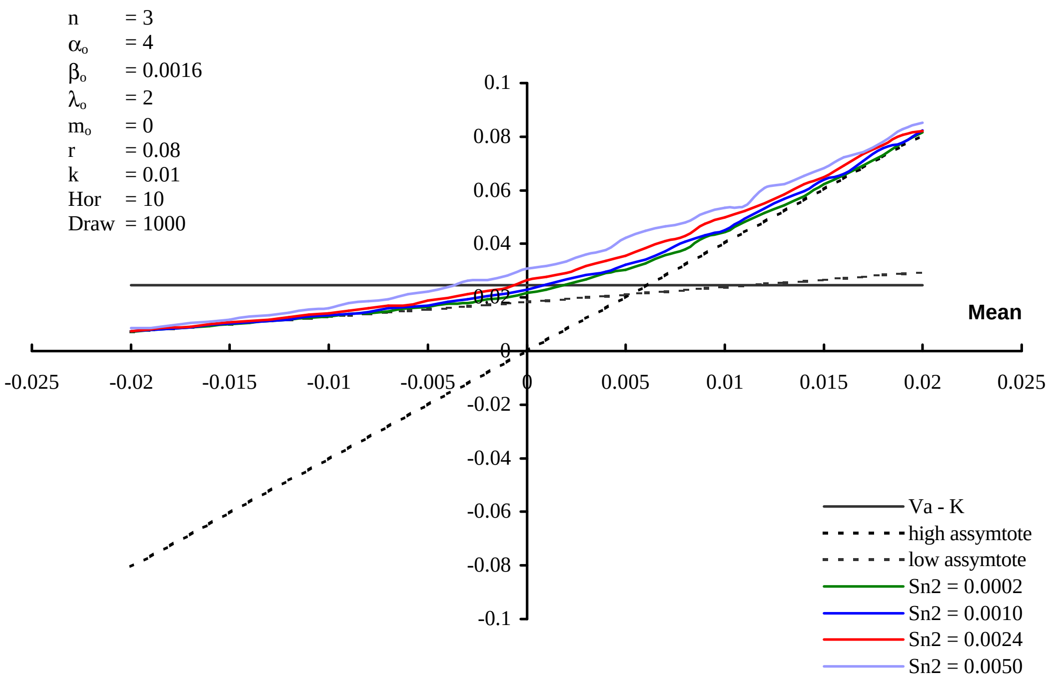


Figure 6.19 High risk free rate

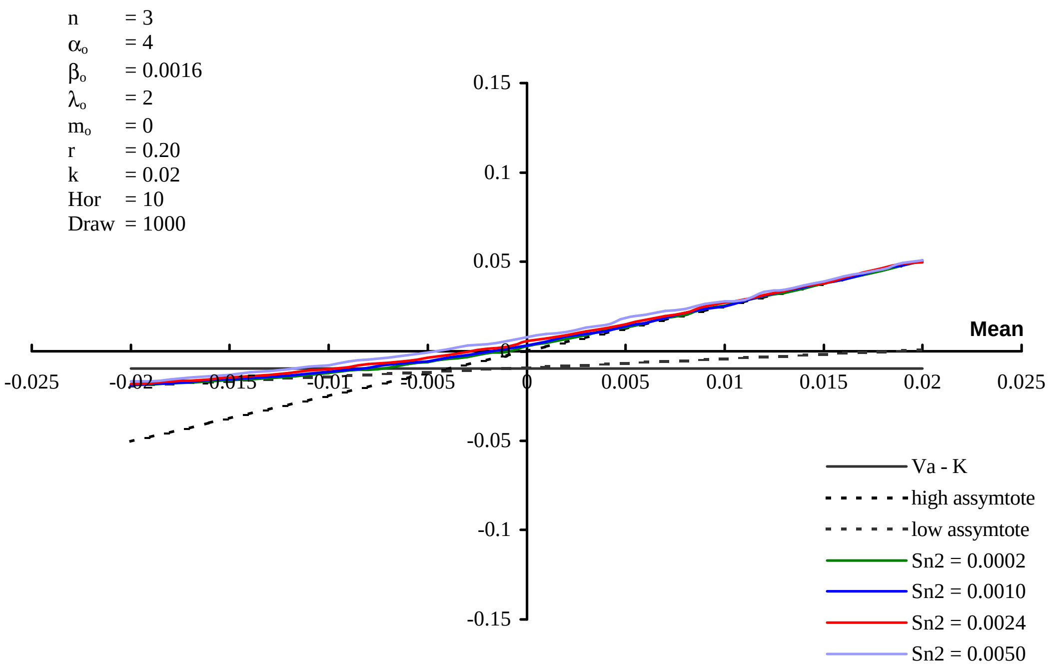
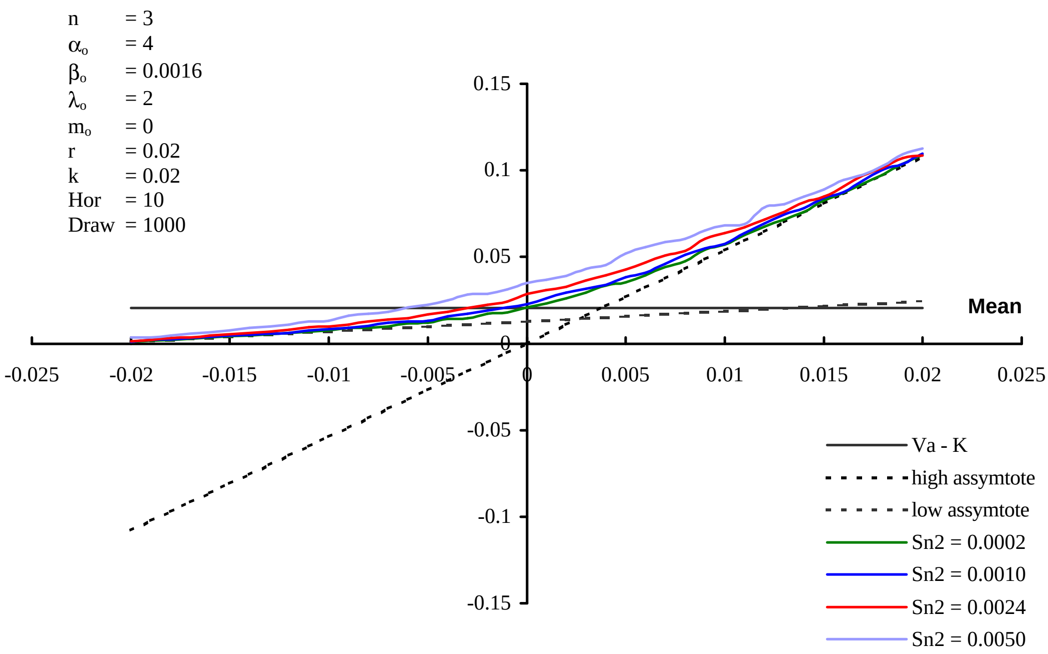


Figure 6.20 Low risk free rate



6.6 Testable implications and future research

The model of investors hiring and firing decisions that is presented here has a number of testable implications. It is my intention to confront a subset of these implications of the model with UK pension fund data in future research.

Implication 1 Other things equal, investors will more highly value investment managers that have shorter observable investment histories because investors' valuation of active management is increasing in uncertainty over the value of μ. Therefore, other things equal, more money will flow to managers with shorter observable investment histories. Further, we can expect to see that, of the pension fund managers which are dismissed by trustee boards, managers with shorter observable investment histories sustain lower levels of performance before being dismissed. These implications could be tested using pension fund or mutual fund data. Both sources are available in the US and the UK.

The first implication requires an estimation of a model of the flows of new money to fund managers. In that estimation one of the explanatory variables would be the age of the fund, or another proxy for the level of investors' prior uncertainty over the -to-benchmark return distribution. The discussion of the literature on the strengths and weaknesses of existing fund manager performance-flow studies can guide the design of the model of portfolio flows. The second implication, regarding the level of performance preceding dismissal, can be tested directly by regression of performance at dismissal on the proxy for uncertainty over the mean of excess-to-benchmark returns. Lunde, Timmermann and Blake (1998) investigate the hazard function of mutual funds using semi-parametric technique.

