# The Managerial Performance Of Mutual Funds: An Empirical Study

**Tim Burrows**

**A Doctoral Thesis**

Submitted In Partial Fulfillment Of The Requirements For The Award Of Doctor Of Philosophy Of Loughborough University

**September 2013**



**School Of Business And Economics**

Loughborough University

"..... Our reluctance to accept randomness leads us to make false judgements about the abilities of sports teams and fund managers."

Tony Mann: Review Of Leonard Mlodinow (2008), The Drunkard's Walk: How Randomness Rules Our Lives, London, Allen Lane, In Times Higher Education No. 1861, 4th-10th September 2008, Pg 44-45.

## *Abstract*

For as long as managed mutual funds have been in existence there has been a desire to accurately assess their relative performance against each other, and also their respective performance in relation to an appropriate stock market index. There has been a specific interest in whether the expensive, professionally managed mutual funds can justify their high cost with respect to low cost, simple index trackers by producing superior, post-cost performance, and this proposition is implicitly tested within this thesis.

The aim of this thesis is to undertake an empirical assessment of the managerial performance of mutual funds utilising a three-stage DEA-SFA-DEA methodology which combines linear mathematical programming (DEA) and stochastic frontier analysis (SFA). Specifically, this thesis focuses on evaluating the managerial performance of UK domiciled open-ended investment companies (OEICs) and unit trusts (UTs) over a three year period from 1st January 2008 to 31st December 2010. Various DEA models are utilised including CCR, BCC and SBM DEA models with various orientations, and also versions of these DEA models which make use of the SORM procedure. These are used to carry out an initial evaluation of the managerial performance of the OEICs/UTs, before two of these DEA models are combined with SFA regression analysis in a three-stage DEA-SFA-DEA methodology to purge the influence of environmental factors and statistical noise, thus leading to a more robust evaluation of the 'true' managerial performance of the OEICs/UTs under assessment. The results of this thesis extend support to the premise of the Efficient Market Hypothesis (EMH) that financial markets are 'information efficient', and thus it is not possible, given the information available when the investment is made, to consistently obtain returns in excess of the average market return on a risk-adjusted basis, and this thesis does so through the use of a novel approach.

**Keywords:** Open-Ended Investment Companies (OEICs), Unit Trusts (UTs), UK Domiciled, Linear Mathematical Programming, Data Envelopment Analysis (DEA), Stochastic Frontier Analysis (SFA).

# Acknowledgements

I would like to acknowledge the guidance and support provided by the supervisors of my PhD, Professor Tom Weyman-Jones, Dr Karligash Kenjegalieva and Dr Lawrence Leger. I would also like to acknowledge the scholarship provided by Loughborough University to allow me to carry out my PhD. I would also like to thank the School Of Business And Economics for giving me the opportunity to undertake this PhD thesis.

I would like to thank my family, my Mum, brothers James, Nick, Marc and Jon, and sister Katie, for their support whilst I undertook this PhD thesis, in particular my Mum for all her help over the years. I would also like to thank the many friends from my time at Loughborough, especially those from Loughborough Students' Union Sub-Aqua Club, for their friendship and the many fond memories from my eight years at Loughborough.

Finally, I would like to thank the examiners of my thesis, Dr Meryem Duygun (University Of Leicester) and Dr Adrian Gourlay (Loughborough University).

# Definitions Of The Abbreviations Used In The Thesis

**AMC** – Annual Management Charge

**ANN** – Artificial Neural Network

**APT** – Arbitrage Pricing Theory

**AR** – Assurance Region

**BCC** – Banker, Charnes And Cooper

**CAL** – Capital Allocation Line

**CAPM** – Capital Asset Pricing Model

**CCR** – Charnes, Cooper And Rhodes

**CRS** – Constant Returns-To-Scale

**DEA** – Data Envelopment Analysis

**DGP** – Data Generating Process

**DMU** – Decision Making Unit

**DPEI** – DEA Portfolio Efficiency Index

**EFAMA** – European Fund And Asset Management Association

**EGDH** – Elton, Gruber, Das And Hlavka Measure

**EMH** – Efficient Market Hypothesis

**ERM** – Enhanced Russell Measure

**ERVaR** – Excess Return On Value At Risk

**ETF** – Exchange-Traded Fund

**FDH** – Free Disposal Hull

**FTSE** – Financial Times And Stock Exchange

**FUM** – Funds Under Management

**GDP** – Gross Domestic Product

**GFCI** – Global Financial Centres Index

**ICI** – Investment Company Institute

**IMA** – Investment Management Association

**IPO** – Initial Public Offering

**IRR** – Internal Rate Of Return

**ISA** – Individual Savings Account

**LPM** – Lower Partial Moment

**$M^2$ RAP** – Modigliani And Modigliani Risk-Adjusted Performance Measure

**MPT** – Modern Portfolio Theory

**MRAP** – Market Risk-Adjusted Performance Measure

**MSBM** – Modified Slacks-Based Measure

**MSCI** – Morgan Stanley Capital International

**NAI** – Non-Archimedean Infinitesimal

**NASDAQ** – National Association Of Securities Dealer Automated Quotation

**OEIC** – Open-Ended Investment Company

**PMPT** – Post-Modern Portfolio Theory

**RDM** – Range Directional Measure

**S&P** – Standard & Poor’s

**SBM** – Slacks-Based Measure

**SFA** – Stochastic Frontier Analysis

**SFSF** – Stochastic Feasible Slack Frontier

**SICAF** – Société D’Investissement À Capital Fixe

**SICAV** – Société D’Investissement À Capital Variable

**SML** – Security Market Line

**SORM** – Semi-Oriented Radial Measure

**SPDR** – Standard & Poor’s Depositary Receipt

**SSC** – Constrained Sum Of Squares

**SSU –** Unconstrained Sum Of Squares

**StoNED –** Stochastic Non-Parametric Envelopment Of Data

**TER –** Total Expense Ratio

**UPR –** Upside Potential Ratio

**UT –** Unit Trust

**VaR –** Value At Risk

**VRS –** Variable Returns-To-Scale

**WEBS –** World Equity Benchmark Shares

# Table Of Contents

# Chapter 1: Introduction

For as long as actively managed mutual funds have been in existence there has been a question as to whether they are able to add value by producing abnormal performance through the use of private information and manager skill. This claimed ability to produce superior performance in this way is the *raison d'être* for actively managed mutual funds. There is also a desire and need to be able to objectively measure the performance of these actively managed mutual funds against each other to facilitate investment decisions made by investors. Related to this, there has been particularly intense interest in the question as to whether the actively managed mutual funds are able to outperform a simple, low-cost passively managed index tracker, and thus whether these funds are worth the higher charges for the investment skill and expertise of their managers. The critical nature of these questions is underlined by the fact that as of 31$^{st}$ December 2010, the total assets of mutual funds worldwide equaled $24.7 trillion.

However, measuring and evaluating the performance of mutual funds, both against each other and against a benchmark index tracker, is no easy task and has been the focus of many studies using a variety of different methods and models. There are a number of key questions here including how to actually measure the superior outperformance of the mutual funds and what are the appropriate variables to use, whether the outperformance of mutual funds can be identified ex-ante or only ex-post, and does this outperformance persist in to the future, whether the outperformance returns from active mutual funds accrue to investors or do they end up being absorbed by the managers of the funds through management fees and other costs, can the return due to the skill of the managers be separated from that due to luck and environmental factors such as the performance of a representative market index, and what data is available and are there issues with survivorship bias.

The traditional approach to the problem of assessing the performance of mutual funds is based around modern portfolio theory (MPT) and post-modern portfolio theory (PMPT), and the performance measures associated with these theories. The classic MPT performance measures such as the Treynor ratio (Treynor 1965), the Sharpe ratio (Sharpe 1966) and Jensen's alpha (Jensen 1968), represent the earliest attempts to assess the performance of mutual funds, utilising a mean-variance framework. Two of the major problems with these classic measures are that they are based on the assumptions that the returns of securities and portfolios are normally distributed, and that variance/standard deviation is the correct measure of risk to use. These are problematic assumptions with regard to securities and financial portfolios due to the fact that their returns are unlikely to be accurately approximated by a normal distribution and using variance/standard deviation as the risk measure is likely to be inaccurate as a representation of investors risk preferences as it fails to recognise their preference for upside volatility over downside volatility. This led to the development of the theory of post-modern portfolio theory which includes a three-parameter log-normal distribution and the use of downside risk. The associated performance measures include the Omega ratio (Shadwick and Keating 2002), the Kappa ratio (Kaplan and Knowles 2004) and the Upside Potential Ratio (Sortino et al 1999). However, all of these measures are limited by the fact that they only consider the performance of mutual funds in terms of a risk/return framework, thus excluding the influence of other factors such as management fees.

More recently, a body of work has appeared that has examined the usefulness of data envelopment analysis (DEA) as a method for evaluating the managerial performance of mutual funds. The main benefits that the utilisation of DEA brings to attempts to investigate this subject are that it does not require the imposition of any functional form on the problem and it can incorporate any number of factors in the model. The work in this area was pioneered with the DPEI index (Murthi et al 1997) which was the first attempt to implement a DEA process to the assessment of mutual fund performance. Further work in this area came in the form of the $I_{DEA\_1}$ index and the $I_{DEA\_2}$ index (Basso and Funari 2001), and later, the $I_{DEA\_G}$ index (Basso and Funari 2005).

This thesis aims to investigate the managerial performance of mutual funds, specifically open-end investment companies (OEICs) and unit trusts (UTs), in the UK using a mutual fund universe of 565 OEICs/UTs over the three year period of time from 1st January 2008 to 31st December 2010. The justification behind the selection of UK domiciled OEICs and UTs is that the UK has, in London, one of the major financial hubs of the world as highlighted in the Global Financial Centres Index (GFCI) 14 report (Yeandle and Danev 2013) which ranks London as the number 1 financial centre in the world, and the London financial market is comparable to New York in equities and commodities trading, and larger in bond and derivatives trading (Forbes 2008). Therefore, given the prominence of London within the global financial system, the managerial performance of UK domiciled OEICs and UTs is an important area for research. The three year time period from 1st January 2008 to 31st December 2010 over which the managerial performance of the UK domiciled OEICs/UTs is evaluated warrants use as it encompasses a range of conditions in the financial markets, from the height of the Credit Crunch financial crisis in September and October 2008, through the associated recession which lasted into mid-2009, to the subsequent economic recovery in late 2009 and 2010.

This thesis aims to compare the OEICs/UTs against each other and also against a relevant benchmark in the form of a low-cost, passively managed index tracker to evaluate if the expensive actively managed OEICs/UTs can justify their cost through superior performance over the low-cost index tracker. It makes use of DEA to achieve this, both on its own and in combination with SFA in a three-stage DEA-SFA-DEA model.

This thesis contributes to this area of research in the following ways. It conducts a comprehensive evaluation of UK-based OEICs/UTs using DEA. Amongst the many DEA models utilised in this thesis is the SORMSBM DEA model in a form which can accommodate both negative inputs and negative outputs at the same time, which to my knowledge is a new innovation. Furthermore, it also implements the three-stage DEA-SFA-DEA model (Fried et al 2002), with a modified data adjustment process in the second stage (Tone and Tsutsui 2009), to the assessment of the managerial performance of mutual funds to try and assess accurately the 'true' managerial performance, which to my knowledge is the first time it has been utilised for this.

The remainder of this thesis is structured as follows. Chapter 2 discusses the mutual fund industry in detail, covering its inception and history, the different types of mutual funds that exist, and finally the different investment styles of mutual funds and how they are classified. Chapter 3 reviews the literature in the area of portfolio theory, covering both modern portfolio theory and post-modern portfolio theory, and the main performance measures associated with these theories. Chapter 4 reviews the literature in the area of data envelopment analysis (DEA) and stochastic frontier analysis (SFA), examining the development of DEA and SFA, the problem of negative data in DEA and the potential solutions that have been proposed, the application of DEA to the assessment of the managerial performance of mutual funds, and finally models that incorporate environmental effects and statistical noise in to DEA, specifically combined DEA/SFA models. Following this, Chapter 5 details how the data required for this thesis was selected and where it was subsequently sourced from. Next, Chapter 6 presents the methodology utilised in this thesis, including the construction of the standalone DEA models used for the initial assessment of the managerial performance of the mutual funds, details of how the DEA models for utilisation in the full three-stage DEA-SFA-DEA methodology were selected and finally the methodology behind the full three-stage DEA-SFA-DEA model for the evaluation of the managerial performance of the mutual funds. Chapter 7, Chapter 8 and Chapter 9 contain the standalone DEA results and subsequent analysis for CCR DEA and SORMCCR DEA, BCC DEA and SORMBCC DEA, and SBM DEA and SORMSBM DEA respectively, across the entire mutual fund universe under evaluation. Following this, Chapter 10 presents the results and subsequent analysis from the full three-stage DEA-SFA-DEA model, using output-oriented SORMCCR DEA and output-oriented SORMSBM(CRS) DEA as the underlying DEA models, for the evaluation of the managerial performance of the mutual funds. Finally, Chapter 11 concludes the main body of this thesis with an evaluation of the results from the examination of the managerial performance of mutual funds in this thesis, followed by a discussion of further work that could be undertaken to advance this area of knowledge.

Subsequent to the main body of this thesis, the appendices are presented. These cover the underlying data used in this thesis, the detailed MATLAB coding for the various DEA models utilised and four appendices corresponding to each of the four chapters of results which contain the detailed results of the managerial performance of the mutual funds at an individual level.

# Chapter 2: The Mutual Fund Industry

## *2.1: The History Of The Mutual Fund Industry*

The first mutual funds appeared in Europe in the late 1800s, with one of the earliest being the Foreign & Colonial Government Trust which was established in London in 1868, and has survived to this day as the Foreign & Colonial Investment Trust which trades on the London Stock Exchange. Mutual funds first appeared in the US in the 1890s, with the Boston Personal Property Trust, established in 1893, being the earliest. These early mutual funds were of the closed-end type which meant they had a fixed number of shares which would trade at either a premium or a discount to the net asset value of the underlying portfolio.

The mutual fund industry continued to grow throughout the early years of the 20$^{th}$ century, and the Massachusetts Investors Trust which was established in the US in 1924 was the first of a new type of mutual fund known as an open-end fund. This fund still exists today as one of the MFS family of funds. The open-end fund is characterised by redeemable shares which trade at a price equal to the net asset value of the underlying portfolio. However, closed-end funds remained more popular than their open-end compatriots throughout the 1920s. In particular, 1928 was a seminal year for the development of the mutual fund industry with two major innovations being introduced. The first of these was the launch of the first no-load mutual fund which is a fund which sells its shares without a commission or sales charge by selling directly to the investor, and therefore all the money invested by the investor will go into the fund. The second major innovation introduced into the mutual fund industry in 1928 was the launch of the Wellington Fund which was the first mutual fund to include stocks and bonds in its investment portfolio, as opposed to the direct style of investments in business and trade that was the standard method of investment utilised by mutual funds prior to this.

The Wall Street Crash of 1929, the subsequent Great Depression and the outbreak of the Second World War led to the stagnation of growth in the mutual fund industry during the 1930s and 1940s. Confidence did not return to the financial sector until the 1950s, and during this period of time the mutual fund industry experienced a resumption of growth. The 1960s saw the introduction and rise of the aggressive growth mutual fund which was a fund which aimed to attain the highest capital gains for investors by targeting companies with the potential for high growth. However, these companies are also likely to be high risk and exhibit share price volatility, and consequently these funds are only suitable for investors willing to accept a high risk/return trade-off. During the 1970s the economies of the world experienced an era of high interest rates which led to the birth of the money market mutual fund, and resulted in a period of dramatic growth for the mutual fund industry. Money market mutual funds are open-end mutual funds that invest in short-term debt securities such as short-term government bonds and commercial paper. Also, in 1976, the first retail index fund was established by The Vanguard Group. It was called the First Index Investment Trust and exists today as the Vanguard 500 Index Fund which is currently one of the largest mutual funds in the world with over $100 billion in assets as of the end of 2010. An index fund is usually either an open-end mutual fund or an exchange-traded fund (ETF) which aims to replicate the movements of an index of a specific financial market such as, for example, the FTSE 100.

The growth of the mutual fund industry continued through the 1980s and 1990s, driven by a number of factors. The first factor driving the growth in the mutual fund industry over this time period was the bull market in both the stock market and bond market sectors in most of the financial markets around the world during the 80s and 90s, with the ensuing investor confidence resulting in strong growth in mutual fund investment. A second factor driving the growth was the development of new mutual fund products during this time period such as sector mutual funds which target a specific sector, for example, mining companies or UK-based large-capitalisation companies, international mutual funds which target an overseas market, for example, a US-based fund which aims to invest in the shares of European companies, and target date mutual funds which aim for a portfolio whose asset mix becomes more conservative as the target date of the fund approaches, for example, starting out with a share-based portfolio which switches towards cash and fixed income instruments as the target date nears. Also, the 1990s saw the rise of the exchange-traded fund (ETF) which combined features of both open-end and closed-end mutual funds so that their shares traded throughout the trading day at a price very close to the net asset value per share of the underlying portfolio. The first ETF, launched in January 1993, was called the Standard & Poor's Depositary Receipts (SPDRs or 'Spiders') S&P 500 and it tracked the S&P 500 index. Barclays Global Investors launched the World Equity Benchmark Shares (WEBS) ETFs in 1996 which tracked a number of different MSCI country indices, and this line of ETFs subsequently became part of the iShares line which by 2005 had the largest assets of any ETF line. The iShares line of ETFs has been owned by BlackRock since 2009. Other prominent early ETFs included the 'Dow Diamonds' which aimed to track the Dow Jones Industrial Average and the 'Cubes' which aimed to track the NASDAQ 100. This is not an exhaustive list of all the innovative mutual fund products that were introduced during the 1980s and 1990s. A final factor driving the growth in the mutual fund industry in the 80s and 90s was the wider distribution of mutual fund shares due to demand from new areas such as retirement plans where the shares of mutual funds are now an important investment component in some increasingly popular types of plan such as defined contribution pension plans.

During the first decade of the 21$^{st}$ century the financial markets of the world faced a volatile period characterised by the dot-com bubble stock market crash of 2000-2002, aggravated by the September 11$^{th}$ 2001 terrorist attack on the US, the recovery in the following years, and then the Credit Crunch financial crisis of 2008 and the subsequent recession. These events in the financial markets made for challenging conditions for mutual funds to carry out their investment activities and eroded investor confidence which dampened the demand for investment in mutual funds. However, despite this, as of 31st December 2010, the Investment Company Institute (ICI) reported that worldwide mutual fund assets equalled $24.7 trillion. To put this in perspective the GDP of the US, the largest economy in the world, was $14.5 trillion in 2010.

## 2.2: Types Of Mutual Fund

The basic premise behind the idea of a mutual fund is that of a collective investment scheme in which the money from many investors is pooled together to buy stocks, bonds, short-term money market instruments and other securities in a professionally managed portfolio in accordance with the investment aims of the fund. In generic terms, mutual funds have a number of advantages and disadvantages for investors compared to direct investment in individual securities. The main generic advantages of mutual funds include increased diversification and reduced investment capital risk, the ability to participate in investments that may only be available to larger investors, access to professional investment management, higher liquidity, ease of comparison across funds and government regulation of the industry. The main generic disadvantages of mutual funds include the fees charged to invest in them which can include sales charges known as loads, brokerage commissions and annual management fees, the lack of ability to customise your investment in the fund and the loss of share ownership rights. The mutual fund investment vehicle can take a multitude of different forms, with advantages and disadvantages associated with each different type of mutual fund. The most prominent types of mutual fund are outlined in detail in the following section.

### 2.2.1: Open-End Mutual Funds

The open-end mutual fund is a mutual fund which can issue and redeem shares at any time, with no legal limit on the number of shares that can be issued. When these shares are issued or redeemed they are done so at a price which varies in proportion to the underlying net asset value per share of the fund's portfolio, and consequently the buy and sell prices for the fund's shares directly reflect the fund's performance. An investor will usually purchase shares in the open-end mutual fund directly from the fund itself, rather than from existing shareholders, and the fund must be willing to buy back their shares from the investors at the end of every trading day at the net asset value per share computed on that trading day. As a result of this continual obligation to sell and buy back fund shares on demand, these open-end mutual funds provide a very useful and convenient investment vehicle to investors.

Almost all open-end mutual funds are actively managed by a professional investment manager who will oversee the investment portfolio, buying and selling securities as appropriate. It is important to note that if the investment manager of an open-end mutual fund assesses that its total assets have exceeded a level beyond which the fund becomes unable to effectively execute its stated investment aims, the manager will close the fund to new investors in the first instance, and may subsequently close it to new investment by existing investors in the fund. The charges for investors to invest in a fund will vary from one fund to another, but in generally some will charge a percentage on the purchase or sale of shares, which is known as the load and usually goes to the broker as commission, and all are likely to charge an annual management fee whilst the investment is held.

There are various types of open-end mutual fund, with the terminology and modus operandi usually varying on a country by country basis. In the UK the main types of open-end mutual fund are the open-ended investment company (OEIC), which is an open-end fund with a corporate structure, and the unit trust, which is an open-end fund with a trust structure. In the US the main type of open-end mutual fund is the mutual fund, which is an open-end fund with either a corporate or a trust structure. Across Western Europe the main type of open-end mutual fund is the SICAV which translates to 'investment company with variable capital', and the SICAV is an open-end fund with a corporate structure. The majority of mutual funds in existence across the world are of the open-end type.

### *2.2.2: Closed-End Mutual Funds*

The closed-end mutual fund is a mutual fund which issues a limited number of shares at its inception in an initial public offering (IPO), and new shares are very rarely issued after the fund has been launched. After the IPO has taken place the closed-end fund manager will invest the money raised in a portfolio of securities in line with the investment aims of the fund, and the fixed number of shares issued will be traded continually throughout the trading day on a secondary financial market between investors who want to buy or sell fund shares. This exchange-tradability of closed-end fund shares also means that investors can take advantage of advanced types of share order such as stop orders and limit orders. The shares in a closed-end fund are not normally redeemable for either cash or securities until the fund liquidates. If an investor wants to invest in a closed-end mutual fund they can normally acquire shares in a closed-end fund by purchasing shares on a secondary financial market from either a broker, a market maker or an existing investor in the fund. The price of a closed-end mutual fund share is determined partly by the underlying value of the investments in the fund, its net asset value per share, and partly by the premium or discount placed on the share by the market. There can be a premium or discount placed on the share of a closed-end mutual fund by the market due to the limited number of shares in the fund in circulation, with the resulting creation of the market forces of excess demand and excess supply leading to either the price of a share in the fund to be higher than the underlying intrinsic net asset value per share, known as selling at a premium, or the price of a share in the fund to be lower than the underlying intrinsic net asset value per share, known as selling at a discount.

Again, almost all closed-end mutual funds are actively managed by a professional investment manager who will oversee the investment portfolio, buying and selling securities as appropriate in accordance with the investment aims of the fund. An important feature of the closed-end mutual fund is the ability to use leverage/gearing to improve the returns of the fund by borrowing to raise additional investment capital using the issuance of either preferred stock, long-term debt or reverse-repurchase agreements. This additional excess investment capital can then be invested by the closed-end fund manager with the aim of providing a higher return. This can be particularly beneficial if the financial markets are in the midst of a period of rapid growth as it gives the closed-end fund the potential to take advantage of the growth to a larger extent than would have been the case if the fund had only the pool of money obtained from investors through the initial share sale to invest. However, it is important to consider that this only works on the basis that the cost of these 'borrowings' is less than the increased growth that is obtained. If this is not the case then the fund will make a loss, and thus using leverage can greatly increase the investment risk of the closed-end mutual fund due to the increased volatility and the increased capital risk exposure. This increased investment risk has come to fruition in the past, with notable examples being the wiping out of highly-leveraged closed-end mutual funds during the stock market crash of 1929, contrasted against the survival of their open-end counterparts, and the split capital investment trust crisis in the UK in 2002.

As a result of closed-end funds being listed on secondary financial market exchanges, they have to comply with certain rules and laws such as filling reports with the listing body and holding annual shareholder meetings. This means that shareholders are able to find information about their fund with a greater degree of ease and they can also engage in shareholder activism at the annual shareholder meetings to hold the fund managers to account for their performance. Also, the trading of closed-end mutual fund shares on the secondary market like a normal company share means that an investor trading in the shares of the fund will have to pay a brokerage commission on any trades they execute. The closed-end fund will also charge an annual management fee whilst the investment is held.

There are various types of closed-end mutual fund, with the terminology and modus operandi usually varying on a country by country basis. In the UK the main type of closed-end mutual fund is the investment trust, which is a closed-end fund with a corporate structure. In the US the main type of closed-end mutual fund is the closed-end fund, which is a closed-end fund with a corporate structure. Across Western Europe the main type of closed-end mutual fund is the SICAF which translates to 'investment company with fixed capital', and the SICAF is a closed-end fund with a corporate structure.

### *2.2.3: Exchange-Traded Funds (ETFs)*

The exchange-traded fund (ETF) is a fairly recent innovation in the mutual fund industry, with the earliest ETFs appearing in the 1990s. An ETF will in most cases be structured like an open-end mutual fund with a corporate structure. Yet as the name suggests, the shares of an ETF are traded on a secondary financial market exchange throughout the trading day, with the price determined by market forces. Exchange-traded funds are hybrid investment vehicles which combine features from both open-end mutual funds and closed-end mutual funds. The main feature of open-end funds that is incorporated in to an ETF is the valuation feature whereby the shares of the fund can be purchased or sold at the end of each trading day at a price equal to the net asset value per share of the fund's underlying investment portfolio. The main feature of closed-end funds that is incorporated in to an ETF is the tradability feature whereby the shares of the fund can be purchased or sold throughout the trading day at a price that can be more or less than the net asset value per share of the fund's underlying investment portfolio. Therefore, the result is that the shares of an

ETF can be traded throughout the trading day at a price very close to the net asset value per share of the ETF's underlying investment portfolio.

The exchange-traded fund achieves this hybrid feature of tradability throughout the trading day at a price very close to the net asset value per share of the fund by only allowing authorised participants, typically the large institutional investors, to buy and sell shares in the ETF directly from or to the fund manager in creation units. These are large blocks of ETF shares numbering in the tens of thousands which are usually exchanged in kind with 'baskets' of the underlying securities of the same type and proportion held by the ETF. In most cases these authorised participants act as market makers on the open secondary market, providing liquidity in the ETF shares via their ability to exchange creation units with the underlying securities. This allows other investors, such as individuals making use of a retail broker, to trade the shares of the ETF on the secondary financial market.

It is important to note that this ability of the authorised participants to swap creation units for the underlying securities is also the mechanism by which the price of the ETF shares are kept very close to the net asset value per share of the underlying investment portfolio. This mechanism works because if the secondary market price of the ETF shares was to diverge substantially from the net asset value per share there would be the potential for arbitrage profits to be made. If the secondary market price of the ETF shares was substantially above the net asset value per share, then the institutional investors would have an incentive to purchase additional creation unit blocks from the ETF manager in exchange for a 'basket' of the underlying portfolio securities as the ETF shares in the creation unit block would have a higher value than the 'basket' of underlying securities exchanged in kind, and therefore the institutional investors could sell the ETF shares on the secondary market and make an arbitrage profit. This additional supply of ETF shares would reduce the market price of the ETF shares until the premium over the net asset value per share was eliminated. Vice versa, if the secondary market price of the ETF shares was substantially below the net asset value per share, then the institutional investors would have an incentive to redeem creation unit blocks of ETF shares, composed from ETF shares purchased on the secondary market, in exchange for a 'basket' of the underlying portfolio securities as the underlying securities would have a higher value than the creation unit block of ETF shares redeemed in kind, and therefore the institutional investors could make an arbitrage profit. This contraction in the number of ETF shares in circulation on the secondary market would increase the market price of the ETF shares until the discount on the net asset value per share was eliminated.

An exchange-traded fund will, like open-end and closed-end mutual funds, hold a mixture of securities such as stocks, bonds and other money market instruments in accordance with the investment aims of the ETF. The overwhelming majority of exchange-traded funds are passively managed index trackers which aim to replicate the performance of a target stock market index, such as the FTSE 100, by either holding 100% of its assets in the securities that make up the index in the relevant proportions, known as 'replication' investment, or by holding around 80% to 90% of its assets in the securities that make up the index in the relevant proportions and investing the remaining 10% to 20% of its assets in other securities such as futures, options and swaps which the manager of the ETF selects to help the fund achieve its investment aims, known as 'representative sampling' investment. Other types of exchange-traded fund include commodity ETFs, bond ETFs, currency ETFs and actively managed ETFs. Exchange-traded funds are an internationally recognised type of mutual fund, with a similar structure and a common modus operandi across countries.

The main benefits of using ETF investment vehicles are as follows. Firstly, ETFs usually have lower costs for investors to invest in them when compared with other investment vehicles such as open-end mutual funds because they are, in most cases, passively managed and they are also protected from the expense of having to buy and sell securities to meet investor demand for purchases and redemptions of fund shares. Therefore, the cost to the investor to invest in ETF shares is likely to comprise of a brokerage commission to trade the shares on the secondary market and an annual management fee for as long as the investment in the ETF is held, and this annual fee is likely to be significantly lower than the annual charge to hold an investment in other investment vehicles like open-end and closed-end mutual funds. ETFs also offer investors flexibility when buying or selling fund shares as ETF fund shares can be purchased and sold at the current market price, which will be close to the net asset value per share of the underlying portfolio of securities for the reasons previously outlined, throughout the trading day. As ETF shares are traded publicly on a secondary financial market exchange, the shares can be purchased on margin and sold short which can facilitate the implementation of hedging strategies, and the shares can also be traded using stop orders and limit orders which allow the investors to select the price points at which they are prepared to trade, thus providing further trading flexibility to the investor. Finally, ETFs provide investors with economical exposure to a diverse range of markets including broad-based indices, broad-based international indices, country-specific indices, sector-specific indices, bond indices and commodities amongst others, and in the case of the index ETFs which account for the vast majority of ETFs, the ETF provides diversification across the entire index the fund aims to track.

## *2.3: Mutual Fund Investment Style And Classification*

Mutual funds are able to invest in a wide variety of securities. Each mutual fund will produce a fund prospectus which will set out the investment aim of the fund, the investment approach the fund will use, the permitted securities and investments the fund can hold in its investment portfolio, and other important information for prospective investors. The investment aim will set out what the fund intends to achieve such as capital growth from increases in the prices of the securities it holds, or income generation from dividend or interest income from the securities it holds. The investment approach of the fund and the securities it can hold in its investment portfolio give the investor an idea of how the fund manager will select the investments the fund makes. So, for example, is the fund actively managed or is it passively managed, and will its principal investments be in equity, in bonds or in another type of investment security. This information will give potential investors an idea of the investment style of the mutual fund, and consequently whether it is suitable for their investment needs.

This information can also be used to classify mutual funds according to their investment style. In general, once grouped according to their type, either as an open-end fund, closed-end fund or exchange-traded fund, mutual funds are classified according to their principal investment securities, and there are four main categories of classification that are widely recognised. They are equity funds, bond funds, money market funds and hybrid funds. Within these categories of classification, mutual funds can be further subclassified in numerous ways. The main benefits from classifying mutual funds in this way are that it allows investors to easily select and compare mutual funds which match their investment requirements, and it allows mutual funds to be ranked and compared in terms of their performance against their peers with a similar investment aim and a similar investment style.

### *2.3.1: Equity Funds*

Equity funds, as the name suggests, primarily invest in equity shares. Equity mutual funds can be further subclassified in a number of ways. Firstly, they can be subclassified according to the country's or countries' shares that the equity fund primarily invests in which could be primarily domestic shares, resulting in a domestic equity fund, both domestic and foreign shares, resulting in a global or world equity fund, or primarily foreign shares, resulting in an international equity fund. They may also be further subclassified by the specific industry or sector that the equity fund targets for shares to invest in such as, for example, the mining industry or the technology sector. Or as an alternative, they may be further subclassified using a combination of the market capitalisation of the companies targeted for investment and the investment 'style' the fund aims for when selecting shares for investment. In terms of the market capitalisation, the funds can be classified as targeting small-capitalisation companies, medium-capitalisation companies or large-capitalisation companies. The specific dimensions of each capitalisation classification is likely to vary with market conditions and the boundaries can be defined by either a monetary value of the capitalisation of the companies, so for example all companies above £10 billion are classified as large-cap, or a percentage of the total capitalisation of the country or region, so for example the companies that account for the top 70% of the capitalisation in the UK are classified as large-cap. In terms of the investment 'style' the fund is aiming for, the funds can be classified as either growth, blend or value. Funds that are classified as growth aim to invest in the shares of companies which are growing fast, funds that are classified as value aim to invest in the shares of companies which appear to be undervalued, and finally funds that are classified as blend are not biased towards either growth shares or value shares in terms of the companies they aim to invest in. This subclassification using a combination of market capitalisation and investment 'style' is often represented by a grid known as a 'style box', of which perhaps one of the most well known is the Morningstar Style Box.

### *2.3.2: Bond Funds*

Bond funds are funds which primarily invest in fixed income securities. Bond funds can be further subclassified in a number of different ways. As with equity funds, they can be subclassified according to the country's or countries' bonds that the bond fund primarily invests in which could be primarily domestic bonds, resulting in a domestic bond fund, both domestic and foreign bonds, resulting in a global or world bond fund, or primarily foreign bonds, resulting in an international bond fund. They may also be further subclassified in one of two ways. Firstly, they may be further subclassified according to the specific types of bonds that the fund invests in such as government bonds, corporate bonds, high-yield bonds, investment-grade bonds or junk bonds. Secondly, they may be further subclassified according to the maturity of the bonds that the fund holds such as short-term bonds, intermediate-term bonds or long-term bonds.

### *2.3.3: Money Market Funds*

Money market funds are funds which primarily invest in money market instruments which are fixed income securities with, specifically, a very short time to maturity and a high credit quality. It is common for investors to use money market funds as a substitute for bank savings accounts, but it is important to remember in this context that money market funds are not government insured like bank savings accounts are. Also, money market funds are slightly different in that they aim to maintain a stable net asset value per share, for example £1 per share, which preserves the capital in the fund, and means that the investors earn interest income from the fund whilst experiencing no capital gain or loss. If a money market fund fails to maintain this stable net asset value per share due to a decline in the value of its securities, then the fund is said to have 'broken the buck'. In the history of the money market fund only two funds have 'broken the buck', the Community Banker's US Government Money Market Fund in 1994 and the Reserve Primary Fund in 2008.

Money market funds can be further subclassified in a number of different ways. Firstly, they can be subclassified according to the currency in which they primarily invest in, so for example GBP sterling or US dollars. They may also be subclassified along the lines of whether they target institutional investors or retail investors.

### *2.3.4: Hybrid Funds*

Hybrid funds are funds which primarily invest in either a combination of both shares and bonds, or in convertible securities which are securities that can be converted into another type of security, most commonly they are preference shares or bonds that can be converted into common shares. Examples of hybrid funds include balanced funds which have a relatively fixed mix of shares and bonds with either a moderate orientation which has a higher equity component in the mix or a conservative orientation which has a higher fixed-income component in the mix, and other asset allocation funds like target date funds which usually have a mix of shares and bonds that varies over time.

Hybrid funds can be further subclassified in a number of different ways. Firstly, they can be subclassified along the lines of the country's or countries' shares and bonds that the hybrid fund primarily invests in which could be primarily domestic, resulting in a domestic hybrid fund, both domestic and foreign, resulting in a global or world hybrid fund, or primarily foreign, resulting in an international hybrid fund. They may also be subclassified according to the type of hybrid fund they are, so for example a balanced fund or a target date fund.

## *2.4: Worldwide Mutual Fund Industry Statistics*

This section of the thesis presents a picture of the worldwide mutual fund industry. Table WS1 shows the worldwide total net assets of mutual funds on a country-by-country basis from 2008-2010.

***Table WS1: Worldwide Total Net Assets Of Mutual Funds From 2008-2010***

| Country/Area | 2008 *Total Net Assets ($ Mn)* | 2009 *Total Net Assets ($ Mn)* | 2010 *Total Net Assets ($ Mn)* |
|---|---|---|---|
| Argentina | $3,867 | $4,470 | $5,179 |
| Brazil | $479,321 | $783,970 | $980,448 |
| Canada | $416,031 | $565,156 | $636,947 |
| Chile | $17,587 | $34,227 | $38,243 |
| Costa Rica | $1,098 | $1,309 | $1,470 |
| Mexico | $60,435 | $70,659 | $98,094 |
| United States | $9,603,649 | $11,112,970 | $11,831,878 |
| **AMERICAS** | **$10,581,988** | **$12,578,593** | **$13,598,071** |
| Austria | $93,269 | $99,628 | $94,670 |
| Belgium | $105,057 | $106,721 | $96,288 |
| Bulgaria | $226 | $256 | $302 |
| Czech Republic | $5,260 | $5,436 | $5,508 |
| Denmark | $65,182 | $83,024 | $89,800 |
| Finland | $48,750 | $66,131 | $71,210 |
| France | $1,591,082 | $1,805,641 | $1,617,176 |
| Germany | $237,986 | $317,543 | $333,713 |
| Greece | $12,189 | $12,434 | $8,627 |
| Hungary | $9,188 | $11,052 | $11,532 |
| Ireland | $720,486 | $860,515 | $1,014,104 |
| Italy | $263,588 | $279,474 | $234,313 |
| Liechtenstein | $20,489 | $30,329 | $35,387 |
| Luxembourg | $1,860,763 | $2,293,973 | $2,512,874 |
| Netherlands | $77,379 | $95,512 | $85,924 |
| Norway | $41,157 | $71,170 | $84,505 |
| Poland | $17,782 | $23,025 | $25,595 |
| Portugal | $13,572 | $15,808 | $11,004 |
| Romania | $326 | $1,134 | $1,713 |
| Russia | $2,026 | $3,182 | $3,917 |
| Slovakia | $3,841 | $4,222 | $4,349 |
| Slovenia | $2,067 | $2,610 | $2,663 |
| Spain | $270,983 | $269,611 | $216,915 |
| Sweden | $113,331 | $170,277 | $205,449 |
| Switzerland | $135,052 | $168,260 | $261,893 |
| Turkey | $15,404 | $19,426 | $19,545 |
| United Kingdom | $504,681 | $729,141 | $854,413 |
| **EUROPE** | **$6,231,116** | **$7,545,535** | **$7,903,389** |
| Australia | $841,133 | $1,198,838 | $1,455,850 |
| China | $276,303 | $381,207 | $364,985 |
| India | $62,805 | $130,284 | $111,421 |
| Japan | $575,327 | $660,666 | $785,504 |
| South Korea | $221,992 | $264,573 | $266,495 |
| New Zealand | $10,612 | $17,657 | $19,562 |
| Pakistan | $1,985 | $2,224 | $2,290 |
| Philippines | $1,263 | $1,488 | $2,184 |

| | | | |
|---|---|---|---|
| Taiwan | $46,116 | $58,297 | $59,032 |
| **ASIA AND PACIFIC** | **$2,037,536** | **$2,715,234** | **$3,067,323** |
| South Africa | $69,417 | $106,261 | $141,615 |
| **AFRICA** | **$69,417** | **$106,261** | **$141,615** |
| | | | |
| **WORLD** | **$18,920,057** | **$22,945,623** | **$24,710,398** |

Source: Investment Company Institute (ICI)

Excellent sources of information on the mutual fund industry can be found on the Investment Company Institute (ICI) website www.ici.org for the US mutual fund industry and some basic worldwide mutual fund industry data, the European Fund And Asset Management Association (EFAMA) website www.efama.org for the European mutual fund industry and the Investment Management Association (IMA) website www.investmentfunds.org.uk for the UK mutual fund industry. Of particular relevance here is an industry report published annually by the ICI called the Investment Company Fact Book (ICI 2011) which reviews trends and activities in the US investment company industry, and also contains basic data regarding the worldwide mutual fund industry including worldwide total net assets of mutual funds and worldwide total numbers of mutual funds. Also of use is an industry report published annually by the EFAMA called Asset Management In Europe (EFAMA 2012) which present a useful overview of the European asset management industry.

## *2.5: UK Mutual Fund Industry Statistics*

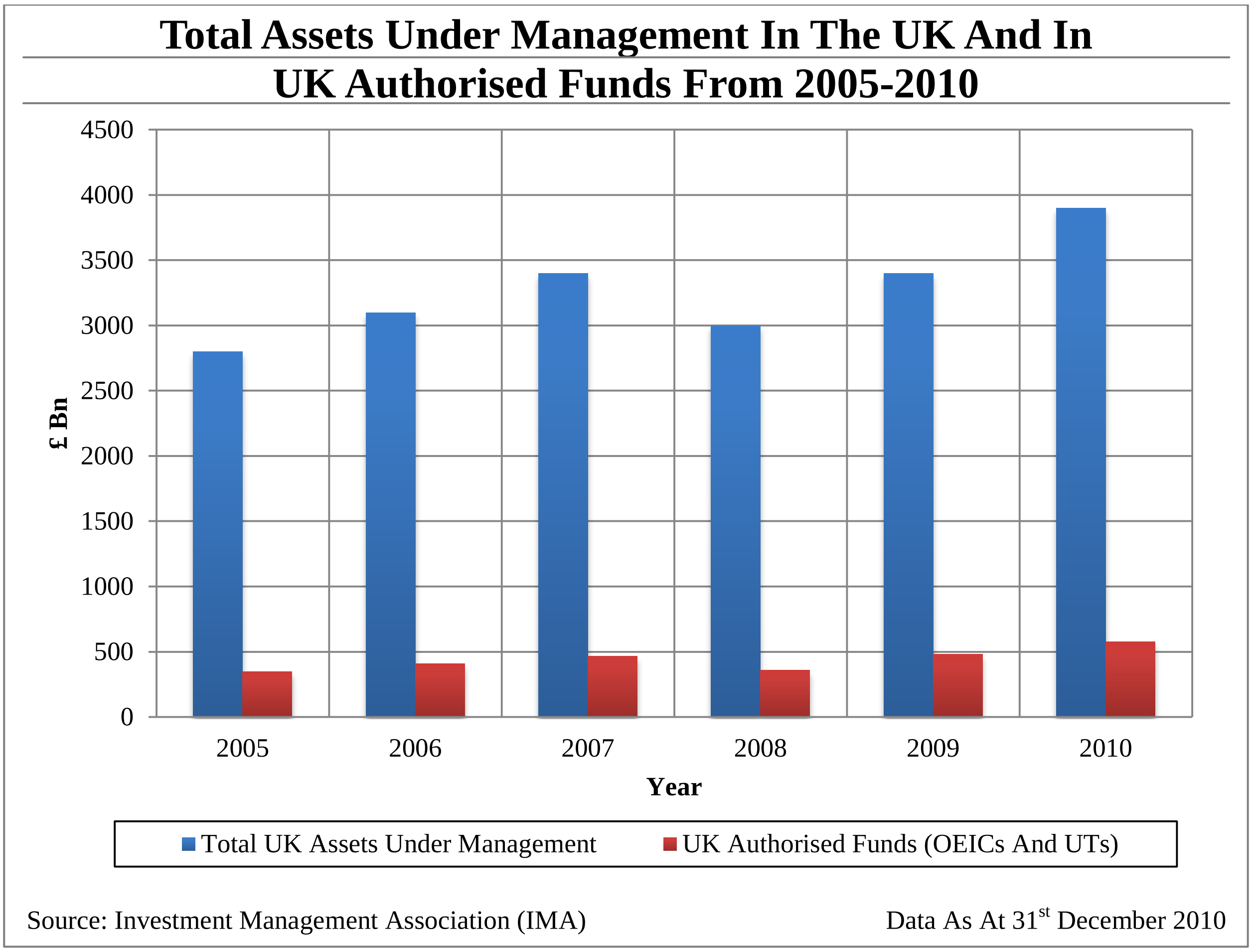
This section of the thesis presents a raft of statistical information on the UK mutual fund industry. The first graphic highlights the key statistics relating to the UK investment management industry. Following this there are four graphs that present detailed breakdowns of important areas of the UK investment management industry. The first graph compares the total assets under management in the UK with the assets managed in UK OEICs and UTs from 2005-2010. The second graph compares the assets managed in UK OEICs/UTs with the assets in UK index tracker funds from 2005-2010. The third graph shows the assets managed in a range of different UK fund vehicles at the end of 2010. The fourth and final graph presents a breakdown of the assets managed in the UK by the type of client such as, for example, retail clients or institutional clients, at the end of 2010.

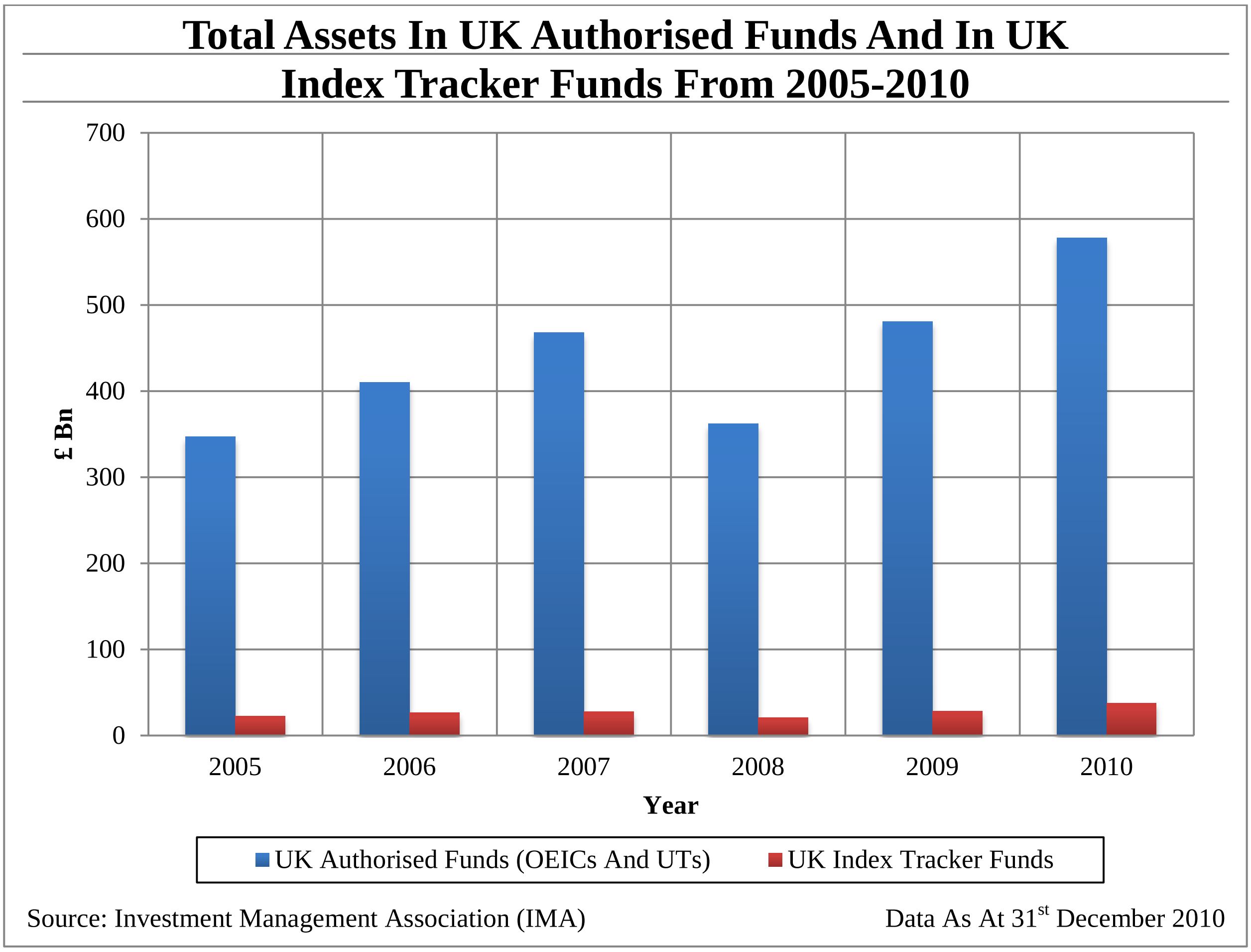
***The UK Investment Management Industry – Key Figures***

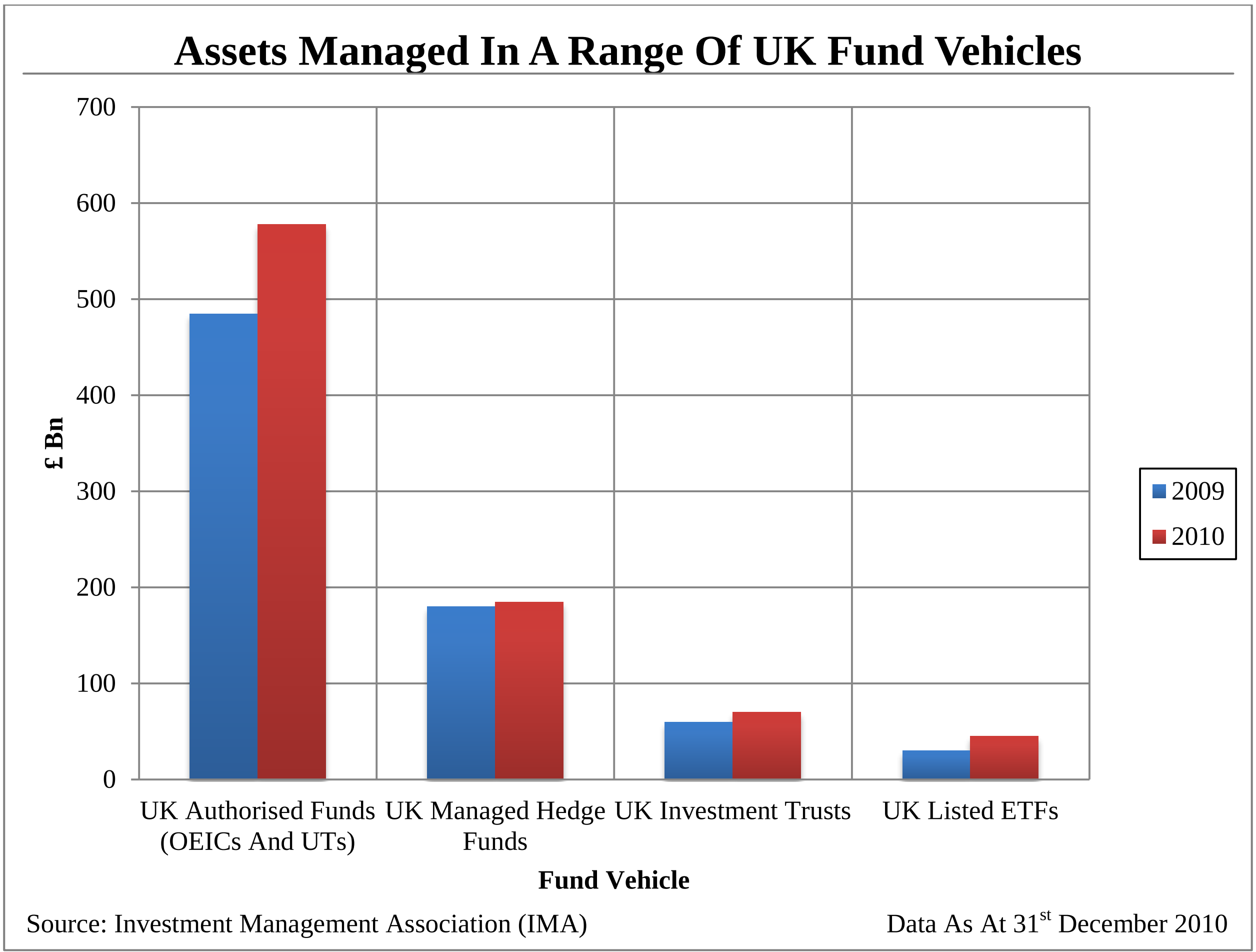
| | |
|---|---|
| **£3.9 Trn**<br>Total Assets Managed In The UK By IMA Member Firms As At December 2010 | **£578 Bn**<br>Managed In UK Authorised Funds (OEICs And UTs) |
| **£617 Bn**<br>UK Managed Funds Domiciled Overseas | **£1.3 Trn**<br>Assets Managed In The UK On Behalf Of Overseas Clients |
| **£2.2 Trn**<br>Assets Managed Worldwide On Behalf Of UK Institutional Clients | **£11 Bn**<br>Revenue Earned By UK Based Asset Management Firms In 2010 |

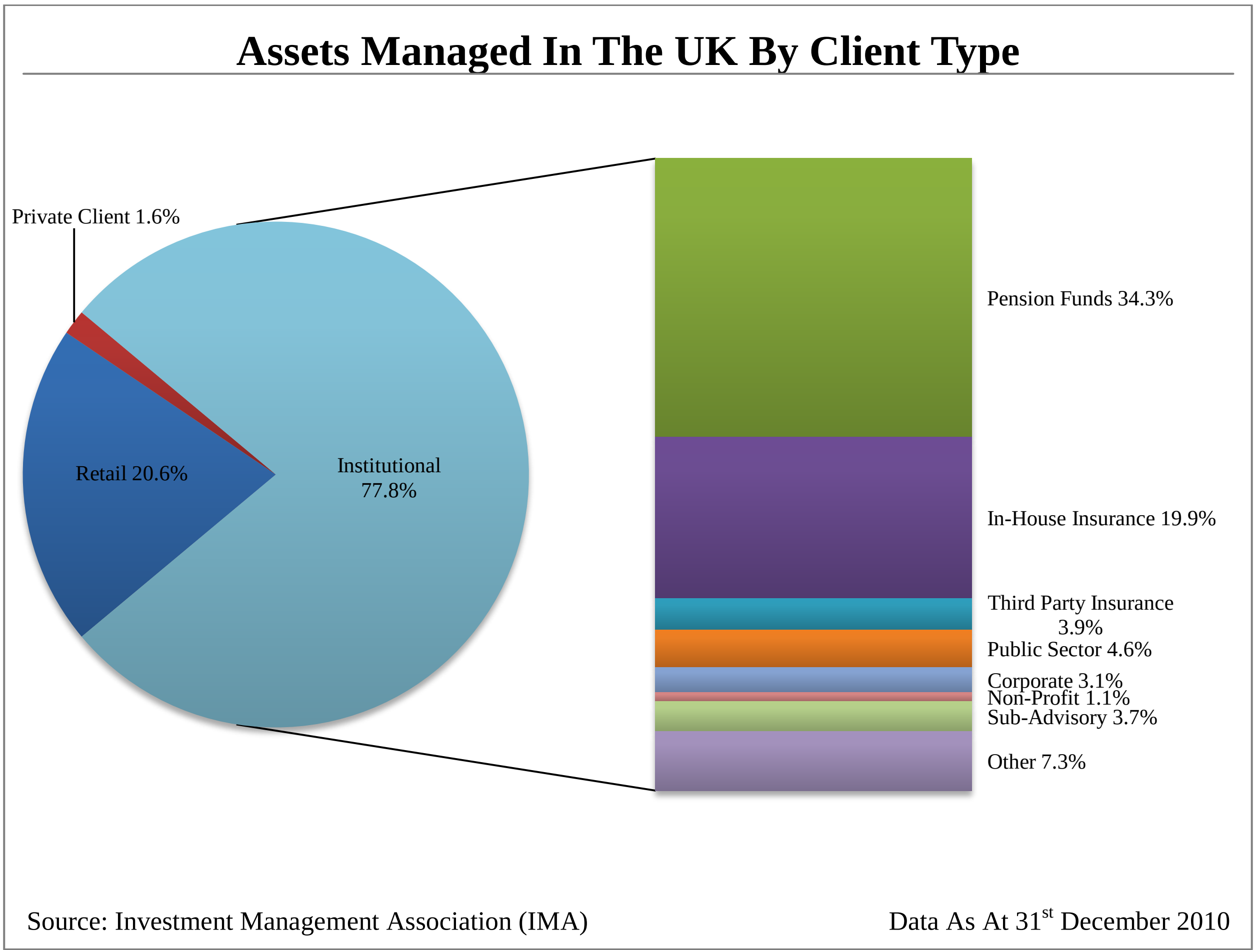
Data As At 31st December 2010

Source: Investment Management Association (IMA)


Total Assets Under Management In The UK And In UK Authorised Funds From 2005-2010
4500
4000
3500
3000
2500
2000
1500
1000
500
0
£ Bn
2005
2006
2007
2008
2009
2010
Year
Total UK Assets Under Management
UK Authorised Funds (OEICs And UTs)
Source: Investment Management Association (IMA)
Data As At 31st December 2010


Total Assets In UK Authorised Funds And In UK Index Tracker Funds From 2005-2010
700
600
500
400
300
200
100
0
£ Bn
2005
2006
2007
2008
2009
2010
Year
UK Authorised Funds (OEICs And UTs)
UK Index Tracker Funds
Source: Investment Management Association (IMA)
Data As At 31st December 2010


Assets Managed In A Range Of UK Fund Vehicles
700
600
500
400
300
200
100
0
£ Bn
2009
2010
UK Authorised Funds (OEICs And UTs)
UK Managed Hedge Funds
UK Investment Trusts
UK Listed ETFs
Fund Vehicle
Source: Investment Management Association (IMA)
Data As At 31st December 2010


Assets Managed In The UK By Client Type
Private Client 1.6%
Retail 20.6%
Institutional 77.8%
Pension Funds 34.3%
In-House Insurance 19.9%
Third Party Insurance 3.9%
Public Sector 4.6%
Corporate 3.1%
Non-Profit 1.1%
Sub-Advisory 3.7%
Other 7.3%
Source: Investment Management Association (IMA)
Data As At 31st December 2010

Finally, there follows three tables of detailed numerical data on the UK mutual fund industry. Table UKS1 presents summary statistics for UK authorised mutual funds, OEICs and UTs, at the end of December 2010. Table UKS2 provides a detailed breakdown of the UK OEIC/UT funds under management by asset class from 2001-2010. Lastly, Table UKS3 provides a detailed breakdown of the UK OEIC/UT funds under management by sector at the end of December 2010.

***Table UKS1: Summary Statistics For UK Authorised Mutual Funds***

| | **December 2010** |
|---|---|
| **UK Domiciled** | |
| Total Funds Under Management | £577.6 Bn |
| OEIC Funds | £354.2 Bn |
| ISA Funds | £105.5 Bn |
| Number Of Reporting Funds | 2,406 |
| Of Which OEICs | 1,670 |
| Number Of Companies | 101 |
| Number Of OEIC Providers | 76 |
| **Overseas Domiciled** | |
| Total Funds Under Management | £26.5 Bn |
| Number Of Reporting Funds | 615 |
| Number Of Companies | 36 |

Source: Investment Management Association (IMA)

***Table UKS2: Summary Of UK Domiciled Funds Under Management By Asset Class From 2001-2010***

| Year | Total Funds Under Management | Equity | | Bond | | Money Market | | Balanced | | Property | | Other | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | *FUM* | *% Of Total* | *FUM* | *% Of Total* | *FUM* | *% Of Total* | *FUM* | *% Of Total* | *FUM* | *% Of Total* | *FUM* | *% Of Total* |
| **2001** | £235,796 Mn | £186,708 Mn | 79.2% | £25,403 Mn | 10.8% | £1,212 Mn | 0.5% | £18,539 Mn | 7.9% | £675 Mn | 0.3% | £3,259 Mn | 1.4% |
| **2002** | £194,611 Mn | £143,997 Mn | 74.0% | £30,531 Mn | 15.7% | £1,169 Mn | 0.6% | £14,822 Mn | 7.6% | £955 Mn | 0.5% | £3,136 Mn | 1.6% |
| **2003** | £241,146 Mn | £179,243 Mn | 74.3% | £38,210 Mn | 15.8% | £1,780 Mn | 0.7% | £17,001 Mn | 7.0% | £1,084 Mn | 0.4% | £3,829 Mn | 1.6% |
| **2004** | £275,641 Mn | £202,975 Mn | 73.6% | £42,027 Mn | 15.2% | £2,188 Mn | 0.8% | £20,012 Mn | 7.3% | £3,100 Mn | 1.1% | £5,339 Mn | 1.9% |
| **2005** | £347,114 Mn | £252,922 Mn | 72.9% | £52,276 Mn | 15.1% | £2,737 Mn | 0.8% | £26,013 Mn | 7.5% | £6,187 Mn | 1.8% | £6,980 Mn | 2.0% |
| **2006** | £409,674 Mn | £293,663 Mn | 71.7% | £58,991 Mn | 14.4% | £3,791 Mn | 0.9% | £31,402 Mn | 7.7% | £12,862 Mn | 3.1% | £8,965 Mn | 2.2% |
| **2007** | £467,412 Mn | £314,980 Mn | 67.4% | £78,953 Mn | 16.9% | £5,263 Mn | 1.1% | £36,108 Mn | 7.7% | £12,403 Mn | 2.7% | £19,705 Mn | 4.2% |
| **2008** | £361,686 Mn | £224,867 Mn | 62.2% | £75,000 Mn | 20.7% | £3,200 Mn | 0.9% | £29,643 Mn | 8.2% | £7,715 Mn | 2.1% | £21,260 Mn | 5.9% |
| **2009** | £480,601 Mn | £293,068 Mn | 61.0% | £95,568 Mn | 19.9% | £4,641 Mn | 1.0% | £39,210 Mn | 8.2% | £9,700 Mn | 2.0% | £38,415 Mn | 8.0% |
| **2010** | £577,633 Mn | £350,461 Mn | 60.7% | £107,689 Mn | 18.6% | £4,344 Mn | 0.8% | £53,208 Mn | 9.2% | £12,551 Mn | 2.2% | £49,381 Mn | 8.5% |

Source: Investment Management Association (IMA)

FUM = Funds Under Management

***Table UKS3: Sector Summary For UK Authorised Mutual Funds December 2010***

| IMA Sector | Funds Under Management (£) | |
|---|---|---|
| | *Total* | *Sector As % Of Total* |
| Europe Excluding UK | £33,044,802,978 | 5.7% |
| Europe Including UK | £3,177,076,191 | 0.6% |
| European Smaller Companies | £3,257,919,567 | 0.6% |
| Asia Pacific Including Japan | £1,562,702,643 | 0.3% |
| Asia Pacific Excluding Japan | £30,139,304,971 | 5.2% |
| Global Emerging Markets | £13,686,920,357 | 2.4% |
| Global Growth | £45,079,778,626 | 7.8% |
| Japan | £7,689,570,311 | 1.3% |
| Japanese Smaller Companies | £295,771,127 | 0.1% |
| North America | £21,528,298,268 | 3.7% |
| North American Smaller Companies | £1,182,118,408 | 0.2% |
| Specialist | £20,377,989,004 | 3.5% |
| Technology And Telecommunications | £713,199,170 | 0.1% |
| UK All Companies | £107,694,489,815 | 18.6% |
| UK Equity Income | £53,645,518,277 | 9.3% |
| UK Smaller Companies | £7,385,235,806 | 1.3% |
| **TOTAL EQUITIES** | **£350,460,695,519** | **60.7%** |
| Global Bonds | £12,522,733,035 | 2.2% |
| £ Strategic Bond | £19,143,729,432 | 3.3% |
| £ Corporate Bond | £49,100,381,255 | 8.5% |
| UK Gilts | £16,020,389,936 | 2.8% |
| UK Index Linked Gilts | £3,365,201,308 | 0.6% |
| £ High Yield | £7,536,583,953 | 1.3% |
| **TOTAL BONDS** | **£107,689,018,919** | **18.6%** |
| Money Market | £4,343,531,064 | 0.8% |
| **TOTAL MONEY MARKETS** | **£4,343,531,064** | **0.8%** |
| Active Managed | £7,587,741,099 | 1.3% |
| Balanced Managed | £23,122,538,597 | 4.0% |
| Cautious Managed | £19,080,945,256 | 3.3% |
| UK Equity And Bond Income | £3,416,461,155 | 0.6% |
| **TOTAL BALANCED FUNDS** | **£53,207,686,108** | **9.2%** |
| Property | £12,551,112,155 | 2.2% |
| **TOTAL PROPERTY** | **£12,551,112,155** | **2.2%** |
| Protected | £3,773,156,332 | 0.7% |
| Personal Pensions | £224,083,022 | 0.0% |
| Unclassified Sector | £29,500,205,797 | 5.1% |
| Absolute Return – UK | £15,883,241,869 | 2.7% |
| **TOTAL OTHERS** | **£49,380,687,020** | **8.5%** |
| | | |
| **UK TOTAL** | **£577,632,730,785** | **100.0%** |
| | | |
| Absolute Return – Offshore | £1,454,946,285 | 5.5% |
| **TOTAL OVERSEAS** | **£26,526,273,591** | **100.0%** |

| | | |
|---|---|---|
| **GRAND TOTAL** | **£604,159,004,375** | **-** |

Source: Investment Management Association (IMA)

An excellent source of information on the UK mutual fund industry is the Investment Management Association (IMA) website www.investmentfunds.org.uk. In particular, there is an industry report published annually by the IMA called the Asset Management Survey (IMA 2011) which provides a comprehensive account of the UK investment management industry.

# Chapter 3: Literature Review Part 1 – Portfolio Theory And Performance Analysis

## *3.1: The Classical Measures Of Portfolio Performance Analysis*

The earliest measures of portfolio performance evaluation are the classical measures of risk-adjusted portfolio performance developed by Treynor (1965), Sharpe (1966), Jensen (1968), Treynor and Mazuy (1966), and Henriksson and Merton (1981). These classical measures can be split into two groupings known as excess return methods and relative return methods. The excess return methods grouping, which includes the measures of Jensen, Treynor and Mazuy, and Henriksson and Merton, contains measures which compare the return of the portfolio to the expected return obtained from either a returns-generating model such as the Capital Asset Pricing Model (CAPM) or the portfolio's benchmark. The relative return methods grouping, which includes the measures of Treynor and Sharpe, contains measures which assess the performance of a portfolio on the basis of return per unit of risk exposure by comparing the ratio for the portfolio relative to that of its benchmark.

The essence of these classical measures of portfolio performance evaluation is that they compare the risk-adjusted return of a managed portfolio to the risk-adjusted return of a benchmark portfolio over a specified time period. This benchmark portfolio needs to represent a feasible alternative investment to the managed portfolio that is having its performance evaluated. That is, the benchmark should represent a feasible alternative investment which is equivalent in all return-related aspects to the managed portfolio under analysis except that it should not incorporate the investment ability of the portfolio manager. Thus, this allows for the measure to evaluate the investment ability of the portfolio manager as intended. It is important to note at this point that it is also possible for the Treynor and Sharpe ratios to use a simple rank-order of funds as opposed to using a benchmark.

To implement such a benchmark requires the use of a model that provides the aspects of a portfolio that result in higher or lower expected returns. In short, there is a requirement for asset pricing models. Consequently, there is a substantial link between portfolio performance measures and empirical asset pricing models which is reflected in their development in the literature. This link can be followed from the classical portfolio performance measures discussed here, through to some of the more recent measures of portfolio performance that will be discussed later.

The earliest classical measures, Treynor's ratio, Sharpe's ratio and Jensen's alpha, are selectivity measures which look at the ability of professionally managed mutual funds to choose 'winning' stocks. The later classical measures of Treynor and Mazuy, and Henriksson and Merton, are measures which combine selectivity and timing, and therefore look at the ability of professionally managed mutual funds to choose 'winning' stocks and to pick up-turns and down-turns in the market. Thus, these combined selectivity and timing measures should provide better estimates of fund performance.

### *3.1.1: The Treynor Ratio*

The Treynor ratio was developed in Treynor (1965) based on mean-variance analysis from the seminal paper by Markowitz (1952) which introduced modern portfolio theory. It is a selectivity-based measure which draws on the market model as an underlying model for asset pricing information. The market model is shown below:

$$R_{it} = \alpha_i + \beta_i R_{mt} + \varepsilon_{it}$$

Where:

1. $R_{it}$ is the rate of return for asset $i$ during period $t$

2. $\alpha_i$ is the constant term for asset $i$

3. $\beta_i$ is the beta of asset $i$

4. $R_{mt}$ is the rate of return for the market portfolio $m$ during period $t$

5. $\varepsilon_{it}$ is the random error term

The Treynor ratio measure is based on the idea that when a portfolio is completely diversified, the unique returns for individual stocks should cancel out, leaving the portfolio's un-diversifiable risk as the appropriate risk measure. Consequently, the Treynor ratio measures the risk-adjusted performance of a portfolio using its un-diversifiable risk which is also more commonly known as systematic risk or market risk. This risk is measured by beta $(\beta)$.

Treynor's (1965) reward-to-volatility ratio, where volatility is used to mean beta, is shown below:

$$T_{pt} = \frac{R_{pt}^{M} - R_f}{\beta_p}$$

Where:

1. $T_{pt}$ is the Treynor ratio

2. $R_{pt}^{M}$ is the portfolio mean return

3. $R_f$ is the risk-free rate of return

4. $\beta_p$ is the portfolio beta

Treynor's reward-to-volatility ratio calculates the portfolio return earned in excess of the return that could have been earned on a riskless investment, and divides this by the risk measure, the portfolio beta. A closer examination of the Treynor ratio reveals that the numerator, $R_{pt}^{M} - R_f$, is the portfolio's risk premium, whilst the denominator, $\beta_p$, is the measure of risk for the portfolio, thus meaning that the Treynor ratio expression shows the portfolio's risk premium return per unit of systematic risk.

The beta of the market portfolio is always equal to 1, which consequently reduces the Treynor ratio for the market portfolio to $R_{mt}^{M} - R_f$, the market risk premium. If the beta of a portfolio is positive, a portfolio with a Treynor value which is higher than the market risk premium would have a better risk-adjusted performance than the benchmark market portfolio. Conversely, when a portfolio with a positive beta has a Treynor value which is lower than the market risk premium, this indicates that this portfolio has a risk-adjusted performance that is worse than the benchmark market portfolio.

At this point, it is also important to note that in some circumstances, Treynor ratios can be negative. One potential, but unlikely, possibility that can result in a negative Treynor ratio is if the return from the portfolio exceeds the risk-free rate, but beta is negative, which could occur if the fund bet against the market and managed to outperform the risk-free rate. Another possibility is that the return from the portfolio is less than the risk-free rate and beta stays positive, which could occur if the fund took on systematic risk but failed to better the risk-free rate.

Therefore, in this way the Treynor ratio can be used to rank the risk-adjusted managerial performance of portfolios. However, there are a number of limitations and caveats to consider when using the Treynor ratio measure to assess the risk-adjusted performance of portfolio managers. Firstly, due to the fact that the Treynor ratio utilises beta in its formulation, it also suffers from the drawbacks associated with beta. Namely, beta is based on historical performance and thus the Treynor ratio is calculated using historical performance data which, consequently, limits its usefulness, as trying to predict the future performance using the past performance leads to questionable reliability. Furthermore, the usefulness of beta is also completely dependent on the level of correlation between beta and its underlying market benchmark. The R-squared statistical measure can be useful here as it determines how much of the movement of a portfolio can be attributed to movements in its benchmark, with a higher R-squared meaning the performance of a portfolio is more attributable to the performance of its benchmark and a lower R-squared meaning the portfolio performance is not closely related to that of its benchmark. Consequently, the higher the R-squared for a portfolio, the more relevant its beta value will be.

Also, the usefulness of the Treynor ratio is limited because the ranking of portfolios that it provides is only meaningful if the portfolios being ranked are sub-portfolios of a broad and fully diversified portfolio. If they are not, then portfolios with identical systematic risk, but different total risk, will be given the same Treynor ratio value despite the fact that the portfolio with the higher total risk is less diversified and consequently has a higher unsystematic risk. Finally, the Treynor ratio is a ranking measure only, and it does not quantify the added return from the active management of a portfolio.

Examples of studies that have used the Treynor ratio to assess the performance of financial funds can be found in McDonald (1974) which looks at the performance of 123 American mutual funds and finds that under the Treynor ratio approximately half of the funds outperform the benchmark index, and Kreander et al (2005) which looks at the performance of 40 ethical and 40 matched non-ethical funds and finds that there is no statistical difference in the risk-adjusted performance as measured by the Treynor ratio between the ethical funds and the matched group of non-ethical funds.

### 3.1.2: The Sharpe Ratio

The Sharpe ratio was developed in Sharpe (1966) based on the mean-variance analysis of Markowitz (1952). It is a selectivity-based measure which draws on the Capital Allocation Line (CAL). The CAL formulation is shown below:

$$E(R_c) = R_f + \sigma_c \frac{E(R_p) - R_f}{\sigma_p}$$

Where:

1. $R_c$ is the return from a portfolio which is a combination of $P$ and $F$
2. $R_p$ is the return from portfolio $P$
3. $R_f$ is the risk-free rate of return
4. $\sigma_c$ is the standard deviation of portfolio $C$'s return
5. $\sigma_p$ is the standard deviation of portfolio $P$'s return

If an investor is able to borrow or lend at a riskless rate $R_f$ and/or invest in a portfolio with expected performance $E(R_p)$ and $\sigma_p$, then if the investor allocates their funds between borrowing or lending and the portfolio, they can attain any point on the CAL. Therefore, a portfolio will produce a complete linear boundary of combinations of $E(R_c)$ and $\sigma_c$, and the best portfolio will be the one that produces the best boundary of combinations. This will be the portfolio for which $\frac{E(R_p) - R_f}{\sigma_p}$, the slope of the CAL, is highest. The slope of the CAL is the risk premium return per unit of total risk and is also called the reward-to-variability ratio.

Thus, Sharpe's (1966) original reward-to-variability ratio is shown below:

$$S_{pt} = \frac{R_{pt}^{M} - R_f}{\sigma_p}$$

Where:

1. $S_{pt}$ is the Sharpe ratio

2. $R_{pt}^{M}$ is the portfolio mean return

3. $R_f$ is the risk-free rate of return

4. $\sigma_p$ is the standard deviation of the portfolio's return

Therefore, it is possible to observe that Sharpe's reward-to-variability ratio is the ratio of a portfolio's excess return over its standard deviation. Using the standard deviation of the returns as the risk measure means that the Sharpe ratio considers the total risk of a portfolio as opposed to the Treynor ratio which only considers the un-diversifiable systematic risk of a portfolio. As with the Treynor ratio, the numerator, $R_{pt}^{M} - R_f$, is the portfolio's risk premium, consequently meaning that the Sharpe ratio expression shows the portfolio's risk premium return per unit of total risk.

A fund that achieves a high Sharpe ratio has obtained a better return relative to the volatility of its portfolio than that of a fund that has a lower Sharpe ratio. It is worth noting that although a higher Sharpe ratio indicates that a fund has achieved higher historical risk-adjusted performance, this does not necessarily mean it is a low-volatility fund, it just means that the risk/return trade-off of the fund is more favourable. The Sharpe ratio measure of portfolio performance is informative in that it is able to identify funds that outperform their peers, but also come with a large degree of additional volatility, which consequently makes this outperformance look less attractive. So, for example, a fund that achieves a 10% return with low volatility is more preferable to a fund that achieves a 12.5% return with much higher volatility, and the Sharpe ratio is able to highlight this. Thus, the

Sharpe ratio enables a financial practitioner to evaluate whether the return obtained from a fund justifies the risk of its portfolio.

Therefore, in this way the Sharpe ratio can be used to rank the risk-adjusted managerial performance of portfolios. However, there are a number of limitations and caveats to consider when using the Sharpe ratio measure to assess the risk-adjusted performance of portfolio managers. Firstly, the Sharpe ratio, like the Treynor ratio previously mentioned, is based on historical returns data which limits the usefulness of the Sharpe ratio as trying to predict future performance by using past performance is of questionable reliability, especially if the management of the fund has changed or the investment aims of the fund have changed, which may result in the fund pursuing a different investment strategy in the future. Also, because the Sharpe ratio is a raw number, when it is used to analyse one fund in isolation, it is difficult to attain whether the Sharpe ratio is high or low, good or bad, and thus it is most useful when used to compare similar funds, a fund against an appropriate index or a fund against a category average.

Furthermore, negative Sharpe ratios can arise and they are problematic when they do because when you have negative returns, an increase in the level of risk results in a higher Sharpe ratio which is nonsensical. In addition, the premise behind the Sharpe ratio is that it assesses the excess returns of the fund in terms of total risk, and when the Sharpe ratio is negative with the fund having negative returns, the fund is clearly not outperforming the risk-free rate, leading to a question regarding the relevance of the negative Sharpe ratio as there is no excess return present.

Also, the use of the standard deviation as the risk measure in the Sharpe ratio leads to the imposition of a limitation in that the standard deviation assumes a normal returns distribution. When funds display skewness and/or kurtosis in the returns, the use of standard deviation as a measure of volatility can be troublesome, thus leading to a question over the validity of the Sharpe ratio in these cases. Another limitation of the Sharpe ratio is that is assumes a constant risk-free rate over time which is a strong assumption that is unlikely to hold in reality. Furthermore, it is important to note that, like the Treynor ratio, the Sharpe ratio measure is a ranking measure only, and it does not quantify the added return from the active management of a portfolio.

Finally, as previously mentioned, the original Sharpe ratio assumed that the risk-free rate of return remained constant over time which is a fairly strong assumption which is unlikely to hold in reality. Sharpe recognised this, and consequently developed Sharpe's (1994) revised ratio in which the risk-free rate of return is replaced by a relevant benchmark which is allowed to vary over time. Sharpe's (1994) revision to the original ratio, known as the information ratio, is shown below:

$$S_{pt} = \frac{\left(R_{pt}^{M} - R_{bt}\right)}{\sqrt{VAR\left(R_{pt} - R_{bt}\right)}}$$

Where:

1. $S_{pt}$ is the Sharpe ratio

2. $\left(R_{pt}^{M} - R_{bt}\right)$ is the excess of the portfolio mean return over the benchmark mean return

3. $\sqrt{VAR\left(R_{pt} - R_{bt}\right)}$ is the standard deviation of the difference between $R_{pt}$ and $R_{bt}$

Examples of studies that have used the Sharpe ratio to assess the performance of financial funds can be found in Ackermann et al (1999) which looks at the performance of 547 hedge funds and finds that the Sharpe ratio shows that hedge funds have a clear performance advantage over mutual funds, but they are unable to consistently beat the market, and Shukla and Van Inwegen (1995) which looks at whether local fund managers perform better than foreign fund managers when investing in the US and finds that the Sharpe ratio indicates that the local fund managers obtain a better risk-adjusted return than the foreign fund managers when investing in the US.

### *3.1.3: Jensen's Alpha*

The previous two classic portfolio performance measures, the Treynor ratio and the Sharpe ratio, are both relative measures in that they only rank the portfolios under evaluation against each other and they do not quantify the added return from the active management of a portfolio. Jensen's suggested portfolio performance measure, Jensen's alpha, is an absolute measure which both ranks the portfolios under evaluation against each other and also quantifies the added return from the active management of a portfolio against an absolute standard.

Jensen's alpha is perhaps the most well known of the classical measures of risk-adjusted portfolio performance. It is a selectivity-based measure which draws on the Capital Asset Pricing Model (CAPM) as an underlying model for asset pricing information. The CAPM uses the formula shown below to calculate the expected one-period return on any security or portfolio:

$$E(R_p) = R_f + \beta_p(E(R_m) - R_f)$$

Where:

1. $E(R_p)$ is the expected return on security or portfolio $p$
2. $R_f$ is the one-period risk-free interest rate
3. $\beta_p$ is the beta for security or portfolio $p$
4. $E(R_m)$ is the expected return on the market portfolio $m$

The beta for security or portfolio $p$, $\beta_p$, is obtained using the following equation:

$$\beta_p = \frac{COV(R_p, R_m)}{\sigma^2(R_m)}$$

Jensen assumes the joint validity of the CAPM above and the market model, $R_{it} = \alpha_i + \beta_i R_{mt} + \varepsilon_{it}$, to derive an ex-post CAPM, which requires using a market index instead of the market portfolio, and thus derives the formula for alpha in the following way. First, Jensen's assumption that the CAPM and the market model are empirically valid means that the expectations formula for the one-period return on any security or portfolio can be expressed in terms of realised rates of return over a time period $t$, leading to the formula below:

$$R_{pt} = R_{ft} + \beta_p(R_{mt} - R_{ft}) + \varepsilon_{pt}$$

Jensen then subtracts the one-period risk-free rate of return from each side to give:

$$R_{pt} - R_{ft} = \beta_p(R_{mt} - R_{ft}) + \varepsilon_{pt}$$

From the Security Market Line (SML) it is possible to say that this expression shows that the risk premium earned on security or portfolio $p$ is equal to the beta of security or portfolio $p$ multiplied by the market risk premium, plus a random error term, $\varepsilon_{pt}$. Portfolio managers who deliver superior risk-adjusted returns will have consistently positive random error terms due to the fact that their portfolio's actual returns will consistently exceed the returns expected by this model. Whereas portfolio managers who deliver inferior risk-adjusted returns will have consistently negative random error terms due to the fact that their portfolio's actual returns will consistently fall below the returns expected by this model. Thus, to detect and measure whether a portfolio manager is delivering superior or inferior risk-adjusted returns, Jensen inserts an intercept coefficient in to the expression to measure consistent differences from the model. Thus, the formula becomes:

$$R_{pt} - R_{ft} = \alpha_p^J + \beta_p(R_{mt} - R_{ft}) + \varepsilon_{pt}$$

The intercept coefficient in this formula, $\alpha_p^J$, known as alpha, indicates how much of a portfolio's rate of return can be attributed to the ability of the portfolio manager to derive risk-adjusted returns that are higher than the risk-adjusted return of the market. By assuming a zero residual random error term, Jensen rearranges the expression to solve for alpha, resulting in the well known formula for Jensen's alpha. The formulation for Jensen's (1968) alpha, also known as Jensen's differential return, is shown below:

$$\alpha_p^J = (R_{pt}^M - R_{ft}) - \beta_p(R_{mt}^M - R_{ft})$$

Where:

1. $\alpha_p^J$ is Jensen's alpha
2. $(R_{pt}^M - R_{ft})$ is the risk premium earned on portfolio $p$
3. $\beta_p(R_{mt}^M - R_{ft})$ is equal to the beta of portfolio $p$ times the market risk premium

A significantly positive alpha indicates that the portfolio manager has derived a superior risk-adjusted return, whereas a significantly negative alpha indicates that the portfolio manager has only managed to achieve an inferior risk-adjusted return. In the case where alpha is not significantly different from zero, the conclusion to be drawn is that the portfolio manager has basically matched the performance of the market in terms of risk-adjusted returns. Thus, Jensen's alpha can be used to rank the risk-adjusted managerial performance of portfolios, and it also quantifies the level of that performance, giving it an advantage over the earlier measures of portfolio performance evaluation by Treynor and Sharpe which only rank the portfolios.

However, there are a number of limitations and caveats to consider when using Jensen's alpha to assess the risk-adjusted performance of portfolio managers. Firstly, the validity of Jensen's alpha depends on the validity of the underlying empirical model of asset pricing, the CAPM, and there are a number of issues with the CAPM related to the restrictive and infeasible assumptions that are required in order for its validity to hold. These include the assumption that all investors can borrow and lend an unlimited amount of money at the risk-free rate of interest which is infeasible as it is unlikely that individual investors will be able to borrow as cheaply as a government can, and the assumption that investors can trade assets with no transaction or taxation costs which is again unlikely to be true for all investors as any trade in an asset is likely to incur some form of transaction cost. The CAPM also assumes that all investments are infinitely divisible, resulting in the possibility of buying or selling fractional shares of an asset, which is not the reality of what occurs in practice, and it also assumes that all investors have homogeneous expectations in that they have access to the same information and have identical probability distributions for expected rates of return on assets, which is highly unlikely in reality as some investors will always have an asymmetric information advantage over others and investors are likely to have differing expectations of the future probabilities of rates of return on assets. These issues call in to question the validity of the CAPM which is the underlying model of empirical asset pricing for Jensen's alpha, thus questioning the validity of Jensen's alpha as a measure of portfolio performance.

Furthermore, the validity of Jensen's alpha as a measure of portfolio performance also depends on the existence of the market portfolio, which in theory is an efficient, diversified portfolio that contains all the risky assets in the economy, weighted by their market values. The major issue with the market portfolio is that it is difficult to obtain a real-world proxy for this theoretical market portfolio as most of the proxies that are commonly used, such as the FTSE 100 index, exclude many risky assets which in theory should be included in the market portfolio. Thus, this inability to obtain an accurate real-world proxy for the market portfolio means that the true market portfolio is unobservable. This is the second statement of critique in Richard Roll's (1977) famous analysis, the Roll critique, resulting in a problem known as benchmark error. The benchmark error occurs when the proxy for the market portfolio is not the true, efficient market portfolio, and consequently the SML derived using this proxy is unlikely to be the true SML. As a result, the true SML could, for example, have a higher slope, and therefore a portfolio that plotted above the SML derived using the poor proxy could, in reality, plot below the true SML. A second issue is that the beta of a portfolio derived using the poor proxy for the market portfolio is unlikely to match the true beta of the portfolio that would be obtained if the true market portfolio was used. The consequence of this is that if, for example, the true beta of a portfolio was higher than the beta obtained using the proxy, the true position of the portfolio would be to the right of that indicated by the position obtained using the proxy. In both of these cases, there is the potential for inaccurate conclusions to be drawn about whether the risk-adjusted performance of a portfolio is superior or inferior to that of the benchmark portfolio.

Also, there is paradox with Jensen's alpha in that if $\alpha \neq 0$, then the CAPM is violated, and thus the question arises as to why the CAPM is being used as a benchmark. Again, as with the Treynor ratio and the Sharpe ratio, Jensen's alpha is based on using historical data which limits the usefulness of alpha as trying to predict future performance on the basis of past performance is of questionable reliability. Finally, the usefulness of alpha and beta is completely dependent on the level of correlation between a portfolio and its underlying market benchmark. The R-squared statistical measure can be useful here as it determines how much of the movement of a portfolio can be attributed to movements in its benchmark, with a higher R-squared meaning the performance of a portfolio is more attributable to the performance of its benchmark and a lower R-squared meaning the portfolio performance is not closely related to that of its benchmark. Consequently, the higher the R-squared for a portfolio, the more relevant its alpha and beta values will be.

Examples of studies that have used Jensen's alpha to assess the performance of financial funds can be found in Ippolito (1989) which looks at the performance of 143 US mutual funds and finds that alpha shows that the mutual funds outperform index funds on the basis of risk-adjusted performance, and Leger (1997) which looks at the performance of 72 UK investment trusts and finds that alpha shows weak risk-adjusted performance with very little persistence for the 72 UK investment trusts.

### *3.1.4: The Treynor And Mazuy Market Timing Measure*

The Treynor ratio, the Sharpe ratio and Jensen's alpha are all selectivity measures of portfolio performance in that they look at the ability of portfolio managers to select 'winning' stocks. Selectivity is also known as micro-forecasting. These selectivity measures assume that the beta of the portfolio, $\beta_p$, is constant, however $\beta_p$ is in reality controlled by the portfolio manager. So although the betas of the individual stocks, $\beta_i$, are fixed, the portfolio manager can vary the asset weighting in their portfolio to manipulate the beta of the portfolio. Thus, this means that for a high market rate of return the portfolio manager can earn high returns by utilising a high beta, and for a low market rate of return the portfolio manager can utilise a low beta to protect the portfolio from poor returns. As a consequence, a portfolio manager who can accurately forecast future changes in the market index can obtain a better return through the systematic variation of $\beta_p$. This is known as market timing or macro-forecasting. The Treynor and Mazuy market timing measure incorporates both selectivity and market timing, and as a result it should provide more accurate estimates of the performance of a portfolio.

Treynor and Mazuy (1966) propose a method to evaluate the market timing ability of an investor which involves the utilisation of a bivariate regression model where an additional variable is added to the CAPM which in itself is a special case of a one-factor model. This additional variable represents the squared market risk premium which encapsulates the convexity of the managed portfolio return function of the market return. Thus, the Treynor and Mazuy (1966) market timing measure is formulated below:

$$R_{pt}^{M} - R_{ft} = \alpha_{p}^{TM} + \beta_{1p}\left(R_{mt}^{M} - R_{ft}\right) + \beta_{2p}\left(R_{mt}^{M} - R_{ft}\right)^{2} + \varepsilon_{pt}$$

Where:

1. $R_{pt}^{M} - R_{ft}$ is the risk premium earned on portfolio $p$
2. $\alpha_{p}^{TM}$ is a measure of selectivity performance
3. $\left(R_{mt}^{M} - R_{ft}\right)$ is the market risk premium
4. $\beta_{1p}$ is the systematic risk sensitivity of returns on portfolio $p$
5. $\beta_{2p}$ is the market timing coefficient

The Treynor and Mazuy market timing measure provides $\alpha_{p}^{TM}$ which is a measure of selectivity performance and $\beta_{2p}$ which is a market timing coefficient, and when $\beta_{2p} > 0$ this indicates successful market timing.

Admati et al (1986) have extended the Treynor and Mazuy market timing measure to provide a total performance measure. They suggest conditions under which $\alpha_{p}^{TM}$ can be interpreted as the selectivity component of performance and $\beta_{2p}VAR\left(R_{mt} - R_{ft}\right)$ can be interpreted as the timing component of performance, leading to the Treynor and Mazuy total performance measure shown below:

$$TMTPM = \alpha_{p}^{TM} + \beta_{2p}VAR\left(R_{mt} - R_{ft}\right)$$

The Treynor and Mazuy market timing measure is based around Jensen's alpha and thus also the CAPM model underlying Jensen's alpha. Therefore, as a consequence of this, the Treynor and Mazuy market timing measure suffers from many of the same limitations and caveats as Jensen's alpha with regard to assessing the risk-adjusted performance of portfolio managers. These include the issues around both the validity of the CAPM model and the existence of the market portfolio. Also, the Treynor and Mazuy measure uses historical data which limits its usefulness of the results as trying to predict future performance on the basis of past performance is of questionable reliability. Finally, the usefulness of $\alpha_p^{TM}$, $\beta_{1p}$ and $\beta_{2p}$ is completely dependent on the level of correlation between a portfolio and its underlying market benchmark. The R-squared statistical measure can be useful here as it determines how much of the movement of a portfolio can be attributed to movements in its benchmark, with a higher R-squared meaning the performance of a portfolio is more attributable to the performance of its benchmark and a lower R-squared meaning the portfolio performance is not closely related to that of its benchmark. Consequently, the higher the R-squared for a portfolio, the more relevant these values will be.

Examples of studies that have used the Treynor and Mazuy market timing measure to assess the performance of financial funds can be found in Coggin et al (1993) which looks at the performance of 71 US equity pension fund managers and finds that, in general, the selectivity measure is positive whilst the market timing measure is negative, and Dellva et al (2001) which looks at the performance of 35 Fidelity Select Mutual Funds and also finds that the selectivity measure is positive whilst the market timing measure is negative.

### *3.1.5: The Henriksson And Merton Market Timing Measure*

The Henriksson and Merton market timing measure is, like the Treynor and Mazuy measure, able to incorporate both selectivity and market timing, and as a result it should provide more accurate estimates of the performance of a portfolio. Henriksson and Merton (1981) propose a method to evaluate the market timing ability of an investor which involves the utilisation of a bivariate regression model for market timing based on the introduction of a put option pay-off that interacts with the returns of the market portfolio, and allows the individual identification of both the selectivity and market timing abilities of the investor.

They start with the assumption that portfolio managers have two separate target risk levels which are represented by two different betas in the model, and these are dependent on whether the return to the market is to exceed or not exceed the return on a riskless asset. Thus, there is one target beta for the case when the return to the market exceeds the return on the risk-free asset and a second target beta for the case when the return to the market is equal to or below the return on the risk-free asset. These two states of the market can be represented as follows:

$$Down - Market\ Conditions\ \rightarrow\ \beta_t\ =\ \eta_1\ For\ R_{mt}\ \leq\ R_{ft}$$

$$Up - Market\ Conditions\ \rightarrow\ \beta_t\ =\ \eta_2\ For\ R_{mt}\ >\ R_{ft}$$

Here, $\beta_t$ is the time varying systematic risk of the portfolio at time $t$, and the first state represents the case where a bear market is being anticipated by the portfolio manager and the second state represents the case where a bull market is being anticipated by the portfolio manager. However, $\beta_t$ is unobservable, so Henriksson and Merton (1981) define the unconditional expected value of $\beta_t$ as $b$ as follows:

$$b\ =\ q[p_1\eta_1\ +\ (1\ -\ p_1)\eta_2]\ +\ (1\ -\ q)[p_2\eta_2\ +\ (1\ -\ p_2)\eta_1]$$

Here, $q$ is the unconditional probability that $R_{mt}\ \leq\ R_{ft}$. They also define another variable $\theta_t$ as follows:

$$\theta_t = (\beta_t - b)$$

Here, $\theta_t$ is the unanticipated component of beta and its distribution, conditional on the realised excess return of the market $R_{mt} - R_{ft}$, when $R_{mt} - R_{ft} \leq 0$. This leads to the following formulation for the return on the managed portfolio per period:

$$R_{pt} = R_{ft} + (b + \theta_t)(R_{mt} - R_{ft}) + \lambda + \varepsilon_{pt}$$

Here, $\lambda$ represents the additional return from the selection abilities of the manager of a portfolio. Using this returns process for a portfolio, least squares regression analysis can be undertaken to identify the individual additional increments to portfolio performance due to both selectivity and market timing. This regression model formulation, which is the Henriksson and Merton (1981) market timing measure, is shown below:

$$R_{pt}^{M} - R_{ft} = \alpha_p^{HM} + \beta_{1p}(R_{mt}^{M} - R_{ft}) + \beta_{2p}MAX(0, R_{ft} - R_{mt}^{M}) + \varepsilon_{pt}$$

Where:

1. $R_{pt}^{M} - R_{ft}$ is the risk premium earned on portfolio $p$
2. $\alpha_p^{HM}$ is a measure of selectivity performance
3. $R_{mt}^{M}$ is the mean return on the market
4. $R_{ft}$ is the risk-free rate of return
5. $\beta_{1p}$ is the systematic risk sensitivity of returns on portfolio $p$
6. $\beta_{2p}$ is the market timing coefficient

Here, the term $\beta_{2p}MAX(0, R_{ft} - R_{mt}^{M})$ represents a no cost put option on the market portfolio. The motivation behind this measure is that the market timing strategy previously mentioned is equal to pursuing a protective, costless, put option investment strategy on the market portfolio. The Henriksson and Merton market timing measure provides $\alpha_p^{HM}$ which is a measure of selectivity and $\beta_{2p}$ which is a market timing coefficient, and when $\beta_{2p} > 0$ this indicates successful market timing.