Implication 2 The sample mean of the manager's excess return at the date of dismissal will be decreasing in sample variance because V_n is increasing in s_n^2. This implication is the sample data version of the second of the implications above. Again a direct test from pension fund data should be feasible.

Implication 3 Other things equal, the volume of money managed by managers which impose low costs of changing manager will be higher. The observable costs of changing manager would include redemption charges of mutual funds. Data on the charges of UK unit trusts and US mutual funds is available. The test involves estimating a model of the asset size of different unit trusts. In that model one of the explanatory variables is level of entry and exit charges.

Implication 4 The sample mean of the manager's excess return at the date of dismissal will be decreasing in the cost of changing manager. In this case, different asset classes might proxy for the cost of changing manager. The portfolio changes arising from a change in small capitalisation stock manager will create larger transaction costs than the portfolio changes associated with a change of large capitalisation stock manager.

Implication 5 The proportion of new funds that flow to passive managers will be increasing in the level of the riskless rate of interest and decreasing in the costs of changing managers. These implications can be tested cross-sectionally and across time using UK unit trust or US mutual fund data.

6.7 Concluding remarks on the hiring and firing model

The model of hiring and firing of pension fund managers and the associated simulation study are motivated by a desire to understand how the decisions of investors, regarding which fund manager to choose and whether to retain that manager, affect the equilibrium in asset markets. Investors' decisions on dismissal can help us to understand the downside risk that fund managers face from poor portfolio performance results. As argued in chapter 2, an understanding of fund manager incentives is crucial in studying the market equilibrium.

Empirical studies find that significant poor under-performance by fund managers may be sustained before the volume of funds under management decreases substantially. In the model presented here, that observation is explained by the positive value of the option to delay the decision to dismiss the manager.

In the two period model, the value of active management can be broken down into four components, one of which is the option to decide next period, rather than this period, whether to dismiss the manager. The simulation of the value of active management to an investor with an investment horizon of 10 periods shows that this option value is not trivial. The simulation draws out the crucial role of the level of uncertainty over the expected value of the manager's excess return distribution. In the simulation the difference between a high prior level of uncertainty and a low prior level is nearly 500 basis points in the value of the manager, and 110 basis points in the sample mean of excess-to-benchmark returns before the manager is dismissed. For a longer horizon these values would be commensurately larger.

This level of uncertainty over μ is also increasing in the sample variance of excess-to-benchmark returns, which has implications for the incentives of fund managers who are approaching performance levels at which investors are considering dismissal.

The model highlights the role of the cost of changing manager in the decisions of investors. The simulation shows the value of active management decreasing in the cost of changing managers with a sensitivity of less than one. The model also potentially provides insights into the role of the cost of changing manager in the balance between the total volume of funds under active versus passive management. Individual managers who have performed poorly do not have the same incentives as highly performed managers to minimise the costs to their investors of changing manager. Since the value of active management, unlike passive management, is decreasing in the cost of changing manager, there is a negative externality associated with these costs.

Chapter 7 Concluding Remarks

This thesis is concerned with the decisions of private investors and institutional fund managers. It is contended here that private and institutional investors are fundamentally different in at least one way – they face different incentives. Further, that we expect the decisions taken by private and institutional investors to reflect this difference. In turn, we expect the difference in those decisions to be reflected in financial market outcomes. The research presented here demonstrates that the differences in the decisions of private investors and fund managers are substantial and explain outcomes observed in financial markets.

The organising principle for this study of the decisions of investors and their fund managers is the familiar starting point of all microeconomic analysis - the maximisation problem faced by economic agents. In the rise of delegated portfolio management essay, the questions are: how large is delegated portfolio management?; how did the rise of institutional fund management come about?; what do we know about the differences between the incentives, and hence optimisation problems, faced by private investors and fund managers?; and what can be explained by studying these differences?