The Henriksson and Merton market timing measure is based around Jensen's alpha and the CAPM model underlying Jensen's alpha. Therefore, as a consequence of this, the Henriksson and Merton market timing measure suffers from many of the same limitations and caveats as Jensen's alpha with regard to assessing the risk-adjusted performance of portfolio managers. These include the concerns surrounding the validity of the CAPM model and the existence of the market portfolio. Furthermore, the Henriksson and Merton measure is based on the use of historical data which hinders the insights that can be drawn from the results as it is dubious to try and predict the future performance on the basis of past performance. Finally, the insight in to the performance of a managed portfolio provided by $\alpha_p^{HM}$, $\beta_{1p}$ and $\beta_{2p}$ is completely dependent on the level of correlation between the portfolio and its underlying market benchmark. The R-squared statistical measure can be useful here as it determines how much of the movement of the portfolio can be attributed to movements in its benchmark, with a higher R-squared meaning the performance of the portfolio is more attributable to the performance of its benchmark and a lower R-squared meaning the portfolio performance is not closely related to that of its benchmark. Consequently, the higher the R-squared for the portfolio, the more relevant these values will be.

Examples of studies that have used the Henriksson and Merton market timing measure to assess the performance of financial funds can be found in Chang and Lewellen (1984) which looks at the performance of 67 mutual funds and finds that there is little evidence of market timing ability, and that mutual funds have been unable to collectively outperform a passive investment strategy, and

Henriksson (1984) which looks at the performance of 116 open-end mutual funds and finds that there is no evidence to support the market timing ability of mutual fund managers.

## *3.2: Later Developments Of The Classical Models Of Portfolio Performance Analysis*

The five main classical measures of portfolio performance analysis discussed in the previous section have been the catalyst for a large array of model developments in this field too numerous to mention in detail. However, some of the more important ones are discussed here.

The first of these is the Treynor and Black appraisal ratio proposed in Treynor and Black (1973) which is developed by building on the single-index market model and Jensen's alpha. The appraisal ratio is the ratio of Jensen's alpha to the standard deviation of a portfolio's unsystematic risk, and in effect, it measures the performance of a portfolio manager by comparing the return from their stock picks to the specific risk associated with those picks. The appraisal ratio is formulated as shown below:

$$Appraisal\ Ratio\ = \frac{\alpha_p^J}{\sigma_{(\varepsilon_p)}}$$

Where:

1. $\alpha_p^J$ is Jensen's alpha

2. $\sigma_{(\varepsilon_p)}$ is the standard deviation of portfolio $p$'s unsystematic risk

The second of these is the $M^2$ Risk-Adjusted Performance (RAP) measure proposed by Modigliani and Modigliani (1997) which is derived from the Sharpe ratio. The principal behind the $M^2$ measure is that every portfolio is adjusted to the same level of risk as its unmanaged benchmark, and the performance of this risk-equivalent portfolio is then measured. The adjustment of the risk of the portfolio returns is achieved by utilising the market opportunity cost of risk in terms of return and the financial operation of leverage by borrowing and lending. Thus, with all portfolios on the same scale, the $M^2$ measure allows a direct and fair comparison of the performance of the portfolio managers. The $M^2$ measure is formulated as follows:

$$M_p^2 = \left(R_{pt}^M - R_{ft}\right)\frac{\sigma_m}{\sigma_p} + R_{ft} = SR_p\sigma_m + R_{ft}$$

Where:

1. $M_p^2$ is the $M^2$ Risk-Adjusted Performance (RAP) measure for portfolio $p$

2. $R_{pt}^M$ is the portfolio mean return

3. $R_{ft}$ is the risk-free rate of return

4. $\sigma_p$ is the standard deviation of portfolio $p$'s returns

5. $\sigma_m$ is the standard deviation of the market returns

6. $SR_p$ is the Sharpe ratio of portfolio $p$

The ranking of the performance of portfolio managers provided by $M_p^2$ is identical to the ranking provided by the Sharpe ratio, but $M_p^2$ provides a score that is manifested in absolute terms in basis points which is much more intuitive to understand.

To determine whether on the basis of risk-adjusted performance, a portfolio $p$ has outperformed the benchmark market index, the differential return of $M^2$ can be calculated, with a positive value confirming that portfolio $p$ has outperformed the benchmark market index. The differential return of $M^2$ is formulated below:

$$DR_p^{M^2} = M_p^2 - M_m^2 = (SR_p - SR_m)\sigma_m$$

Finally, the $M^2$ RAP measure can be formulated using other risk measures such as $\beta$ as undertaken by Scholtz and Wilkens (2005) to develop the Market Risk-Adjusted Performance (MRAP) measure, which is more relevant for investors who invest in many different funds as opposed to the $M^2$ measure which is more relevant for investors who invest in a single fund. The MRAP measure is formulated as shown below:

$$MRAP_P = (R_{pt}^M - R_{ft})\frac{\beta_m}{\beta_p} + R_{ft} = (R_{pt}^M - R_{ft})\frac{1}{\beta_p} + R_{ft} = TR_p + R_{ft}$$

Where:

1. $MRAP_p$ is the Market Risk-Adjusted Performance (MRAP) measure for portfolio $p$
2. $R_{pt}^M$ is the portfolio mean return
3. $R_{ft}$ is the risk-free rate of return
4. $\beta_p$ is the $\beta$ for portfolio $p$
5. $\beta_m$ is the market $\beta$
6. $TR_p$ is the Treynor ratio of portfolio $p$

The ranking of the performance of portfolio managers provided by $MRAP_p$ is identical to the ranking provided by the Treynor ratio, but $MRAP_p$ provides a score that is manifested in absolute terms in basis points which is much more intuitive to understand.

To determine whether on the basis of risk-adjusted performance, a portfolio $p$ has outperformed the benchmark market index, the differential return of MRAP can be calculated, with a positive value confirming that portfolio $p$ has outperformed the benchmark market index. The differential return of MRAP is formulated below:

$$DR_p^{MRAP} = MRAP_p - MRAP_m$$

The third of these is the multi-index model proposed by Elton et al (1993) which is developed from the Arbitrage Pricing Theory (APT) and Jensen's alpha. The APT was developed by Ross (1976) as an alternative to the CAPM which has almost identical underlying assumptions but allows for several risk factors to explain portfolio returns. So whilst the CAPM is a single-index factor model, the APT is a multi-factor model. The key difference between the APT and the CAPM is that the APT does not allow for any arbitrage opportunities, and therefore if two portfolios have the same level of risk associated with them, they must have the same expected return, otherwise there would be an opportunity for arbitrage in that an investor could short sell one portfolio whilst holding a long position in the second portfolio, and make a risk-free profit. Thus, this lack of any arbitrage opportunities results in a linear relationship between the expected return and the betas in the model. The APT model can be formulated as follows:

$$R_p = \alpha_p + \beta_{1p}F_1 + \beta_{2p}F_2 + \dots + \beta_{kp}F_k + \varepsilon_p$$

It can also be formulated in risk premium form as follows:

$$E(R_p) = R_f + \beta_{1p}\left(E(RF_1) - R_f\right) + \beta_{2p}\left(E(RF_2) - R_f\right) + \dots + \beta_{kp}\left(E(RF_k) - R_f\right)$$

Elton et al (1993) propose a variation of this multi-factor APT model, the multi-index model, that can be applied to the assessment of the risk-adjusted managerial performance of portfolios. This EGDH measure is formulated below:

$$R_{pt}^{M} - R_{ft} = \alpha_p^{EGDH} + \beta_{mp}(R_{mt}^{M} - R_{ft}) + \beta_{np}(R_{nt}^{M} - R_{ft}) + \ldots + \beta_{kp}(R_{kt}^{M} - R_{ft}) + \varepsilon_{pt}$$

Where:

1. $R_{pt}^{M} - R_{ft}$ is the risk premium earned on portfolio $p$
2. $\alpha_p^{EGDH}$ is a measure of selectivity performance
3. $\beta_{kp}$ is the systematic risk sensitivity of returns on portfolio $p$ to the relevant index $k$
4. $R_{kt}^{M} - R_{ft}$ is the market specific risk premium where $R_{kt}^{M}$ is the mean return on index $k$

The fourth of these is the Fama-French three-factor model proposed by Fama and French (1993) which is developed by extending the single-index factor CAPM model through the addition of two extra factors. They started with the observation that two categories of stocks have shown a tendency to perform better than the market in general, small-cap stocks and value stocks. Thus, they add two additional factors to the CAPM to reflect the exposure of the portfolio to these two categories. These two additional factors are $SMB$ (Small Minus Big) which measures the historic excess return of small-caps over large-caps and $HML$ (High Minus Low) which measures the historic excess return of value stocks over growth stocks. The Fama-French three-factor model is formulated below:

$$R_{pt}^{M} - R_{ft} = \alpha_p^{FF} + \beta_{mp}(R_{mt}^{M} - R_{ft}) + \beta_{sp}(R_{SMBt}) + \beta_{vp}(R_{HMLt}) + \varepsilon_{pt}$$

Where:

1. $R_{pt}^{M} - R_{ft}$ is the risk premium earned on portfolio $p$
2. $\alpha_p^{FF}$ is a measure of selectivity performance
3. $\beta_{mp}$ is the systematic risk sensitivity of returns on portfolio $p$
4. $R_{mt}^{M} - R_{ft}$ is the market risk premium

5. $\beta_{sp}$ is the sensitivity of portfolio $p$ to $SMB$

6. $R_{SMBt}$ is the $SMB$ excess return

7. $\beta_{vp}$ is the sensitivity of portfolio $p$ to $HML$

8. $R_{HMLt}$ is the $HML$ excess return

The fifth and final of these is the Carhart four-factor model proposed by Carhart (1997) which is developed by extending the Fama-French three-factor model, which in itself is an extension of the single-index factor CAPM model, through the addition of an extra factor. Starting with the observation that the 'hot hands' effect in the persistence of mutual fund performance over short term time horizons as documented in Hendricks et al (1993) can be accounted for by Jegadeesh and Titman's (1993) one-year momentum in the return on stocks, a momentum factor is added as fourth factor to reflect the exposure of the portfolio to momentum. Momentum in a stock is the tendency for the stock price to continue rising if it is going up and to continue falling if it is going down. This additional factor is $PR1YR$ (Previous 1 Year) which measures the one-year momentum in stock returns versus contrarian stocks by calculating the equal-weight average of stocks with the highest 30% eleven month returns lagged one month minus the equal-weight average of stocks with the lowest 30% eleven month returns lagged one month. The Carhart four-factor model is formulated below:

$$R_{pt}^{M} - R_{ft} = \alpha_{p}^{C} + \beta_{mp}\left(R_{mt}^{M} - R_{ft}\right) + \beta_{sp}(R_{SMBt}) + \beta_{vp}(R_{HMLt}) + \beta_{pp}(R_{PR1YRt}) + \varepsilon_{pt}$$

Where:

1. $R_{pt}^{M} - R_{ft}$ is the risk premium earned on portfolio $p$

2. $\alpha_{p}^{C}$ is a measure of selectivity performance

3. $\beta_{mp}$ is the systematic risk sensitivity of returns on portfolio $p$

4. $R_{mt}^{M} - R_{ft}$ is the market risk premium

5. $\beta_{sp}$ is the sensitivity of portfolio $p$ to $SMB$

6. $R_{SMBt}$ is the $SMB$ excess return

7. $\beta_{vp}$ is the sensitivity of portfolio $p$ to $HML$

8. $R_{HMLt}$ is the $HML$ excess return

9. $\beta_{pp}$ is the sensitivity of portfolio $p$ to $PR1YR$

10. $R_{PR1YRt}$ is the one-year momentum in stock returns

There are a number of limitations and caveats to consider when using these later models to assess the risk-adjusted performance of portfolio managers. The Treynor and Black appraisal ratio builds on Jensen's alpha and thus suffers from some of the limitations associated with Jensen's alpha such as the question mark surrounding the validity of the underlying CAPM model. The $M^2$ RAP measure is derived from the Sharpe ratio and thus uses standard deviation as a measure of risk which carries a caveat in that it assumes a normal returns distribution which is problematic if the fund under analysis displays any skewness or kurtosis in its returns. The related MRAP measure utilises beta as a measure of risk as opposed to the standard deviation, and thus the MRAP measure is limited by some of the issues related to beta such as the usefulness of beta being completely dependent on the level of correlation between beta and its underlying market benchmark. The EGDH measure is based on the APT which has almost identical underlying assumptions to the CAPM, and the Fama-French three-factor model and the Carhart four-factor model are extensions of the CAPM, and thus they are limited by the concerns surrounding the assumptions of the CAPM model and the effect these have on its validity. Finally, all of these models use historical data which limits the usefulness of the results they provide as trying to predict the future performance on the basis of past performance is of questionable reliability.

## 3.3: Post-Modern Portfolio Theory And Its Associated Performance Measures

The performance measures mentioned in this chapter up to now are all based on the ideas of modern portfolio theory (MPT) as introduced in the seminal paper by Markowitz (1952). The basic premise behind MPT is that investment decision-making can be considered in terms of a risk/return trade-off with the aim of either maximising the expected return of a portfolio for a given portfolio risk level or minimising the level of portfolio risk for a given expected portfolio return. Under MPT, asset returns are modelled as an elliptically distributed random variable and risk is defined as the standard deviation of asset returns, and thus it models a portfolio as a weighted combination of assets. Therefore, the return of a portfolio is the weighted combination of the asset returns, and through combining various assets with returns that are not perfectly positively correlated, it aspires to reduce the total variance of the return of the portfolio. Consequently, MPT is a form of investment diversification. The two major limitations of MPT are the assumptions that the returns of all securities and portfolios can be represented using an elliptical distribution, and the variance of security or portfolio returns is the appropriate risk measure.

These major limitations of MPT led to the development of what was named post-modern portfolio theory (PMPT) by Rom and Ferguson (1993), although the pillars that make up PMPT are drawn from the earlier research of several authors. The principal idea of PMPT that distinguishes it from MPT is that it is based on determining the return that needs to be earned on the assets in a portfolio to meet some future payout. This return, the internal rate of return (IRR), is used as the basis against which to measure risk and reward in PMPT. The premise underlying this principal idea of PMPT is that investors do not view returns above the minimum they need to earn to meet their investment objectives as risky, and thus that the risk is related to when the return is below the required target, not when the return is above the required target. Thus, PMPT provides a framework for investment decision-making based on the preference of investors for upside volatility over downside volatility, in tandem with a more accurate model for returns based on the three-parameter log-normal distribution. Six examples of portfolio performance measures based on PMPT are the Sortino ratio from Sortino and Van Der Meer (1991), the Upside Potential Ratio from Sortino et al (1999), the Omega ratio from Shadwick and Keating (2002), the Kappa ratio from Kaplan and Knowles (2004), the Sterling Ratio from Kestner (1996) and the Excess Return On VaR measure from Dowd (2000).

### *3.3.1: The Sortino Ratio*

The Sortino ratio from Sortino and Van Der Meer (1991) is perhaps the most well known of the PMPT managed portfolio performance measures. It is the rate of return on the portfolio minus the required rate of return to meet the investment objectives, divided by the downside risk which is represented by the target semi-deviation. Thus, the Sortino ratio incorporates the idea that investors are most concerned about returns being below the required target rate, the downside risk. The Sortino ratio is related to the Sharpe ratio in that it is the equivalent of the Sharpe ratio in mean-downside deviation space, and thus it punishes only downside volatility as opposed to the Sharpe ratio which punishes both downside and upside volatility. The Sortino ratio is formulated as shown below:

$$SORT_p = \frac{R_{pt}^M - R_\tau}{\sqrt{\frac{1}{T}\sum_{t=1}^{T} MAX\left(R_\tau - R_{pt}, 0\right)^2}}$$

Where:

1. $SORT_p$ is the Sortino ratio for portfolio $p$

2. $R_{pt}^M$ is the mean return on portfolio $p$

3. $R_{pt}$ is the return on portfolio $p$ in period $t$

4. $R_\tau$ is the target rate of return

5. $\sqrt{\frac{1}{T}\sum_{t=1}^{T} MAX(R_\tau - R_{pt}, 0)^2}$ is the below target semi-deviation or downside deviation/risk

### *3.3.2: The Omega Ratio*

The Omega ratio from Shadwick and Keating (2002) is another of the PMPT managed portfolio performance measures. It is the returns on the portfolio above the target rate of return, over the downside deviation of returns on the portfolio below the target rate of return. The Omega ratio incorporates the desired return target of investors and attributes the risk to when the return of the portfolio is below this target rate of return as theorised in the PMPT world. The Omega ratio is formulated as shown below:

$$\Omega_p = \frac{\frac{1}{T}\sum_{t=1}^{T} MAX(R_{pt} - R_\tau, 0)}{\frac{1}{T}\sum_{t=1}^{T} MAX(R_\tau - R_{pt}, 0)} \quad Or \quad \Omega_p = \frac{R_{pt}^{M} - R_\tau}{\frac{1}{T}\sum_{t=1}^{T} MAX(R_\tau - R_{pt}, 0)} + 1$$

Where:

1. $\Omega_p$ is the Omega ratio for portfolio $p$

2. $R_{pt}^{M}$ is the mean return on portfolio $p$

3. $R_{pt}$ is the return on portfolio $p$ in period $t$

4. $R_\tau$ is the target rate of return

5. $\frac{1}{T}\sum_{t=1}^{T} MAX(R_\tau - R_{pt}, 0)$ is the downside deviation/risk

### *3.3.3: The Kappa Ratio*

The Kappa ratio from Kaplan and Knowles (2004) is another of the PMPT managed portfolio performance measures. It is a generalised downside risk-adjusted return performance measure in the

PMPT framework of which the Sortino ratio and Omega ratio are special cases. It is calculated as the rate of return on the portfolio minus the target rate of return, over the downside risk. The Kappa ratio is formulated as shown below:

$$Kappa_p = \frac{R_{pt}^M - R_\tau}{\sqrt[n]{\frac{1}{T}\sum_{t=1}^{T} MAX(R_\tau - R_{pt}, 0)^n}}$$

Where:

1. $Kappa_p$ is the Kappa ratio for portfolio $p$
2. $R_{pt}^M$ is the mean return on portfolio $p$
3. $R_{pt}$ is the return on portfolio $p$ in period $t$
4. $R_\tau$ is the target rate of return
5. $\sqrt[n]{\frac{1}{T}\sum_{t=1}^{T} MAX(R_\tau - R_{pt}, 0)^n}$ is the downside deviation/risk

Thus, when the Kappa ratio is formulated with $n = 1$ the result is the Omega ratio and when the Kappa ratio is formulated with $n = 2$ the result is the Sortino ratio. There are an infinite number of related Kappa downside risk-adjusted performance measures occurring when $n$ takes any positive value. It is important to highlight that the variable $n$ represents the risk tolerance of the investor, with $n < 1$ corresponding to risk loving, $n = 1$ corresponding to risk neutral and $n > 1$ corresponding to increasing risk aversion, and thus varying this variable allows the tailoring of the risk measure in the model to the risk preference of the investor.

Furthermore, it is important to note here that the Sortino ratio, the Omega ratio, the Kappa ratio and the Upside Potential Ratio (UPR) are all using a type of risk measure known as a Lower Partial Moment (LPM) downside risk measure as developed by Bawa (1975) and Fishburn (1977). The

LPM is able to represent the whole spectrum of human behaviour it terms of risk, from risk loving, through risk neutral, to risk aversion. The LPM downside risk measure is formulated as follows:

$$LPM_n = \frac{1}{T}\sum_{t=1}^{T} MAX(\tau - R_t, 0)^n$$

Where:

1. $n$ is the degree of the lower partial moment equivalent to the risk tolerance of the investor

2. $T$ is the number of observations

3. $\tau$ is the target rate of return

4. $R_t$ is the return for the security in time period $t$

### *3.3.4: The Upside Potential Ratio*

The Upside Potential Ratio from Sortino et al (1999) is also a PMPT managed portfolio performance measure. It is a refinement of the Sortino ratio that aims to better represent the risk preferences of investors who, in general, want to promote upside variation of returns and penalise downside variation of returns. It is calculated as the variation of the returns on the portfolio above the target rate of return divided by the variation of the returns on the portfolio below the target rate of return. Thus, the Upside Potential Ratio highlights portfolios which have a relatively good upside rate of return performance per unit of downside deviation/risk. The Upside Potential Ratio (UPR) is formulated as shown below:

$$UPR_p = \frac{\frac{1}{T}\sum_{t=1}^{T} MAX\left(R_{pt} - R_\tau, 0\right)}{\sqrt{\frac{1}{T}\sum_{t=1}^{T} MAX\left(R_\tau - R_{pt}, 0\right)^2}}$$

Where:

1. $UPR_p$ is the Upside Potential Ratio for portfolio $p$

2. $R_{pt}$ is the return on portfolio $p$ in period $t$

3. $R_\tau$ is the target rate of return

4. $\sqrt{\frac{1}{T}\sum_{t=1}^{T} MAX\left(R_\tau - R_{pt}, 0\right)^2}$ is the below target semi-deviation or downside deviation/risk

### *3.3.5: The Sterling Ratio*

The Sterling Ratio from Kestner (1996) is also a PMPT managed portfolio performance measure. It is a modified version of the Sharpe ratio which uses the average drawdown over several years, usually three years, as the risk measure instead of standard deviation, thus incorporating downside risk in to the performance measure. It is calculated as the returns on the portfolio minus the risk-free rate of return, over the average drawdown over the period of analysis. The Sterling Ratio is formulated as follows:

$$STER_p = \frac{R_{pt}^M - R_f}{\frac{1}{K}\sum_{k=1}^{K} -D_{pk}}$$

Where:

1. $STER_p$ is the Sterling Ratio for portfolio $p$

2. $R_{pt}^M$ is the mean return on portfolio $p$

3. $R_f$ is the risk-free rate of return

4. $\frac{1}{K}\sum_{k=1}^{K} -D_{pk}$ is the average drawdown with $k$ drawdowns

### *3.3.6: The Excess Return On VaR*

The Excess Return On VaR measure from Dowd (2000) is the final PMPT managed portfolio performance measure examined. It is a modified version of the Sharpe ratio which uses value at risk (VaR) as the risk measure instead of standard deviation, and in this way it incorporates and punishes the downside deviation of returns only, rather than both the upside and downside deviation as is the case when using the standard deviation. It is calculated as the returns of the portfolio minus the risk-free rate of return, divided by the VaR of the portfolio. The Excess Return On VaR (ERVaR) is formulated as shown below:

$$ERVaR_p = \frac{R_{pt}^M - R_f}{VaR_p}$$

Where:

1. $ERVaR_p$ is the Excess Return On VaR for portfolio $p$

2. $R_{pt}^M$ is the mean return on portfolio $p$

3. $R_f$ is the risk-free rate of return

4. $VaR_p$ is the VaR of portfolio $p$

## *3.4: Summary Of The Portfolio Performance Measures*

To summarise, these traditional approaches to the measurement of the performance of mutual funds using performance measures based on the theories of modern portfolio theory (MPT) and post-modern portfolio theory (PMPT), represent the most common methods employed to assess the performance of mutual funds, and do so using a risk/return framework. Whilst these portfolio performance measures provide intuitive and realitively simple measures of portfolio performance, they do so by only considering portfolio performance in terms of a risk/return framework, excluding the influence of other important factors, and they also require the imposition of problematic assumptions. The shortcomings of these traditional approaches have led researchers and practitioners to turn to other methods to try to improve the accuracy and robustness of the measurement of mutual fund performance, and one area that is attracting increasing attention in this regard is the field of data envelopment analysis. Therefore, the current state of the research in this field is reviewed in the next chapter of this thesis.

# Chapter 4: Literature Review Part 2 – Data Envelopment Analysis (DEA) And Stochastic Frontier Analysis (SFA), And Their Application To The Managerial Performance Of Mutual Funds

## *4.1: The Development Of Data Envelopment Analysis (DEA)*

A simple measure to evaluate productivity would be to use a ratio such as $\frac{Output}{Input}$. This type of productivity measure is known as a 'partial productivity measure' because it only considers one input and one output. The problem with this type of productivity measure is that a gain in output may be unintentionally attributed to the wrong input. This issue can be resolved by using a 'total factor productivity measure' which uses all the relevant inputs and outputs in a single ratio. However, using a total factor productivity measure in place of a partial productivity measure presents a new set of problems including the choice of which inputs and outputs to use, and what weighting to assign to each input and each output. Also, when you assign a fixed weighting to the different inputs and outputs it raises the issue of how you justify the weightings that you have applied to them, and thus it is likely that your selection of weights will have been quite arbitrary. As a consequence of this, the results are likely to be misleading because the productivity ratings given to entities are likely to be inaccurate due to the arbitrary fixed weights that have been used and the unproductiveness associated with some entities may not be due to the entity itself. The use of DEA to examine the productivity of various entities comes into its own here because it allows for the incorporation of multiple inputs and multiple outputs and, as highlighted by Cooper et al (2007; 2), it does not require fixed weights to be attached a priori to each input and output. The DEA outcome does attach weights, but these are optimised with respect to each decision making unit.

As noted by Charnes et al (1978; 429), DEA was original developed with the aim of evaluating the decision making efficiency of not for profit entities in the public sector such as, for example, universities. Later research has extended the use of DEA to a wide variety of applications including private sector firms, banks and importantly, in the context of this thesis, its application to the assessment of the performance of mutual funds as proposed by Murthi et al (1997) and Basso and Funari (2001).

Data envelopment analysis involves collecting an appropriate sample of data, including both a number of common inputs and outputs with respect to a collection of decision making units (DMUs), relevant to the aims of the study being undertaken. So using the example of evaluating the decision making efficiency of universities, you would have a number of different universities as the collection of DMUs, and you would collect data on a number of common inputs such as tuition fees and research grants, and a number of common outputs such as the percentage of 'good' degrees awarded and the percentage of research staff assessed to be carrying out research at an internationally significant level.

DEA then makes use of mathematical programming to deal with the large numbers of inputs and outputs, and the complex relationships between them, to determine an appropriate efficiency rating for each DMU. DEA assigns variable weights to each input and each output for each individual DMU by deriving the weights from the data which optimise each individual DMU's input-to-output ratio relative to all the other DMUs when the same weights are assigned to their inputs and outputs.

There are a number of advantages to using DEA to assess the relative efficiency of individual DMUs including the avoidance of prior assumptions such as the weights to be used, and the functional form of the relationship between inputs and outputs does not have to be specified and it can differ between different DMUs. Also, it has the ability to estimate the amounts and sources of inefficiency for each DMU, and to identify the benchmark DMUs that form the efficient set. However, there are also some disadvantages associated with using DEA to assess the relative efficiency of individual DMUs including the sensitivity of the efficiency ratings results to the selection of inputs and outputs, with the inclusion of irrelevant variables and the exclusion of relevant variables leading to unreliable results, and the issue with DEA in its standard form having difficulty dealing with negative input/output values in the underlying data which can result in bias in the efficiency ratings results. Furthermore, the non-stochastic nature of DEA means all deviations from the frontier are attributed to inefficiency, and thus DEA does not explicitly account for stochastic events such as environmental factors and statistical noise. Finally, DEA has been criticised for being sensitive to outliers such as in Coelli et al (2005), however Thompson et al (1994) presents evidence that disputes this and Fare et al (2001) suggest that the sensitivity to outliers issue in DEA is overemphasised.

There are various different types of DEA models that have been developed and they are usually either input-oriented or output-oriented. When the model used in DEA measures the efficiency as input-oriented it means that the DMU's objective is to minimise the inputs used to produce given targets of output. Whereas when the model used measures the efficiency as output-oriented it means that the DMU's objective is to maximise the level of outputs obtained using given levels of inputs. Some of the more commonly employed types of DEA model include the 'classic' radial models, the CCR DEA model and the BCC DEA model, the Additive models, the later non-radial models such as the Slacks-Based Measure (SBM) model, and the Hybrid model which can combine both radial and non-radial factors into its programming. In addition to these, there are numerous other types of DEA models that have been developed and the Data Envelopment Analysis text by Cooper et al (2007) provides an excellent guide to them.

### *4.1.1: The CCR And BCC Radial DEA Models*

Data envelopment analysis (DEA) is a non-parametric methodology which is used in the area of operational research to measure the relative efficiency of decision making units (DMUs). The DEA technique was originally suggested by Charnes et al (1978) who developed DEA from the work of Michael Farrell in his 1957 paper on the measurement of productive efficiency.

Charnes et al (1978) started out with a definition of productivity as shown below:

$$[FP_0] \quad \underset{(v_i\, u_r)}{\text{Max}}\; h_0 = \frac{\sum_{r=1}^{s} u_r y_{r0}}{\sum_{i=1}^{m} v_i x_{i0}}$$

Subject To:

$$\frac{\sum_{r=1}^{s} u_r y_{rj}}{\sum_{i=1}^{m} v_i x_{ij}} \leq 1$$

$$v_i, u_r \geq 0$$

$$i = 1, \dots, m \qquad r = 1, \dots, s \qquad j = 1, \dots, n$$

Where:

1. $j$ are the decision making units

2. $i$ are the inputs

3. $r$ are the outputs

4. $x_{ij}$ is the amount of input $i$ for unit $j$

5. $y_{rj}$ is the amount of output $r$ for unit $j$

6. $v_i$ is the weight assigned to input $i$

7. $u_r$ is the weight assigned to output $r$

However, this fractional programming problem cannot be implemented because it has infinitely many solutions. Consequently, the researcher must normalise the problem to convert it into an equivalent linear programming problem. This can be performed by either letting $\sum_{i=1}^{m} v_i x_{i0} = 1$ in which case the result is the input-oriented CCR linear model or by letting $\sum_{r=1}^{s} u_r y_{r0} = 1$ in which case the result is the output-oriented CCR linear model. The linear programming problem shown below is based on the input-oriented CCR multiplier linear model:

$$[LP_0] \quad \text{Max}\, \theta = \sum_{r=1}^{s} u_r y_{r0}$$

Subject To:

$$\sum_{i=1}^{m} v_i x_{i0} = 1$$

$$\sum_{r=1}^{s} u_r y_{rj} \leq \sum_{i=1}^{m} v_i x_{ij}$$

$$v_i, u_r \geq 0$$

$$i = 1, \ldots, m \qquad r = 1, \ldots, s \qquad j = 1, \ldots, n$$

The linear programming dual of the above linear programming problem is shown below:

$$Dual \quad \text{Min}\, \theta$$

Subject To:

$$\sum_{j=1}^{n} \lambda_j x_{ij} \leq x_{i0}\theta$$

$$\sum_{j=1}^{n} \lambda_j y_{rj} \ \geq \ y_{r0}$$

$$\lambda_j \ \geq \ 0$$

$$i \ = \ 1, \dots, m \qquad r \ = \ 1, \dots, s \qquad j \ = \ 1, \dots, n$$

$0 \ \leq \ \theta \ \leq \ 1$ → This is a measure of efficiency

This is the input-oriented CCR DEA envelopment model.

To obtain the output-oriented CCR DEA model requires the restriction imposed when transforming the fractional programming problem into the linear programming problem to be changed to $\sum_{r=1}^{s} u_r y_{r0} \ = \ 1$. This gives the linear programming problem shown below which is the output-oriented CCR multiplier linear model:

$$[LP_0] \quad \text{Max}\, \theta \ = \ \frac{1}{\sum_{i=1}^{m} v_i x_{i0}}$$

Subject To:

$$\sum_{r=1}^{s} u_r y_{r0} \ = \ 1$$

$$\sum_{r=1}^{s} u_r y_{rj} \ \leq \ \sum_{i=1}^{m} v_i x_{ij}$$

$$v_i, u_r \ \geq \ 0$$

$$i \ = \ 1, \dots, m \qquad r \ = \ 1, \dots, s \qquad j \ = \ 1, \dots, n$$

The linear programming dual of this linear programming problem is as follows:

$Dual$ Min $\theta$

Subject To:

$$\sum_{j=1}^{n} \lambda_j x_{ij} \leq x_{i0}$$

$$\sum_{j=1}^{n} \lambda_j y_{rj} \geq \frac{y_{r0}}{\theta}$$

$$\lambda_j \geq 0$$

$$i = 1, \ldots, m \qquad r = 1, \ldots, s \qquad j = 1, \ldots, n$$

However, there is now an issue with solving this using linear programming because $\theta$ is now in the denominator and thus, this is now a non-linear programming problem. Therefore, to allow for the dual to be solved requires the definition of $\frac{1}{\theta} = \gamma$, leading to the dual problem below:

$Dual$ Max $\gamma$

Subject To:

$$\sum_{j=1}^{n} \lambda_j x_{ij} \leq x_{i0}$$

$$\sum_{j=1}^{n} \lambda_j y_{rj} \geq y_{r0}\gamma$$

$$\lambda_j \geq 0$$

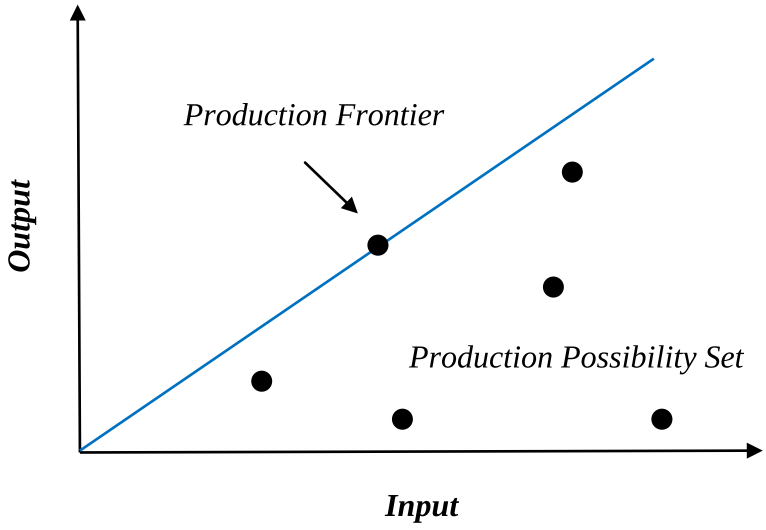
$i = 1, \ldots, m \qquad r = 1, \ldots, s \qquad j = 1, \ldots, n$

$0 \leq \frac{1}{\gamma} \leq 1$ → This is a measure of efficiency

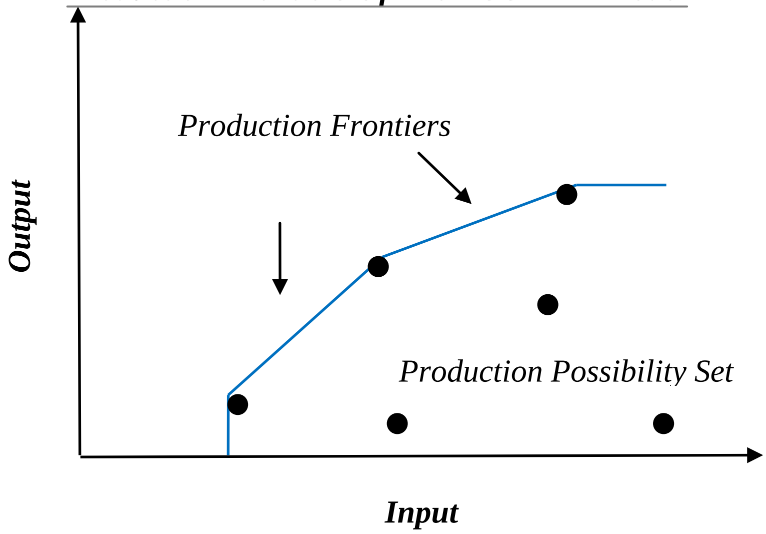
Thus, this is the output-oriented CCR DEA envelopment model.

The CCR model developed by Charnes, Cooper and Rhodes in 1978 is a radial-type DEA model that uses constant returns-to-scale, and can be specified as either input-oriented or output-oriented. The BCC model is an extension of the CCR model developed by Banker, Charnes and Cooper in 1984 that uses variable returns-to-scale, utilises a radial metric and can be specified as either input-oriented or output-oriented. The different returns-to-scale metrics used by the two different models are highlighted below in the graphical representation of their production frontiers:

***Production Frontier Of The CCR DEA Model***




***Production Frontiers Of The BCC DEA Model***




Banker et al (1984) extended the CCR DEA model from constant returns-to-scale to variable returns-to-scale by adding an extra constraint to the dual program, $\sum \lambda_j = 1$. The imposition of this new constraint in the dual program requires a corresponding variable to be added to the linear program, $u_0$. Thus, the new linear program and the new dual program that are produced as a result of these additions make up the BCC DEA model, and can be solved using linear programming. Starting with the definition of productivity used by Charnes et al (1978) for the CCR DEA model, and adding the new variable $u_0$, gives the BCC DEA model fractional program shown below:

$$[FP_0] \quad \underset{(v_i\, u_r)}{\text{Max}}\ h_0 = \frac{\sum_{r=1}^{s} u_r y_{r0} - u_0}{\sum_{i=1}^{m} v_i x_{i0}}$$

Subject To:

$$\frac{\sum_{r=1}^{s} u_r y_{rj} - u_0}{\sum_{i=1}^{m} v_i x_{ij}} \leq 1$$

$$v_i, u_r \geq 0$$

$$u_0 \ is \ free$$

$$i = 1, \dots, m \qquad r = 1, \dots, s \qquad j = 1, \dots, n$$

Where:

1. $j$ are the decision making units

2. $i$ are the inputs

3. $r$ are the outputs

4. $x_{ij}$ is the amount of input $i$ for unit $j$

5. $y_{rj}$ is the amount of output $r$ for unit $j$

6. $v_i$ is the weight assigned to input $i$

7. $u_r$ is the weight assigned to output $r$

8. $u_0$ is the free variable

As the BCC DEA model is based on the CCR DEA model, it follows that like the fractional program in the CCR DEA model, this fractional program cannot be implemented as it has infinitely many solutions. Thus, it must be normalised into an equivalent linear programming problem, in this case using the restriction $\sum_{i=1}^{m} v_i x_{i0} = 1$ to obtain the input-oriented BCC multiplier linear model as shown below:

$$[LP_0] \quad \text{Max}\, \theta = \sum_{r=1}^{s} u_r y_{r0} - u_0$$

Subject To:

$$\sum_{i=1}^{m} v_i x_{i0} = 1$$

$$\sum_{r=1}^{s} u_r y_{rj} - u_0 e \leq \sum_{i=1}^{m} v_i x_{ij}$$

$$v_i, u_r \geq 0$$

$$u_0 \; is \; free$$

$$i = 1, \dots, m \qquad r = 1, \dots, s \qquad j = 1, \dots, n$$

The linear programming dual of this linear programming problem is shown below:

$$Dual \quad \text{Min}\, \theta$$

Subject To:

$$\sum_{j=1}^{n} \lambda_j x_{ij} \leq x_{i0} \theta$$

$$\sum_{j=1}^{n} \lambda_j y_{rj} \geq y_{r0}$$

$$\sum_{j=1}^{n} \lambda_j = 1$$

$$\lambda_j \geq 0$$

$i = 1, \ldots, m \qquad r = 1, \ldots, s \qquad j = 1, \ldots, n$

$0 \leq \theta \leq 1$ → This is a measure of efficiency

This is the input-oriented BCC DEA envelopment model.

When formulating the output-oriented BCC DEA model it is necessary to start with a slightly different fractional program to that used for the input-oriented BCC DEA model. The new variable added to the program is defined as $v_0$, but it is identical in nature to the variable added in the case of the input-oriented BCC DEA model fractional program, $u_0$. The resulting BCC DEA model fractional program is shown below:

$$[FP_0] \qquad \underset{(v_i\, u_r)}{\text{Max}}\ h_0 = \frac{\sum_{r=1}^{s} u_r y_{r0}}{\sum_{i=1}^{m} v_i x_{i0} - v_0}$$

Subject To:

$$\frac{\sum_{r=1}^{s} u_r y_{rj}}{\sum_{i=1}^{m} v_i x_{ij} - v_0} \leq 1$$

$v_i, u_r \geq 0$

$v_0\ is\ free$

$i = 1, \ldots, m \qquad r = 1, \ldots, s \qquad j = 1, \ldots, n$

Where:

1. $j$ are the decision making units

2. $i$ are the inputs

3. $r$ are the outputs

4. $x_{ij}$ is the amount of input $i$ for unit $j$

5. $y_{rj}$ is the amount of output $r$ for unit $j$

6. $v_i$ is the weight assigned to input $i$

7. $u_r$ is the weight assigned to output $r$

8. $v_0$ is the free variable

To obtain the output-oriented BCC DEA model requires the restriction imposed when transforming the fractional programming problem into the linear programming problem to be changed to $\sum_{r=1}^{s} u_r y_{r0} = 1$. This leads to the linear programming problem shown below which is the output-oriented BCC multiplier linear model:

$$[LP_0] \quad \text{Max}\, \theta = \frac{1}{\sum_{i=1}^{m} v_i x_{i0} - v_0}$$

Subject To:

$$\sum_{r=1}^{s} u_r y_{r0} = 1$$

$$\sum_{r=1}^{s} u_r y_{rj} \leq \sum_{i=1}^{m} v_i x_{ij} - v_0 e$$

$$v_i, u_r \geq 0$$

$$v_0 \; is \; free$$

$$i = 1, \dots, m \qquad r = 1, \dots, s \qquad j = 1, \dots, n$$

The linear programming dual of this linear programming problem is as follows:

$$Dual \quad \text{Min}\, \theta$$

Subject To:

$$\sum_{j=1}^{n} \lambda_j x_{ij} \leq x_{i0}$$

$$\sum_{j=1}^{n} \lambda_j y_{rj} \geq \frac{y_{r0}}{\theta}$$

$$\sum_{j=1}^{n} \lambda_j = 1$$

$$\lambda_j \geq 0$$

$$i = 1, \dots, m \qquad r = 1, \dots, s \qquad j = 1, \dots, n$$

However, there is now an issue with solving this using linear programming because $\theta$ is now in the denominator and thus, this is now a non-linear programming problem. Therefore, to allow for the dual to be solved requires the definition of $\frac{1}{\theta} = \gamma$, leading to the dual problem below:

$Dual$ Max $\gamma$

Subject To:

$$\sum_{j=1}^{n} \lambda_j x_{ij} \leq x_{i0}$$

$$\sum_{j=1}^{n} \lambda_j y_{rj} \geq y_{r0}\gamma$$

$$\sum_{j=1}^{n} \lambda_j = 1$$

$$\lambda_j \geq 0$$

$i = 1, \dots, m \qquad r = 1, \dots, s \qquad j = 1, \dots, n$

$0 \le \frac{1}{\gamma} \le 1$ → This is a measure of efficiency

Thus, this is the output-oriented BCC DEA envelopment model.

These two DEA models, the CCR model and the BCC model, have been the catalyst for the development of the numerous DEA models that have been introduced since the idea of data envelopment analysis was originally proposed. Some of the major model innovations are considered in the following sections, including the Additive DEA model, the Slacks-Based Measure (SBM) DEA model and the Hybrid DEA model.

### *4.1.2: The Additive DEA Model*

Within the field of economics, the concept of efficiency is entwined with the concept of Pareto optimality, and thus an input/output parcel is not Pareto optimal if there exists the possibility of an increase in outputs or a decrease in inputs. Therefore, a DMU cannot be assessed as Pareto efficient so long as there are any input and/or output slacks. The previous radial DEA models, the CCR DEA model and the BCC DEA model, measure efficiency in terms of Farrell technical efficiency, with the drawback of this being the presence of input and/or output slacks in the optimal solution. The Additive DEA models are a class of DEA models which have the same production possibility set as the CCR and BCC models, but they treat the slacks, the input excesses and the output shortfalls, directly in the objective function of the model, and thus they measure efficiency in terms of Pareto-Koopmans efficiency. It is worthwhile highlighting here that the radial models are also able to treat the slacks directly in the objective function, but only at the cost of imposing an arbitrary non-Archimedean penalty score. The Archimedean property is that when you add together many small numbers you eventually get a large number, and thus if when you add many small numbers together you do get a large number, the original numbers are Archimedean, whereas if when you add many small numbers together you still end up with a small number, the original numbers are non-Archimedean infinitesimals. There are several types of Additive DEA model, but here we consider the basic Additive DEA model from Charnes et al (1985b). This Additive DEA model is formulated as follows:

$$[LP_0] \quad \text{Min Z} = \sum_{i=1}^{m} v_i x_{i0} - \sum_{r=1}^{s} u_r y_{r0} + u_0$$

Subject To:

$$\sum_{i=1}^{m} v_i x_{ij} \geq \sum_{r=1}^{s} u_r y_{rj} - u_0 e$$

$$v_i \geq 1$$

$$u_r \geq 1$$

$$u_0 \text{ } is \text{ } free$$

$$i = 1, \ldots, m \qquad r = 1, \ldots, s \qquad j = 1, \ldots, n$$

Where:

1. $j$ are the decision making units

2. $i$ are the inputs

3. $r$ are the outputs

4. $x_{ij}$ is the amount of input $i$ for unit $j$

5. $y_{rj}$ is the amount of output $r$ for unit $j$

6. $v_i$ is the weight assigned to input $i$

7. $u_r$ is the weight assigned to output $r$

8. $u_0$ is the free variable

The linear programming dual of this linear programming problem is shown below:

$$Dual \quad \text{Max Z} = \sum_{i=1}^{m} s_{i0}^{-} + \sum_{r=1}^{s} s_{r0}^{+}$$

Subject To:

$$\sum_{j=1}^{n} \lambda_j x_{ij} + s_{i0}^{-} = x_{i0}$$

$$\sum_{j=1}^{n} \lambda_j y_{rj} - s_{r0}^{+} = y_{r0}$$

$$\sum_{j=1}^{n} \lambda_j = 1$$

$$\lambda_j \geq 0$$

$$s_{i0}^{-}, s_{r0}^{+} \geq 0$$

$$i = 1, \ldots, m \qquad r = 1, \ldots, s \qquad j = 1, \ldots, n$$

In the above linear programming dual, $s_{i0}^{-}$ and $s_{r0}^{+}$ represent the input and output slacks for the DMU under evaluation. A DMU is ranked as efficient if, and only if, $s_{i0}^{-*} = s_{r0}^{+*} = 0$ at optimality. This Additive DEA model formulated by Charnes et al (1985b) determines the inefficiency in each input and in each output in a single model, however unlike the radial CCR and BCC DEA models of Charnes et al (1978) and Banker et al (1984) respectively, it does not yield an efficiency score, $\theta$, between 0 and 1. In the case of the Additive DEA model, although the efficiency score $\theta$ is not measured explicitly by the model, it is implicitly present in the model slacks. Furthermore, whilst the efficiency ratings in the CCR and BCC DEA models only reflect Farrell or weak efficiency, the objective in the Additive model reflects all inefficiencies that can be identified in both the inputs and the outputs. The Additive DEA model shown above from Charnes et al (1985b) contains the convexity constraint, $\sum \lambda_j = 1$, and therefore it uses the variable returns-to-scale metric. It can be formulated without the convexity constraint as shown in Ali and Seiford (1993), in which case it would be based on a constant returns-to-scale metric.

As shown in Ali and Seiford (1990), the Additive DEA model as formulated in Charnes et al (1985b) with variable returns-to-scale is translation invariant with respect to both inputs and outputs, as translating the original input and output data will result in a new problem, to which the optimal solution will be the same as the optimal solution from the original problem. Therefore, the efficiency ratings from the Additive DEA model are invariant to a translation of the underlying data through the addition of a constant, and thus the original data and the translated data will lead to the same rankings of the DMUs. This property of the Additive DEA model is particularly useful in the case of a project which involves a dataset containing negative values in both inputs and outputs as commonly found in, for example, financial datasets. This is contrasted against the earlier CCR and BCC DEA models, with the CCR DEA model not being translation invariant under any circumstances, and the BCC DEA model being translation invariant with respect to inputs only in the case of the output-oriented BCC model and with respect to outputs only in the case of the input-oriented BCC model.

### *4.1.3: The Slacks-Based Measure (SBM) DEA Model*

The Slacks-Based Measure (SBM) DEA model was developed in Tone (2001) as a scalar measure of efficiency which deals directly with the input excesses and output shortfalls of the DMUs. The

SBM DEA model is a non-radial model and it can utilise either constant returns-to-scale or variable returns-to-scale depending on the inclusion or exclusion of the convexity constraint, $\sum \lambda_j = 1$. It is important to highlight a number of properties of the SBM DEA model which are advantageous in the context of an efficiency measure including firstly, the SBM DEA model being units invariant which means the underlying input and output data can be scaled by being multiplied by a constant without changing the rankings of the DMUs, and thus the efficiency ratings of the DMUs obtained under the SBM DEA model are invariant to the units of measurement of the underlying data. The SBM DEA model also benefits from being monotone decreasing with respect to the slacks, both input excesses and output shortfalls, and finally being reference-set dependent in that the efficiency measure is determined by consulting only the reference-set of the DMU concerned and therefore it is not influenced by statistics over the whole dataset. The standard form of the SBM DEA model is non-oriented, and this is shown below utilising the constant returns-to-scale metric:

$$\{SBM - NO\} \quad \text{Min}\,\rho = 1 - \frac{1}{m}\sum_{i=1}^{m}\frac{s_i^-}{x_{i0}}$$

Subject To:

$$1 = \frac{1}{s}\sum_{r=1}^{s}\frac{s_r^+}{y_{r0}}$$

$$\sum_{j=1}^{n}\lambda_j x_{ij} + s_i^- = x_{i0} \qquad \forall i$$

$$\sum_{j=1}^{n}\lambda_j y_{rj} - s_r^+ = y_{r0} \qquad \forall r$$

$$\lambda_j \geq 0 \qquad s_i^- \geq 0 \qquad s_r^+ \geq 0$$

$$i = 1, \dots, m \qquad r = 1, \dots, s \qquad j = 1, \dots, n$$

$0 \leq \rho \leq 1$ → This is a measure of efficiency

Here, the objective function measures one minus the average ratio of input slack to input used and the first constraint is that the average ratio of output slack to output produced is equal to one. This non-oriented SBM DEA model can be modified to obtain both the input-oriented SBM DEA model, by excluding the denominator from the objective function, and the output-oriented SBM DEA model, by excluding the numerator of the objective function, and thus these models optimise either the input slacks only or the output slacks only respectively. These are formulated, utilising the constant returns-to-scale metric, as shown below:

$$\{SBM - IO\} \quad \text{Min}\, \rho_I = 1 - \frac{1}{m}\sum_{i=1}^{m}\frac{s_i^-}{x_{io}}$$

Subject To:

$$\sum_{j=1}^{n}\lambda_j x_{ij} + s_i^- = x_{i0} \qquad \forall i$$

$$\sum_{j=1}^{n}\lambda_j y_{rj} - s_r^+ = y_{r0} \qquad \forall r$$

$$\lambda_j \geq 0 \qquad s_i^- \geq 0 \qquad s_r^+ \geq 0$$

$$i = 1, \ldots, m \qquad r = 1, \ldots, s \qquad j = 1, \ldots, n$$

$0 \leq \rho_I \leq 1$ → This is a measure of efficiency

$$\{SBM - OO\} \quad \text{Max}\, \rho_O = \frac{1}{1 + \frac{1}{s}\sum_{r=1}^{s}\frac{s_r^+}{y_{r0}}}$$

Subject To:

$$\sum_{j=1}^{n} \lambda_j x_{ij} + s_i^- = x_{i0} \qquad \forall i$$

$$\sum_{j=1}^{n} \lambda_j y_{rj} - s_r^+ = y_{r0} \qquad \forall r$$

$$\lambda_j \geq 0 \qquad s_i^- \geq 0 \qquad s_r^+ \geq 0$$

$$i = 1, \dots, m \qquad r = 1, \dots, s \qquad j = 1, \dots, n$$

$0 \leq \frac{1}{\rho_O} \leq 1$ → This is a measure of efficiency

### *4.1.4: The Hybrid DEA Model*

In the radial approach to DEA the optimal adjustments of the inputs/outputs are subject to change proportionally whereas in the non-radial approach to DEA the optimal adjustments of the inputs/outputs can vary in different proportions, and thus when a DEA problem contains a mix of radial and non-radial optimal adjustments of the inputs/outputs, these differences should be reflected in the efficiency evaluation undertaken. The CCR and BCC DEA models represent the radial approach to DEA, with their drawback being that they neglect any non-radial input and/or output slacks, whilst the SBM DEA model represents the non-radial approach to DEA, with its drawback being that it neglects the radial nature of the optimal adjustments of the inputs and/or outputs. The Hybrid DEA model was proposed in Tone (2004) as a hybrid measure of efficiency in DEA which is able to unify the radial and non-radial approaches to DEA in a single framework, and thus is useful for measuring the efficiency of DMUs when there are both radial and non-radial optimal adjustments of the inputs/outputs mixed in the problem being evaluated. The Hybrid DEA model can be formulated using either constant returns-to-scale or variable returns-to-scale based on the exclusion or inclusion respectively of the convexity constraint, $\sum \lambda_j = 1$. In its standard form the Hybrid DEA model is non-oriented and is formulated as shown below, under the constant returns-to-scale metric:

$$X \in R^{m*n} \qquad X = \begin{pmatrix} X^R \\ X^{NR} \end{pmatrix} \qquad Radial \rightarrow X^R \in R^{m_1*n}, Non-Radial \rightarrow X^{NR} \in R^{m_2*n}$$

$$Y \in R^{s*n} \qquad Y = \begin{pmatrix} Y^R \\ Y^{NR} \end{pmatrix} \qquad Radial \rightarrow Y^R \in R^{s_1*n}, Non-Radial \rightarrow Y^{NR} \in R^{s_2*n}$$

$$m = m_1 + m_2 \qquad s = s_1 + s_2$$

$$\{HYBRID-NO\} \quad \text{Min}\, \rho = 1 - \frac{m_1}{m}(1 - \theta) - \frac{1}{m}\sum_{i=1}^{m_2} \frac{s_i^{NR-}}{x_{i0}^{NR}}$$

Subject To:

$$1 = \frac{s_1}{s}(\Theta - 1) + \frac{1}{s}\sum_{r=1}^{s_2} \frac{s_r^{NR+}}{y_{r0}^{NR}}$$

$$\theta x_{i0}^R \geq \sum_{i=1,j=1}^{m_1,n} x_{ij}^R \lambda_j$$

$$x_{i0}^{NR} = \sum_{i=1,j=1}^{m_2,n} x_{ij}^{NR} \lambda_j + s_i^{NR-}$$

$$\Theta y_{r0}^R \leq \sum_{r=1,j=1}^{s_1,n} y_{rj}^R \lambda_j$$

$$y_{r0}^{NR} = \sum_{r=1,j=1}^{s_2,n} y_{rj}^{NR} \lambda_j - s_r^{NR+}$$

$$\theta \leq 1 \qquad \Theta \geq 1 \qquad \lambda_j \geq 0 \qquad s_i^{NR-} \geq 0 \qquad s_r^{NR+} \geq 0$$

$$j = 1, \ldots, n$$

$0 \leq \rho \leq 1$ → This is a measure of efficiency

Using the optimal solution, the Hybrid efficiency measure, $\rho^*$, can be decomposed into four measures of inefficiency as follows:

$$Radial\ Input\ Inefficiency \rightarrow \alpha_1 = \frac{m_1}{m}(1 - \theta^*)$$

$$Non - Radial\ Input\ Inefficiency \rightarrow \alpha_2 = \frac{1}{m}\sum_{i=1}^{m_2}\frac{s_i^{NR-*}}{x_{i0}^{NR}}$$

$$Radial\ Output\ Inefficiency \rightarrow \beta_1 = \frac{s_1}{s}(\Theta^* - 1)$$

$$Non - Radial\ Output\ Inefficiency \rightarrow \beta_2 = \frac{1}{s}\sum_{r=1}^{s_2}\frac{s_r^{NR+*}}{y_{r0}^{NR}}$$

$$Input\ Inefficiency \rightarrow \alpha = \alpha_1 + \alpha_2$$

$$Output\ Inefficiency \rightarrow \beta = \beta_1 + \beta_2$$

$$\rho^* = \frac{1 - \alpha}{1 + \beta} = \frac{1 - \alpha_1 - \alpha_2}{1 + \beta_1 + \beta_2}$$

This decomposition of the Hybrid efficiency measure provides useful information on the sources of inefficiency and the magnitude of their effect on the efficiency rating.

The Hybrid DEA model can be modified in a similar way to the SBM DEA model to obtain both an input-oriented version and an output-oriented version. This is achieved by excluding the denominator to obtain the input-oriented Hybrid DEA model and excluding the numerator to obtain the output-oriented Hybrid DEA model. These models, utilising the constant returns-to-scale metric, are formulated as follows:

$X \in R^{m*n} \qquad X = \begin{pmatrix} X^R \\ X^{NR} \end{pmatrix} \qquad Radial \rightarrow X^R \in R^{m_1*n}, Non - Radial \rightarrow X^{NR} \in R^{m_2*n}$

$Y \in R^{s*n} \qquad Y = \begin{pmatrix} Y^R \\ Y^{NR} \end{pmatrix} \qquad Radial \rightarrow Y^R \in R^{s_1*n}, Non - Radial \rightarrow Y^{NR} \in R^{s_2*n}$

$m = m_1 + m_2 \qquad s = s_1 + s_2$

$$\{HYBRID - IO\} \quad \text{Min}\, \rho_I = 1 - \frac{m_1}{m}(1 - \theta) - \frac{1}{m}\sum_{i=1}^{m_2} \frac{s_i^{NR-}}{x_{i0}^{NR}}$$

Subject To:

$$\theta x_{i0}^R \geq \sum_{i=1,j=1}^{m_1,n} x_{ij}^R \lambda_j$$

$$x_{i0}^{NR} = \sum_{i=1,j=1}^{m_2,n} x_{ij}^{NR} \lambda_j + s_i^{NR-}$$

$$y_{r0}^R \leq \sum_{r=1,j=1}^{s_1,n} y_{rj}^R \lambda_j$$

$$y_{r0}^{NR} \leq \sum_{r=1,j=1}^{s_2,n} y_{rj}^{NR} \lambda_j$$

$\theta \leq 1 \qquad \lambda_j \geq 0 \qquad s_i^{NR-} \geq 0$

$j = 1, \ldots, n$

$0 \leq \rho_I \leq 1$ → This is a measure of efficiency

$$\{HYBRID - OO\} \quad \text{Max}\, \rho_O = \frac{1}{1 + \frac{s_1}{s}(\Theta - 1) + \frac{1}{s}\sum_{r=1}^{s_2} \frac{s_r^{NR+}}{y_{r0}^{NR}}}$$

Subject To:

$$x_{i0}^{R} \geq \sum_{i=1,j=1}^{m_1,n} x_{ij}^{R}\lambda_j$$

$$x_{i0}^{NR} \geq \sum_{i=1,j=1}^{m_2,n} x_{ij}^{NR}\lambda_j$$

$$\Theta y_{r0}^{R} \leq \sum_{r=1,j=1}^{s_1,n} y_{rj}^{R}\lambda_j$$

$$y_{r0}^{NR} = \sum_{r=1,j=1}^{s_2,n} y_{rj}^{NR}\lambda_j - s_r^{NR+}$$

$$\Theta \geq 1 \qquad \lambda_j \geq 0 \qquad s_r^{NR+} \geq 0$$

$$j = 1, \dots, n$$

$0 \leq \frac{1}{\rho_o} \leq 1$ → This is a measure of efficiency

The decomposition of the efficiency measure shown for the non-oriented Hybrid DEA model is still valid in these models, albeit in terms of only input inefficiency in the input-oriented Hybrid DEA model and in terms of only output inefficiency in the output-oriented Hybrid DEA model.

One consideration when implementing the Hybrid DEA model to evaluate the efficiency of a set of DMUs is the decision as to whether an input/output should be treated as a radial or non-radial variable. In Tone (2004) it is suggested that if the slacks for an input/output are considered to be important in the measurement of efficiency, they should be incorporated directly in the objective function of the model, and thus the input/output should be treated as a non-radial variable, whilst if the slacks for an input/output are considered freely disposable, they do not need to be incorporated directly in the objective function of the model, and thus the input/output should be treated as a radial variable.

### *4.1.5: Further DEA Models*

The DEA models discussed thus far are some of the main, most commonly employed DEA models, but they do not exhaust the DEA model variations available. The DEA text by Cooper et al (2007) provides an excellent compendium of a large range of the available DEA models for reference. Furthermore, the journal paper by Cook and Seiford (2009) is also useful in this regard, providing a guide to the main methodological developments in the thirty years since the seminal paper by Charnes et al (1978) that introduced DEA.

However, some further DEA models that are worth highlighting briefly include the Russell Measure Model in Fare and Lovell (1978) and the Enhanced Russell Measure (ERM) in Pastor et al (1999) which are described as being ‘closed’ in that the efficiency measure includes all inefficiencies that the model can identify, thus avoiding the main drawback of the radial measures which only include some of the input or output inefficiencies and consequently only measure efficiency in terms of weak efficiency. This ‘closed’ characteristic of these efficiency measures is shared with the SBM DEA model. There is also the Connected-SBM model proposed in Avkiran et al (2008) which links the radial and non-radial approaches in a unified framework with two scalar parameters whose values can be varied to control the proportionality of the slacks, allowing the adjustment of the location of the model analysis anywhere between the radial and non-radial models, thus potential allowing the model to negate the drawbacks inherent in the two individual approaches. At the two extremes of the Connected-SBM model, the CCR DEA model and the SBM DEA model will be obtained. The Connected-SBM model can be classed as a weight setting method in DEA and another method in this category worth noting is the Assurance Region (AR) method from

Thompson et al (1986) which involves imposing constraints on the relative magnitude of the weights for special items, thus limiting the region of the weights to a specific area through lower and upper bounds. This can result in more satisfactory efficiency ratings, particularly when there are zero weights present in the original solution, but the selection of the lower and upper bounds requires careful consideration making use of evidence such as expert opinion or appropriate data.

Another type of DEA model to highlight is that of 'Window Analysis' in DEA proposed in Charnes et al (1985a) which was developed to capture the variations in efficiency over time for DMUs. This was achieved by treating a DMU as a different entity in each time period allowing an assessment of the efficiency of a DMU tracked over time. This original method of 'Window Analysis' was set up such, that when a new period was added to the window, the earliest period was removed. Talluri et al (1997) proposed a modification to this method, known as 'Modified Window Analysis', which dropped the poorest performing period from the window, as opposed to the earliest period. This is advantageous in the sense that the new period that has been added is challenged by the best of the previous periods, thus enhancing performance improvement. Finally, there are a group of models that aim to deal with undesirable outputs within the context of DEA efficiency analysis. DEA usually works on the premise that producing more outputs relative to less inputs is more efficient, yet when there are undesirable outputs in the problem being analysed, technologies that produce more of the desirable outputs and less of the undesirable outputs relative to inputs should be considered to be more efficient. The most common example of this would be related to environmental concerns such as air pollution and hazardous waste which are often by-products of production. The traditional way to measure DEA efficiency in the presence of undesirable outputs is to treat the undesirable outputs as inputs and then apply a standard DEA model to the dataset as done in, for example, Korhonen and Luptacik (2004). Fare et al (1989) developed an efficiency measure in which they assume weak disposability for undesirable outputs to allow for the fact that undesirable outputs may not be freely disposable and they allow the desirable outputs and the undesirable outputs to be separable. Scheel (2001) suggests an efficiency measure in which the desirable outputs and the undesirable outputs are non-separable on the basis that it is inevitable that reducing undesirable outputs will also reduce desirable outputs. Finally, Cooper et al (2007) propose models for both the separable and non-separable cases based on a modified SBM DEA model, and they also suggest that this SBM scheme can be extended to a model able to incorporate the co-existence of both separable desirable and undesirable outputs, and non-separable desirable and undesirable outputs.

### *4.1.6: Ranking Efficient DMUs In Data Envelopment Analysis (Super-Efficiency)*

On some occasions when DEA is used to evaluate the efficiency of a group of DMUs, a situation arises where there are a large proportion of the DMUs that achieve the maximum efficiency rating of 1. This is often the case when the number of DMUs under assessment is small relative to the number of variables, inputs and outputs, employed in the assessment. The issue here is how to disseminate these results to enable the ranking of these efficient DMUs. This led to the development of super-efficiency measures of efficiency which aim to rank these efficient DMUs, leading to more useful efficiency ratings results in these cases. There are, in common with standard DEA, two main approaches to super-efficiency measures, radial and non-radial.

Andersen and Petersen (1993) developed the initial super-efficiency DEA model which was a radial super-efficiency measure in which the data pertaining to the DMU under evaluation, $DMU_0$, is removed from the production possibility set. This is formulated in the form of a CCR model with constant returns-to-scale as shown below:

$\{SuperCCR - IO\}$ $\quad \text{Min}\,\theta$

Subject To:

$$\sum_{j=1,\neq 0}^{n} \lambda_j x_{ij} \leq x_{i0}\theta$$

$$\sum_{j=1,\neq 0}^{n} \lambda_j y_{rj} \geq y_{r0}$$

$$\lambda_j \geq 0$$

$$i = 1, \dots, m \qquad r = 1, \dots, s \qquad j = 1, \dots, n$$

$\theta$ → This is a measure of efficiency

$\{SuperCCR - OO\}$ Max $\gamma$

Subject To:

$$\sum_{j=1,\neq 0}^{n} \lambda_j x_{ij} \leq x_{i0}$$

$$\sum_{j=1,\neq 0}^{n} \lambda_j y_{rj} \geq y_{r0}\gamma$$

$$\lambda_j \geq 0$$

$$i = 1, \dots, m \qquad r = 1, \dots, s \qquad j = 1, \dots, n$$

$\frac{1}{\gamma}$ → This is a measure of efficiency

It is also possible to formulate this super-efficiency scheme in the form of a BCC model with variable returns-to-scale with the imposition of the convexity constraint, $\sum \lambda_j = 1$, as shown below:

$\{SuperBCC - IO\}$ Min $\theta$

Subject To:

$$\sum_{j=1,\neq 0}^{n} \lambda_j x_{ij} \leq x_{i0}\theta$$

$$\sum_{j=1,\neq 0}^{n} \lambda_j y_{rj} \geq y_{r0}$$

$$\sum_{j=1}^{n} \lambda_j = 1$$

$$\lambda_j \geq 0$$

$i = 1, \dots, m \qquad r = 1, \dots, s \qquad j = 1, \dots, n$

$\theta$ → This is a measure of efficiency

$\{SuperBCC - OO\}$ Max $\gamma$

Subject To:

$$\sum_{j=1,\neq 0}^{n} \lambda_j x_{ij} \leq x_{i0}$$

$$\sum_{j=1,\neq 0}^{n} \lambda_j y_{rj} \geq y_{r0}\gamma$$

$$\sum_{j=1}^{n} \lambda_j = 1$$

$$\lambda_j \geq 0$$

$$i = 1, \dots, m \qquad r = 1, \dots, s \qquad j = 1, \dots, n$$

$\frac{1}{\gamma}$ → This is a measure of efficiency

However, there is an issue in that in some circumstances these two models may be infeasible. For example, if for $r = 1$ we have $y_{r0} > Max_{j=1,\neq 0}^{n}\{y_{rj}\}$ then the constraint $\sum_{j=1,\neq 0}^{n} \lambda_j y_{rj} \geq y_{r0}$ in $SuperBCC - IO$ is infeasible due to $\sum \lambda_j = 1$, and thus $SuperBCC - IO$ has no feasible solution. Likewise, if for example, for $i = 1$ we have $x_{i0} < Min_{j=1,\neq 0}^{n}\{x_{ij}\}$ then the constraint $\sum_{j=1,\neq 0}^{n} \lambda_j x_{ij} \leq x_{i0}$ in $SuperBCC - OO$ is infeasible due to $\sum \lambda_j = 1$, and thus $SuperBCC - OO$ has no feasible solution. Thus, these two super-efficient BCC DEA models with variable returns-to-scale represent the feasible set by piecewise linear bounds which may exclude the DMU being evaluated in such a way that it cannot be projected on to the frontier. This is in contrast to the two super-efficient CCR DEA models with constant returns-to-scale which represent the feasible set with a single piecewise linear bound such that every super-efficient DMU can be projected on to the frontier.

Tone (2002) developed a non-radial super-efficiency measure based on using the SBM DEA model which deals directly with both the input and output slacks, and the data pertaining to the DMU under evaluation, $DMU_0$, is removed from the production possibility set. This is formulated, with constant returns-to-scale, as follows:

$$\{SuperSBM - NO\} \quad \text{Min}\,\rho = \frac{1}{m}\sum_{i=1}^{m}\frac{\overline{x_i}}{x_{i0}}$$

Subject To:

$$1 = \frac{1}{s}\sum_{r=1}^{s}\frac{\overline{y_r}}{y_{r0}}$$

$$\sum_{j=1,\neq 0}^{n}\lambda_j x_{ij} \leq \bar{x} \qquad \forall i$$

$$\sum_{j=1,\neq 0}^{n}\lambda_j y_{rj} \geq \bar{y} \qquad \forall r$$

$$\lambda_j \geq 0 \qquad \bar{x} \geq x_0 \qquad \bar{y} \leq y_0 \qquad \bar{y} \geq 0$$

$$i = 1,\dots,m \qquad r = 1,\dots,s \qquad j = 1,\dots,n$$

$\rho$ → This is a measure of efficiency

$$\{SuperSBM - IO\} \quad \text{Min}\,\rho_I = \frac{1}{m}\sum_{i=1}^{m}\frac{\overline{x_i}}{x_{io}}$$

Subject To:

$$\sum_{j=1,\neq 0}^{n}\lambda_j x_{ij} \leq \bar{x} \qquad \forall i$$

$$\sum_{j=1,\neq 0}^{n}\lambda_j y_{rj} \geq \bar{y} \qquad \forall r$$

$$\lambda_j \geq 0 \qquad \bar{x} \geq x_0 \qquad \bar{y} = y_0$$

$i = 1, \dots, m \qquad r = 1, \dots, s \qquad j = 1, \dots, n$

$\rho_I$ → This is a measure of efficiency

$$\{SuperSBM - OO\} \quad \text{Max}\, \rho_O = \frac{1}{\frac{1}{s}\sum_{r=1}^{s}\frac{\bar{y}_r}{y_{r0}}}$$

Subject To:

$$\sum_{j=1,\neq 0}^{n} \lambda_j x_{ij} \leq \bar{x} \qquad \forall i$$

$$\sum_{j=1,\neq 0}^{n} \lambda_j y_{rj} \geq \bar{y} \qquad \forall r$$

$\lambda_j \geq 0 \qquad \bar{x} = x_0 \qquad 0 \leq \bar{y} \leq y_0$

$i = 1, \dots, m \qquad r = 1, \dots, s \qquad j = 1, \dots, n$

$\frac{1}{\rho_O}$ → This is a measure of efficiency

In effect these three non-radial super-efficiency measures aim to measure super-efficiency by minimising a weighted $l_1$ distance from an efficient DMU to the production possibility set excluding the DMU being assessed. This non-radial super-efficiency measure based on the SBM model can be extended to variable returns-to-scale through the imposition of the convexity constraint, $\sum \lambda_j = 1$. Under this variable returns-to-scale metric, the non-oriented model is feasible, but the input-oriented and output-oriented models suffer the same potential infeasibility issues as the radial super-efficiency measures under variable returns-to-scale.

### 4.1.7: DEA Model Selection

Model selection is an important problem for consideration when utilising DEA in a study, not just in terms of whether the DEA model itself is suitable for use in meeting the aims of the study and the justification for its use in the study, but also in terms of whether multiple models are used to test whether the results obtained are or are not dependent on the DEA models utilised as, for example, undertaken in Ahn and Seiford (1993). Furthermore, continuing in this vein, it can be beneficial to cross-check the results from DEA against other methods such as statistical regression as performed in Lovell et al (1994). Some important points to consider when selecting the type of DEA model to be utilised in a study include unit invariance, translation invariance, the orientation of the model, the shape of the production possibility set and whether a radial or non-radial DEA model is most suitable given the characteristics of the inputs and outputs.

### 4.1.8: Bootstrapping In Data Envelopment Analysis

The method to implement bootstrapping in data envelopment analysis was introduced by Simar and Wilson (1998), and it allowed an analysis of the sensitivity of efficiency ratings relative to the sampling variations of the estimated production frontier. The statistical estimators of the production frontier in DEA are based on a finite sample of observed DMUs, thus leading to the sensitivity of the corresponding efficiency measures to the sampling variations of the obtained frontier. It is crucial to emphasise that up to this point the efficiency rating has been a deterministic measure of distance, however Simar and Wilson introduce the idea that there is a ‘true’ measure of efficiency which is observed with error, and that the DEA rating is an estimator of this ‘true’ rating, but the properties of the error are unknown. It was shown in Korostelev et al (1995a) and Korostelev et al (1995b) that DEA estimators are consistent under very weak general conditions, but the convergence rates were very slow, and thus this led to the attractiveness of the bootstrap methodology for the analysis of the sensitivity of efficiency ratings to the sampling variations.

The bootstrap was introduced in Efron (1979) based around the repeated simulation of the data generating process (DGP) and applying the original estimator to imitate the sampling distribution of the original estimator. The repeated simulation of the DGP is usually done through a process of re-sampling. In theory, this can be performed for any estimator based on the data, conditional on the proper simulation of the underlying DGP. In the case of the non-parametric frontier estimation of DEA, the main problem in implementing the bootstrap is related to the simulation of the DGP.

The complete bootstrap process for bootstrapping in DEA as developed in Simar and Wilson (1998) is outlined as follows:

1 → For each $(x_j, y_j)$ $j = 1, \dots, n$ compute $\hat{\theta}_j$ using the DEA model. Here, in common with Simar and Wilson (1998), the input-oriented BCC DEA model is used, but the procedure can be modified to use other DEA model variations.

2 → Define the empirical distribution function $\hat{F}$ putting mass $\frac{1}{n}$ on $\hat{\theta}_i$ $i = 1, \dots, n$.

3 → Generate a random sample of size $n$ from a smoothed version of $\hat{F}$: $\theta^*_{1b}, \dots, \theta^*_{nb}$.

4 → Compute $X^*_b = \{(x^*_{ib}, y_i)\ i = 1, \dots, n\}$ where $x^*_{ib} = \frac{\hat{\theta}_i}{\theta^*_{ib}} x_i$ $i = 1, \dots, n$.

5 → Compute the bootstrap estimate of $\hat{\theta}_j$: $\hat{\theta}^*_{j,b}$ for $j = 1, \dots, n$ by solving:

$$\hat{\theta}^*_{j,b} = \text{Min}\left\{\theta \middle| \ \theta x_j \geq \sum_{i=1}^{n} \lambda_i x^*_{j,b}, y_j \leq \sum_{i=1}^{n} \lambda_i y_i ; \sum_{i=1}^{n} \lambda_i = 1;\ \lambda_i \geq 0;\ i = 1, \dots, n\right\}$$

6 → Repeat steps 3 to 5 $B$ times to provide for $j = 1, \dots, n$ a set of estimates $\{\hat{\theta}^*_{j,b}, b = 1, \dots, B\}$.

It is worthwhile noting here that in the Simar and Wilson (1998) DEA bootstrap discussed above there is a drawback due to the procedure for constructing the confidence intervals which depends on the bias of the DEA estimators being corrected using bootstrap estimates of bias. Using these bias estimates leads to additional noise in the procedure, and thus in Simar and Wilson (2000) an improved procedure is outlined which automatically corrects for bias without the use of the bias estimator, negating the drawback of additional noise.

DEA bootstrapping is usually used to carry out testing of hypotheses such as whether two DMUs from the same sample have significantly different efficiency ratings, whether two DMUs from different samples have significantly different efficiency ratings and finally, whether two samples have equal average efficiency ratings.

### *4.1.9: The Application Of Data Envelopment Analysis*

Since the introduction of data envelopment analysis in the seminal paper by Charnes et al (1978), it has been applied to undertake an evaluation of efficiency in numerous studies targeting a plethora of different areas. The diverse range of areas which have been the subject of studies using DEA to assess the efficiency of DMUs include banks and other financial institutions, universities, hospitals, police forces, electricity distribution networks, power plants, the airline industry, container ports, U.S. Air Force fighter wings, mining, agriculture, software development, sports teams, construction, telecommunications, the macroeconomic performance of governments and cities, turbofan jet engine efficiency, manufacturing performance, resource allocation and site selection. This small selection of applications to which DEA efficiency analysis has been applied highlights the diverse range of disciplines to which the techniques of DEA have spread, from banking and finance through to engineering.

When DEA was originally introduced, it was mainly targeted at public and not-for-profit entities. Applications in this area include the efficiency of hospitals in Sherman (1984), Banker et al (1986) and Jacobs (2001), the efficiency of universities and university departments in Athanassopoulos and Shale (1997), Cohn et al (1989), and Abbott and Doucouliagos (2003), police force efficiency in Thanassoulis (1995) and Drake and Simper (2000), and the macroeconomic performance of cities in Charnes et al (1989). Later, the application of DEA was extended to private sector, for-profit entities such as the airline industry and airports in Gillen and Lall (1997), Schefczyk (1993) and Scheraga (2004).

The use of DEA efficiency analysis in the assessment of bank and financial institution performance was pioneered by the likes of Sherman and Gold (1985) who looked at evaluating the operating efficiency of bank branches by focusing on a savings bank branch with 14 branch offices. Most DEA studies on banking efficiency concentrate on banking institutions as a whole such as the recent studies by Lozano-Vivas et al (2002), Webb (2003) and Drake et al (2006). There are a large range of problems that have been the focus of studies in this area including the selection of appropriate input and outputs in Berger and Humphrey (1997), adjusting bank efficiency ratings for risk and environmental factors in Pastor (2002) and Avkiran (2009), bank branch network efficiency in Drake and Howcroft (1994), and cross-country comparisons of banking efficiency in Casu and Molyneux (2003) and Beccalli et al (2006). This represents only a fraction of the studies undertaken in terms of evaluating bank efficiency utilising DEA, and Fethi and Pasiouras (2010) provide a comprehensive overview of the studies undertaken and problems assessed in the area of bank efficiency.

Some other interesting applications of the DEA technique include maintenance operations efficiency in U.S. Air Force fighter wings in Charnes et al (1985a), turbofan jet engine efficiency in

Bulla et al (2000), electricity distribution networks in Weyman-Jones et al (2010), resource allocation in Bessent et al (1983) and site selection in Desai et al (1994).

## 4.2: Dealing With Negative Data In Data Envelopment Analysis

One particular issue with data envelopment analysis concerns the presence of negative data in the underlying dataset of inputs and/or outputs of the DMUs under evaluation. This is particularly prevalent in financial data such as that for banks and importantly, in the context of this thesis, mutual funds where you have the possibility of both positive and negative returns. One of the original assumptions of traditional DEA models was that all the input and output variables have to be non-negative. The most common method that has traditionally been used to deal with negative data is data transformations such as in Lovell (1995) and Seiford and Zhu (2002). These data transformations can involve various different procedures to achieve the transformation to positive data, with an example being to substitute a very small positive value for a negative output value on the basis that DEA aims to show each DMU in the best way possible by accentuating the outputs it performs best on, and thus an output with a very small positive value would be unlikely to contribute towards the efficiency rating of the DMU. Furthermore, the translation invariant Additive model of Charnes et al (1985b) can be applied to a dataset containing negative data in one of two ways, either it can be applied directly to the negative data or it can be applied to the data after it has had a large enough positive value added to make all the data positive. However, although the Additive model is able to correctly determine the efficient and inefficient DMUs, its disadvantages are that it does not provide an actually measure of efficiency and it is units-dependent. Finally, Scheel (2001) suggests dealing with negative data in DEA by treating the absolute values of negative inputs as outputs and treating the absolute values of negative outputs as inputs. However, this approach can only be used when all the DMUs have a negative value on the variable, such as may be the case with undesirable outputs. It cannot be used when a variable is positive for some DMUs and negative for other DMUs.

In addition to these methods which attempt to deal with the problem of negative data in DEA, there are three more recent approaches to the problem that are worth highlighting. They are the Range Directional Measure (RDM) developed by Portela et al (2004), the Modified Slacks-Based Measure (MSBM) developed by Sharp et al (2006) and the Semi-Oriented Radial Measure (SORM) developed by Emrouznejad et al (2010).

### *4.2.1: The Range Directional Measure (RDM)*

Portela et al (2004) introduced the Range Directional Measure (RDM) DEA model for when some of the inputs and/or outputs take a mix of positive and negative values. The main advantages of the model they propose are that, firstly, it can be applied to negative data without requiring any transformation of the data and secondly, it leads to a measure of efficiency similar to the original radial measures in DEA. The RDM DEA model is based on a modified version of the generic directional distance model from Chambers et al (1996) and Chambers et al (1998). This generic directional distance model which is the basis of the RDM DEA model is shown below:

Max $\beta_0$

Subject To:

$$\sum_{j=1}^{n} \lambda_j x_{ij} \leq x_{i0} - \beta_0 g_{xi}$$

$$\sum_{j=1}^{n} \lambda_j y_{rj} \geq y_{r0} + \beta_0 g_{yr}$$

$$\sum_{j=1}^{n} \lambda_j = 1$$

$$\lambda_j \geq 0 \qquad \beta_0 \geq 0 \qquad g_{xi} \geq 0 \qquad g_{yr} \geq 0$$

$$i = 1, \ldots, m \qquad r = 1, \ldots, s \qquad j = 1, \ldots, n$$

$0 \leq 1 - \beta_0 \leq 1$ → This is a measure of efficiency

The normal selection for the direction vectors, $g_{xi}$ and $g_{yr}$, when the data is positive, is to utilise the input and output values respectively of the DMU under assessment, $DMU_0$. However, when negative data is present in the underlying dataset, the input and output values cannot be used as this would violate the non-negative constraints of the model. This led Portela et al (2004) to modify this generic directional distance model by creating an ideal point to identify the direction vectors as follows:

$$Ideal\ Point\ (I) = \left(\underset{j}{\mathrm{Min}}\{X_{ij}, i = 1, \ldots, m\}, \underset{j}{\mathrm{Max}}\{Y_{rj}, r = 1, \ldots, s\}\right)$$

$$R_{i0} = X_{i0} - \underset{j}{\mathrm{Min}}\{X_{ij}, j = 1, \ldots, n\} \qquad i = 1, \ldots, m$$

$$R_{r0} = \underset{j}{\mathrm{Max}}\{Y_{rj}, j = 1, \ldots, n\} - Y_{r0} \qquad r = 1, \ldots, s$$

The directions $R_{i0}$ and $R_{r0}$ represent the direction from $DMU_0$ to the ideal point. Using these modified directions, Portela et al (2004) create two different versions of the RDM DEA model, the $RDM^{+}$ model and the $RDM^{-}$ model, as formulated below:

$\{RDM^{+}\}$ $\quad \mathrm{Max}\, \beta_0$

Subject To:

$$\sum_{j=1}^{n} \lambda_j X_{ij} \leq X_{i0} - \beta_0 R_{i0}$$

$$\sum_{j=1}^{n} \lambda_j Y_{rj} \geq Y_{r0} + \beta_0 R_{r0}$$

$$\sum_{j=1}^{n} \lambda_j = 1$$

$\lambda_j \geq 0 \qquad \beta_0 \geq 0$

$i = 1, \dots, m \qquad r = 1, \dots, s \qquad j = 1, \dots, n$

$0 \leq 1 - \beta_0 \leq 1$ → This is a measure of efficiency

$\{RDM^{-}\}$ Max $\beta_0$

Subject To:

$$\sum_{j=1}^{n} \lambda_j X_{ij} \leq X_{i0} - \beta_0 \frac{1}{R_{i0}}$$

$$\sum_{j=1}^{n} \lambda_j Y_{rj} \geq Y_{r0} + \beta_0 \frac{1}{R_{r0}}$$

$$\sum_{j=1}^{n} \lambda_j = 1$$

$\lambda_j \geq 0 \qquad \beta_0 \geq 0$

$i = 1, \dots, m \qquad r = 1, \dots, s \qquad j = 1, \dots, n$

$0 \leq 1 - \beta_0 \leq 1$ → This is a measure of efficiency

The $RDM^+$ model aims to identify targets for $DMU_0$ such that the main aim is to improve its performance in those areas where it performs worst in terms of the distance from the efficient frontier, whilst the $RDM^-$ model aims to identify targets for $DMU_0$ such that the main aim is to improve its performance in those areas where it performs best in terms of the distance from the efficient frontier.

### *4.2.2: The Modified Slacks-Based Measure (MSBM)*

The Modified Slacks-Based Measure (MSBM) DEA model was proposed in Sharp et al (2006), based on modifying the standard SBM DEA model by drawing from the $RDM^+$ method from Portela et al (2004). The MSBM DEA model is formulated as shown below:

$$\{MSBM\} \quad \text{Min}\, \rho = 1 - \sum_{i=1}^{m} \frac{w_i s_i^-}{R_{i0}}$$

Subject To:

$$1 = \sum_{r=1}^{s} \frac{v_r s_r^+}{R_{r0}}$$

$$\sum_{j=1}^{n} \lambda_j x_{ij} + s_i^- = x_{i0} \qquad \forall i$$

$$\sum_{j=1}^{n} \lambda_j y_{rj} - s_r^+ = y_{r0} \qquad \forall r$$

$$\sum_{j=1}^{n} \lambda_j = 1 \qquad \sum_{i=1}^{m} w_i = 1 \qquad \sum_{r=1}^{s} v_r = 1$$

$\lambda_j \geq 0 \qquad s_i^- \geq 0 \qquad s_r^+ \geq 0 \qquad w_i \geq 0 \qquad v_r \geq 0$

$i = 1, \dots, m \qquad r = 1, \dots, s \qquad j = 1, \dots, n$

$0 \leq \rho \leq 1$ → This is a measure of efficiency

Where:

1. $R_{i0} = X_{i0} - \text{Min}_j\{X_{ij}, j = 1, \dots, n\} \qquad i = 1, \dots, m$
2. $R_{r0} = \text{Max}_j\{Y_{rj}, j = 1, \dots, n\} - Y_{r0} \qquad r = 1, \dots, s$
3. $w_i$ and $v_r$ are user specified weights to reflect the strength of preference for improving the value of the input or output concerned

This MSBM measure of efficiency produces an efficiency rating between 0 and 1, takes into account both the input and output slacks, and is also both units invariant and translation invariant. However, it is important to consider that, as highlighted in Sharp et al (2006), the MSBM DEA model is designed for 'naturally negative' inputs and outputs. The consequence of this is that the application of the MSBM DEA model is more restricted than both the RDM and SORM models.

### *4.2.3: The Semi-Oriented Radial Measure (SORM)*

The Semi-Oriented Radial Measure (SORM) was developed by Emrouznejad et al (2010) as a modification that can be applied to a standard DEA model that enables the model to deal with variables, both inputs and outputs, that are positive for some DMUs and negative for other DMUs, whilst still providing a measure of efficiency. The problem that arises with the presence of negative data is that when there is an input that is positive for some DMUs and negative for other DMUs, the absolute value of the input should fall when the DMU has a positive value for the input and it should rise when the DMU has a negative value for the input in order for the DMU concerned to improve its performance. In the case of an output that is positive for some DMUs and negative for other DMUs, the absolute value of the output should rise when the DMU has a positive value for the output and it should fall when the DMU has a negative value for the output in order for the DMU concerned to improve its performance.

The SORM procedure deals with the negative data issue by splitting each input and each output that has positive values for some DMUs and negative values for other DMUs in to two variables. So taking an input variable $x_k$ which is positive for some DMUs and negative for other DMUs, it can be split in to two variables, $x_k^1$ and $x_k^2$, which for the $jth$ DMU take the values $x_{kj}^1$ and $x_{kj}^2$ defined such that:

$$x_{kj}^1 = \begin{cases} x_{kj} & if\ x_{kj} \geq 0 \\ 0 & if\ x_{kj} < 0 \end{cases} \qquad \& \qquad x_{kj}^2 = \begin{cases} 0 & if\ x_{kj} \geq 0 \\ -x_{kj} & if\ x_{kj} < 0 \end{cases}$$

Also, $x_{kj}^1 \geq 0$ and $x_{kj}^2 \geq 0$, whilst $x_{kj} = x_{kj}^1 - x_{kj}^2$ for all $j$.

Thus, this creates two non-negative variables for each DMU from a single input variable that originally took positive values for some of the DMUs and negative values for the other DMUs. The result of this is that, in effect, we can treat the negative input values as outputs due to the fact that the model will search for improved solutions which raise the absolute value of the negative input. However, this is only the case for the DMUs which have a negative value on the input variable in question, whilst for those DMUs which have a positive value on the input variable in question, the variable is treated as a normal input.

For the case of output variables, if we have an output variable $y_l$ which is positive for some DMUs and negative for other DMUs, it can be split in to two variables, $y_l^1$ and $y_l^2$, which for the $jth$ DMU take the values $y_{lj}^1$ and $y_{lj}^2$ defined such that:

$$y_{lj}^1 = \begin{cases} y_{lj} & if\ y_{lj} \geq 0 \\ 0 & if\ y_{lj} < 0 \end{cases} \qquad \& \qquad y_{lj}^2 = \begin{cases} 0 & if\ y_{lj} \geq 0 \\ -y_{lj} & if\ y_{lj} < 0 \end{cases}$$

Also, $y_{lj}^1 \geq 0$ and $y_{lj}^2 \geq 0$, whilst $y_{lj} = y_{lj}^1 - y_{lj}^2$ for all $j$.

Thus, this creates two non-negative variables for each DMU from a single output variable that originally took positive values for some of the DMUs and negative values for the other DMUs. The result of this is that, in effect, we are able to treat the negative output values as inputs due to the fact that the model searches for improved solutions which will reduce the absolute value of the negative output. However, this is only the case for the DMUs which have a negative value on the output variable in question, whilst for those DMUs which have a positive value on the output variable in question, the variable is treated as a normal output.

This SORM methodology can then be used to modify the standard DEA model to allow it to deal with negative data in both inputs and outputs. In common with Emrouznejad et al (2010), it is used to modify the BCC DEA model of Banker et al (1984), leading to the SORMBCC DEA model as shown below:

$$I \cup K = 1, \dots, m \quad I \cap K = \emptyset$$

$$R \cup L = 1, \dots, s \quad R \cap L = \emptyset$$

$$\begin{matrix} x_i & i \in I \\ y_r & r \in R \end{matrix} \rightarrow Positive\ For\ All\ DMUs$$

$$\begin{matrix} x_k & k \in K \\ y_l & l \in L \end{matrix} \rightarrow \textit{Positive For Some And Negative For Other DMUs}$$

$\{SORMBCC - IO\}$ Min $\theta$

Subject To:

$$\sum_{j=1}^{n} \lambda_j x_{ij} \leq x_{i0}\theta \qquad \forall i \in I$$

$$\sum_{j=1}^{n} \lambda_j x_{kj}^1 \leq x_{k0}^1\theta \qquad \forall k \in K$$

$$\sum_{j=1}^{n} \lambda_j x_{kj}^2 \geq x_{k0}^2\theta \qquad \forall k \in K$$

$$\sum_{j=1}^{n} \lambda_j y_{rj} \geq y_{r0} \qquad \forall r \in R$$

$$\sum_{j=1}^{n} \lambda_j y_{lj}^1 \geq y_{l0}^1 \qquad \forall l \in L$$

$$\sum_{j=1}^{n} \lambda_j y_{lj}^2 \leq y_{l0}^2 \qquad \forall l \in L$$

$$\sum_{j=1}^{n} \lambda_j = 1$$

$\lambda_j \geq 0$

$j = 1, \dots, n$

$0 \leq \theta \leq 1$ → This is a measure of efficiency

$\{SORMBCC - OO\}$ Max $\gamma$

Subject To:

$$\sum_{j=1}^{n} \lambda_j x_{ij} \leq x_{i0} \qquad \forall i \in I$$

$$\sum_{j=1}^{n} \lambda_j x_{kj}^{1} \leq x_{k0}^{1} \qquad \forall k \in K$$

$$\sum_{j=1}^{n} \lambda_j x_{kj}^{2} \geq x_{k0}^{2} \qquad \forall k \in K$$

$$\sum_{j=1}^{n} \lambda_j y_{rj} \geq y_{r0}\gamma \qquad \forall r \in R$$

$$\sum_{j=1}^{n} \lambda_j y_{lj}^{1} \geq y_{l0}^{1}\gamma \qquad \forall l \in L$$

$$\sum_{j=1}^{n} \lambda_j y_{lj}^{2} \leq y_{l0}^{2}\gamma \qquad \forall l \in L$$

$$\sum_{j=1}^{n} \lambda_j = 1$$

$$\lambda_j \geq 0$$

$$j = 1, \dots, n$$

$0 \leq \frac{1}{\gamma} \leq 1$ → This is a measure of efficiency

These two SORMBCC DEA models, input-oriented and output-oriented, are able to cope with both positive and negative data values in both inputs and outputs. The SORM procedure can be applied to other standard DEA models to allow them to deal with negative data in the same way as in, for example, Hadad et al (2012).

The most important feature of the SORM method is that for each input or output variable that takes positive values for some DMUs and negative values for other DMUs, the method creates two variables, one of which takes the positive values and one of which takes the negative values, so that when combined, the result is the original value of the variable. This distinguishes the SORM method from the other approaches to negative data mentioned, the RDM model and the MSBM model, leading to both an advantage and disadvantage. The advantage of the SORM method is that the negative part of a variable can be considered in terms of absolute value, and therefore in positive terms without the necessity of arbitrary changes of origin. The disadvantage of the SORM method is that there is an increase in the dimensionality of the problem due to the negative part of a variable being considered as a distinct variable, and thus part of the original production possibility set is deleted so Pareto efficient targets may not be obtained.