In the accuracy of herding measures essay, the questions proceed from the view that the differences in incentives are important: if we believe that private investors and institutional investors form two groups that are fundamentally different in their trading, then how do we test that belief? A body of empirical literature finds that fund managers form a herd separate to the rest of the market (private investors), but how do we know that the measures of herding are accurate? More generally, how do we test whether any particular measure which is derived from portfolio holdings is accurate; and can we generalise the findings of studies of herding by US fund managers to the behaviour of managers in other comparable markets?

The hiring and firing of fund managers essay, is motivated by unanswered questions about investors' decisions and fund managers' incentives: how can the portfolio performance of managers who are fired be characterised?; what does the attrition rule mean for the downside of the incentive schedule faced by fund managers?; what is it that makes investors choose to delegate portfolio management when the average manager under-performs obtainable market indexes?; and how do the hiring and firing decisions of investors aggregate to create observed dynamics in the investment management industry?

The contribution of the first essay is an analysis of the significance of the transfer of control of a large part of the financial asset market from households to institutional investors. The first point addressed is the scale of the transfer of financial assets from households to professionally managed portfolios. It is important to bring out in clear terms what a massive change has occurred in the control of assets and financial intermediation in the US and UK. The figures themselves beg the question ‘what does this mean for financial markets?’

Once the data is presented it becomes clear what is driving the shift to delegated portfolio management in the US, the growth in pension money managed by institutional investors. The transition of household ownership of US equities from 69 percent of the market in 1969 to 41 percent at year end 1998 is explained largely by three structural ownership changes. State and local government employee funds have taken their holding of US equities from near zero to over 10 percent of the market as their assets grew to 28 percent of GDP and their US equity allocation grew to 62 percent, between 1967 and 1998. Private pension fund holdings have increased from 6 to 14 percent of the US equity market in the same period. US mutual funds held 4 percent of the US equity market in 1983, 7 percent in 1990 and 16 percent in 1998.

For researchers of financial asset markets, the historical perspective of the rise of portfolio management is important. If the level of institutional ownership affects market outcomes then it should be recognised that important empirical finance studies span the period in which the level of institutional ownership is changing rapidly. As far as I can tell, the possible mis-specification of these studies has not been recognised elsewhere.

The first essay then analyses what is known and not known about fund manager incentives. The papers that relate to fund manager incentives are first identified from disparate parts of the literature. Some evidence is drawn from studies that address psychological issues of rationality, cognitive dissonance and reaction to quality shocks, but nonetheless provide analysis of the flow of funds to managers. The conflicting results from the studies of funds flows are subjected to two tests. Firstly, that the econometrics of the study is sound and secondly, that the results make sense in the framework of the fund manager's optimisation problem. This is a crucial step for the thesis. This analysis characterises what is known about fund manager incentives.

The incentive schedule of a fund manager relates end of period wealth, or firm value, to fund rank or the excess-to-benchmark return of the manager. The schedule is convex in out-performance and concave in under-performance. The schedule shows that there is little gain to portfolio performance that is only slightly better than that of peer fund managers. The rewards of new money flow to managers with the highest return ranking. The schedule is not symmetric in that funds can have poor performance and not lose much money. The relationship between end of period wealth (y axis) and relative portfolio performance (x axis) is not as concave in poor performance as it is convex in high performance.

The incentive schedule of a private investor is a linear relationship between portfolio total return, or excess-to-benchmark return, and end of period wealth. Therein lies the essential difference between the incentives of private investors and fund managers. There are two immediate implications of this difference that can be understood in terms of the incentive schedule. Firstly, assume that a fund manager wishes to maximise the expected utility of wealth $E[u(w\{r_{pt}-r_{mt}\})]$. The expectation operator is linear, the utility function of wealth is concave and wealth is convex in positive excess return and concave in negative excess return.[74]

Under these circumstances fund managers will value assets with positive skewness.[75] The testable implications of this conjecture are manifold and can form the basis of

[74] This statement is a simplification because the location of the inflexion point of the schedule depends upon past performance of the fund.