## *4.3: The Application Of Data Envelopment Analysis To The Assessment Of The Managerial Performance Of Mutual Funds*

Murthi et al (1997) were the first to apply the non-parametric data envelopment analysis methodology to the assessment of mutual fund performance. Murthi et al (1997; 408) noted that the traditional attempts at assessing mutual fund performance, such as the Sharpe (1966) reward-to-variability ratio index and the Jensen (1968) alpha index, suffered from a number of limitations including the issue of the selection of an appropriate benchmark to be used and the incorporation of transaction costs into the model. They proposed the use of a non-parametric DEA based methodology to attempt to develop a relative performance measure for assessing mutual fund performance called the DEA portfolio efficiency index (DPEI), which deals with the issues that are associated with the traditional indices by removing the need for the specification of a benchmark and by including the transaction costs in the analysis.

Murthi et al (1997) developed the DPEI index by modifying the reward-to-variability ratio index proposed by Sharpe (1966) and then using the radial CCR DEA model to formulate a fractional program that can then be reduced to a linear program which is easy to solve. The DPEI index model they developed is shown below:

$$\{DPEI\} \quad \text{Max} \frac{R_0}{\sum_{i=1}^{I} w_i x_{i0} + v\sigma_0}$$

Subject To:

$$\frac{R_j}{\sum_{i=1}^{I} w_i x_{ij} + v\sigma_j} \leq 1$$

$$w_i, v \geq \varepsilon$$

$$j = 1, \ldots, J$$

Where:

1. $R_j$ is the value of the return for the $jth$ fund

2. $x_{ij}$ is the value of the $ith$ transaction cost for the $jth$ fund

3. $J$ is the number of funds in the category

4. $I$ is the number of inputs

5. $\varepsilon$ is a non-Archimedean infinitesimal (NAI)

The DPEI index model uses one output for mutual funds, the return, and four inputs for mutual funds which are the standard deviation as the measure of risk, the expense ratio as a measure of the operational expenses incurred, the turnover as a measure of the trading activity of the fund manager and the load as a measure of the cost investors may face on initial investment in the fund or withdrawal of their investment from the fund. The main issue with the DPEI index is that it restricts the risk measures to only one risk factor, standard deviation, and in doing so it is likely to restrict the accuracy and usefulness of the results as the DPEI index is unable to incorporate the influence of any other risk measures on the return of the mutual funds.

Choi and Murthi (2001) develop the DPEI index model further by suggesting that individual mutual funds operate at different levels of scale, and consequently this may have an impact on the performance of the fund despite the skill of the manager of the fund. As a result it is necessary to deal with the impact that the differing scales at which mutual funds operate has on the performance evaluation of mutual funds, and Choi and Murthi (2001) accomplish this by utilising the variable returns-to-scale BCC DEA model in place of the constant returns-to-scale CCR DEA model used by Murthi et al (1997) for the DPEI index. Choi and Murthi (2001) use the same inputs and outputs, and the same dataset, as the earlier work by Murthi et al (1997). Consequently, the model developed in Choi and Murthi (2001) has the same flaw as the earlier DPEI index in that it restricts the risk measures to the standard deviation of the fund return only, and therefore like the DPEI index model the accuracy and usefulness of the results will be restricted due to the inability of the model to incorporate the influence of other risk measures on the return of the mutual funds.

Basso and Funari (2001) develop the work started by Murthi et al (1997) by creating two DEA performance measures for mutual funds called $I_{DEA\_1}$ and $I_{DEA\_2}$. The fractional linear programming problem formulation of the $I_{DEA\_1}$ index is shown below:

$$\{I_{DEA_1}\} \qquad \underset{(u,v_i,w_i)}{\text{Max}} \frac{uo_{j_0}}{\sum_{i=1}^{h} v_i q_{ij_0} + \sum_{i=1}^{k} w_i c_{ij_0}}$$

Subject To:

$$\frac{uo_j}{\sum_{i=1}^{h} v_i q_{ij} + \sum_{i=1}^{k} w_i c_{ij}} \leq 1$$

$u, v_i, w_i \geq \varepsilon$

$j = 1, \dots, n$

Where:

1. $o_j$ is the output which is either the return or the excess return

2. $c_{ij}$ are the subscription and redemption costs

3. $q_{ij}$ are the risk measures

4. $\varepsilon$ is a non-Archimedean infinitesimal (NAI)

The $I_{DEA\_1}$ index incorporates either the return or the excess return as its single output, three different risk measures, standard deviation, standard semideviation and beta, as inputs along with the percentage subscription costs per different amounts of initial investment and the percentage redemption costs per length of investment period as the other inputs. The $I_{DEA\_1}$ index differs from the DPEI index as it can incorporate a number of risk measures whereas the DPEI index is only designed to use the standard deviation as the single risk measure, and therefore the $I_{DEA\_1}$ index can be considered to be a generalisation of the earlier DPEI index. The $I_{DEA\_1}$ index has only one output which differentiates it from the second DEA performance measure for mutual funds developed by Basso and Funari (2001), the $I_{DEA\_2}$ index, which has two outputs. The fractional linear programming problem formulation of the $I_{DEA\_2}$ index is shown below:

$$\{I_{DEA_2}\} \qquad \underset{(u_r, v_i, w_i)}{\text{Max}} \frac{u_1 o_{j_0} + u_2 d_{j_0}}{\sum_{i=1}^{h} v_i q_{ij_0} + \sum_{i=1}^{k} w_i c_{ij_0}}$$

Subject To:

$$\frac{u_1 o_j + u_2 d_j}{\sum_{i=1}^{h} v_i q_{ij} + \sum_{i=1}^{k} w_i c_{ij}} \leq 1$$

$$u_r, v_i, w_i \geq \varepsilon$$

$$j = 1, \dots, n$$

Where:

1. $o_j$ is the first output which is either the return or the excess return

2. $d_j$ is the second output which is the relative number of sub-periods in which the fund being evaluated is not dominated by any other fund (Stochastic Dominance Indicator)

3. $c_{ij}$ are the subscription and redemption costs

4. $q_{ij}$ are the risk measures

5. $\varepsilon$ is a non-Archimedean infinitesimal (NAI)

The $I_{DEA\_2}$ index is developed by extending the $I_{DEA\_1}$ index to incorporate an additional output which in this case is the stochastic dominance indicator. This additional output provides further information about the mutual fund return as it is important to take account of the stochastic dominance relationships between mutual fund returns due to the fact that a fund which is dominated by other funds should be rated less favourably.

Basso and Funari (2005a) develop their earlier work further by creating the $I_{DEA\_G}$ index which is a generalised, multiple input, multiple output DEA index. In addition to the outputs previously used in the $I_{DEA\_1}$ and $I_{DEA\_2}$ indices, the return and the stochastic dominance indicator, the $I_{DEA\_G}$ index includes the traditional performance indices, the Treynor index, the Sharpe index, the Jensen index and the reward-to-half-variance index. The fractional linear programming problem formulation of the $I_{DEA\_G}$ index is shown below:

$$\{I_{DEA_G}\} \quad \underset{(u_r, w_r, v_i, w_i)}{\text{Max}} \frac{u_1 o_{j_0} + u_2 d_{j_0} + \sum_{r=1}^{p} w_r I_{r j_0}}{\sum_{i=1}^{h} v_i q_{i j_0} + \sum_{i=1}^{k} w_i c_{i j_0}}$$

Subject To:

$$\frac{u_1 o_j + u_2 d_j + \sum_{r=1}^{p} w_r I_{rj}}{\sum_{i=1}^{h} v_i q_{ij} + \sum_{i=1}^{k} w_i c_{ij}} \leq 1$$

$$u_r, w_r, v_i, w_i \geq \varepsilon$$

$$j = 1, \dots, n$$

Where:

1. $o_j$ is the first output which is either the return or the excess return

2. $d_j$ is the second output which is the relative number of sub-periods in which the fund being evaluated is not dominated by any other fund (Stochastic Dominance Indicator)

3. $I_{rj}$ are the traditional performance indices included in the $I_{DEA\_G}$ index model as outputs $\left(I_1 = I_{Sharpe}, I_2 = I_{Half-Variance}, I_3 = I_{Treynor}, I_4 = I_{Jensen}\right)$

4. $c_{ij}$ are the subscription and redemption costs

5. $q_{ij}$ are the risk measures

6. $\varepsilon$ is a non-Archimedean infinitesimal (NAI)

The $I_{DEA\_1}$ index, the $I_{DEA\_2}$ index and the $I_{DEA\_G}$ index are all analysed empirically on the same dataset, and consequently Basso and Funari (2005a) compare the efficiency ratings obtained for the mutual funds in the dataset using the three different DEA performance indices.

Galagedera and Silvapulle (2002) take a different approach and look at using DEA to assess mutual fund performance across different time horizons. They utilise the variable returns-to-scale BCC DEA model and run eleven different input/output specifications which contain between five and eleven variables. They incorporate different time horizons into the model by using the 1, 2, 3 and 5 year gross return, and the 1, 2, 3 and 5 year standard deviation of returns. They produce some interesting results which suggest that using DEA relative efficiency ratings to rank mutual funds is robust to the time horizon. Some other interesting studies in the area of the assessment of mutual fund performance using DEA include Basso and Funari (2003) who develop a DEA performance measure for ethical mutual funds, and Morey and Morey (1999) who apply the philosophy of DEA to mutual fund performance assessment in a novel way that simultaneously examines both the mutual fund risk and the mutual fund return over different time horizons.

Some of the main advantages of the use of the non-parametric DEA approach in the assessment of mutual fund performance over the use of the traditional indices that have been identified in the literature are as follows. Firstly, because DEA is a non-parametric technique it measures the performance of a fund relative to the best set of funds within a similar investment objective category, and consequently DEA does not require the use of theoretical models like the capital asset pricing model (CAPM) or the arbitrage pricing theory (APT) to provide benchmarks. The use of DEA does not impose an assumed functional form on the input/output specification which is a useful feature when the relationship is unknown. Finally, DEA does not only allow the identification of the inefficient funds, it can also identify the source and magnitude of inefficiency, thus suggesting the route to turn an inefficient fund into an efficient one.

Finally, it is worth highlighting two recently developed non-parametric frontier methods, namely the Order-*m* methodology of Cazals et al (2002) and the Order-α methodology of Aragon et al (2005) / Daouia and Simar (2007), which have been applied to the assessment of the performance of mutual funds. These two methodologies are closely related to DEA and its non-convex variant, Free Disposal Hull (FDH) proposed by De Prins et al (1984), but they differ in that the underlying idea is to estimate a partial frontier within the cloud of DMU data points that is close to either the lower or upper boundary, and thus it is simultaneously both sensitive to the magnitude of extreme outliers and robust to their influence. In this way they negate the issue of sensitivity to extreme outliers that afflicts DEA and FDH estimators, and thus they can improve the estimation of efficiency.

The Order-*m* methodology developed by Cazals et al (2002) uses as the benchmark either the expected minimum input achieved by any *m* DMUs selected randomly from the population in the input-oriented case or the expected maximum output achieved by any *m* DMUs selected randomly from the population in the output-oriented case. The selection of a high value for *m* leads to the Order-*m* estimators producing the same benchmark as FDH, and thus the same efficiency results. The Order-*m* methodology is really useful if instead a finite value of *m* is selected as in this case the Order-*m* model does not envelop all the data, and therefore it is more robust to extreme outliers and consequently should produce more accurate estimations of efficiency. Order-*m* efficiency ratings are not bounded by 1 as DEA and FDH ratings are, Order-*m* efficiency ratings of 1 are still efficient DMUs but inefficient DMUs have ratings higher than 1.

The Order-α methodology developed by Aragon et al (2005), and extended by Daouia and Simar (2007), has some of the same foundations as the Order-*m* methodology, but while in the Order-*m* model *m* is a trimming parameter which enables the determination of the percentage of data points that will not be bounded by the frontier, in the Order-α model the frontier is calculated by setting the probability $(1 - \alpha)$ of observing data points outside the bounds of the Order-α frontier. So in essence the 'discrete' Order-*m* partial frontier is replaced by a 'continuous' Order-α partial frontier with α corresponding to the level of an appropriate non-standard conditional quantile frontier. Thus, for the Order-α model the benchmark is either the input level exceeded by $(1 - \alpha)$ x 100% of

DMUs among the population of DMUs in the input-oriented case or the output level not exceeded by $(1 - \alpha)$ x 100% of DMUs among the population of DMUs in the output-oriented case. When α is equal to 1 the Order-α estimators produces the same results as FDH estimators. Order-α efficiency ratings of 1 are classed as efficient and ratings greater than 1 are classed as inefficient.

These two non-parametric partial frontier methods, Order-*m* and Order-α, have recently been applied to the assessment of the performance of mutual funds in Matallin et al (2014), Abdelsalam et al (2013) and Abdelsalam et al (2014). In Matallin et al (2014), the Order-*m* and Order-α models are used to evaluate a sample of US mutual funds over the time period from 2001-2011 to determine the performance of the mutual funds, and the robustness of these results in terms of persistence is analysed. In Abdelsalam et al (2013), a two-stage analysis is used to undertake a direct comparison of socially responsible and Islamic mutual funds, with the first stage using partial frontier methods (Order-*m* and Order-α) to provide a robust analysis of the performance of the funds and the second stage using quantile regression methods to explicitly evaluate the comparative performance of socially responsible and Islamic funds. It finds that the average efficiency of socially responsible funds is slightly higher than that of Islamic funds, but this is only significant for the most inefficient funds and in the case of the best funds this higher performance evaporates, with Islamic funds actually performing better. In Abdelsalam et al (2014), a multi-stage analysis is used to evaluate the performance persistence of socially responsible and Islamic mutual funds, with a first stage using partial frontier methods (Order-*m* and Order-α) to measure the performance of the different mutual funds, a second stage in which these results are plugged in to different investment strategies based on a recursive estimation methodology and a third stage in which these different investment strategies have their performance persistence evaluated. The results indicate that for both socially responsible and Islamic mutual funds, there is persistence in performance, but only for the worst and the best funds.

Excellent summaries of the current state of the art literature in this field of mutual fund performance using non-parametric frontier methodologies can be found in Glawischnig and Sommersguter-Reichmann (2010), Kerstens et al (2011) and Brandouy et al (2012).

## *4.4: The Development Of Stochastic Frontier Analysis (SFA)*

Stochastic frontier analysis (SFA) was developed and published simultaneously in 1977 by Aigner et al (1977), and Meeusen and Van Den Broeck (1977). It is a parametric technique, that like the non-parametric DEA, was developed from the work of Farrell (1957). The original model specification that they proposed is shown below:

$$Y_i = x_i\beta + (v_i - u_i)$$

$$i = 1, \ldots, N$$

Where:

1. $Y_i$ is the production, or logarithm of the production, of the $ith$ firm

2. $x_i$ is a $k$ x 1 vector of input quantities of the $ith$ firm

3. $\beta$ is a vector of unknown parameters

4. $v_i$ are random variables which are assumed to be distributed as $N(0, \sigma_v^2)$ and independent of $u_i$ which are non-negative realisations of random variables which are assumed to account for technical inefficiency in production and are distributed as $N^+(0, \sigma_u^2)$

It is important to note at this point that having $u_i$ distributed as $u_i \sim N^+(0, \sigma_u^2)$ means that $u_i$ are normally distributed random variables, but negative drawings are discarded by nature and only non-negative values are assumed to be relevant in the sample. As a consequence, the composed error term, $(v_i - u_i)$, has a skewed distribution.

From looking at this original model specification it is possible to see that it involves a production function which uses cross-sectional data, and most importantly it has an error term which has two components to it, one of which accounts for random effects and one of which accounts for technical inefficiency. The SFA regressions can be solved using the econometric technique of maximum likelihood estimation.

This original methodology has been extended in numerous ways, of which the most important within the context of this thesis is the extension of the methodology to cost functions. In order to implement a stochastic frontier cost function, the error term has to be modified from $(v_i - u_i)$ to $(v_i + u_i)$. The reasoning behind this is that in the context of production, the efficient frontier is an upper bound to the dataset so the non-negative inefficiency term is subtracted from the frontier, whereas in the context of cost, the efficient frontier is a lower bound to the dataset so the non-negative inefficiency term is added to the frontier. This leads to the stochastic frontier cost function specified below:

$$Y_i = x_i\beta + (v_i + u_i)$$

$$i = 1, \dots, N$$

Where:

1. $Y_i$ is the cost of production, or logarithm of the cost of production, of the $ith$ firm
2. $x_i$ is a $k$ x 1 vector of input prices and output of the $ith$ firm
3. $\beta$ is a vector of unknown parameters

4. $v_i$ are random variables which are assumed to be distributed as $N(0, \sigma_v^2)$ and independent of $u_i$ which are non-negative random variables which are assumed to account for the cost of inefficiency in production and are distributed as $N(0, \sigma_u^2)$

## *4.5: Incorporating Environmental Effects And Statistical Noise Into DEA (DEA And SFA Combinations)*

One issue that has received a large amount of coverage in the literature is that of incorporating environmental effects and statistical noise into performance evaluation using data envelopment analysis. As noted by Fried et al (2002; 158), the performance of a decision making unit (DMU) is influenced by three distinct phenomena which are the efficiency of the management of the DMU at organising its activities, the operating environment in which the DMU carries out its activities, and the impact of luck, omitted variables and other related influences which would be collected in a random error term in a regression-based DMU performance evaluation. The first of these phenomena is endogenous to the DMU, whilst the other two are exogenous to the DMU, which means it is highly desirable to separate the impacts of the three phenomena on the performance of the DMU from each other. In this way it is possible to get a true rating of the managerial efficiency of the DMU's management which is free from the influence of the operating environment and statistical noise.

A large number of models have been proposed which aim to incorporate environmental effects, and in some of the most recent models, statistical noise, into DEA-based DMU performance evaluation. These models can be grouped into one-stage models, two-stage models and three-stage models.

The one-stage models were developed by incorporating the inputs, outputs and environmental factors into a DEA model in one go. The aim of this approach was to control for the impact of environmental factors in the DMU performance assessment. The main attempt at implementing a one-stage model approach was developed by Banker and Morey (1986) in which they developed a model which included non-discretionary environmental factors in the single-stage DEA model along with the inputs and outputs, but they then restrict the optimisation to either the inputs or the outputs. There are two major problems with the one-stage model approach which are that the impact direction of the environmental factors on the performance of the DMU must be known in advance and they are deterministic models which means that they cannot account for the effects of statistical noise.

The two-stage models were developed by incorporating the inputs and outputs into the first stage which employs DEA, and the environmental factors into the second stage. There are two categories of model within the two-stage model group which are differentiated according to the nature of the second stage of the model. The first sub-category contains models which employ a second stage which is also based on DEA, and therefore these two-stage models are deterministic and cannot account for the impact of statistical noise on the performance of the DMU. The second sub-category contains models which employ a second stage based on regression, and consequently these two-stage models are able to attribute part of the variation in the performance of a DMU to statistical noise.

The two-stage model approach was pioneered by Timmer (1971) who developed a two-stage model with a DEA first stage using inputs and outputs, followed by a second stage using regression analysis to attempt to explain the variation in the first stage DEA efficiency ratings caused by the impact of environmental factors. Since Timmer's pioneering work there have been numerous studies that have developed his two-stage approach further. McCarty and Yaisawarng (1993) and Bhattacharyya et al (1997) improve on the two-stage model by taking the residuals from the second stage regression and using them to adjust the first stage DEA efficiency ratings. Fried et al (1993) also implement a variation of the two-stage model by modifying the second stage regression analysis to use the slacks from the first stage as opposed to using the radial efficiency ratings from the first stage as previous studies had done.

Fried et al (1999) expanded the basic two-stage model into a four-stage variant. Fried et al's four-stage model starts with a standard first stage DEA analysis of the performance of the DMUs. This is followed by a second stage which uses Tobit regressions to regress the first stage slacks on the environmental factors to obtain predictions of the impact of these environmental factors on the first stage DEA efficiency ratings of the DMUs. The third stage involves using the results from the Tobit regressions to adjust the original data to account for the impact of the environmental factors and in the fourth stage, the initial DEA analysis is repeated using the adjusted data. The advantages of this procedure are that the second stage is stochastic in nature and it manages to incorporate the impact of the operating environment into the model. However, its major drawback is that it does not take account of the impact of statistical noise.

The three-stage model was proposed by Fried et al (2002) in their seminal paper which developed the three-stage DEA-SFA-DEA model by extending the two-stage regression-based model to devise a procedure that could incorporate the impact of both the operating environment and statistical noise on the DEA managerial efficiency ratings. Thus, for the first time, this three-stage DEA-SFA-DEA procedure allowed the three phenomena that influence the performance of DMUs to be fully decomposed. The first stage of the DEA-SFA-DEA procedure involves undertaking a standard DEA analysis of the performance of the DMUs. In the second stage, SFA is used to regress the first stage slacks on the environmental factors. The results from the second stage SFA regressions can then be used to adjust the original data for the impact of both the operating environment and statistical noise. Finally, in the third stage, the DEA analysis is repeated using the adjusted data. As a result, the third stage DEA managerial efficiency ratings obtained using this three-stage DEA-

SFA-DEA model will have been purged of the impact of the operating environment and statistical noise, and can therefore be considered more accurate and reliable. The details of this procedure can be seen in the methodology section of this thesis, Chapter 6, as it utilises this three-stage DEA-SFA-DEA method.

However, this three-stage DEA-SFA-DEA model developed by Fried et al (2002) has not been immune from criticism. A major concern with Fried et al's three-stage approach is that if the environmental factors and statistical noise are important, then this implies that the model should treat them directly because the three-stage model has to impose assumptions on performance in order to measure the impact of the operating environment and statistical noise which may not be true. As a consequence, it is possible that a one-stage stochastic frontier analysis (SFA) model may be a better option.

Another criticism that has been made about Fried et al's three-stage DEA-SFA-DEA model is that it uses the slacks from the BCC model which are not unit invariant, and they are also divided into radial and non-radial slacks which could result in the loss of useful information. Avkiran and Rowlands (2008) propose a modification of the three-stage model to address this issue. They propose the use of a non-oriented slacks-based measure (SBM) DEA model in the three-stage approach in order to obtain improved estimates of slacks that are unit invariant. Also, they propose a modification to the second stage of the three-stage model which involves using both input slacks and output slacks in the second stage SFA regressions to obtain more reliable efficiency results. Thus, the adjusted data they use in the third stage comprises of inputs and outputs that have been adjusted for the impact of the operating environment and statistical noise, resulting in third stage SBM DEA managerial efficiency ratings that have been purged of the influence of these two exogenous phenomena.

Furthermore, Avkiran and Rowlands (2008) propose a modification to the adjustment formula used in the second stage of the procedure to adjust the input and output data which is based around the notion of taking ratios instead of differences as done in the original procedure. The taking of ratios leads to an adjustment factor which then multiplies the observed input or output. The advantage of this approach is that the practitioner is able to easily identify the degree of adjustment that is attributable to the operating environment and the degree of adjustment that is attributable to statistical noise. The input ratio adjustment formula is as follows:

$$x_{ij}^{A} = x_{ij}\left(1 + AdjFactorEnviroment_{x_{ij}} + AdjFactorNoise_{x_{ij}}\right)$$

$$AdjFactorEnviroment_{x_{ij}} = \left(\frac{\mathrm{Max}_j\{z_j\hat{\beta}^i\}}{x_{ij}}\right)\left(1 - \frac{z_j\hat{\beta}^i}{\mathrm{Max}_j\{z_j\hat{\beta}^i\}}\right)$$

$$AdjFactorNoise_{x_{ij}} = \left(\frac{\mathrm{Max}_j\{\hat{v}_{ij}\}}{x_{ij}}\right)\left(1 - \frac{\hat{v}_{ij}}{\mathrm{Max}_j\{\hat{v}_{ij}\}}\right)$$

Where:

1. $x_{ij}^{A}$ is the adjusted quantity of the $ith$ input for the $jth$ DMU
2. $x_{ij}$ is the observed quantity of the $ith$ input for the $jth$ DMU
3. $z_j\hat{\beta}^i$ is the $ith$ input slack in the $jth$ DMU which can be attributed to environmental factors
4. $\hat{v}_{ij}$ is the $ith$ input slack in the $jth$ DMU which can be attributed to statistical noise

Here, $AdjFactorEnvironment_{x_{ij}}$ represents the upward percentage adjustment of the observed input for the impact of the environment, and $AdjFactorNoise_{x_{ij}}$ represents the upward percentage adjustment of the observed input for the impact of statistical noise.

The output ratio adjustment formula is as follows:

$$y_{rj}^{A} = y_{rj}\left(1 + AdjFactorEnviroment_{y_{rj}} + AdjFactorNoise_{y_{rj}}\right)$$

$$AdjFactorEnviroment_{y_{rj}} = \left(\frac{z_j\hat{\beta}^r}{y_{rj}}\right)\left(1 - \frac{\mathrm{Min}_j\{z_j\hat{\beta}^r\}}{z_j\hat{\beta}^r}\right)$$

$$AdjFactorNoise_{y_{rj}} = \left(\frac{\hat{v}_{rj}}{y_{rj}}\right)\left(1 - \frac{\mathrm{Min}_j\{\hat{v}_{rj}\}}{\hat{v}_{rj}}\right)$$

Where:

1. $y_{rj}^{A}$ is the adjusted quantity of the $rth$ output for the $jth$ DMU

2. $y_{rj}$ is the observed quantity of the $rth$ output for the $jth$ DMU

3. $z_j\hat{\beta}^r$ is the $rth$ output slack in the $jth$ DMU which can be attributed to environmental factors

4. $\hat{v}_{rj}$ is the $rth$ output slack in the $jth$ DMU which can be attributed to statistical noise

Here, $AdjFactorEnvironment_{y_{rj}}$ represents the upward percentage adjustment of the observed output for the impact of the environment, and $AdjFactorNoise_{y_{rj}}$ represents the upward percentage adjustment of the observed output for the impact of statistical noise.

Liu and Tone (2008) also propose modifications to Fried et al's three-stage DEA-SFA-DEA model in an attempt to deal with some of the criticisms that have been directed at it. They also suggest the use of a non-oriented weighted slacks-based measure (SBM) DEA model to address the problem of slacks that are not unit invariant, thus resulting in the estimation of slacks that are unit invariant. They also propose a second modification to deal with another criticism of Fried et al's three-stage DEA-SFA-DEA model which is that the standard SFA estimates of DMU inefficiency are highly sensitive to heteroscedasticity in the composed error term. Liu and Tone (2008; 76) note that because the success of Fried et al's three-stage approach depends on the robust decomposition of the composed error term, it is critical to correct for heteroscedasticity, and they propose to do this by employing a double heteroscedastic SFA model in the second stage to obtain estimates of inefficiency and statistical noise that are robust to heteroscedasticity. Liu and Tone's modified three-stage model aims to provide a significantly more accurate procedure for the assessment of DMU performance.

Finally, Tone and Tsutsui (2009) highlight a major shortcoming in the original data adjustment procedure in the original three-stage DEA-SFA-DEA method from Fried et al (2002) in that it may cause serious bias in the third stage DEA results due to the translation by adding a fixed constant value. It is worth noting here that this shortcoming is also present in the data adjustment procedure proposed in Avkiran and Rowlands (2008). They suggest a new data adjustment procedure that can be used in the second stage of the three-stage DEA-SFA-DEA method which deals with this shortcoming. This is formulated as follows:

$$Input\ Adjustment \rightarrow x_{ij}^{A} = x_{ij} - z_j^i \hat{\beta}^i - \hat{v}_{ij}$$

Where:

1. $x_{ij}^{A}$ is the adjusted quantity of the $ith$ input for the $jth$ DMU
2. $x_{ij}$ is the observed quantity of the $ith$ input for the $jth$ DMU
3. $z_j^i \hat{\beta}^i$ is the $ith$ input slack in the $jth$ DMU which can be attributed to environmental factors
4. $\hat{v}_{ij}$ is the $ith$ input slack in the $jth$ DMU which can be attributed to statistical noise

$$Output\ Adjustment \rightarrow y_{rj}^{A} = y_{rj} + z_j^r \hat{\beta}^r + \hat{v}_{rj}$$

Where:

1. $y_{rj}^{A}$ is the adjusted quantity of the $rth$ output for the $jth$ DMU

2. $y_{rj}$ is the observed quantity of the $rth$ output for the $jth$ DMU

3. $z_j^r \hat{\beta}^r$ is the $rth$ output slack in the $jth$ DMU which can be attributed to environmental factors

4. $\hat{v}_{rj}$ is the $rth$ output slack in the $jth$ DMU which can be attributed to statistical noise

$$Input\ Re - Adjustment\ \rightarrow\ x_{ij}^{AA} = \frac{x_{iMAX} - x_{iMIN}}{x_{iMAX}^{A} - x_{iMIN}^{A}}\left(x_{ij}^{A} - x_{iMIN}^{A}\right) + x_{iMIN}$$

Where:

1. $x_{ij}^{AA}$ is the re-adjusted quantity of the $ith$ input for the $jth$ DMU

2. $x_{ij}^{A}$ is the adjusted quantity of the $ith$ input for the $jth$ DMU

3. $x_{iMAX} = \mathrm{Max_j}\{x_{ij}\}$

4. $x_{iMIN} = \mathrm{Min_j}\{x_{ij}\}$

5. $x_{iMAX}^{A} = \mathrm{Max_j}\{x_{ij}^{A}\}$

6. $x_{iMIN}^{A} = \mathrm{Min_j}\{x_{ij}^{A}\}$

$$Output\ Re - Adjustment\ \rightarrow\ y_{rj}^{AA} = \frac{y_{rMAX} - y_{rMIN}}{y_{rMAX}^{A} - y_{rMIN}^{A}}\left(y_{rj}^{A} - y_{rMIN}^{A}\right) + y_{rMIN}$$

Where:

1. $y_{rj}^{AA}$ is the re-adjusted quantity of the $rth$ output for the $jth$ DMU

2. $y_{rj}^{A}$ is the adjusted quantity of the $rth$ output for the $jth$ DMU

3. $y_{rMAX} = \mathrm{Max_j}\{y_{rj}\}$

4. $y_{rMIN} = \mathrm{Min_j}\{y_{rj}\}$

5. $y_{rMAX}^{A} = \mathrm{Max_j}\{y_{rj}^{A}\}$

6. $y^{A}_{rMIN} = \mathrm{Min}_{j}\{y^{A}_{rj}\}$

Therefore, for the input side, the re-adjusted dataset $x^{AA}_{ij}$ remains in the range $|x_{iMIN}, x_{iMAX}|$ for all inputs, and the maximum and minimum values are the same between $x_{ij}$ and $x^{AA}_{ij}$. Further, for the output side, the re-adjusted dataset $y^{AA}_{rj}$ remains in the range $|y_{rMIN}, y_{rMAX}|$ for all outputs, and the maximum and minimum values are the same between $y_{rj}$ and $y^{AA}_{rj}$. These properties of this data adjustment procedure are beneficial in that they remove the ambiguity concerning the range of the adjusted input and output values that can affect the DEA ratings significantly.

# Chapter 5: Data Selection And Sourcing

The data that is used in this thesis has been obtained from three main sources, Morningstar, Datastream and MSCI. In the context of this thesis, Morningstar is used as the source for all the fundamental data concerning the mutual funds, while Datastream and MSCI are used solely as the sources for the data on market indices used in the SFA second stage of the three-stage DEA-SFA-DEA models.

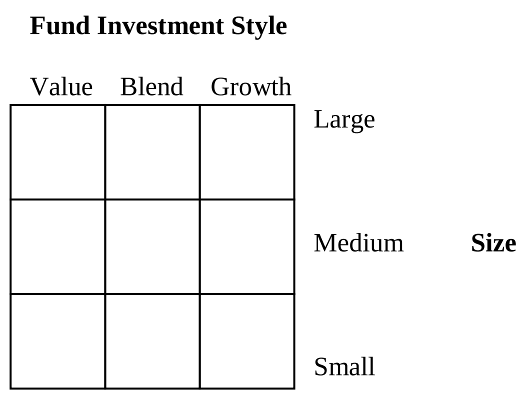
It is important to note at this point that in the context of this thesis two types of UK domiciled mutual fund are examined, the open-ended investment company (OEIC) which is an open-ended fund with a corporate structure, and the unit trust (UT) which is an open-ended fund with a trust structure. These two types of mutual fund are similar in nature, with the major difference being that the OEIC has a corporate organisational structure whereas the UT has a trust organisational structure. Another major difference is that a UT will have different purchase (Offer) and sale (Bid) prices for a unit, leading to the bid-offer spread which can be taken as a profit by the trust manager, whereas an OEIC will normally have a single price for both purchase and sale. However, recent change to the regulatory rules governing OEICs have permitted dual pricing to be introduced for OEICs, bringing them into line with UTs in this respect. A final difference is that an OEIC can act as an umbrella fund which holds various separate sub-funds which each have their own investment goals, resulting in some cost savings for the investment manager.

The OEIC is the preferred type of open-ended fund structure in the UK, specifically over the older unit trust fund structure, and in recent years many unit trusts have been converted into OEICs. The main rationale behind the preference for the OEIC is that they offer simplification and cost savings, and the possibility of cross-border marketing within the EU. It is important to highlight that in the US, OEICs and UTs are collectively known as mutual funds, to avoid any possible confusion. A more detailed examination of the different types of mutual fund and their naming can be found in the mutual fund industry chapter of this thesis.

This thesis will specifically target UK domiciled OEICs and UTs which have an investment focus target of either UK equity, US equity or global equity. OEICs/UTs in the global equity investment focus category invest in equity from any country. The OEICs/UTs will have an accumulation distribution status which means that they reinvest their income distributions such as dividends. Also, this thesis only includes OEICs and UTs which offer a non-institutional, retail class share/unit which is available to the general public as this is the class of share/unit used for the assessment of the managerial performance of the OEICs/UTs. The OEICs and UTs that are assessed in this thesis will be categorised using a combination of their investment focus and the Morningstar Style Box. Using these criteria results in a fund universe that totals 565 OEICs/UTs.

The Morningstar Style Box is a proprietary, nine-square grid that provides a graphical representation of the investment style of stocks and mutual funds as shown below:

Morningstar Style Box




Source: Morningstar UK

From looking at the style box above it is possible to see how it classifies equity shares and equity mutual funds by growth and value factors on the horizontal axis, and market capitalisation on the vertical axis. The horizontal axis provides three style categories, two of which, value and growth, are common to both equity shares and equity mutual funds. However, the central column of the style box represents the core style for shares which are shares for which neither value or growth characteristics dominate, whilst for equity mutual funds it represents the blend style which are funds which have either a mixture of value and growth shares, or mostly core style shares. The vertical axis provides three size categories which are small-capitalisation, medium-capitalisation and large-capitalisation.

The assignment of a style box begins at the level of the individual share when the investment style and capitalisation band of each individual share is determined. Individual shares are evaluated against other shares from the same geographical region in terms of both investment style and capitalisation. Firstly, to determine the horizontal, investment style placement of a share requires an assessment of the value and growth characteristics of that share using the following criteria:

**1. Value Score – Components And Weights**

a) Forward-looking measures (50%)

→ Price/prospective earnings

b) Historical-based measures (50%)

→ Price/book (12.5%)

→ Price/sales (12.5%)

→ Price/cash flow (12.5%)

→ Dividend yield (12.5%)

**2. Growth Score – Components And Weights**

a) Forward-looking measures (50%)

→ Long-term projected earnings growth

b) Historical-based measures (50%)

→ Historical earnings growth (12.5%)

→ Sales growth (12.5%)

→ Cash flow growth (12.5%)

→ Book value growth (12.5%)

The value and growth characteristics of the individual share under assessment are then compared to those of other shares which are in the same capitalisation band and located in the same geographical region, thus allowing the individual share to be scored from zero to 100 for both value and growth characteristics. Finally, to compute the overall investment style score for the individual share under assessment, the value score is subtracted from the growth score. The resulting investment style score will range from 100 for extreme growth shares to -100 for extreme value shares. A share is placed in the growth style if the net style score is equal to, or exceeds, the 'growth threshold', and is placed in the value style if the net style score is equal to, or less than, the 'value threshold'. If the net style score of a share falls between the two thresholds, then it is placed in the core style. The two thresholds vary over time as a result of variations in the distribution of shares' investment styles within the market, so that the three share investment styles each account for approximately a third of the free float market capitalisation in each capitalisation band.

The second step is to determine the vertical, capitalisation size placement of a share using the following process. For each geographical region, large-capitalisation shares account for the top 70% of the capitalisation of the region, with medium-capitalisation shares accounting for the next 20% of the capitalisation and small-capitalisation shares accounting for the final 10% of the capitalisation.

Lastly, to place an equity mutual fund in an appropriate style box, the style placings of the individual shares the fund has invested in are aggregated on one style box grid. Then an asset-weighted average of the investment style and capitalisation size of the underlying shares is calculated to determine the overall placement of the equity mutual fund in the style box.

By using, as the underlying basis for categorisation, a combination of both the investment focus of a fund and the Morningstar Style Box, the fund universe of 565 OEICs/UTs can be split into the following categories:

1 → UK Focused Large-Capitalisation Value Equity Funds

2 → UK Focused Large-Capitalisation Growth Equity Funds

3 → UK Focused Large-Capitalisation Blend Equity Funds

4 → UK Focused Mid-Capitalisation Equity Funds

5 → UK Focused Small-Capitalisation Equity Funds

6 → US Focused Large-Capitalisation Value And Growth Equity Funds

7 → US Focused Large-Capitalisation Blend Equity Funds

8 → US Focused Mid-Capitalisation And Small-Capitalisation Equity Funds

9 → Global Focused Large-Capitalisation Value Equity Funds

10 → Global Focused Large-Capitalisation Growth Equity Funds

11 → Global Focused Large-Capitalisation Blend Equity Funds

12 → Global Focused Mid-Capitalisation And Small-Capitalisation Equity Funds

By breaking the fund universe of 565 OEICs/UTs down into these categories, it allows a more valid comparison of the managerial performance of the funds to be made as they can be assessed against other funds which have similar investment aims. In addition to the relevant OEICs/UTs, each category will also contain an exchange-traded fund (ETF) that tracks an appropriate market index, thus allowing an evaluation of whether the expensive, professionally managed OEICs/UTs can justify their high cost with respect to low-cost, simple index trackers by producing superior, post-cost performance. The ETFs used are as follows:

1 → iShares FTSE 100 ETF – Categories 1, 2 And 3

2 → iShares FTSE 250 ETF – Categories 4 And 5

3 → iShares S&P 500 ETF – Categories 6, 7 And 8

4 → iShares MSCI World ETF – Categories 9, 10, 11 And 12

The data that is being used in this thesis covers a three year period from 1st January 2008 to 31st December 2010. The data used is monthly frequency data over this period for two of the inputs, the three-year standard deviation and the three-year Sharpe ratio, the one output, the three-year annualised return, and the data on the market indices in the form of their three-year annualised returns. For the remaining two inputs, the total expense ratio (TER) and the fund size, the data used is as at the 31st December 2010. The time period from 1st January 2008 to 31st December 2010 is an interesting one during which to examine the managerial performance of OEICs/UTs due to the challenging conditions in the financial markets during this time. This time period encompasses the height of the Credit Crunch financial crisis in September and October 2008, the associated recession which lasted into mid-2009, and the subsequent economic recovery in late 2009 and 2010.

The models constructed in the course of this thesis will utilise a common set of inputs and outputs concerning the fundamental factors for assessing the managerial performance of the OEICs/UTs under evaluation. The relevant input factors for the OEICs/UTs that are used in this thesis are as follows:

**1. The three-year standard deviation** (Source: Morningstar) → This is used as an input to represent the risk of holding an investment in the OEIC/UT. Standard deviation is a commonly used measurement of variability in statistics which shows the amount of variation or dispersion there is around the mean, with a low value indicating the data points tend to be very close to the mean, whilst a high value indicates the data points are spread over a large range around the mean. The standard deviation is calculated from taking the square root of the variance.

Using standard deviation in the context of the performance of OEICs/UTs is important as the standard deviation of the rate of return on the portfolio of securities held by an OEIC/UT acts as a measure of the volatility of the returns from that portfolio. If the assumption that an OEIC's/UT's returns follow a normal distribution is made, then approximately 68% of the time the returns will fall within one standard deviation of the mean return, and 95% of the time the returns will fall within two standard deviations of the mean return. So for an OEIC/UT with a mean return of 20% and a standard deviation of 5%, it would be expected that the return would be between 15% and 25% approximately 68% of the time, and between 10% and 30% approximately 95% of the time.

Morningstar calculates the three-year standard deviation using the historical monthly total returns for the appropriate three-year time period to obtain the monthly standard deviation which is then annualised so that it is in a more useful one-year context. The formula used to calculate the monthly standard deviation is shown below:

$$\sigma_M = \sqrt{\frac{1}{n - 1} \sum_{t=1}^{n} (R_t - \bar{R})^2}$$

Where:

1. $\sigma_M$ is the monthly standard deviation

2. $n$ is the number of months

3. $R_t$ is the return of the investment in month $t$

4. $\bar{R}$ is the average monthly total return for the investment

$\bar{R}$ is also known as the arithmetic mean, and is calculated by adding together all the monthly returns for the investment and then dividing this by the number of months, as shown in the following formula:

$$\bar{R} = \frac{1}{n}\sum_{t=1}^{n} R_t$$

Finally, Morningstar annualise the monthly standard deviation which puts it into a more useful one-year context by multiplying it by the square root of 12, as shown in the formula below:

$$\sigma_A = \sigma_M\sqrt{12}$$

**2. The three-year Sharpe ratio** (Source: Morningstar) → This is used as an input to represent the risk-adjusted performance of an investment in an OEIC/UT. The Sharpe ratio is calculated by using the excess return and the standard deviation to obtain the excess return/risk premium per unit of risk for the investment in the OEIC/UT. The Sharpe ratio indicates how well the return of an investment in the OEIC/UT compensates the investor for the risk taken. In this sense, a higher Sharpe ratio indicates a better investment in terms of risk-adjusted return as investments with a higher Sharpe ratio give more return for the same risk.

Morningstar calculates the three-year Sharpe ratio using the historical monthly total returns for the appropriate three-year time period and a risk-free benchmark based on the OEIC's/UT's domicile, which for the UK domiciled OEICs/UTs assessed in this thesis is the monthly return over the appropriate three-year time period of the 90-day UK Government Treasury Bill. The resulting monthly Sharpe ratio is then annualised to put it in a more useful one-year context. The formula used to calculate the monthly Sharpe ratio is shown below:

$$Sharpe\ Ratio_M = \frac{\overline{R^e}}{\sigma_M^e}$$

The numerator of the monthly Sharpe ratio formula, $\overline{R^e}$, is the average monthly excess return of the investment, given by the formula below:

$$\overline{R^e} = \frac{1}{n}\sum_{t=1}^{n}(R_t - RF_t)$$

Where:

1. $\overline{R^e}$ is the average monthly excess return of the investment

2. $R_t$ is the return of the investment in month $t$

3. $RF_t$ is the return of the risk-free benchmark in month $t$

4. $n$ is the number of months

The denominator of the monthly Sharpe ratio formula, $\sigma_M^e$, is a measure of the monthly standard deviation of excess returns. This is slightly different to the commonly used standard deviation of total returns which measures the standard deviation of the spread between the investment and its average total return. Instead, the standard deviation of excess returns measures the standard deviation of the spread between the investment and the risk-free rate. Thus, the formula for calculating the monthly standard deviation of excess returns is as shown below:

$$\sigma_M^e = \sqrt{\frac{1}{n-1}\sum_{t=1}^{n}(R_t - RF_t - \overline{R^e})^2}$$

Where:

1. $\sigma_M^e$ is the monthly standard deviation of excess returns

2. $\overline{R^e}$ is the average monthly excess return of the investment

3. $R_t$ is the return of the investment in month $t$

4. $RF_t$ is the return of the risk-free benchmark in month $t$

5. $n$ is the number of months

Finally, to obtain the annualised Sharpe ratio, Morningstar multiplies the monthly Sharpe ratio by the square root of 12, as shown in the formula below:

$$Sharpe\ Ratio_A = Sharpe\ Ratio_M\sqrt{12}$$

**3. The total expense ratio (TER)** (Source: Morningstar) → This is used as an input to represent the cost to the investor of their investment in the OEIC/UT. Investors are interested in the size of the TER because the costs come directly out of the fund, thus affecting the return investors get from the fund. It is calculated on an annual basis using the following formula:

$$Total\ Expense\ Ratio = \frac{Total\ Fund\ Cost}{Total\ Fund\ Assets}$$

The total fund cost will include the annual management charge (AMC) of the OEIC/UT, along with other charges and expenses incurred in the operation of the OEIC/UT such as fees payable to auditors and legal fees. It is important to note that costs such as transaction costs from the trading of the fund's assets, performance related fees, initial investment charges and exit charges are not included. The total fund cost is then divided by the total fund assets to arrive at the TER, which is expressed as a percentage. Because the TER contains these other costs in addition to the AMC, it is considered to be a more accurate measure of the cost to the investor of holding the investment in the OEIC/UT, than the AMC alone.

**4. The fund size** (Source: Morningstar) → This is used as an input to represent the size of the fund that is available to the manager of the OEIC/UT. The fund size is simply the net assets of the OEIC/UT in millions of GBP as at the appropriate date.

There are a number of reasons why it is useful to include the fund size as a factor in the assessment of the managerial performance of OEICs/UTs. Firstly, there can be economies of scale in terms of the costs associated with the operation of the OEIC/UT in so far as the operational charges and expenses, such as fees for auditors and legal fees, are spread across a larger net asset base, thus reducing the TER which then consequently causes less drag on the return produced by the OEIC/UT. Also, a fund that has a very small net asset base is likely to be less diversified, and consequently its performance is likely to be more volatile as one or two stocks which either perform well, or perform poorly, will have an associated large positive impact, or large negative impact, on the overall performance of the fund.

However, it is also important to consider that there are potential downsides to increases in the size of the net assets of an equity OEIC/UT. It is possible for a fund to become a victim of its own success in that its above average performance attracts too much extra investment into the fund to the extent that the manager of the fund struggles to find a place to invest these additional funds without compromising the investment style and strategy of the equity OEIC/UT which has thus far been successful. This is not a particular issue for bond, index and money market funds because of the large, highly liquid market segments in which they operate. However, this problem of 'asset bloat' is much more of an issue for equity funds, which is the type of OEIC/UT that is the focus of this thesis, because the equity market segment is, in comparison, less liquid, especially as you move from large-cap equity funds, through mid-cap funds, down to small-cap equity funds. A further related issue is that an equity OEIC/UT which grows to have a large net assets base will tend to spread its investment assets over a large number of stocks, resulting in a portfolio which resembles an index fund, and thus the investors are paying the high fees for an actively managed fund whilst receiving performance that is near identical to that which they could of obtained from a low cost index tracker. Funds that suffer in this way due to their large net assets base are known as 'closet index funds'.

Finally, OEICs/UTs with a small net assets base will benefit from being able to move quickly in and out of stock positions they hold because it is far easier to take or sell a stock position of say £1 million than it would be to take or sell a stock position of say £50 million. Trying to take or sell a stock position of say £50 million could take a number of days and would also more than likely result in upward pressure on the stock price in the case of an attempt to take a position, and conversely downward pressure on the stock price in the case of an attempt to sell a position. Thus, an OEIC/UT with a small net assets base, and consequently small stock positions, will have the ability to be more decisive in moving in and out of stock positions quickly, which can help the manager of a fund to obtain a better return performance.

For these reasons the size of the net assets base of an equity OEIC/UT can influence their performance, and therefore fund size is an important factor in the assessment of the managerial performance of these OEICs/UTs.

The one relevant output factor for the OEICs/UTs that is used in this thesis is as follows:

**1. The three-year annualised return** (Source: Morningstar) → This is used as an output to represent the return to the investor from the OEIC/UT over the appropriate period of time, and the return an investor gets from their investment in an OEIC/UT is the most important factor they are interested in. The three-year annualised return is the monthly return from the OEIC/UT over three years, expressed in yearly percentage terms. So, for example, a fund that has returned 15% over three years, will have a three-year annualised return of 5%.

Morningstar calculates the three-year annualised return using the historical monthly total returns for the appropriate three-year time period which are annualised to put them in a more useful one-year context. The formula used to calculate the monthly total return is shown below:

$$TR_t = \left\{\frac{P_e}{P_b}\prod_{i=1}^{n}\left(1 + \frac{D_i}{P_i}\right)\right\} - 1$$

Where:

1. $TR_t$ is the total return for the fund for month $t$

2. $P_e$ is the end of month net asset value per share

3. $P_b$ is the beginning of month net asset value per share

4. $D_i$ is the per share distribution at time $i$

5. $P_i$ is the reinvestment net asset value per share at time $i$

6. $n$ is the number of distributions during the month

In this formula, the distributions include any dividends, distributed capital gains and return of capital. This calculation used by Morningstar to calculate the monthly total return for a fund assumes that investors incur no transaction fees and reinvest all distributions paid out during the month.

The cumulative total return for the fund over the appropriate three-year time period is then calculated using the following formula:

$$TR_c = \left\{ \prod_{t=1}^{T} (1 + TR_t) \right\} - 1$$

Where:

1. $TR_c$ is the cumulative total return for the fund

2. $TR_t$ is the total return for the fund for month $t$

3. $T$ is the number of months in the time period

Finally, Morningstar annualise the cumulative total return for the fund over the appropriate three-year time period to put it in a more useful one-year context using the following formula:

$$Three - Year\ Annualised\ Return = \left\{ (1 + TR_c)^{\frac{12}{T}} \right\} - 1$$

Where:

1. $TR_c$ is the cumulative total return for the fund

2. $T$ is the number of months in the time period

The final sets of data utilised in this thesis concern a number of market indices as detailed below:

**Market indices** (Sources: Datastream and MSCI) → In addition to these four inputs and one output, the SFA second stage of the three-stage DEA-SFA-DEA models utilises an appropriate market index as an environmental factor whose influence is to be removed from the performance of the OEICs/UTs to obtain a more reliable measurement of their managerial performance. For the UK focused large-cap equity OEIC/UT categories the appropriate market index is the FTSE 100 and for the UK focused mid-cap and small-cap equity OEIC/UT categories the appropriate market index is the FTSE 250. For the US focused equity OEIC/UT categories the appropriate market index is the S&P 500 and for the global focused equity OEIC/UT categories the appropriate market index is the MSCI World.

For each of the market indices the month-end level of the index for each month in the appropriate three-year time period has been used to form the dataset. From this dataset, the three-year annualised return from the index has been calculated by taking the percentage change in the index each month and using this to calculate a cumulative total return from the index for the appropriate three-year time period, which has then been annualised to put it in a more useful one-year context. The formula used to perform this calculation is shown below:

$$AR_I = \left\{ \left( \prod_{t=1}^{T} IR_t \right)^{\frac{12}{T}} \right\} - 1$$

Where:

1. $AR_I$ is the three-year annualised return for the index

2. $IR_t$ is the percentage change in the index for month $t$

3. $T$ is the number of months in the time period

The details of the models that have been constructed during this thesis to assess the managerial performance of the OEICs/UTs can be found in the methodology section of this thesis. Finally, the data that has been collected in the process of performing this thesis can be found in the data appendix.

# Chapter 6: Methodology

The methodology utilised in this thesis to evaluate the managerial performance of the OEICs/UTs is based around Fried et al's (2002) three-stage DEA-SFA-DEA methodology in which the first stage involves using DEA to carry out an initial evaluation of the managerial efficiency of the OEICs/UTs, followed by a second stage which uses SFA regressions to purge the influence of environmental factors and statistical noise from the data, and finally a third stage which re-performs the initial DEA evaluation of the managerial efficiency of the OEICs/UTs using the adjusted data from the second stage to obtain a more accurate evaluation of the true managerial efficiency of the OEICs/UTs. Furthermore, this thesis enhances the basic three-stage DEA-SFA-DEA methodology with the implementation of Tone and Tsutsui's (2009) modification to the data adjustment process which deals with the identified shortcomings of the traditional data adjustment process and leads to a data adjustment procedure which does not suffer from the loss in discriminatory power in the efficiency ratings results that the traditional process did, thus resulting in ratings for the managerial efficiency of the OEICs/UTs that will be more satisfactory.

The first section of the methodology for this thesis presents the data envelopment analysis (DEA) methodologies which will be used to generate the efficiency ratings for the evaluation of the managerial performance of the OEICs/UTs. In the second section the process of selecting the DEA models to be utilised in the full three-stage DEA-SFA-DEA evaluation of the managerial performance of the OEICs/UTs is outlined. The final section of the methodology for this thesis details the full three-stage DEA-SFA-DEA procedure that will be used to evaluate the managerial performance of the OEICs/UTs being assessed.

## *6.1: Data Envelopment Analysis (DEA) Model Methodologies*

The OEICs/UTs that are assessed in this thesis are evaluated for their managerial efficiency on the basis of four inputs, the three-year standard deviation of returns, the three-year Sharpe ratio, the total expense ratio (TER) and the fund size, and one output, the three-year annualised return, as outlined in the previous chapter. Also, the fund universe of OEICs/UTs under evaluation consists of 565 UK domiciled OEICs/UTs.

All of the different DEA models outlined in the following section have been specifically coded for this thesis using the MATLAB programming language, and the MATLAB coding is included in the MATLAB coding appendix of this thesis, made available to other researchers for further research as part of the research contribution of this thesis. This code has then been used in the MATLAB program along with the data collected for this thesis to produce the managerial efficiency ratings for the OEICs/UTs under evaluation, across the range of DEA models employed.

### *6.1.1: The CCR DEA Model*

The CCR DEA model was introduced by Charnes et al (1978) as the first modelling methodology in the field of data envelopment analysis (DEA) with the aim of measuring the relative efficiency of decision making units (DMUs) which have multiple inputs and multiple outputs. In the case of this thesis the DMUs are the OEICs/UTs. The CCR DEA model employs a radial metric and constant returns-to-scale, with either an input orientation or an output orientation. The formulations for these models are as follows:

***Input-Oriented CCR DEA Model For $OEIC/UT_0$:***

Min $\theta$

Subject To:

$$\sum_{j=1}^{n} \lambda_j x_{ij} \leq x_{i0}\theta \qquad \forall i$$

$$\sum_{j=1}^{n} \lambda_j y_{rj} \geq y_{r0} \qquad \forall r$$

$$\lambda_j \geq 0$$

$$i = 1, \dots, m \qquad r = 1, \dots, s \qquad j = 1, \dots, n$$

$0 \leq \theta \leq 1$ → This is a measure of efficiency

***Output-Oriented CCR DEA Model For $OEIC/UT_0$:***

Max $\gamma$

Subject To:

$$\sum_{j=1}^{n} \lambda_j x_{ij} \leq x_{i0} \qquad \forall i$$

$$\sum_{j=1}^{n} \lambda_j y_{rj} \geq y_{r0}\gamma \qquad \forall r$$

$$\lambda_j \geq 0$$

$i = 1, \ldots, m \qquad r = 1, \ldots, s \qquad j = 1, \ldots, n$

$0 \leq \frac{1}{\gamma} \leq 1$ → This is a measure of efficiency

### *6.1.2: The SORMCCR DEA Model*

The SORMCCR DEA model is a modified form of the standard CCR DEA model based on the use of the SORM procedure developed by Emrouznejad et al (2010) which aims to enable the standard CCR DEA model to measure the efficiency of the DMUs, which in the case of this thesis are the OEICs/UTs, in the presence of negative data in the inputs and/or outputs of some of the OEICs/UTs. The issue that arises with the presence of negative data is that when there is, for example, an input that is positive for some OEICs/UTs and negative for other OEICs/UTs, the absolute value should fall when the OEIC/UT has a positive value for the input and it should rise when the OEIC/UT has a negative value for the input in order for the OEIC/UT concerned to improve its performance. Furthermore, when there is, for example, an output that is positive for some OEICs/UTs and negative for other OEICs/UTs, the absolute value should rise when the OEIC/UT has a positive value for the output and it should fall when the OEIC/UT has a negative value for the output in order for the OEIC/UT concerned to improve its performance. This issue is resolved in the SORMCCR DEA model by implementing a procedure in which each input and each output that has positive values for some OEICs/UTs and negative values for other OEICs/UTs is split in to two variables.

So taking an input variable $x_k$ which is positive for some OEICs/UTs and negative for other OEICs/UTs, it can be split in to two variables, $x_k^1$ and $x_k^2$, which for the $jth$ OEIC/UT take the values $x_{kj}^1$ and $x_{kj}^2$ defined such that:

$$x_{kj}^{1} = \begin{cases} x_{kj} & if\ x_{kj} \geq 0 \\ 0 & if\ x_{kj} < 0 \end{cases} \quad \& \quad x_{kj}^{2} = \begin{cases} 0 & if\ x_{kj} \geq 0 \\ -x_{kj} & if\ x_{kj} < 0 \end{cases}$$

Also, $x_{kj}^{1} \geq 0$ and $x_{kj}^{2} \geq 0$, whilst $x_{kj} = x_{kj}^{1} - x_{kj}^{2}$ for all $j$.

Thus, this creates two non-negative variables for each OEIC/UT from a single input variable that originally took positive values for some of the OEICs/UTs and negative values for the other OEICs/UTs. The result of this is that, in effect, we can treat the negative input values as outputs due to the fact that the model will search for improved solutions which raise the absolute value of the negative input. However, this is only the case for the OEICs/UTs which have a negative value on the input variable in question, whilst for those OEICs/UTs which have a positive value on the input variable in question, the variable is treated as a normal input.

For the case of output variables, if we have an output variable $y_l$ which is positive for some OEICs/UTs and negative for other OEICs/UTs, it can be split in to two variables, $y_l^1$ and $y_l^2$, which for the $jth$ OEIC/UT take the values $y_{lj}^1$ and $y_{lj}^2$ defined such that:

$$y_{lj}^{1} = \begin{cases} y_{lj} & if\ y_{lj} \geq 0 \\ 0 & if\ y_{lj} < 0 \end{cases} \quad \& \quad y_{lj}^{2} = \begin{cases} 0 & if\ y_{lj} \geq 0 \\ -y_{lj} & if\ y_{lj} < 0 \end{cases}$$

Also, $y_{lj}^{1} \geq 0$ and $y_{lj}^{2} \geq 0$, whilst $y_{lj} = y_{lj}^{1} - y_{lj}^{2}$ for all $j$.

Thus, this creates two non-negative variables for each OEIC/UT from a single output variable that originally took positive values for some of the OEICs/UTs and negative values for the other OEICs/UTs. The result of this is that, in effect, we are able to treat the negative output values as inputs due to the fact that the model searches for improved solutions which will reduce the absolute value of the negative output. However, this is only the case for the OEICs/UTs which have a negative value on the output variable in question, whilst for those OEICs/UTs which have a positive value on the output variable in question, the variable is treated as a normal output.

Therefore, the original CCR DEA model can now be modified using this SORM procedure to construct the SORMCCR DEA model, in both input-oriented and output-oriented form, with the ability to handle positive and negative values in both input variables and output variables. The formulations for these models are as follows:

***Input-Oriented SORMCCR DEA Model For $OEIC/UT_0$:***

$$I \cup K = 1, \dots, m \quad I \cap K = \emptyset$$

$$R \cup L = 1, \dots, s \quad R \cap L = \emptyset$$

$$\begin{matrix} x_i & i \in I \\ y_r & r \in R \end{matrix} \rightarrow \text{Positive For All OEICs/UTs}$$

$$\begin{matrix} x_k & k \in K \\ y_l & l \in L \end{matrix} \rightarrow \text{Positive For Some And Negative For Other OEICs/UTs}$$

Min $\theta$

Subject To:

$$\sum_{j=1}^{n} \lambda_j x_{ij} \leq x_{i0}\theta \qquad \forall i \in I$$

$$\sum_{j=1}^{n} \lambda_j x_{kj}^1 \leq x_{k0}^1\theta \qquad \forall k \in K$$

$$\sum_{j=1}^{n} \lambda_j x_{kj}^2 \geq x_{k0}^2\theta \qquad \forall k \in K$$

$$\sum_{j=1}^{n} \lambda_j y_{rj} \geq y_{r0} \qquad \forall r \in R$$

$$\sum_{j=1}^{n} \lambda_j y_{lj}^1 \geq y_{l0}^1 \qquad \forall l \in L$$

$$\sum_{j=1}^{n} \lambda_j y_{lj}^2 \leq y_{l0}^2 \qquad \forall l \in L$$

$$\lambda_j \geq 0$$

$$j = 1, \dots, n$$

$0 \leq \theta \leq 1$ → This is a measure of efficiency

***Output-Oriented SORMCCR DEA Model For $OEIC/UT_0$:***

$$I \cup K = 1, \dots, m \quad I \cap K = \emptyset$$

$$R \cup L = 1, \dots, s \quad R \cap L = \emptyset$$

$$\begin{matrix} x_i & i \in I \\ y_r & r \in R \end{matrix} \rightarrow \mathit{Positive\ For\ All\ OEICs/UTs}$$

$$\begin{matrix} x_k & k \in K \\ y_l & l \in L \end{matrix} \rightarrow \mathit{Positive\ For\ Some\ And\ Negative\ For\ Other\ OEICs/UTs}$$

$\text{Max}\,\gamma$

Subject To:

$$\sum_{j=1}^{n} \lambda_j x_{ij} \leq x_{i0} \qquad \forall i \in I$$

$$\sum_{j=1}^{n} \lambda_j x_{kj}^1 \leq x_{k0}^1 \qquad \forall k \in K$$

$$\sum_{j=1}^{n} \lambda_j x_{kj}^2 \geq x_{k0}^2 \qquad \forall k \in K$$

$$\sum_{j=1}^{n} \lambda_j y_{rj} \geq y_{r0}\gamma \qquad \forall r \in R$$

$$\sum_{j=1}^{n} \lambda_j y_{lj}^1 \geq y_{l0}^1\gamma \qquad \forall l \in L$$

$$\sum_{j=1}^{n} \lambda_j y_{lj}^2 \leq y_{l0}^2\gamma \qquad \forall l \in L$$

$$\lambda_j \geq 0$$

$$j = 1, \dots, n$$

$0 \leq \frac{1}{\gamma} \leq 1$ → This is a measure of efficiency

### *6.1.3: The BCC DEA Model*

The BCC DEA model was developed as an evolution of the CCR DEA model by Banker et al (1984) by switching from constant returns-to-scale to variable returns-to-scale. Thus, the BCC DEA model employs a radial metric and variable returns-to-scale, with either an input orientation or an output orientation, to measure the relative efficiency of the DMUs which have multiple inputs and multiple outputs. In this thesis the DMUs are the OEICs/UTs whose managerial efficiency is under evaluation. The formulations for these models are as follows:

***Input-Oriented BCC DEA Model For $OEIC/UT_0$:***

Min $\theta$

Subject To:

$$\sum_{j=1}^{n} \lambda_j x_{ij} \leq x_{i0}\theta \qquad \forall i$$

$$\sum_{j=1}^{n} \lambda_j y_{rj} \geq y_{r0} \qquad \forall r$$

$$\sum_{j=1}^{n} \lambda_j = 1$$

$$\lambda_j \geq 0$$

$$i = 1, \dots, m \qquad r = 1, \dots, s \qquad j = 1, \dots, n$$

$0 \leq \theta \leq 1$ → This is a measure of efficiency

***Output-Oriented BCC DEA Model For $OEIC/UT_0$:***

Max $\gamma$

Subject To:

$$\sum_{j=1}^{n} \lambda_j x_{ij} \leq x_{i0} \qquad \forall i$$

$$\sum_{j=1}^{n} \lambda_j y_{rj} \geq y_{r0}\gamma \qquad \forall r$$

$$\sum_{j=1}^{n} \lambda_j = 1$$

$$\lambda_j \geq 0$$

$$i = 1, \ldots, m \qquad r = 1, \ldots, s \qquad j = 1, \ldots, n$$

$0 \leq \frac{1}{\gamma} \leq 1$ → This is a measure of efficiency

### *6.1.4: The SORMBCC DEA Model*

The SORMBCC DEA model is a modified form of the standard BCC DEA model developed by Emrouznejad et al (2010) which aims to enable the standard BCC DEA model to measure the efficiency of the DMUs, which in the case of this thesis are the OEICs/UTs, in the presence of negative data in the inputs and/or outputs of some of the OEICs/UTs. The issue that arises with the presence of negative data is that when there is, for example, an input that is positive for some OEICs/UTs and negative for other OEICs/UTs, the absolute value should fall when the OEIC/UT has a positive value for the input and it should rise when the OEIC/UT has a negative value for the input in order for the OEIC/UT concerned to improve its performance. Furthermore, when there is, for example, an output that is positive for some OEICs/UTs and negative for other OEICs/UTs, the absolute value should rise when the OEIC/UT has a positive value for the output and it should fall when the OEIC/UT has a negative value for the output in order for the OEIC/UT concerned to improve its performance. The procedure implemented in the SORMBCC DEA model to deal with this issue is to split each input and each output that has positive values for some OEICs/UTs and negative values for other OEICs/UTs in to two variables.

So taking an input variable $x_k$ which is positive for some OEICs/UTs and negative for other OEICs/UTs, it can be split in to two variables, $x_k^1$ and $x_k^2$, which for the $jth$ OEIC/UT take the values $x_{kj}^1$ and $x_{kj}^2$ defined such that:

$$x_{kj}^1 = \begin{cases} x_{kj} & if\ x_{kj} \geq 0 \\ 0 & if\ x_{kj} < 0 \end{cases} \qquad \& \qquad x_{kj}^2 = \begin{cases} 0 & if\ x_{kj} \geq 0 \\ -x_{kj} & if\ x_{kj} < 0 \end{cases}$$

Also, $x_{kj}^1 \geq 0$ and $x_{kj}^2 \geq 0$, whilst $x_{kj} = x_{kj}^1 - x_{kj}^2$ for all $j$.

Thus, this creates two non-negative variables for each OEIC/UT from a single input variable that originally took positive values for some of the OEICs/UTs and negative values for the other OEICs/UTs. The result of this is that, in effect, we can treat the negative input values as outputs due to the fact that the model will search for improved solutions which raise the absolute value of the negative input. However, this is only the case for the OEICs/UTs which have a negative value on the input variable in question, whilst for those OEICs/UTs which have a positive value on the input variable in question, the variable is treated as a normal input.

For the case of output variables, if we have an output variable $y_l$ which is positive for some OEICs/UTs and negative for other OEICs/UTs, it can be split in to two variables, $y_l^1$ and $y_l^2$, which for the $jth$ OEIC/UT take the values $y_{lj}^1$ and $y_{lj}^2$ defined such that:

$$y_{lj}^1 = \begin{cases} y_{lj} & if\ y_{lj} \geq 0 \\ 0 & if\ y_{lj} < 0 \end{cases} \qquad \& \qquad y_{lj}^2 = \begin{cases} 0 & if\ y_{lj} \geq 0 \\ -y_{lj} & if\ y_{lj} < 0 \end{cases}$$

Also, $y_{lj}^1 \geq 0$ and $y_{lj}^2 \geq 0$, whilst $y_{lj} = y_{lj}^1 - y_{lj}^2$ for all $j$.

Thus, this creates two non-negative variables for each OEIC/UT from a single output variable that originally took positive values for some of the OEICs/UTs and negative values for the other OEICs/UTs. The result of this is that, in effect, we are able to treat the negative output values as inputs due to the fact that the model searches for improved solutions which will reduce the absolute value of the negative output. However, this is only the case for the OEICs/UTs which have a negative value on the output variable in question, whilst for those OEICs/UTs which have a positive value on the output variable in question, the variable is treated as a normal output.

Therefore, the original BCC DEA model can now be modified using this procedure to construct the SORMBCC DEA model, in both input-oriented and output-oriented form, and in both cases with the ability to handle positive and negative values in both input variables and output variables. The formulations for these models are as follows:

***Input-Oriented SORMBCC DEA Model For $OEIC/UT_0$:***

$I \cup K = 1, \ldots, m \quad I \cap K = \emptyset$

$R \cup L = 1, \ldots, s \quad R \cap L = \emptyset$

$$\begin{matrix} x_i & i \in I \\ y_r & r \in R \end{matrix} \rightarrow \ Positive\ For\ All\ OEICs/UTs$$

$$\begin{matrix} x_k & k \in K \\ y_l & l \in L \end{matrix} \rightarrow \ Positive\ For\ Some\ And\ Negative\ For\ Other\ OEICs/UTs$$

Min $\theta$

Subject To:

$$\sum_{j=1}^{n} \lambda_j x_{ij} \leq x_{i0}\theta \qquad \forall i \in I$$

$$\sum_{j=1}^{n} \lambda_j x_{kj}^1 \leq x_{k0}^1 \theta \qquad \forall k \in K$$

$$\sum_{j=1}^{n} \lambda_j x_{kj}^2 \geq x_{k0}^2 \theta \qquad \forall k \in K$$

$$\sum_{j=1}^{n} \lambda_j y_{rj} \geq y_{r0} \qquad \forall r \in R$$

$$\sum_{j=1}^{n} \lambda_j y_{lj}^1 \geq y_{l0}^1 \qquad \forall l \in L$$

$$\sum_{j=1}^{n} \lambda_j y_{lj}^2 \leq y_{l0}^2 \qquad \forall l \in L$$

$$\sum_{j=1}^{n} \lambda_j = 1$$

$$\lambda_j \geq 0$$

$$j = 1, \dots, n$$

$0 \leq \theta \leq 1$ → This is a measure of efficiency

***Output-Oriented SORMBCC DEA Model For $OEIC/UT_0$:***

$$I \cup K = 1, \dots, m \quad I \cap K = \emptyset$$

$$R \cup L = 1, \dots, s \quad R \cap L = \emptyset$$

$$\begin{matrix} x_i & i \in I \\ y_r & r \in R \end{matrix} \rightarrow \ Positive\ For\ All\ OEICs/UTs$$

$$\begin{matrix} x_k & k \in K \\ y_l & l \in L \end{matrix} \rightarrow \ Positive\ For\ Some\ And\ Negative\ For\ Other\ OEICs/UTs$$

$\text{Max}\,\gamma$

Subject To:

$$\sum_{j=1}^{n} \lambda_j x_{ij} \leq x_{i0} \qquad \forall i \in I$$

$$\sum_{j=1}^{n} \lambda_j x_{kj}^{1} \leq x_{k0}^{1} \qquad \forall k \in K$$

$$\sum_{j=1}^{n} \lambda_j x_{kj}^{2} \geq x_{k0}^{2} \qquad \forall k \in K$$

$$\sum_{j=1}^{n} \lambda_j y_{rj} \geq y_{r0}\gamma \qquad \forall r \in R$$

$$\sum_{j=1}^{n} \lambda_j y_{lj}^{1} \geq y_{l0}^{1}\gamma \qquad \forall l \in L$$

$$\sum_{j=1}^{n} \lambda_j y_{lj}^{2} \leq y_{l0}^{2}\gamma \qquad \forall l \in L$$

$$\sum_{j=1}^{n} \lambda_j = 1$$

$\lambda_j \geq 0$

$j = 1, \dots, n$

$0 \leq \frac{1}{\gamma} \leq 1$ → This is a measure of efficiency

### *6.1.5: The Slacks-Based Measure (SBM) DEA Model*

The Slacks-Based Measure (SBM) DEA model was developed by Tone (2001) as a non-radial scalar measure of efficiency which deals directly with the slacks of the DMUs, both input excesses and output shortfalls. The DMUs under evaluation in this thesis are the OEICs/UTs, thus allowing an assessment of their managerial performance. The SBM DEA model also attains a number of properties which are considered important for a measure of efficiency including being units invariant, being monotone decreasing with respect to slacks and being reference-set dependent in that the efficiency measure is determined by consulting only the reference-set of the DMU concerned. Although in standard form the SBM DEA model is non-oriented, it can be modified to produce either an input-oriented SBM DEA model or an output-oriented SBM DEA model. Furthermore, the SBM DEA model can be formulated with either constant returns-to-scale or with the imposition of the convexity constraint $\sum_{j=1}^{n} \lambda_j = 1$, variable returns-to-scale. The formulations for these models, under the constant returns-to-scale metric, are as follows:

***Non-Oriented SBM DEA Model For $OEIC/UT_0$:***

$$\text{Min}\, \rho = 1 - \frac{1}{m} \sum_{i=1}^{m} \frac{s_i^-}{x_{i0}}$$

Subject To:

$$1 = \frac{1}{s} \sum_{r=1}^{s} \frac{s_r^+}{y_{r0}}$$

$$\sum_{j=1}^{n} \lambda_j x_{ij} + s_i^- = x_{i0} \qquad \forall i$$

$$\sum_{j=1}^{n} \lambda_j y_{rj} - s_r^+ = y_{r0} \qquad \forall r$$

$$\lambda_j \geq 0 \qquad s_i^- \geq 0 \qquad s_r^+ \geq 0$$

$$i = 1, \dots, m \qquad r = 1, \dots, s \qquad j = 1, \dots, n$$

$0 \leq \rho \leq 1$ → This is a measure of efficiency

The non-oriented SBM DEA model can be modified to obtain both the input-oriented SBM DEA model and the output-oriented SBM DEA model. This is achieved by excluding the denominator from the objective function of the SBM DEA model to obtain the input-oriented version and the numerator to obtain the output-oriented version.

***Input-Oriented SBM DEA Model For $OEIC/UT_0$:***

$$\text{Min}\, \rho_I = 1 - \frac{1}{m} \sum_{i=1}^{m} \frac{s_i^-}{x_{io}}$$

Subject To:

$$\sum_{j=1}^{n} \lambda_j x_{ij} + s_i^- = x_{i0} \qquad \forall i$$

$$\sum_{j=1}^{n} \lambda_j y_{rj} - s_r^+ = y_{r0} \qquad \forall r$$

$$\lambda_j \geq 0 \qquad s_i^- \geq 0 \qquad s_r^+ \geq 0$$

$$i = 1, \dots, m \qquad r = 1, \dots, s \qquad j = 1, \dots, n$$

$0 \leq \rho_I \leq 1$ → This is a measure of efficiency

***Output-Oriented SBM DEA Model For $OEIC/UT_0$:***

$$\text{Max}\, \rho_O = \frac{1}{1 + \frac{1}{s}\sum_{r=1}^{s}\frac{s_r^+}{y_{r0}}}$$

Subject To:

$$\sum_{j=1}^{n} \lambda_j x_{ij} + s_i^- = x_{i0} \qquad \forall i$$

$$\sum_{j=1}^{n} \lambda_j y_{rj} - s_r^+ = y_{r0} \qquad \forall r$$

$$\lambda_j \geq 0 \qquad s_i^- \geq 0 \qquad s_r^+ \geq 0$$

$$i = 1, \dots, m \qquad r = 1, \dots, s \qquad j = 1, \dots, n$$

$0 \leq \frac{1}{\rho_O} \leq 1$ → This is a measure of efficiency

### *6.1.6: The SORMSBM DEA Model*

The SORMSBM DEA model is an evolution of Tone's (2001) standard SBM DEA model achieved with the implementation of the SORM procedure developed in Emrouznejad et al (2010) with the aim of enabling the standard SBM DEA model, in the presence of negative data in the inputs and/or outputs of some of the OEICs/UTs, to measure reliably the efficiency of the OEICs/UTs under evaluation. As previously mentioned in this chapter, the issue that manifests itself in the presence of negative data is that when there is an input that has both positive and negative values, the absolute value should fall when the OEIC/UT has a positive value for the input and it should rise when the OEIC/UT has a negative value for the input if the OEIC/UT concerned is to improve its performance, whilst when there is an output that has both positive and negative values, the absolute value should rise when the OEIC/UT has a positive value for the output and it should fall when the OEIC/UT has a negative value for the output if the OEIC/UT concerned is to improve its performance. The resolution of this issue in the SORMSBM DEA model is achieved by implementing a procedure in which each input and each output that has positive values for some OEICs/UTs and negative values for the other OEICs/UTs is split in to two variables.

So, as with the previous implementations of the SORM procedure, taking an input variable $x_k$ which is positive for some OEICs/UTs and negative for other OEICs/UTs, it can be split in to two variables, $x_k^1$ and $x_k^2$, which for the $jth$ OEIC/UT take the values $x_{kj}^1$ and $x_{kj}^2$ defined such that:

$$x_{kj}^1 = \begin{cases} x_{kj} & if\ x_{kj} \geq 0 \\ 0 & if\ x_{kj} < 0 \end{cases} \qquad \& \qquad x_{kj}^2 = \begin{cases} 0 & if\ x_{kj} \geq 0 \\ -x_{kj} & if\ x_{kj} < 0 \end{cases}$$

Also, $x_{kj}^1 \geq 0$ and $x_{kj}^2 \geq 0$, whilst $x_{kj} = x_{kj}^1 - x_{kj}^2$ for all $j$.

Thus, this creates two non-negative variables for each OEIC/UT from a single input variable that originally took positive values for some of the OEICs/UTs and negative values for the other OEICs/UTs. The result of this is that, in effect, we can treat the negative input values as outputs due to the fact that the model will search for improved solutions which raise the absolute value of the negative input. However, this is only the case for the OEICs/UTs which have a negative value on the input variable in question, whilst for those OEICs/UTs which have a positive value on the input variable in question, the variable is treated as a normal input.

For the case of output variables, as with the previous implementations of the SORM procedure, if we have an output variable $y_l$ which is positive for some OEICs/UTs and negative for other OEICs/UTs, it can be split in to two variables, $y_l^1$ and $y_l^2$, which for the $jth$ OEIC/UT take the values $y_{lj}^1$ and $y_{lj}^2$ defined such that:

$$y_{lj}^1 = \begin{cases} y_{lj} & if\ y_{lj} \geq 0 \\ 0 & if\ y_{lj} < 0 \end{cases} \qquad \& \qquad y_{lj}^2 = \begin{cases} 0 & if\ y_{lj} \geq 0 \\ -y_{lj} & if\ y_{lj} < 0 \end{cases}$$

Also, $y_{lj}^1 \geq 0$ and $y_{lj}^2 \geq 0$, whilst $y_{lj} = y_{lj}^1 - y_{lj}^2$ for all $j$.

Thus, this creates two non-negative variables for each OEIC/UT from a single output variable that originally took positive values for some of the OEICs/UTs and negative values for the other OEICs/UTs. The result of this is that, in effect, we are able to treat the negative output values as inputs due to the fact that the model searches for improved solutions which will reduce the absolute value of the negative output. However, this is only the case for the OEICs/UTs which have a negative value on the output variable in question, whilst for those OEICs/UTs which have a positive value on the output variable in question, the variable is treated as a normal output.

Therefore, the original SBM DEA model can now be modified using this SORM procedure to construct the SORMSBM DEA model, in non-oriented, input-oriented and output-oriented forms, with the ability to handle positive and negative values in both input variables and output variables. The formulations for these models, which in common with the formulations for the standard SBM DEA models in the previous section utilise a constant returns-to-scale metric, are as follows:

***Non-Oriented SORMSBM DEA Model For $OEIC/UT_0$:***

$$I \cup K = 1, \dots, m \quad I \cap K = \emptyset$$

$$R \cup L = 1, \dots, s \quad R \cap L = \emptyset$$

$$\begin{matrix} x_i & i \in I \\ y_r & r \in R \end{matrix} \rightarrow \text{Positive For All OEICs/UTs}$$

$$\begin{matrix} x_k & k \in K \\ y_l & l \in L \end{matrix} \rightarrow \text{Positive For Some And Negative For Other OEICs/UTs}$$

$$\text{Min}\,\rho = 1 - \frac{1}{m}\sum\left(\frac{s_i^-}{x_{i0}} + \frac{s_k^{1-}}{x_{k0}^1} + \frac{s_l^{2+}}{y_{l0}^2}\right) \qquad \forall i \in I, \forall k \in K, \forall l \in L$$

Subject To:

$$1 = \frac{1}{s}\sum\left(\frac{s_r^+}{y_{r0}} + \frac{s_l^{1+}}{y_{l0}^1} + \frac{s_k^{2-}}{x_{k0}^2}\right) \qquad \forall r \in R, \forall k \in K, \forall l \in L$$

$$\sum_{j=1}^{n} \lambda_j x_{ij} + s_i^- = x_{i0} \qquad \forall i \in I$$

$$\sum_{j=1}^{n} \lambda_j x_{kj}^1 + s_k^{1-} = x_{k0}^1 \qquad \forall k \in K$$

$$\sum_{j=1}^{n} \lambda_j x_{kj}^2 - s_k^{2-} = x_{k0}^2 \qquad \forall k \in K$$

$$\sum_{j=1}^{n} \lambda_j y_{rj} - s_r^+ = y_{r0} \qquad \forall r \in R$$

$$\sum_{j=1}^{n} \lambda_j y_{lj}^1 - s_l^{1+} = y_{l0}^1 \qquad \forall l \in L$$

$$\sum_{j=1}^{n} \lambda_j y_{lj}^2 + s_l^{2+} = y_{l0}^2 \qquad \forall l \in L$$

$$\lambda_j \geq 0 \qquad s_i^- \geq 0 \qquad s_k^{1-} \geq 0 \qquad s_k^{2-} \geq 0 \qquad s_r^+ \geq 0 \qquad s_l^{1+} \geq 0 \qquad s_l^{2+} \geq 0$$

$j = 1, \dots, n$

$0 \le \rho \le 1$ → This is a measure of efficiency

The non-oriented SORMSBM DEA model can be modified to obtain both the input-oriented SORMSBM DEA model and the output-oriented SORMSBM DEA model. This is achieved by excluding the denominator from the objective function of the SORMSBM DEA model to obtain the input-oriented version and the numerator to obtain the output-oriented version.

***Input-Oriented SORMSBM DEA Model For $OEIC/UT_0$:***

$I \cup K = 1, \dots, m \quad I \cap K = \emptyset$

$R \cup L = 1, \dots, s \quad R \cap L = \emptyset$

$$\left.\begin{matrix} x_i & i \in I \\ y_r & r \in R \end{matrix}\right. \rightarrow \ Positive\ For\ All\ OEICs/UTs$$

$$\left.\begin{matrix} x_k & k \in K \\ y_l & l \in L \end{matrix}\right. \rightarrow \ Positive\ For\ Some\ And\ Negative\ For\ Other\ OEICs/UTs$$

$$\text{Min}\,\rho_I = 1 - \frac{1}{m}\sum\left(\frac{s_i^-}{x_{i0}} + \frac{s_k^{1-}}{x_{k0}^1} + \frac{s_l^{2+}}{y_{l0}^2}\right) \qquad \forall i \in I, \forall k \in K, \forall l \in L$$

Subject To:

$$\sum_{j=1}^{n} \lambda_j x_{ij} + s_i^- = x_{i0} \qquad \forall i \in I$$

$$\sum_{j=1}^{n} \lambda_j x_{kj}^1 + s_k^{1-} = x_{k0}^1 \qquad \forall k \in K$$

$$\sum_{j=1}^{n} \lambda_j x_{kj}^2 - s_k^{2-} = x_{k0}^2 \qquad \forall k \in K$$

$$\sum_{j=1}^{n} \lambda_j y_{rj} - s_r^{+} = y_{r0} \qquad \forall r \in R$$

$$\sum_{j=1}^{n} \lambda_j y_{lj}^1 - s_l^{1+} = y_{l0}^1 \qquad \forall l \in L$$

$$\sum_{j=1}^{n} \lambda_j y_{lj}^2 + s_l^{2+} = y_{l0}^2 \qquad \forall l \in L$$

$$\lambda_j \geq 0 \qquad s_i^- \geq 0 \qquad s_k^{1-} \geq 0 \qquad s_k^{2-} \geq 0 \qquad s_r^+ \geq 0 \qquad s_l^{1+} \geq 0 \qquad s_l^{2+} \geq 0$$

$$j = 1, \dots, n$$

$0 \leq \rho_I \leq 1$ → This is a measure of efficiency

***Output-Oriented SORMSBM DEA Model For $OEIC/UT_0$:***

$$I \cup K = 1, \dots, m \quad I \cap K = \emptyset$$

$$R \cup L = 1, \dots, s \quad R \cap L = \emptyset$$

$$\begin{matrix} x_i & i \in I \\ y_r & r \in R \end{matrix} \rightarrow \mathit{Positive\ For\ All\ OEICs/UTs}$$

$$\begin{matrix} x_k & k \in K \\ y_l & l \in L \end{matrix} \rightarrow \mathit{Positive\ For\ Some\ And\ Negative\ For\ Other\ OEICs/UTs}$$

$$\text{Max}\,\rho_O = \frac{1}{1 + \frac{1}{s}\sum\left(\frac{s_r^+}{y_{r0}} + \frac{s_l^{1+}}{y_{l0}^1} + \frac{s_k^{2-}}{x_{k0}^2}\right)} \qquad \forall r \in R, \forall k \in K, \forall l \in L$$

Subject To:

$$\sum_{j=1}^{n} \lambda_j x_{ij} + s_i^- = x_{i0} \qquad \forall i \in I$$

$$\sum_{j=1}^{n} \lambda_j x_{kj}^1 + s_k^{1-} = x_{k0}^1 \qquad \forall k \in K$$

$$\sum_{j=1}^{n} \lambda_j x_{kj}^2 - s_k^{2-} = x_{k0}^2 \qquad \forall k \in K$$

$$\sum_{j=1}^{n} \lambda_j y_{rj} - s_r^+ = y_{r0} \qquad \forall r \in R$$

$$\sum_{j=1}^{n} \lambda_j y_{lj}^1 - s_l^{1+} = y_{l0}^1 \qquad \forall l \in L$$

$$\sum_{j=1}^{n} \lambda_j y_{lj}^2 + s_l^{2+} = y_{l0}^2 \qquad \forall l \in L$$

$$\lambda_j \geq 0 \qquad s_i^- \geq 0 \qquad s_k^{1-} \geq 0 \qquad s_k^{2-} \geq 0 \qquad s_r^+ \geq 0 \qquad s_l^{1+} \geq 0 \qquad s_l^{2+} \geq 0$$

$$j = 1, \dots, n$$

$0 \leq \frac{1}{\rho_O} \leq 1$ → This is a measure of efficiency

## *6.2: The Selection Of The DEA Models To Be Utilised In The Three-Stage DEA-SFA-DEA Model*

The first and third stages of the three-stage DEA-SFA-DEA model require the utilisation of a DEA model to obtain the managerial efficiency ratings of the OEICs/UTs under evaluation, thus leading to the question of which DEA model to utilise, and the justification for this selection. The criteria on which this selection of the appropriate DEA model is carried out is based on three elements.

Firstly, the orientation of the DEA model, secondly, the underlying returns-to-scale metric of the DEA model and thirdly, whether the DEA model is radial or non-radial in nature.

So considering the first element of the selection process, the options available for the orientation of the DEA model are non-oriented, input-oriented and output-oriented. Discarding the non-oriented option due to the fact it is not available for the CCR and BCC models, the choice is between the input-oriented and output-oriented options. If the orientation utilised is input-oriented, then the DEA model program is formulated to determine the amount of the inputs that a DMU is using that could be contracted if the inputs were used as efficiently as they are by those DMUs on the efficient frontier, whilst still achieving the same output. In contrast, if the orientation utilised is output-oriented, then the DEA model program is formulated to determine the potential output of the DMU given its inputs, if the DMU is operated as efficiently as those DMUs on the efficient frontier. Evaluating which of these orientations would be most appropriate for the case of the OEICs/UTs assessed in this thesis, based on the notion that the managers of the OEICs/UTs have as their main goal the aim of maximising the return to the investors in their fund given the inputs used, it seems that the most appropriate orientation to employ in the DEA model utilised in the three-stage DEA-SFA-DEA system will be an output-oriented approach.

The second element to consider involves determining the appropriate returns-to-scale metric to employ, either constant returns-to-scale or variable returns-to-scale. It is important to note here that not only is this important in determining the selection of the DEA model that is to be utilised in the three-stage DEA-SFA-DEA method, it is also useful in determining whether the SBM and SORMSBM DEA models should use constant returns-to-scale or variable returns-to-scale. In this thesis the decision on which returns-to-scale metric to employ is based on the results of Banker's (1996) hypothesis test for the returns-to-scale characteristics of the production frontier in DEA. The test procedure is based around the fact that if you impose an additional row constraint, strengthen an existing row constraint or remove a constraint column, the result is a decrease in the sum of squares of the efficiency ratings. Therefore, $SSC \leq SSU$ with SSU being the unconstrained sum of squares of the efficiency ratings, the constant returns-to-scale CCR DEA model in this thesis, and SSC being the constrained sum of squares of the efficiency ratings, the variable returns-to-scale BCC DEA model in this thesis. This holds for both the input-oriented variation and the output-oriented variation. Thus, the null hypothesis and the formulation for this returns-to-scale hypothesis test are as follows:

$$H_0 : T = 1 \quad H_1 : T > 1$$

Where:

$$T = \frac{SSU}{SSC} = \frac{\sum_{j=1}^{n}\left(\hat{E}_{jUNC} - 1\right)^2}{\sum_{j=1}^{n}\left(\hat{E}_{jCON} - 1\right)^2}$$

The null hypothesis here is tested by $T \sim F(J, J)$, and thus we reject the null hypothesis at the 5% significance level when T exceeds the F-Value $F_{0.95,J,J}$.

This test can also be performed using the P-Value procedure where as $Pr\left(F < F_{0.95,J,J}\right) = 0.95$ we have $1 - Pr\left(F < F_{0.95,J,J}\right) = 0.05$. Therefore, to calculate the P-Value involves using the following formulation:

$$P - Value(H_0) = Pr\left(\frac{SSU}{SSC} > F\right) = 1 - Pr\left(F < \frac{SSU}{SSC}\right) = 1 - pf\left(\frac{SSU}{SSC}, J, J\right)$$

These tests are all carried out in the R Program for statistical computing using an R coding program provided by Professor Tom Weyman-Jones. This Banker (1996) hypothesis test for returns-to-scale was implemented in this thesis before the standalone SBM and SORMSBM DEA model efficiency ratings were obtained so that the appropriate returns-to-scale metric could be used in these models. However, those results still apply here to the selection of the returns-to-scale metric to be used in the DEA model employed in the three-stage DEA-SFA-DEA methodology. These results can be found in Chapter 9.1 of this thesis, with the efficiency ratings used for the underlying data for the test coming from the output-oriented SORMCCR DEA model (Chapter 7) for the unconstrained variable and the output-oriented SORMBCC DEA model (Chapter 8) for the constrained variable, using the category dataset UK Large-Cap Blend Equity. The conclusion drawn from the results of this test is that the null hypothesis should be accepted, and thus the appropriate returns-to-scale metric for use in the DEA model utilised in the three-stage DEA-SFA-DEA methodology is constant returns-to-scale.

Finally, the third element of the selection process involves the choice between either a radial DEA model or a non-radial DEA model. In a radial DEA model, such as the CCR DEA model and the BCC DEA model, the values of the inputs or outputs change proportionally so that, for example, if the radial DEA model was output-oriented, it would aim to achieve the maximum expansion of the outputs with the same proportions given the current inputs. In contrast to this, in a non-radial DEA model, such as the SBM DEA model, the values of the inputs or outputs are not restricted to vary by the same proportions so that, for example, if the non-radial DEA model was output-oriented, it would aim to achieve the maximum expansion of the outputs without recourse to expanding the outputs proportionally given the current inputs. In the case of this thesis, both a radial and a non-radial DEA model will be utilised in the three-stage DEA-SFA-DEA methodology, thus allowing an assessment to be made about which of these two fundamental approaches to the measurement of efficiency using DEA is more suitable in the case of the analysis undertaken in this thesis to determine the managerial performance of the OEICs/UTs under evaluation using the three-stage DEA-SFA-DEA methodology.

Given the results of the three elements of the selection process above, the selected DEA models for use in the three-stage DEA-SFA-DEA methodology are characterised by being output-oriented, having constant returns-to-scale, and one will be radial and the other will be non-radial. In addition the DEA models will be implemented with the SORM procedure to deal with the negative data present in the dataset for the OEICs/UTs whose managerial performance is being evaluated. Thus, in conclusion, the two DEA models that are going to be utilised in the three-stage DEA-SFA-DEA methodology to evaluate fully the managerial performance of the OEICs/UTs under assessment are the output-oriented SORMCCR DEA model and the output-oriented SORMSBM(CRS) DEA model.

## *6.3: The Three-Stage Methodology Combining Data Envelopment Analysis (DEA) And Stochastic Frontier Analysis (SFA)*

This thesis involves two main strands of investigation with regard to evaluating the managerial performance of the OEICs/UTs under assessment. The first strand involves using standalone DEA to carry out the evaluation of the managerial performance of the OEICs/UTs, and the methodology relating to the various different DEA models utilised to achieve this is detailed earlier in this chapter in Chapter 6.1. This section of the methodology covers the second main strand which is based around the three-stage DEA-SFA-DEA method proposed by Fried et al (2002), and using this to provide more reliable managerial efficiency ratings for the OEICs/UTs under evaluation. The Fried et al (2002) three-stage DEA-SFA-DEA methodology has previously been applied to a number of research projects, but to my knowledge, it has not previously been applied to undertake an assessment of the managerial performance of mutual funds such as the OEICs/UTs which are the research focus of this thesis. As previously mentioned, the three-stage DEA-SFA-DEA methodology involves an initial first stage in which DEA is used to perform an initial evaluation of the managerial efficiency of the OEICs/UTs, followed by a second stage in which SFA regression analysis is used to decompose the first stage DEA slacks in to inefficiency caused by environmental factors, statistical noise and managerial inefficiency, with the influence of environmental factors and statistical noise then purged from the data, followed by a final third stage using the adjusted data to re-perform the DEA evaluation of the managerial efficiency of the OEICs/UTs which should now deliver truer managerial efficiency ratings. The implementation of this three-stage DEA-SFA-DEA methodology, utilised in this thesis to evaluate the managerial performance of the OEICs/UTs under assessment, is detailed below.