[75] In fact managers will have a preference for all positive values of all the odd moments, 1st, 3rd, 5th,….

ongoing research. For example we should expect to see fund managers' holdings of assets with positive skewness to be greater than that of private investors. Such assets would include initial public offering stocks and deeply out of the money options.

The second implication of the nature of the incentive schedule is as follows. Assume that the end of period wealth of a fund manager is a function of excess return over a window of say three years. Then each year the performance of four years ago drops out and last year's performance is inserted. That change in the window shifts the schedule to the left or the right. That shift leads to a new optimal portfolio. This is a form of dynamic hedging which may have profound implications. For instance, say one manager owns none of stock A that is 2 percent of the index and another manager holds 4 percent of the stock and the stock goes up 150 percent. The dynamic hedging response will not be symmetric. As the stock rises the manager who is short versus the market will be induced to buy but the other manager may also be induced to buy. The relationship between such asymmetric hedging and serial correlation in stock prices can be investigated in future research.

A testable implication of the conjecture that private investors and fund managers have substantially different incentives is that, as groups, they will hold significantly different aggregate portfolios. As they change those portfolios in response to changes in variables that affect the two differently, we should expect to see net trade between them which appears as herding by the groups.

Previous studies provide evidence of herding by mutual fund managers and pension fund managers in the US. But the measures employed in those studies are founded on assumptions that are invalid but crucial for the accuracy of the measures. This problem is not unique to measures of herding. Unfortunately, it is standard practice in much of empirical finance, and especially investment management studies, to devise a metric and then simply assume that the metric will return a value of zero in the absence of the phenomenon being measured. Yet, in most of these studies researchers could simulate datasets, in which the phenomenon is absent, to empirically estimate the sampling distribution of the metric under null conditions.

An alternative to testing the existing herding measures is to devise a new measure of herding. The testing approach was chosen for two reasons. Firstly, tests of the accuracy of the extant measures can help determine whether existing empirical studies of herding are soundly based. Secondly, the attempt to create measures of herding that encompass all the phenomena that are considered to be herding is part of the problem with herding measures. That approach has led to measures that do not have well defined alternative hypotheses. A much better approach is to identify separate testable predictions for each of the theoretical explanations of herding and then devise separate tests for each prediction. This is the approach that shall be taken in ongoing research on fund manager herding.

The contribution of this essay can be summarised as follows. Firstly, the mathematical description of different types of herding is defined and it is shown that the major explanations of herding all arise from the same source - fund managers solve similar optimisation problems. The analysis of explanations of herding in an optimisation framework presented here hopefully will help to clarify the discussion of herding.

Secondly, a methodology is developed for estimating the sampling distribution of any metric which is derived from portfolio holdings data. Researchers can employ a version of this methodology to test the accuracy of a metric on any portfolio holdings dataset. There is no need to simply assume that a metric is well calculated. Thirdly, the accuracy of the existing measures of herding is tested, and the types of stocks for which these measures are inaccurate, in the UK dataset, are identified. It is found that the LSV measure overstates the level of herding in small capitalisation stocks and stocks traded by a small number of managers as a result of the invalid short sales assumption. The Wermers measure of herding is found to be substantially mis-specified. The caveats associated with this general test of the model should be reiterated here. We cannot be sure that the all herding was eliminated in re-sampling procedure of the test. The re-sampled datasets do not maintain all the essential characteristics of the actual dataset and the number of re-sampled datasets is finite.

Finally, the existing measures are adjusted for estimated inaccuracy and a significant level of herding among UK equity unit trust managers is recorded. The level of herding found is commensurate with 14 managers buying or 12 managers selling where 20 managers trade a stock during a period.[76] A large amount of herding by UK unit trust managers in the smallest market capitalisation stocks is found. Curiously, that herding is almost entirely herding in buying of the small stocks.