***1st Stage – DEA Evaluation Of The Managerial Efficiency Of The OEICs/UTs:***

The first stage of the three-stage DEA-SFA-DEA method that is being utilised to evaluate the managerial performance of the OEICs/UTs under assessment involves an initial DEA analysis of their managerial efficiency. As already mentioned, in this thesis the DEA analysis is carried out using data based on four inputs, the three-year standard deviation, the three-year Sharpe ratio, the total expense ratio (TER) and the fund size, and one output, the three-year annualised return, and it targets a fund universe consisting of 565 UK domiciled OEICs/UTs. The standalone DEA models that are carried through for use in this three-stage DEA-SFA-DEA methodology were selected in Chapter 6.2, and they are the output-oriented SORMCCR DEA model and the output-oriented SORMSBM(CRS) DEA model. The details of these two DEA models can be found in the standalone DEA model section of this methodology, Chapter 6.1. The results from these two DEA models, obtained using the MATLAB program and the MATLAB DEA coding created for this thesis, form the initial, first stage evaluation of the managerial efficiency of the OEICs/UTs.

***2nd Stage – Using SFA To Decompose The 1st Stage DEA Slacks And Adjust The Data:***

The second stage of the three-stage DEA-SFA-DEA method that is being utilised to evaluate the managerial performance of the OEICs/UTs under assessment involves using stochastic frontier analysis (SFA) to decompose the first stage DEA slacks and then using the results to adjust the data to purge it of the influence of environmental factors and statistical noise, with the aim of obtaining truer managerial efficiency ratings for the OEICs/UTs. To decompose the first stage DEA slacks using SFA requires regressing the first stage DEA slacks against the relevant environmental factors and a composed error term. In this thesis the focus is on the output slacks, the deficiency in the achieved return for each OEIC/UT in turn relative to the achieved return of the frontier OEICs/UTs, from the first stage DEA models due to the fact that the two DEA models that are being utilised in this three-stage DEA-SFA-DEA methodology are output-oriented. It is also important to consider here that the two DEA models being used both employ the SORM procedure to deal with the negative data present in the OEIC/UT dataset which means that, in effect, the negative outputs are treated as inputs and the negative inputs are treated as outputs. Given this, it is consistent to decompose and adjust the negative inputs that are treated as outputs within this framework, and exclude the negative outputs that are treated as inputs. The exogenous environmental factors that are used in the SFA regressions in this thesis are stock market indices as they are likely to be the main environmental factors influencing the initial managerial efficiency ratings for the OEICs/UTs. The specific stock market index that is used as an environmental factor varies depending on the category of OEIC/UT being assessed, and the details of which stock market index is associated with which category of OEIC/UT can be found in Chapter 5.

Therefore, the SFA regressions that are used in the second stage of this three-stage DEA-SFA-DEA method are constructed with the dependent variable being the total first stage output slacks defined as follows:

$$s_{rj} = Y_r\lambda - y_{rj} \geq 0$$

$$r = 1, \ldots, s \qquad j = 1, \ldots, n$$

Here $s_{rj}$ is the first stage slack in the use of the $rth$ output for the $jth$ OEIC/UT, $Y_r$ is the $rth$ row of $Y$ and $Y_r\lambda$ is the optimal projection of $y_{rj}$ on to the output efficient subset for the input vector $x_i$. The independent variable used in the construction of the SFA regressions is the observable environmental factor, an appropriate stock market index given the category of OEIC/UT, represented by $z_j$ with $j = 1, \ldots, n$. Therefore, the SFA regressions used to decompose the first stage DEA model output slacks take the general form of the stochastic cost frontier formulation shown below:

$$s_{rj} = f^r(z_j;\, \beta^r) + v_{rj} + u_{rj}$$

$$r = 1, \ldots, s \qquad j = 1, \ldots, n$$

Where:

1. $f^r(z_j;\, \beta^r)$ are the deterministic feasible slack frontiers with parameter vectors $\beta^r$ to be estimated and a composed error structure of $v_{rj} + u_{rj}$

2. $v_{rj}$ and $u_{rj}$ are distributed independently of each other, and of $z_j$

3. $v_{rj}$ is distributed as $v_{rj} \sim N(0, \sigma_{vr}^2)$ and reflects statistical noise

4. $u_{rj}$ is distributed as $u_{rj} \sim N^+(\mu^r, \sigma_{ur}^2)$ and when $u_{rj} \geq 0$ it reflects managerial inefficiency

This stochastic cost frontier formulation can then be solved using maximum likelihood techniques. In this thesis the SFA regressions are estimated using the Frontier package by Tim Coelli and Arne Henningsen in the R Program for statistical computing. This R coded Frontier program is an updated and de-bugged version of the original Tim Coelli Frontier software, and this revised R code has improved convergence criteria for the maximum likelihood estimations.

The stochastic feasible slack frontiers (SFSFs), $f^r(z_j;\ \beta^r) + v_{rj}$, represent the minimum output slacks that can be achieved in a noisy environment with $f^r(z_j;\ \beta^r)$ capturing the impact of the environmental factors on the first stage output slacks and $v_{rj}$ capturing the impact of statistical noise on the first stage output slacks. Thus, any slacks in excess of the SFSFs can be interpreted as being due to the impact of managerial inefficiency, and will show up in the non-negative error component, $u_{rj} \geq 0$.

Given these results from the second stage SFA regressions of the first stage DEA model output slacks of the OEICs/UTs, the next step is to use the results to adjust the outputs of the OEICs/UTs to purge them of the impact of the environmental factors and statistical noise, with the result being that the OEICs/UTs will be evaluated under the same operating environment and with the element of luckiness/unluckiness removed when the third stage re-evaluation of the managerial efficiency of the OEICs/UTs is undertaken. In this thesis the procedure for the adjustment of the data is to increase the outputs of the OEICs/UTs that have been disadvantaged by their relatively poor operating environment and/or their relatively bad luck according to the parameter estimates in the results of the second stage SFA regressions.

Whilst the appropriate adjustment for the impact of the environmental factors can easily be obtained from the results of the second stage SFA regressions, the adjustment for the impact of statistical noise is harder to deduce. The residuals of the second stage SFA regression provide a composed error term consisting of both the statistical noise and the managerial inefficiency, $v_{rj} + u_{rj}$. In order to decompose this composed error term, this thesis, in common with the methodology outlined by Fried et al (2002), follows the technique proposed by Jondrow et al (1982), obtaining conditional estimators for managerial inefficiency, $\hat{E}[u_{rj}|v_{rj} + u_{rj}]$, using the following formulation:

$$\hat{E}[u_{rj}|v_{rj} + u_{rj}] = \frac{\sigma\lambda}{1 + \lambda^2}\left(\frac{\Phi\left(\frac{\varepsilon\lambda}{\sigma}\right)}{1 - \phi\left(\frac{\varepsilon\lambda}{\sigma}\right)} - \frac{\varepsilon\lambda}{\sigma}\right)$$

Where:

1. $\Phi$ represents the standard normal density

2. $\phi$ represents the cumulative distribution function

3. $\varepsilon = v_{rj} + u_{rj}$

4. $\lambda = \frac{\sigma_u}{\sigma_v}$

5. $\sigma = \sqrt{\sigma_v^2 + \sigma_u^2}$

6. $\frac{\varepsilon\lambda}{\sigma} = \frac{\widehat{-\mu_*}}{\hat{\sigma}_*}$

These conditional estimators for managerial inefficiency can then be used to obtain estimators for statistical noise which are derived residually using the following equation:

$$\hat{E}[v_{rj}|v_{rj} + u_{rj}] = s_{rj} - z_j\hat{\beta}^r - \hat{E}[u_{rj}|v_{rj} + u_{rj}]$$

$$r = 1, \ldots, s \qquad j = 1, \ldots, n$$

This equation provides, conditional on $v_{rj} + u_{rj}$, estimators of $\hat{v}_{rj}$ which can be used to adjust the outputs for statistical noise.

Therefore, with this, the complete adjustment process for the data for the outputs of the OEICs/UTs using the results from the second stage SFA regression analysis can be performed. This thesis implements an improved procedure to carry out this adjustment as suggested by Tone and Tsutsui (2009), rather than that used in the original method by Fried et al (2002). This improved procedure for the data adjustment process is formulated with two steps as follows:

*Output Adjustment:*

$$y_{rj}^{A} = y_{rj} + z_j^r \hat{\beta}^r + \hat{v}_{rj}$$

$$r = 1, \ldots, s \qquad j = 1, \ldots, n$$

Where:

1. $y_{rj}^{A}$ is the adjusted quantity of the $rth$ output for the $jth$ OEIC/UT
2. $y_{rj}$ is the observed quantity of the $rth$ output for the $jth$ OEIC/UT
3. $z_j^r \hat{\beta}^r$ is the $rth$ output slack in the $jth$ OEIC/UT which can be attributed to environmental factors
4. $\hat{v}_{rj}$ is the $rth$ output slack in the $jth$ OEIC/UT which can be attributed to statistical noise

*Output Re-Adjustment:*

$$y_{rj}^{AA} = \frac{y_{rMAX} - y_{rMIN}}{y_{rMAX}^{A} - y_{rMIN}^{A}}\left(y_{rj}^{A} - y_{rMIN}^{A}\right) + y_{rMIN}$$

$$r = 1, \ldots, s \qquad j = 1, \ldots, n$$

Where:

1. $y_{rj}^{AA}$ is the re-adjusted quantity of the $rth$ output for the $jth$ OEIC/UT

2. $y_{rj}^{A}$ is the adjusted quantity of the $rth$ output for the $jth$ OEIC/UT

3. $y_{rMAX} = \text{Max}_{\text{j}}\{y_{rj}\}$

4. $y_{rMIN} = \text{Min}_{\text{j}}\{y_{rj}\}$

5. $y_{rMAX}^{A} = \text{Max}_{\text{j}}\{y_{rj}^{A}\}$

6. $y_{rMIN}^{A} = \text{Min}_{\text{j}}\{y_{rj}^{A}\}$

***3rd Stage – Using The Adjusted Data To Re-Perform The DEA Evaluation Of The Managerial Efficiency Of The OEICs/UTs:***

The third and final stage of the three-stage DEA-SFA-DEA method that is being utilised to evaluate the managerial performance of the OEICs/UTs under assessment involves re-performing the DEA analysis of their managerial efficiency using the adjusted dataset which has been purged of the influence of environmental factors and statistical noise. The same two DEA models, the output-oriented SORMCCR DEA model and the output-oriented SORMSBM(CRS) DEA model, that were utilised in the initial DEA analysis are utilised here for the re-evaluation, and again this is undertaken by using the MATLAB program and the MATLAB DEA coding created for this thesis. The resulting managerial efficiency ratings for the OEICs/UTs under evaluation will be free from the influence of environmental factors and statistical noise, and thus should be a truer reflection of the managerial performance of the OEICs/UTs.

# Chapter 7: Results Section 1 – Standalone CCR DEA And SORMCCR DEA Model Results

This first section of results contains the results for the efficiency ratings of the OEICs/UTs in the mutual fund universe under evaluation using standalone CCR and SORMCCR DEA modelling methodologies. All of these results were produced using the MATLAB program, utilising the MATLAB DEA model coding created for this study, as seen in the MATLAB coding appendix. The four DEA models utilised in this section of results are the CCR DEA model, with either an input-orientation or an output-orientation, and the SORMCCR DEA model, with either an input-orientation or an output-orientation.

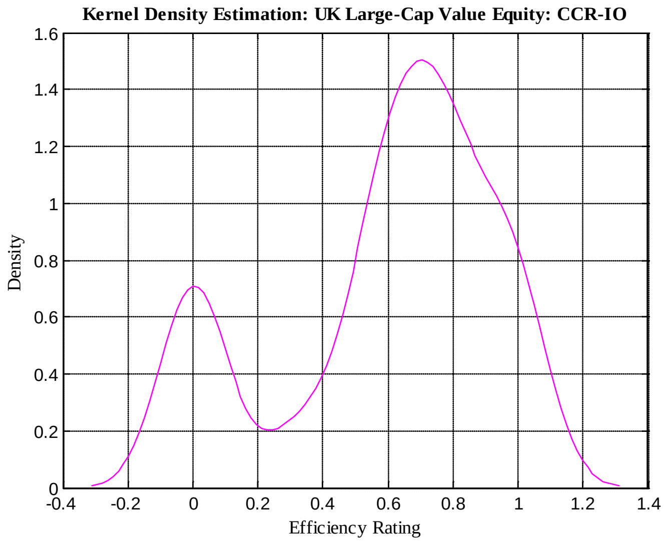
## *7.1: UK Domiciled OEICs And UTs With A UK Investment Focus*

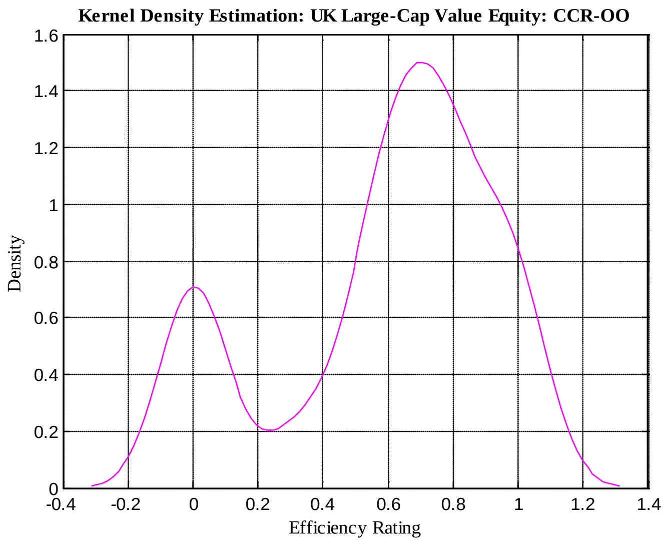
### *UK Large-Cap Value Equity (1st January 2008 – 31st December 2010)*

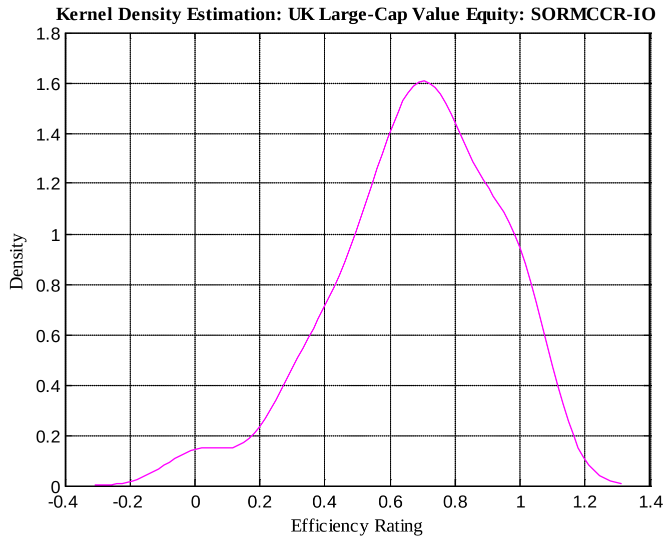
The detailed breakdown of the results from the individual OEICs/UTs in this category across the four DEA model variations can be found in Results Appendix 1 Table RA1.1, with a summary of the results provided in the table below, along with a kernel density estimation graph for each of the four DEA model variations.

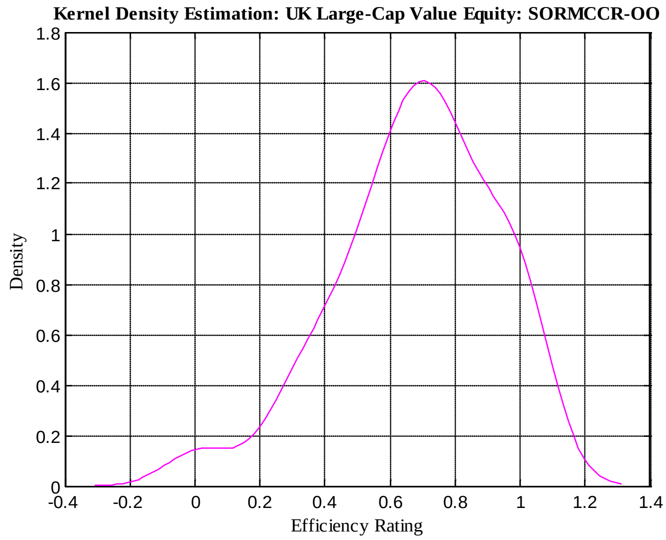
| Summary Results | CCR-IO | CCR-OO | SORMCCR-IO | SORMCCR-OO |
|---|---|---|---|---|
| **Maximum Efficiency Rating** (Number Of OEICs/UTs) | **1.000** (11) | **1.000** (11) | **1.000** (13) | **1.000** (13) |
| **Minimum Efficiency Rating** (Number Of OEICs/UTs) | **0.000** (12) | **0.000** (12) | **0.004** (1) | **0.004** (1) |
| **Mean Efficiency Rating** | **0.597** | **0.597** | **0.678** | **0.678** |
| **Standard Deviation Of Efficiency Ratings** | **0.331** | **0.331** | **0.242** | **0.242** |

| | | | | |
|---|---|---|---|---|
| **Number Of OEICs/UTs Outperforming The Benchmark ETF** | **14** (17.50%) | **14** (17.50%) | **16** (20.00%) | **16** (20.00%) |
| **Number Of OEICs/UTs Underperforming The Benchmark ETF** | **66** (82.50%) | **66** (82.50%) | **64** (80.00%) | **64** (80.00%) |






These results from the 80 UK large-cap value equity OEICs/UTs and the benchmark ETF, the iShares FTSE 100, provide a number of results that are worth highlighting. Firstly, it is important to highlight a peculiar pattern of results for 12 of the OEICs/UTs which have an efficiency rating of 0.000 for the input-oriented and output-oriented CCR models, which is also illustrated in graphical form by an outlier spike at an efficiency rating of 0.000 in the corresponding kernel density estimation graphs. Investigating these strange results shows that the OEICs/UTs that exhibit this pattern are also the ones that contain negative data in their inputs and/or outputs. Thus, this suggests that it is essential that a procedure, such as SORM, is implemented to deal with the negative data issue. This is duly undertaken, leading to the final two columns of results from the SORMCCR model in both input and output orientation. This deals with the negative data issue and produces a more robust looking set of results for the efficiency ratings of the OEICs/UTs in this category.

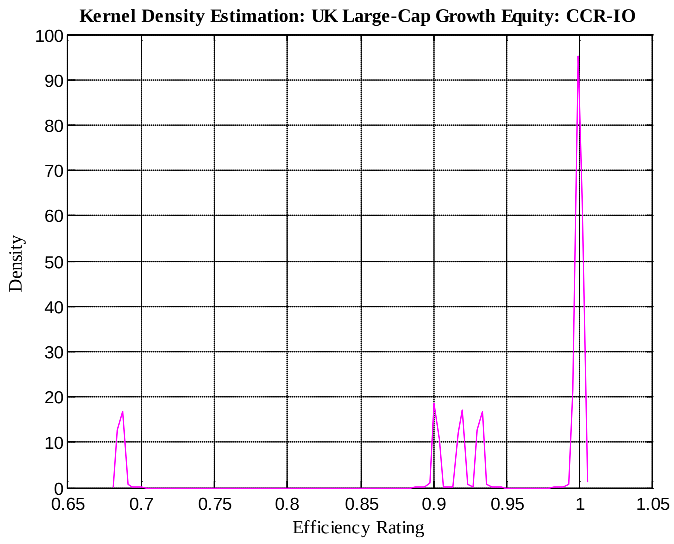
Also, as would be expected due to the underlying constant returns-to-scale, the input-oriented CCR DEA model and the output-oriented CCR DEA model produce near identical results for each OEIC/UT. However, there are some differences between the ratings obtained from the CCR DEA model and those obtained from the SORMCCR DEA model for some of the OEICs/UTs, whilst others obtain the same efficiency rating across the board, most likely due to the removal of the inaccuracies in the efficiency ratings caused by the presence of negative data when the SORMCCR DEA model is utilised.

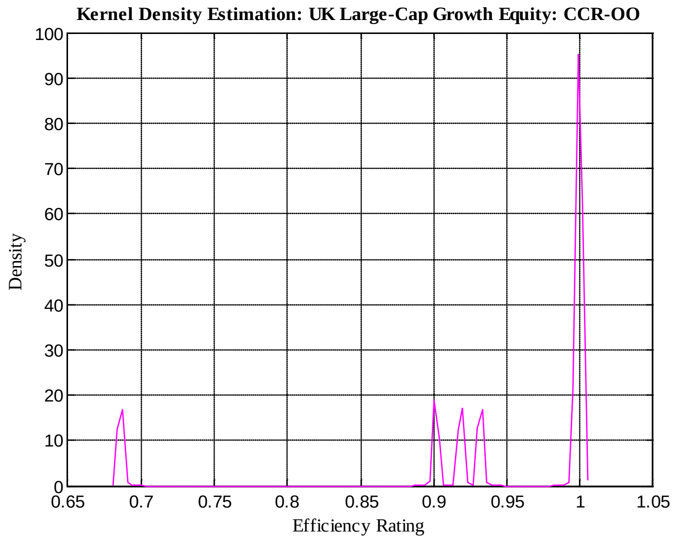
Finally, it is interesting to highlight that in the case of the CCR DEA model, both input-oriented and output-oriented, 14 of the OEICs/UTs show a superior efficiency rating to that of the benchmark iShares FTSE 100 ETF which is only rated at around 0.912/0.913, suggesting that the mangers of these OEICs/UTs could be showing some stock picking ability which allows them to outperform the market. When the SORMCCR DEA model results are examined, it is clear to see that in both the input-oriented and output-oriented cases, 16 of the OEICs/UTs show a superior efficiency rating to that of the benchmark iShares FTSE 100 ETF which is again only rated at around 0.912/0.913, thus once again suggesting the managers of these OEICs/UTs could be showing some stock picking ability which allows them to outperform the market. Also, a significant proportion of the OEICs/UTs, 82.50% under the CCR model and 80.00% under the SORMCCR model, underperform compared to the benchmark iShares FTSE 100 ETF, indicating that a significant number of these more expensive, actively managed funds are outperformed by the low-cost, passively managed iShares FTSE 100 ETF.

## *UK Large-Cap Growth Equity (1st January 2008 – 31st December 2010)*

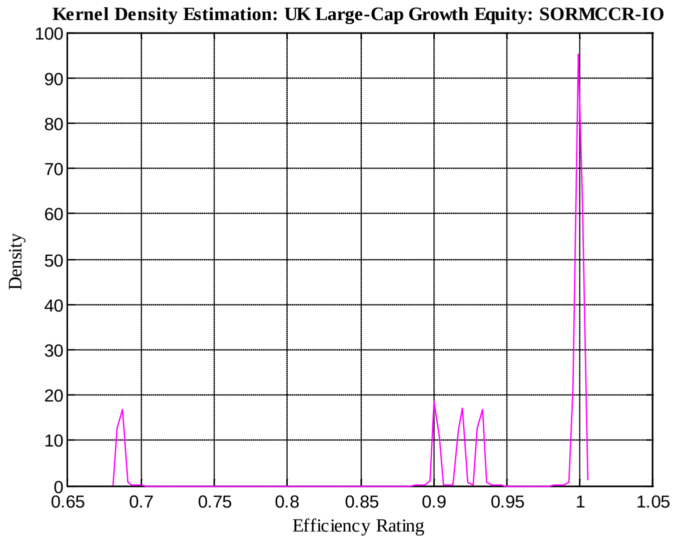
The detailed breakdown of the results from the individual OEICs/UTs in this category across the four DEA model variations can be found in Results Appendix 1 Table RA1.2, with a summary of the results provided in the table below, along with a kernel density estimation graph for each of the four DEA model variations.

| Summary Results | CCR-IO | CCR-OO | SORMCCR-IO | SORMCCR-OO |
|---|---|---|---|---|
| **Maximum Efficiency Rating** (Number Of OEICs/UTs) | **1.000** (4) | **1.000** (4) | **1.000** (4) | **1.000** (4) |
| **Minimum Efficiency Rating** (Number Of OEICs/UTs) | **0.686** (1) | **0.686** (1) | **0.686** (1) | **0.686** (1) |
| **Mean Efficiency Rating** | **0.943** | **0.943** | **0.943** | **0.943** |
| **Standard Deviation Of Efficiency Ratings** | **0.099** | **0.099** | **0.099** | **0.099** |
| **Number Of OEICs/UTs Outperforming The Benchmark ETF** | **0** (0.00%) | **0** (0.00%) | **0** (0.00%) | **0** (0.00%) |
| **Number Of OEICs/UTs Underperforming The Benchmark ETF** | **5** (55.56%) | **5** (55.56%) | **5** (55.56%) | **5** (55.56%) |

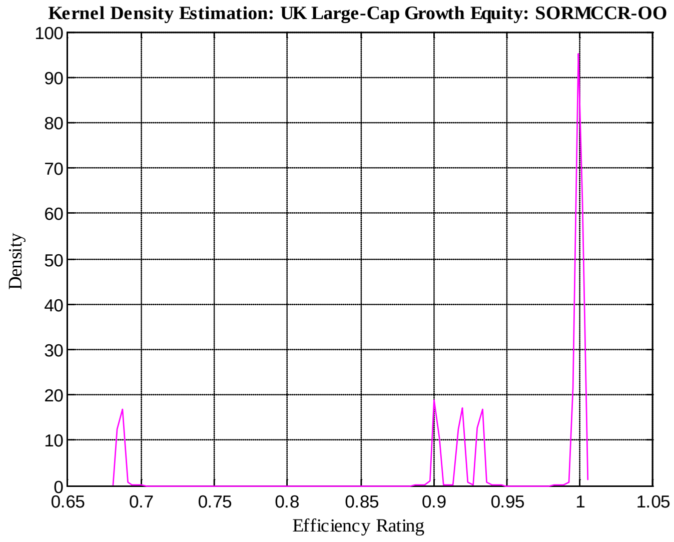




Kernel Density Estimation: UK Large-Cap Growth Equity: CCR-OO
Density
Efficiency Rating
0
10
20
30
40
50
60
70
80
90
100
0.65
0.7
0.75
0.8
0.85
0.9
0.95
1
1.05

Kernel Density Estimation: UK Large-Cap Growth Equity: SORMCCR-IO
Density
Efficiency Rating
0
10
20
30
40
50
60
70
80
90
100
0.65
0.7
0.75
0.8
0.85
0.9
0.95
1
1.05

Kernel Density Estimation: UK Large-Cap Growth Equity: SORMCCR-OO
Density
Efficiency Rating
0
10
20
30
40
50
60
70
80
90
100
0.65
0.7
0.75
0.8
0.85
0.9
0.95
1
1.05

These results from the 9 UK large-cap growth equity OEICs/UTs and the benchmark ETF, the iShares FTSE 100, provide a number of results that are worth highlighting. Firstly, there is no issue with negative data for the OEICs/UTs in this category, but the SORM procedure is still implemented for the purposes of comparison across the entire universe of mutual funds. Also, the input-oriented and output-oriented CCR DEA models provide identical efficiency ratings as expected due to the underlying constant returns-to-scale, and there is no difference between the efficiency ratings the OEICs/UTs obtain from the CCR model compared against those they obtain from the SORMCCR model, most likely as a result of the absence of negative data in this category of OEICs/UTs.

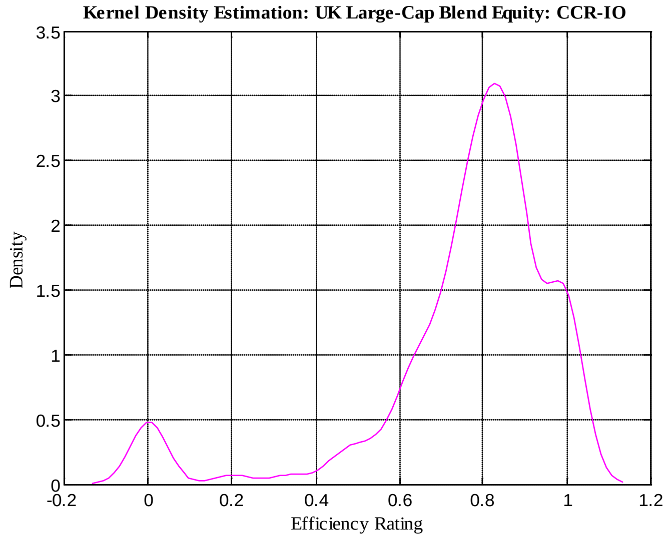
Finally, for all four DEA model variations, it can be seen that the benchmark iShares FTSE 100 ETF is ranked at the maximum rating of 1.000, along with 4 of the OEICs/UTs, suggesting the managers of the OEICs/UTs in this category are failing to show an ability to pick stocks and outperform the market. However, it is important to note that this category has a small sample size, and consequently this subsequent analysis is based on that small sample size.

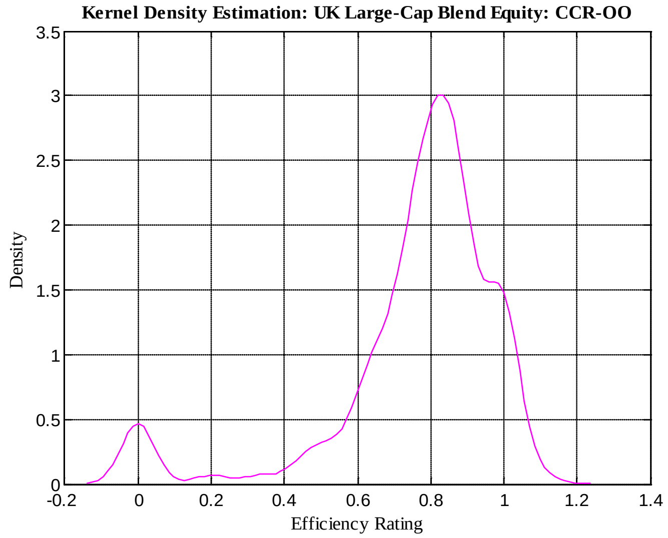
***UK Large-Cap Blend Equity (1st January 2008 – 31st December 2010)***

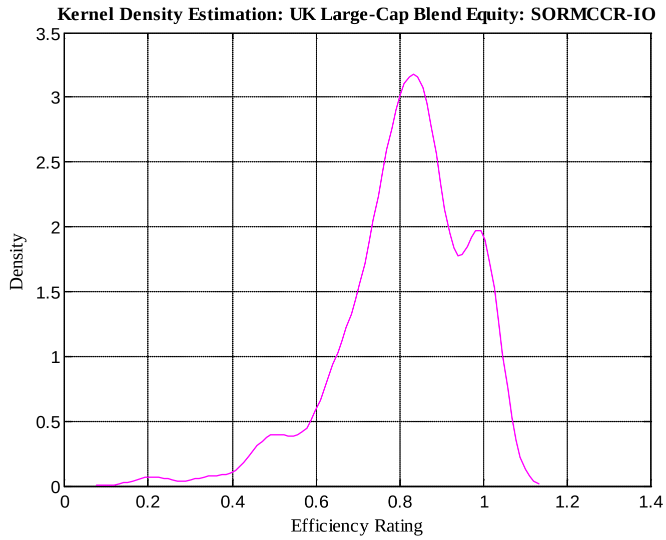
The detailed breakdown of the results from the individual OEICs/UTs in this category across the four DEA model variations can be found in Results Appendix 1 Table RA1.3, with a summary of the results provided in the table below, along with a kernel density estimation graph for each of the four DEA model variations.

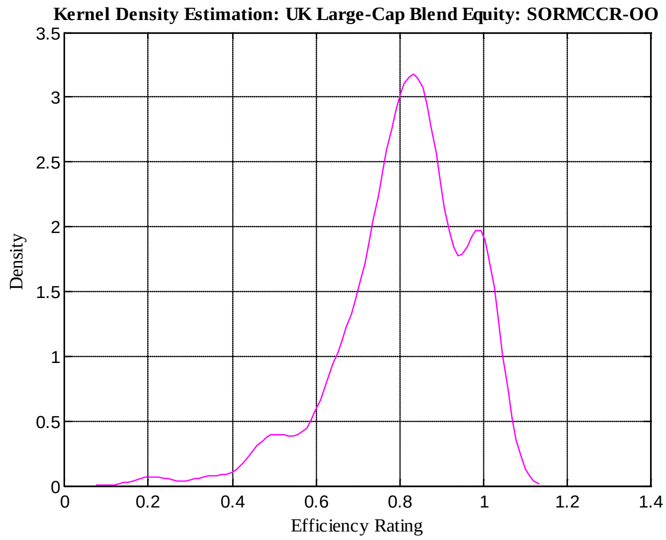
| Summary Results | CCR-IO | CCR-OO | SORMCCR-IO | SORMCCR-OO |
|---|---|---|---|---|
| **Maximum Efficiency Rating** (Number Of OEICs/UTs) | **1.000** (17) | **1.099** (1) | **1.000** (25) | **1.000** (25) |
| **Minimum Efficiency Rating** (Number Of OEICs/UTs) | **0.000** (7) | **0.000** (7) | **0.209** (1) | **0.209** (1) |

| | | | | |
|---|---|---|---|---|
| **Mean Efficiency Rating** | **0.760** | **0.763** | **0.815** | **0.815** |
| **Standard Deviation Of Efficiency Ratings** | **0.230** | **0.232** | **0.148** | **0.148** |
| **Number Of OEICs/UTs Outperforming The Benchmark ETF** | **103** (79.23%) | **103** (79.23%) | **111** (85.38%) | **111** (85.38%) |
| **Number Of OEICs/UTs Underperforming The Benchmark ETF** | **27** (20.77%) | **27** (20.77%) | **19** (14.62%) | **19** (14.62%) |






These results from the 130 UK large-cap blend equity OEICs/UTs and the benchmark ETF, the iShares FTSE 100, provide a number of results that are worth highlighting. Firstly, it is apparent from examining the results that 7 of the OEICs/UTs exhibit the peculiar pattern in their efficiency ratings of being rated at 0.000 for input-oriented and output-oriented CCR DEA, which also manifests itself in the form of an outlier spike in the corresponding kernel density estimation graphs around an efficiency rating of 0.000. These peculiar results correspond to the OEICs/UTs which contain negative data in their inputs and/or outputs, thus suggesting that it is essential to implement a procedure, such as SORM, to deal with the negative data issue. This leads to the SORMCCR DEA efficiency ratings results shown in the final two columns, both input-oriented and output-oriented, which deal with the negative data issue and produce a more robust looking set of efficiency rating results for the OEICs/UTs in this category.

Also, the input-oriented and output-oriented CCR DEA models provide near identical results in all cases apart from one, that of the Lazard UK Alpha Fund, with efficiency ratings of 0.817 and 1.099 respectively. It is clear to see that not only are the efficiency ratings different, but also the output-oriented CCR DEA efficiency rating exceeds 1.000. Examining the underlying dataset reveals that although the Lazard UK Alpha Fund itself does not contain negative data, there are funds in the category dataset that do, raising the possibility that this could be the cause of the anomaly. Thus, it will be beneficial to implement a procedure such as SORM to deal with the negative data issue, and see if this resolves the problem. This was duly carried out, and the efficiency rating results from the SORMCCR DEA model for the Lazard UK Alpha Fund no longer suffer from this issue, returning a rating of 0.818 for both the input-oriented and output-oriented variations. Furthermore, there are some differences between the ratings obtained from the CCR DEA model and those obtained from the SORMCCR DEA model for some of the OEICs/UTs, whilst others obtain the same efficiency rating across the board, as might be expected due to the resolution of the negative data problem.

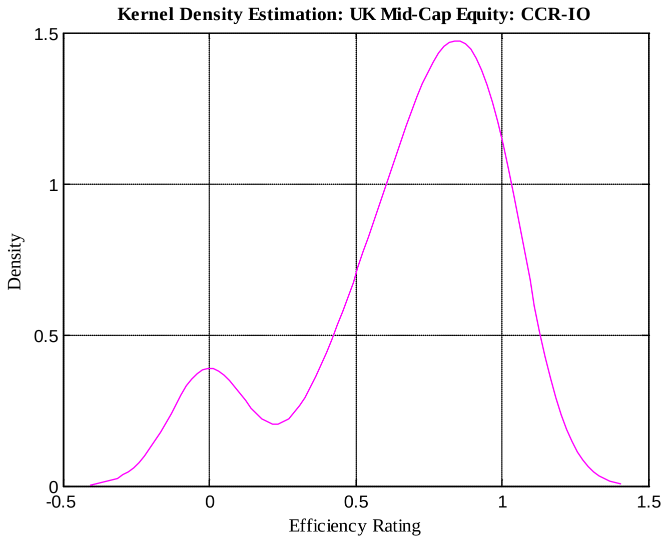
Finally, in the case of the CCR DEA model, both input-oriented and output-oriented, 103 of the OEICs/UTs show a superior efficiency rating to that of the benchmark iShares FTSE 100 ETF which is only rated at around 0.671/0.672, suggesting that the managers of these OEICs/UTs could be showing some ability to pick stocks which allows them to outperform the market. When the SORMCCR DEA model results are examined, it is clear to see that in both the input-oriented and output-oriented cases, 111 of the OEICs/UTs show a superior efficiency rating to that of the benchmark iShares FTSE 100 ETF which is only rated at around 0.671/0.672, thus again suggesting that the managers of these OEICs/UTs could be showing some ability to pick stocks which allows them to outperform the market. It is important to note therefore, that a significant proportion of the

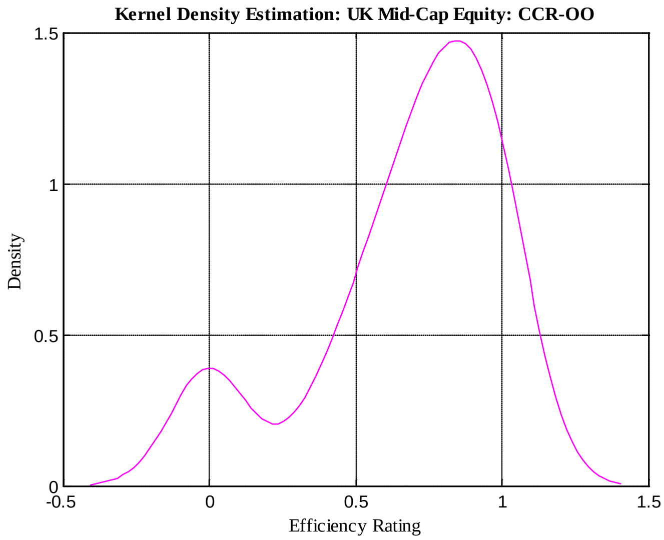
OEICs/UTs, 79.23% under the CCR model and 85.38% under the SORMCCR model, outperform the benchmark iShares FTSE 100 ETF, indicating that a significant number of these more expensive, actively managed funds outperform the low-cost, passively managed iShares FTSE 100 ETF.

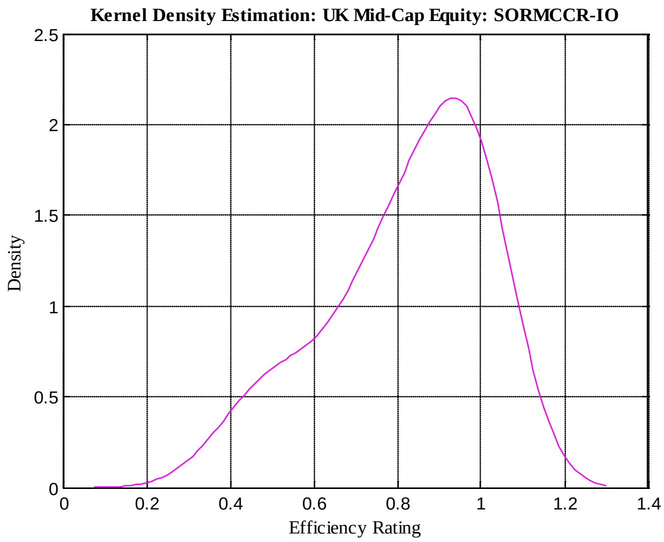
***UK Mid-Cap Equity (1st January 2008 – 31st December 2010)***

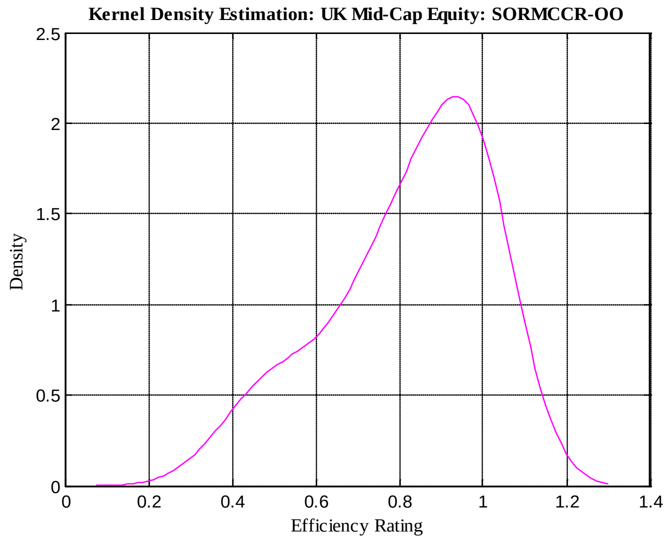
The detailed breakdown of the results from the individual OEICs/UTs in this category across the four DEA model variations can be found in Results Appendix 1 Table RA1.4, with a summary of the results provided in the table below, along with a kernel density estimation graph for each of the four DEA model variations.

| Summary Results | CCR-IO | CCR-OO | SORMCCR-IO | SORMCCR-OO |
|---|---|---|---|---|
| **Maximum Efficiency Rating** (Number Of OEICs/UTs) | **1.000** (8) | **1.000** (8) | **1.000** (12) | **1.000** (12) |
| **Minimum Efficiency Rating** (Number Of OEICs/UTs) | **0.000** (6) | **0.000** (6) | **0.374** (1) | **0.374** (1) |
| **Mean Efficiency Rating** | **0.677** | **0.677** | **0.820** | **0.820** |
| **Standard Deviation Of Efficiency Ratings** | **0.317** | **0.317** | **0.183** | **0.183** |
| **Number Of OEICs/UTs Outperforming The Benchmark ETF** | **0** (0.00%) | **0** (0.00%) | **0** (0.00%) | **0** (0.00%) |
| **Number Of OEICs/UTs Underperforming The Benchmark ETF** | **37** (82.22%) | **37** (82.22%) | **33** (73.33%) | **33** (73.33%) |


Kernel Density Estimation: UK Mid-Cap Equity: CCR-IO
Density
Efficiency Rating
1.5
1
0.5
0
-0.5
0
0.5
1
1.5


Kernel Density Estimation: UK Mid-Cap Equity: CCR-OO
Density
Efficiency Rating
1.5
1
0.5
0
-0.5
0
0.5
1
1.5


Kernel Density Estimation: UK Mid-Cap Equity: SORMCCR-IO
Density
Efficiency Rating
2.5
2
1.5
1
0.5
0
0
0.2
0.4
0.6
0.8
1
1.2
1.4




These results from the 45 UK mid-cap equity OEICs/UTs and the benchmark ETF, the iShares FTSE 250, provide a number of results that are worth highlighting. Firstly, from examining the results it is clear to see that 6 of the OEICs/UTs exhibit the odd pattern in their efficiency ratings of being rated at 0.000 for both input-oriented CCR and output-oriented CCR, which is also apparent in the corresponding kernel density estimation graphs in the form of an outlier spike around an efficiency rating of 0.000. As before, these odd results correspond to the OEICs/UTs which contain negative data in their inputs and/or outputs, thus suggesting that SORM should be implemented to deal with the negative data issue. This leads to the input-oriented and output-oriented SORMCCR DEA efficiency ratings results which deal with the negative data issue and produce a more robust set of efficiency rating results for the OEICs/UTs in this category.

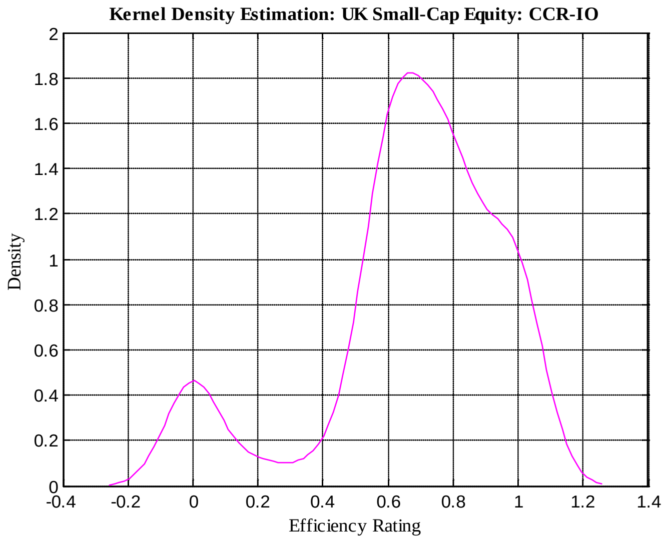
Also, the input-oriented and output-oriented CCR DEA models provide identical efficiency ratings for each OEIC/UT as expected due to the underlying constant returns-to-scale. There are some differences between the ratings obtained from the CCR DEA model and those obtained from the SORMCCR DEA model for some of the OEICs/UTs, whilst others obtain the same efficiency rating across the board, as might be expected as a result of the resolution of the negative data problem.

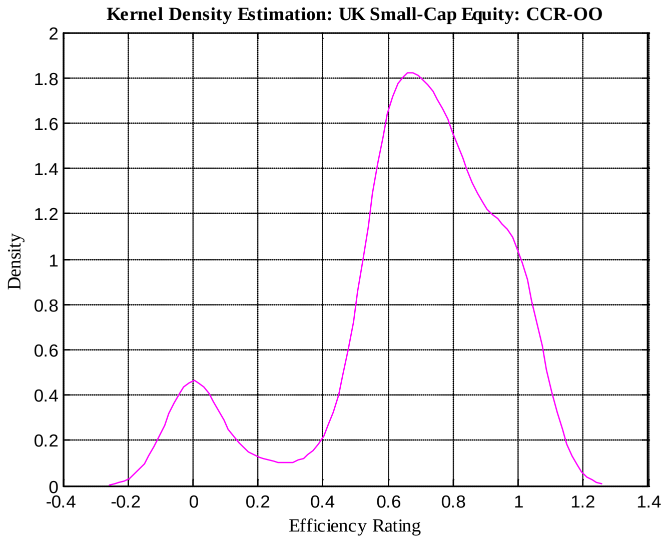
Finally, for each of the four DEA models utilised, none of the OEICs/UTs show a superior efficiency rating to that of the benchmark iShares FTSE 250 ETF which obtains the maximum efficiency rating of 1.000 under each of the four DEA models used. Thus, this suggests that in this category, none of the managers of these OEICs/UTs are showing an ability to pick stocks which would allow them to outperform the market. Also, it is important to note that a significant proportion of the OEICs/UTs, 82.22% under the CCR model and 73.33% under the SORMCCR model, underperform relative to the benchmark iShares FTSE 250 ETF, indicating that a significant number of these more expensive, actively managed funds underperform the low-cost, passively managed iShares FTSE 250 ETF.

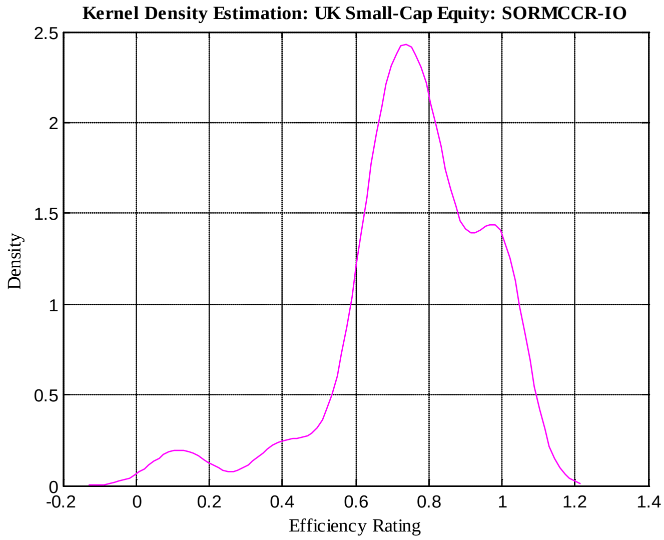
### *UK Small-Cap Equity (1st January 2008 – 31st December 2010)*

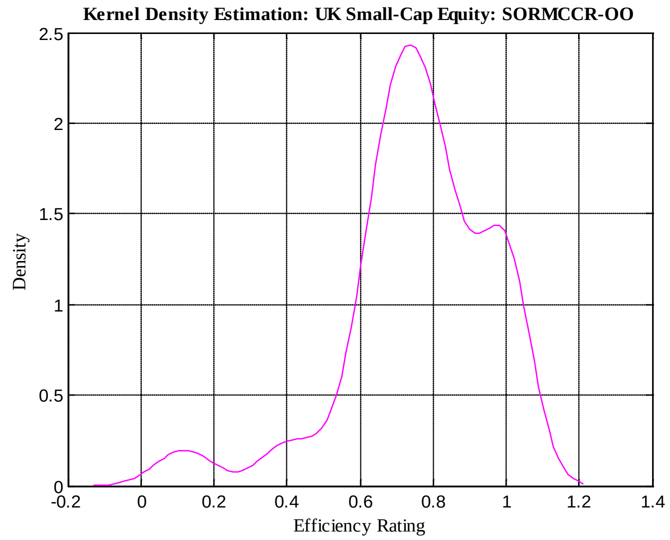
The detailed breakdown of the results from the individual OEICs/UTs in this category across the four DEA model variations can be found in Results Appendix 1 Table RA1.5, with a summary of the results provided in the table below, along with a kernel density estimation graph for each of the four DEA model variations.

| Summary Results | CCR-IO | CCR-OO | SORMCCR-IO | SORMCCR-OO |
|---|---|---|---|---|
| **Maximum Efficiency Rating** (Number Of OEICs/UTs) | **1.000** (8) | **1.000** (8) | **1.000** (9) | **1.000** (9) |
| **Minimum Efficiency Rating** (Number Of OEICs/UTs) | **0.000** (5) | **0.000** (5) | **0.085** (1) | **0.085** (1) |
| **Mean Efficiency Rating** | **0.672** | **0.672** | **0.758** | **0.758** |
| **Standard Deviation Of Efficiency Ratings** | **0.281** | **0.281** | **0.201** | **0.201** |
| **Number Of OEICs/UTs Outperforming The Benchmark ETF** | **0** (0.00%) | **0** (0.00%) | **0** (0.00%) | **0** (0.00%) |
| **Number Of OEICs/UTs Underperforming The Benchmark ETF** | **42** (84.00%) | **42** (84.00%) | **41** (82.00%) | **41** (82.00%) |


Kernel Density Estimation: UK Small-Cap Equity: CCR-IO
Density
Efficiency Rating
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
-0.4
-0.2
0
0.2
0.4
0.6
0.8
1
1.2
1.4


Kernel Density Estimation: UK Small-Cap Equity: CCR-OO
Density
Efficiency Rating
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
-0.4
-0.2
0
0.2
0.4
0.6
0.8
1
1.2
1.4


Kernel Density Estimation: UK Small-Cap Equity: SORMCCR-IO
Density
Efficiency Rating
2.5
2
1.5
1
0.5
0
-0.2
0
0.2
0.4
0.6
0.8
1
1.2
1.4




These results from the 50 UK small-cap equity OEICs/UTs and the benchmark ETF, the iShares FTSE 250, provide a number of results that are worth highlighting. Firstly, an inspection of the results shows that 5 of the OEICs/UTs exhibit the odd pattern in their efficiency rating results of being rated at 0.000 for both input-oriented and output-oriented CCR DEA, which also appears in graphical form in the corresponding kernel density estimation graphs as an outlier spike around an efficiency rating of 0.000. As in the previous cases, these odd results correspond to the OEICs/UTs which contain negative data in their inputs and/or outputs, thus suggesting that SORM should be implemented to deal with the negative data issue, leading to the input-oriented and output-oriented SORMCCR efficiency ratings results which deal with this issue and result in a more robust set of efficiency rating results for the OEICs/UTs in this category.

Again, as expected due to the underlying constant returns-to-scale, the input-oriented and output-oriented CCR DEA models provide identical efficiency ratings for each OEIC/UT. As might be expected due to the resolution of the negative data issue, there are some differences between the ratings obtained from the CCR DEA model compared to those obtained from the SORMCCR DEA model for some of the OEICs/UTs, whilst others obtain the same efficiency rating across the board.

Finally, for each of the four DEA models employed, none of the OEICs/UTs show a superior efficiency rating to that of the benchmark iShares FTSE 250 ETF which records the maximum efficiency rating of 1.000 under each of the four DEA models employed, thus suggesting that in this category, none of the managers of these OEICs/UTs are showing an ability to pick stocks which would allow them to outperform the market. Also, it is important to again note that a significant proportion of the OEICs/UTs, 84.00% under the CCR model and 82.00% under the SORMCCR model, underperform relative to the benchmark iShares FTSE 250 ETF, thus indicating that a significant number of these more expensive, actively managed funds underperform the low-cost, passively managed iShares FTSE 250 ETF.

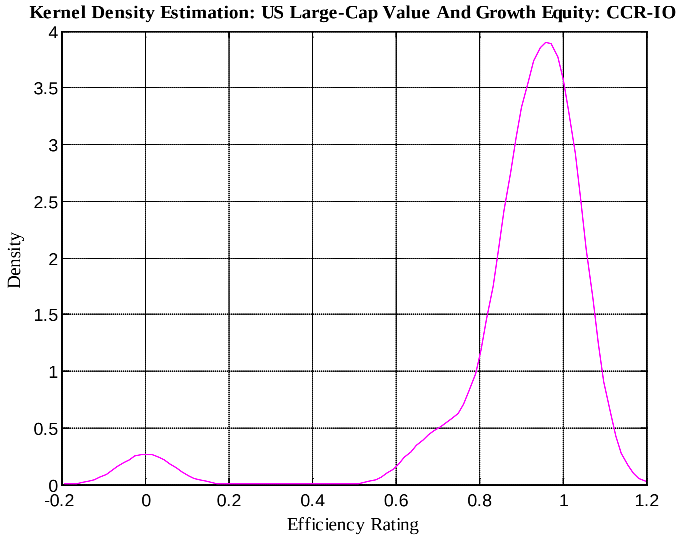
## *7.2: UK Domiciled OEICs And UTs With A US Investment Focus*

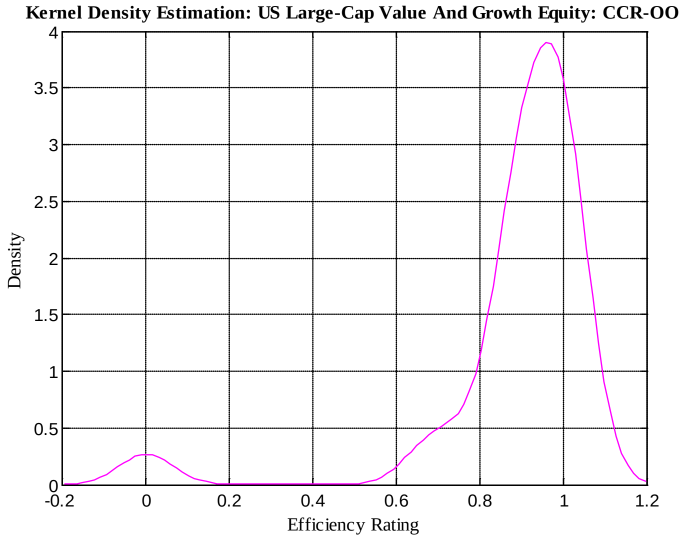
### *US Large-Cap Value And Growth Equity (1st January 2008 – 31st December 2010)*

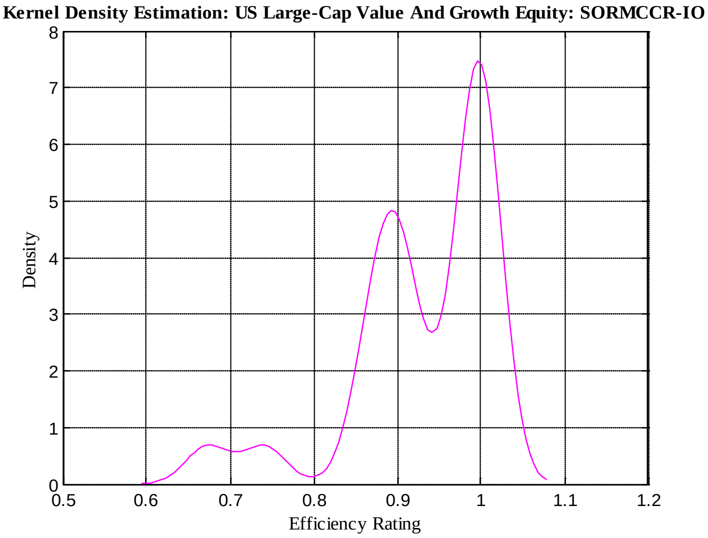
The detailed breakdown of the results from the individual OEICs/UTs in this category across the four DEA model variations can be found in Results Appendix 1 Table RA1.6, with a summary of the results provided in the table below, along with a kernel density estimation graph for each of the four DEA model variations.

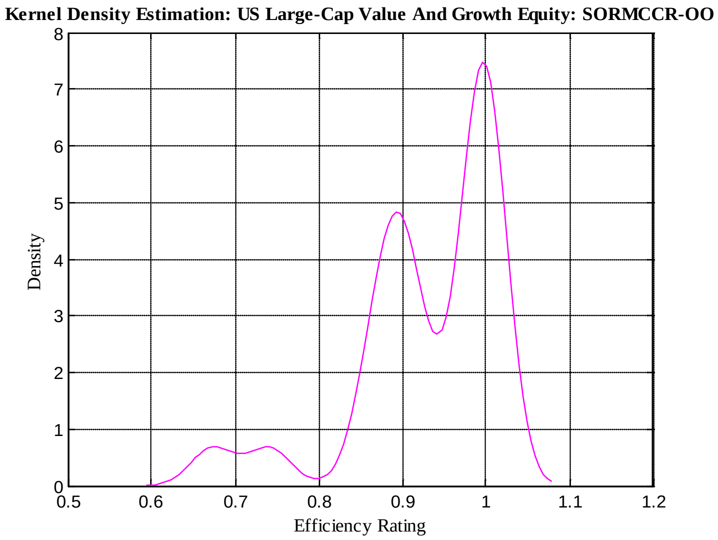
| Summary Results | CCR-IO | CCR-OO | SORMCCR-IO | SORMCCR-OO |
|---|---|---|---|---|
| **Maximum Efficiency Rating** (Number Of OEICs/UTs) | **1.000** (7) | **1.000** (7) | **1.000** (8) | **1.000** (8) |
| **Minimum Efficiency Rating** (Number Of OEICs/UTs) | **0.000** (1) | **0.000** (1) | **0.673** (1) | **0.673** (1) |
| **Mean Efficiency Rating** | **0.887** | **0.887** | **0.930** | **0.930** |
| **Standard Deviation Of Efficiency Ratings** | **0.212** | **0.212** | **0.088** | **0.088** |
| **Number Of OEICs/UTs Outperforming The Benchmark ETF** | **0** (0.00%) | **0** (0.00%) | **0** (0.00%) | **0** (0.00%) |

| | | | | |
|---|---|---|---|---|
| **Number Of OEICs/UTs Underperforming The Benchmark ETF** | **15** (68.18%) | **15** (68.18%) | **14** (63.64%) | **14** (63.64%) |






These results from the 22 US large-cap value and growth equity OEICs/UTs and the benchmark ETF, the iShares S&P 500, provide a number of results that are worth highlighting. Firstly, from examining the results it is possible to see that one of the OEICs/UTs exhibits the peculiar pattern in its efficiency ratings of being rated at 0.000 for both input-oriented and output-oriented CCR. This peculiar result corresponds to an OEIC/UT which contains negative data in its inputs and/or outputs, suggesting that SORM should be employed to deal with the negative data issue. Thus, this leads to the input-oriented and output-oriented SORMCCR DEA efficiency ratings results which deal with this issue and lead to a more robust set of efficiency rating results for the OEICs/UTs in this category.

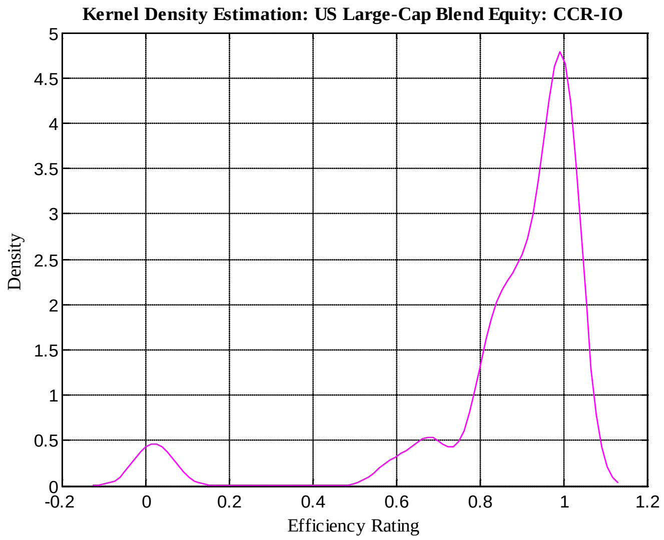
The input-oriented and output-oriented CCR DEA models provide identical efficiency ratings for each OEIC/UT as expected due to the underlying constant returns-to-scale. Again, there are some differences between the ratings obtained from the CCR DEA model and those obtained from the SORMCCR DEA model for some of the OEICs/UTs, whilst others obtain the same efficiency rating across all four DEA models, as a result of the negative data issue being resolved.

Finally, for each of the four DEA models used, none of the OEICs/UTs show a superior efficiency rating to that of the benchmark iShares S&P 500 ETF which achieves the maximum efficiency rating of 1.000 under all four of the DEA models. This suggests that in this category, none of the managers of these OEICs/UTs are showing an ability to pick stocks which allows them to outperform the market. It is also important to highlight the fact that a significant proportion of the OEICs/UTs, 68.18% under the CCR model and 63.64% under the SORMCCR model, underperform relative to the benchmark iShares S&P 500 ETF, indicating that a significant number of these more expensive, actively managed funds underperform the low-cost, passively managed iShares S&P 500 ETF.

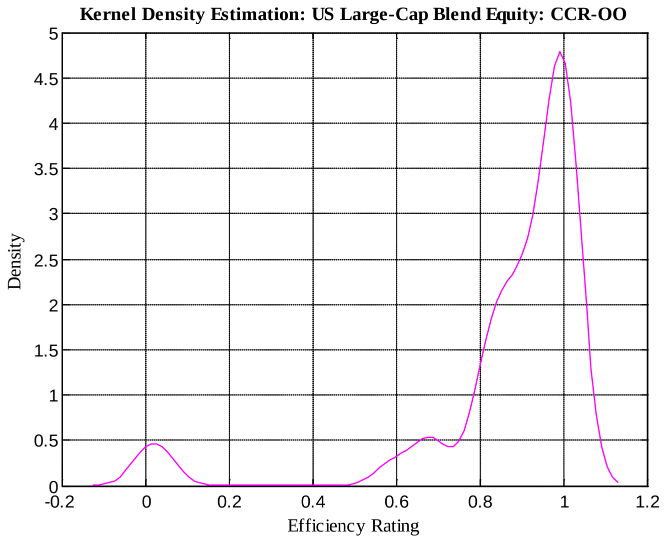
### ***US Large-Cap Blend Equity (1st January 2008 – 31st December 2010)***

The detailed breakdown of the results from the individual OEICs/UTs in this category across the four DEA model variations can be found in Results Appendix 1 Table RA1.7, with a summary of the results provided in the table below, along with a kernel density estimation graph for each of the four DEA model variations.

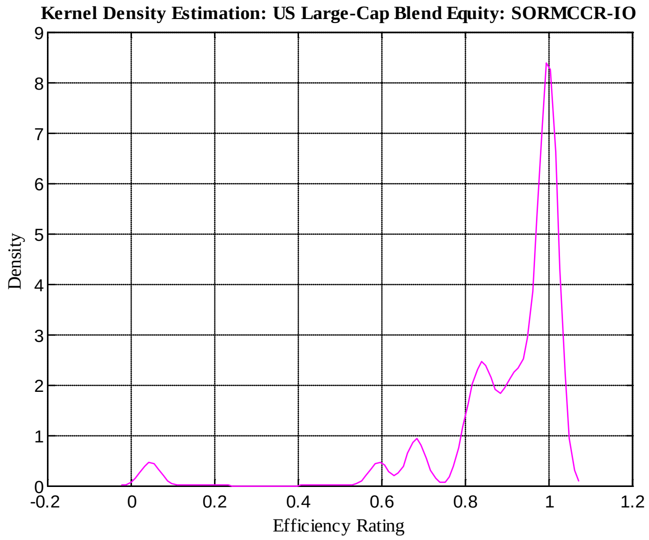
| Summary Results | CCR-IO | CCR-OO | SORMCCR-IO | SORMCCR-OO |
|---|---|---|---|---|
| **Maximum Efficiency Rating** (Number Of OEICs/UTs) | **1.000** (13) | **1.000** (13) | **1.000** (14) | **1.000** (14) |
| **Minimum Efficiency Rating** (Number Of OEICs/UTs) | **0.000** (1) | **0.000** (1) | **0.044** (1) | **0.044** (1) |
| **Mean Efficiency Rating** | **0.868** | **0.868** | **0.897** | **0.897** |
| **Standard Deviation Of Efficiency Ratings** | **0.231** | **0.231** | **0.178** | **0.178** |
| **Number Of OEICs/UTs Outperforming The Benchmark ETF** | **28** (77.78%) | **28** (77.78%) | **29** (80.56%) | **29** (80.56%) |
| **Number Of OEICs/UTs Underperforming The Benchmark ETF** | **8** (22.22%) | **8** (22.22%) | **7** (19.44%) | **7** (19.44%) |



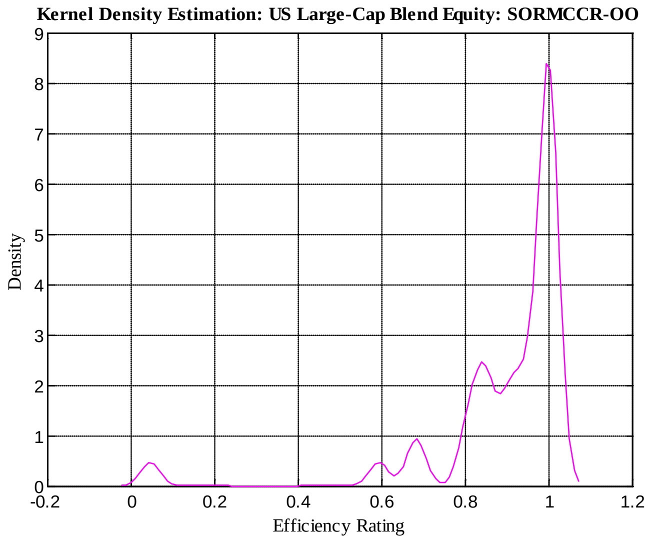
Kernel Density Estimation: US Large-Cap Blend Equity: CCR-IO
Density
Efficiency Rating

Kernel Density Estimation: US Large-Cap Blend Equity: CCR-OO
Density
Efficiency Rating

Kernel Density Estimation: US Large-Cap Blend Equity: SORMCCR-IO
Density
Efficiency Rating




These results from the 36 US large-cap blend equity OEICs/UTs and the benchmark ETF, the iShares S&P 500, provide a number of results that are worth highlighting. Firstly, it is apparent from examining the results that one of the OEICs/UTs is showing the odd pattern in its efficiency ratings of being rated at 0.000 for both input-oriented and output-oriented CCR. This odd result corresponds with an OEIC/UT which has negative data present in its inputs and/or outputs, thus suggesting that SORM should be implemented to deal with this negative data issue. Consequently, this results in the input-oriented and output-oriented SORMCCR DEA efficiency ratings results which deal with this issue and result in a more robust set of efficiency rating results for the OEICs/UTs in this category.

Again, the input-oriented and output-oriented CCR DEA models show near identical efficiency ratings for each OEIC/UT. There are some differences between the efficiency ratings obtained from the CCR DEA model and those obtained from the SORMCCR DEA model for some of the OEICs/UTs, whilst others obtain the same efficiency rating across all four of the DEA model variations, most likely due to the resolution of the negative data issue.

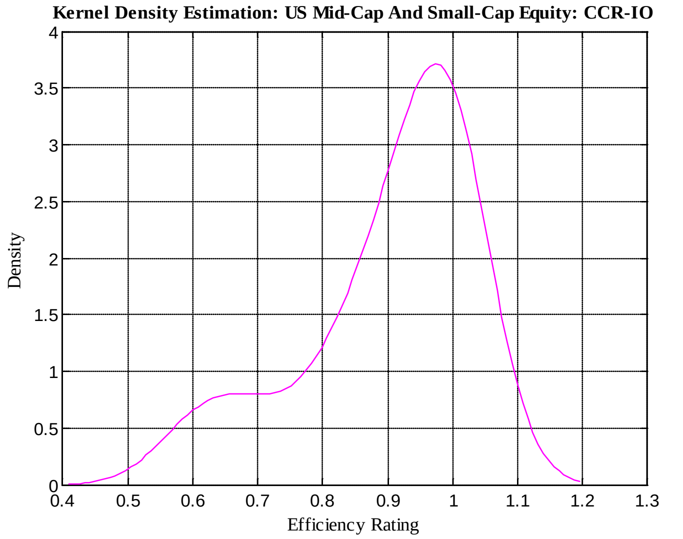
Finally, under the evaluation of the CCR DEA model, both input-oriented and output-oriented, 28 of the OEICs/UTs show a superior efficiency rating to that of the benchmark iShares S&P 500 ETF which only achieves an efficiency rating of around 0.840/0.841, suggesting that the managers of these OEICs/UTs could be showing some ability to pick stocks that allows them to outperform the market. When the SORMCCR DEA results are examined, it is clear to see that in both the input-oriented and output-oriented cases, 29 of the OEICs/UTs show a superior efficiency rating to that of the benchmark iShares S&P 500 ETF which is only rated at around 0.840/0.841, thus suggesting that the managers of these OEICs/UTs could be showing some ability to pick stocks that allows them to outperform the market. Therefore, it is important to note that a significant proportion of the OEICs/UTs, 77.78% under the CCR model and 80.56% under the SORMCCR model, outperform the benchmark iShares S&P 500 ETF, indicating that a significant number of these more expensive, actively managed funds outperform the low-cost, passively managed iShares S&P 500 ETF.

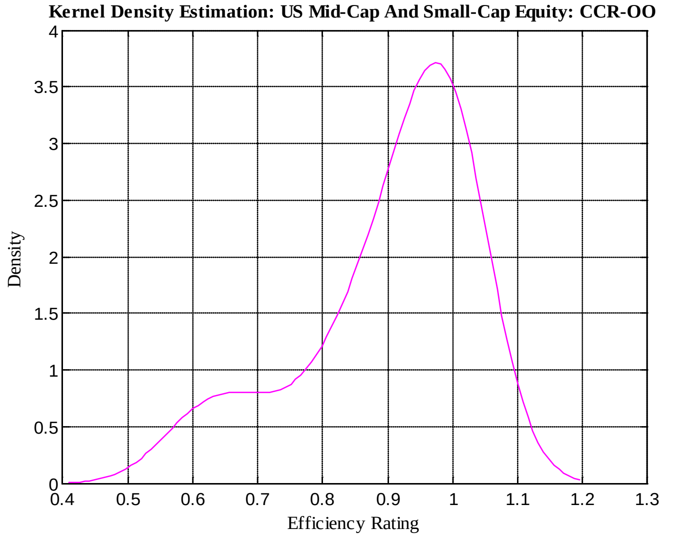
***US Mid-Cap And Small-Cap Equity (1st January 2008 – 31st December 2010)***

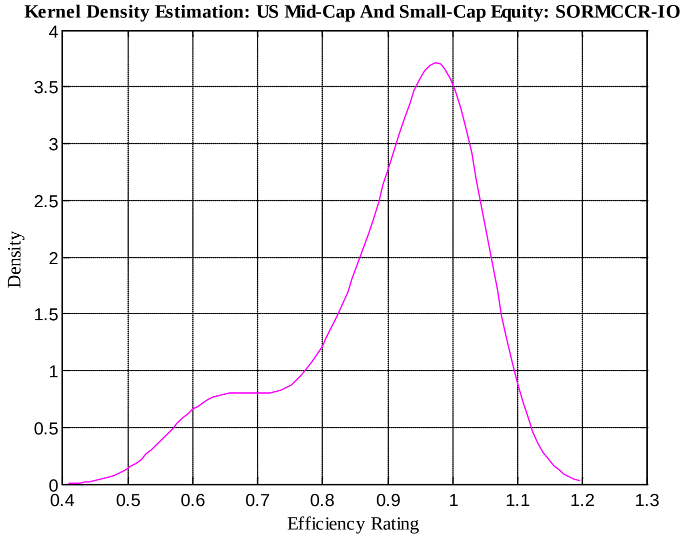
The detailed breakdown of the results from the individual OEICs/UTs in this category across the four DEA model variations can be found in Results Appendix 1 Table RA1.8, with a summary of the results provided in the table below, along with a kernel density estimation graph for each of the four DEA model variations.

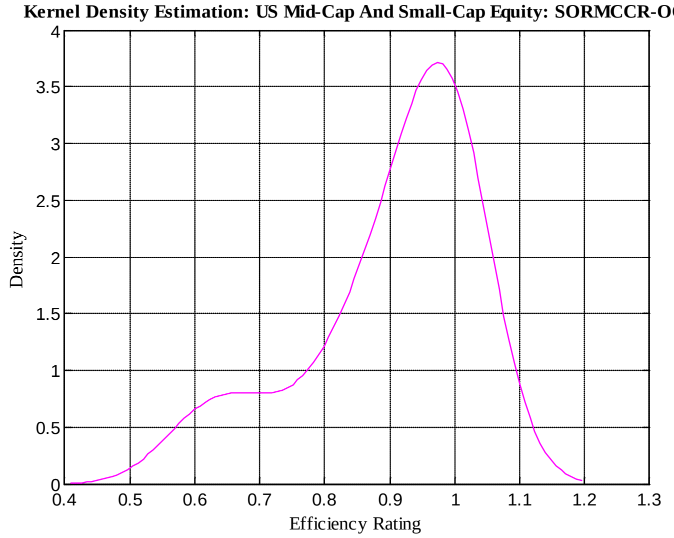
| Summary Results | CCR-IO | CCR-OO | SORMCCR-IO | SORMCCR-OO |
|---|---|---|---|---|
| **Maximum Efficiency Rating** (Number Of OEICs/UTs) | **1.000** (4) | **1.000** (4) | **1.000** (4) | **1.000** (4) |
| **Minimum Efficiency Rating** (Number Of OEICs/UTs) | **0.604** (1) | **0.604** (1) | **0.604** (1) | **0.604** (1) |
| **Mean Efficiency Rating** | **0.900** | **0.900** | **0.900** | **0.900** |
| **Standard Deviation Of Efficiency Ratings** | **0.130** | **0.130** | **0.130** | **0.130** |
| **Number Of OEICs/UTs Outperforming The Benchmark ETF** | **0** (0.00%) | **0** (0.00%) | **0** (0.00%) | **0** (0.00%) |

| | | | | |
|---|---|---|---|---|
| **Number Of OEICs/UTs Underperforming The Benchmark ETF** | **8** (66.67%) | **8** (66.67%) | **8** (66.67%) | **8** (66.67%) |






These results from the 12 US mid-cap and small-cap equity OEICs/UTs and the benchmark ETF, the iShares S&P 500, provide a number of results that are worth highlighting. Firstly, there is no issue with negative data for the OEICs/UTs in this category, but the SORM procedure is still implemented for the purposes of comparison across the entire universe of mutual funds. Also, the input-oriented and output-oriented CCR DEA models again show identical efficiency ratings as expected due to the underlying constant returns-to-scale, and there are no differences between the efficiency ratings the OEICs/UTs obtain from the CCR model compared against those they obtain from the SORMCCR model, almost certainly due to the lack of negative data in this category of OEICs/UTs.

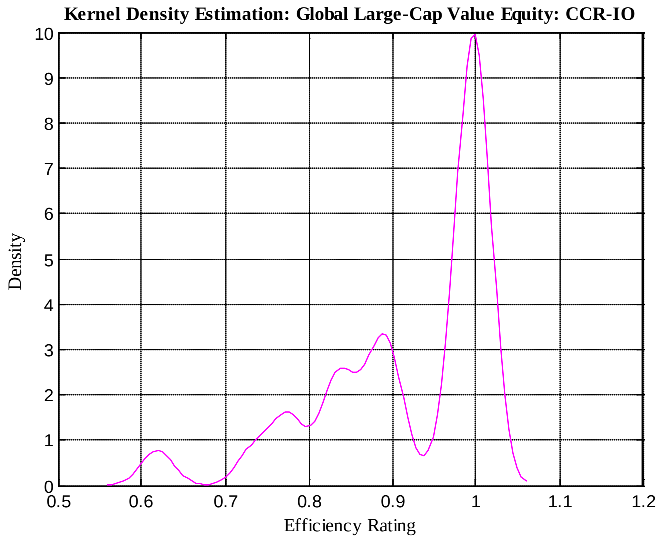
Finally, for each of the four DEA model variations, none of the OEICs/UTs in this category show a superior efficiency rating to that of the benchmark iShares S&P 500 ETF which is rated at the maximum rating of 1.000 in all four cases, thus suggesting that the managers of the OEICs/UTs are failing to show an ability to pick stocks which allows them to outperform the market. It is also important to note that a significant proportion of the OEICs/UTs, 66.67% under both the CCR and SORMCCR models, underperform relative to the benchmark iShares S&P 500 ETF, indicating that a significant number of these more expensive, actively managed funds underperform the low-cost, passively managed iShares S&P 500 ETF.

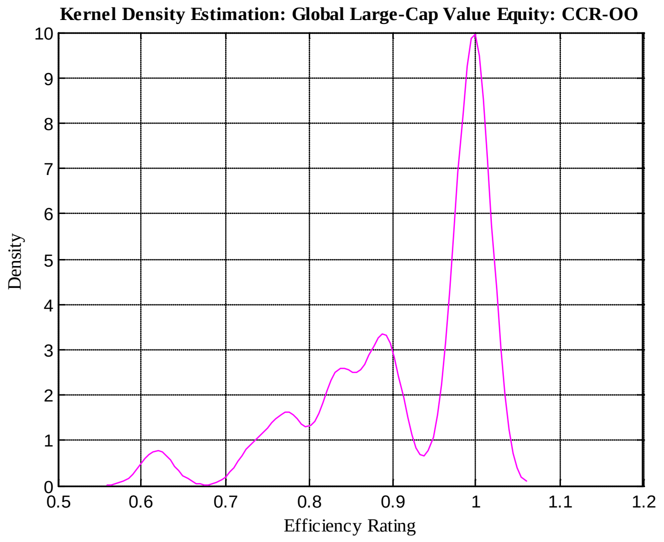
## *7.3: UK Domiciled OEICs And UTs With A Global Investment Focus*

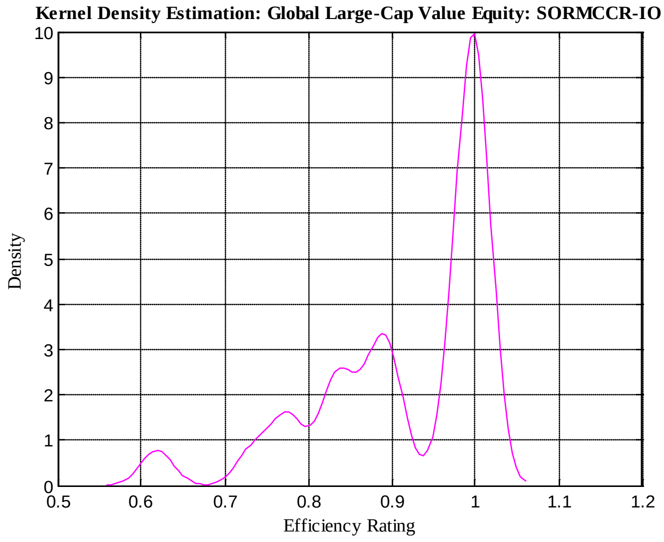
### *Global Large-Cap Value Equity (1st January 2008 – 31st December 2010)*

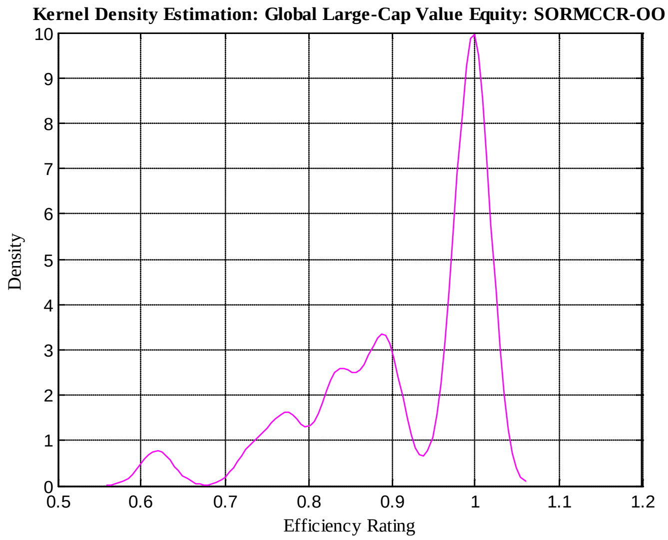
The detailed breakdown of the results from the individual OEICs/UTs in this category across the four DEA model variations can be found in Results Appendix 1 Table RA1.9, with a summary of the results provided in the table below, along with a kernel density estimation graph for each of the four DEA model variations.

| Summary Results | CCR-IO | CCR-OO | SORMCCR-IO | SORMCCR-OO |
|---|---|---|---|---|
| **Maximum Efficiency Rating** (Number Of OEICs/UTs) | **1.000** (11) | **1.000** (11) | **1.000** (11) | **1.000** (11) |
| **Minimum Efficiency Rating** (Number Of OEICs/UTs) | **0.619** (1) | **0.619** (1) | **0.619** (1) | **0.619** (1) |
| **Mean Efficiency Rating** | **0.915** | **0.915** | **0.915** | **0.915** |
| **Standard Deviation Of Efficiency Ratings** | **0.105** | **0.105** | **0.105** | **0.105** |
| **Number Of OEICs/UTs Outperforming The Benchmark ETF** | **24** (96.00%) | **24** (96.00%) | **24** (96.00%) | **24** (96.00%) |
| **Number Of OEICs/UTs Underperforming The Benchmark ETF** | **1** (4.00%) | **1** (4.00%) | **1** (4.00%) | **1** (4.00%) |


Kernel Density Estimation: Global Large-Cap Value Equity: CCR-IO
Density
Efficiency Rating
0
1
2
3
4
5
6
7
8
9
10
0.5
0.6
0.7
0.8
0.9
1
1.1
1.2


Kernel Density Estimation: Global Large-Cap Value Equity: CCR-OO
Density
Efficiency Rating
0
1
2
3
4
5
6
7
8
9
10
0.5
0.6
0.7
0.8
0.9
1
1.1
1.2


Kernel Density Estimation: Global Large-Cap Value Equity: SORMCCR-IO
Density
Efficiency Rating
0
1
2
3
4
5
6
7
8
9
10
0.5
0.6
0.7
0.8
0.9
1
1.1
1.2




These results from the 25 global large-cap value equity OEICs/UTs and the benchmark ETF, the iShares MSCI World, provide a number of results that are worth highlighting. Firstly, there is no issue with negative data influencing the efficiency rating results for the OEICs/UTs in this category, but the SORM procedure is still implemented for the purposes of comparison across the entire universe of mutual funds. Again, the input-oriented and output-oriented CCR DEA models show identical efficiency ratings for each OEIC/UT as would be expected due to the underlying constant returns-to-scale, and there are no differences between these efficiency ratings from the CCR model and those obtained from the SORMCCR model, again almost certainly as a result of the lack of negative data in this category of OEICs/UTs.

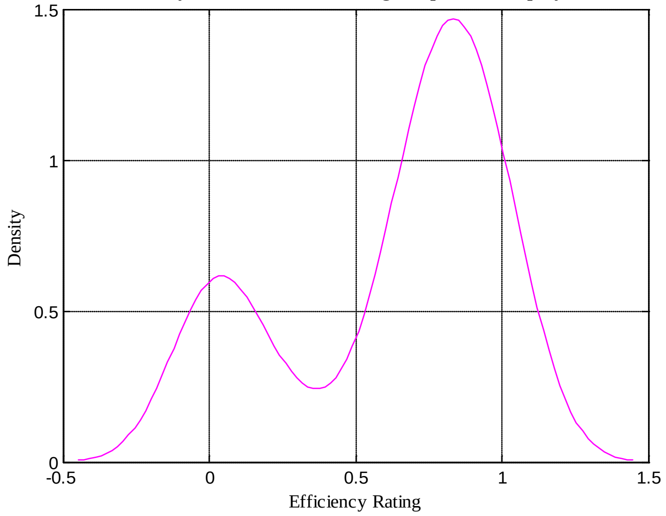
Finally, under the evaluation of the CCR DEA model, both input-oriented and output-oriented, and the SORMCCR DEA model, both input-oriented and output-oriented, 24 of the OEICs/UTs show a superior efficiency rating to that of the benchmark iShares MSCI World ETF which only achieves an efficiency rating of 0.733, suggesting that the managers of these OEICs/UTs are showing some ability to pick stocks which allows them to outperform the market. Thus, it follows that a significant proportion of the OEICs/UTs, 96.00% under all four DEA model variations, outperform the benchmark iShares MSCI World ETF, indicating that a significant number of these more expensive, actively managed funds outperform the low-cost, passively managed iShares MSCI World ETF.

### *Global Large-Cap Growth Equity (1st January 2008 – 31st December 2010)*

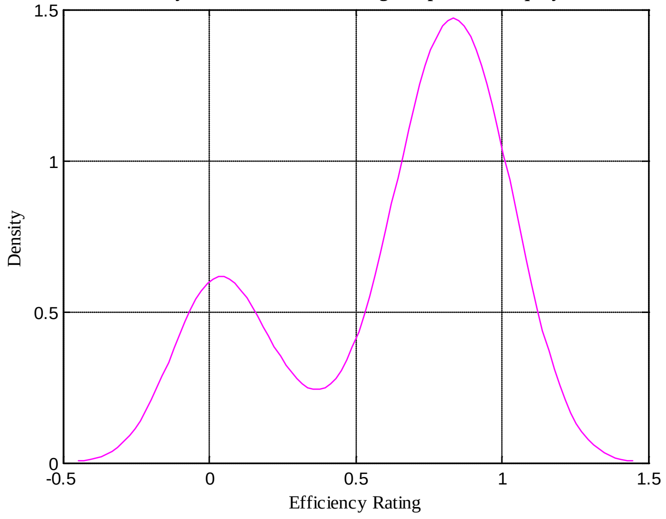
The detailed breakdown of the results from the individual OEICs/UTs in this category across the four DEA model variations can be found in Results Appendix 1 Table RA1.10, with a summary of the results provided in the table below, along with a kernel density estimation graph for each of the four DEA model variations.

| Summary Results | CCR-IO | CCR-OO | SORMCCR-IO | SORMCCR-OO |
|---|---|---|---|---|
| **Maximum Efficiency Rating** (Number Of OEICs/UTs) | **1.000** (4) | **1.000** (4) | **1.000** (9) | **1.000** (9) |
| **Minimum Efficiency Rating** (Number Of OEICs/UTs) | **0.000** (4) | **0.000** (4) | **0.151** (1) | **0.151** (1) |
| **Mean Efficiency Rating** | **0.623** | **0.623** | **0.822** | **0.822** |
| **Standard Deviation Of Efficiency Ratings** | **0.367** | **0.367** | **0.240** | **0.240** |
| **Number Of OEICs/UTs Outperforming The Benchmark ETF** | **8** (32.00%) | **8** (32.00%) | **15** (60.00%) | **15** (60.00%) |
| **Number Of OEICs/UTs Underperforming The Benchmark ETF** | **17** (68.00%) | **17** (68.00%) | **10** (40.00%) | **10** (40.00%) |

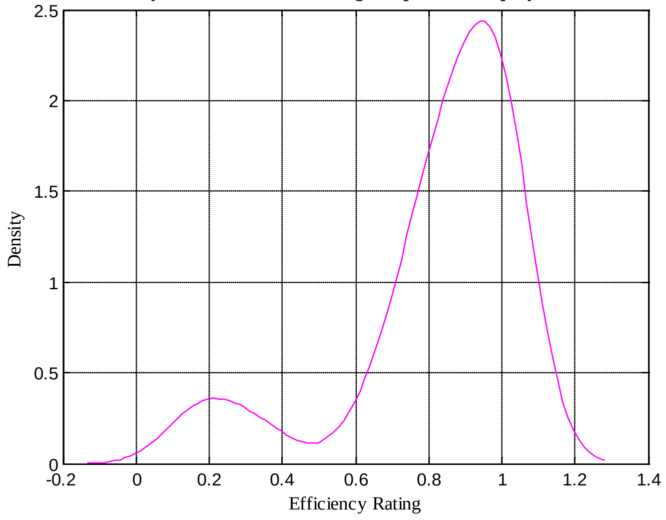
Kernel Density Estimation: Global Large-Cap Growth Equity: CCR-IO

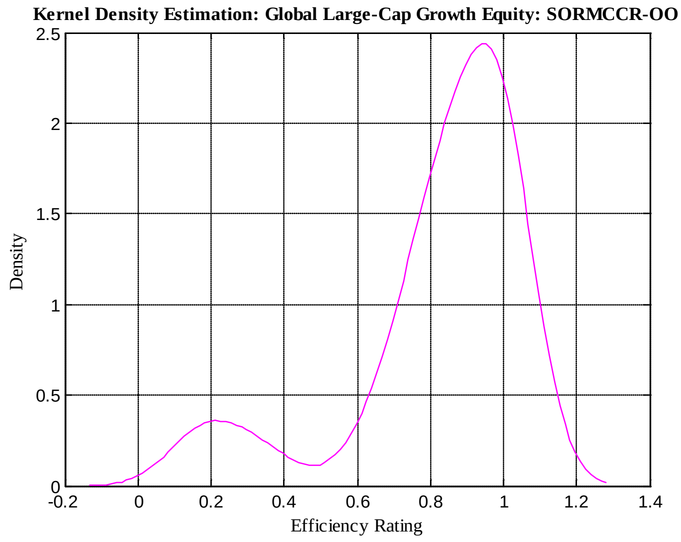



Kernel Density Estimation: Global Large-Cap Growth Equity: CCR-OO




Kernel Density Estimation: Global Large-Cap Growth Equity: SORMCCR-IO






These results from the 25 global large-cap growth equity OEICs/UTs and the benchmark ETF, the iShares MSCI World, provide a number of results that are worth highlighting. Firstly, from looking at the results it is apparent that 4 of the OEICs/UTs are showing the peculiar pattern in their efficiency rating results of being rated at 0.000 for both input-oriented and output-oriented CCR DEA, also illustrated in graphical form by an outlier spike around an efficiency rating of 0.000 in the corresponding kernel density estimation graphs, and these OEICs/UTs are those that have negative data present in their inputs and/or outputs. This suggests that the SORM procedure should be implemented, leading to the input-oriented and output-oriented SORMCCR DEA efficiency rating results, which deal with this negative data issue and result in a more robust set of efficiency rating results for the OEICs/UTs in this category.

The input-oriented and output-oriented CCR DEA models again show identical efficiency ratings for each OEIC/UT as would be expected due to the underlying constant returns-to-scale, and there are some differences between the efficiency ratings obtained from the CCR DEA model and those obtained from the SORMCCR DEA model for some of the OEICs/UTs, whilst others obtain the same efficiency rating across all four of the DEA model variations, almost certainly due to the resolution of the negative data issue.

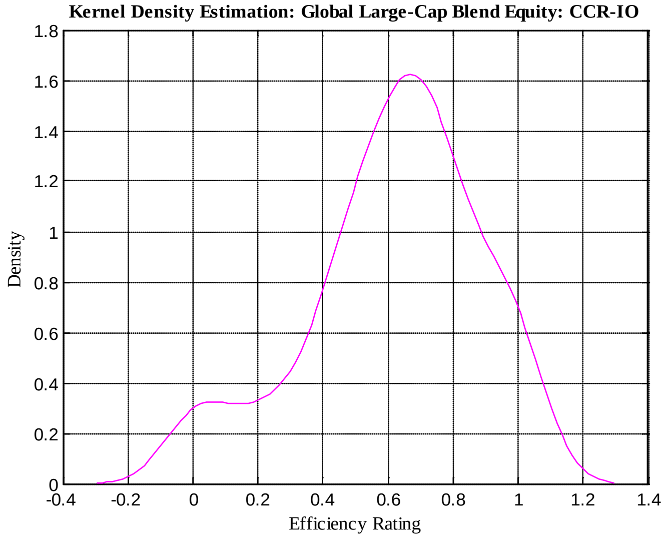
Finally, under the evaluation of the input-oriented and output-oriented CCR DEA models, 8 of the OEICs/UTs show a superior efficiency rating to that of the benchmark iShares MSCI World ETF which is only rated at an efficiency rating of 0.837, suggesting that the managers of these OEICs/UTs could be showing an ability to select stocks that allows them to outperform the market. When under the evaluation of the SORMCCR DEA model in both input-orientation and output-orientation, it is clear to see that 15 of the OEICs/UTs are now outperforming the benchmark iShares MSCI World ETF which is only rated at 0.837, thus suggesting that the mangers of these OEICs/UTs could be showing an ability to select stocks that allows them to outperform the market. It is interesting to note that under the CCR model 32.00% of the OEICs/UTs outperform the benchmark, yet under the SORMCCR model, a more significant 60.00% of the OEICs/UTs outperform the benchmark. Thus, under the SORMCCR model there are indications that a significant number of the more expensive, actively managed OEICs/UTs are outperforming the low-cost, passively managed iShares MSCI World ETF.