It is difficult to judge the economic significance of these figures. For two reasons we should not expect to observe ratios of managers trading in the same direction that approach unity. Firstly, the household sector in the UK holds only 22 percent of the UK equity market. Therefore the household sector cannot absorb a great deal of correlated trading from managers. Secondly, if fund managers herd in their trading of a stock then resultant trading pressure will move the price in the direction that weakens the force which originally created the herding. For instance, if a large number of managers buy in concert because they observe a manager who is perceived to be informed buying the stock, then we can expect the price of the stock to rise, which in turn induces some managers to sell.

Ongoing research in herding can take two directions. The first, as previously mentioned, is to identify separate testable predictions from the major theoretical explanations of herding and test them. A test of the correlated information theory of herding is afforded by the overlapping nature of the UK unit trust dataset. Fund managers who report in the January-July cycle overlap managers in the February-August cycle by five months and managers in the March-September cycle by four months and so on. By the correlated information hypothesis, the smaller the overlap period between funds, the less the herding that should be found between them. Preliminary tests show that the UK portfolio holdings data does support the correlated trading explanation of herding.

The hiring and firing essay presents results that have the pleasing quality of being unanticipated when the study began. The first motivation for the study was a need to better understand the process by which investors decide when to dismiss a poor performing manager and then which alternative manager to choose. The intention was to better understand the downside risk faced by managers, by modelling the

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[76] The difference arises because in the absence of herding, on average 11.6 managers would buy.

events leading up to dismissal. Further, to understand aspects of the structure of the investment management industry, such as the balance between active and passive management and the concentration of pension fund mandates with only a few of the largest managers, by studying the hiring and firing decisions of individual investors.

The hiring and firing essay of chapters 5 and 6 contributes to the understanding of these questions and addresses other questions which were not part of the original motivation. The principle contributions are twofold. Firstly, to recognise that the investor has a sequence of real options to delay the project of firing the manager. Secondly, to understand the dynamic programming nature of the investor's hiring and firing decision.

The value of the real option explains some investor behaviour that otherwise seems incongruous. It partially explains observations of empirical studies of funds flows that were reviewed in the rise of delegated portfolio management essay. Ippolito (1992), Goetzmann and Peles (1997) and Sirri and Tufano (1998) find that investor reaction to poor portfolio performance does not mirror their reaction to high returns. In many instances investors do not leave poor performing funds at a great rate. This observation is explained in part by the omission of the worst performing funds from datasets because they merge with other funds. Another explanation is that investors are trapped by the high cost of changing manager, including the cost of realising capital gains. The additional cost recognised in the hiring and firing essay is the cost of relinquishing the option to delay the costly project of changing manager until the arrival of information that reduces uncertainty over the decision.

The real option also partially explains the observation of Ippolito (1992) and Chevalier and Ellison (1997a) that, after controlling for size and portfolio performance, more money flows to a fund with a two year history than a fund with a ten year track record. For the two year manager, other things equal, waiting one more period before deciding on dismissal resolves more uncertainty about the manager's ability. Therefore the option to wait is more valuable. The greater uncertainty in the posterior distribution over the mean of the excess-to-benchmark return distribution of the two year manager gives the real option associated with that manager a higher value.

The dynamic programming nature of the investor's problem comes about because the investor must choose another manager if the current manager is fired. This gives the model the real world property that the investor expects to hire a sequence of managers over time. Then we have the result that an investor may choose active management even when the investor's prior expectation is that the mean of the chosen manager's excess return distribution is negative. The intuition here is that if an investor on average holds on to good managers for longer than bad managers, then even if the average manager's average return is negative, the investor's time weighted return can be positive. Therefore, the model partially explains why investors choose active management when studies show that the average manager under-performs the market index.

The next step in the study of investors' hiring and firing decisions is to draw out the testable implications of the hiring and firing model and confront them with a real dataset of these decisions.

In the most general terms, this thesis has sought to document the rise of delegated portfolio management and analyse the significance of this structural change in financial markets; examine evidence of whether private investors and institutional investors really are fundamentally different in their trading behaviour; and finally go to the point of contact between investors and fund managers and investigate the nature of investor choice decisions and its meaning for fund manager incentives and market outcomes. The results of this research have, hopefully, progressed the understanding of the significance of the differences in incentives faced by private investors and fund managers.

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