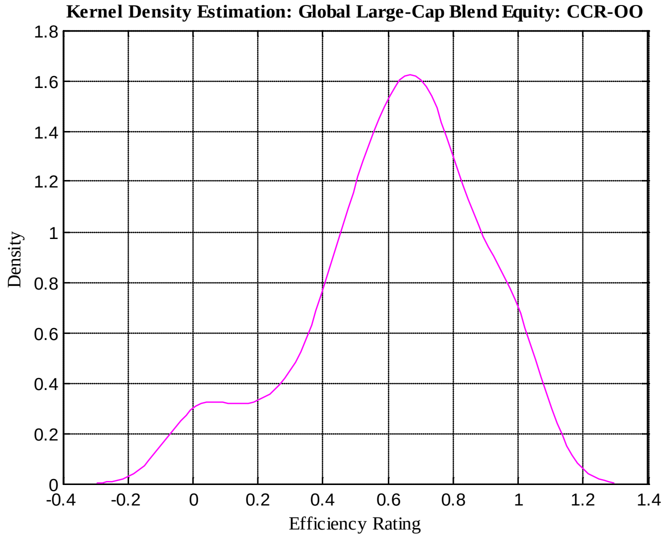
***Global Large-Cap Blend Equity (1st January 2008 – 31st December 2010)***

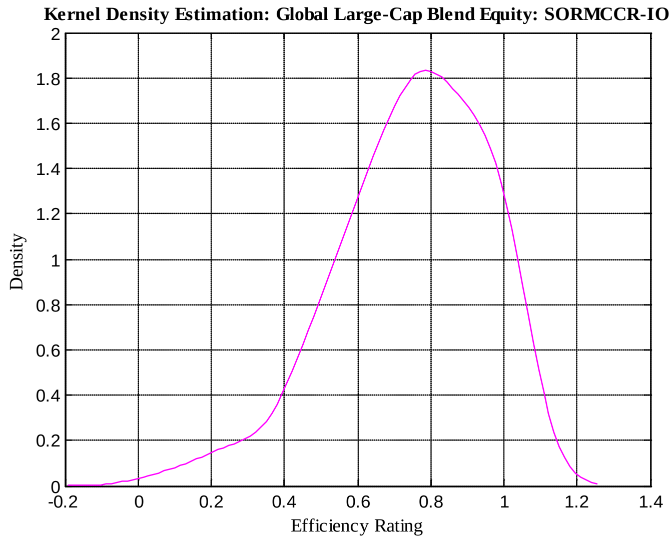
The detailed breakdown of the results from the individual OEICs/UTs in this category across the four DEA model variations can be found in Results Appendix 1 Table RA1.11, with a summary of the results provided in the table below, along with a kernel density estimation graph for each of the four DEA model variations.

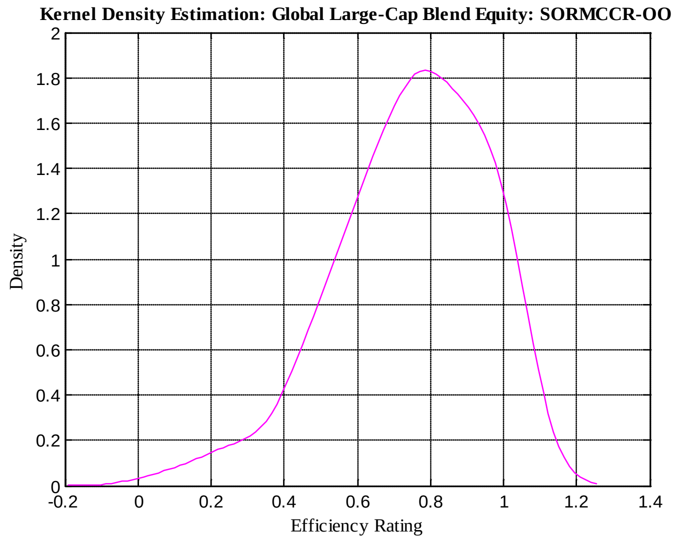
| Summary Results | CCR-IO | CCR-OO | SORMCCR-IO | SORMCCR-OO |
|---|---|---|---|---|
| **Maximum Efficiency Rating** (Number Of OEICs/UTs) | **1.000** (11) | **1.000** (11) | **1.000** (18) | **1.000** (18) |
| **Minimum Efficiency Rating** (Number Of OEICs/UTs) | **0.000** (6) | **0.000** (6) | **0.064** (1) | **0.064** (1) |
| **Mean Efficiency Rating** | **0.617** | **0.617** | **0.746** | **0.746** |
| **Standard Deviation Of Efficiency Ratings** | **0.262** | **0.262** | **0.201** | **0.201** |

| | | | | |
|---|---|---|---|---|
| **Number Of OEICs/UTs Outperforming The Benchmark ETF** | **48** (40.68%) | **48** (40.68%) | **54** (45.76%) | **54** (45.76%) |
| **Number Of OEICs/UTs Underperforming The Benchmark ETF** | **70** (59.32%) | **70** (59.32%) | **64** (54.24%) | **64** (54.24%) |






These results from the 118 global large-cap blend equity OEICs/UTs and the benchmark ETF, the iShares MSCI World, provide a number of results that are worth highlighting. Firstly, from examining the results it is apparent that 6 of the OEICs/UTs in this category exhibit the peculiar pattern in their efficiency rating results of being rated at 0.000 for both input-oriented and output-oriented CCR DEA, and there are also indications of this in the corresponding kernel density estimation graphs. A closer examination of these OEICs/UTs shows that they are the ones that have negative data present in their inputs and/or outputs, suggesting that the SORM procedure should be implemented, thus resulting in the input-oriented and output-oriented SORMCCR DEA efficiency rating results. This deals with the negative data issue and results in a more robust set of efficiency rating results for the OEICs/UTs in this category.

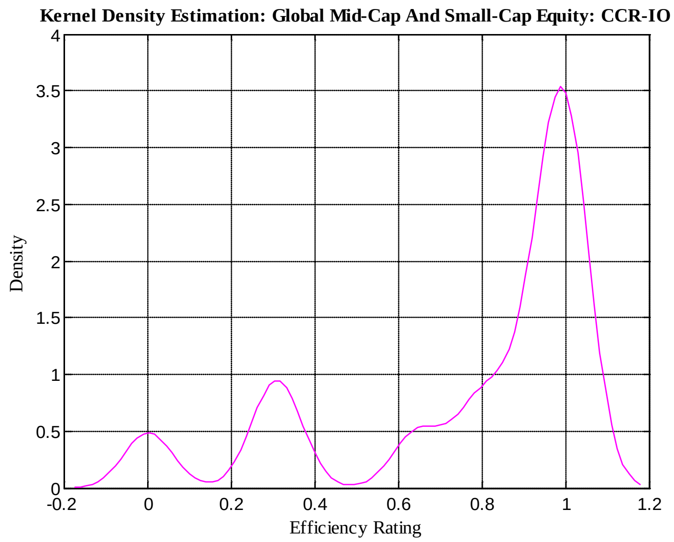
The input-oriented and output-oriented CCR DEA models show identical efficiency ratings for each OEIC/UT as would be expected due to the underlying constant returns-to-scale, and there are some differences between the efficiency ratings obtained under the CCR DEA model and those obtained from the SORMCCR DEA model for some of the OEICs/UTs, whilst others obtain the same efficiency rating across all four of the DEA model variations, most likely as a result of the resolution of the negative data problem.

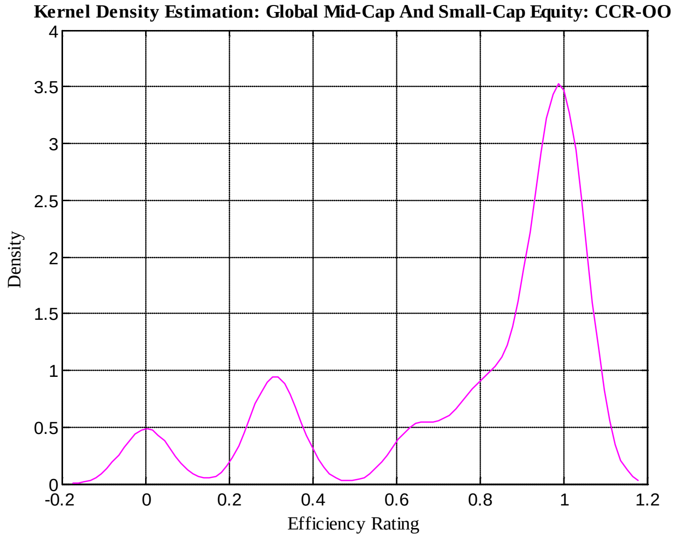
Finally, under the evaluation of the CCR DEA model, both input-oriented and output-oriented, 48 of the OEICs/UTs show a superior efficiency rating to that of the benchmark iShares MSCI World ETF which only achieves an efficiency rating of 0.692, whilst under the evaluation of the SORMCCR DEA model, both input-oriented and output-oriented, this increases slightly to 54 of the OEICs/UTs showing a superior efficiency rating to that of the benchmark iShares MSCI World ETF which now achieves an efficiency rating of 0.792. This suggests that under all four DEA model variations the managers of a number of the more expensive, actively managed OEICs/UTs could be showing an ability to pick stocks that allows them to outperform the market, and hence also the low-cost, passively managed iShares MSCI World ETF. In this category the split between the OEICs/UTs outperforming/underperforming the benchmark iShares MSCI World ETF is 40.68%/59.32% under the CCR DEA model and 45.76%/54.24% under the SORMCCR DEA model, thus showing there is close to an even split between the OEICs/UTs outperforming/underperforming the benchmark ETF.

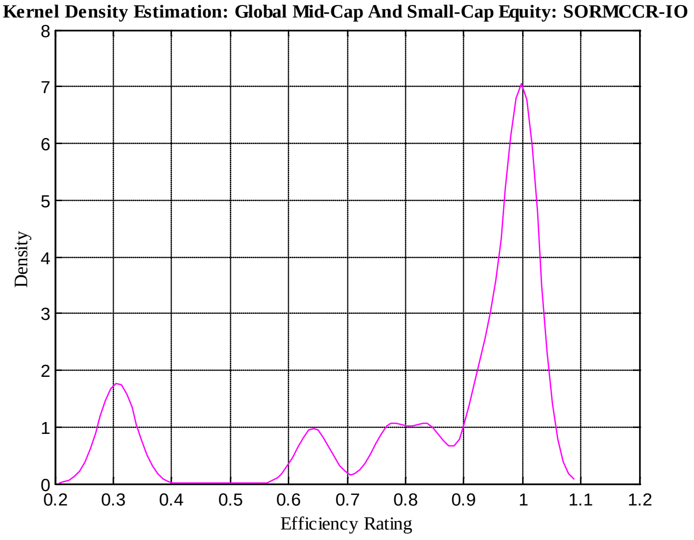
## *Global Mid-Cap And Small-Cap Equity (1st January 2008 – 31st December 2010)*

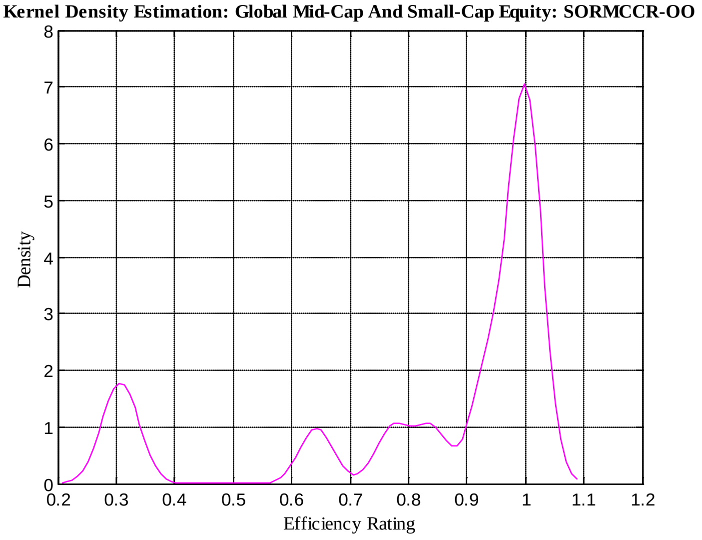
The detailed breakdown of the results from the individual OEICs/UTs in this category across the four DEA model variations can be found in Results Appendix 1 Table RA1.12, with a summary of the results provided in the table below, along with a kernel density estimation graph for each of the four DEA model variations.

| Summary Results | CCR-IO | CCR-OO | SORMCCR-IO | SORMCCR-OO |
|---|---|---|---|---|
| **Maximum Efficiency Rating** (Number Of OEICs/UTs) | **1.000** (5) | **1.000** (5) | **1.000** (6) | **1.000** (6) |
| **Minimum Efficiency Rating** (Number Of OEICs/UTs) | **0.000** (1) | **0.000** (1) | **0.294** (1) | **0.294** (1) |
| **Mean Efficiency Rating** | **0.767** | **0.767** | **0.839** | **0.839** |
| **Standard Deviation Of Efficiency Ratings** | **0.330** | **0.330** | **0.250** | **0.250** |
| **Number Of OEICs/UTs Outperforming The Benchmark ETF** | **0** (0.00%) | **0** (0.00%) | **0** (0.00%) | **0** (0.00%) |
| **Number Of OEICs/UTs Underperforming The Benchmark ETF** | **8** (61.54%) | **8** (61.54%) | **7** (53.85%) | **7** (53.85%) |




Kernel Density Estimation: Global Mid-Cap And Small-Cap Equity: CCR-OO
Density
Efficiency Rating
0
0.5
1
1.5
2
2.5
3
3.5
4
-0.2
0
0.2
0.4
0.6
0.8
1
1.2


Kernel Density Estimation: Global Mid-Cap And Small-Cap Equity: SORMCCR-IO
Density
Efficiency Rating
0
1
2
3
4
5
6
7
8
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
1.1
1.2


Kernel Density Estimation: Global Mid-Cap And Small-Cap Equity: SORMCCR-OO
Density
Efficiency Rating
0
1
2
3
4
5
6
7
8
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
1.1
1.2

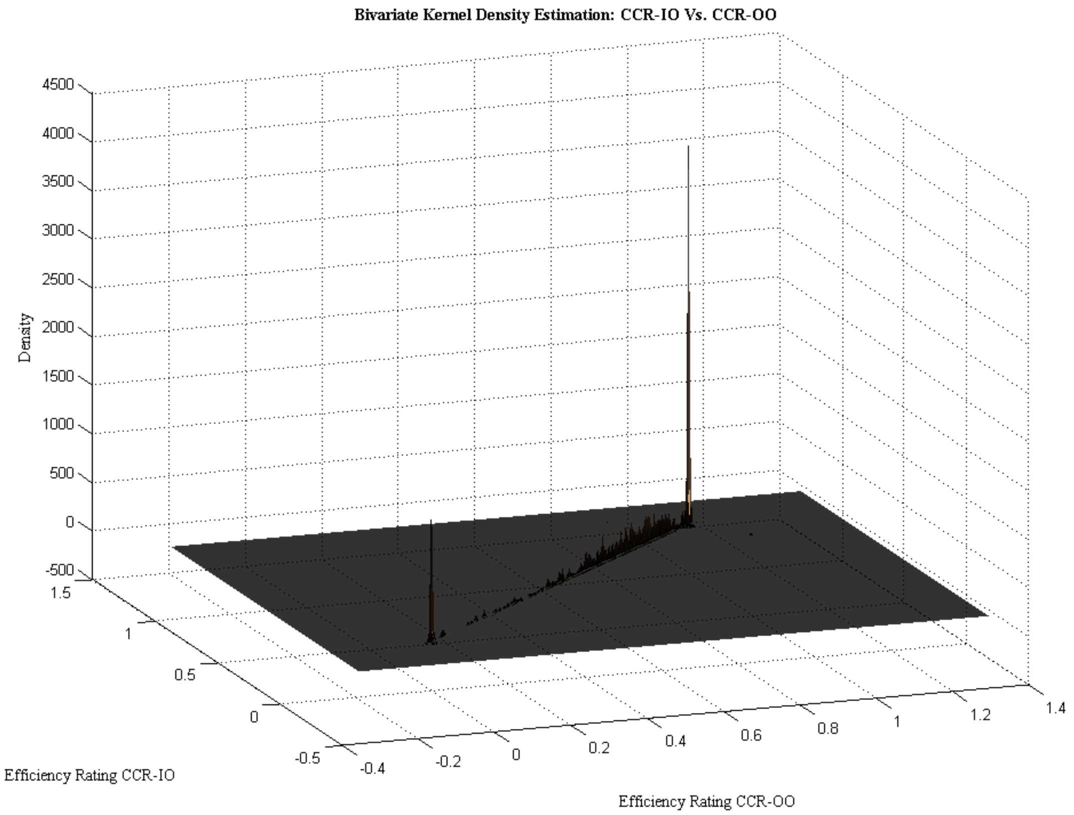
These results from the 13 global mid-cap and small-cap equity OEICs/UTs and the benchmark ETF, the iShares MSCI World, provide a number of results that are worth highlighting. Firstly, from looking at the results it is apparent that one of the OEICs/UTs in this category exhibits the odd pattern in its efficiency rating results of being rated at 0.000 for both input-oriented and output-oriented CCR DEA, and a closer inspection reveals that this OEIC/UT contains negative data in its inputs and/or outputs, thus suggesting that the SORM procedure should be implemented. This results in the input-oriented and output-oriented SORMCCR DEA efficiency rating results which deal with the negative data problem, leading to a more robust set of efficiency rating results for the OEICs/UTs in this category.

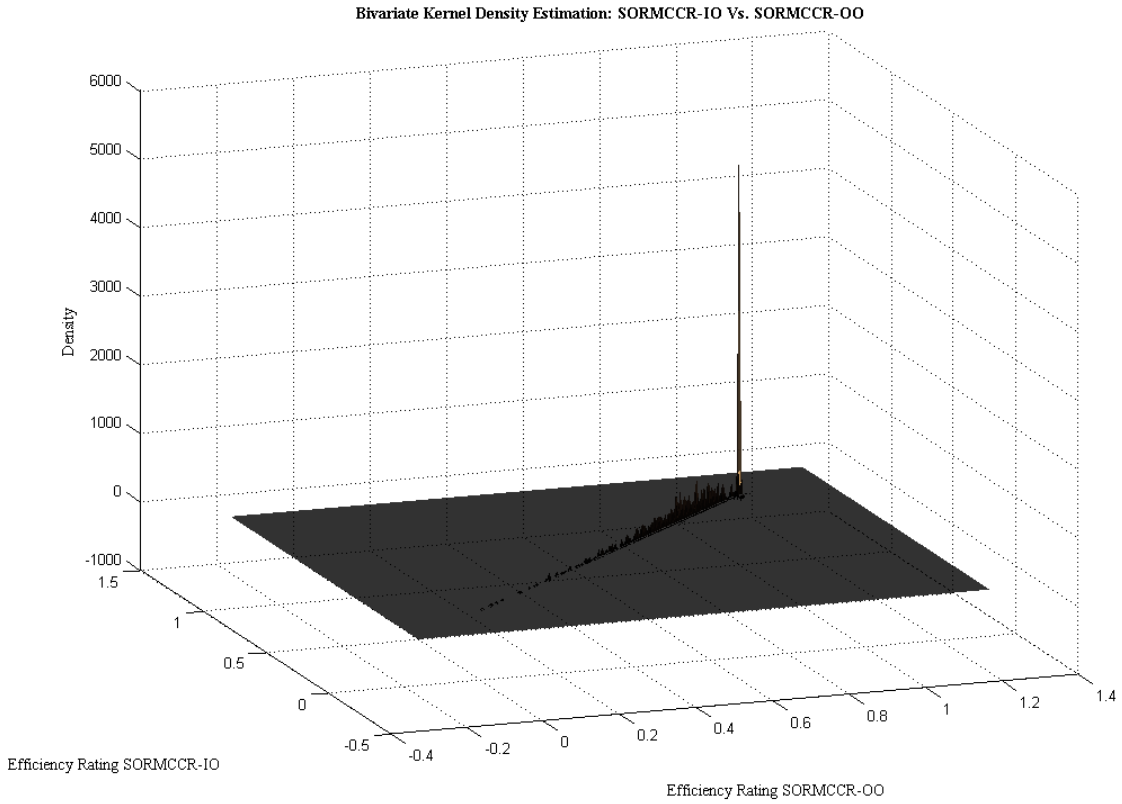
Again, the input-oriented and output-oriented CCR DEA models show identical efficiency ratings for each OEIC/UT as would be expected as a result of the underlying constant returns-to-scale, and there are some differences between the efficiency ratings obtained from the CCR DEA model compared to those obtained from the SORMCCR DEA model for some of the OEICs/UTs, whilst others obtain the same efficiency rating across all four of the DEA model variations, almost certainly due to the resolution of the negative data problem.

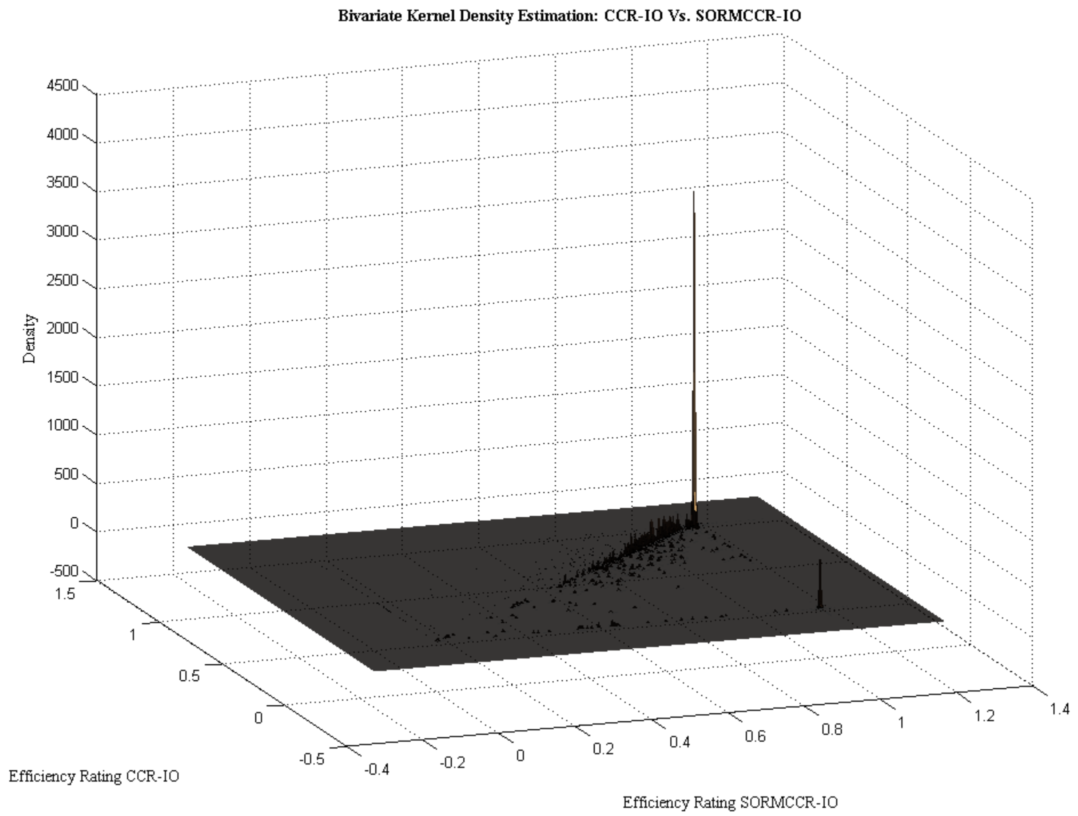
Finally, when evaluated under all four of the DEA model variations, none of the OEICs/UTs in this category show a superior efficiency rating to that of the benchmark iShares MSCI World ETF which is rated at the maximum rating of 1.000 in all four cases, thus suggesting that the managers of the OEICs/UTs are failing to show an ability to select stocks which subsequently allows them to outperform the market. It is important to note that a large proportion of the OEICs/UTs, 61.54% under the CCR model and 53.85% under the SORMCCR model, underperform the benchmark iShares MSCI World ETF, thus indicating that a large number of these more expensive, actively managed funds underperform the low-cost, passively managed iShares MSCI World ETF.

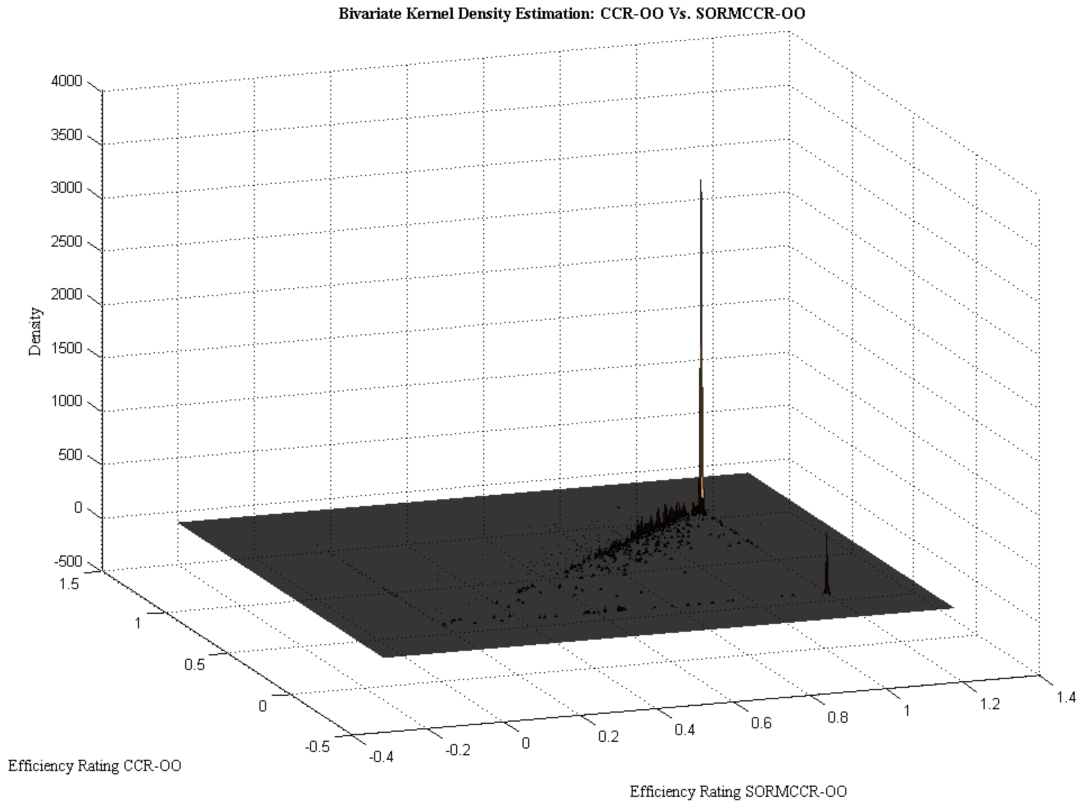
## 7.4: Summary Conclusions

To provide a graphical summary of the results for the managerial performance of the OEICs/UTs under assessment from this section of results for the standalone CCR DEA model and the standalone SORMCCR DEA model, there are four bivariate kernel density estimation graphs below.




Bivariate Kernel Density Estimation: SORMCCR-IO Vs. SORMCCR-OO
Density
6000
5000
4000
3000
2000
1000
0
-1000
1.5
1
0.5
0
-0.5
-0.4
-0.2
0
0.2
0.4
0.6
0.8
1
1.2
1.4
Efficiency Rating SORMCCR-IO
Efficiency Rating SORMCCR-OO


Bivariate Kernel Density Estimation: CCR-IO Vs. SORMCCR-IO
Density
4500
4000
3500
3000
2500
2000
1500
1000
500
0
-500
1.5
1
0.5
0
-0.5
-0.4
-0.2
0
0.2
0.4
0.6
0.8
1
1.2
1.4
Efficiency Rating CCR-IO
Efficiency Rating SORMCCR-IO




To conclude this section of results it is possible to emphasise the following points. Firstly, the underlying constant returns-to-scale metric of the CCR and SORMCCR models means that the input-oriented and output-oriented variations of each of these two models produce identical efficiency ratings results for the OEICs/UTs under assessment. Furthermore, the critical necessity of implementing the SORM procedure to deal with the negative data present in the dataset of the OEICs/UTs can be seen from the bias in the efficiency ratings results of the standard CCR DEA model, which the SORMCCR DEA model is not afflicted by. Finally, across the mutual fund universe of 565 OEICs/UTs, the efficiency ratings of the OEICs/UTs show a mixed pattern of results under the evaluation of the CCR and SORMCCR models. In particular, across the 12 investment categories of OEIC/UT, there are some categories in which there are a number of OEICs/UTs which outperform the benchmark iShares ETF index tracker, suggesting that the managers of these OEICs/UTs are able to deliver consistent superior returns and outperform the market, whilst in other categories the benchmark iShares ETF index tracker is rated at the maximum of 1.000 and there are no OEIC/UT managers that are able to outperform the market. Critically however, any influence exerted by environmental factors and statistical noise/luck on the managerial efficiency ratings of the OEICs/UTs will still be present in the results from these standalone CCR and SORMCCR DEA models, and thus these managerial efficiency ratings may not reflect the 'true' managerial performance of the managers of the OEICs/UTs under assessment.

There are some linkages between the empirical results in this chapter and the existing literature. The inappropriateness of standard DEA models in the presence of negative data is consistent with the small amount of research that has been done on mutual fund performance that specifically deals with the issue of negative data such as Basso and Funari (2007), and this reinforces the need for all studies of mutual fund performance using DEA to deal with the issue of negative data to produce reliable results. There are no large studies of UK mutual fund performance using DEA, but there is a small study of the UK market of ethical mutual funds in Basso and Funari (2005b) which produces results somewhat similar to those in this chapter, with all the funds assessed in a single category, there are some funds outperforming the benchmark and others underperforming the benchmark. There is however a large study of UK mutual fund performance using the traditional measures by Cuthbertson et al (2008) which suggests that between 5% and 10% of UK equity mutual funds show some stock picking ability, and thus this is quite different to the results in this chapter as across the investment categories there is either a much higher percentage of funds showing a stock picking ability, or there are none.

In the next chapter of results, the returns-to-scale metric is switched to the variable returns-to-scale metric of the BCC and SORMBCC DEA models to look at the effects of this on the efficiency ratings obtained for the assessment of the managerial performance of the OEICs/UTs.

# Chapter 8: Results Section 2 – Standalone BCC DEA And SORMBCC DEA Model Results

This second section of results contains the results for the efficiency ratings of the OEICs/UTs in the mutual fund universe under evaluation using standalone BCC and SORMBCC DEA modelling methodologies. All of these results were produced using the MATLAB program, utilising the MATLAB DEA model coding created for this study, as seen in the MATLAB coding appendix. The four DEA models utilised in this section of results are the BCC DEA model, with either an input-orientation or an output-orientation, and the SORMBCC DEA model, with either an input-orientation or an output-orientation.

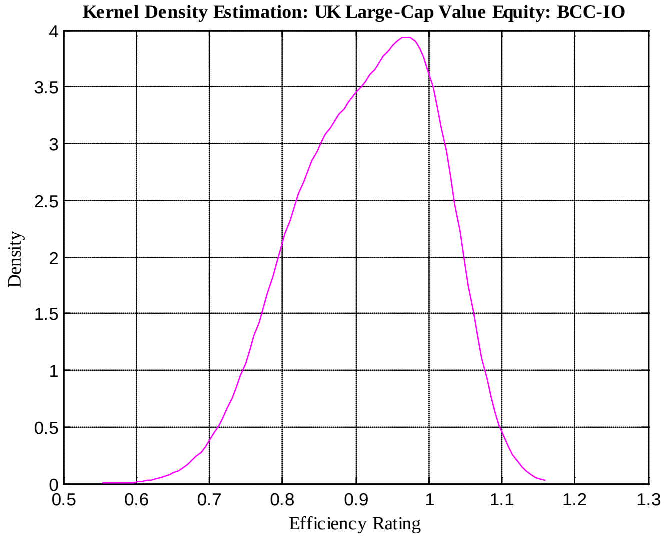
## *8.1: UK Domiciled OEICs And UTs With A UK Investment Focus*

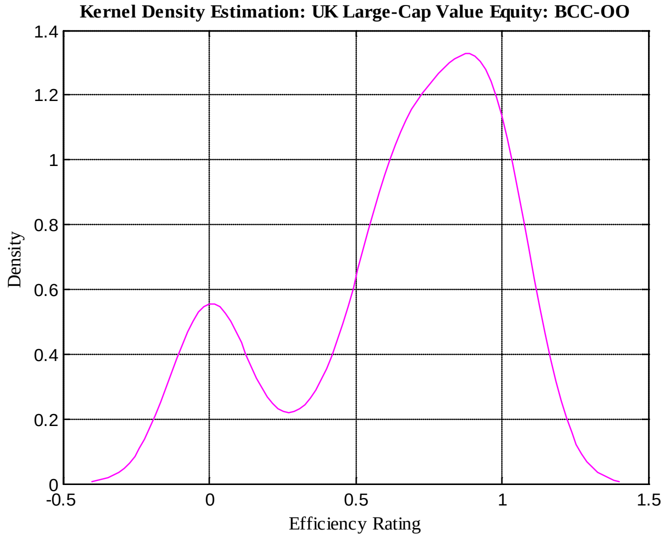
### *UK Large-Cap Value Equity (1st January 2008 – 31st December 2010)*

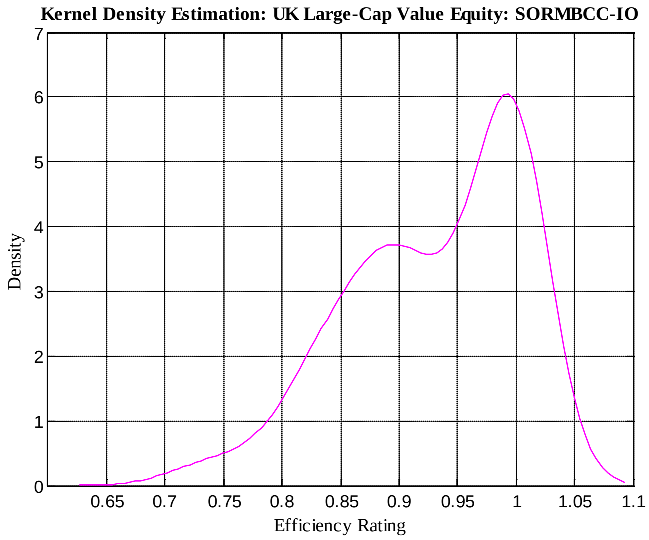
The detailed breakdown of the results from the individual OEICs/UTs in this category across the four DEA model variations can be found in Results Appendix 2 Table RA2.1, with a summary of the results provided in the table below, along with a kernel density estimation graph for each of the four DEA model variations.

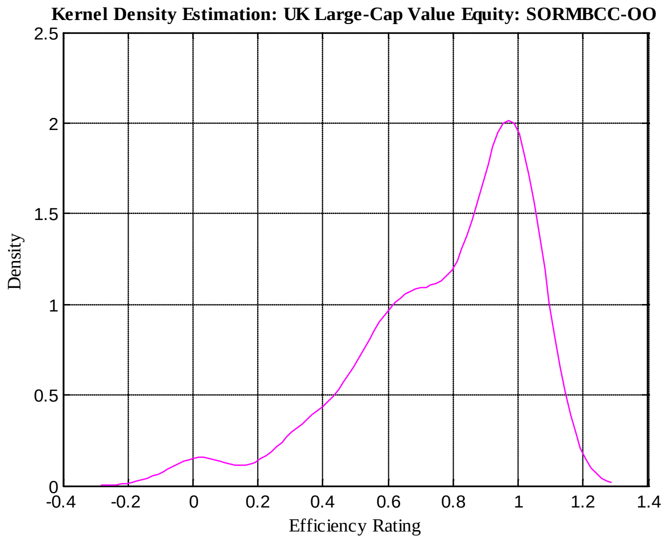
| Summary Results | BCC-IO | BCC-OO | SORMBCC-IO | SORMBCC-OO |
|---|---|---|---|---|
| **Maximum Efficiency Rating** (Number Of OEICs/UTs) | **1.000** (21) | **1.000** (15) | **1.000** (27) | **1.000** (26) |
| **Minimum Efficiency Rating** (Number Of OEICs/UTs) | **0.712** (1) | **0.000** (12) | **0.719** (1) | **0.004** (1) |
| **Mean Efficiency Rating** | **0.916** | **0.643** | **0.930** | **0.774** |
| **Standard Deviation Of Efficiency Ratings** | **0.079** | **0.351** | **0.072** | **0.256** |

| | | | | |
|---|---|---|---|---|
| **Number Of OEICs/UTs Outperforming The Benchmark ETF** | **0** (0.00%) | **0** (0.00%) | **0** (0.00%) | **0** (0.00%) |
| **Number Of OEICs/UTs Underperforming The Benchmark ETF** | **59** (73.75%) | **65** (81.25%) | **53** (66.25%) | **54** (67.50%) |






These results from the 80 UK large-cap value equity OEICs/UTs and the benchmark ETF, the iShares FTSE 100, provide a number of results that are worth highlighting. Firstly, from looking at the results it is possible to see that 12 of the OEICs/UTs have an odd pattern in their efficiency ratings results of being rated at 0.000 under the output-oriented BCC model, highlighted in graphical form by an outlier spike at an efficiency rating of 0.000 in the kernel density estimation graph for the output-oriented BCC model. Looking at these results in more detail reveals that they correspond to the OEICs/UTs which contain negative data in their inputs and/or outputs, thus suggesting that the SORM procedure should be implemented to deal with the negative data issue. This is duly undertaken, leading to the results for the SORMBCC DEA model, both input-oriented and output-oriented, which deal with this negative data issue and produce a more robust looking set of efficiency ratings results for the OEICs/UTs in this category.

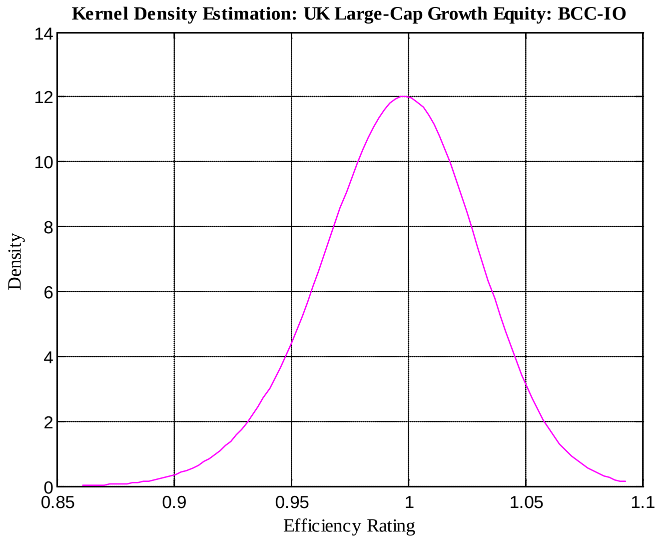
As a consequence of the variable returns-to-scale which underpins the BCC DEA model, there are differences in the efficiency ratings obtained from the input-oriented version compared against those obtained from the output-oriented version for each individual OEIC/UT. Also, there are some differences between the ratings obtained under the BCC DEA model compared to those from the SORMBCC DEA model for some of the OEICs/UTs, whilst for other OEICs/UTs the efficiency ratings do not change with the move to the SORMBCC DEA model, and this is most likely due to the resolution of the negative data issue.

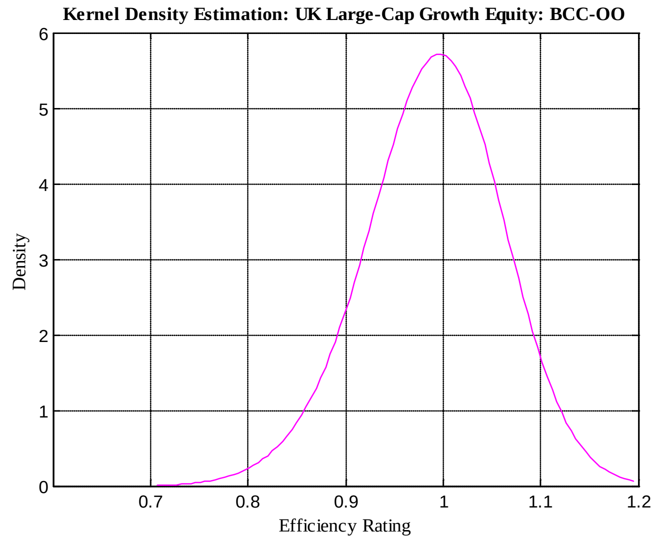
Finally, under the evaluation of the four DEA models utilised here, none of the OEICs/UTs show a superior efficiency rating to that of the benchmark iShares FTSE 100 ETF which obtains the maximum efficiency rating of 1.000 under each of the four DEA models used. Thus, this indicates that none of the managers of the OEICs/UTs in this category of funds are showing an ability to pick stocks which would allow them to outperform the market. It is important to also highlight that across the four DEA model variations, a significant proportion of the OEICs/UTs, ranging from 66.25% up to 81.25%, underperform the benchmark iShares FTSE 100 ETF, thus indicating that a significant number of these more expensive, actively managed funds underperform relative to the low-cost, passively managed iShares FTSE 100 ETF.

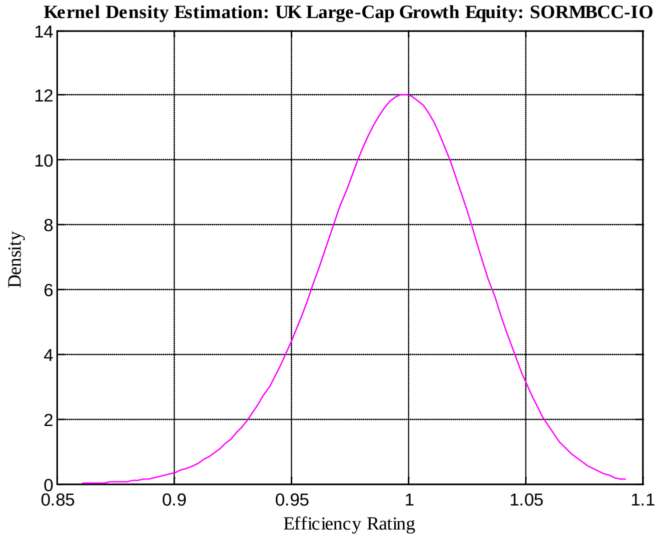
***UK Large-Cap Growth Equity (1st January 2008 – 31st December 2010)***

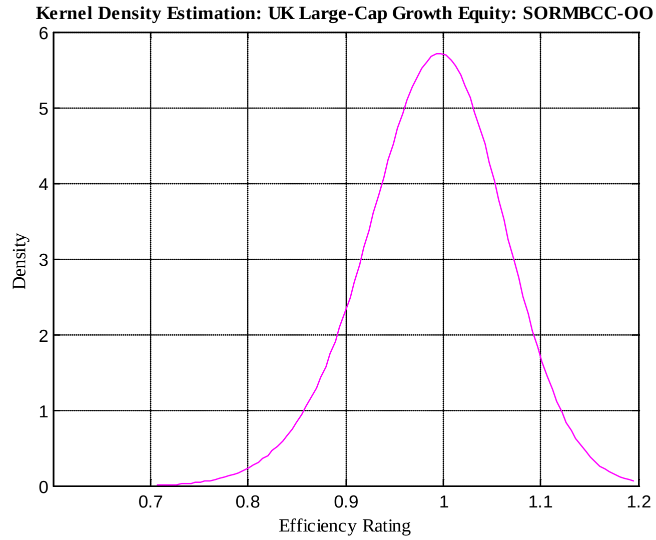
The detailed breakdown of the results from the individual OEICs/UTs in this category across the four DEA model variations can be found in Results Appendix 2 Table RA2.2, with a summary of the results provided in the table below, along with a kernel density estimation graph for each of the four DEA model variations.

| Summary Results | BCC-IO | BCC-OO | SORMBCC-IO | SORMBCC-OO |
|---|---|---|---|---|
| **Maximum Efficiency Rating** (Number Of OEICs/UTs) | **1.000** (8) | **1.000** (8) | **1.000** (8) | **1.000** (8) |
| **Minimum Efficiency Rating** (Number Of OEICs/UTs) | **0.954** (1) | **0.902** (1) | **0.954** (1) | **0.902** (1) |
| **Mean Efficiency Rating** | **0.995** | **0.990** | **0.995** | **0.990** |
| **Standard Deviation Of Efficiency Ratings** | **0.015** | **0.031** | **0.015** | **0.031** |
| **Number Of OEICs/UTs Outperforming The Benchmark ETF** | **0** (0.00%) | **0** (0.00%) | **0** (0.00%) | **0** (0.00%) |
| **Number Of OEICs/UTs Underperforming The Benchmark ETF** | **1** (11.11%) | **1** (11.11%) | **1** (11.11%) | **1** (11.11%) |




Kernel Density Estimation: UK Large-Cap Growth Equity: BCC-OO
Density
Efficiency Rating
0
1
2
3
4
5
6
0.7
0.8
0.9
1
1.1
1.2


Kernel Density Estimation: UK Large-Cap Growth Equity: SORMBCC-IO
Density
Efficiency Rating
0
2
4
6
8
10
12
14
0.85
0.9
0.95
1
1.05
1.1


Kernel Density Estimation: UK Large-Cap Growth Equity: SORMBCC-OO
Density
Efficiency Rating
0
1
2
3
4
5
6
0.7
0.8
0.9
1
1.1
1.2

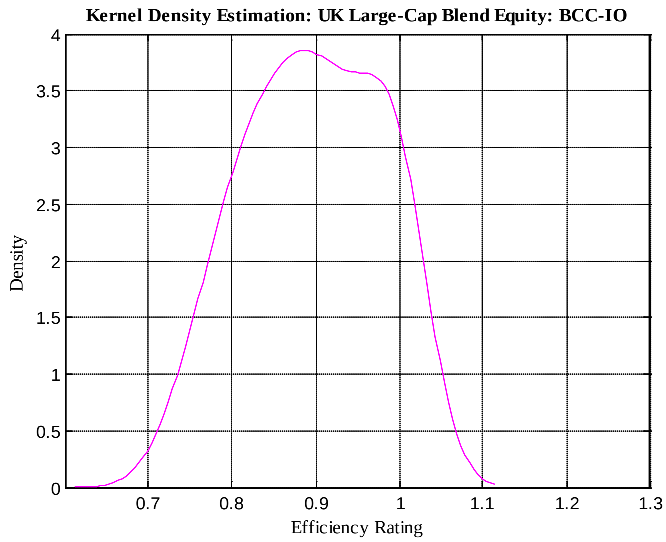
These results from the 9 UK large-cap growth equity OEICs/UTs and the benchmark ETF, the iShares FTSE 100, provide a number of results that are worth highlighting. Again, like in the previous chapter of CCR and SORMCCR standalone DEA model results, there is no issue with negative data for the OEICs/UTs in this category, but the SORM procedure is still implemented for the purposes of comparison across the entire universe of mutual funds. Also, the underlying variable returns-to-scale of the BCC DEA model means that the input-oriented and output-oriented variations produce differing efficiency ratings results, and there is no difference between the efficiency ratings the OEICs/UTs obtain from the BCC model compared against those they obtain from the SORMBCC model, almost certainly due to the absence of negative data in this category of OEICs/UTs.

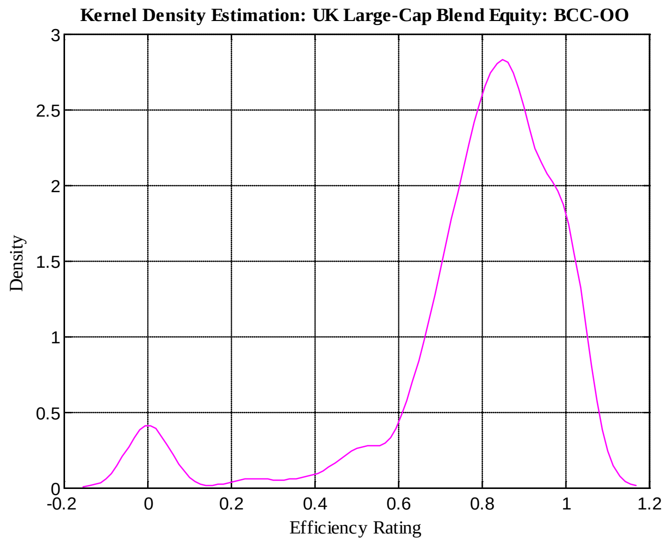
Finally, across all four DEA model variations utilised here, the benchmark iShares FTSE 100 ETF is ranked at the maximum rating of 1.000, along with 8 of the OEICs/UTs, thus suggesting that the managers of the OEICs/UTs in this category are not showing an ability to pick stocks that allows them to outperform the market. However, it is again important to note, as in the previous chapter of CCR and SORMCCR standalone DEA model results, that this category has a small sample size, and consequently this subsequent analysis is based on that small sample size.

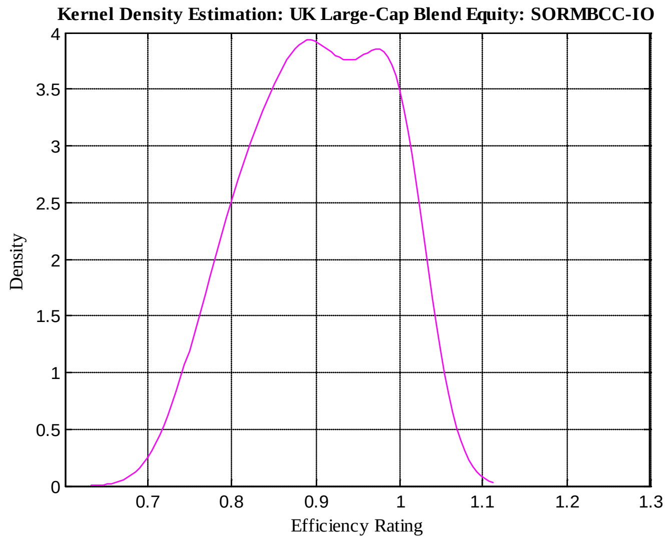
***UK Large-Cap Blend Equity (1st January 2008 – 31st December 2010)***

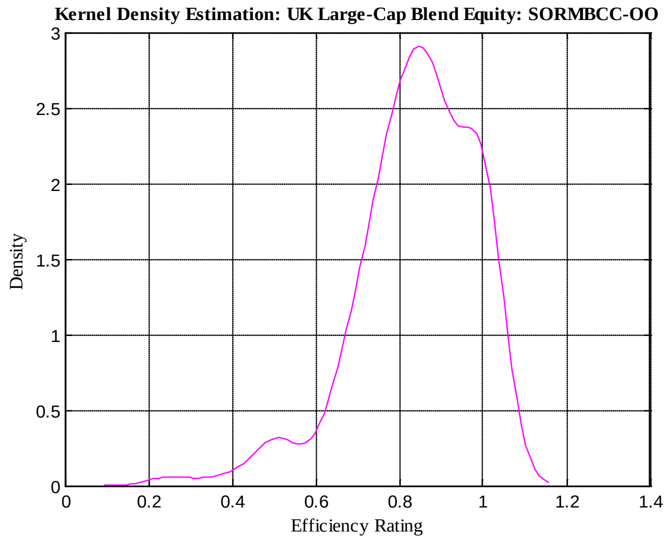
The detailed breakdown of the results from the individual OEICs/UTs in this category across the four DEA model variations can be found in Results Appendix 2 Table RA2.3, with a summary of the results provided in the table below, along with a kernel density estimation graph for each of the four DEA model variations.

| Summary Results | BCC-IO | BCC-OO | SORMBCC-IO | SORMBCC-OO |
|---|---|---|---|---|
| **Maximum Efficiency Rating** (Number Of OEICs/UTs) | **1.000** (28) | **1.011** (1) | **1.000** (32) | **1.000** (32) |
| **Minimum Efficiency Rating** (Number Of OEICs/UTs) | **0.727** (1) | **0.000** (7) | **0.744** (1) | **0.251** (1) |
| **Mean Efficiency Rating** | **0.897** | **0.785** | **0.903** | **0.840** |
| **Standard Deviation Of Efficiency Ratings** | **0.079** | **0.231** | **0.077** | **0.141** |
| **Number Of OEICs/UTs Outperforming The Benchmark ETF** | **32** (24.62%) | **95** (73.08%) | **35** (26.92%) | **104** (80.00%) |
| **Number Of OEICs/UTs Underperforming The Benchmark ETF** | **98** (75.38%) | **34** (26.15%) | **95** (73.08%) | **25** (19.23%) |






These results from the 130 UK large-cap blend equity OEICs/UTs and the benchmark ETF, the iShares FTSE 100, provide a number of results that are worth highlighting. Firstly, from examining the results it is apparent that 7 of the OEICs/UTs exhibit the odd pattern in their efficiency ratings results of being rated at 0.000 under the output-oriented BCC model, which also manifests itself in graphical form as an outlier spike at an efficiency rating of 0.000 in the kernel density estimation graph for the output-oriented BCC model. As before, looking more closely at these results reveals that they correspond to the OEICs/UTs which contain negative data in their inputs and/or outputs, thus suggesting that it is essential to implement the SORM procedure to deal with the negative data issue. This is duly undertaken, resulting in the SORMBCC DEA efficiency ratings results shown in the final two columns, both input-oriented and output-oriented, which consequently deal with the negative data issue and produce a more robust looking set of efficiency ratings results for the OEICs/UTs in this category.

Also, an examination of the results for the efficiency ratings of the OEICs/UTs in this category also flags up another anomaly for one particular OEIC/UT, the Lazard UK Alpha Fund, which records efficiency ratings of 0.877 and 1.011 for input-oriented and output-oriented BCC DEA respectively. Clearly, the output-oriented BCC DEA efficiency rating of 1.011 is erroneous, and although inspecting the underlying dataset reveals that the Lazard UK Alpha Fund itself does not contain negative data, there are funds in the category dataset that do, thus raising the possibility that this could be the cause of this erroneous result. Consequently, this suggests that the implementation of a procedure such as SORM to deal with the negative data problem will be beneficial, and indeed, when SORM is implemented to produce the SORMBCC DEA efficiency ratings results, the Lazard UK Alpha Fund returns efficiency ratings of 0.880 and 0.835 for the input-oriented and output-oriented variations respectively, confirming the erroneous result is no longer present.

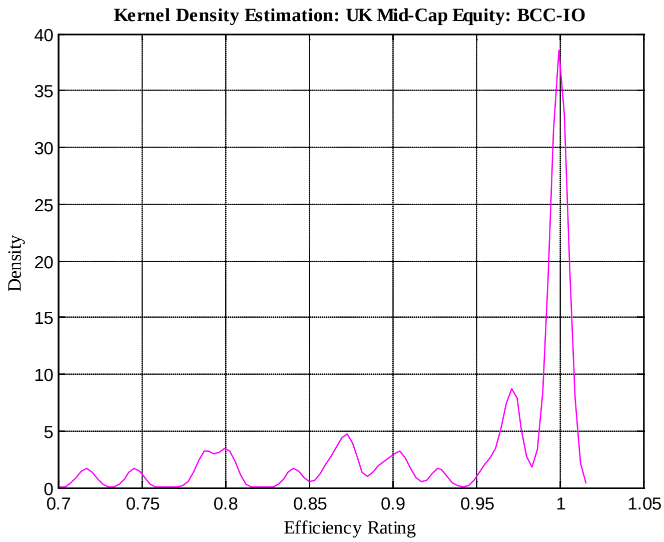
As a consequence of the variable returns-to-scale which underpins the BCC DEA model, there are differences in the efficiency ratings obtained from the input-oriented variation compared against those obtained from the output-oriented variation for the OEICs/UTs in this category. Also, there are some differences between the ratings obtained under the BCC DEA model compared to those obtained from the SORMBCC DEA model for some of the OEICs/UTs, whilst for other OEICs/UTs the efficiency ratings do not change with the move to the SORMBCC DEA model, as might be expected as a result of the resolution of the negative data issue.

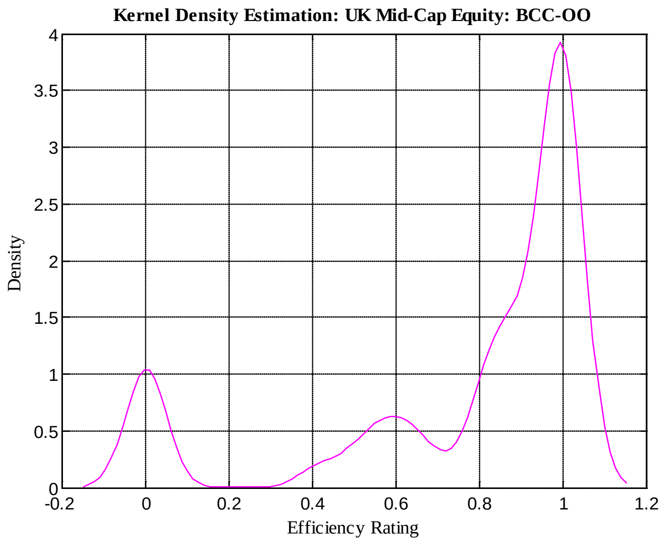
Finally, in the case of the BCC DEA model, 32 of the OEICs/UTs under the input-oriented variation and 95 of the OEICs/UTs under the output-oriented variation show a superior efficiency rating to that of the benchmark iShares FTSE 100 ETF which is only rated at 0.964 and 0.749 under the respective variations, thus suggesting that the managers of these OEICs/UTs are showing some ability to select stocks which allows them to outperform the market. Furthermore, when the SORMBCC DEA model efficiency ratings results are evaluated, 35 of the OEICs/UTs under the input-oriented variation and 104 of the OEICs/UTs under the output-oriented variation outperform the benchmark iShares FTSE 100 ETF which is only rated at 0.964 and 0.749 under the respective variations, thus again suggesting that the mangers of these OEICs/UTs are showing some ability to select stocks which allows them to outperform the market. It is interesting to note that for the input-oriented variation of the BCC and SORMBCC models, a significant proportion of the OEICs/UTs, 75.38% and 73.08% respectively, underperform the benchmark iShares FTSE 100 ETF, therefore indicating that a significant number of these more expensive, actively managed funds are underperforming relative to the low-cost, passively managed iShares FTSE 100 ETF. However, in the case of the output-oriented variation of the BCC and SORMBCC models, a significant proportion of the OEICs/UTs, 73.08% and 80.00% respectively, outperform the benchmark iShares FTSE 100 ETF, thus indicating that in contrast to the results of the input-oriented variation of the models, a significant number of these more expensive, actively managed funds manage to outperform the low-cost, passively managed iShares FTSE 100 ETF.

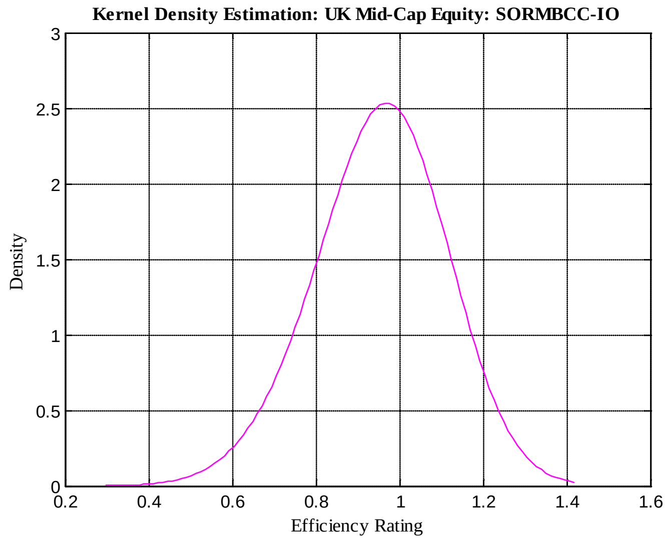
### *UK Mid-Cap Equity (1st January 2008 – 31st December 2010)*

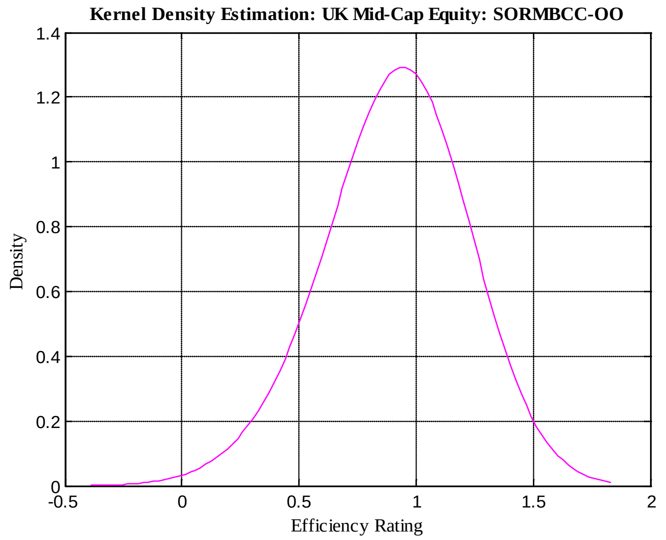
The detailed breakdown of the results from the individual OEICs/UTs in this category across the four DEA model variations can be found in Results Appendix 2 Table RA2.4, with a summary of the results provided in the table below, along with a kernel density estimation graph for each of the four DEA model variations.

| Summary Results | BCC-IO | BCC-OO | SORMBCC-IO | SORMBCC-OO |
|---|---|---|---|---|
| **Maximum Efficiency Rating** (Number Of OEICs/UTs) | **1.000** (21) | **1.000** (19) | **1.000** (27) | **1.000** (27) |
| **Minimum Efficiency Rating** (Number Of OEICs/UTs) | **0.717** (1) | **0.000** (6) | **0.717** (1) | **0.439** (1) |
| **Mean Efficiency Rating** | **0.943** | **0.769** | **0.953** | **0.910** |
| **Standard Deviation Of Efficiency Ratings** | **0.081** | **0.338** | **0.079** | **0.155** |
| **Number Of OEICs/UTs Outperforming The Benchmark ETF** | **0** (0.00%) | **0** (0.00%) | **0** (0.00%) | **0** (0.00%) |
| **Number Of OEICs/UTs Underperforming The Benchmark ETF** | **24** (53.33%) | **26** (57.78%) | **18** (40.00%) | **18** (40.00%) |






These results from the 45 UK mid-cap equity OEICs/UTs and the benchmark ETF, the iShares FTSE 250, provide a number of results that are worth highlighting. It is clear to see that when the results for this category of OEICs/UTs are evaluated, 6 of the OEICs/UTs exhibit the odd pattern in their efficiency ratings results of being rated at 0.000 under the output-oriented BCC model, and this is also apparent in the corresponding kernel density estimation graph for the output-oriented BCC DEA model as an outlier spike around an efficiency rating of 0.000. A closer examination of these results reveals that they again correspond to those OEICs/UTs which contain negative data in their inputs and/or outputs, thus suggesting that SORM should be implemented to deal with this. This leads to the efficiency ratings results for the SORMBCC DEA model, both input-oriented and output-oriented, which deal with the negative data problem and produce a more robust looking set of efficiency ratings results for the OEICs/UTs in this category.

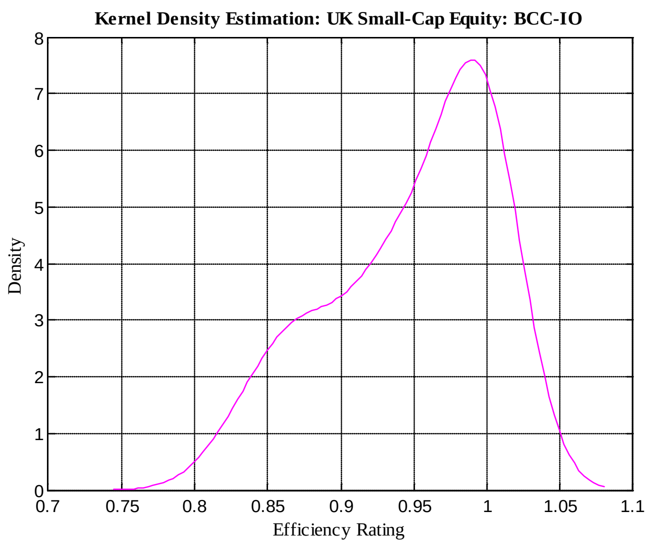
The variable returns-to-scale which underpin the BCC DEA model result in differences between the efficiency ratings obtained from the input-oriented variation compared against those obtained from the output-oriented variation for the OEICs/UTs in this category. There are some differences between the efficiency ratings obtained from the BCC DEA model versus those obtained from the SORMBCC DEA model for some of the OEICs/UTs, whilst for other OEICs/UTs the efficiency ratings remain the same with the implementation of the SORMBCC DEA model, as would be expected due to the resolution of the negative data issue.

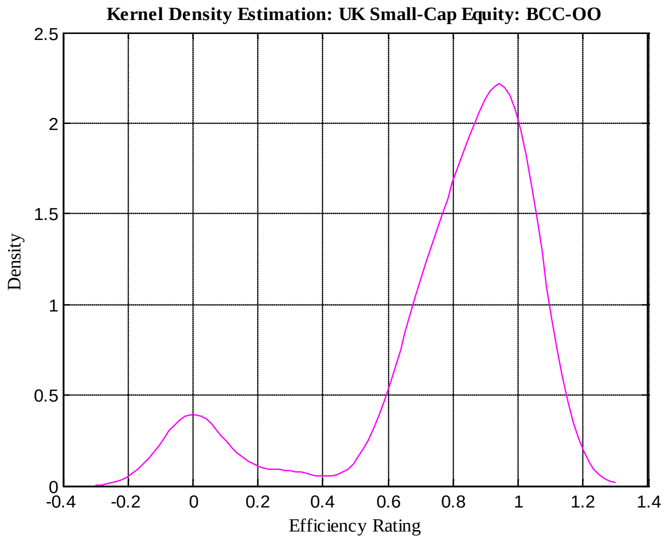
Finally, under the evaluation of the four DEA models utilised here, none of the OEICs/UTs show a superior efficiency rating to that of the benchmark iShares FTSE 250 ETF which achieves the maximum efficiency rating of 1.000 under each of the four DEA models used, indicating that none of the managers of the OEICs/UTs in this category are showing an ability to select stocks which would allow them to outperform the market. Also, under the evaluation of the input-oriented and output-oriented BCC DEA models, a large proportion of the OEICs/UTs, 53.33% and 57.78% respectively, underperform the benchmark iShares FTSE 250 ETF. This indicates that a large number of these more expensive, actively managed funds are underperforming relative to the low-cost, passively managed iShares FTSE 250 ETF. In addition to this, under the evaluation of the SORMBCC DEA model, both input-oriented and output-oriented, 40.00% of the OEICs/UTs underperform the benchmark iShares FTSE 250 ETF, thus indicating that a smaller number of these more expensive, actively managed funds are now underperforming relative to the low-cost, passively managed iShares FTSE 250 ETF.

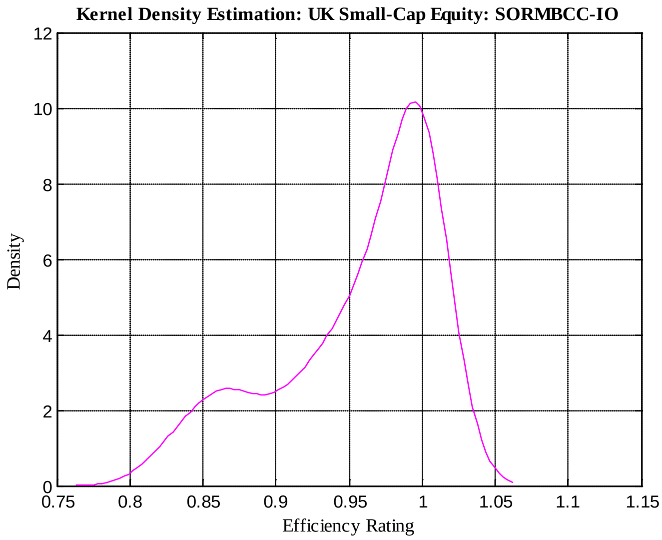
## *UK Small-Cap Equity (1st January 2008 – 31st December 2010)*

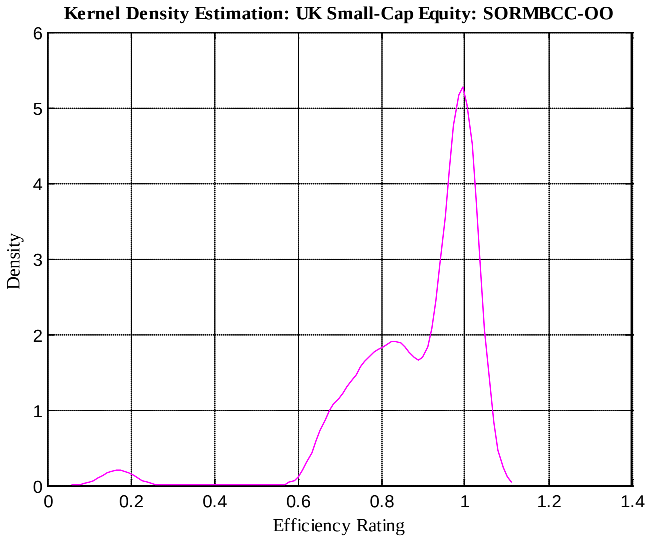
The detailed breakdown of the results from the individual OEICs/UTs in this category across the four DEA model variations can be found in Results Appendix 2 Table RA2.5, with a summary of the results provided in the table below, along with a kernel density estimation graph for each of the four DEA model variations.

| Summary Results | BCC-IO | BCC-OO | SORMBCC-IO | SORMBCC-OO |
|---|---|---|---|---|
| **Maximum Efficiency Rating** (Number Of OEICs/UTs) | **1.000** (17) | **1.000** (15) | **1.000** (21) | **1.000** (21) |
| **Minimum Efficiency Rating** (Number Of OEICs/UTs) | **0.825** (1) | **0.000** (5) | **0.825** (1) | **0.170** (1) |
| **Mean Efficiency Rating** | **0.948** | **0.784** | **0.956** | **0.889** |
| **Standard Deviation Of Efficiency Ratings** | **0.055** | **0.296** | **0.054** | **0.151** |
| **Number Of OEICs/UTs Outperforming The Benchmark ETF** | **0** (0.00%) | **0** (0.00%) | **0** (0.00%) | **0** (0.00%) |
| **Number Of OEICs/UTs Underperforming The Benchmark ETF** | **33** (66.00%) | **35** (70.00%) | **29** (58.00%) | **29** (58.00%) |




Kernel Density Estimation: UK Small-Cap Equity: BCC-OO
Density
Efficiency Rating
2.5
2
1.5
1
0.5
0
-0.4
-0.2
0
0.2
0.4
0.6
0.8
1
1.2
1.4


Kernel Density Estimation: UK Small-Cap Equity: SORMBCC-IO
Density
Efficiency Rating
12
10
8
6
4
2
0
0.75
0.8
0.85
0.9
0.95
1
1.05
1.1
1.15


Kernel Density Estimation: UK Small-Cap Equity: SORMBCC-OO
Density
Efficiency Rating
6
5
4
3
2
1
0
0
0.2
0.4
0.6
0.8
1
1.2
1.4

These results from the 50 UK small-cap equity OEICs/UTs and the benchmark ETF, the iShares FTSE 250, provide a number of results that are worth highlighting. Firstly, from evaluating the results from this category of OEICs/UTs, it is obvious that 5 of the OEICs/UTs exhibit the odd pattern in their efficiency ratings results of being rated at 0.000 under the output-oriented BCC model, and this is also present in graphical form in the kernel density estimation graph for the output-oriented BCC DEA model as an outlier spike at an efficiency rating of 0.000. Examining these results more closely reveals that they correspond to the OEICs/UTs which contain negative data in their inputs and/or outputs, implying that SORM should be implemented to resolve this, leading to the SORMBCC DEA efficiency ratings results which deal with the negative data issue and produce a more robust looking set of efficiency ratings results for the OEICs/UTs in this category.

The variable returns-to-scale underpinning the BCC DEA model means that there are differences between the efficiency ratings obtained from the input-oriented variation compared against those obtained from the output-oriented variation for the OEICs/UTs in this category. Also, there are some differences between the efficiency ratings obtained under the BCC DEA model versus those obtained under the SORMBCC DEA model for some of the OEICs/UTs, whilst for other OEICs/UTs the efficiency ratings remain the same with the implementation of the SORMBCC DEA model, as would be expected due to the resolution of the negative data issue.

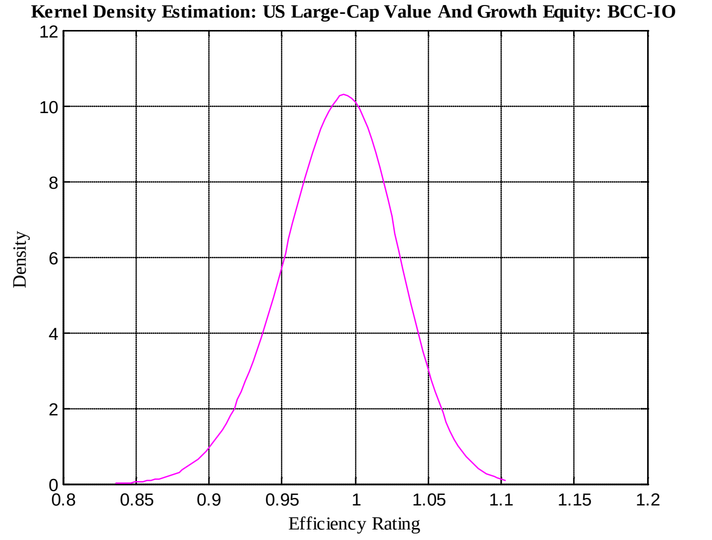
Finally, for each of the four DEA models employed in this section, none of the OEICs/UTs show a superior efficiency rating to that of the benchmark iShares FTSE 250 ETF which achieves the maximum efficiency rating of 1.000 in all four cases, thus indicating that none of the managers of the OEICs/UTs in this category are showing an ability to select stocks which would allow them to outperform the market. Under the evaluation of the BCC model, a significant proportion of the OEICs/UTs, 66.00% under the input-oriented variation and 70.00% under the output-oriented variation, underperform the benchmark iShares FTSE 250 ETF, indicating that a significant number of these more expensive, actively managed funds are underperforming relative to the low-cost, passively managed iShares FTSE 250 ETF. Following on from this, under the evaluation of the SORMBCC model, the proportion of OEICs/UTs underperforming the benchmark iShares FTSE 250 ETF reduces slightly to 58.00% under both the input-oriented and output-oriented versions, suggesting a large number of these more expensive, actively managed funds are still underperforming relative to the low-cost, passively managed iShares FTSE 250 ETF.

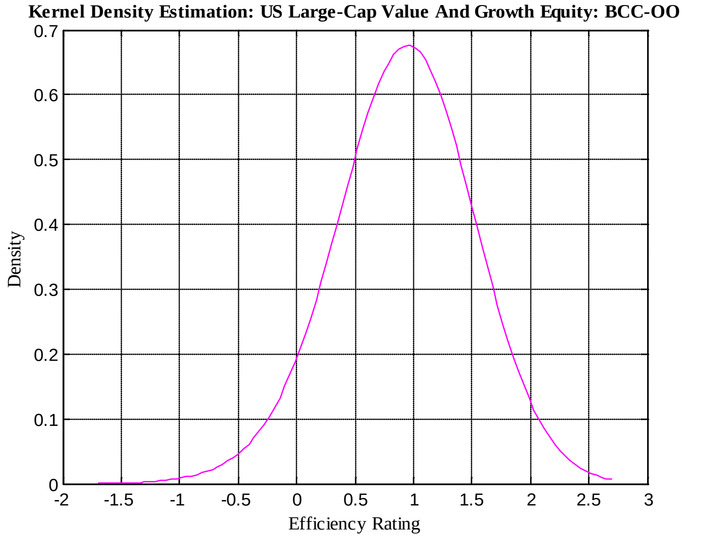
## *8.2: UK Domiciled OEICs And UTs With A US Investment Focus*

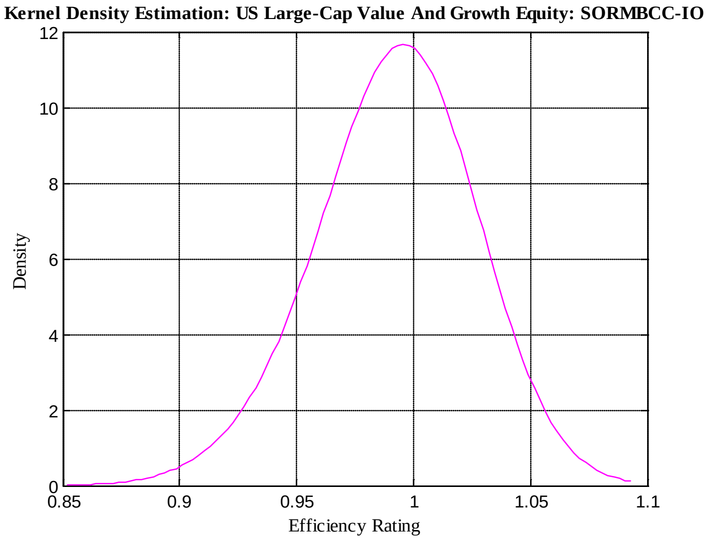
### *US Large-Cap Value And Growth Equity (1st January 2008 – 31st December 2010)*

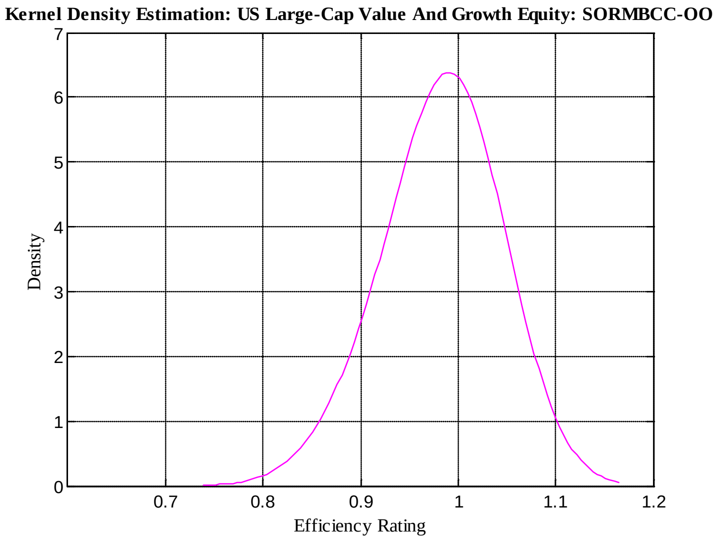
The detailed breakdown of the results from the individual OEICs/UTs in this category across the four DEA model variations can be found in Results Appendix 2 Table RA2.6, with a summary of the results provided in the table below, along with a kernel density estimation graph for each of the four DEA model variations.

| Summary Results | BCC-IO | BCC-OO | SORMBCC-IO | SORMBCC-OO |
|---|---|---|---|---|
| **Maximum Efficiency Rating** (Number Of OEICs/UTs) | **1.000** (13) | **1.000** (12) | **1.000** (15) | **1.000** (15) |
| **Minimum Efficiency Rating** (Number Of OEICs/UTs) | **0.939** (1) | **0.000** (1) | **0.945** (1) | **0.903** (1) |
| **Mean Efficiency Rating** | **0.989** | **0.918** | **0.992** | **0.982** |
| **Standard Deviation Of Efficiency Ratings** | **0.020** | **0.213** | **0.017** | **0.033** |
| **Number Of OEICs/UTs Outperforming The Benchmark ETF** | **0** (0.00%) | **0** (0.00%) | **0** (0.00%) | **0** (0.00%) |
| **Number Of OEICs/UTs Underperforming The Benchmark ETF** | **9** (40.91%) | **10** (45.45%) | **7** (31.82%) | **7** (31.82%) |


Kernel Density Estimation: US Large-Cap Value And Growth Equity: BCC-IO
Density
Efficiency Rating
0
2
4
6
8
10
12
0.8
0.85
0.9
0.95
1
1.05
1.1
1.15
1.2


Kernel Density Estimation: US Large-Cap Value And Growth Equity: BCC-OO
Density
Efficiency Rating
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
-2
-1.5
-1
-0.5
0
0.5
1
1.5
2
2.5
3


Kernel Density Estimation: US Large-Cap Value And Growth Equity: SORMBCC-IO
Density
Efficiency Rating
0
2
4
6
8
10
12
0.85
0.9
0.95
1
1.05
1.1




These results from the 22 US large-cap value and growth equity OEICs/UTs and the benchmark ETF, the iShares S&P 500, provide a number of results that are worth highlighting. Firstly, from examining the results for this category of OEICs/UTs, it is apparent that one of the OEICs/UTs exhibits the peculiar pattern in its efficiency ratings of being rated at 0.000 under the output-oriented BCC model, and a closer inspection reveals that this peculiar result corresponds to an OEIC/UT which contains negative data in its inputs and/or outputs. Consequently, the SORM procedure is implemented, leading to the SORMBCC DEA model efficiency ratings results which deal with the issue caused by the negative data and produce a more robust looking set of efficiency ratings results for the OEICs/UTs in this category.

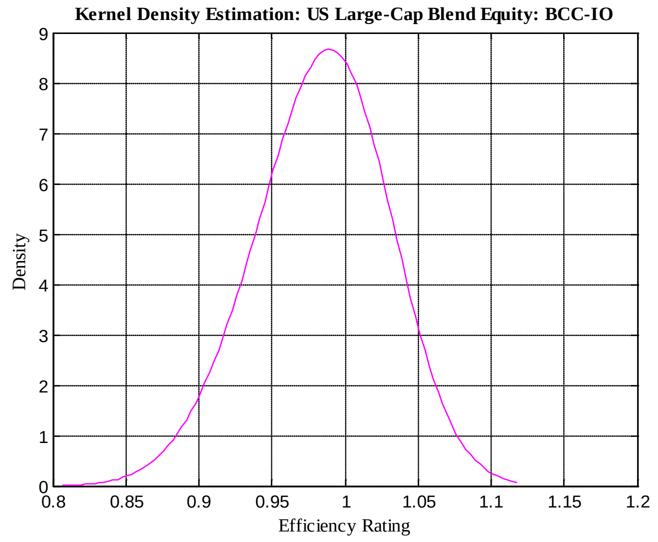
The BCC DEA model is underpinned by variable returns-to-scale, and therefore as a consequence this means that there are differences between the efficiency ratings obtained from the input-oriented and output-oriented variations for the OEICs/UTs in this category. Again, there are some differences between the efficiency ratings obtained under the BCC DEA model compared against those obtained under the SORMBCC DEA model for some of the OEICs/UTs, whilst for others the efficiency ratings remain the same with the implementation of the SORMBCC DEA model, most likely due to the negative data problem being resolved.

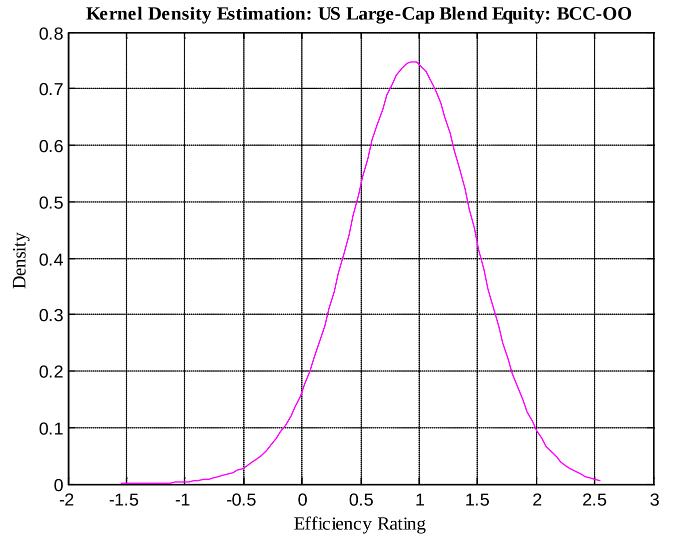
Finally, across all four of the DEA models utilised in this section, none of the OEICs/UTs show a superior efficiency rating to that of the benchmark iShares S&P 500 ETF which achieves the maximum efficiency rating of 1.000 under the evaluation of all four of the DEA model variations, thus indicating that none of the managers of the OEICs/UTs in this category are showing an ability to select stocks which would allow them to outperform the market. Also, under the evaluation of the four DEA models utilised in this section, a small proportion of the OEICs/UTs, ranging from 31.82% to 45.45%, underperform the benchmark iShares S&P 500 ETF, suggesting only a small number of these more expensive, actively managed funds are underperforming relative to the low-cost, passively managed iShares S&P 500 ETF.

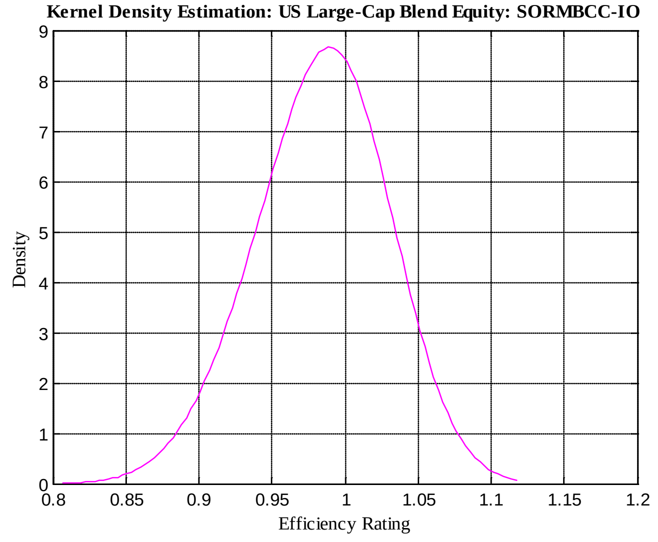
***US Large-Cap Blend Equity (1st January 2008 – 31st December 2010)***

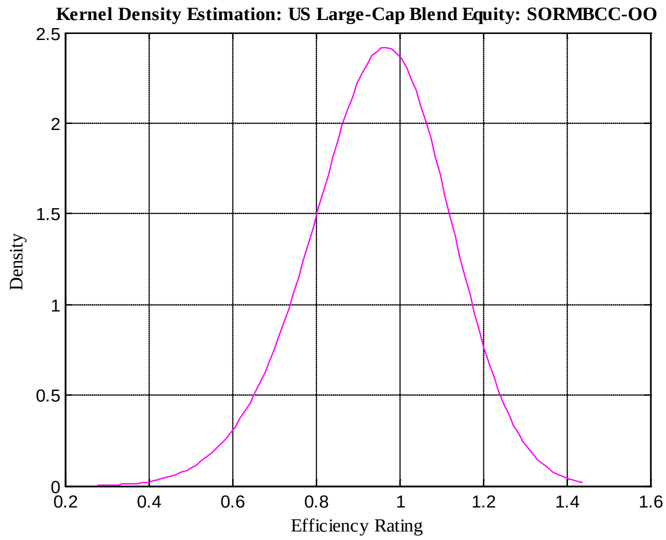
The detailed breakdown of the results from the individual OEICs/UTs in this category across the four DEA model variations can be found in Results Appendix 2 Table RA2.7, with a summary of the results provided in the table below, along with a kernel density estimation graph for each of the four DEA model variations.

| Summary Results | BCC-IO | BCC-OO | SORMBCC-IO | SORMBCC-OO |
|---|---|---|---|---|
| **Maximum Efficiency Rating** (Number Of OEICs/UTs) | **1.000** (20) | **1.000** (19) | **1.000** (21) | **1.000** (21) |
| **Minimum Efficiency Rating** (Number Of OEICs/UTs) | **0.924** (1) | **0.000** (1) | **0.924** (1) | **0.717** (2) |
| **Mean Efficiency Rating** | **0.983** | **0.922** | **0.984** | **0.949** |
| **Standard Deviation Of Efficiency Ratings** | **0.025** | **0.177** | **0.025** | **0.085** |
| **Number Of OEICs/UTs Outperforming The Benchmark ETF** | **0** (0.00%) | **0** (0.00%) | **0** (0.00%) | **0** (0.00%) |
| **Number Of OEICs/UTs Underperforming The Benchmark ETF** | **16** (44.44%) | **17** (47.22%) | **15** (41.67%) | **15** (41.67%) |


Kernel Density Estimation: US Large-Cap Blend Equity: BCC-IO
Density
Efficiency Rating
0
1
2
3
4
5
6
7
8
9
0.8
0.85
0.9
0.95
1
1.05
1.1
1.15
1.2


Kernel Density Estimation: US Large-Cap Blend Equity: BCC-OO
Density
Efficiency Rating
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
-2
-1.5
-1
-0.5
0
0.5
1
1.5
2
2.5
3


Kernel Density Estimation: US Large-Cap Blend Equity: SORMBCC-IO
Density
Efficiency Rating
0
1
2
3
4
5
6
7
8
9
0.8
0.85
0.9
0.95
1
1.05
1.1
1.15
1.2




These results from the 36 US large-cap blend equity OEICs/UTs and the benchmark ETF, the iShares S&P 500, provide a number of results that are worth highlighting. Firstly, it is apparent from the results for the OEICs/UTs in this category that one of the OEICs/UTs is showing the odd pattern in its efficiency ratings of being rated at 0.000 under the output-oriented BCC model, and a closer examination reveals that this corresponds to an OEIC/UT which contains negative data in its inputs and/or outputs, implying that SORM should be implemented. This leads to the SORMBCC model efficiency ratings results which deal with the negative data problem and produce a more robust looking set of efficiency ratings results for the OEICs/UTs in this category.

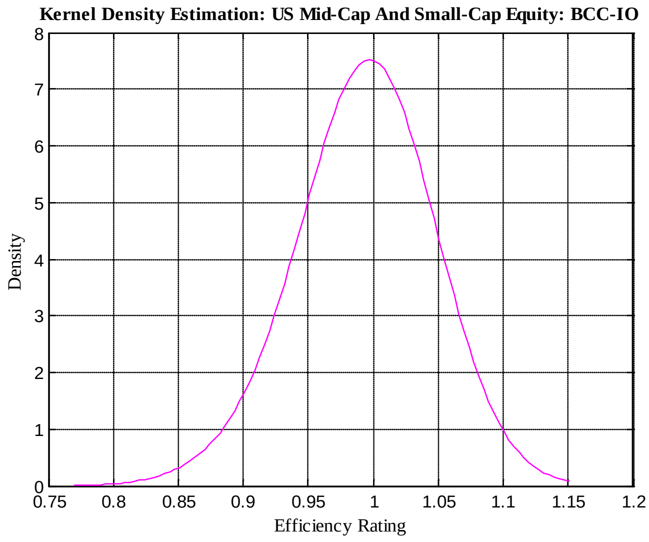
Again, there are differences between the efficiency ratings obtained from the input-oriented BCC model and those obtained from the output-oriented BCC model for the OEICs/UTs in this category due to the underlying variable returns-to-scale. Also, it follows that there are some differences between the efficiency ratings obtained under the BCC DEA model compared against those obtained under the SORMBCC DEA model for some of the OEICs/UTs, whilst for others the efficiency ratings remain the same after the implementation of the SORMBCC DEA model, as would be expected due to the resolution of the negative data issue.

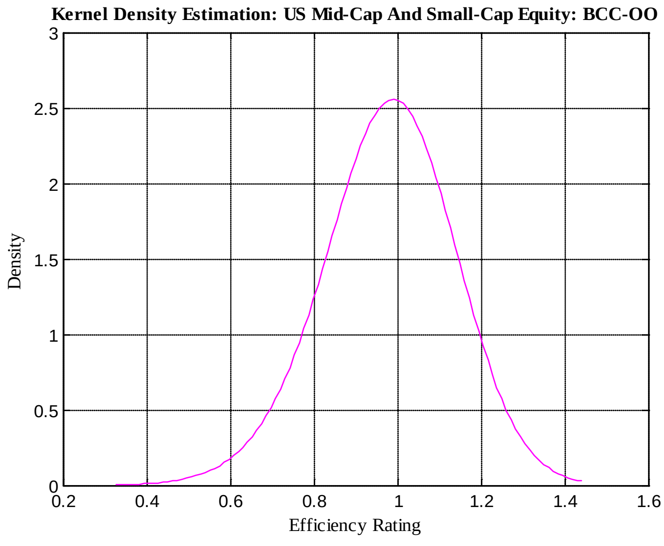
Finally, under the evaluation of the four DEA models employed in this section, none of the OEICs/UTs show a superior efficiency rating to that of the benchmark iShares S&P 500 ETF which obtains the maximum efficiency rating of 1.000 in all four cases, indicating that none of the managers of the OEICs/UTs in this category are showing an ability to select stocks which would allow them to outperform the market. Also, across the four DEA models utilised in this section, slightly under half of the OEICs/UTs, from 41.67% to 47.22%, underperform the benchmark iShares S&P 500 ETF, indicating that just under half of these more expensive, actively managed funds are underperforming relative to the low-cost, passively managed iShares S&P 500 ETF.

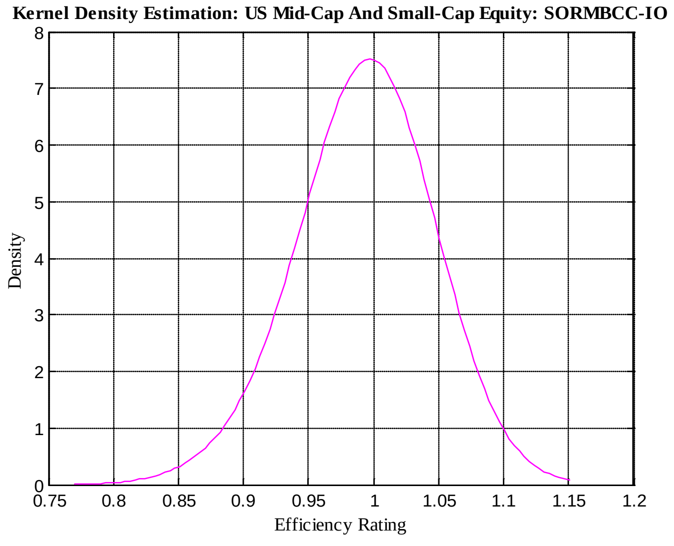
***US Mid-Cap And Small-Cap Equity (1st January 2008 – 31st December 2010)***

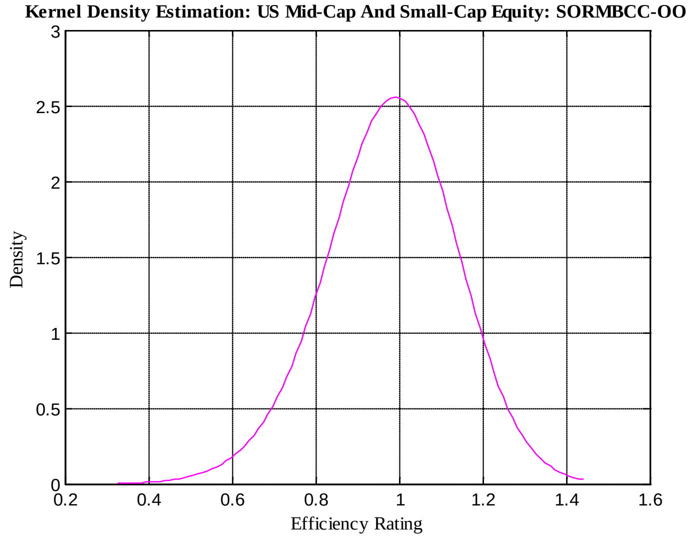
The detailed breakdown of the results from the individual OEICs/UTs in this category across the four DEA model variations can be found in Results Appendix 2 Table RA2.8, with a summary of the results provided in the table below, along with a kernel density estimation graph for each of the four DEA model variations.

| Summary Results | BCC-IO | BCC-OO | SORMBCC-IO | SORMBCC-OO |
|---|---|---|---|---|
| **Maximum Efficiency Rating** (Number Of OEICs/UTs) | **1.000** (10) | **1.000** (10) | **1.000** (10) | **1.000** (10) |
| **Minimum Efficiency Rating** (Number Of OEICs/UTs) | **0.921** (1) | **0.768** (1) | **0.921** (1) | **0.768** (1) |
| **Mean Efficiency Rating** | **0.993** | **0.979** | **0.993** | **0.979** |
| **Standard Deviation Of Efficiency Ratings** | **0.022** | **0.065** | **0.022** | **0.065** |
| **Number Of OEICs/UTs Outperforming The Benchmark ETF** | **0** (0.00%) | **0** (0.00%) | **0** (0.00%) | **0** (0.00%) |
| **Number Of OEICs/UTs Underperforming The Benchmark ETF** | **2** (16.67%) | **2** (16.67%) | **2** (16.67%) | **2** (16.67%) |


Kernel Density Estimation: US Mid-Cap And Small-Cap Equity: BCC-IO
Density
Efficiency Rating
0.75
0.8
0.85
0.9
0.95
1
1.05
1.1
1.15
1.2


Kernel Density Estimation: US Mid-Cap And Small-Cap Equity: BCC-OO
Density
Efficiency Rating
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6


Kernel Density Estimation: US Mid-Cap And Small-Cap Equity: SORMBCC-IO
Density
Efficiency Rating
0.75
0.8
0.85
0.9
0.95
1
1.05
1.1
1.15
1.2




These results from the 12 US mid-cap and small-cap equity OEICs/UTs and the benchmark ETF, the iShares S&P 500, provide a number of results that are worth highlighting. Firstly, there is no issue with negative data for the OEICs/UTs in this category, but the SORM procedure is still implemented for the purposes of comparison across the entire universe of mutual funds. Again, the variable returns-to-scale of the BCC model lead to differences between the efficiency ratings obtained from the input-oriented and output-oriented variations, and there are no differences between the efficiency ratings the OEICs/UTs obtain under the BCC model compared against those they obtain under the SORMBCC model, almost certainly due to the lack of negative data in this category of OEICs/UTs.

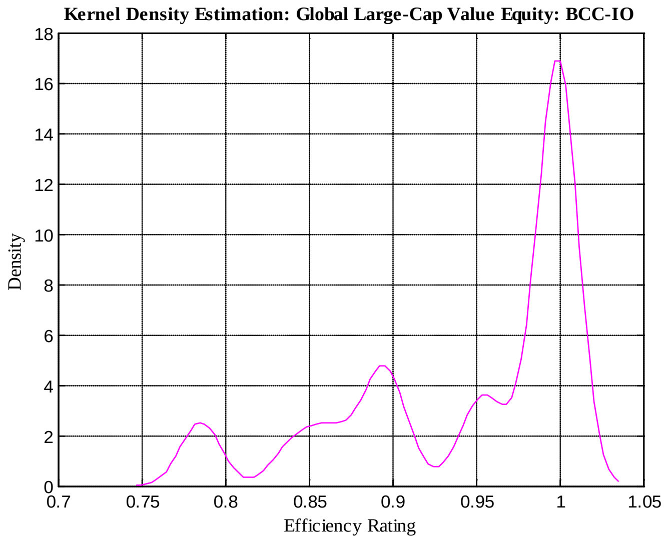
Finally, under the evaluation of the four DEA models utilised here, none of the OEICs/UTs show a superior efficiency rating to that of the benchmark iShares S&P 500 ETF which is rated at the maximum efficiency rating of 1.000 under each of the four DEA models used, thus suggesting that the managers of the OEICs/UTs in this category of funds are failing to show an ability to select stocks which would allow them to outperform the market. It is important to note that although under all four DEA models utilised here, only a small proportion of the OEICs/UTs, 16.67% in all four cases, underperform relative to the benchmark iShares S&P 500 ETF, 10 out of the 12 funds in this category obtain the maximum efficiency rating of 1.000 alongside the benchmark iShares S&P 500 ETF. Clearly, the analysis here could potential be improved by implementing super-efficiency in some form to disseminate the efficiency ratings results for these OEICs/UTs.

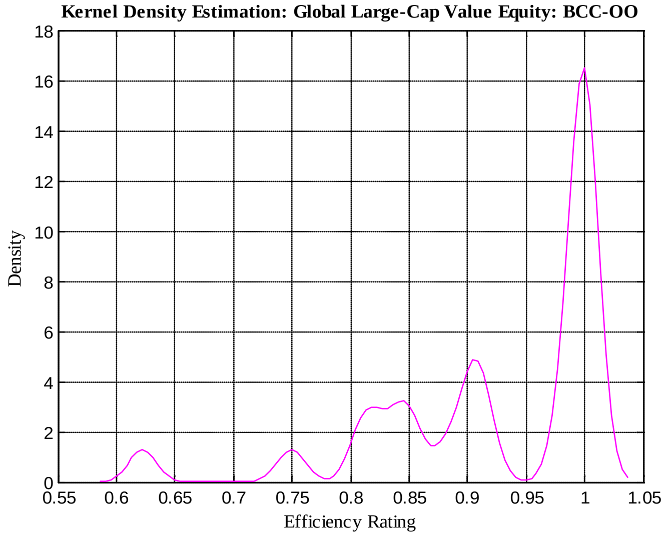
## *8.3: UK Domiciled OEICs And UTs With A Global Investment Focus*

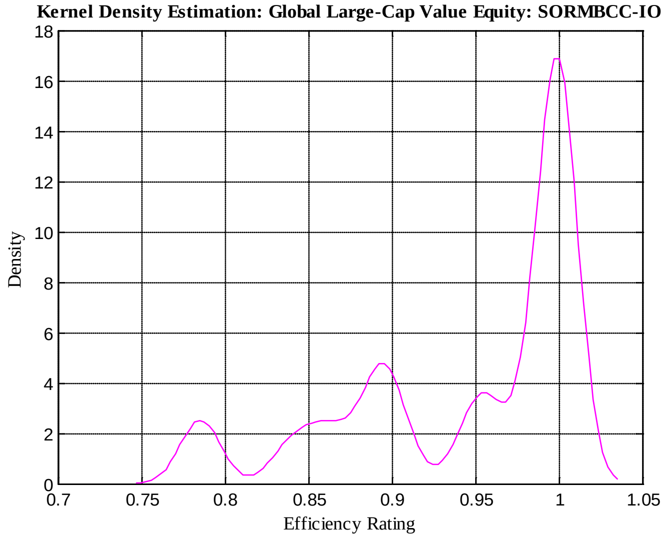
### *Global Large-Cap Value Equity (1st January 2008 – 31st December 2010)*

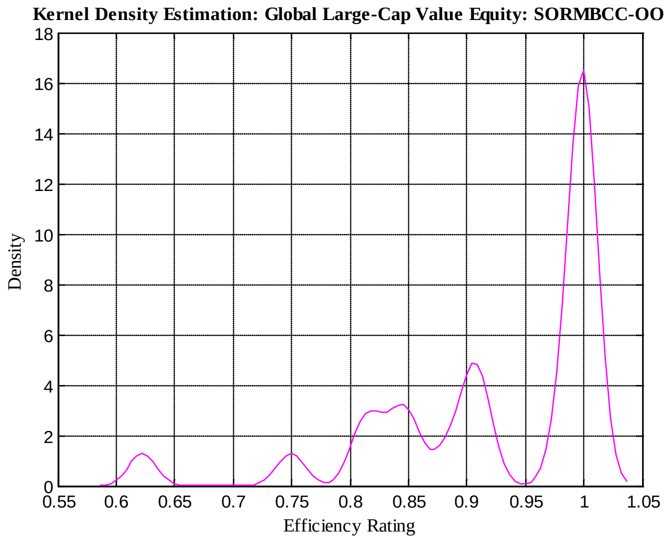
The detailed breakdown of the results from the individual OEICs/UTs in this category across the four DEA model variations can be found in Results Appendix 2 Table RA2.9, with a summary of the results provided in the table below, along with a kernel density estimation graph for each of the four DEA model variations.

| Summary Results | BCC-IO | BCC-OO | SORMBCC-IO | SORMBCC-OO |
|---|---|---|---|---|
| **Maximum Efficiency Rating** (Number Of OEICs/UTs) | **1.000** (12) | **1.000** (12) | **1.000** (12) | **1.000** (12) |
| **Minimum Efficiency Rating** (Number Of OEICs/UTs) | **0.782** (1) | **0.622** (1) | **0.782** (1) | **0.622** (1) |
| **Mean Efficiency Rating** | **0.944** | **0.924** | **0.944** | **0.924** |
| **Standard Deviation Of Efficiency Ratings** | **0.071** | **0.099** | **0.071** | **0.099** |
| **Number Of OEICs/UTs Outperforming The Benchmark ETF** | **20** (80.00%) | **24** (96.00%) | **20** (80.00%) | **24** (96.00%) |
| **Number Of OEICs/UTs Underperforming The Benchmark ETF** | **5** (20.00%) | **1** (4.00%) | **5** (20.00%) | **1** (4.00%) |


Kernel Density Estimation: Global Large-Cap Value Equity: BCC-IO
Density
Efficiency Rating
0
2
4
6
8
10
12
14
16
18
0.7
0.75
0.8
0.85
0.9
0.95
1
1.05


Kernel Density Estimation: Global Large-Cap Value Equity: BCC-OO
Density
Efficiency Rating
0
2
4
6
8
10
12
14
16
18
0.55
0.6
0.65
0.7
0.75
0.8
0.85
0.9
0.95
1
1.05


Kernel Density Estimation: Global Large-Cap Value Equity: SORMBCC-IO
Density
Efficiency Rating
0
2
4
6
8
10
12
14
16
18
0.7
0.75
0.8
0.85
0.9
0.95
1
1.05




These results from the 25 global large-cap value equity OEICs/UTs and the benchmark ETF, the iShares MSCI World, provide a number of results that are worth highlighting. Firstly, there is no issue with negative data influencing the efficiency ratings results for the OEICs/UTs in this category, but again the SORM procedure is still implemented for the purposes of comparison across the entire universe of mutual funds. Also, the variable returns-to-scale which underpins the BCC model leads to differences in the efficiency ratings obtained from the input-oriented variation compared against those obtained from the output-oriented variation, and there are no differences between these efficiency ratings from the BCC model and those obtained under the SORMBCC model, as would be expected due to the lack of negative data in this category of OEICs/UTs.

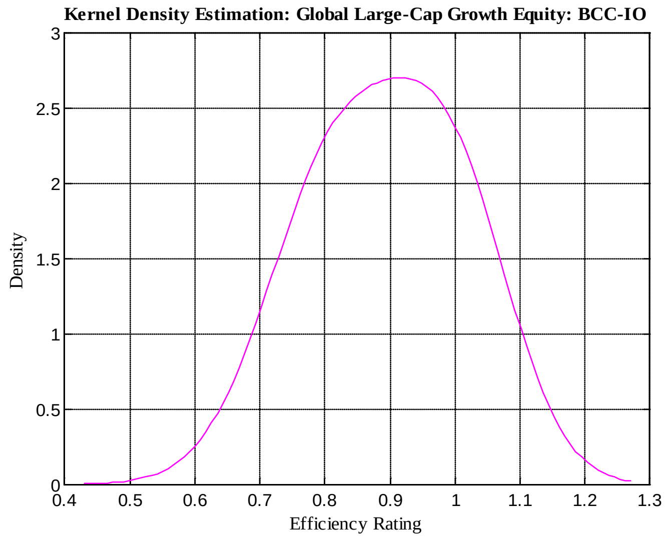
Finally, under the evaluation of the BCC DEA model and the SORMBCC DEA model, 20 of the OEICs/UTs under the input-oriented variations and 24 of the OEICs/UTs under the output-oriented variations show a superior efficiency rating to that of the benchmark iShares MSCI World ETF which is only rated at 0.890 and 0.749 under the respective variations for both BCC and SORMBCC DEA, suggesting that the managers of these OEICs/UTs are showing an ability to select stocks which allows them to outperform the market. Thus, it follows that a significant proportion of the OEICs/UTs, 80.00% under the input-oriented variations of the BCC and

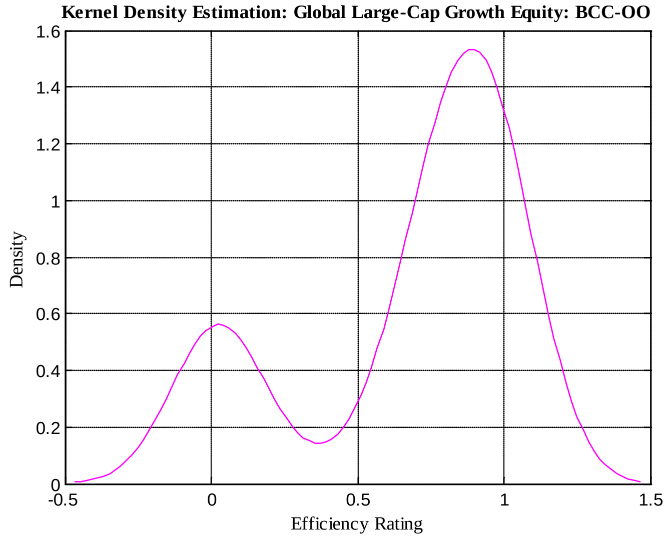
SORMBCC models and 96.00% under the output-oriented variations of the BCC and SORMBCC models, outperform the benchmark iShares MSCI World ETF, indicating that a significant number of these more expensive, actively managed funds outperform the low-cost, passively managed iShares MSCI World ETF.

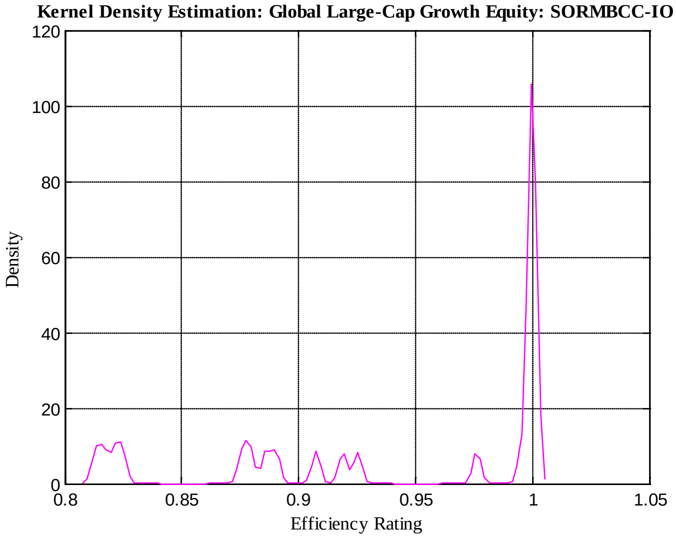
### *Global Large-Cap Growth Equity (1st January 2008 – 31st December 2010)*

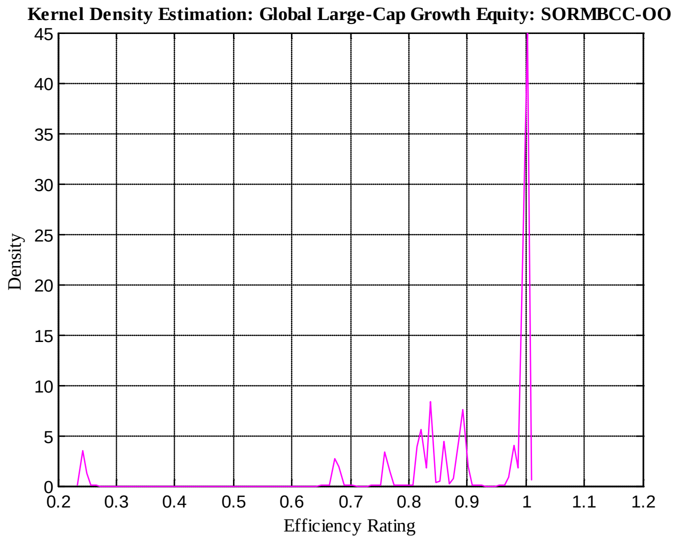
The detailed breakdown of the results from the individual OEICs/UTs in this category across the four DEA model variations can be found in Results Appendix 2 Table RA2.10, with a summary of the results provided in the table below, along with a kernel density estimation graph for each of the four DEA model variations.

| Summary Results | BCC-IO | BCC-OO | SORMBCC-IO | SORMBCC-OO |
|---|---|---|---|---|
| **Maximum Efficiency Rating** (Number Of OEICs/UTs) | **1.000** (9) | **1.000** (6) | **1.000** (12) | **1.000** (12) |
| **Minimum Efficiency Rating** (Number Of OEICs/UTs) | **0.702** (1) | **0.000** (4) | **0.813** (1) | **0.244** (1) |
| **Mean Efficiency Rating** | **0.895** | **0.679** | **0.944** | **0.904** |
| **Standard Deviation Of Efficiency Ratings** | **0.099** | **0.378** | **0.071** | **0.163** |
| **Number Of OEICs/UTs Outperforming The Benchmark ETF** | **0** (0.00%) | **0** (0.00%) | **0** (0.00%) | **0** (0.00%) |
| **Number Of OEICs/UTs Underperforming The Benchmark ETF** | **16** (64.00%) | **19** (76.00%) | **13** (52.00%) | **13** (52.00%) |


Kernel Density Estimation: Global Large-Cap Growth Equity: BCC-IO
Density
Efficiency Rating
0
0.5
1
1.5
2
2.5
3
0.4
0.5
0.6
0.7
0.8
0.9
1
1.1
1.2
1.3


Kernel Density Estimation: Global Large-Cap Growth Equity: BCC-OO
Density
Efficiency Rating
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
-0.5
0
0.5
1
1.5


Kernel Density Estimation: Global Large-Cap Growth Equity: SORMBCC-IO
Density
Efficiency Rating
0
20
40
60
80
100
120
0.8
0.85
0.9
0.95
1
1.05




These results from the 25 global large-cap growth equity OEICs/UTs and the benchmark ETF, the iShares MSCI World, provide a number of results that are worth highlighting. Firstly, from examining the results it is apparent that 4 of the OEICs/UTs are exhibiting the odd pattern in their efficiency ratings results of being rated at 0.000 under the output-oriented BCC model, and this also manifests itself as an outlier spike at an efficiency rating of 0.000 in the kernel density estimation graph for the output-oriented BCC model. The underlying data reveals that the corresponding OEICs/UTs contain negative data in their inputs and/or outputs, suggesting that SORM should be implemented, resulting in the SORMBCC DEA efficiency ratings results which deal with this negative data issue and lead to a more robust set of efficiency ratings results for the OEICs/UTs in this category.

The BCC DEA model is underpinned by variable returns-to-scale, and as a consequence therefore, there are differences in the efficiency ratings obtained from the input-oriented variation compared to those obtained from the output-oriented variation. Also, as might be expected with the resolution of the negative data problem, there are some differences between the efficiency ratings obtained under the BCC model compared to the corresponding ones obtained from the SORMBCC model for some of the OEICs/UTs, whilst for others the efficiency ratings they achieve do not change with the use of the SORMBCC DEA model.

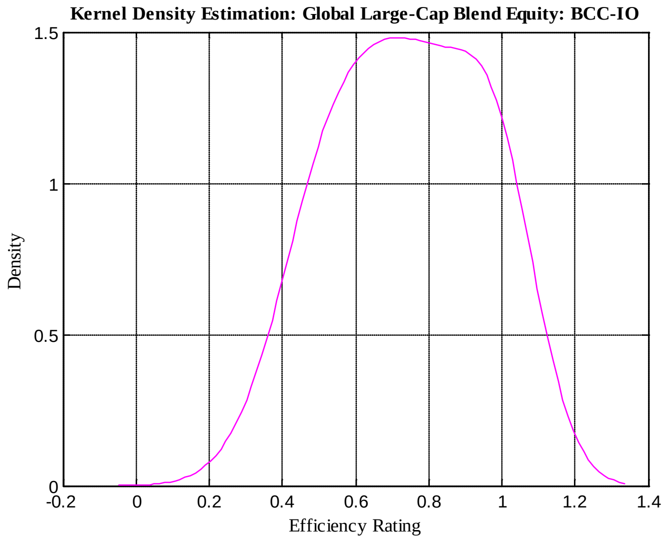
Finally, under the evaluation of the four DEA model variations in this section, none of the OEICs/UTs in this category show a superior efficiency rating to that of the benchmark iShares MSCI World ETF which obtains the maximum efficiency rating of 1.000 under each of the four DEA models used, thus indicating that none of the managers of the OEICs/UTs are showing an ability to select stocks which would allow them to outperform the market. It is interesting to note that when the BCC DEA model is used a significant proportion of the OEICs/UTs, 64.00% under the input-oriented variation and 76.00% under the output-oriented variation, underperform the benchmark iShares MSCI World ETF, indicating that a significant number of these more expensive, actively managed funds underperform relative to the low-cost, passively managed iShares MSCI World ETF. With the move to the SORMBCC DEA model these proportions drop to 52.00% of the OEICs/UTs under both the input-oriented and output-oriented variations, indicating that just over half of these more expensive, actively managed funds are now underperforming relative to the low-cost, passively managed iShares MSCI World ETF.

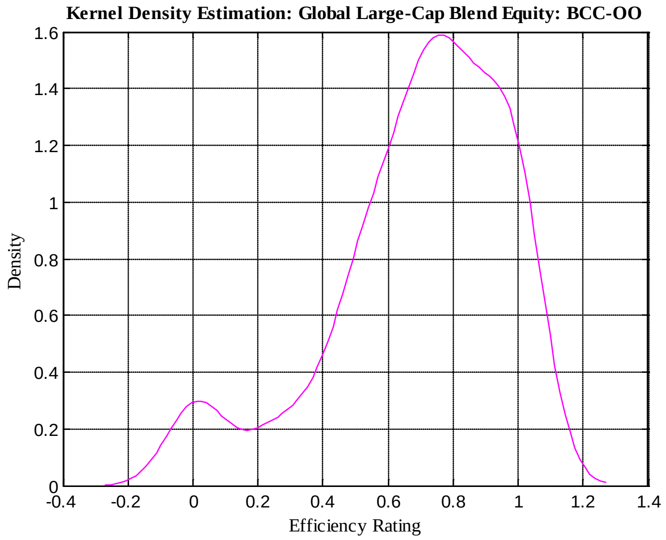
### *Global Large-Cap Blend Equity (1st January 2008 – 31st December 2010)*

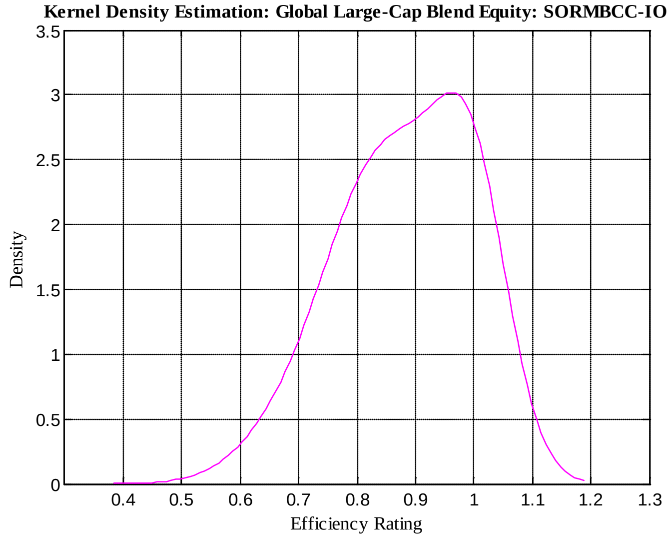
The detailed breakdown of the results from the individual OEICs/UTs in this category across the four DEA model variations can be found in Results Appendix 2 Table RA2.11, with a summary of the results provided in the table below, along with a kernel density estimation graph for each of the four DEA model variations.

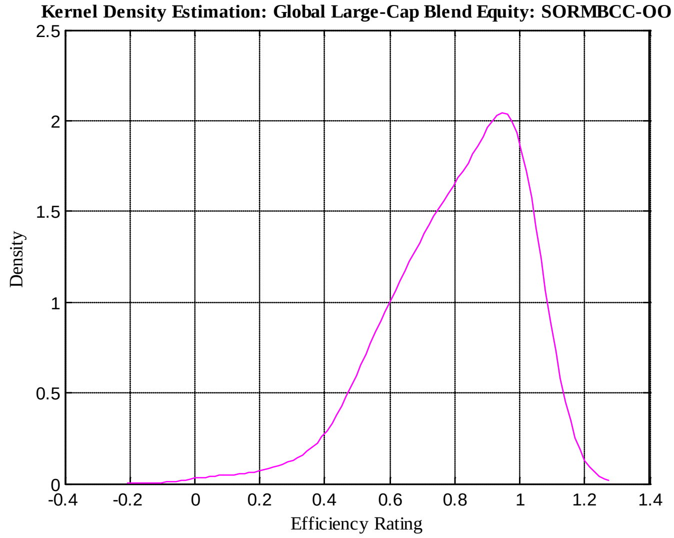
| Summary Results | BCC-IO | BCC-OO | SORMBCC-IO | SORMBCC-OO |
|---|---|---|---|---|
| **Maximum Efficiency Rating** (Number Of OEICs/UTs) | **1.000** (22) | **1.000** (21) | **1.000** (33) | **1.000** (33) |

| | | | | |
|---|---|---|---|---|
| **Minimum Efficiency Rating** (Number Of OEICs/UTs) | **0.288** (1) | **0.000** (6) | **0.573** (1) | **0.067** (1) |
| **Mean Efficiency Rating** | **0.742** | **0.694** | **0.884** | **0.808** |
| **Standard Deviation Of Efficiency Ratings** | **0.196** | **0.270** | **0.107** | **0.192** |
| **Number Of OEICs/UTs Outperforming The Benchmark ETF** | **54** (45.76%) | **74** (62.71%) | **40** (33.90%) | **59** (50.00%) |
| **Number Of OEICs/UTs Underperforming The Benchmark ETF** | **64** (54.24%) | **44** (37.29%) | **77** (65.25%) | **59** (50.00%) |






These results from the 118 global large-cap blend equity OEICs/UTs and the benchmark ETF, the iShares MSCI World, provide a number of results that are worth highlighting. After evaluating the efficiency ratings results for the OEICs/UTs in this category, it is apparent that 6 of the OEICs/UTs are exhibiting the odd pattern in their efficiency ratings results of being rated at 0.000 under the output-oriented BCC DEA model, which is also apparent in the corresponding kernel density estimation graph as a small outlier spike at an efficiency rating of 0.000. The underlying data reveals that these OEICs/UTs contain negative data in their inputs and/or outputs, thus leading to the implementation of the SORM procedure to produce the SORMBCC DEA efficiency ratings results which deal with the negative data issue and produce a more robust looking set of efficiency ratings results for the OEICs/UTs in this category.

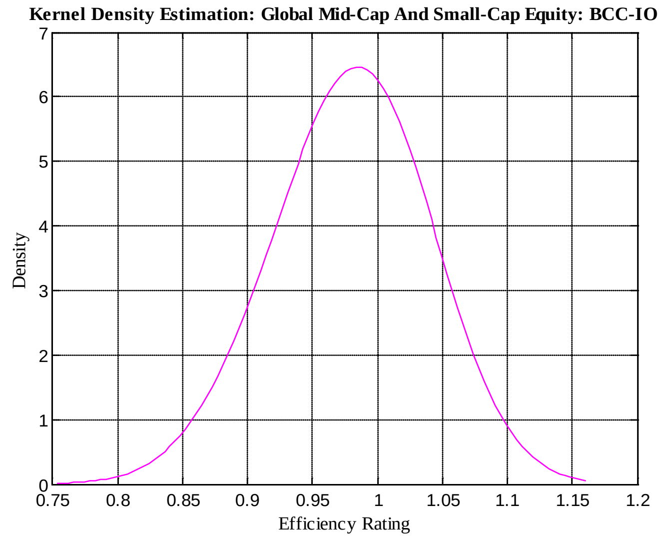
As a consequence of the variable returns-to-scale which underpins the BCC DEA model, there are differences in the efficiency ratings obtained from the input-oriented variation compared against those obtained from the output-oriented variation for the OEICs/UTs in this category. Again however, there are some differences between the efficiency ratings obtained under the BCC DEA model versus those obtained under the SORMBCC DEA model for some of the OEICs/UTs, whilst for other OEICs/UTs the efficiency ratings they achieve remain the same with the implementation of the SORMBCC model, most likely as a result of the resolution of the negative data problem.

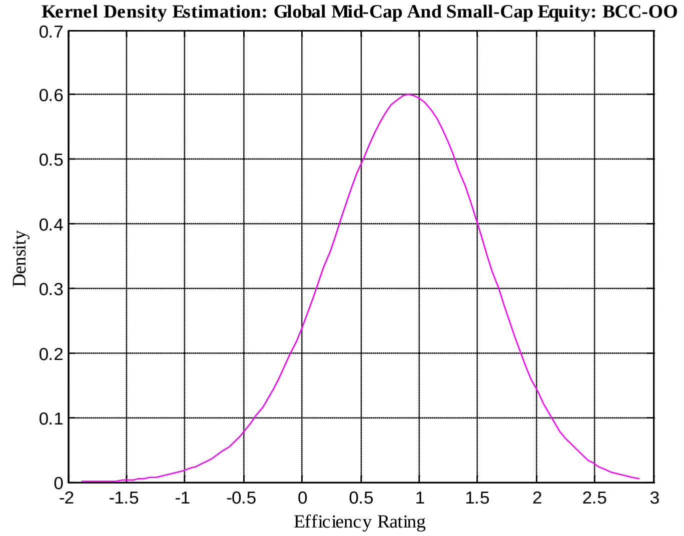
Finally, under the evaluation of the BCC model, 54 of the OEICs/UTs under the input-oriented variation and 74 of the OEICs/UTs under the output-oriented variation show a superior efficiency rating to that of the benchmark iShares MSCI World ETF which is only rated at 0.769 and 0.697 under the respective variations, thus suggesting that the managers of these OEICs/UTs are showing some ability to select stocks which subsequently allows them to outperform the market. When the SORMBCC model is used to evaluate the OEICs/UTs in this category, 40 of the OEICs/UTs under the input-oriented variation and 59 of the OEICs/UTs under the output-oriented variation show a superior efficiency rating to that of the benchmark iShares MSCI World ETF which is only rated at 0.962 and 0.848 under the respective variations, thus again suggesting that the managers of these OEICs/UTs are showing some ability to select stocks which allows them to outperform the market. However, it is important to note that for the input-oriented variation of the BCC and SORMBCC models, 54.24% and 65.25% of the OEICs/UTs respectively underperform the benchmark iShares MSCI World ETF, indicating that more of these more expensive, actively managed funds are underperforming, rather than outperforming, relative to the low-cost, passively managed iShares MSCI World ETF. For the output-oriented variation of the BCC model, 62.71% of the OEICs/UTs outperform the benchmark iShares MSCI World ETF, thus indicating that more of these more expensive, actively managed funds are outperforming, rather than underperforming, relative to the low-cost, passively managed iShares MSCI World ETF. Yet for the output-oriented variation of the SORMBCC model the split between the OEICs/UTs outperforming/underperforming the benchmark iShares MSCI World ETF is 50.00%/50.00%, and therefore there is an even split between the more expensive, actively managed funds outperforming/underperforming the low-cost, passively managed iShares MSCI World ETF.

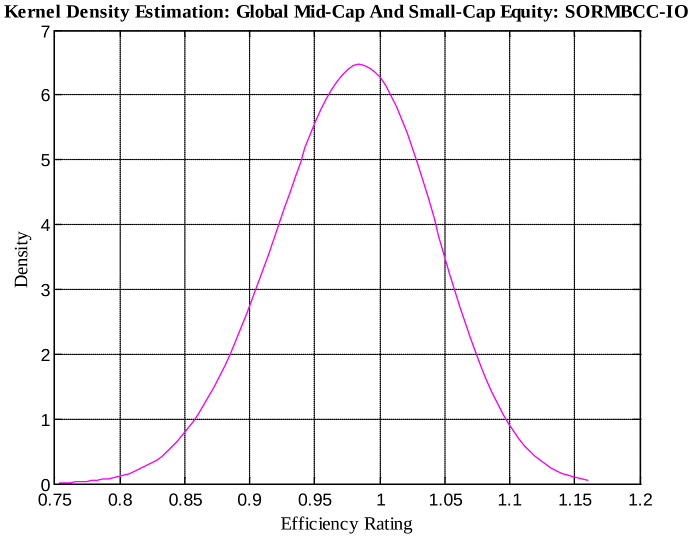
### *Global Mid-Cap And Small-Cap Equity (1st January 2008 – 31st December 2010)*

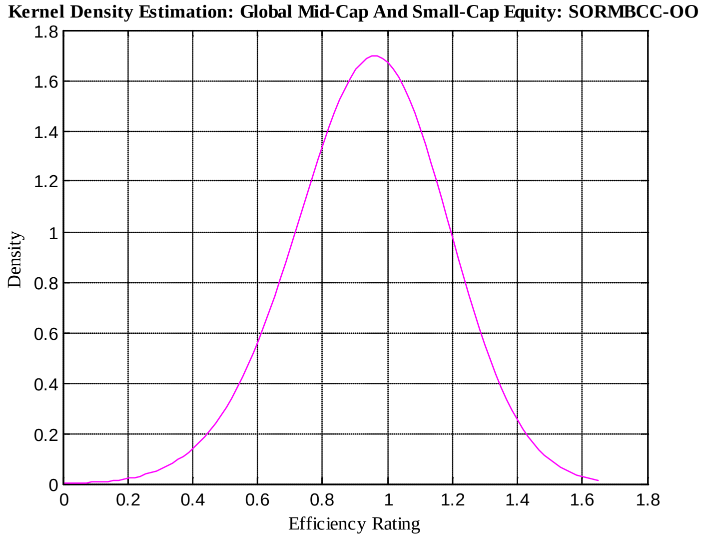
The detailed breakdown of the results from the individual OEICs/UTs in this category across the four DEA model variations can be found in Results Appendix 2 Table RA2.12, with a summary of the results provided in the table below, along with a kernel density estimation graph for each of the four DEA model variations.

| Summary Results | BCC-IO | BCC-OO | SORMBCC-IO | SORMBCC-OO |
|---|---|---|---|---|
| **Maximum Efficiency Rating** (Number Of OEICs/UTs) | **1.000** (8) | **1.000** (7) | **1.000** (8) | **1.000** (8) |
| **Minimum Efficiency Rating** (Number Of OEICs/UTs) | **0.914** (1) | **0.000** (1) | **0.914** (1) | **0.654** (1) |
| **Mean Efficiency Rating** | **0.979** | **0.872** | **0.979** | **0.944** |
| **Standard Deviation Of Efficiency Ratings** | **0.032** | **0.271** | **0.032** | **0.104** |
| **Number Of OEICs/UTs Outperforming The Benchmark ETF** | **0** (0.00%) | **0** (0.00%) | **0** (0.00%) | **0** (0.00%) |
| **Number Of OEICs/UTs Underperforming The Benchmark ETF** | **5** (38.46%) | **6** (46.15%) | **5** (38.46%) | **5** (38.46%) |


Kernel Density Estimation: Global Mid-Cap And Small-Cap Equity: BCC-IO
Density
Efficiency Rating
0.75 0.8 0.85 0.9 0.95 1 1.05 1.1 1.15 1.2
0 1 2 3 4 5 6 7


Kernel Density Estimation: Global Mid-Cap And Small-Cap Equity: BCC-OO
Density
Efficiency Rating
-2 -1.5 -1 -0.5 0 0.5 1 1.5 2 2.5 3
0 0.1 0.2 0.3 0.4 0.5 0.6 0.7


Kernel Density Estimation: Global Mid-Cap And Small-Cap Equity: SORMBCC-IO
Density
Efficiency Rating
0.75 0.8 0.85 0.9 0.95 1 1.05 1.1 1.15 1.2
0 1 2 3 4 5 6 7



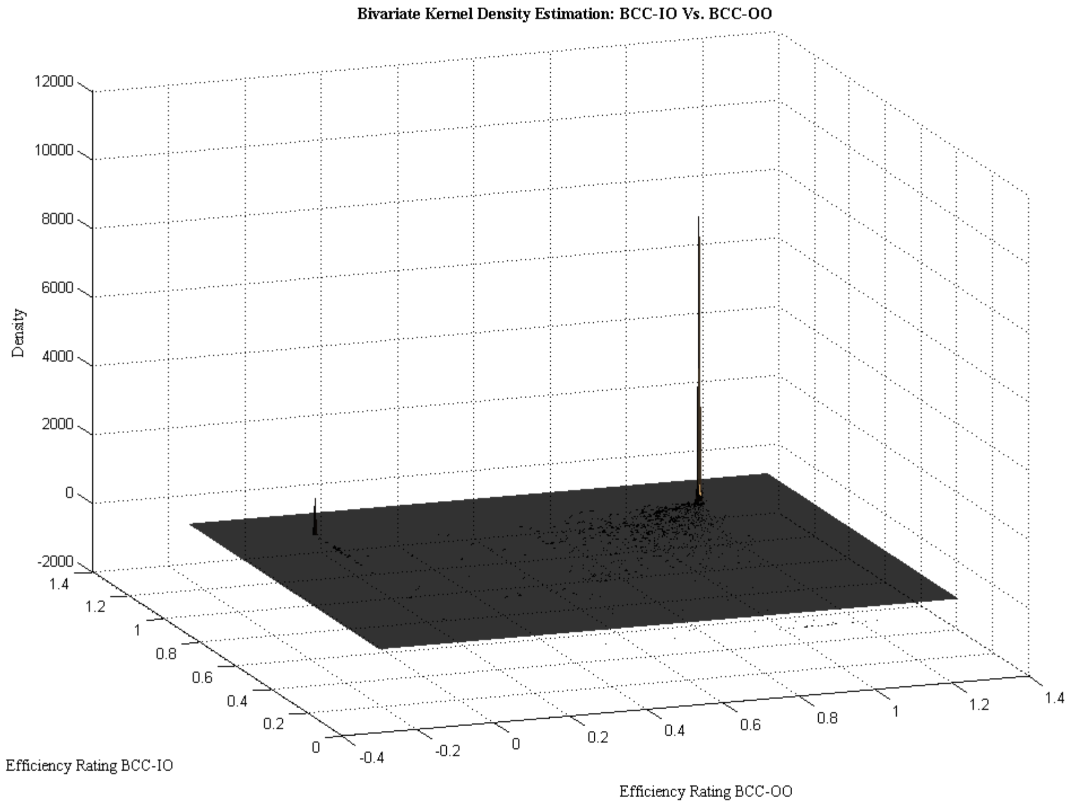

These results from the 13 global mid-cap and small-cap equity OEICs/UTs and the benchmark ETF, the iShares MSCI World, provide a number of results that are worth highlighting. An examination of the results for the OEICs/UTs in this category shows that one of the OEICs/UTs exhibits the odd pattern in its efficiency ratings results of being rated at 0.000 under the output-oriented BCC model, and the underlying data reveals that this OEIC/UT contains negative data in its inputs and/or outputs, suggesting that the SORM procedure should be employed. This leads to the SORMBCC DEA model efficiency ratings results, both input-oriented and output-oriented, which deal with the problem caused by the negative data, resulting in a more robust set of efficiency ratings results for the OEICs/UTs in this category.

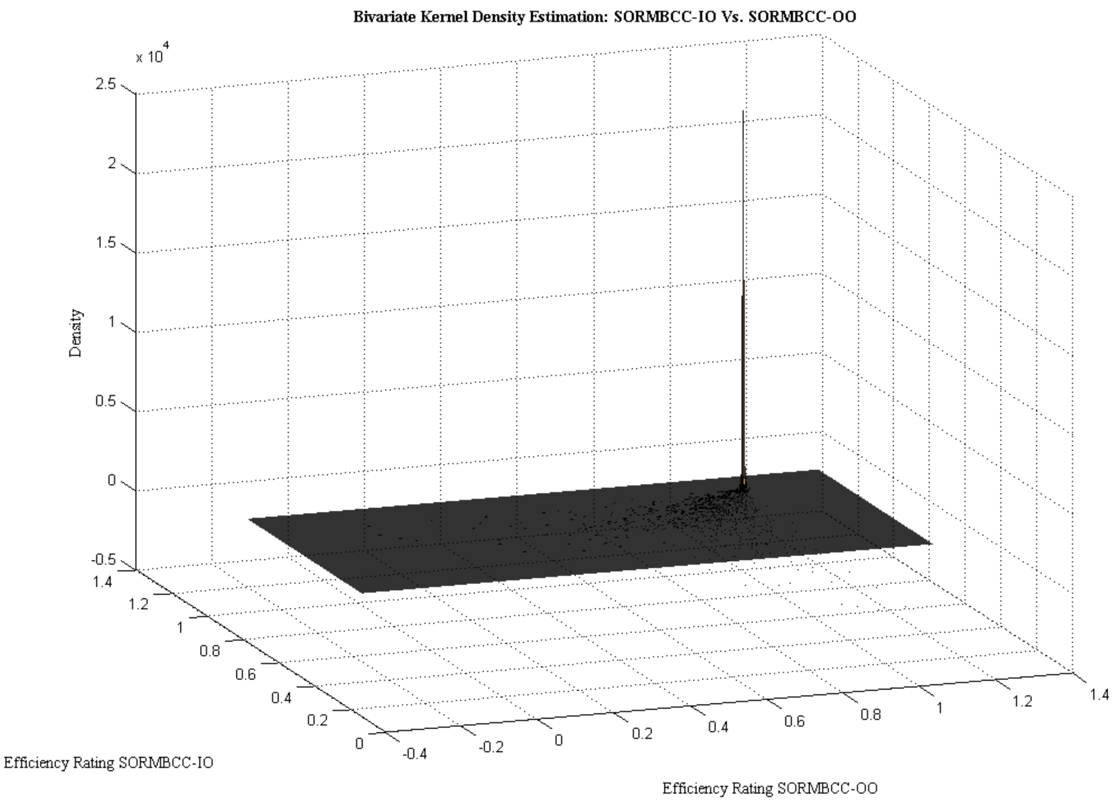
As a result of the BCC DEA model being underpinned by variable returns-to-scale, there are differences in the efficiency ratings obtained under the input-oriented variation compared to those obtained under the output-oriented variation. Furthermore, there are some differences between the efficiency ratings obtained from the BCC model compared to those obtained from the SORMBCC model for some of the OEICs/UTs, whilst for others the efficiency ratings they obtain do not change with the employment of the SORMBCC model.

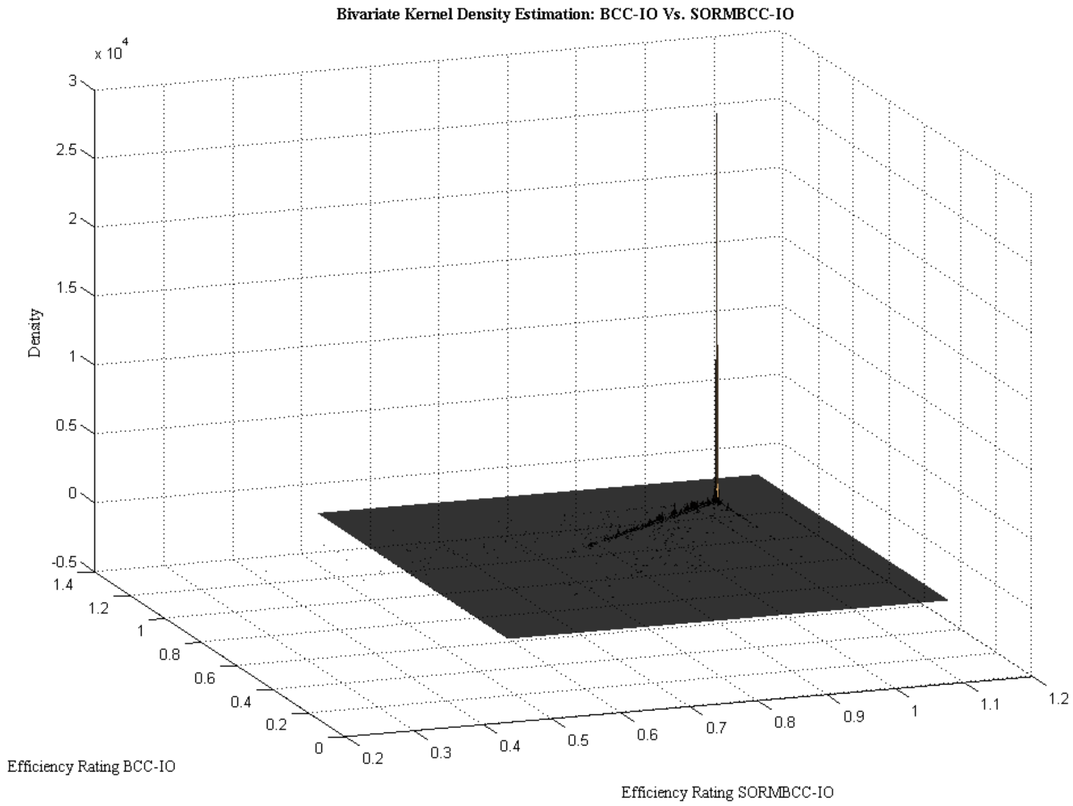
Finally, under the evaluation of the four DEA model variations used in this section, none of the OEICs/UTs in this category show a superior efficiency rating to that of the benchmark iShares MSCI World ETF which achieves the maximum efficiency rating of 1.000 under all four of these DEA model variations, thus indicating that none of the managers of the OEICs/UTs are showing an ability to select stocks which would allow them to outperform the market. It is important to note that under all four of the DEA model variations, 38.46% to 46.15% of the OEICs/UTs underperform relative to the benchmark iShares MSCI World ETF, but also that a high number of the funds in this category, 7 to 8 out of 13, achieve the maximum efficiency rating of 1.000 alongside the benchmark iShares MSCI World ETF. Thus, the analysis here could potential be improved by implementing super-efficiency in some form to disseminate the efficiency ratings results for these OEICs/UTs.

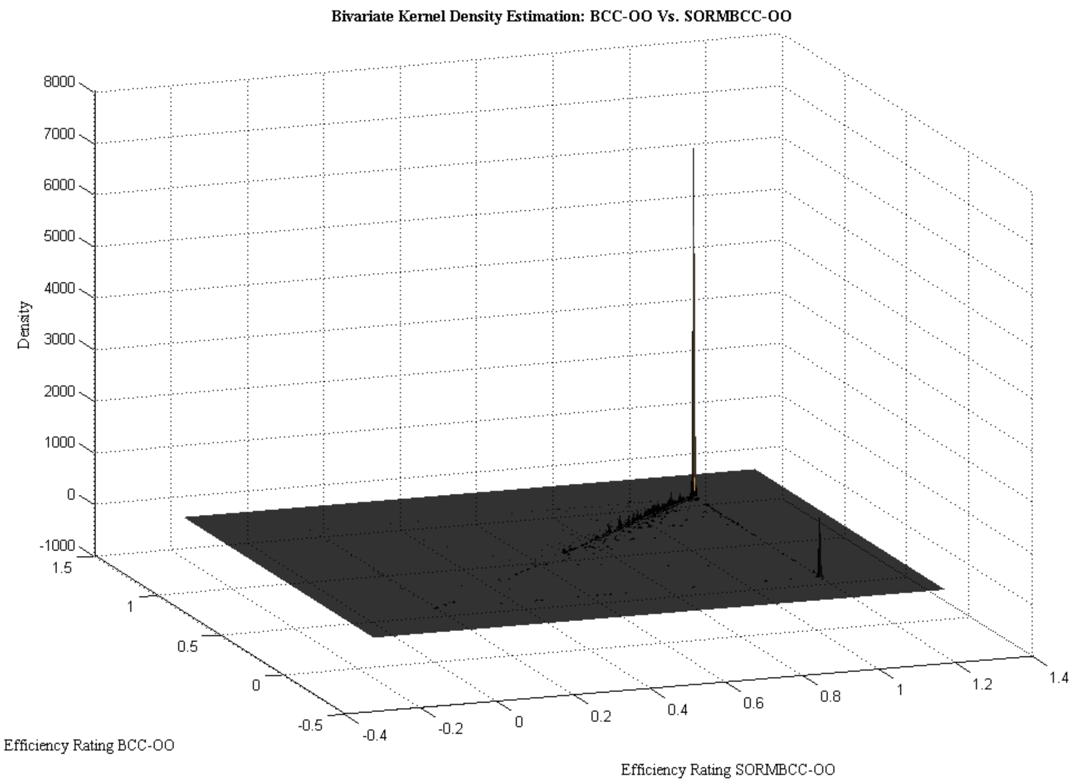
## *8.4: Summary Conclusions*

To provide a graphical summary of the results for the managerial performance of the OEICs/UTs under assessment from this section of results for the standalone BCC DEA model and the standalone SORMBCC DEA model, there are four bivariate kernel density estimation graphs below.


Bivariate Kernel Density Estimation: BCC-IO Vs. BCC-OO
Density
12000
10000
8000
6000
4000
2000
0
-2000
Efficiency Rating BCC-IO
1.4
1.2
1
0.8
0.6
0.4
0.2
0
Efficiency Rating BCC-OO
-0.4
-0.2
0
0.2
0.4
0.6
0.8
1
1.2
1.4


Bivariate Kernel Density Estimation: SORMBCC-IO Vs. SORMBCC-OO
x 10^4
Density
2.5
2
1.5
1
0.5
0
-0.5
Efficiency Rating SORMBCC-IO
1.4
1.2
1
0.8
0.6
0.4
0.2
0
Efficiency Rating SORMBCC-OO
-0.4
-0.2
0
0.2
0.4
0.6
0.8
1
1.2
1.4


Bivariate Kernel Density Estimation: BCC-IO Vs. SORMBCC-IO
x 10^4
Density
Efficiency Rating BCC-IO
Efficiency Rating SORMBCC-IO


Bivariate Kernel Density Estimation: BCC-OO Vs. SORMBCC-OO
Density
Efficiency Rating BCC-OO
Efficiency Rating SORMBCC-OO

To conclude this section of results it is possible to emphasise the following points. Firstly, the underlying variable returns-to-scale metric of the BCC and SORMBCC models means that the input-oriented and output-oriented variations of each of these two models produce differing efficiency ratings results for the OEICs/UTs under assessment, with the input-oriented variations producing higher efficiency ratings for the OEICs/UTs in general compared to the output-oriented variations. Also, the variable returns-to-scale metric provides a less challenging efficient frontier for the OEICs/UTs compared to the constant returns-to-scale metric, and thus the efficiency ratings for the OEICs/UTs under the assessment of the BCC and SORMBCC models are generally higher than those under the assessment of the corresponding CCR and SORMCCR models. Furthermore, the critical necessity of implementing the SORM procedure to deal with the negative data present in the dataset of the OEICs/UTs can be seen in the obvious bias in the efficiency ratings results of the standard output-oriented BCC DEA model, which the output-oriented SORMBCC DEA model is not afflicted by. Finally, across the mutual fund universe of 565 OEICs/UTs, the efficiency ratings of the OEICs/UTs show a mixed pattern of results under the evaluation of the BCC and SORMBCC models. In particular, across the 12 investment categories of OEIC/UT, there are some categories in which there are a number of OEICs/UTs which outperform the benchmark iShares ETF index tracker, implying that the managers of these OEICs/UTs are able to deliver consistent superior returns and outperform the market, whilst in other categories the benchmark iShares ETF index tracker is rated at the maximum of 1.000 and there are no OEIC/UT managers that are showing an ability to outperform the market. Critically however, any influence exerted by environmental factors and statistical noise/luck on the managerial efficiency ratings of the OEICs/UTs will still be present in the results from these standalone BCC and SORMBCC DEA models, and thus these managerial efficiency ratings may not reflect the 'true' managerial performance of the managers of the OEICs/UTs under assessment.

There are some linkages between the empirical results in this chapter and the existing literature. Again, the finding of the inappropriateness of standard DEA models in the presence of negative data is consistent with the small amount of previous research that has been done on mutual fund performance that specifically deals with the negative data issue such as Basso and Funari (2007), again reinforcing the need to deal with negative data when evaluating mutual fund performance using DEA. There are no large studies of UK mutual fund performance using DEA which highlights the gap in the research literature that this thesis fills, however there is a large study of UK mutual fund performance using the traditional measures by Cuthbertson et al (2008) which finds that between 5% and 10% of UK equity mutual funds exhibit some stock picking ability in contrast to the results in this chapter as across the investment categories there is either a much higher percentage of funds showing a stock picking ability, or there are none.

In the next chapter of results, the question of whether the constant returns-to-scale metric or the variable returns-to-scale metric is most appropriate for the accurate assessment of the managerial performance of the OEICs/UTs will be resolved. Also, the assumption of radial efficiency measurement will be relaxed to allow the consideration of the non-radial slacks-based measure (SBM) DEA model for the assessment of the managerial performance of the OEICs/UTs.

# Chapter 9: Results Section 3 – Standalone SBM DEA And SORMSBM DEA Model Results

This third section of results contains the results for the efficiency ratings of the OEICs/UTs in the mutual fund universe under evaluation using standalone SBM and SORMSBM DEA modelling methodologies. All of these results were produced using the MATLAB program, utilising the MATLAB DEA model coding created for this study, as seen in the MATLAB coding appendix. The four DEA models utilised in this section of results are the SBM DEA model, with either an input-orientation or an output-orientation, and the SORMSBM DEA model, with either an input-orientation or an output-orientation.

## *9.1: Banker (1996) Test – CRS Or VRS*

Before proceeding with producing the efficiency ratings results for the OEICs/UTs in the mutual fund universe using the SBM and SORMSBM DEA model variations, it is vital to determine whether to utilise the constant returns-to-scale or variable returns-to-scale versions. Rather than just selecting the returns-to-scale metric at random, this study makes use of a hypothesis test from Banker (1996) to determine the appropriate metric to utilise. The detailed methodology of this hypothesis test is contained in the methodology section of this study, and the corresponding results are presented in the tables below. The efficiency ratings used for the underlying data are from the SORMCCR output-oriented DEA model (Chapter 7) for the unconstrained variable and the SORMBCC output-oriented DEA model (Chapter 8) for the constrained variable, from the category dataset UK Large-Cap Blend Equity.

For $T = \frac{SSU}{SSC}$ the hypothesis is $H_0 : T = 1 \quad H_1 : T > 1$, with accepting the null hypothesis leading to the use of the constant returns-to-scale metric and rejecting the null hypothesis leading to the use of the variable returns-to-scale metric.

At a significance level for $H_0$ of 5% the critical F-Value is $F_{0.95,131,131} = 1.334383$.

***Test 1: Compare Test Value And Critical Value***

| SSU | SSC | T | $H_0$ |
|---|---|---|---|
| 7.330807 | 5.942119 | 1.233702 | ACCEPT |

***Test 2: Compute P-Value (Probability Of $H_0$)***

| SSU | SSC | T | $H_0$ | P-Value $H_0$ |
|---|---|---|---|---|
| 7.330807 | 5.942119 | 1.233702 | ACCEPT | 0.115360 |

From looking at these results, the conclusion to be drawn is that the null hypothesis should be accepted and therefore the appropriate returns-to-scale metric for utilisation is constant returns-to-scale. It is important to highlight at this point that this hypothesis test from Banker (1996) is a large-scale, asymptotic test, and consequently these results from the largest category dataset, the UK Large-Cap Blend Equity dataset, will hold for the other smaller category datasets in this study.

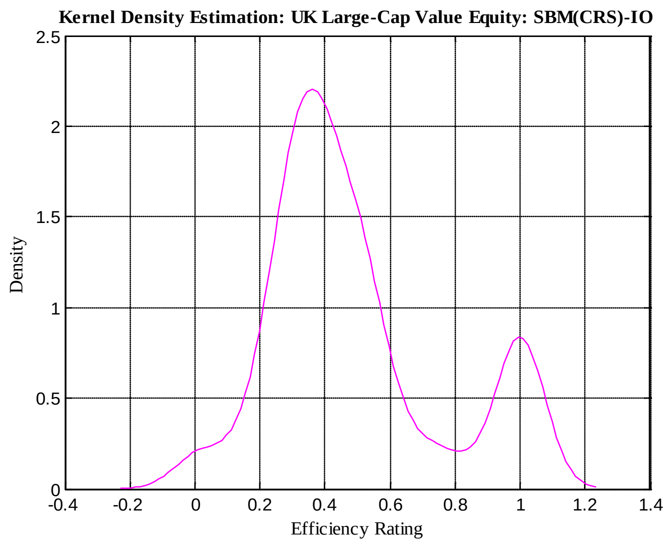
As a result of this, in the remainder of this chapter, the SBM and SORMSBM DEA model variations utilised will be the constant returns-to-scale versions.

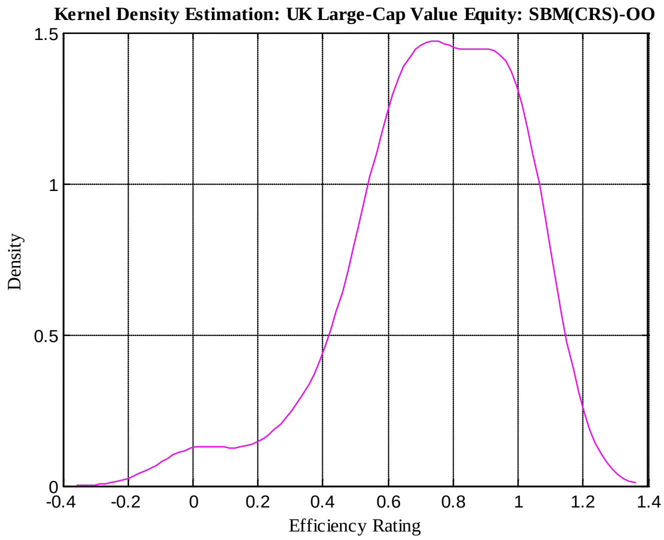
## 9.2: UK Domiciled OEICs And UTs With A UK Investment Focus

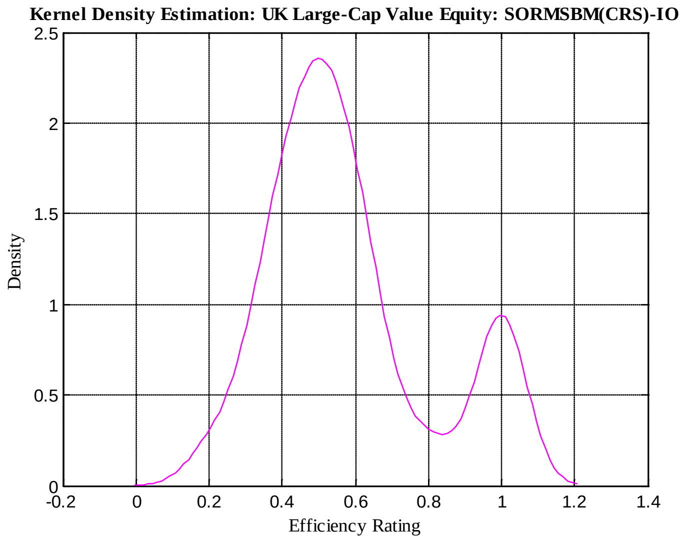
### UK Large-Cap Value Equity (1st January 2008 – 31st December 2010)

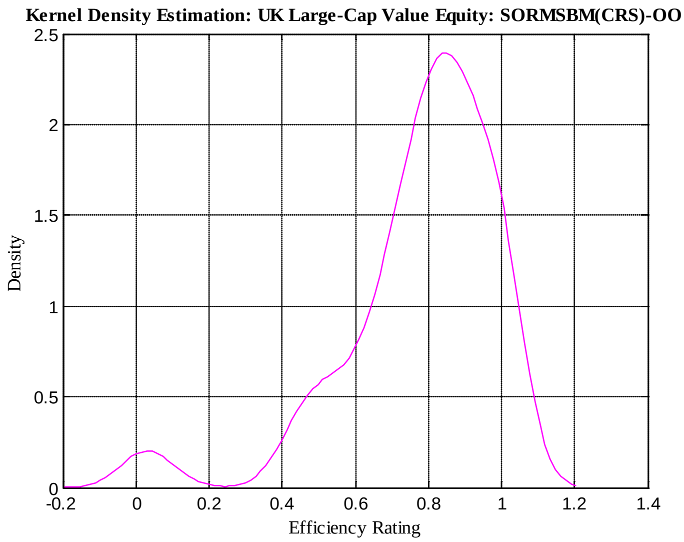
The detailed breakdown of the results from the individual OEICs/UTs in this category across the four DEA model variations can be found in Results Appendix 3 Table RA3.1, with a summary of the results provided in the table below, along with a kernel density estimation graph for each of the four DEA model variations.

| Summary Results | SBM-IO | SBM-OO | SORMSBM-IO | SORMSBM-OO |
|---|---|---|---|---|
| **Maximum Efficiency Rating** (Number Of OEICs/UTs) | **1.000** (13) | **1.000** (23) | **1.000** (13) | **1.000** (13) |
| **Minimum Efficiency Rating** (Number Of OEICs/UTs) | **0.002** (1) | **0.004** (1) | **0.202** (1) | **0.008** (1) |
| **Mean Efficiency Rating** | **0.488** | **0.745** | **0.580** | **0.779** |
| **Standard Deviation Of Efficiency Ratings** | **0.266** | **0.241** | **0.221** | **0.211** |
| **Number Of OEICs/UTs Outperforming The Benchmark ETF** | **40** (50.00%) | **26** (32.50%) | **38** (47.50%) | **16** (20.00%) |
| **Number Of OEICs/UTs Underperforming The Benchmark ETF** | **40** (50.00%) | **54** (67.50%) | **41** (51.25%) | **64** (80.00%) |




Kernel Density Estimation: UK Large-Cap Value Equity: SBM(CRS)-OO
Density
Efficiency Rating
1.5
1
0.5
0
-0.4
-0.2
0
0.2
0.4
0.6
0.8
1
1.2
1.4


Kernel Density Estimation: UK Large-Cap Value Equity: SORMSBM(CRS)-IO
Density
Efficiency Rating
2.5
2
1.5
1
0.5
0
-0.2
0
0.2
0.4
0.6
0.8
1
1.2
1.4


Kernel Density Estimation: UK Large-Cap Value Equity: SORMSBM(CRS)-OO
Density
Efficiency Rating
2.5
2
1.5
1
0.5
0
-0.2
0
0.2
0.4
0.6
0.8
1
1.2
1.4

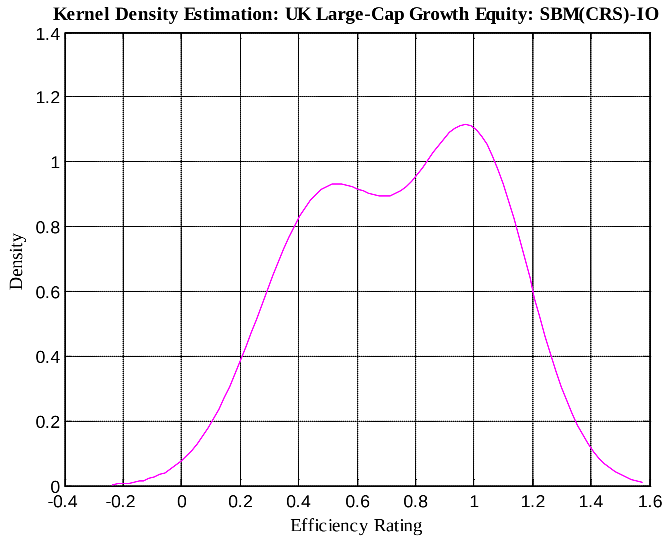
These results from the 80 UK large-cap value equity OEICs/UTs and the benchmark ETF, the iShares FTSE 100, provide a number of results that are worth highlighting. Firstly, from the previous chapters of results for standalone CCR, SORMCCR, BCC and SORMBCC DEA it was discovered that in this category of OEICs/UTs there are 12 OEICs/UTs which contain negative data in their inputs and/or outputs. Although the results for the efficiency ratings for the OEICs/UTs in this category under the SBM DEA model, both input-oriented and output-oriented, do not show an explicitly obvious bias caused by the negative data, it is likely that it will be influencing the efficiency ratings results, thus leading to a desire to implement SORM to deal with this negative data issue. The SORMSBM DEA model efficiency ratings results that are subsequently produced should therefore be more robust and valid.

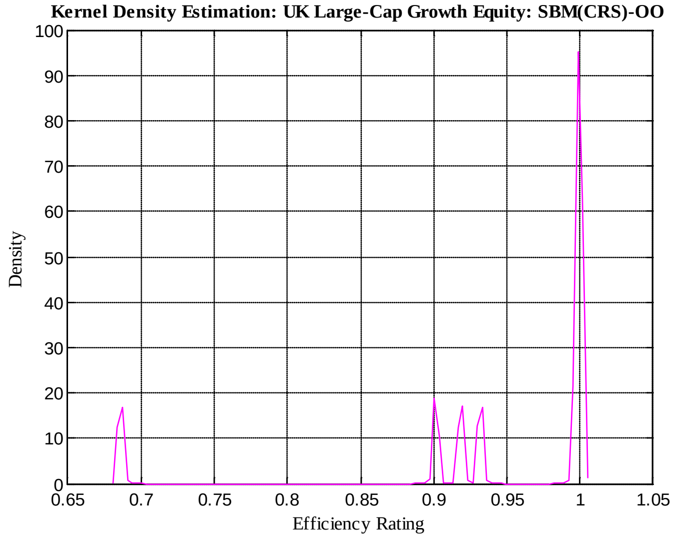
Under the evaluation of the input-oriented SBM model, 40 of the OEICs/UTs show a superior efficiency rating to that of the benchmark iShares FTSE 100 ETF which is only rated at 0.422, and under the evaluation of the output-oriented SBM model, 26 of the OEICs/UTs show a superior efficiency rating to that of the benchmark iShares FTSE 100 ETF which is rated at 0.912, suggesting that the managers of these OEICs/UTs could be showing some ability to select stocks which allows them to outperform the market. Furthermore, under the evaluation of the SORMSBM model, 38 of the OEICs/UTs under the input-oriented variation and 16 of the OEICs/UTs under the output-oriented variation, show a superior efficiency rating to that of the benchmark iShares FTSE 100 ETF which is rated at 0.538 and 0.956 under the respective variations, thus suggesting that the managers of these OEICs/UTs could be showing some ability to select stocks which allows them to outperform the market. Finally, under the input-oriented variations of the SBM and SORMSBM models, 50.00% and 51.25% of the OEICs/UTs respectively, underperform relative to the benchmark iShares FTSE 100 ETF, indicating that around half of these more expensive, actively managed funds are underperforming compared to the low-cost, passively managed iShares FTSE 100 ETF. Yet, under the output-oriented variations of the SBM and SORMSBM models a significant proportion of the OEICs/UTs, 67.50% and 80.00% respectively, underperform compared to the benchmark iShares FTSE 100 ETF, indicating that a significant number of these more expensive, actively managed funds are underperforming relative to the low-cost, passively managed iShares FTSE 100 ETF.

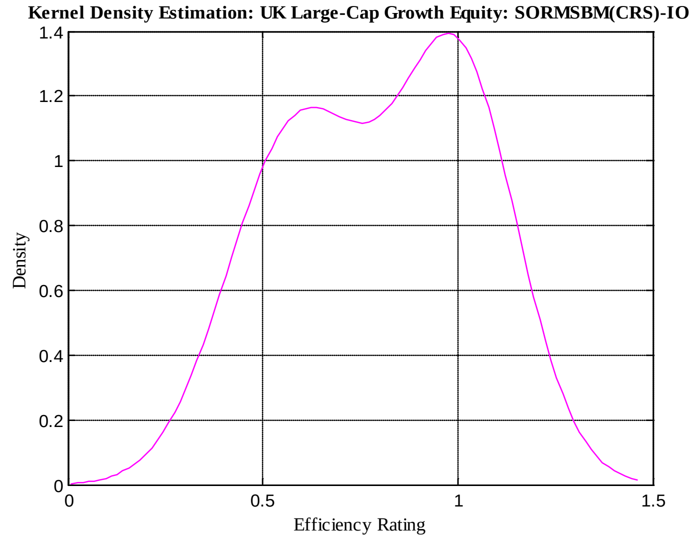
### *UK Large-Cap Growth Equity (1st January 2008 – 31st December 2010)*

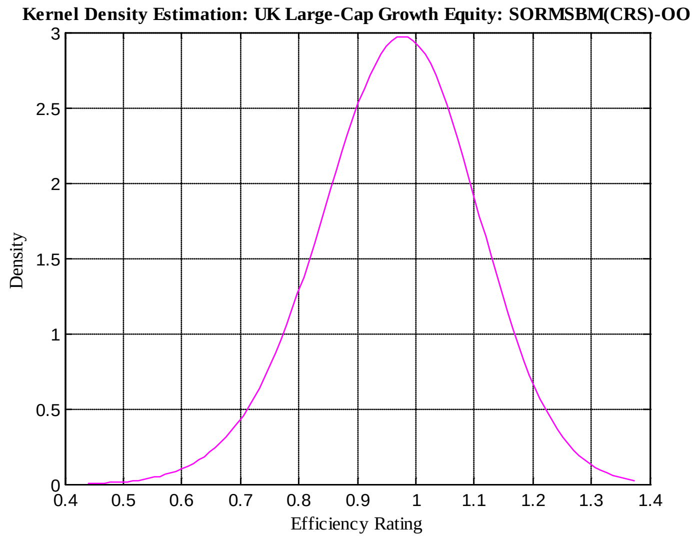
The detailed breakdown of the results from the individual OEICs/UTs in this category across the four DEA model variations can be found in Results Appendix 3 Table RA3.2, with a summary of the results provided in the table below, along with a kernel density estimation graph for each of the four DEA model variations.

| Summary Results | SBM-IO | SBM-OO | SORMSBM-IO | SORMSBM-OO |
|---|---|---|---|---|
| **Maximum Efficiency Rating** (Number Of OEICs/UTs) | **1.000** (4) | **1.000** (4) | **1.000** (4) | **1.000** (5) |
| **Minimum Efficiency Rating** (Number Of OEICs/UTs) | **0.336** (1) | **0.686** (1) | **0.469** (1) | **0.814** (1) |
| **Mean Efficiency Rating** | **0.746** | **0.943** | **0.797** | **0.968** |
| **Standard Deviation Of Efficiency Ratings** | **0.280** | **0.099** | **0.224** | **0.058** |
| **Number Of OEICs/UTs Outperforming The Benchmark ETF** | **0** (0.00%) | **0** (0.00%) | **0** (0.00%) | **0** (0.00%) |
| **Number Of OEICs/UTs Underperforming The Benchmark ETF** | **5** (55.56%) | **5** (55.56%) | **5** (55.56%) | **4** (44.44%) |


Kernel Density Estimation: UK Large-Cap Growth Equity: SBM(CRS)-IO
Density
Efficiency Rating
1.4
1.2
1
0.8
0.6
0.4
0.2
0
-0.4
-0.2
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6


Kernel Density Estimation: UK Large-Cap Growth Equity: SBM(CRS)-OO
Density
Efficiency Rating
100
90
80
70
60
50
40
30
20
10
0
0.65
0.7
0.75
0.8
0.85
0.9
0.95
1
1.05


Kernel Density Estimation: UK Large-Cap Growth Equity: SORMSBM(CRS)-IO
Density
Efficiency Rating
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0
0.5
1
1.5



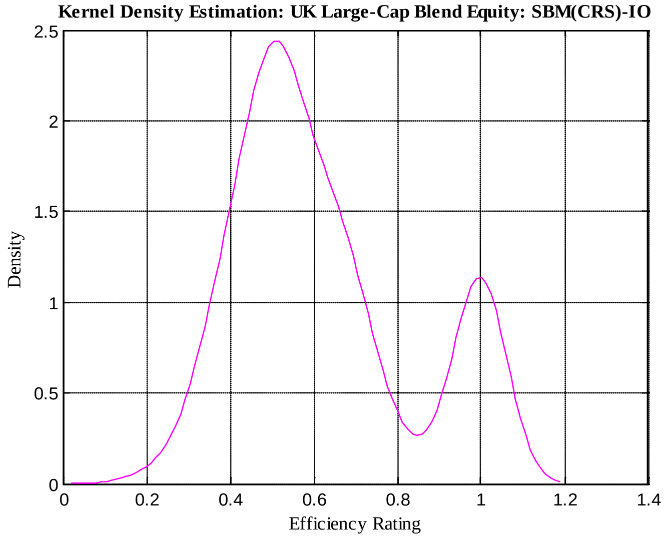

These results from the 9 UK large-cap growth equity OEICs/UTs and the benchmark ETF, the iShares FTSE 100, provide a number of results that are worth highlighting. Firstly, from the previous chapters of results for standalone CCR, SORMCCR, BCC and SORMBCC DEA it was found that in this category of OEICs/UTs there is no issue with negative data. Despite this, to maintain comparability across the entire universe of mutual funds, the SORM procedure is still implemented to obtain the efficiency ratings for the input-oriented and output-oriented SORMSBM models for analysis alongside the standard SBM model variations.

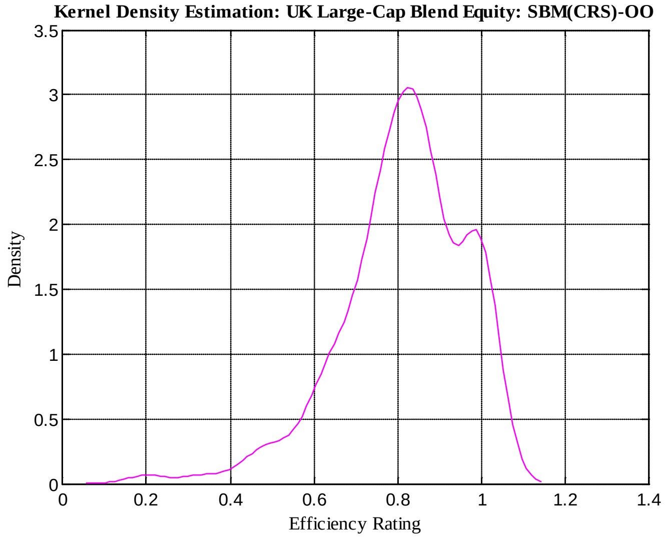
The results for this category of OEICs/UTs show that under all four DEA model variations utilised, none of the OEICs/UTs show a superior efficiency rating to that of the benchmark iShares FTSE 100 ETF which obtains the maximum efficiency rating of 1.000 under each of the four DEA models used, thus suggesting that none of the managers of these OEICs/UTs are showing an ability to select stocks which would allow them to outperform the market. Finally, under the evaluation of all four of the DEA models utilised, between 44.44% and 55.56% of the OEICs/UTs underperform compared against the benchmark iShares FTSE 100 ETF, suggesting that in the region of half of the more expensive, actively managed funds in this category are underperforming relative to the low-cost, passively managed iShares FTSE 100 ETF. However, it is again important to highlight the small sample size of this category, and that this subsequent analysis is based on that small sample size.

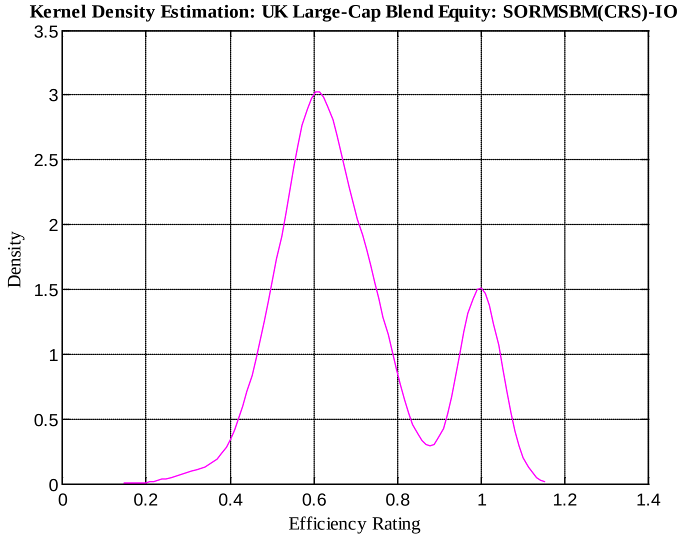
***UK Large-Cap Blend Equity (1st January 2008 – 31st December 2010)***

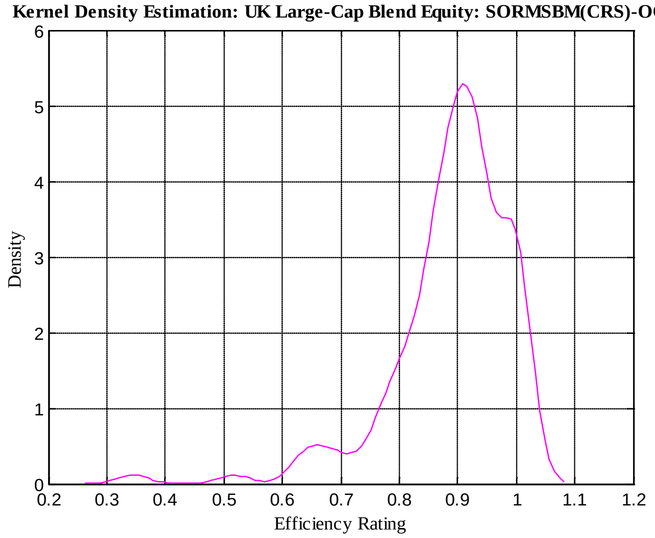
The detailed breakdown of the results from the individual OEICs/UTs in this category across the four DEA model variations can be found in Results Appendix 3 Table RA3.3, with a summary of the results provided in the table below, along with a kernel density estimation graph for each of the four DEA model variations.

| Summary Results | SBM-IO | SBM-OO | SORMSBM-IO | SORMSBM-OO |
|---|---|---|---|---|
| **Maximum Efficiency Rating** (Number Of OEICs/UTs) | **1.000** (23) | **1.000** (24) | **1.000** (25) | **1.000** (25) |
| **Minimum Efficiency Rating** (Number Of OEICs/UTs) | **0.211** (1) | **0.200** (1) | **0.301** (1) | **0.346** (1) |
| **Mean Efficiency Rating** | **0.620** | **0.814** | **0.695** | **0.890** |
| **Standard Deviation Of Efficiency Ratings** | **0.210** | **0.149** | **0.175** | **0.102** |
| **Number Of OEICs/UTs Outperforming The Benchmark ETF** | **119** (91.54%) | **110** (84.62%) | **117** (90.00%) | **111** (85.38%) |
| **Number Of OEICs/UTs Underperforming The Benchmark ETF** | **11** (8.46%) | **20** (15.38%) | **13** (10.00%) | **19** (14.62%) |


Kernel Density Estimation: UK Large-Cap Blend Equity: SBM(CRS)-IO
Density
Efficiency Rating


Kernel Density Estimation: UK Large-Cap Blend Equity: SBM(CRS)-OO
Density
Efficiency Rating


Kernel Density Estimation: UK Large-Cap Blend Equity: SORMSBM(CRS)-IO
Density
Efficiency Rating



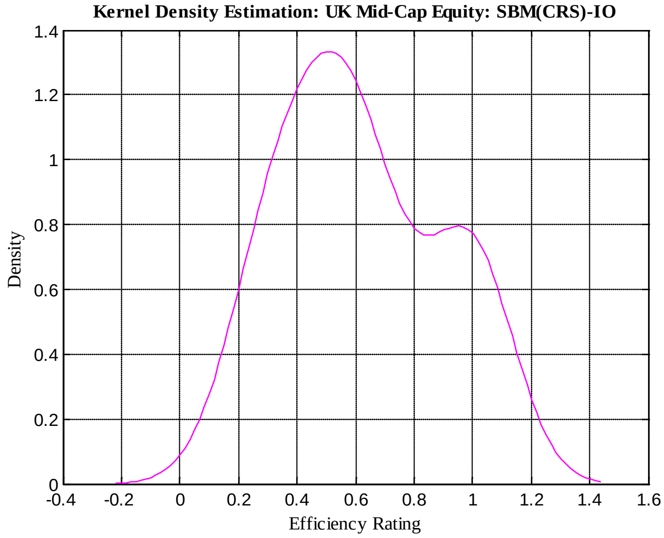

These results from the 130 UK large-cap blend equity OEICs/UTs and the benchmark ETF, the iShares FTSE 100, provide a number of results that are worth highlighting. Firstly, from the previous chapters of results for standalone CCR, SORMCCR, BCC and SORMBCC DEA it was found that in this category of OEICs/UTs there are 7 OEICs/UTs which contain negative data in their inputs and/or outputs. Again, although the efficiency ratings for the OEICs/UTs in this category under the SBM DEA model, both input-oriented and output-oriented, do not exhibit an obvious bias caused by the negative data, it is still likely that it will be influencing the efficiency ratings results that are obtained. Consequently, it is therefore desirable to implement SORM to deal with this negative data issue, leading to the subsequent production of the SORMSBM DEA model efficiency ratings results which should therefore be more robust and valid.

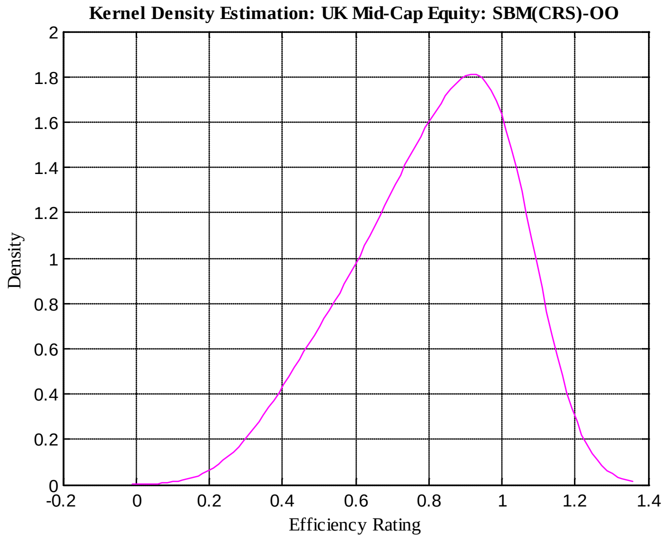
Under the evaluation of the SBM DEA model, 119 of the OEICs/UTs in the input-oriented case and 110 of the OEICs/UTs in the output-oriented case, show a superior efficiency rating to that of the benchmark iShares FTSE 100 ETF which is only rated at 0.385 and 0.671 respectively, thus suggesting that the managers of these OEICs/UTs could be showing an ability to select stocks which allows them to outperform the market. Furthermore, when the SORMSBM DEA model is utilised to assess the performance of the OEICs/UTs, 117 of the OEICs/UTs under the input-oriented variation and 111 of the OEICs/UTs under the output-oriented variation, show a superior efficiency rating to that of the benchmark iShares FTSE 100 ETF which is only rated at 0.508 and 0.804 respectively, again suggesting that the managers of these OEICs/UTs are showing some ability to select stocks which allows them to outperform the market. Finally therefore, across all four of the DEA models utilised, a significant proportion of the OEICs/UTs, ranging from 84.62% to 91.54%, outperform the benchmark iShares FTSE 100 ETF, indicating that the majority of these more expensive, actively managed funds are outperforming the low-cost, passively managed iShares FTSE 100 ETF.

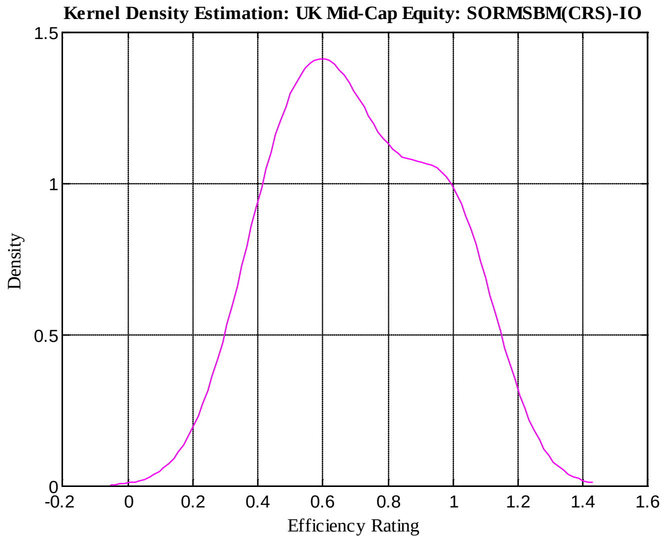
***UK Mid-Cap Equity (1st January 2008 – 31st December 2010)***

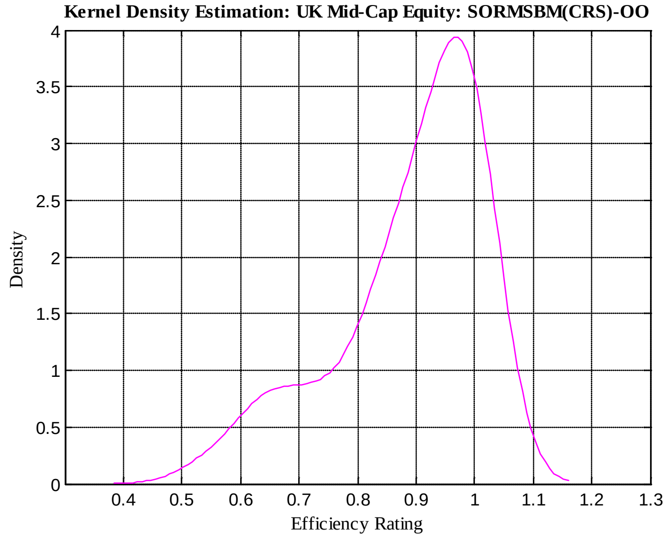
The detailed breakdown of the results from the individual OEICs/UTs in this category across the four DEA model variations can be found in Results Appendix 3 Table RA3.4, with a summary of the results provided in the table below, along with a kernel density estimation graph for each of the four DEA model variations.

| Summary Results | SBM-IO | SBM-OO | SORMSBM-IO | SORMSBM-OO |
|---|---|---|---|---|
| **Maximum Efficiency Rating** (Number Of OEICs/UTs) | **1.000** (10) | **1.000** (14) | **1.000** (12) | **1.000** (12) |
| **Minimum Efficiency Rating** (Number Of OEICs/UTs) | **0.219** (1) | **0.347** (1) | **0.375** (1) | **0.544** (1) |
| **Mean Efficiency Rating** | **0.620** | **0.808** | **0.710** | **0.889** |
| **Standard Deviation Of Efficiency Ratings** | **0.261** | **0.189** | **0.219** | **0.124** |
| **Number Of OEICs/UTs Outperforming The Benchmark ETF** | **0** (0.00%) | **0** (0.00%) | **0** (0.00%) | **0** (0.00%) |
| **Number Of OEICs/UTs Underperforming The Benchmark ETF** | **35** (77.78%) | **31** (68.89%) | **33** (73.33%) | **33** (73.33%) |


Kernel Density Estimation: UK Mid-Cap Equity: SBM(CRS)-IO
Density
Efficiency Rating
1.4
1.2
1
0.8
0.6
0.4
0.2
0
-0.4
-0.2
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6


Kernel Density Estimation: UK Mid-Cap Equity: SBM(CRS)-OO
Density
Efficiency Rating
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
-0.2
0
0.2
0.4
0.6
0.8
1
1.2
1.4


Kernel Density Estimation: UK Mid-Cap Equity: SORMSBM(CRS)-IO
Density
Efficiency Rating
1.5
1
0.5
0
-0.2
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6



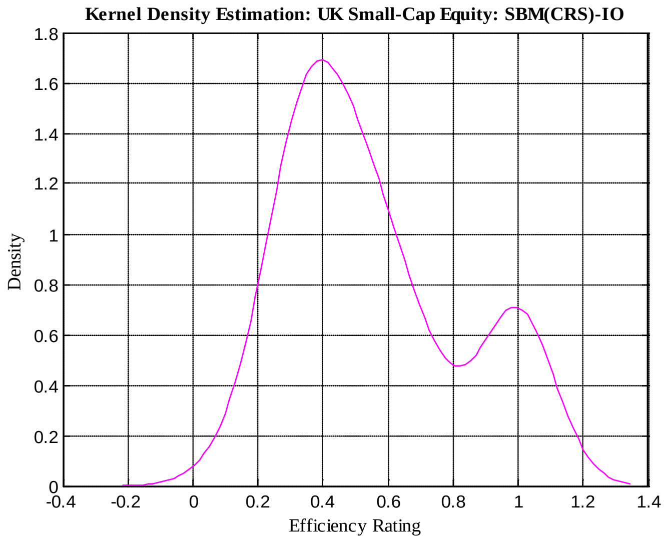

These results from the 45 UK mid-cap equity OEICs/UTs and the benchmark ETF, the iShares FTSE 250, provide a number of results that are worth highlighting. Firstly, the previous chapters of results for standalone CCR, SORMCCR, BCC and SORMBCC DEA indicate that in this category of OEICs/UTs, there are 6 OEICs/UTs which contain negative data in their inputs and/or outputs, and although the results for the efficiency ratings for the OEICs/UTs in this category under both the input-oriented and output-oriented SBM DEA model do not show an obvious bias caused by the negative data, it is likely that it will still be influencing the efficiency ratings results. As a consequence there is a desire to implement SORM to deal with this negative data issue, leading to the efficiency ratings results for the SORMSBM DEA model, both input-oriented and output-oriented, which should therefore be more robust and valid.

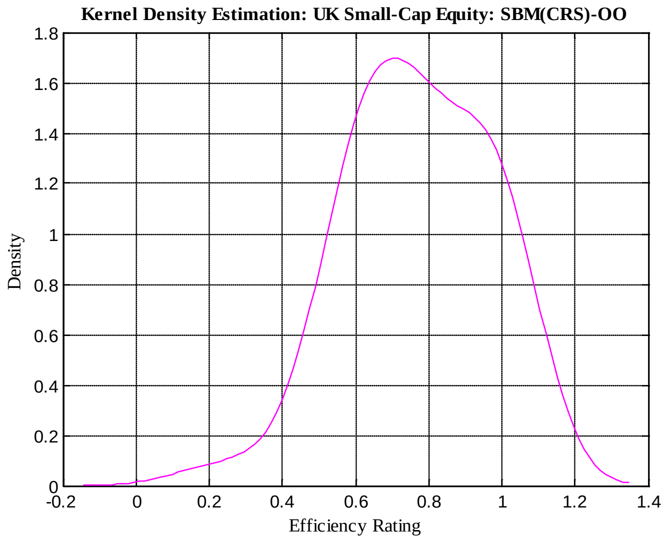
When under the evaluation of each of the four DEA models that are utilised here, none of the OEICs/UTs in this category show a superior efficiency rating to that of the benchmark iShares FTSE 250 ETF which achieves the maximum efficiency rating of 1.000 under each of the four DEA models, thus suggesting that none of the managers of these OEICs/UTs are showing an ability to select stocks which would allow them to outperform the market. Finally, across the four DEA models utilised here, a significant proportion of the OEICs/UTs, ranging from 68.89% to 77.78%, underperform compared against the benchmark iShares FTSE 250 ETF, indicating that a significant number of these more expensive, actively managed funds are underperforming relative to the low-cost, passively managed iShares FTSE 250 ETF.

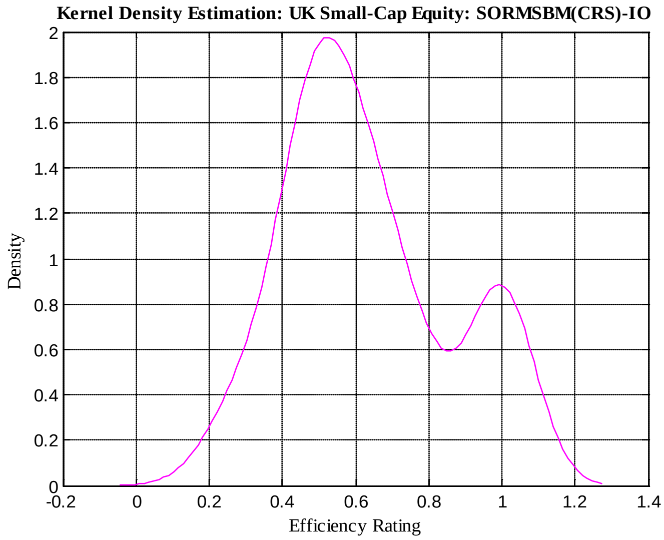
### *UK Small-Cap Equity (1st January 2008 – 31st December 2010)*

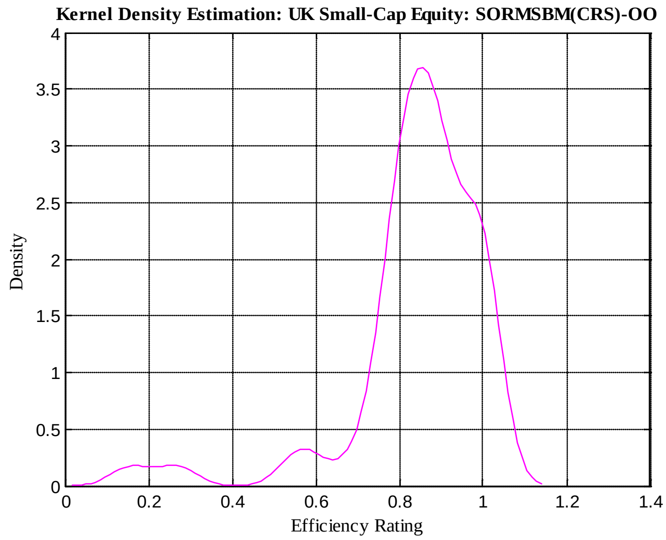
The detailed breakdown of the results from the individual OEICs/UTs in this category across the four DEA model variations can be found in Results Appendix 3 Table RA3.5, with a summary of the results provided in the table below, along with a kernel density estimation graph for each of the four DEA model variations.

| Summary Results | SBM-IO | SBM-OO | SORMSBM-IO | SORMSBM-OO |
|---|---|---|---|---|
| **Maximum Efficiency Rating** (Number Of OEICs/UTs) | **1.000** (9) | **1.000** (13) | **1.000** (9) | **1.000** (9) |
| **Minimum Efficiency Rating** (Number Of OEICs/UTs) | **0.125** (1) | **0.204** (1) | **0.230** (1) | **0.157** (1) |
| **Mean Efficiency Rating** | **0.553** | **0.770** | **0.631** | **0.845** |
| **Standard Deviation Of Efficiency Ratings** | **0.261** | **0.187** | **0.222** | **0.164** |
| **Number Of OEICs/UTs Outperforming The Benchmark ETF** | **0** (0.00%) | **0** (0.00%) | **0** (0.00%) | **0** (0.00%) |
| **Number Of OEICs/UTs Underperforming The Benchmark ETF** | **41** (82.00%) | **37** (74.00%) | **41** (82.00%) | **41** (82.00%) |


Kernel Density Estimation: UK Small-Cap Equity: SBM(CRS)-IO
Density
Efficiency Rating


Kernel Density Estimation: UK Small-Cap Equity: SBM(CRS)-OO
Density
Efficiency Rating


Kernel Density Estimation: UK Small-Cap Equity: SORMSBM(CRS)-IO
Density
Efficiency Rating




These results from the 50 UK small-cap equity OEICs/UTs and the benchmark ETF, the iShares FTSE 250, provide a number of results that are worth highlighting. Firstly, the results from the previous chapters of standalone CCR, SORMCCR, BCC and SORMBCC DEA efficiency ratings show that in this category of OEICs/UTs there are 5 OEICs/UTs which contain negative data in their inputs and/or outputs. However, although the results for the efficiency ratings for the OEICs/UTs in this category under the evaluation of the SBM DEA model, both input-oriented and output-oriented, do not show an immediately obvious bias caused by the negative data, it is highly probable that it will still be influencing the efficiency ratings results, meaning it is desirable to implement the SORM procedure to deal with this negative data issue. The resulting input-oriented and output-oriented SORMSBM DEA efficiency ratings results for the OEICs/UTs in this category should therefore be more robust and valid.

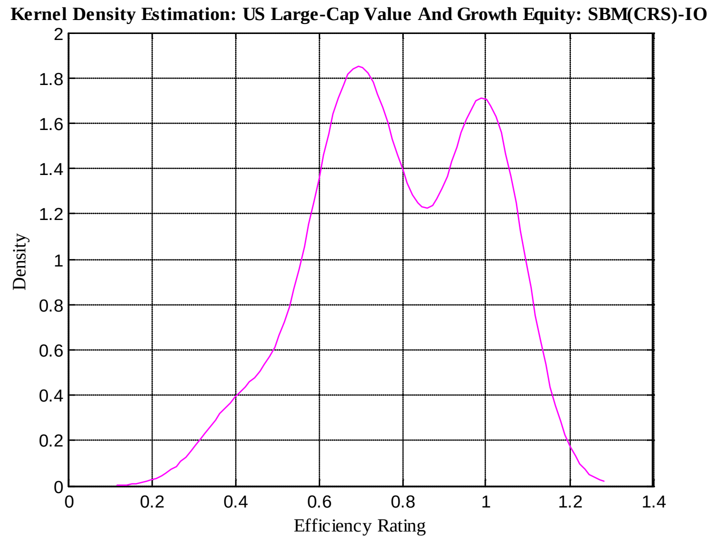
The results for this category of OEICs/UTs under the evaluation of each of the four DEA models utilised here indicate that none of the OEICs/UTs show a superior efficiency rating to that of the benchmark iShares FTSE 250 ETF which obtains the maximum efficiency rating of 1.000 under each of the four DEA models, thus indicating that none of the managers of these OEICs/UTs are showing an ability to select stocks which would allow them to outperform the market. Finally, under the examination of all four of the DEA models utilised here, a significant proportion of the OEICs/UTs, ranging from 74.00% to 82.00%, underperform compared to the benchmark iShares FTSE 250 ETF, indicating that a significant number of these more expensive, actively managed funds are underperforming relative to the low-cost, passively managed iShares FTSE 250 ETF.

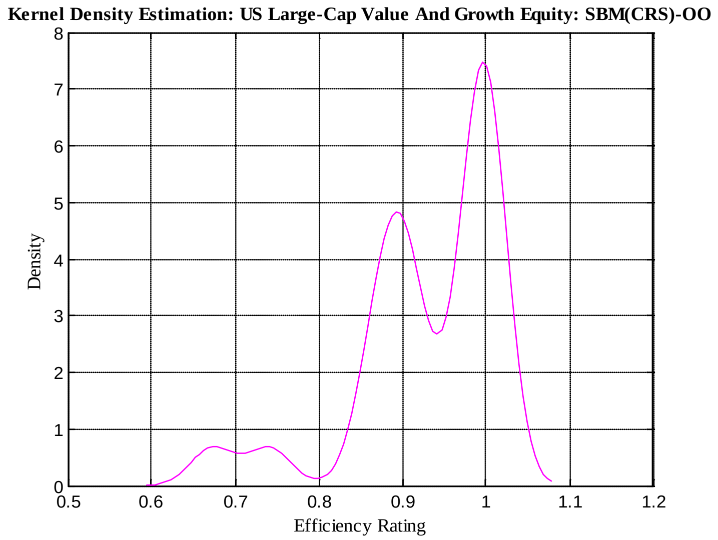
## 9.3: UK Domiciled OEICs And UTs With A US Investment Focus

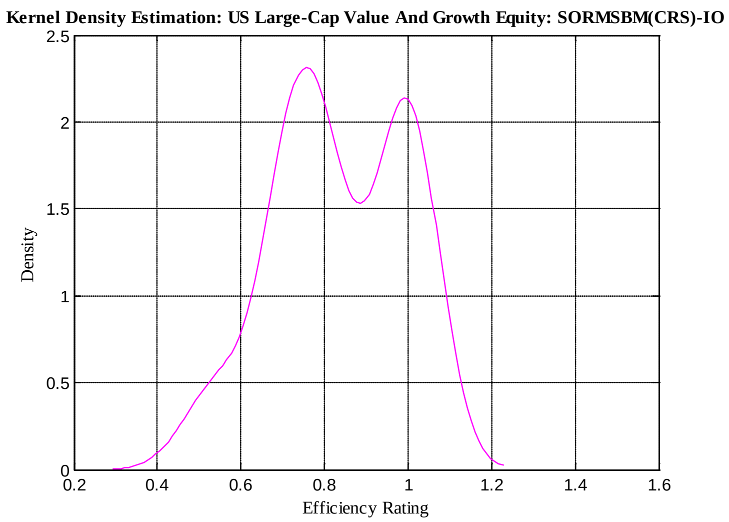
### US Large-Cap Value And Growth Equity (1st January 2008 – 31st December 2010)

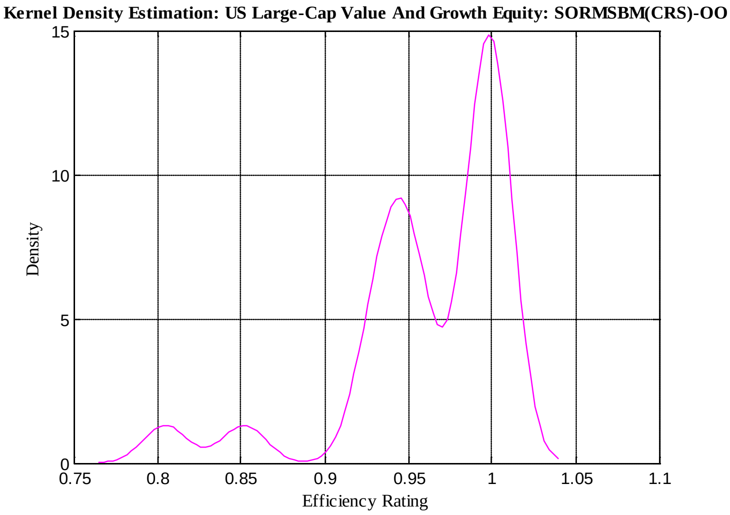
The detailed breakdown of the results from the individual OEICs/UTs in this category across the four DEA model variations can be found in Results Appendix 3 Table RA3.6, with a summary of the results provided in the table below, along with a kernel density estimation graph for each of the four DEA model variations.

| Summary Results | SBM-IO | SBM-OO | SORMSBM-IO | SORMSBM-OO |
|---|---|---|---|---|
| **Maximum Efficiency Rating** (Number Of OEICs/UTs) | **1.000** (8) | **1.000** (8) | **1.000** (8) | **1.000** (8) |
| **Minimum Efficiency Rating** (Number Of OEICs/UTs) | **0.400** (1) | **0.673** (1) | **0.520** (1) | **0.805** (1) |
| **Mean Efficiency Rating** | **0.793** | **0.930** | **0.834** | **0.962** |
| **Standard Deviation Of Efficiency Ratings** | **0.192** | **0.088** | **0.154** | **0.051** |
| **Number Of OEICs/UTs Outperforming The Benchmark ETF** | **0** (0.00%) | **0** (0.00%) | **0** (0.00%) | **0** (0.00%) |
| **Number Of OEICs/UTs Underperforming The Benchmark ETF** | **14** (63.64%) | **14** (63.64%) | **14** (63.64%) | **14** (63.64%) |


Kernel Density Estimation: US Large-Cap Value And Growth Equity: SBM(CRS)-IO
Density
Efficiency Rating
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
2


Kernel Density Estimation: US Large-Cap Value And Growth Equity: SBM(CRS)-OO
Density
Efficiency Rating
0.5
0.6
0.7
0.8
0.9
1
1.1
1.2


Kernel Density Estimation: US Large-Cap Value And Growth Equity: SORMSBM(CRS)-IO
Density
Efficiency Rating
0.5
1
1.5
2
2.5



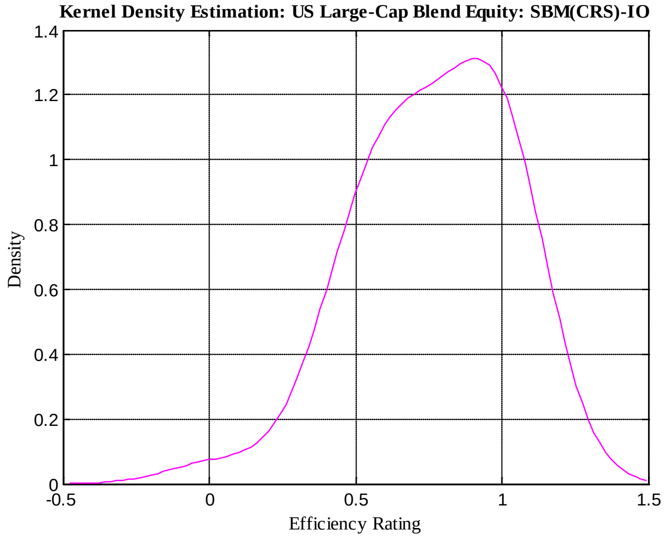

These results from the 22 US large-cap value and growth equity OEICs/UTs and the benchmark ETF, the iShares S&P 500, provide a number of results that are worth highlighting. Firstly, from the previous chapters of efficiency ratings results for standalone CCR, SORMCCR, BCC and SORMBCC DEA it was found that in this category of OEICs/UTs there is one OEIC/UT which contains negative data in its inputs and/or outputs. From examining the results for the efficiency ratings for the OEICs/UTs in this category under the SBM DEA model, both input-oriented and output-oriented, it is clear that although they do not show an obvious bias caused by the negative data, it is likely that the efficiency ratings results will still be being influenced, consequently leading to a desire to implement the SORM procedure to deal with this negative data problem. The result is the SORMSBM DEA model efficiency ratings results which should be more robust.

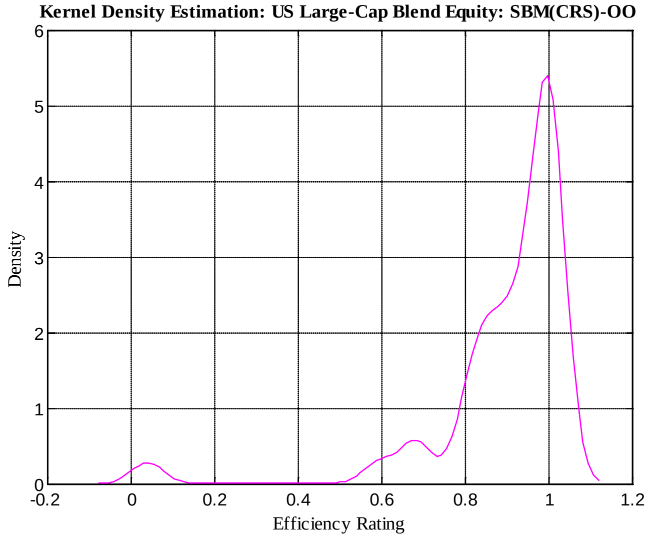
Under the examination of each of the four DEA models utilised here, none of the OEICs/UTs in this category show a superior efficiency rating to that of the benchmark iShares S&P 500 ETF which achieves the maximum efficiency rating of 1.000 under all four of the DEA models used, implying that none of the managers of these OEICs/UTs are showing an ability to select stocks which would allow them to outperform the market. Finally, 63.64% of the OEICs/UTs in this category underperform the benchmark iShares S&P 500 ETF under the evaluation of each of the four DEA models used here, thus suggesting that a large number of these more expensive, actively managed funds are underperforming relative to the low-cost, passively managed iShares S&P 500 ETF.

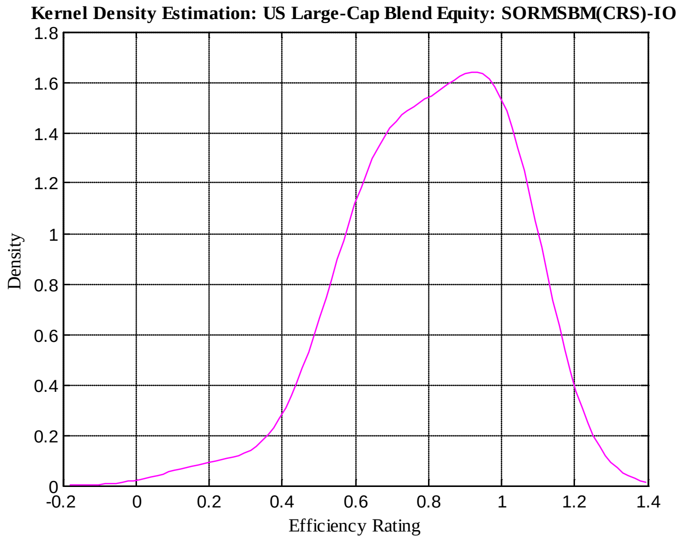
***US Large-Cap Blend Equity (1st January 2008 – 31st December 2010)***

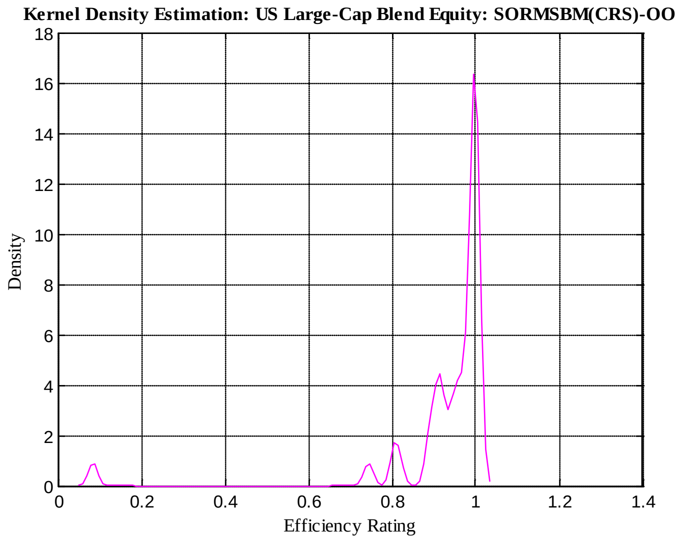
The detailed breakdown of the results from the individual OEICs/UTs in this category across the four DEA model variations can be found in Results Appendix 3 Table RA3.7, with a summary of the results provided in the table below, along with a kernel density estimation graph for each of the four DEA model variations.

| Summary Results | SBM-IO | SBM-OO | SORMSBM-IO | SORMSBM-OO |
|---|---|---|---|---|
| **Maximum Efficiency Rating** (Number Of OEICs/UTs) | **1.000** (14) | **1.000** (14) | **1.000** (14) | **1.000** (15) |
| **Minimum Efficiency Rating** (Number Of OEICs/UTs) | **0.019** (1) | **0.036** (1) | **0.215** (1) | **0.084** (1) |
| **Mean Efficiency Rating** | **0.766** | **0.895** | **0.813** | **0.932** |
| **Standard Deviation Of Efficiency Ratings** | **0.240** | **0.179** | **0.192** | **0.156** |
| **Number Of OEICs/UTs Outperforming The Benchmark ETF** | **30** (83.33%) | **29** (80.56%) | **30** (83.33%) | **29** (80.56%) |
| **Number Of OEICs/UTs Underperforming The Benchmark ETF** | **6** (16.67%) | **7** (19.44%) | **6** (16.67%) | **7** (19.44%) |


Kernel Density Estimation: US Large-Cap Blend Equity: SBM(CRS)-IO
Density
Efficiency Rating
1.4
1.2
1
0.8
0.6
0.4
0.2
0
-0.5
0
0.5
1
1.5


Kernel Density Estimation: US Large-Cap Blend Equity: SBM(CRS)-OO
Density
Efficiency Rating
6
5
4
3
2
1
0
-0.2
0
0.2
0.4
0.6
0.8
1
1.2


Kernel Density Estimation: US Large-Cap Blend Equity: SORMSBM(CRS)-IO
Density
Efficiency Rating
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
-0.2
0
0.2
0.4
0.6
0.8
1
1.2
1.4



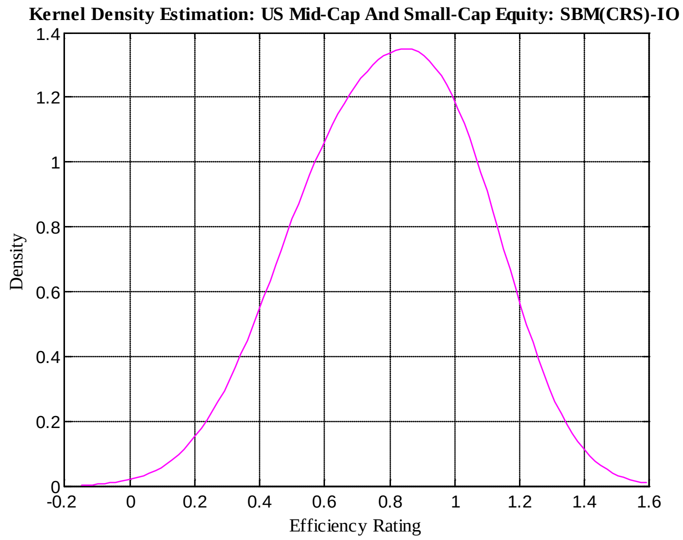

These results from the 36 US large-cap blend equity OEICs/UTs and the benchmark ETF, the iShares S&P 500, provide a number of results that are worth highlighting. From the previous chapters of efficiency ratings results for standalone CCR, SORMCCR, BCC and SORMBCC DEA it was discovered that in this category of OEICs/UTs there is one OEIC/UT which contains negative data in its inputs and/or outputs. Again, although when under the evaluation of the SBM DEA model, both input-oriented and output-oriented, the efficiency ratings results for the OEICs/UTs in this category do not show an obvious bias caused by the issue with negative data, it is still probable that it will be influencing the efficiency ratings results to some degree. This leads to a desire to implement the SORM procedure to deal with this negative data issue, resulting in the input-oriented and output-oriented SORMSBM model efficiency ratings results that should be more robust and valid.

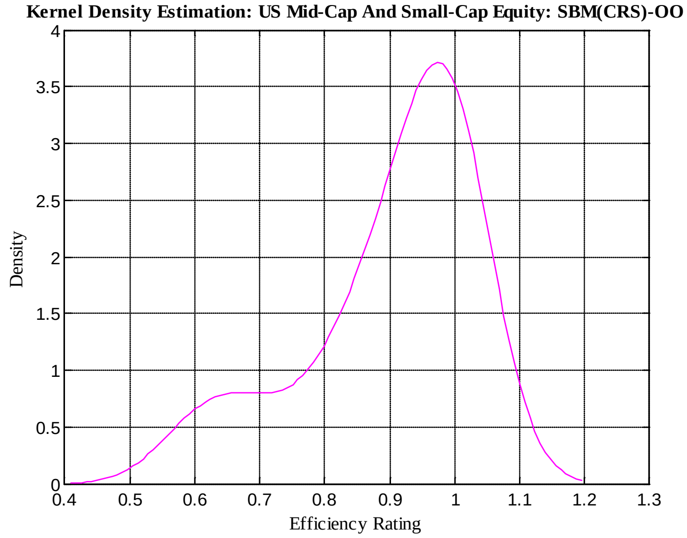
Under the evaluation of the input-oriented variations of the SBM and SORMSBM models, 30 of the OEICs/UTs show a superior efficiency rating to that of the benchmark iShares S&P 500 ETF which is only rated at 0.551 and 0.641 respectively, thus implying that the managers of these OEICs/UTs may be showing some ability to select stocks which allows them to outperform the market. Furthermore, under the evaluation of the output-oriented variations of the SBM and SORMSBM models, 29 of the OEICs/UTs show a superior efficiency rating to that of the benchmark iShares S&P 500 ETF which is only rated at 0.840 and 0.915 respectively, again implying that the managers of these OEICs/UTs may be showing some ability to select stocks which allows them to outperform the market. Finally therefore, under the four DEA models utilised here, a significant proportion of the OEICs/UTs in this category, ranging from 80.56% to 83.33%, outperform compared against the benchmark iShares S&P 500 ETF, thus indicating that a significant number of these more expensive, actively managed funds are outperforming relative to the low-cost, passively managed iShares S&P 500 ETF.

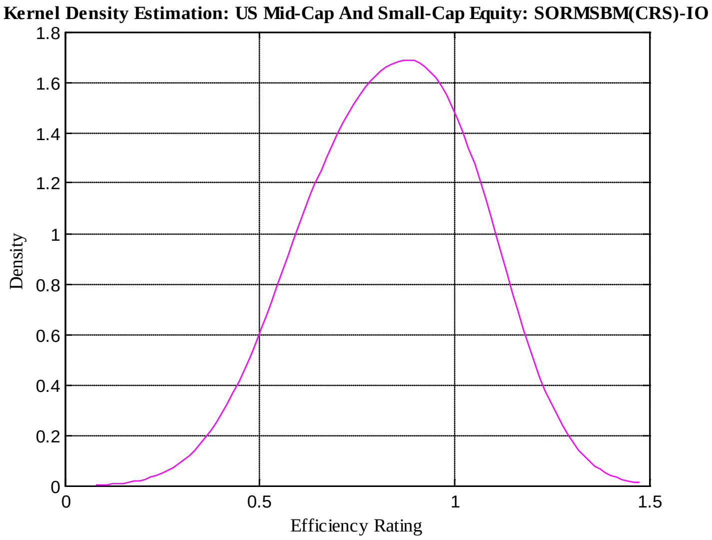
### *US Mid-Cap And Small-Cap Equity (1st January 2008 – 31st December 2010)*

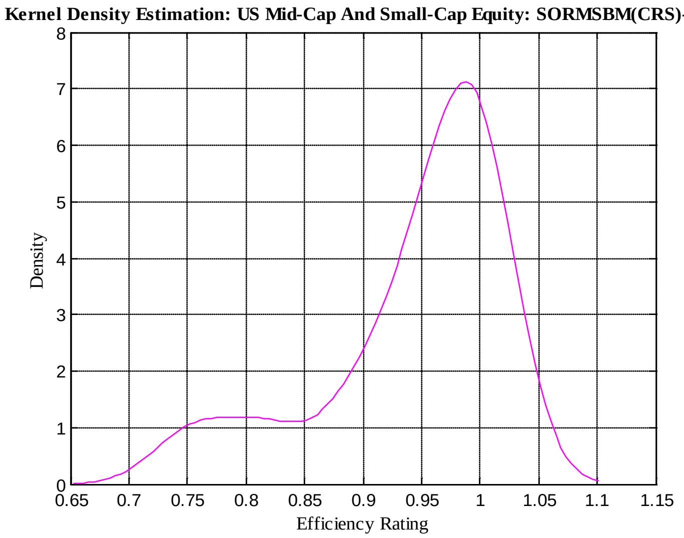
The detailed breakdown of the results from the individual OEICs/UTs in this category across the four DEA model variations can be found in Results Appendix 3 Table RA3.8, with a summary of the results provided in the table below, along with a kernel density estimation graph for each of the four DEA model variations.

| Summary Results | SBM-IO | SBM-OO | SORMSBM-IO | SORMSBM-OO |
|---|---|---|---|---|
| **Maximum Efficiency Rating** (Number Of OEICs/UTs) | **1.000** (4) | **1.000** (4) | **1.000** (4) | **1.000** (4) |
| **Minimum Efficiency Rating** (Number Of OEICs/UTs) | **0.441** (1) | **0.604** (1) | **0.553** (1) | **0.753** (1) |
| **Mean Efficiency Rating** | **0.799** | **0.900** | **0.840** | **0.942** |
| **Standard Deviation Of Efficiency Ratings** | **0.201** | **0.130** | **0.161** | **0.079** |
| **Number Of OEICs/UTs Outperforming The Benchmark ETF** | **0** (0.00%) | **0** (0.00%) | **0** (0.00%) | **0** (0.00%) |
| **Number Of OEICs/UTs Underperforming The Benchmark ETF** | **8** (66.67%) | **8** (66.67%) | **8** (66.67%) | **8** (66.67%) |


Kernel Density Estimation: US Mid-Cap And Small-Cap Equity: SBM(CRS)-IO
Density
Efficiency Rating
0
0.2
0.4
0.6
0.8
1
1.2
1.4
-0.2
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6


Kernel Density Estimation: US Mid-Cap And Small-Cap Equity: SBM(CRS)-OO
Density
Efficiency Rating
0
0.5
1
1.5
2
2.5
3
3.5
4
0.4
0.5
0.6
0.7
0.8
0.9
1
1.1
1.2
1.3


Kernel Density Estimation: US Mid-Cap And Small-Cap Equity: SORMSBM(CRS)-IO
Density
Efficiency Rating
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
0
0.5
1
1.5




These results from the 12 US mid-cap and small-cap equity OEICs/UTs and the benchmark ETF, the iShares S&P 500, provide a number of results that are worth highlighting. The previous chapters of efficiency ratings results for standalone CCR, SORMCCR, BCC and SORMBCC DEA reveal that in this category of OEICs/UTs there is no issue with negative data. However, despite this, to maintain comparability across the entire universe of mutual funds, the SORM procedure is still implemented to obtain the efficiency ratings for the input-oriented and output-oriented SORMSBM models for subsequent analysis alongside the standard SBM model variations.

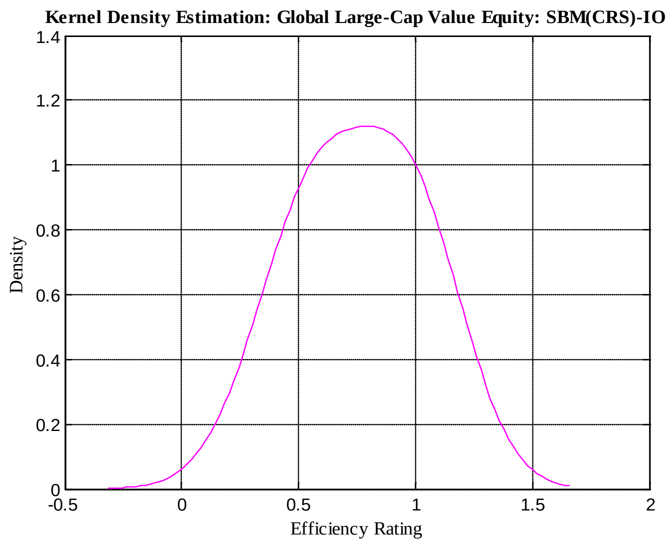
Furthermore, under the evaluation of each of the four DEA models used here, none of the OEICs/UTs show a superior efficiency rating to that of the benchmark iShares S&P 500 ETF which obtains the maximum efficiency rating of 1.000 under each of the four DEA models used, thus implying that none of the managers of these OEICs/UTs are showing an ability to select stocks which would allow them to outperform the market. Finally, under the evaluation of each of the four DEA model variations utilised here, 66.67% of the OEICs/UTs underperform compared to the benchmark iShares S&P 500 ETF, thus suggesting that a significant number of these more expensive, actively managed funds are underperforming relative to the low-cost, passively managed iShares S&P 500 ETF.

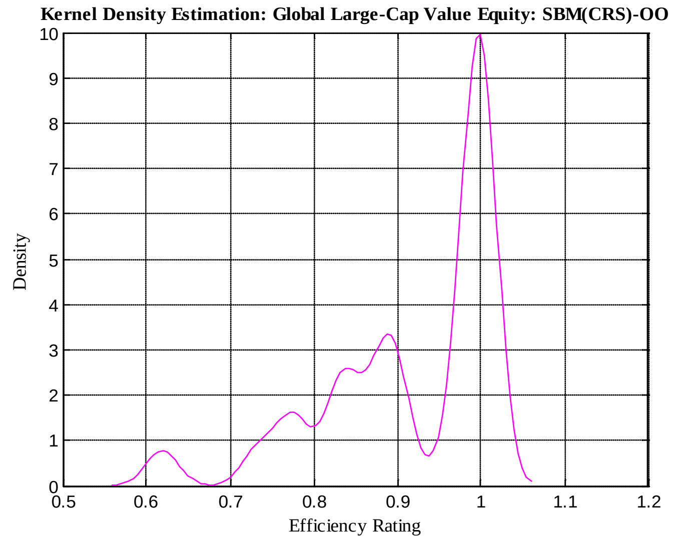
## *9.4: UK Domiciled OEICs And UTs With A Global Investment Focus*

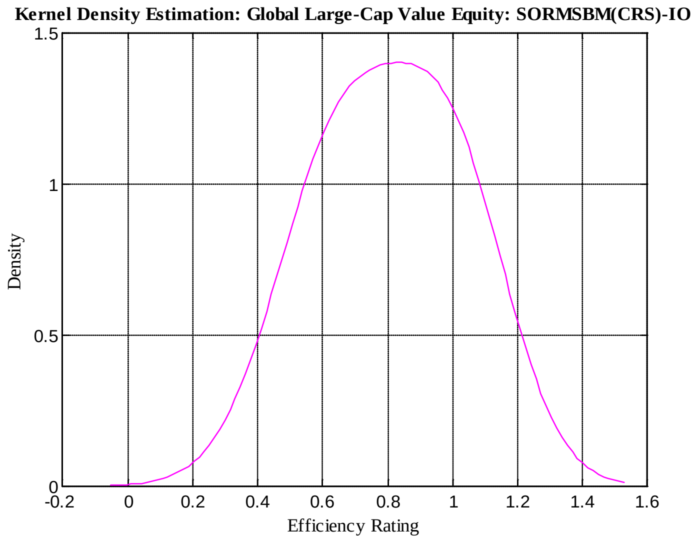
### *Global Large-Cap Value Equity (1st January 2008 – 31st December 2010)*

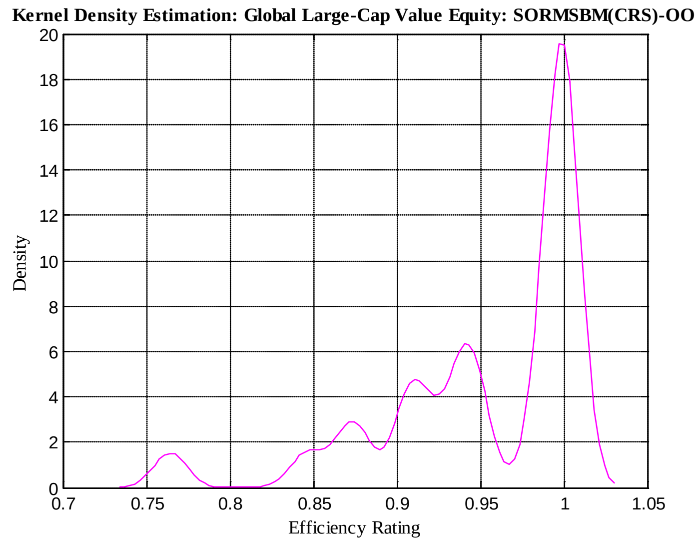
The detailed breakdown of the results from the individual OEICs/UTs in this category across the four DEA model variations can be found in Results Appendix 3 Table RA3.9, with a summary of the results provided in the table below, along with a kernel density estimation graph for each of the four DEA model variations.

| Summary Results | SBM-IO | SBM-OO | SORMSBM-IO | SORMSBM-OO |
|---|---|---|---|---|
| **Maximum Efficiency Rating** (Number Of OEICs/UTs) | **1.000** (11) | **1.000** (11) | **1.000** (11) | **1.000** (11) |
| **Minimum Efficiency Rating** (Number Of OEICs/UTs) | **0.344** (1) | **0.619** (1) | **0.475** (1) | **0.764** (1) |
| **Mean Efficiency Rating** | **0.760** | **0.915** | **0.808** | **0.952** |
| **Standard Deviation Of Efficiency Ratings** | **0.232** | **0.105** | **0.186** | **0.062** |
| **Number Of OEICs/UTs Outperforming The Benchmark ETF** | **15** (60.00%) | **24** (96.00%) | **15** (60.00%) | **24** (96.00%) |
| **Number Of OEICs/UTs Underperforming The Benchmark ETF** | **10** (40.00%) | **1** (4.00%) | **10** (40.00%) | **1** (4.00%) |




Kernel Density Estimation: Global Large-Cap Value Equity: SBM(CRS)-OO
Density
Efficiency Rating
0
1
2
3
4
5
6
7
8
9
10
0.5
0.6
0.7
0.8
0.9
1
1.1
1.2


Kernel Density Estimation: Global Large-Cap Value Equity: SORMSBM(CRS)-IO
Density
Efficiency Rating
0
0.5
1
1.5
-0.2
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6


Kernel Density Estimation: Global Large-Cap Value Equity: SORMSBM(CRS)-OO
Density
Efficiency Rating
0
2
4
6
8
10
12
14
16
18
20
0.7
0.75
0.8
0.85
0.9
0.95
1
1.05

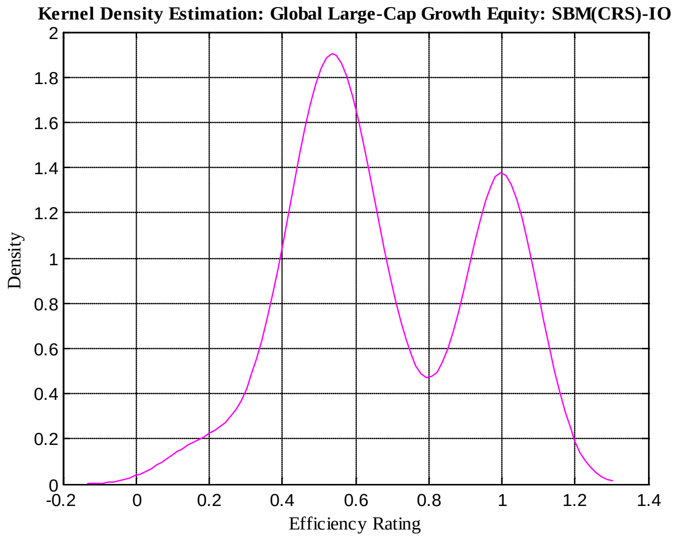
These results from the 25 global large-cap value equity OEICs/UTs and the benchmark ETF, the iShares MSCI World, provide a number of results that are worth highlighting. Firstly, from examining the previous chapters of efficiency ratings results for standalone CCR, SORMCCR, BCC and SORMBCC DEA it is clear that in this category of OEICs/UTs there is no issue with negative data. However, in order to maintain comparability across the entire universe of mutual funds, the SORM procedure is still employed to obtain the efficiency ratings for the input-oriented and output-oriented SORMSBM models for comparison alongside the standard SBM model variations.

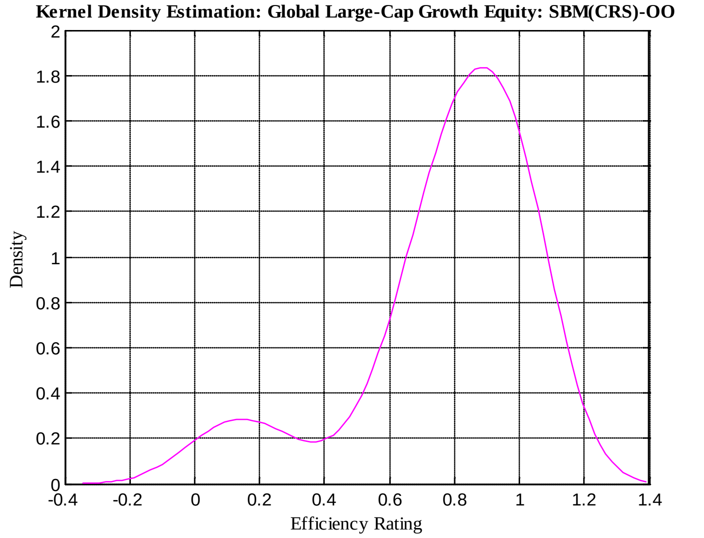
Under the examination of the input-oriented variations of the SBM and SORMSBM models, 15 of the OEICs/UTs show a superior efficiency rating to that of the benchmark iShares MSCI World ETF which is only rated at 0.604 and 0.683 respectively, thus implying that the managers of these OEICs/UTs could be showing some ability to select stocks which allows them to outperform the market. Also, under the examination of the output-oriented variations of the SBM and SORMSBM models, 24 of the OEICs/UTs show a superior efficiency rating to that of the benchmark iShares MSCI World ETF which is only rated at 0.733 and 0.846 respectively, again implying that the managers of these OEICs/UTs could be showing some ability to select stocks which allows them to outperform the market. Finally therefore, under the output-oriented variations of the SBM and SORMSBM models, a significant proportion of the OEICs/UTs in this category, 96.00%, outperform compared to the benchmark iShares MSCI World ETF, indicating that a significant number of these more expensive, actively managed funds are outperforming relative to the low-cost, passively managed iShares MSCI World ETF. Furthermore, under the input-oriented variations of the SBM and SORMSBM models, 60.00% of the OEICs/UTs outperform compared to the benchmark iShares MSCI World ETF, thus indicating that a large number of these more expensive, actively managed funds are outperforming relative to the low-cost, passively managed iShares MSCI World ETF.

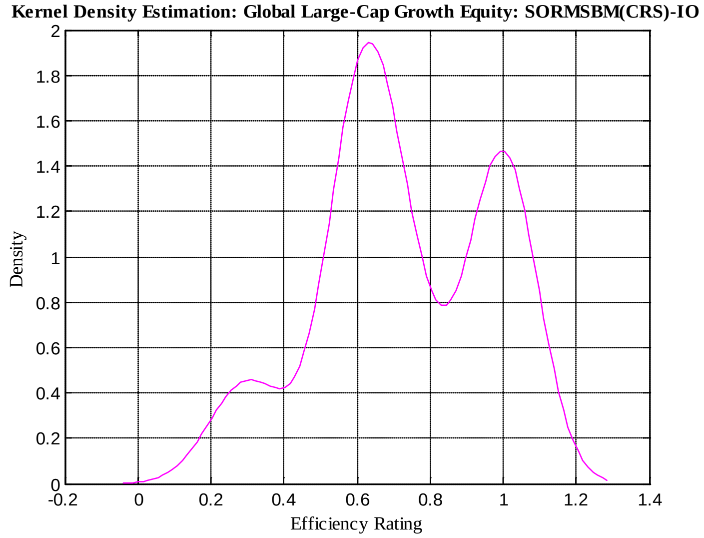
## *Global Large-Cap Growth Equity (1st January 2008 – 31st December 2010)*

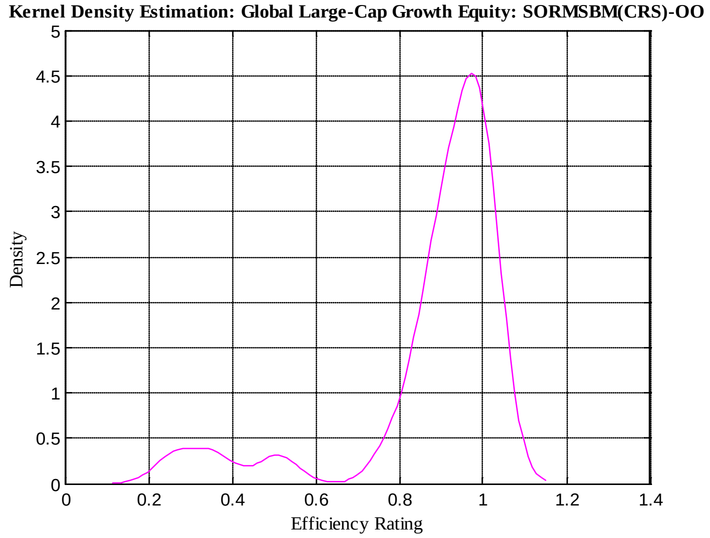
The detailed breakdown of the results from the individual OEICs/UTs in this category across the four DEA model variations can be found in Results Appendix 3 Table RA3.10, with a summary of the results provided in the table below, along with a kernel density estimation graph for each of the four DEA model variations.

| Summary Results | SBM-IO | SBM-OO | SORMSBM-IO | SORMSBM-OO |
|---|---|---|---|---|
| **Maximum Efficiency Rating** (Number Of OEICs/UTs) | **1.000** (9) | **1.000** (8) | **1.000** (9) | **1.000** (9) |
| **Minimum Efficiency Rating** (Number Of OEICs/UTs) | **0.169** (1) | **0.044** (1) | **0.247** (1) | **0.263** (1) |
| **Mean Efficiency Rating** | **0.685** | **0.777** | **0.728** | **0.878** |
| **Standard Deviation Of Efficiency Ratings** | **0.254** | **0.265** | **0.234** | **0.197** |
| **Number Of OEICs/UTs Outperforming The Benchmark ETF** | **16** (64.00%) | **12** (48.00%) | **14** (56.00%) | **15** (60.00%) |
| **Number Of OEICs/UTs Underperforming The Benchmark ETF** | **9** (36.00%) | **13** (52.00%) | **11** (44.00%) | **10** (40.00%) |




Kernel Density Estimation: Global Large-Cap Growth Equity: SBM(CRS)-OO
Density
Efficiency Rating


Kernel Density Estimation: Global Large-Cap Growth Equity: SORMSBM(CRS)-IO
Density
Efficiency Rating


Kernel Density Estimation: Global Large-Cap Growth Equity: SORMSBM(CRS)-OO
Density
Efficiency Rating

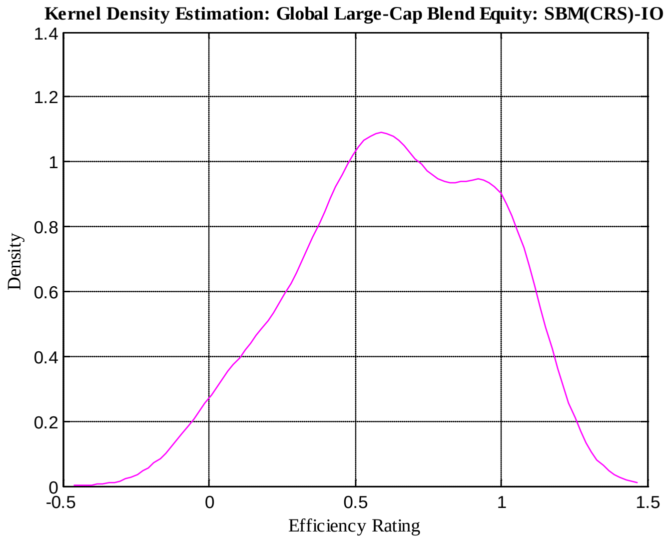
These results from the 25 global large-cap growth equity OEICs/UTs and the benchmark ETF, the iShares MSCI World, provide a number of results that are worth highlighting. From the previous chapters of results for standalone CCR, SORMCCR, BCC and SORMBCC DEA it was revealed that in this category of OEICs/UTs there are 4 OEICs/UTs which contain negative data in their inputs and/or outputs, and although the efficiency ratings results for the OEICs/UTs in this category under the SBM DEA model, both input-oriented and output-oriented, do not exhibit an obvious bias caused by the negative data present in this category, it is likely that it will be influencing the efficiency ratings results nonetheless. This leads to a desire to implement the SORM procedure to deal with this negative data issue, thus resulting in the subsequent production of the SORMSBM DEA model efficiency ratings results which should be more robust.

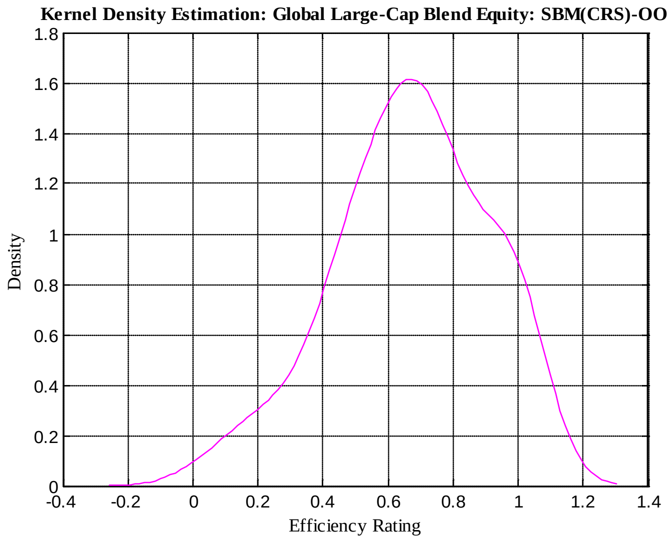
Furthermore, under the evaluation of each of the four DEA model variations utilised here, between 12 and 16 of the OEICs/UTs show a superior efficiency rating to that of the benchmark iShares MSCI World ETF which achieves a rating ranging from 0.550 to 0.912 depending on the DEA model variation utilised, thus suggesting that the managers of these OEICs/UTs could be showing an ability to select stocks which allows them to outperform the market. Finally, across all four of the DEA model variations used here, 48.00% to 64.00% of the OEICs/UTs outperform the benchmark iShares MSCI World ETF, whilst between 36.00% and 52.00% of the OEICs/UTs underperform the benchmark iShares MSCI World ETF. This suggests that in general, across the four DEA models used here, slightly more of the more expensive, actively managed funds outperform rather than underperform the low-cost, passively managed iShares MSCI World ETF.

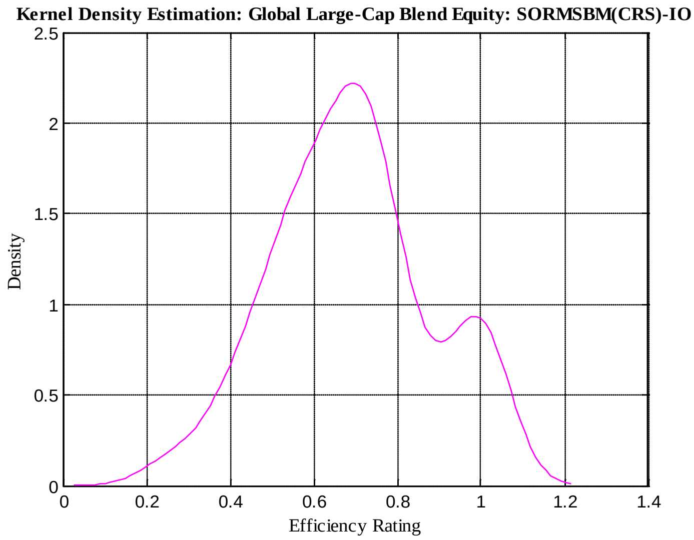
***Global Large-Cap Blend Equity (1<sup>st</sup> January 2008 – 31<sup>st</sup> December 2010)***

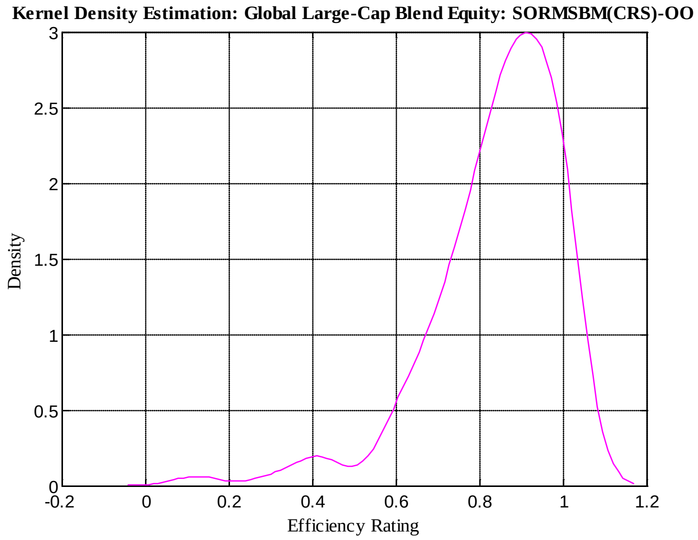
The detailed breakdown of the results from the individual OEICs/UTs in this category across the four DEA model variations can be found in Results Appendix 3 Table RA3.11, with a summary of the results provided in the table below, along with a kernel density estimation graph for each of the four DEA model variations.

| Summary Results | SBM-IO | SBM-OO | SORMSBM-IO | SORMSBM-OO |
|---|---|---|---|---|
| **Maximum Efficiency Rating** (Number Of OEICs/UTs) | **1.000** (35) | **1.000** (17) | **1.000** (18) | **1.000** (18) |
| **Minimum Efficiency Rating** (Number Of OEICs/UTs) | **0.006** (1) | **0.045** (1) | **0.244** (1) | **0.121** (1) |
| **Mean Efficiency Rating** | **0.637** | **0.668** | **0.690** | **0.837** |
| **Standard Deviation Of Efficiency Ratings** | **0.302** | **0.233** | **0.185** | **0.155** |
| **Number Of OEICs/UTs Outperforming The Benchmark ETF** | **82** (69.49%) | **54** (45.76%) | **77** (65.25%) | **51** (43.22%) |
| **Number Of OEICs/UTs Underperforming The Benchmark ETF** | **36** (30.51%) | **64** (54.24%) | **41** (34.75%) | **64** (54.24%) |




Kernel Density Estimation: Global Large-Cap Blend Equity: SBM(CRS)-OO
Density
Efficiency Rating


Kernel Density Estimation: Global Large-Cap Blend Equity: SORMSBM(CRS)-IO
Density
Efficiency Rating


Kernel Density Estimation: Global Large-Cap Blend Equity: SORMSBM(CRS)-OO
Density
Efficiency Rating

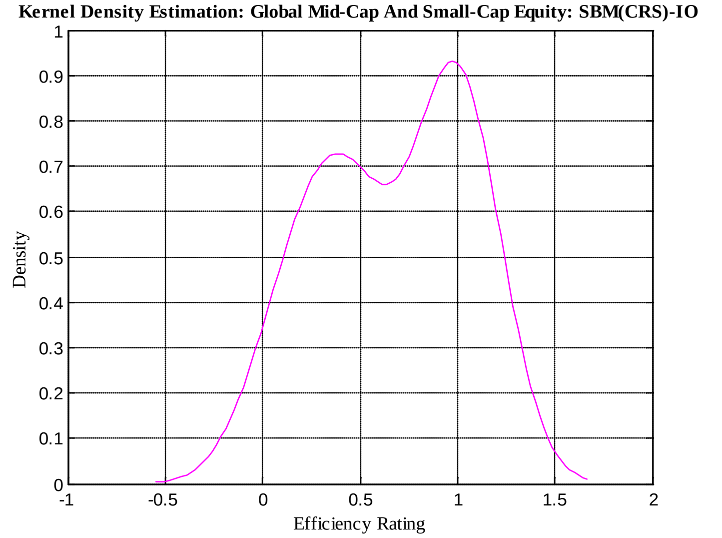
These results from the 118 global large-cap blend equity OEICs/UTs and the benchmark ETF, the iShares MSCI World, provide a number of results that are worth highlighting. Firstly, from examining the previous chapters of efficiency ratings results for standalone CCR, SORMCCR, BCC and SORMBCC DEA it was discovered that in this category of OEICs/UTs there are 6 OEICs/UTs which contain negative data in their inputs and/or outputs. Although the results for the efficiency ratings for the OEICs/UTs in this category under both the input-oriented and output-oriented SBM DEA model do not show an explicitly obvious bias caused by the negative data, it is still highly probable that it will be influencing the efficiency ratings results nevertheless, resulting in a desire to implement SORM to deal with this negative data problem. This leads to the SORMSBM DEA model efficiency ratings results, both input-oriented and output-oriented, which should therefore be more robust and valid.

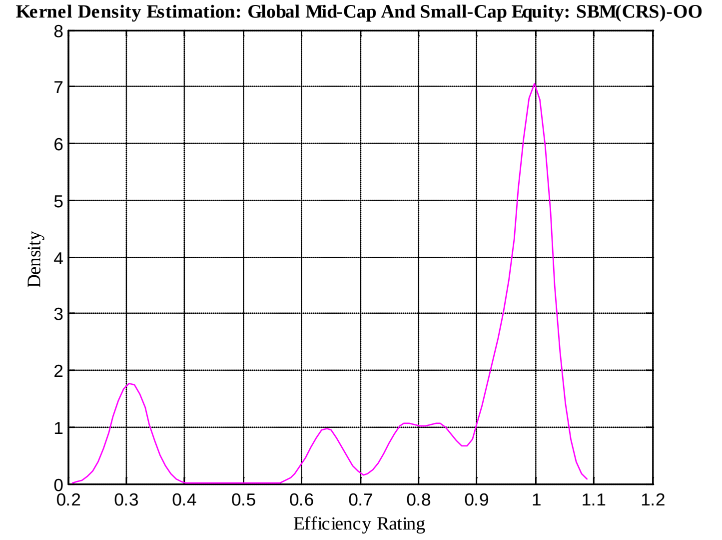
Under the evaluation of the SBM DEA model, 82 of the OEICs/UTs in the input-oriented case and 54 of the OEICs/UTs in the output-oriented case, show a superior efficiency rating to that of the benchmark iShares MSCI World ETF which only achieves a rating of 0.489 and 0.692 respectively, implying that the managers of these OEICs/UTs could be showing some ability to select stocks which allows them to outperform the market. Furthermore, under the evaluation of the SORMSBM DEA model, 77 of the OEICs/UTs in the input-oriented case and 51 of the OEICs/UTs in the output-oriented case, show a superior efficiency rating to that of the benchmark iShares MSCI World ETF which only achieves a rating of 0.619 and 0.885 respectively, again implying that the managers of these OEICs/UTs could be showing some ability to select stocks which allows them to outperform the market. Finally, under the input-oriented variations of the SBM and SORMSBM models, a large proportion of the OEICs/UTs in this category, 69.49% and 65.25% respectively, outperform compared against the benchmark iShares MSCI World ETF, implying that a large number of these more expensive, actively managed funds are outperforming relative to the low-cost, passively managed iShares MSCI World ETF. However, under the output-oriented variations of the SBM and SORMSBM models, there is a near even split between the OEICs/UTs outperforming/underperforming compared against the benchmark iShares MSCI World ETF, 45.76%/54.24% respectively in the SBM case and 43.22%/54.24% respectively in the SORMSBM case. This implies that there is a roughly even split between the number of these more expensive, actively managed funds that are outperforming/underperforming relative to the low-cost, passively managed iShares MSCI World ETF.

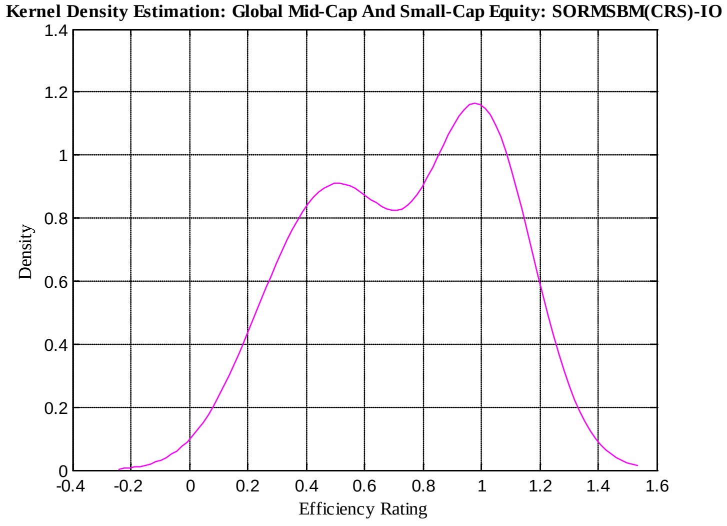
***Global Mid-Cap And Small-Cap Equity (1st January 2008 – 31st December 2010)***

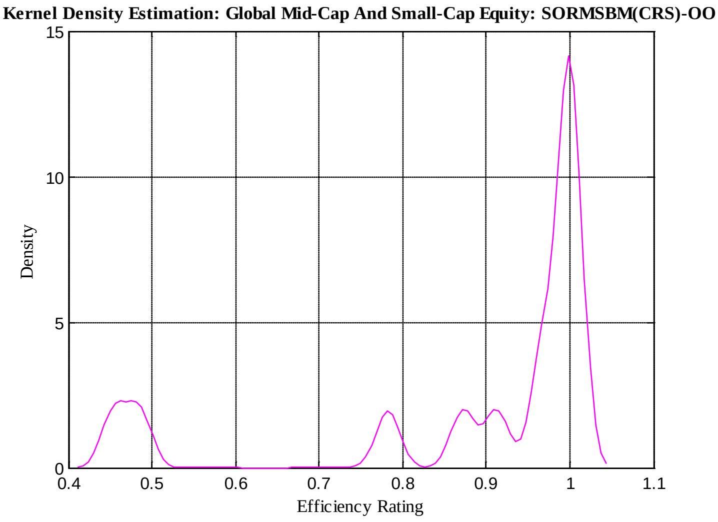
The detailed breakdown of the results from the individual OEICs/UTs in this category across the four DEA model variations can be found in Results Appendix 3 Table RA3.12, with a summary of the results provided in the table below, along with a kernel density estimation graph for each of the four DEA model variations.

| Summary Results | SBM-IO | SBM-OO | SORMSBM-IO | SORMSBM-OO |
|---|---|---|---|---|
| **Maximum Efficiency Rating** (Number Of OEICs/UTs) | **1.000** (6) | **1.000** (6) | **1.000** (6) | **1.000** (6) |
| **Minimum Efficiency Rating** (Number Of OEICs/UTs) | **0.119** (1) | **0.294** (1) | **0.295** (1) | **0.455** (1) |
| **Mean Efficiency Rating** | **0.669** | **0.839** | **0.735** | **0.889** |
| **Standard Deviation Of Efficiency Ratings** | **0.363** | **0.250** | **0.290** | **0.189** |
| **Number Of OEICs/UTs Outperforming The Benchmark ETF** | **0** (0.00%) | **0** (0.00%) | **0** (0.00%) | **0** (0.00%) |
| **Number Of OEICs/UTs Underperforming The Benchmark ETF** | **7** (53.85%) | **7** (53.85%) | **7** (53.85%) | **7** (53.85%) |


Kernel Density Estimation: Global Mid-Cap And Small-Cap Equity: SBM(CRS)-IO
Density
Efficiency Rating


Kernel Density Estimation: Global Mid-Cap And Small-Cap Equity: SBM(CRS)-OO
Density
Efficiency Rating


Kernel Density Estimation: Global Mid-Cap And Small-Cap Equity: SORMSBM(CRS)-IO
Density
Efficiency Rating

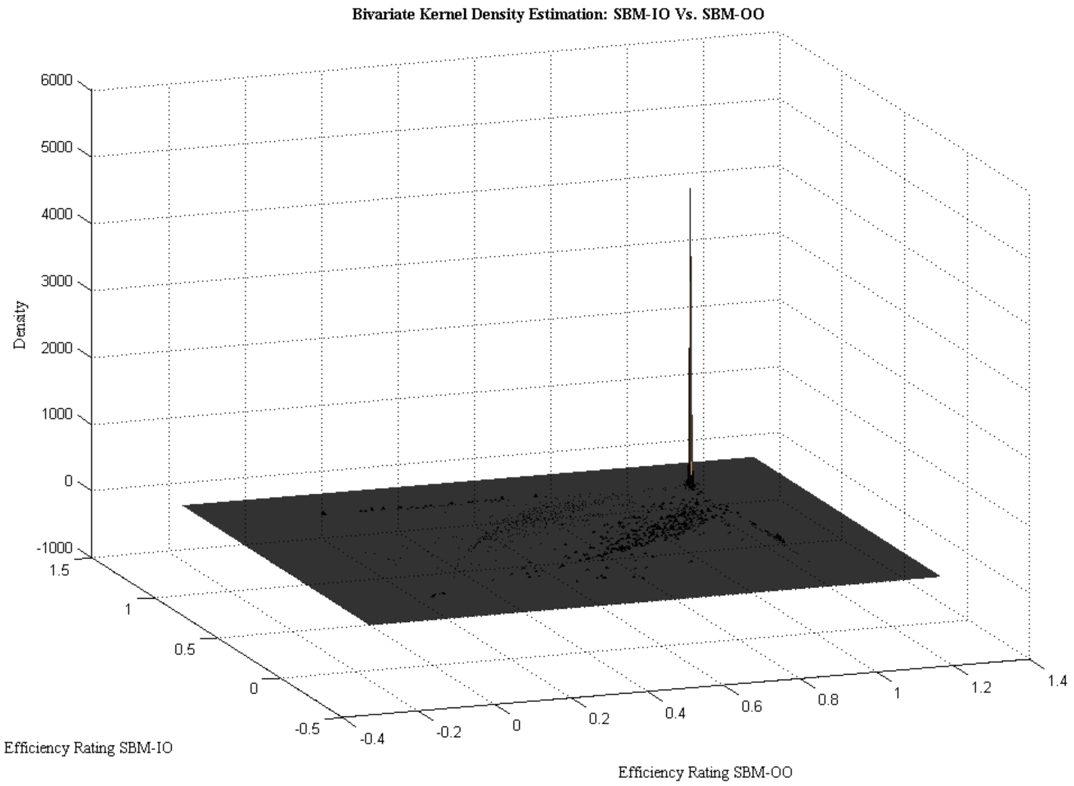


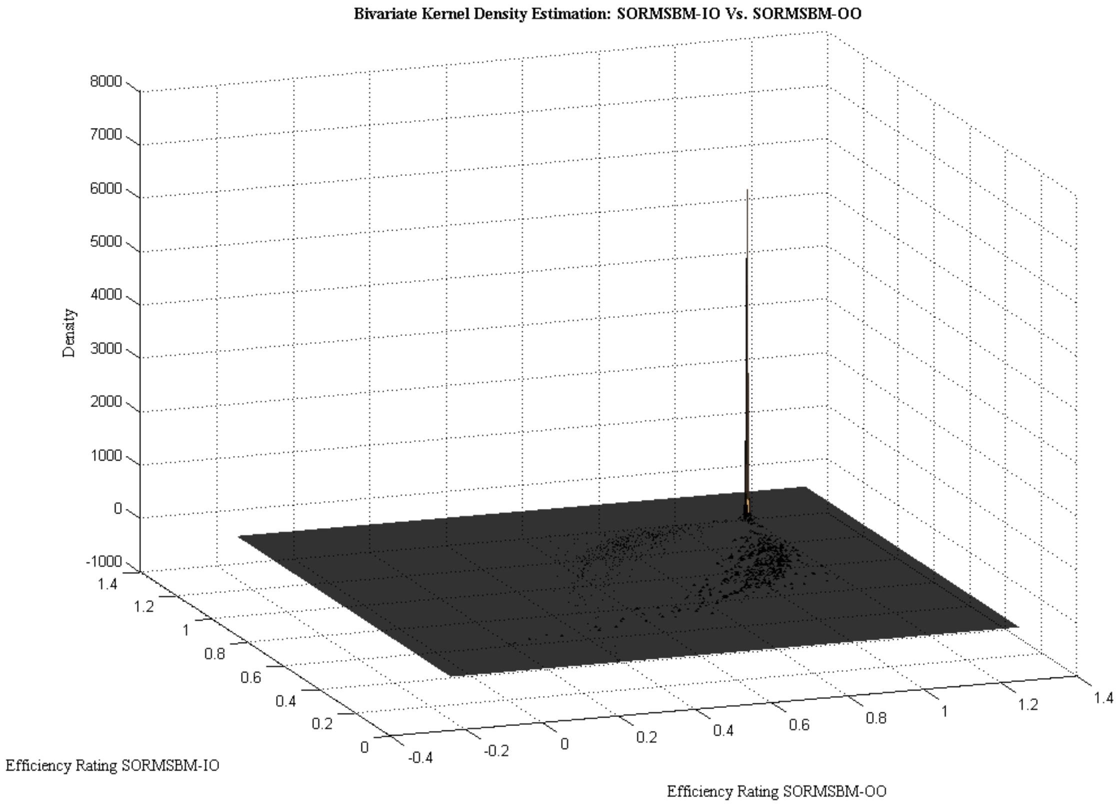

These results from the 13 global mid-cap and small-cap equity OEICs/UTs and the benchmark ETF, the iShares MSCI World, provide a number of results that are worth highlighting. Firstly, from examining the previous chapters of efficiency ratings results for standalone CCR, SORMCCR, BCC and SORMBCC DEA it was found that in this category of OEICs/UTs there is one OEIC/UT which contains negative data in its inputs and/or outputs, and although the results for the efficiency ratings for the OEICs/UTs in this category under both the input-oriented and output-oriented SBM DEA model do not show an obvious bias caused by the negative data, it is likely that it will still be influencing the efficiency ratings results. This makes it desirable to implement the SORM procedure to deal with this negative data problem, leading to the SORMSBM DEA model efficiency ratings results that should therefore be more robust.

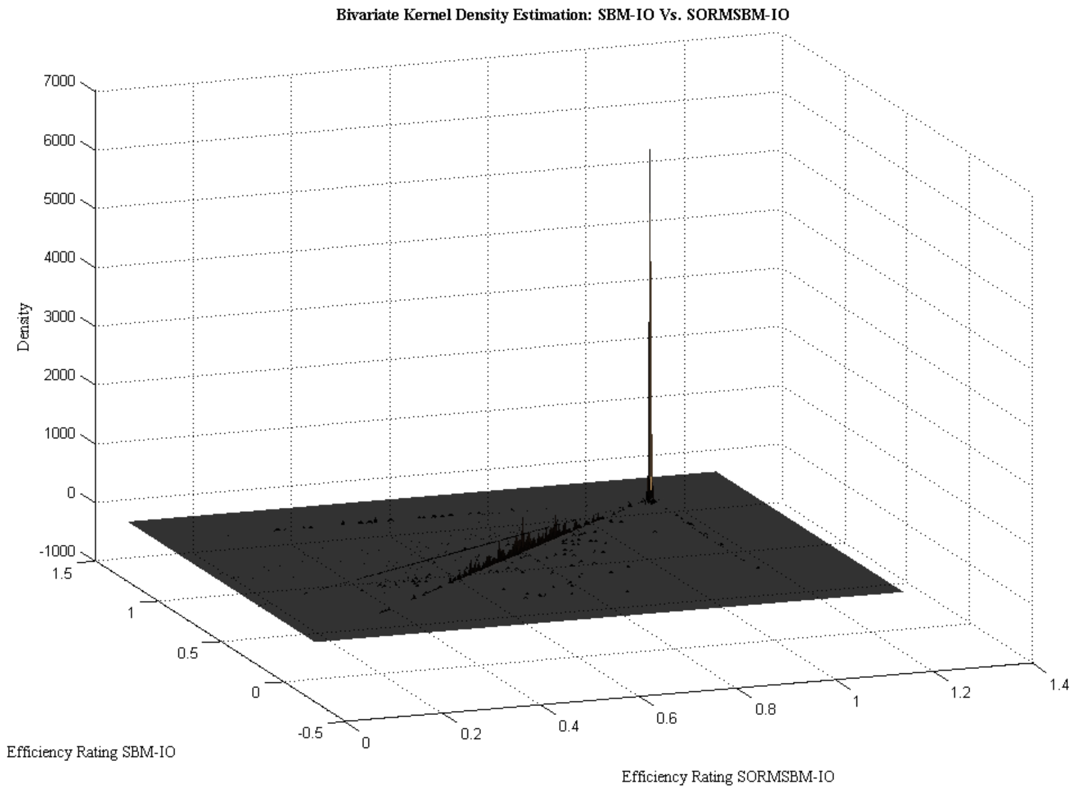
The efficiency ratings results for the OEICs/UTs in this category show that under all four of the DEA models utilised here, none of the OEICs/UTs show a superior efficiency rating to that of the benchmark iShares MSCI World ETF which obtains the maximum efficiency rating of 1.000 under each of the four DEA model variations used, thus suggesting that none of the managers of these OEICs/UTs are showing an ability to select stocks which would allow them to outperform the market. Finally, under the examination of each of the four DEA models used here, 53.85% of the OEICs/UTs in this category underperform compared to the benchmark iShares MSCI World ETF, suggesting that slightly over half of these more expensive, actively managed funds are underperforming relative to the low-cost, passively managed iShares MSCI World ETF.

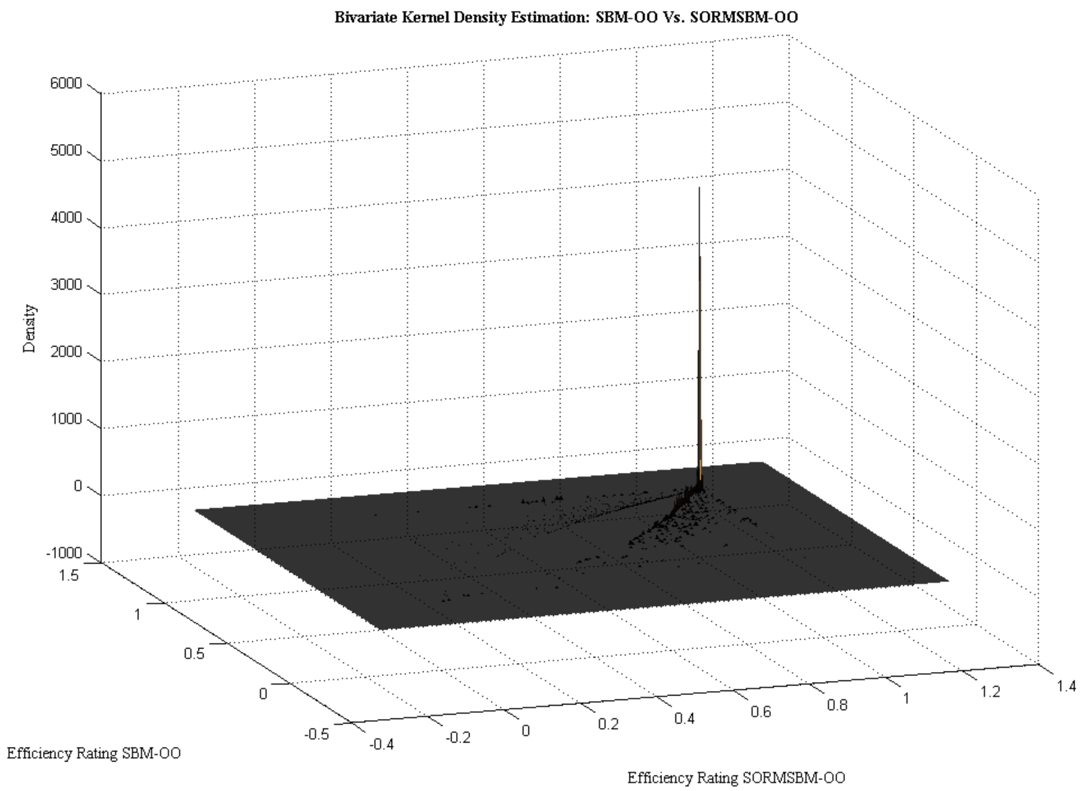
## *9.5: Summary Conclusions*

To provide a graphical summary of the results for the managerial performance of the OEICs/UTs under assessment from this section of results for the standalone SBM DEA model and the standalone SORMSBM DEA model, there are four bivariate kernel density estimation graphs below.




Bivariate Kernel Density Estimation: SORMSBM-IO Vs. SORMSBM-OO
Density
Efficiency Rating SORMSBM-IO
Efficiency Rating SORMSBM-OO


Bivariate Kernel Density Estimation: SBM-IO Vs. SORMSBM-IO
Density
Efficiency Rating SBM-IO
Efficiency Rating SORMSBM-IO




To conclude this section of results it is possible to emphasise the following points. Firstly, although the SBM and SORMSBM models used in this thesis are implemented with an underlying constant returns-to-scale metric, the treatment of the slacks directly in the objective function of the model, and the non-radial optimal adjustments of the inputs and outputs, results in differences in the efficiency ratings results for the OEICs/UTs between the input-oriented and output-oriented variations of each of these two models, with the output-oriented variations producing higher efficiency ratings for the OEICs/UTs in general compared to the input-oriented variations. Furthermore, although not as obvious as it is in the case of the radial models, the negative data present in the dataset of the OEICs/UTs is still likely to be influencing the efficiency ratings results of the standard SBM DEA model, thus leading to the necessity of the development of the SORMSBM DEA model which will not be afflicted by any influence from the negative data. Finally, across the mutual fund universe of 565 OEICs/UTs, the efficiency ratings of the OEICs/UTs show a mixed pattern of results under the evaluation of the SBM and SORMSBM models. In particular, across the 12 investment categories of OEIC/UT, there are some categories in which there are a number of OEICs/UTs which outperform the benchmark iShares ETF index tracker, suggesting that the managers of these OEICs/UTs are showing an ability to deliver consistent superior returns and outperform the market, whilst in other categories the benchmark iShares ETF index tracker is rated at the maximum of 1.000 and there are no OEIC/UT managers that are able to outperform the market. Critically however, any influence exerted by environmental factors and statistical noise/luck on the managerial efficiency ratings of the OEICs/UTs will still be present in the results from these standalone SBM and SORMSBM DEA models, and thus these managerial efficiency ratings may not reflect the 'true' managerial performance of the managers of the OEICs/UTs under assessment.

There are some links between the empirical results in this chapter and the existing research literature. Although there are no large studies of UK mutual fund performance using DEA, there is a small research study of the UK market of ethical mutual funds in Basso and Funari (2005b) which leads to results somewhat similar to those in this chapter, with all the funds assessed in a single category, some funds outperform the benchmark and others underperform the benchmark. However, there is a large research study of UK mutual fund performance using the traditional measures by Cuthbertson et al (2008) which produces results that are markedly different to those in this chapter. It finds that between 5% and 10% of UK equity mutual funds show an ability to select stocks, in contrast to the empirical results in this chapter which indicate that across the investment categories there is either a much higher percentage of funds exhibiting an ability to select stocks, or there are none.

In the next chapter of results, the one-stage standalone DEA models are extended in to the three-stage DEA-SFA-DEA models to purge the efficiency ratings of the OEICs/UTs of the influence of environmental factors and statistical noise/luck, thus obtaining the ‘true’ managerial performance of the managers of the OEICs/UTs under evaluation.

# Chapter 10: Results Section 4 – Three-Stage DEA-SFA-DEA Model Results Utilising SORMCCR-OO And SORMSBM(CRS)-OO DEA Models

This final section of results contains the results for the efficiency ratings of the OEICs/UTs in the mutual fund universe under evaluation using the three-stage DEA-SFA-DEA modelling methodology. As a baseline for comparison it also presents the standalone DEA results for the two DEA models that are used in the three-stage DEA-SFA-DEA model. All of the DEA results for the standalone DEA models, and the first stage and the third stage of the three-stage DEA-SFA-DEA model were produced using the MATLAB program, utilising the MATLAB DEA model coding created for this study, as seen in the MATLAB coding appendix. The two DEA models utilised in this section of results in the first and third stages are the output-oriented SORMCCR DEA model and the output-oriented SORMSBM(CRS) DEA model. The second stage SFA results were produced using the Frontier package in the R Program for statistical computing.

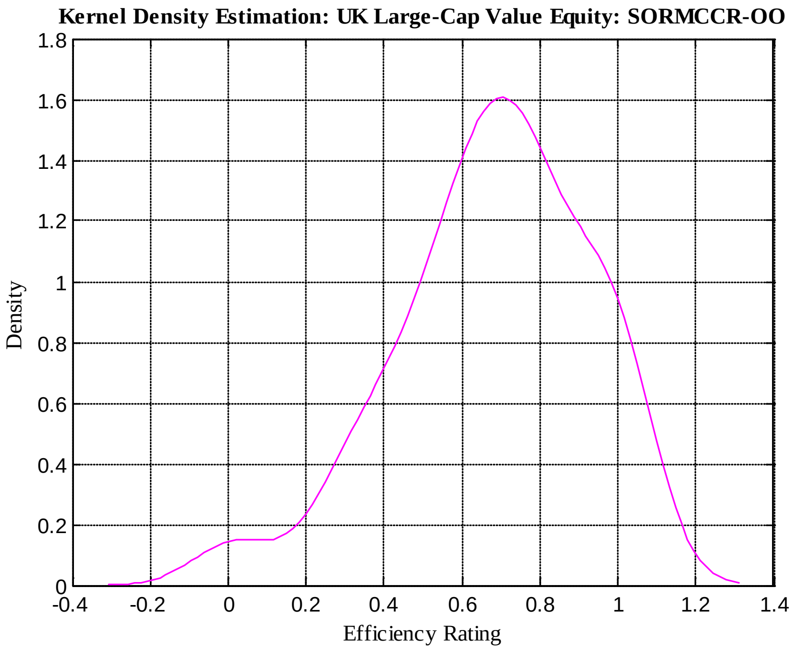
## *10.1: UK Domiciled OEICs And UTs With A UK Investment Focus*

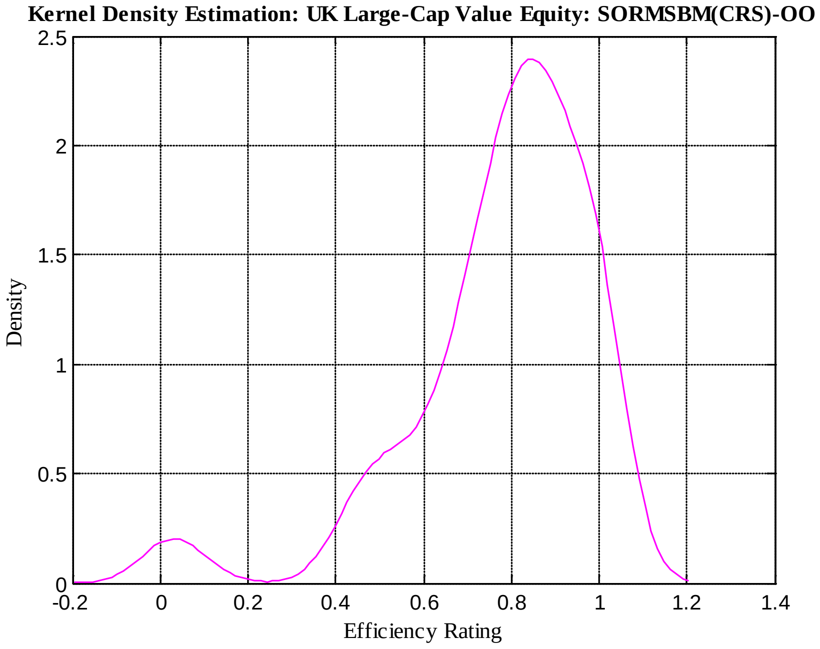
### *UK Large-Cap Value Equity (1st January 2008 – 31st December 2010)*

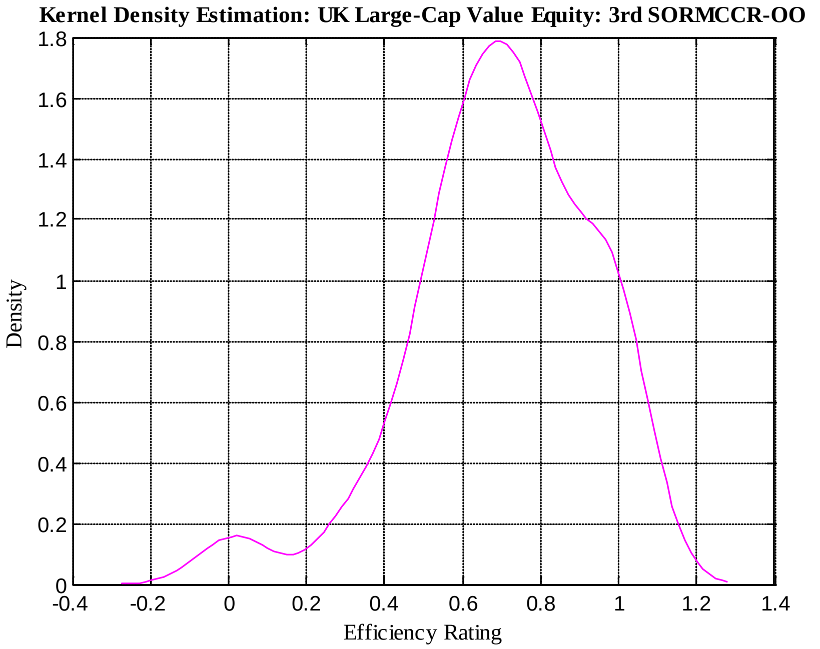
The detailed breakdown of the results from the individual OEICs/UTs in this category across both the two standalone DEA models and the two three-stage DEA-SFA-DEA models can be found in Results Appendix 4 Table RA4.1, with a summary of the results provided in the table below, along with a kernel density estimation graph for each of the four model variations.

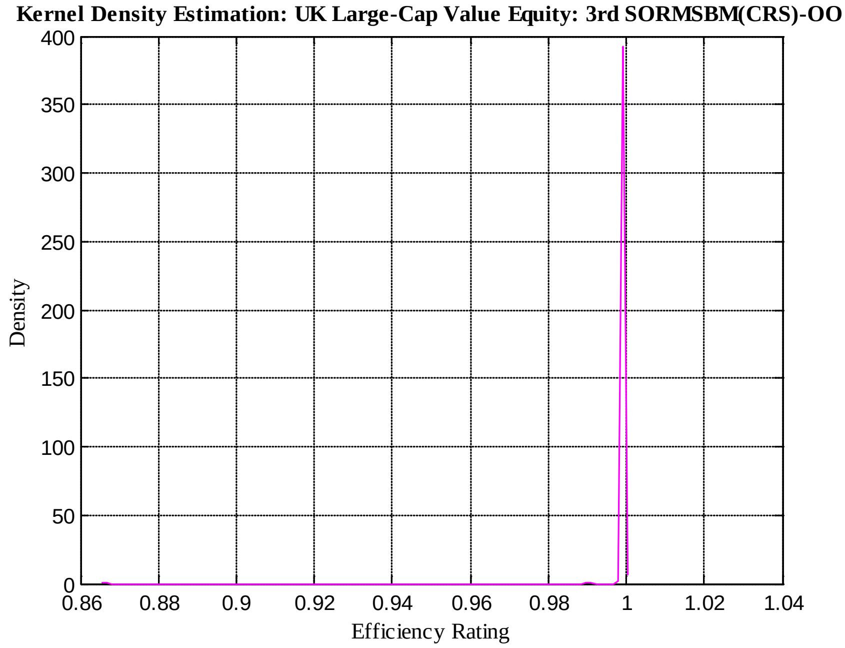
| Summary Results | SORMCCR-OO | Three-Stage SORMCCR-OO | SORMSBM-OO | Three-Stage SORMSBM-OO |
|---|---|---|---|---|
| **Maximum Efficiency Rating** (Number Of OEICs/UTs) | **1.000** (13) | **1.000** (13) | **1.000** (13) | **1.000** (49) |

| | | | | |
|---|---|---|---|---|
| **Minimum Efficiency Rating** (Number Of OEICs/UTs) | **0.004** (1) | **0.004** (1) | **0.008** (1) | **0.866** (1) |
| **Mean Efficiency Rating** | **0.678** | **0.698** | **0.779** | **0.998** |
| **Standard Deviation Of Efficiency Ratings** | **0.242** | **0.229** | **0.211** | **0.015** |
| **Number Of OEICs/UTs Outperforming The Benchmark ETF** | **16** (20.00%) | **17** (21.25%) | **16** (20.00%) | **0** (0.00%) |
| **Number Of OEICs/UTs Underperforming The Benchmark ETF** | **64** (80.00%) | **63** (78.75%) | **64** (80.00%) | **31** (38.75%) |




Kernel Density Estimation: UK Large-Cap Value Equity: SORMSBM(CRS)-OO
Density
Efficiency Rating
2.5
2
1.5
1
0.5
0
-0.2
0
0.2
0.4
0.6
0.8
1
1.2
1.4


Kernel Density Estimation: UK Large-Cap Value Equity: 3rd SORMCCR-OO
Density
Efficiency Rating
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
-0.4
-0.2
0
0.2
0.4
0.6
0.8
1
1.2
1.4




These results from the 80 UK large-cap value equity OEICs/UTs and the benchmark ETF, the iShares FTSE 100, provide a number of results that are worth highlighting. It is clear from the results that when the SORMCCR-OO DEA model is utilised in the three-stage method to remove the influence of environmental factors and statistical noise from the efficiency ratings of the OEICs/UTs to obtain the 'true' managerial performance, there is very little difference in the results produced compared to the standalone case. This is in contrast to the case when the SORMSBM(CRS)-OO DEA model is used in the three-stage method where the results produced are significantly different compared to the standalone case, with a large number of the OEICs/UTs and the benchmark iShares FTSE 100 ETF achieving the maximum efficiency rating of 1.000.

These contrasting results support two opposing conclusions. The results from the SORMCCR-OO case suggest that the variation in the performance of the OEICs/UTs is almost entirely due to differences in managerial performance between the funds, whereas the results from the SORMSBM(CRS)-OO case suggest that the variation in the performance of the OEICs/UTs is almost entirely explained by environmental factors and statistical noise/luck. The most likely cause of this difference between the two cases is the way the two DEA models utilised treat the optimal adjustments of the inputs and outputs, with the SORMCCR-OO model treating them as radial in nature and the SORMSBM(CRS)-OO model treating them as non-radial in nature. This highlights the importance of selecting the most appropriate DEA model when employing DEA as a tool to assess a problem. For the evaluation of the managerial performance of the OEICs/UTs which is the focus of this thesis, the non-radial SORMSBM(CRS)-OO DEA model appears likely to be the most appropriate DEA model to use.

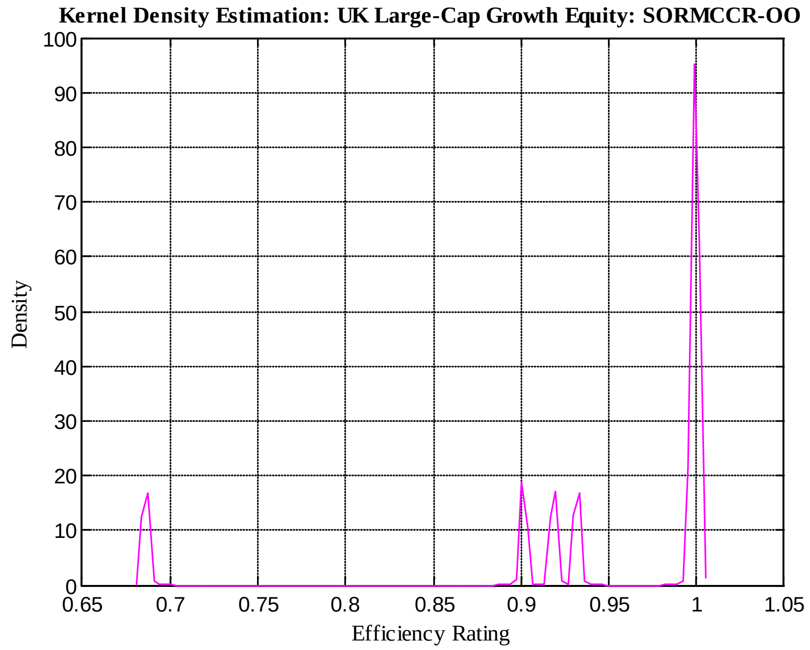
Thus, after using the three-stage DEA-SFA-DEA model, combined with the SORMSBM(CRS)-OO DEA model, to remove the influence of environmental factors and statistical noise/luck, the conclusion to be drawn is that the managers of the OEICs/UTs in this category are unable to outperform the market return as represented by the low-cost index tracker. Of the 80 OEICs/UTs in this category, 49 are ranked at the maximum efficiency rating of 1.000 along with the benchmark iShares FTSE 100 ETF, whilst the remaining 31 underperform and produce a return less than that which could of been obtained from the market index tracker.

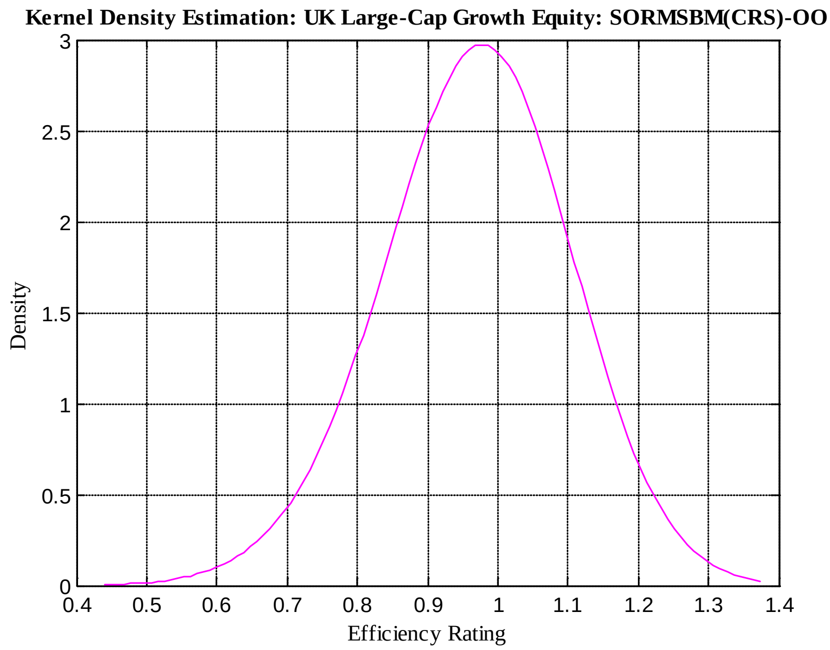
***UK Large-Cap Growth Equity (1st January 2008 – 31st December 2010)***

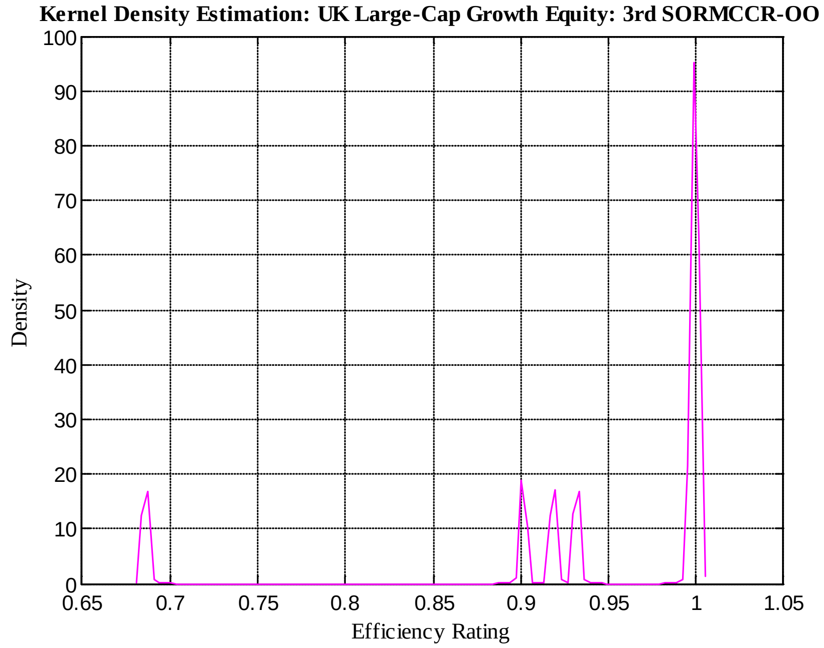
The detailed breakdown of the results from the individual OEICs/UTs in this category across both the two standalone DEA models and the two three-stage DEA-SFA-DEA models can be found in Results Appendix 4 Table RA4.2, with a summary of the results provided in the table below, along with a kernel density estimation graph for each of the four model variations.

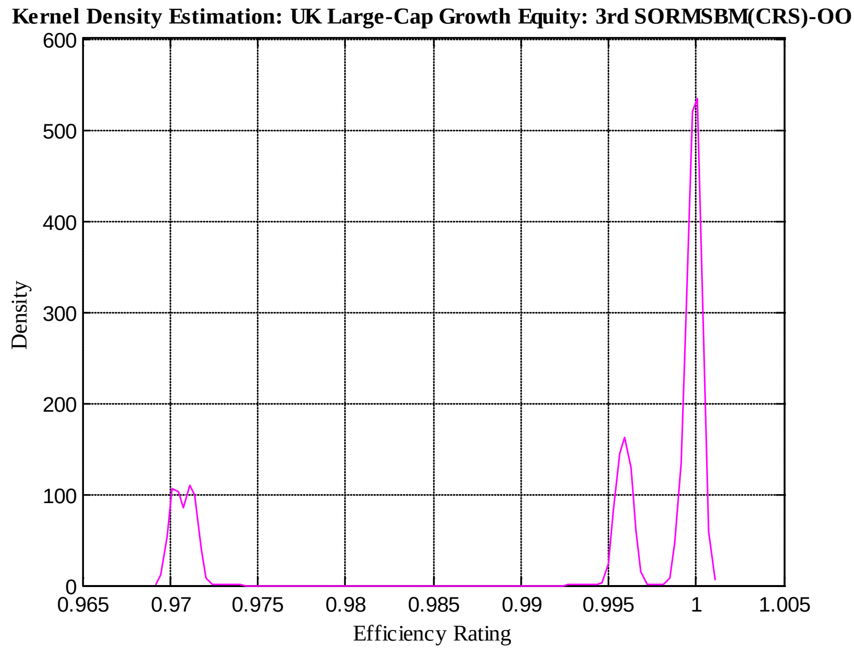
| Summary Results | SORMCCR-OO | Three-Stage SORMCCR-OO | SORMSBM-OO | Three-Stage SORMSBM-OO |
|---|---|---|---|---|
| **Maximum Efficiency Rating** (Number Of OEICs/UTs) | **1.000** (4) | **1.000** (4) | **1.000** (5) | **1.000** (4) |
| **Minimum Efficiency Rating** (Number Of OEICs/UTs) | **0.686** (1) | **0.686** (1) | **0.814** (1) | **0.970** (1) |

| | | | | |
|---|---|---|---|---|
| **Mean Efficiency Rating** | **0.943** | **0.943** | **0.968** | **0.993** |
| **Standard Deviation Of Efficiency Ratings** | **0.099** | **0.099** | **0.058** | **0.012** |
| **Number Of OEICs/UTs Outperforming The Benchmark ETF** | **0** (0.00%) | **0** (0.00%) | **0** (0.00%) | **0** (0.00%) |
| **Number Of OEICs/UTs Underperforming The Benchmark ETF** | **5** (55.56%) | **5** (55.56%) | **4** (44.44%) | **5** (55.56%) |






These results from the 9 UK large-cap growth equity OEICs/UTs and the benchmark ETF, the iShares FTSE 100, provide a number of results that are worth highlighting. They show that when the SORMCCR-OO DEA model is utilised in the three-stage DEA-SFA-DEA method to remove the influence of environmental factors and statistical noise to obtain the ‘true’ managerial performance, there is no difference in the results produced compared against those produced in the standalone case. In contrast, when the SORMSBM(CRS)-OO DEA model is utilised in the three-stage method, there are differences in the results produced compared to the standalone case, with a general increase in the mean efficiency rating from 0.968 to 0.993, and the results for the individual OEICs/UTs revealing that several experience increases in their efficiency ratings whilst two experience a fall.

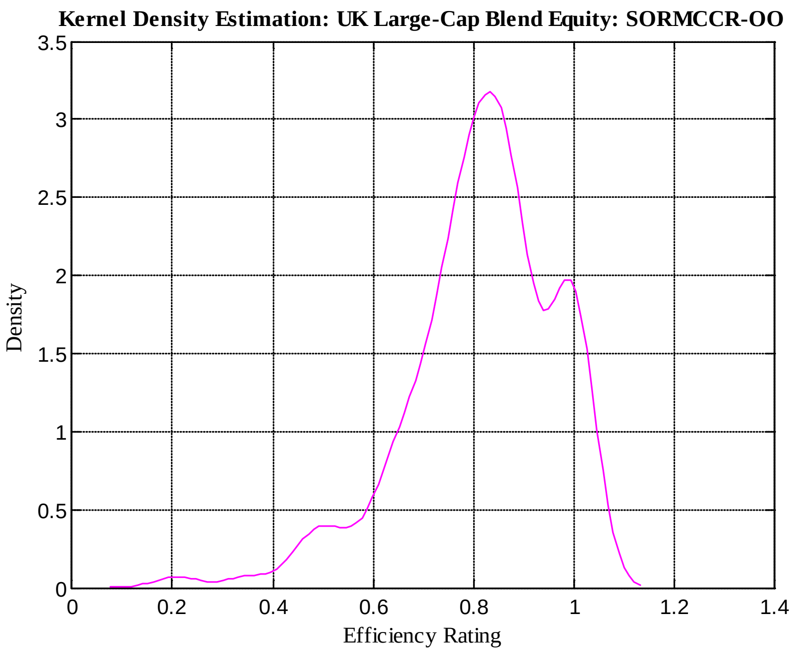
Therefore, the results from the SORMCCR-OO case support the argument that the variation in the performance of the OEICs/UTs is almost entirely due to differences in the managerial performance between the funds, whilst the results from the SORMSBM(CRS)-OO case are more indicative of the suggestion that a large portion of the variation in the performance of the OEICs/UTs is due to environmental factors and statistical noise/luck. This again comes down to whether the most appropriate DEA model for the evaluation of the managerial performance of the OEICs/UTs is the radial SORMCCR-OO model or the non-radial SORMSBM(CRS)-OO model, and the non-radial SORMSBM(CRS)-OO model appears to be the more appropriate model for use in this case.

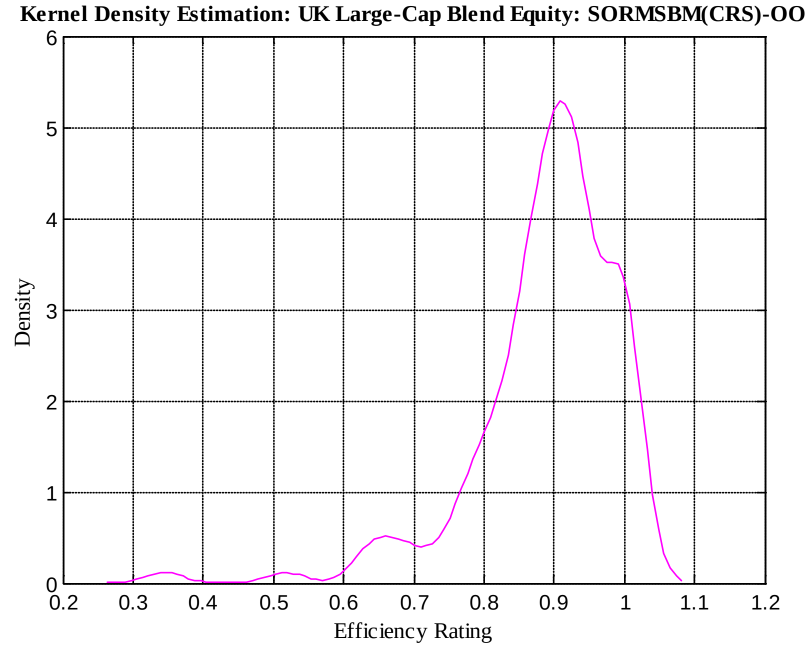
Thus, from using the three-stage DEA-SFA-DEA model in combination with the SORMSBM(CRS)-OO DEA model to remove the influence of environmental factors and statistical noise/luck, the conclusion reached is that the managers of the OEICs/UTs in this category are unable to outperform the low-cost market index tracker, and more than half of the OEICs/UTs, 55.56%, underperform the market index tracker return.

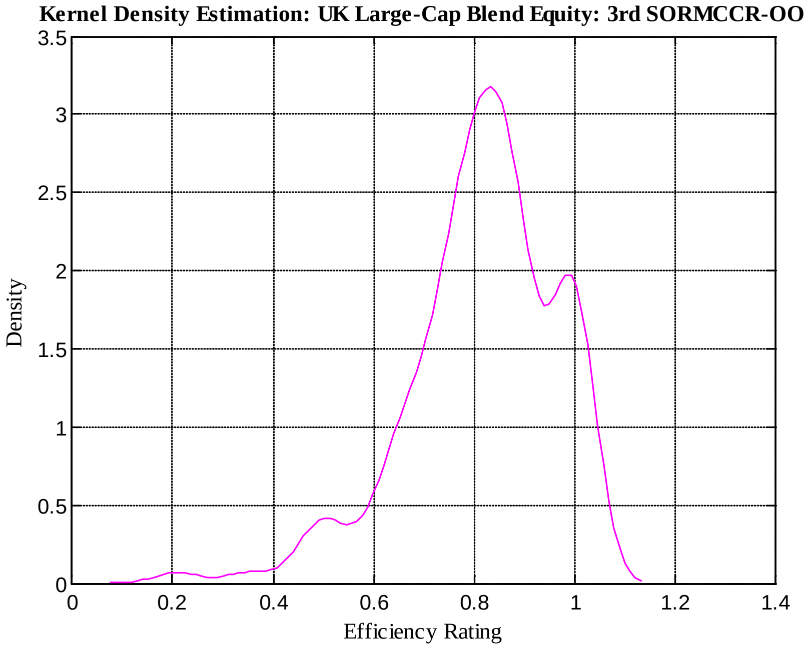
***UK Large-Cap Blend Equity (1st January 2008 – 31st December 2010)***

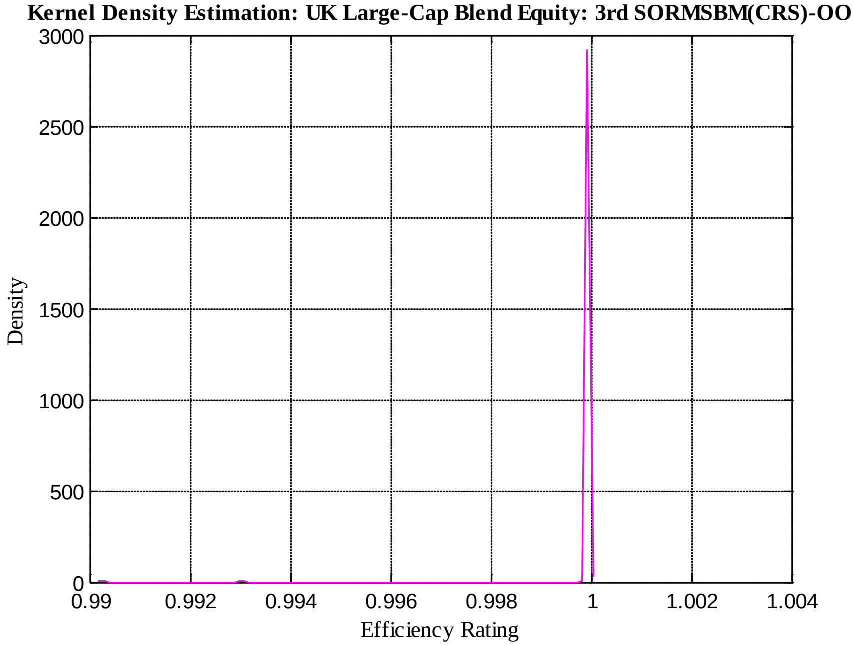
The detailed breakdown of the results from the individual OEICs/UTs in this category across both the two standalone DEA models and the two three-stage DEA-SFA-DEA models can be found in Results Appendix 4 Table RA4.3, with a summary of the results provided in the table below, along with a kernel density estimation graph for each of the four model variations.

| Summary Results | SORMCCR-OO | Three-Stage SORMCCR-OO | SORMSBM-OO | Three-Stage SORMSBM-OO |
|---|---|---|---|---|
| **Maximum Efficiency Rating** (Number Of OEICs/UTs) | **1.000** (25) | **1.000** (25) | **1.000** (25) | **1.000** (128) |
| **Minimum Efficiency Rating** (Number Of OEICs/UTs) | **0.209** (1) | **0.209** (1) | **0.346** (1) | **0.990** (1) |
| **Mean Efficiency Rating** | **0.815** | **0.815** | **0.890** | **1.000** |
| **Standard Deviation Of Efficiency Ratings** | **0.148** | **0.147** | **0.102** | **0.001** |
| **Number Of OEICs/UTs Outperforming The Benchmark ETF** | **111** (85.38%) | **111** (85.38%) | **111** (85.38%) | **0** (0.00%) |
| **Number Of OEICs/UTs Underperforming The Benchmark ETF** | **19** (14.62%) | **19** (14.62%) | **19** (14.62%) | **2** (1.54%) |




Kernel Density Estimation: UK Large-Cap Blend Equity: SORMSBM(CRS)-OO
Density
Efficiency Rating
0
1
2
3
4
5
6
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
1.1
1.2


Kernel Density Estimation: UK Large-Cap Blend Equity: 3rd SORMCCR-OO
Density
Efficiency Rating
0
0.5
1
1.5
2
2.5
3
3.5
0
0.2
0.4
0.6
0.8
1
1.2
1.4




These results from the 130 UK large-cap blend equity OEICs/UTs and the benchmark ETF, the iShares FTSE 100, provide a number of results that are worth highlighting. The results for this category of OEIC/UT indicate that when the SORMCCR-OO DEA model is employed in the three-stage DEA-SFA-DEA method to eliminate the influence of environmental factors and statistical noise from the efficiency ratings of the OEICs/UTs to obtain the 'true' managerial performance, there is virtually no difference in the results produced compared against the standalone case, suggesting that the variation in the performance of the OEICs/UTs is almost entirely due to differences in managerial performance between the funds. However, when the SORMSBM(CRS)-OO DEA model is utilised in the three-stage methodology, the results produced are significantly different compared against those from the standalone case, with almost all the OEICs/UTs and the benchmark iShares FTSE 100 ETF achieving the maximum efficiency rating of 1.000, thus suggesting that the variation in the performance of the OEICs/UTs is entirely explained by environmental factors and statistical noise/luck.

As previously mentioned, the most likely reason behind these contrasting results and opposing conclusions is the differing characterisation of the optimal adjustments of the inputs and outputs between the radial SORMCCR-OO model and the non-radial SORMSBM(CRS)-OO model. For this thesis, which focuses on the evaluation of the managerial performance of the OEICs/UTs, the most appropriate DEA model for utilisation appears to be the non-radial SORMSBM(CRS)-OO DEA model.

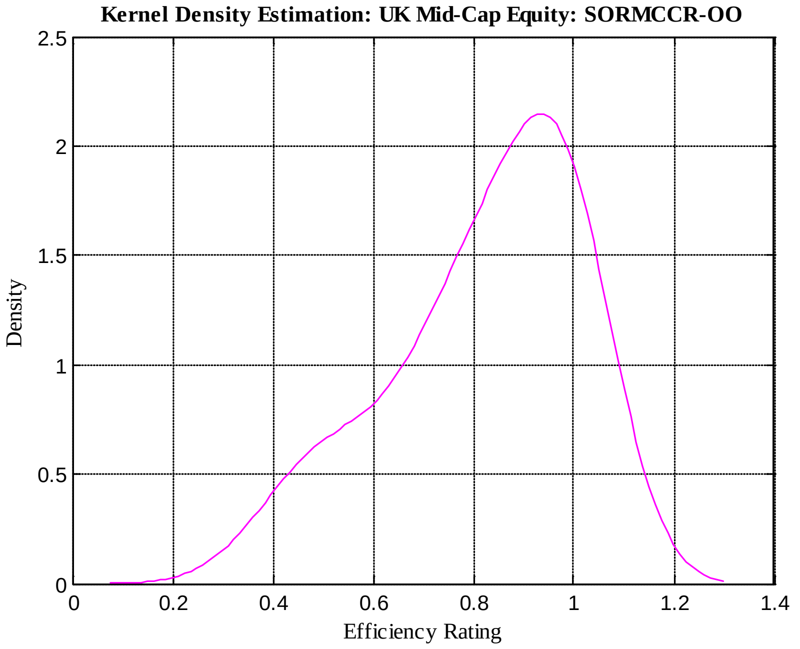
Therefore, after utilising the three-stage DEA-SFA-DEA model, in combination with the SORMSBM(CRS)-OO DEA model, to remove the effects of environmental factors and statistical noise/luck, the resulting conclusion is that the managers of the OEICs/UTs in this category fail to outperform the market return in the form of the relevant low-cost index tracker. Of the 130 OEICs/UTs in this category, 128 are ranked at the maximum efficiency rating of 1.000 along with the benchmark iShares FTSE 100 ETF, and the remaining two underperform the market index tracker.

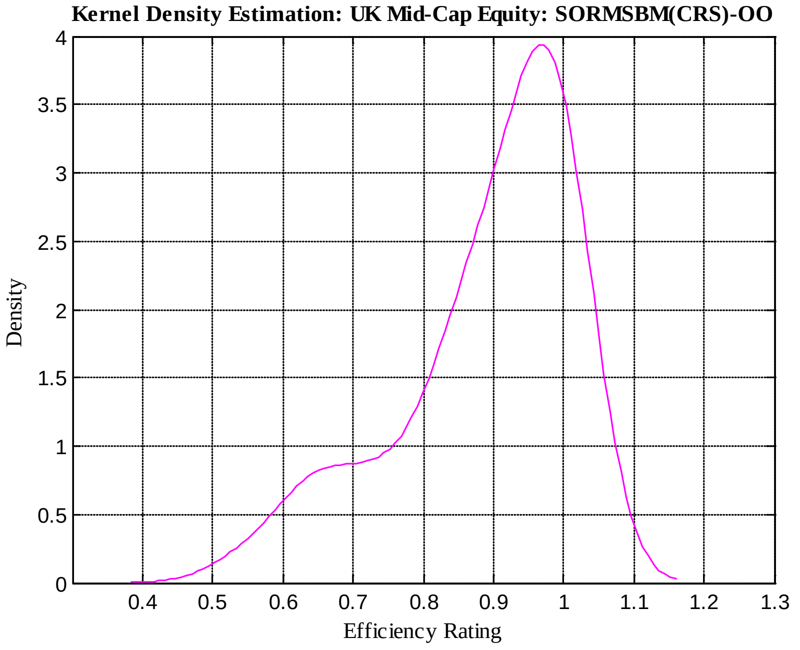
***UK Mid-Cap Equity (1st January 2008 – 31st December 2010)***

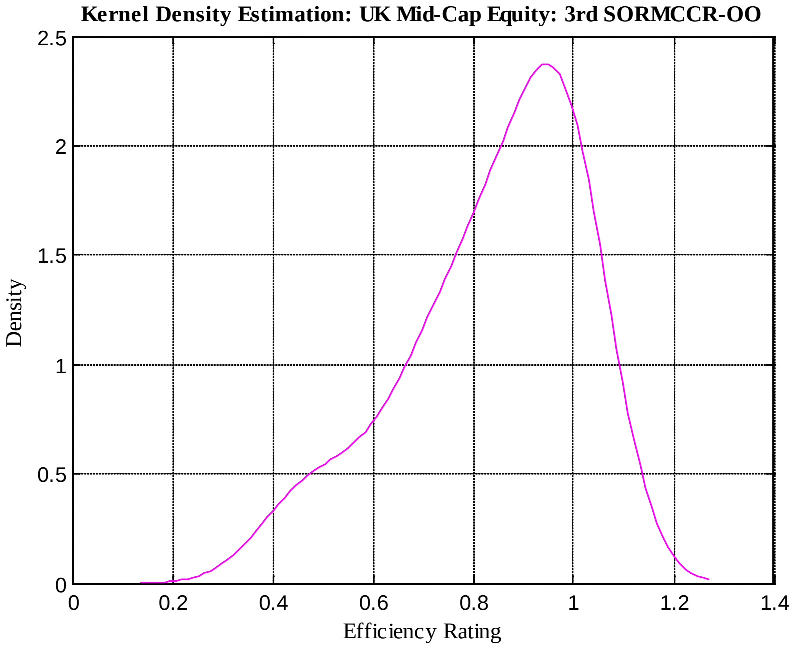
The detailed breakdown of the results from the individual OEICs/UTs in this category across both the two standalone DEA models and the two three-stage DEA-SFA-DEA models can be found in Results Appendix 4 Table RA4.4, with a summary of the results provided in the table below, along with a kernel density estimation graph for each of the four model variations.

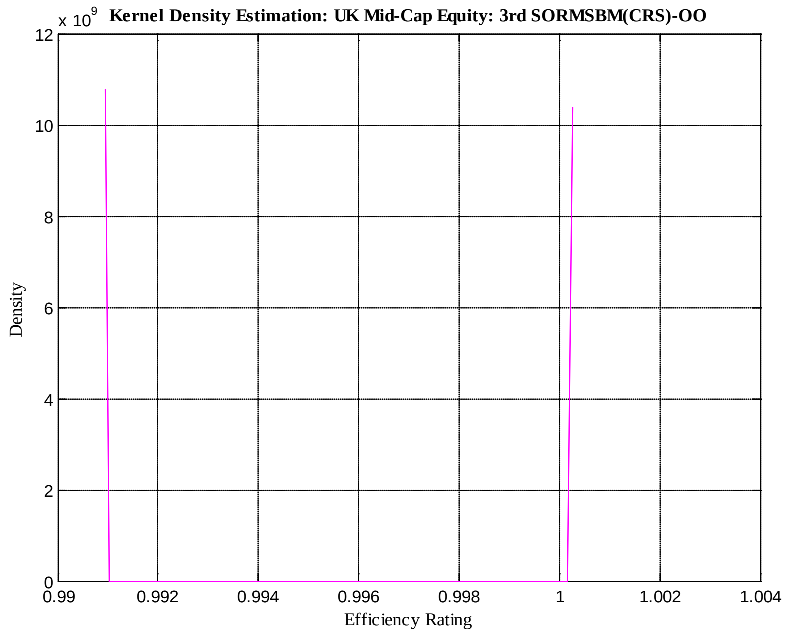
| Summary Results | SORMCCR-OO | Three-Stage SORMCCR-OO | SORMSBM-OO | Three-Stage SORMSBM-OO |
|---|---|---|---|---|
| **Maximum Efficiency Rating** (Number Of OEICs/UTs) | **1.000** (12) | **1.000** (12) | **1.000** (12) | **1.000** (30) |
| **Minimum Efficiency Rating** (Number Of OEICs/UTs) | **0.374** (1) | **0.408** (1) | **0.544** (1) | **0.991** (2) |
| **Mean Efficiency Rating** | **0.820** | **0.837** | **0.889** | **0.999** |
| **Standard Deviation Of Efficiency Ratings** | **0.183** | **0.171** | **0.124** | **0.002** |

| | | | | |
|---|---|---|---|---|
| **Number Of OEICs/UTs Outperforming The Benchmark ETF** | **0** (0.00%) | **0** (0.00%) | **0** (0.00%) | **0** (0.00%) |
| **Number Of OEICs/UTs Underperforming The Benchmark ETF** | **33** (73.33%) | **33** (73.33%) | **33** (73.33%) | **15** (33.33%) |






These results from the 45 UK mid-cap equity OEICs/UTs and the benchmark ETF, the iShares FTSE 250, provide a number of results that are worth highlighting. The results here show that when the SORMCCR-OO DEA model is used in the three-stage method to remove the effects of environmental factors and statistical noise to obtain the ‘true’ managerial performance, there is very little difference between the results that are produced and those from the standalone case, indicating that the majority of the variation in the performance of the OEICs/UTs is as a result of differences in the managerial performance between the funds. Yet when the SORMSBM(CRS)-OO DEA model is used instead in the three-stage DEA-SFA-DEA model, the results that are produced are very different to those produced in the standalone case, with 30 out of the 45 OEICs/UTs and the benchmark iShares FTSE 250 ETF obtaining the maximum efficiency rating of 1.000, indicating that the majority of the variation in the performance of the OEICs/UTs can be explained by environmental factors and statistical noise/luck.

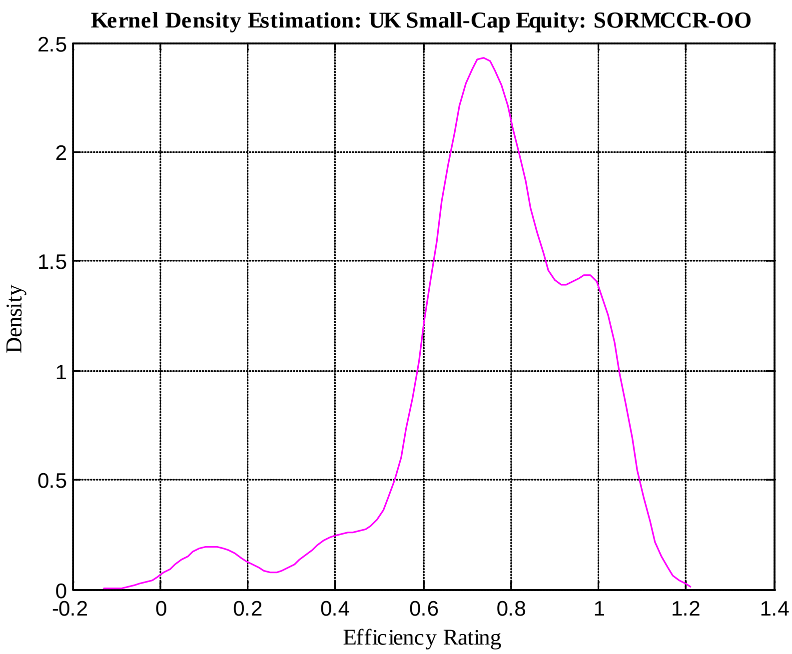
For this thesis, which is concerned with assessing the managerial performance of the OEICs/UTs, the non-radial SORMSBM(CRS) DEA model appears to be the most appropriate model to employ. As a consequence of this, after using the three-stage methodology with the SORMSBM(CRS)-OO DEA model to eliminate the influence of environmental factors and statistical noise/luck, the conclusion that can be drawn is that the managers of the OEICs/UTs in this category fail to outperform the low-cost index tracker, with 15 of the OEICs/UTs underperforming the market index tracker which mimics the return that can be earned from the relevant market index.

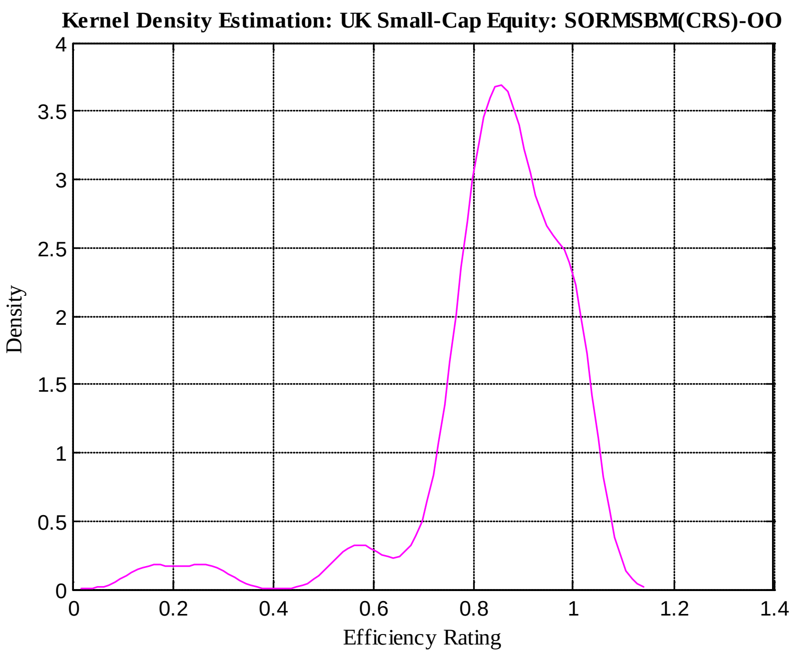
### *UK Small-Cap Equity (1st January 2008 – 31st December 2010)*

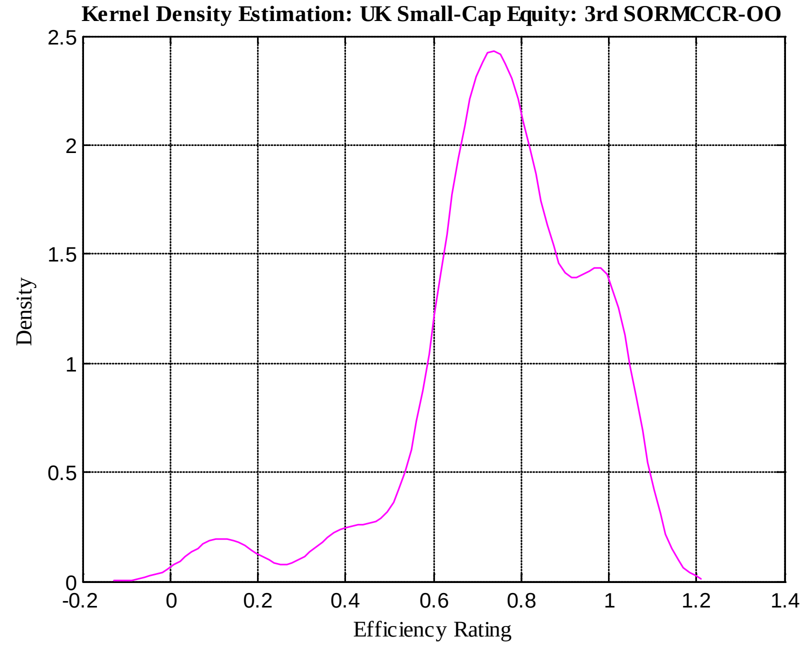
The detailed breakdown of the results from the individual OEICs/UTs in this category across both the two standalone DEA models and the two three-stage DEA-SFA-DEA models can be found in Results Appendix 4 Table RA4.5, with a summary of the results provided in the table below, along with a kernel density estimation graph for each of the four model variations.

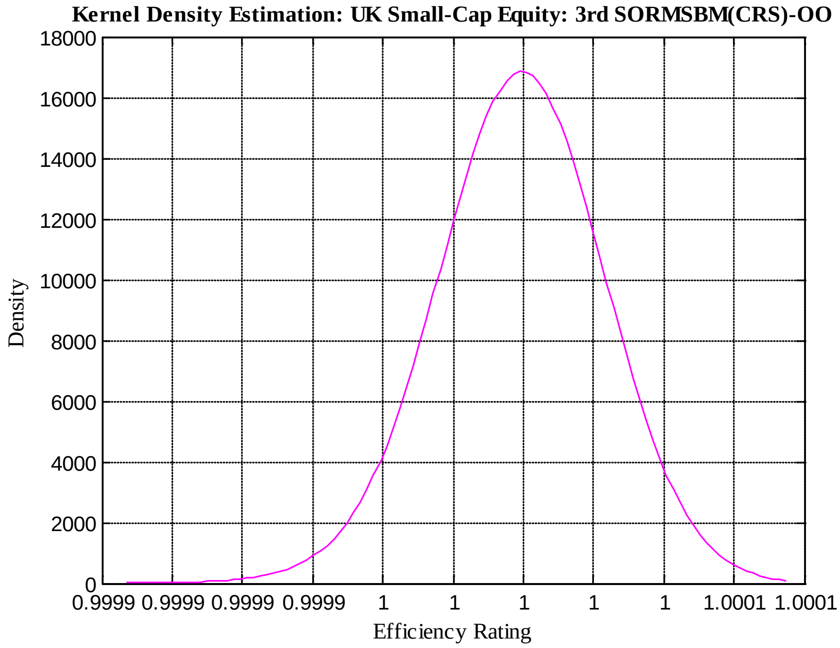
| Summary Results | SORMCCR-OO | Three-Stage SORMCCR-OO | SORMSBM-OO | Three-Stage SORMSBM-OO |
|---|---|---|---|---|
| **Maximum Efficiency Rating** (Number Of OEICs/UTs) | **1.000** (9) | **1.000** (9) | **1.000** (9) | **1.000** (50) |
| **Minimum Efficiency Rating** (Number Of OEICs/UTs) | **0.085** (1) | **0.085** (1) | **0.157** (1) | **1.000** (50) |

| | | | | |
|---|---|---|---|---|
| **Mean Efficiency Rating** | **0.758** | **0.758** | **0.845** | **1.000** |
| **Standard Deviation Of Efficiency Ratings** | **0.201** | **0.201** | **0.164** | **0.000** |
| **Number Of OEICs/UTs Outperforming The Benchmark ETF** | **0** (0.00%) | **0** (0.00%) | **0** (0.00%) | **0** (0.00%) |
| **Number Of OEICs/UTs Underperforming The Benchmark ETF** | **41** (82.00%) | **41** (82.00%) | **41** (82.00%) | **0** (0.00%) |






These results from the 50 UK small-cap equity OEICs/UTs and the benchmark ETF, the iShares FTSE 250, provide a number of results that are worth highlighting. The results for this category of OEIC/UT show that when the SORMCCR-OO DEA model is utilised in the three-stage methodology to remove the influence of environmental factors and statistical noise to find the ‘true’ managerial performance, there is no difference between the results that are obtained and those obtained from the standalone case, implying that almost all the variation in the performance of the

OEICs/UTs is as a result of differences in the managerial performance between the funds. They also show that when the SORMSBM(CRS)-OO DEA model is employed instead in the three-stage model, the results that are produced are significantly different to those produced from the related standalone DEA model, with all 50 of the OEICs/UTs and the benchmark iShares FTSE 250 ETF achieving the maximum efficiency rating of 1.000, thus implying that all of the variation in the performance of the OEICs/UTs can be explained by environmental factors and statistical noise/luck.

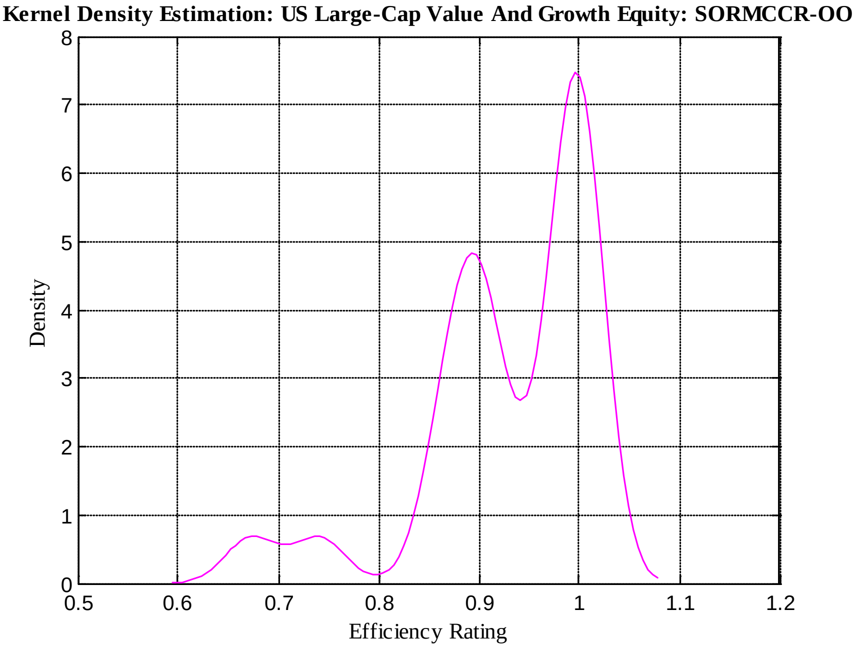
With regard to this thesis, which is tasked with assessing the managerial performance of the OEICs/UTs, the non-radial SORMSBM(CRS)-OO DEA model appears to be the most relevant model to utilise. Thus, after employing the three-stage method with the SORMSBM(CRS)-OO DEA model to eliminate the effects of environmental factors and statistical noise/luck, the conclusion that results is that the managers of the OEICs/UTs in this category are failing to outperform the low-cost index tracker, with all 50 of the OEICs/UTs appearing to replicate the performance of the market index tracker which mimics the return that can be earned from the relevant market index.

## 10.2: UK Domiciled OEICs And UTs With A US Investment Focus

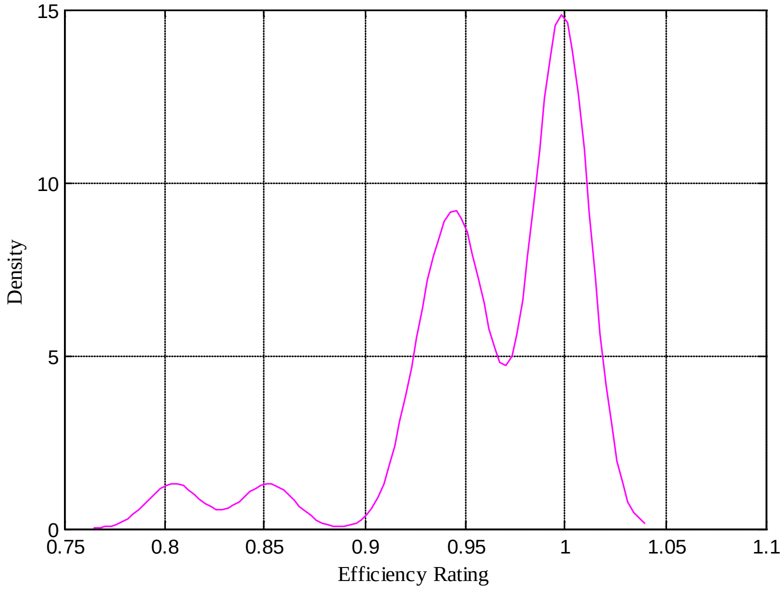
### *US Large-Cap Value And Growth Equity (1st January 2008 – 31st December 2010)*

The detailed breakdown of the results from the individual OEICs/UTs in this category across both the two standalone DEA models and the two three-stage DEA-SFA-DEA models can be found in Results Appendix 4 Table RA4.6, with a summary of the results provided in the table below, along with a kernel density estimation graph for each of the four model variations.

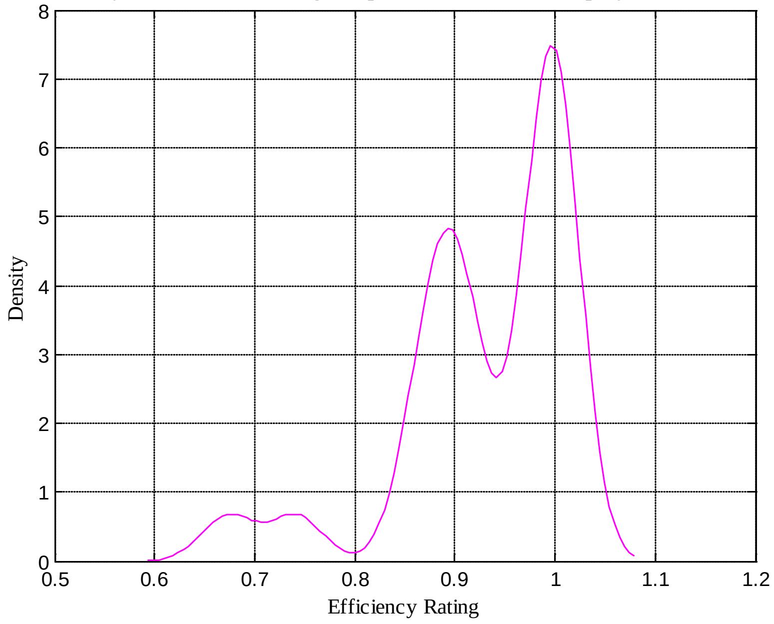
| Summary Results | SORMCCR-OO | Three-Stage SORMCCR-OO | SORMSBM-OO | Three-Stage SORMSBM-OO |
|---|---|---|---|---|
| **Maximum Efficiency Rating** (Number Of OEICs/UTs) | **1.000** (8) | **1.000** (8) | **1.000** (8) | **1.000** (22) |
| **Minimum Efficiency Rating** (Number Of OEICs/UTs) | **0.673** (1) | **0.673** (1) | **0.805** (1) | **1.000** (22) |
| **Mean Efficiency Rating** | **0.930** | **0.930** | **0.962** | **1.000** |
| **Standard Deviation Of Efficiency Ratings** | **0.088** | **0.088** | **0.051** | **0.000** |
| **Number Of OEICs/UTs Outperforming The Benchmark ETF** | **0** (0.00%) | **0** (0.00%) | **0** (0.00%) | **0** (0.00%) |
| **Number Of OEICs/UTs Underperforming The Benchmark ETF** | **14** (63.64%) | **14** (63.64%) | **14** (63.64%) | **0** (0.00%) |

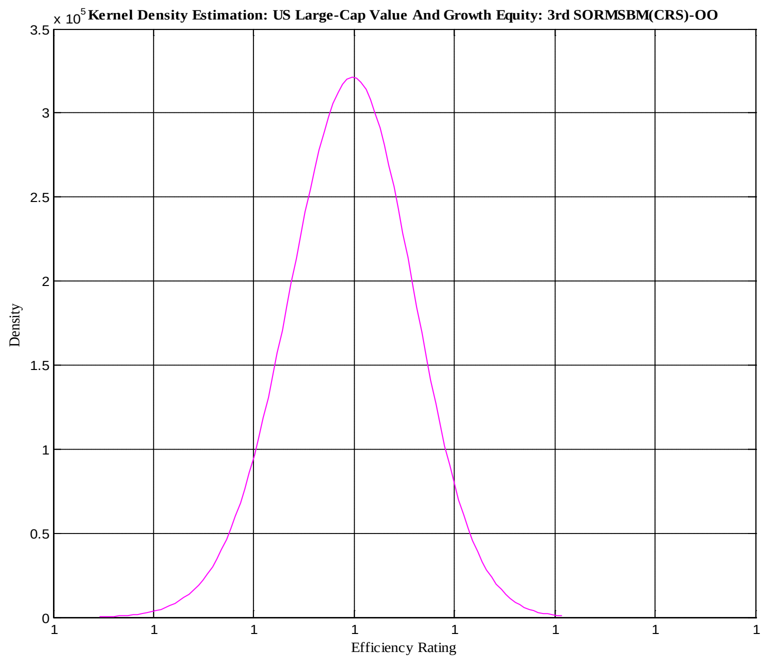


**Kernel Density Estimation: US Large-Cap Value And Growth Equity: SORMSBM(CRS)-OO**




**Kernel Density Estimation: US Large-Cap Value And Growth Equity: 3rd SORMCCR-OO**





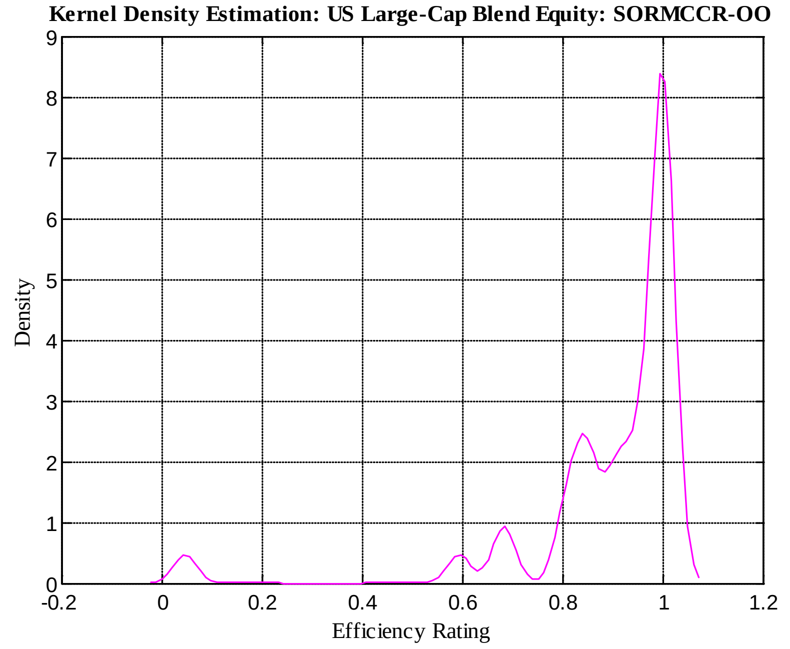

These results from the 22 US large-cap value and growth equity OEICs/UTs and the benchmark ETF, the iShares S&P 500, provide a number of results that are worth highlighting. The results for this category of OEIC/UT clearly show that when the SORMCCR-OO DEA model is used in the three-stage methodology to eliminate the influence of environmental factors and statistical noise to find the ‘true’ managerial performance, there is no difference in the results produced compared against those produced from the standalone DEA model, again suggesting that the variation in the performance of the OEICs/UTs is almost entirely down to differences in managerial performance between the funds. Furthermore, the results also show that when the SORMSBM(CRS)-OO DEA model is used in the three-stage methodology, there is a significant difference between the results that are obtained and those obtained from the standalone case, with all 22 of the OEICs/UTs and the benchmark iShares S&P 500 ETF being rated at the maximum efficiency rating of 1.000, again suggesting that all the variation in the performance of the OEICs/UTs can be explained by the effects of environmental factors and statistical noise/luck.

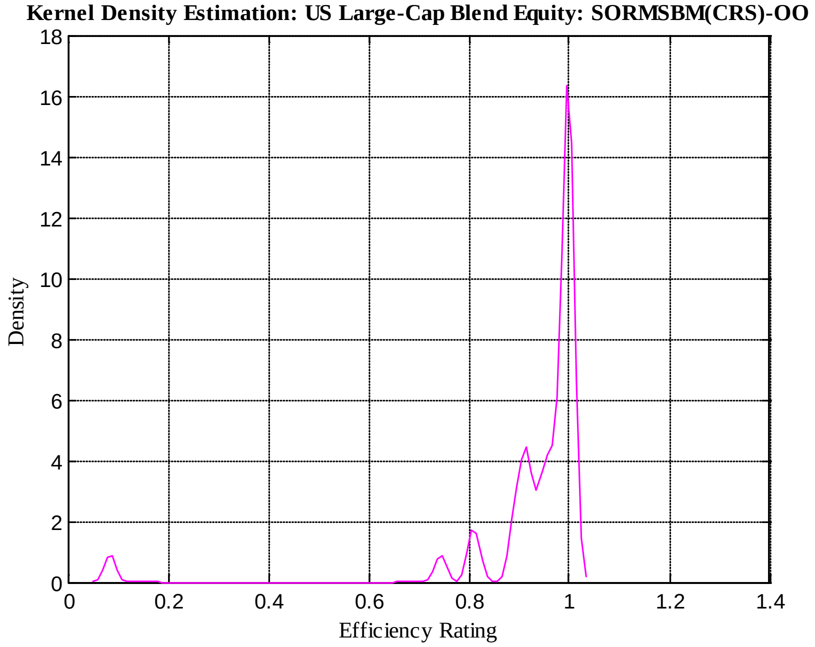
Again, the SORMSBM(CRS)-OO DEA model appears to be the most appropriate DEA model to utilise in the three-stage model. So therefore, after removing the effects of environmental factors and statistical noise/luck by using the three-stage DEA-SFA-DEA model methodology, combined with the SORMSBM(CRS)-OO DEA model, the conclusion drawn is that the managers of the OEICs/UTs in this category are unable to beat the performance of the low-cost market index tracker.

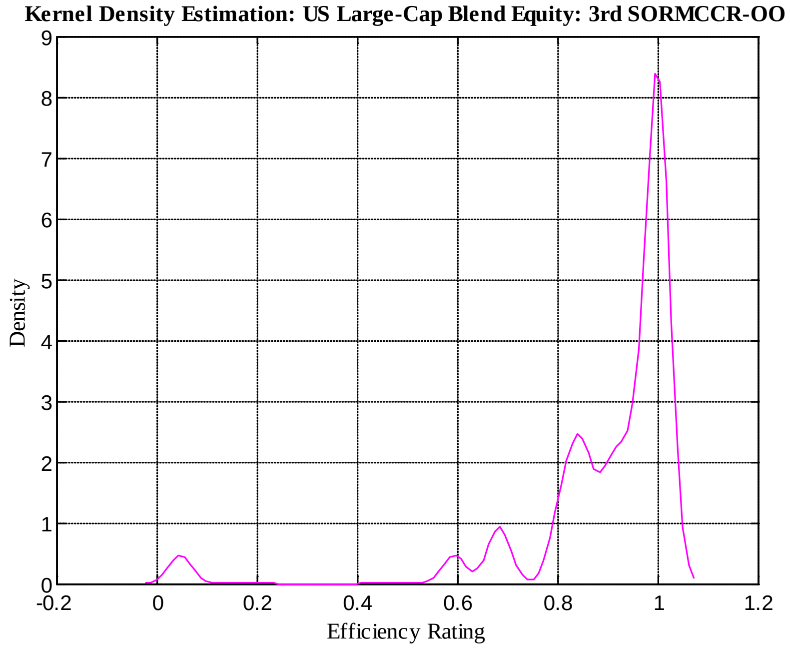
***US Large-Cap Blend Equity (1st January 2008 – 31st December 2010)***

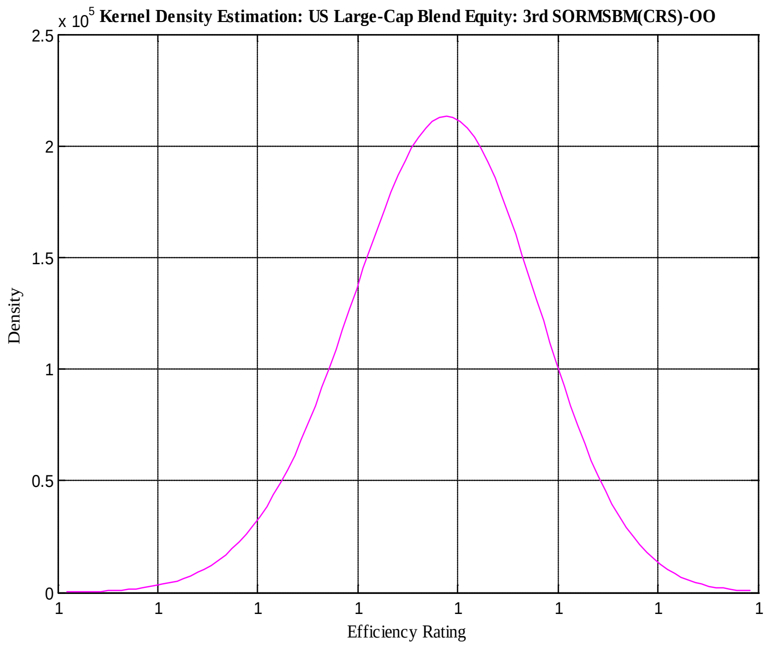
The detailed breakdown of the results from the individual OEICs/UTs in this category across both the two standalone DEA models and the two three-stage DEA-SFA-DEA models can be found in Results Appendix 4 Table RA4.7, with a summary of the results provided in the table below, along with a kernel density estimation graph for each of the four model variations.

| Summary Results | SORMCCR-OO | Three-Stage SORMCCR-OO | SORMSBM-OO | Three-Stage SORMSBM-OO |
|---|---|---|---|---|
| **Maximum Efficiency Rating** (Number Of OEICs/UTs) | **1.000** (14) | **1.000** (14) | **1.000** (15) | **1.000** (36) |
| **Minimum Efficiency Rating** (Number Of OEICs/UTs) | **0.044** (1) | **0.044** (1) | **0.084** (1) | **1.000** (36) |
| **Mean Efficiency Rating** | **0.897** | **0.897** | **0.932** | **1.000** |
| **Standard Deviation Of Efficiency Ratings** | **0.178** | **0.178** | **0.156** | **0.000** |
| **Number Of OEICs/UTs Outperforming The Benchmark ETF** | **29** (80.56%) | **29** (80.56%) | **29** (80.56%) | **0** (0.00%) |
| **Number Of OEICs/UTs Underperforming The Benchmark ETF** | **7** (19.44%) | **7** (19.44%) | **7** (19.44%) | **0** (0.00%) |


Kernel Density Estimation: US Large-Cap Blend Equity: SORMCCR-OO
Density
Efficiency Rating
9
8
7
6
5
4
3
2
1
0
-0.2
0
0.2
0.4
0.6
0.8
1
1.2


Kernel Density Estimation: US Large-Cap Blend Equity: SORMSBM(CRS)-OO
Density
Efficiency Rating
18
16
14
12
10
8
6
4
2
0
0
0.2
0.4
0.6
0.8
1
1.2
1.4



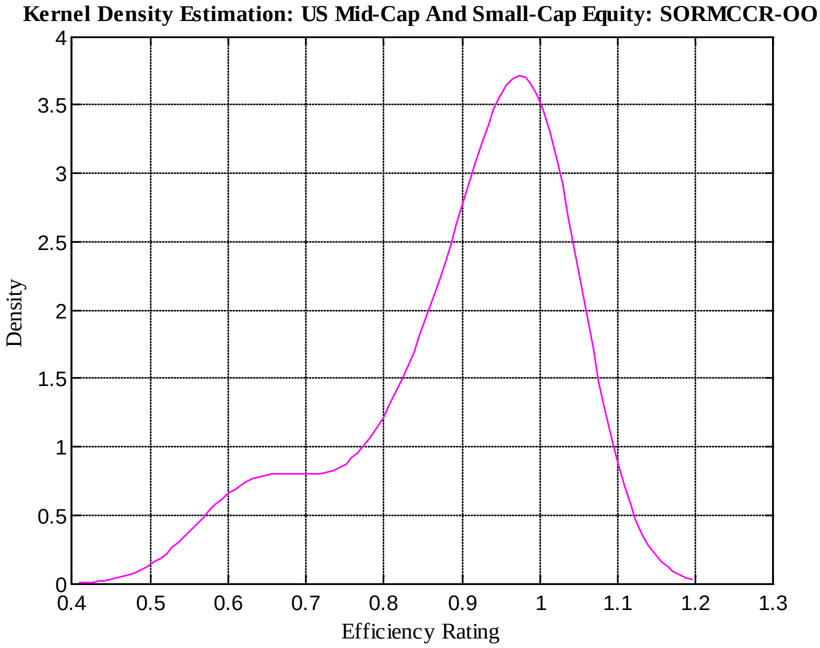

These results from the 36 US large-cap blend equity OEICs/UTs and the benchmark ETF, the iShares S&P 500, provide a number of results that are worth highlighting. The results for the OEICs/UTs in this category indicate that when the SORMCCR-OO DEA model is utilised in the three-stage DEA-SFA-DEA model to eliminate the influence of environmental factors and statistical noise to obtain the 'true' managerial performance, there is no difference between the results obtained and those obtained from the standalone DEA model, suggesting that the variation in the performance of the OEICs/UTs is due to differences in the managerial performance between funds. This is contrasted against the results for the OEICs/UTs in this category when the SORMSBM(CRS)-OO DEA model is used in the three-stage model where there is a significant difference between the results produced here and those produced from the standalone DEA model, with all 36 of the OEICs/UTs and the benchmark iShares S&P 500 ETF achieving the maximum efficiency rating of 1.000, suggesting that all the variation in the performance of the OEICs/UTs can be attributed to environmental factors and statistical noise/luck.

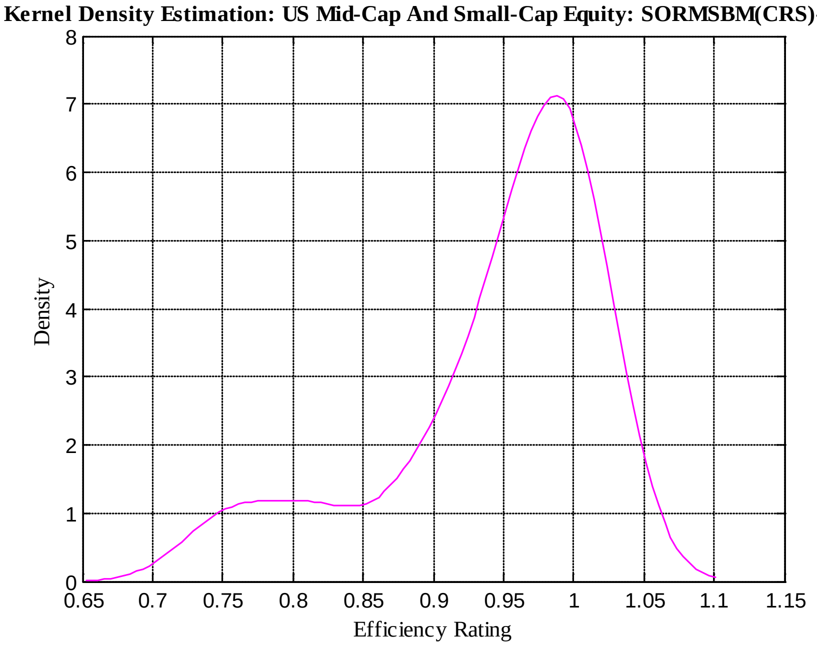
It is likely that the cause of these contrasting conclusions depending on which of the two DEA models is used is due to the way the two models treat the optimal adjustments of the inputs and outputs, either as being radial in the SORMCCR-OO case or non-radial in the SORMSBM(CRS)-OO case. For this thesis which is concerned with evaluating the managerial performance of the OEICs/UTs, the non-radial SORMSBM(CRS)-OO DEA model appears the more appropriate model for use. Thus, the conclusion to be drawn after the three-stage DEA-SFA-DEA model, in combination with the SORMSBM(CRS)-OO DEA model, has been used to remove the effects of environmental factors and statistical noise/luck, is that the managers of the OEICs/UTs in this category fail to outperform the low-cost market index tracker, with all 36 of the OEICs/UTs appearing to replicate the performance of the market index tracker which mimics the return that can be earned from the relevant market index.

***US Mid-Cap And Small-Cap Equity (1st January 2008 – 31st December 2010)***

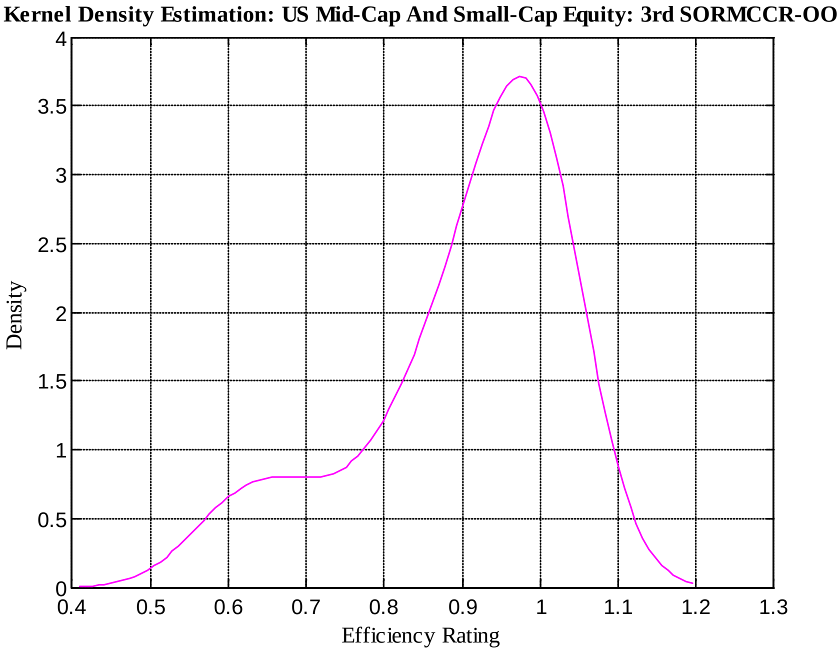
The detailed breakdown of the results from the individual OEICs/UTs in this category across both the two standalone DEA models and the two three-stage DEA-SFA-DEA models can be found in Results Appendix 4 Table RA4.8, with a summary of the results provided in the table below, along with a kernel density estimation graph for each of the four model variations.

| Summary Results | SORMCCR-OO | Three-Stage SORMCCR-OO | SORMSBM-OO | Three-Stage SORMSBM-OO |
|---|---|---|---|---|
| **Maximum Efficiency Rating** (Number Of OEICs/UTs) | **1.000** (4) | **1.000** (4) | **1.000** (4) | **1.000** (12) |
| **Minimum Efficiency Rating** (Number Of OEICs/UTs) | **0.604** (1) | **0.604** (1) | **0.753** (1) | **1.000** (12) |
| **Mean Efficiency Rating** | **0.900** | **0.900** | **0.942** | **1.000** |
| **Standard Deviation Of Efficiency Ratings** | **0.130** | **0.130** | **0.079** | **0.000** |
| **Number Of OEICs/UTs Outperforming The Benchmark ETF** | **0** (0.00%) | **0** (0.00%) | **0** (0.00%) | **0** (0.00%) |
| **Number Of OEICs/UTs Underperforming The Benchmark ETF** | **8** (66.67%) | **8** (66.67%) | **8** (66.67%) | **0** (0.00%) |

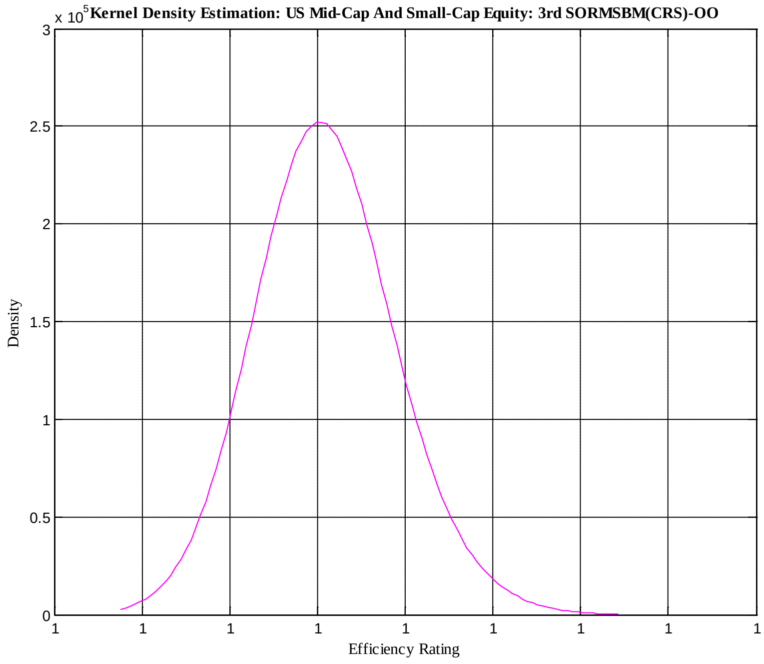




Kernel Density Estimation: US Mid-Cap And Small-Cap Equity: SORMSBM(CRS)-OO
Density
Efficiency Rating
0
1
2
3
4
5
6
7
8
0.65
0.7
0.75
0.8
0.85
0.9
0.95
1
1.05
1.1
1.15

Kernel Density Estimation: US Mid-Cap And Small-Cap Equity: 3rd SORMCCR-OO
Density
Efficiency Rating
0
0.5
1
1.5
2
2.5
3
3.5
4
0.4
0.5
0.6
0.7
0.8
0.9
1
1.1
1.2
1.3




These results from the 12 US mid-cap and small-cap equity OEICs/UTs and the benchmark ETF, the iShares S&P 500, provide a number of results that are worth highlighting. The results for this category of OEIC/UT show that when the three-stage DEA-SFA-DEA model is utilised, with the SORMCCR-OO DEA model as the corresponding DEA model, to remove the influence of environmental factors and statistical noise to find the 'true' managerial performance, there is no difference between the results obtained and those obtained from the standalone DEA model, implying that the variation in the performance of the OEICs/UTs is caused entirely by differences in the managerial performance between funds. However, they also show that when the three-stage DEA-SFA-DEA model is used, with the SORMSBM(CRS)-OO DEA model as the corresponding DEA model, there are marked differences in the results produced compared to those from the standalone DEA model, with all 12 of the OEICs/UTs and the benchmark iShares S&P 500 ETF obtaining the maximum efficiency rating of 1.000, implying that all of the variation in the performance of the OEICs/UTs can be attributed to environmental factors and statistical noise/luck.

For the purposes of this thesis which assesses the managerial performance of OEICs/UTs, the non-radial SORMSBM(CRS)-OO DEA model is likely to be the most appropriate model to use. Therefore, after employing the SORMSBM(CRS)-OO DEA model within the three-stage DEA-SFA-DEA methodology to remove the effects of environmental factors and statistical noise/luck, the conclusion that can be drawn for the OEICs/UTs in this category is that the managers of these OEICs/UTs are unable to outperform the low-cost market index tracker.

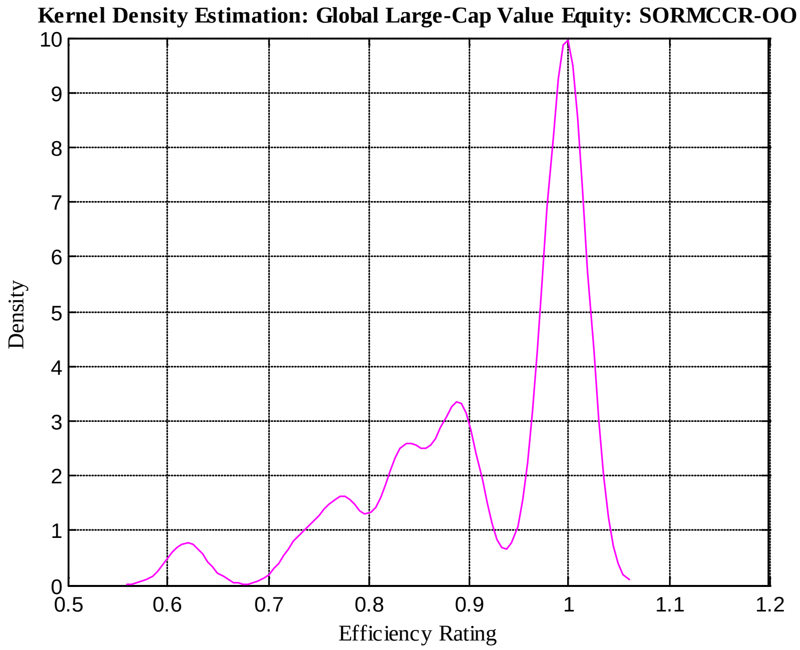
## *10.3: UK Domiciled OEICs And UTs With A Global Investment Focus*

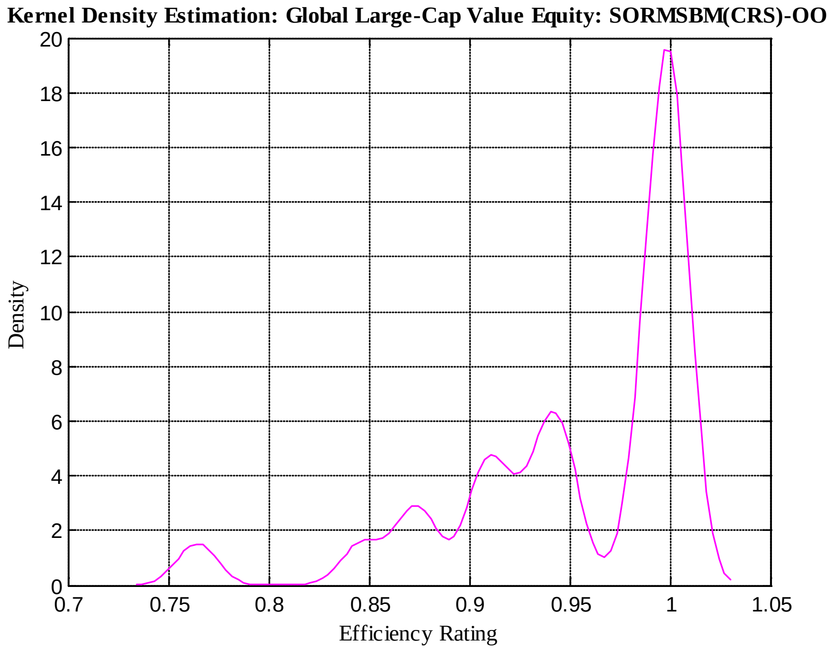
### *Global Large-Cap Value Equity (1st January 2008 – 31st December 2010)*

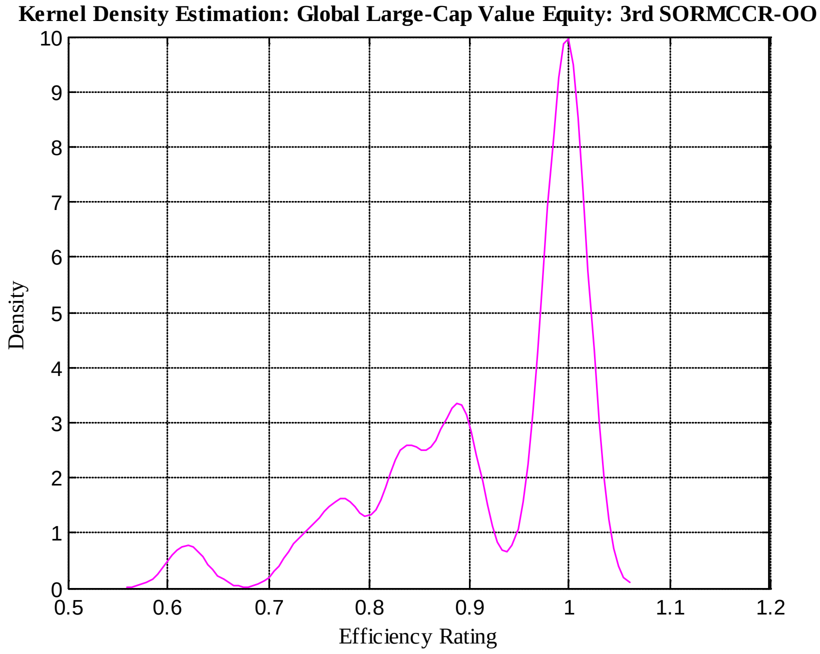
The detailed breakdown of the results from the individual OEICs/UTs in this category across both the two standalone DEA models and the two three-stage DEA-SFA-DEA models can be found in Results Appendix 4 Table RA4.9, with a summary of the results provided in the table below, along with a kernel density estimation graph for each of the four model variations.

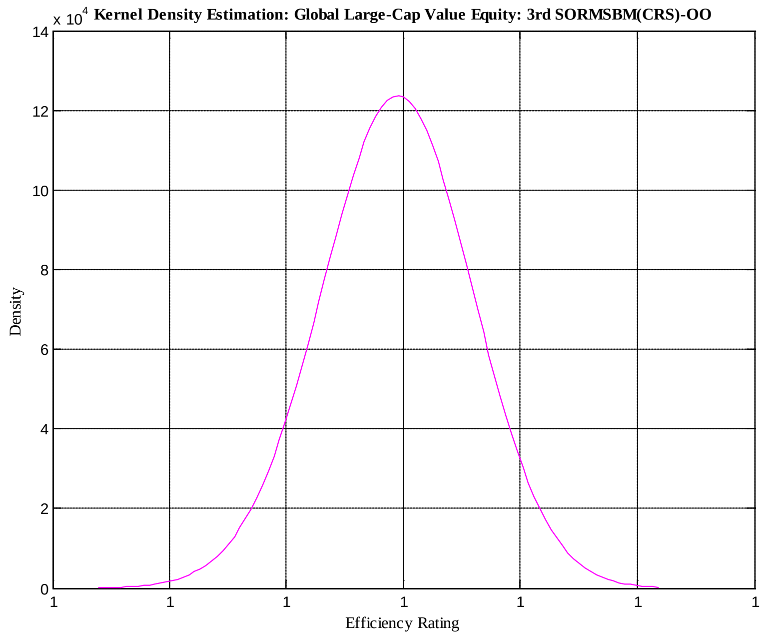
| Summary Results | SORMCCR-OO | Three-Stage SORMCCR-OO | SORMSBM-OO | Three Stage SORMSBM-OO |
|---|---|---|---|---|
| **Maximum Efficiency Rating** (Number Of OEICs/UTs) | **1.000** (11) | **1.000** (11) | **1.000** (11) | **1.000** (25) |
| **Minimum Efficiency Rating** (Number Of OEICs/UTs) | **0.619** (1) | **0.619** (1) | **0.764** (1) | **1.000** (25) |
| **Mean Efficiency Rating** | **0.915** | **0.915** | **0.952** | **1.000** |
| **Standard Deviation Of Efficiency Ratings** | **0.105** | **0.105** | **0.062** | **0.000** |
| **Number Of OEICs/UTs Outperforming The Benchmark ETF** | **24** (96.00%) | **24** (96.00%) | **24** (96.00%) | **0** (0.00%) |

| | | | | |
|---|---|---|---|---|
| **Number Of OEICs/UTs Underperforming The Benchmark ETF** | **1** (4.00%) | **1** (4.00%) | **1** (4.00%) | **0** (0.00%) |






These results from the 25 global large-cap value equity OEICs/UTs and the benchmark ETF, the iShares MSCI World, provide a number of results that are worth highlighting. The results indicate that when the SORMCCR-OO DEA model is utilised in the three-stage DEA-SFA-DEA model to remove the influence of environmental factors and statistical noise from the efficiency ratings for the OEICs/UTs in this category to ascertain the 'true' managerial performance, there is no difference between the efficiency ratings obtained and those obtained from the related standalone

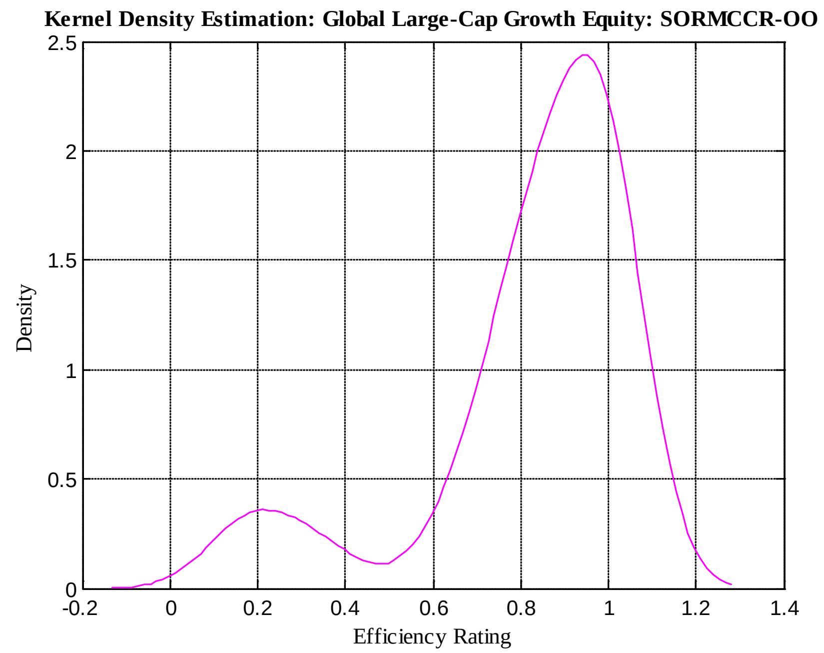
DEA model, suggesting that the variation in the performance of the OEICs/UTs is entirely resulting from differences in the managerial performance between the funds. In contrast to this are the results from the case when the three-stage model utilises the SORMSBM(CRS)-OO DEA model where the efficiency ratings are markedly different to those obtained from the standalone DEA model, with all 25 of the OEICs/UTs and the benchmark iShares MSCI World ETF being evaluated as attaining the maximum efficiency rating of 1.000, suggesting that the variation in the performance of the OEICs/UTs is explained in its entirety by environmental factors and statistical noise/luck.

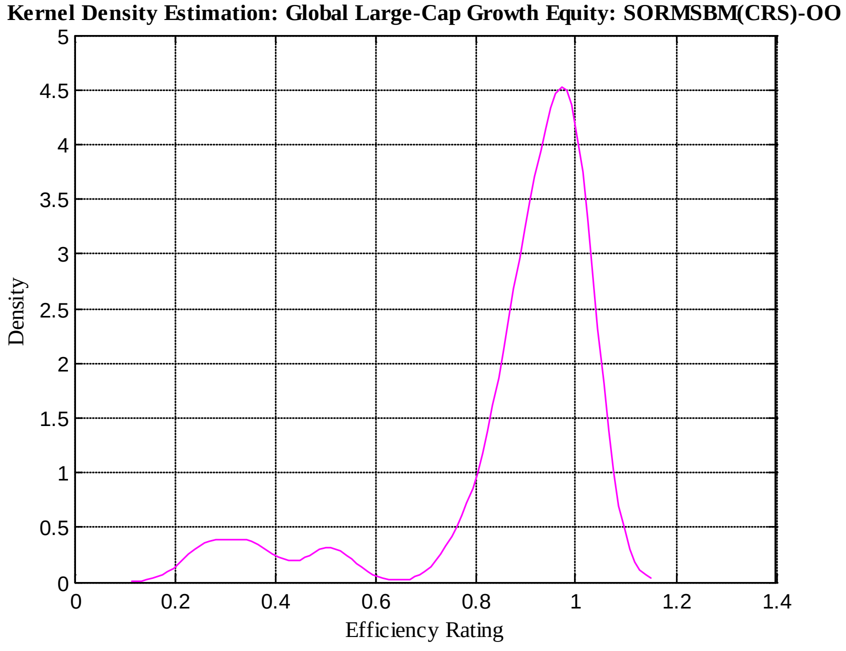
As with the previous categories of OEICs/UTs analysed, the most plausible explanation for these opposing conclusions from the three-stage DEA-SFA-DEA model depending on which of the two DEA models is used within it, is that they are caused by the differing characterisation of the optimal adjustments of the inputs and outputs between the radial SORMCCR-OO model and the non-radial SORMSBM(CRS)-OO model. In terms of this thesis which is concerned with evaluating the managerial performance of the OEICs/UTs, the most appropriate DEA model for use in the three-stage model appears to be the non-radial SORMSBM(CRS)-OO DEA model. So the resulting conclusion that can be drawn after using the three-stage approach with the SORMSBM(CRS)-OO DEA model to remove the effects of environmental factors and statistical noise/luck from the efficiency ratings of the OEICs/UTs in this category is that their managers are failing to outperform the market in terms of the low-cost market index tracker.

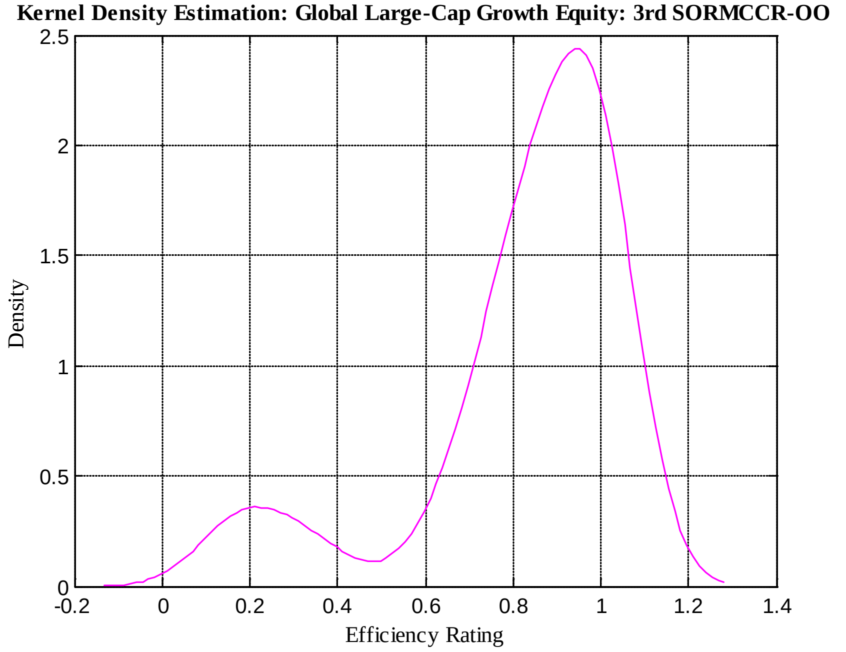
### *Global Large-Cap Growth Equity (1st January 2008 – 31st December 2010)*

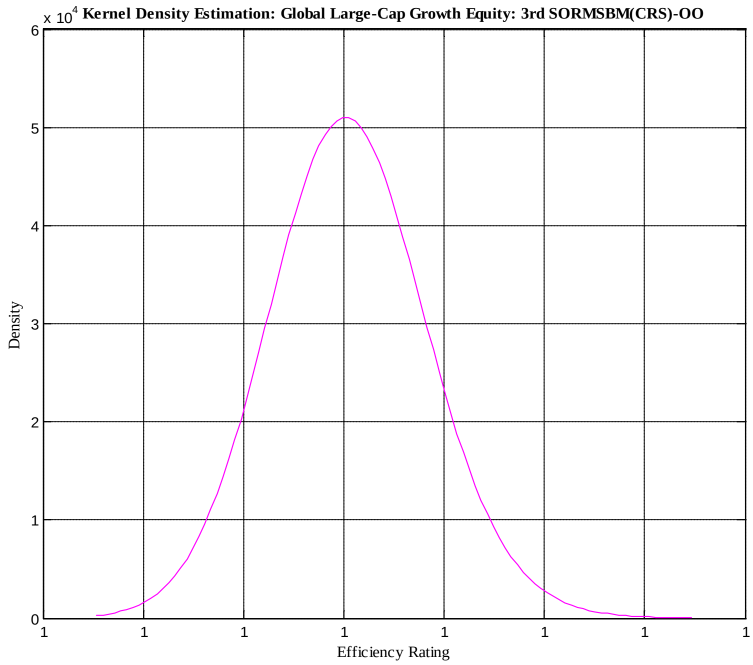
The detailed breakdown of the results from the individual OEICs/UTs in this category across both the two standalone DEA models and the two three-stage DEA-SFA-DEA models can be found in Results Appendix 4 Table RA4.10, with a summary of the results provided in the table below, along with a kernel density estimation graph for each of the four model variations.

| Summary Results | SORMCCR-OO | Three-Stage SORMCCR-OO | SORMSBM-OO | Three-Stage SORMSBM-OO |
|---|---|---|---|---|
| **Maximum Efficiency Rating** (Number Of OEICs/UTs) | **1.000** (9) | **1.000** (9) | **1.000** (9) | **1.000** (25) |
| **Minimum Efficiency Rating** (Number Of OEICs/UTs) | **0.151** (1) | **0.151** (1) | **0.263** (1) | **1.000** (25) |
| **Mean Efficiency Rating** | **0.822** | **0.822** | **0.878** | **1.000** |
| **Standard Deviation Of Efficiency Ratings** | **0.240** | **0.240** | **0.197** | **0.000** |
| **Number Of OEICs/UTs Outperforming The Benchmark ETF** | **15** (60.00%) | **15** (60.00%) | **15** (60.00%) | **0** (0.00%) |
| **Number Of OEICs/UTs Underperforming The Benchmark ETF** | **10** (40.00%) | **10** (40.00%) | **10** (40.00%) | **0** (0.00%) |




Kernel Density Estimation: Global Large-Cap Growth Equity: SORMSBM(CRS)-OO
Density
Efficiency Rating
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
0.2
0.4
0.6
0.8
1.2
1.4


Kernel Density Estimation: Global Large-Cap Growth Equity: 3rd SORMCCR-OO
Density
Efficiency Rating
0
0.5
1
1.5
2
2.5
-0.2
0.2
0.4
0.6
0.8
1.2
1.4




These results from the 25 global large-cap growth equity OEICs/UTs and the benchmark ETF, the iShares MSCI World, provide a number of results that are worth highlighting. The efficiency ratings results produced for the OEICs/UTs in this category show that when the SORMCCR-OO DEA model is used in the three-stage DEA-SFA-DEA model to remove the effects of environmental factors and statistical noise from the efficiency ratings for the OEICs/UTs to obtain the 'true' managerial performance, there is no difference in the efficiency ratings results produced compared to those from the standalone DEA model, implying that the variation seen in the performance of the OEICs/UTs is entirely caused by differences in the managerial performance between the funds. Yet when the DEA model used in the three-stage DEA-SFA-DEA methodology is switched to the SORMSBM(CRS)-OO DEA model, the efficiency ratings results produced for the OEICs/UTs are significantly different to those obtained from the standalone DEA model, with all 25 of the OEICs/UTs and the benchmark iShares MSCI World ETF attaining the maximum efficiency rating of 1.000 under evaluation, implying that the variation in the performance of the OEICs/UTs can be entirely explained by environmental factors and statistical noise/luck.

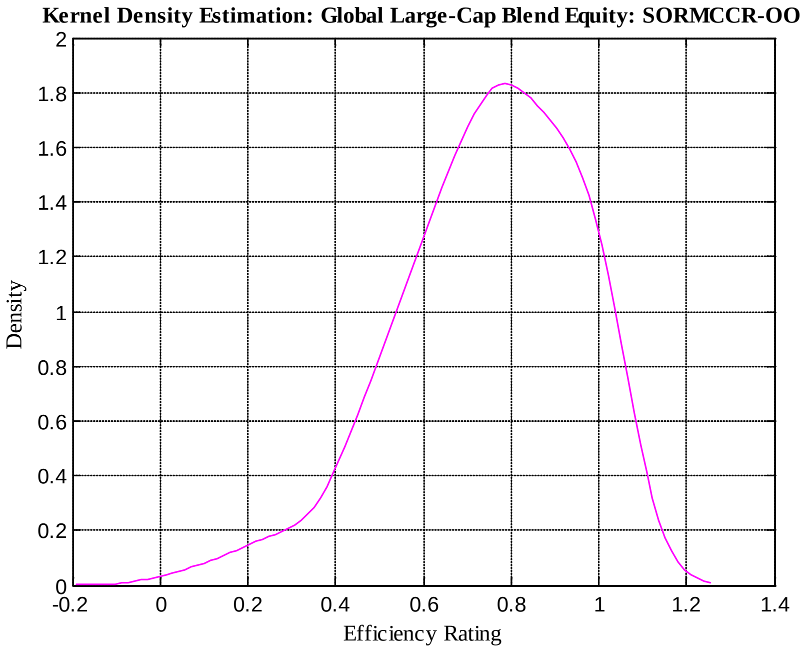
For this thesis, which is focused on assessing the managerial performance of the OEICs/UTs, the most appropriate DEA model for use in the three-stage DEA-SFA-DEA model seems likely to be the non-radial SORMSBM(CRS)-OO DEA model. Thus, from utilising the three-stage DEA-SFA-DEA model, in combination with the SORMSBM(CRS)-OO DEA model, to remove the effects of environmental factors and statistical noise/luck from the efficiency ratings for the OEICs/UTs in this category, the conclusion that results is that the managers of these OEICs/UTs are unable to outperform the return from the low-cost market index tracker, with all 25 of the OEICs/UTs appearing to replicate the performance of the market index tracker which mimics the return that can be earned from the relevant market index.

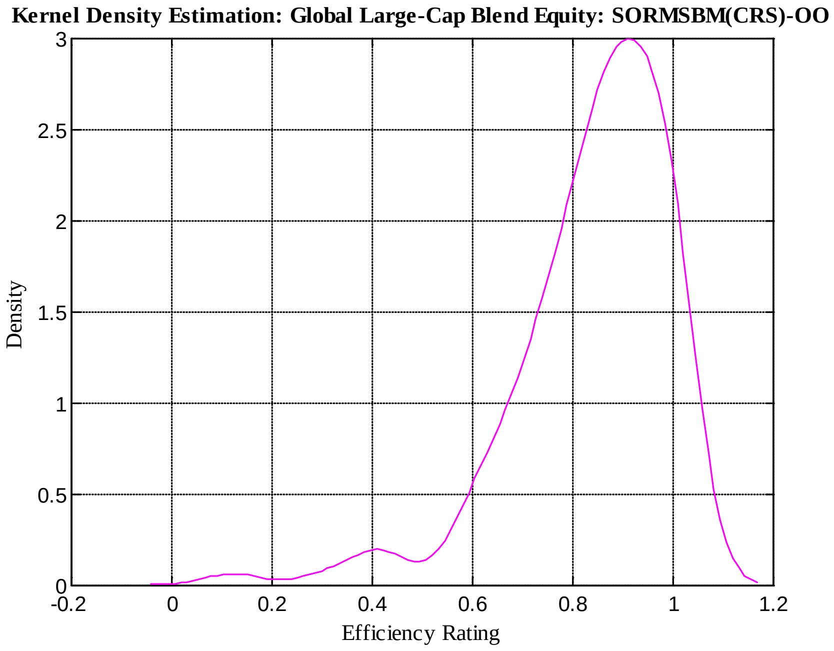
***Global Large-Cap Blend Equity (1st January 2008 – 31st December 2010)***

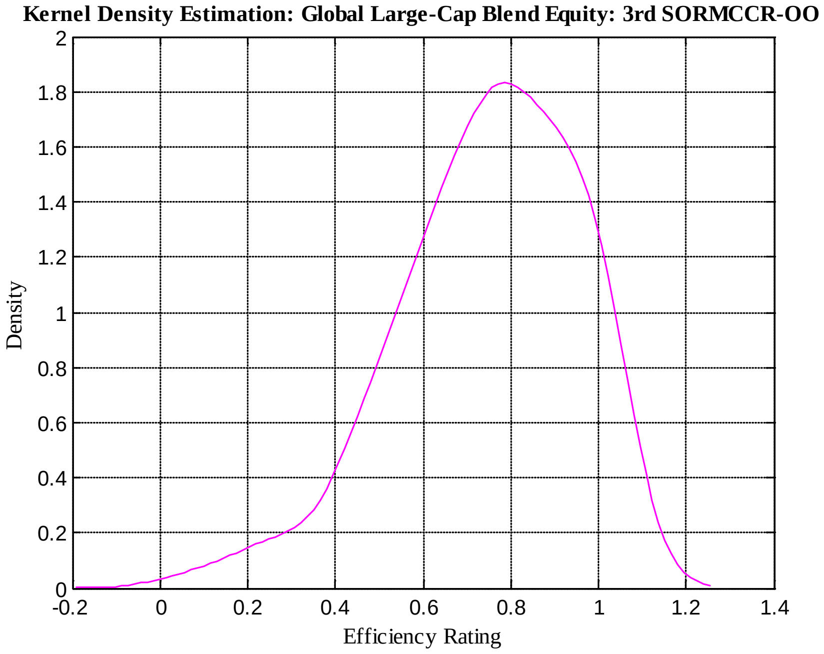
The detailed breakdown of the results from the individual OEICs/UTs in this category across both the two standalone DEA models and the two three-stage DEA-SFA-DEA models can be found in Results Appendix 4 Table RA4.11, with a summary of the results provided in the table below, along with a kernel density estimation graph for each of the four model variations.

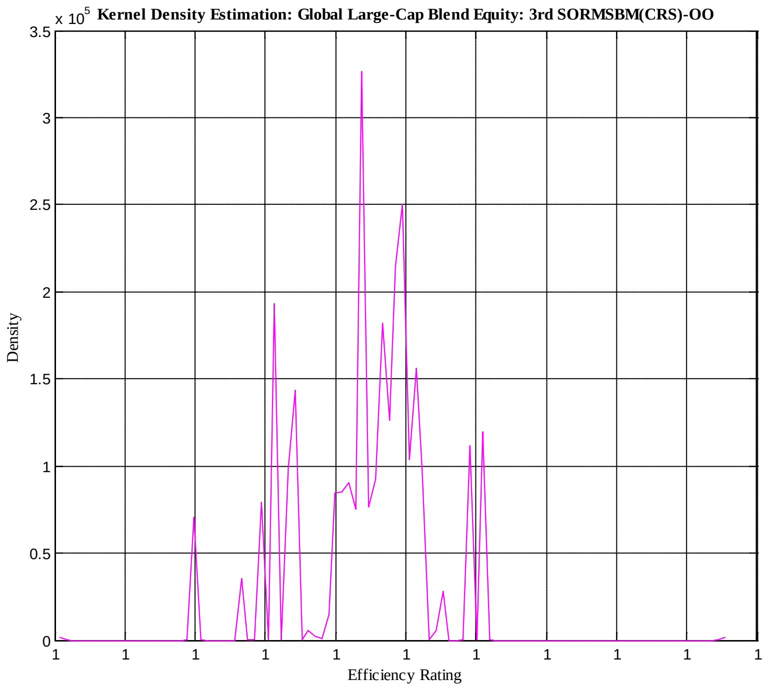
| Summary Results | SORMCCR-OO | Three-Stage SORMCCR-OO | SORMSBM-OO | Three-Stage SORMSBM-OO |
|---|---|---|---|---|
| **Maximum Efficiency Rating** (Number Of OEICs/UTs) | **1.000** (18) | **1.000** (18) | **1.000** (18) | **1.000** (118) |
| **Minimum Efficiency Rating** (Number Of OEICs/UTs) | **0.064** (1) | **0.064** (1) | **0.121** (1) | **1.000** (118) |
| **Mean Efficiency Rating** | **0.746** | **0.746** | **0.837** | **1.000** |
| **Standard Deviation Of Efficiency Ratings** | **0.201** | **0.201** | **0.155** | **0.000** |
| **Number Of OEICs/UTs Outperforming The Benchmark ETF** | **54** (45.76%) | **54** (45.76%) | **51** (43.22%) | **0** (0.00%) |

| | | | | |
|---|---|---|---|---|
| **Number Of OEICs/UTs Underperforming The Benchmark ETF** | **64** (54.24%) | **64** (54.24%) | **64** (54.24%) | **0** (0.00%) |





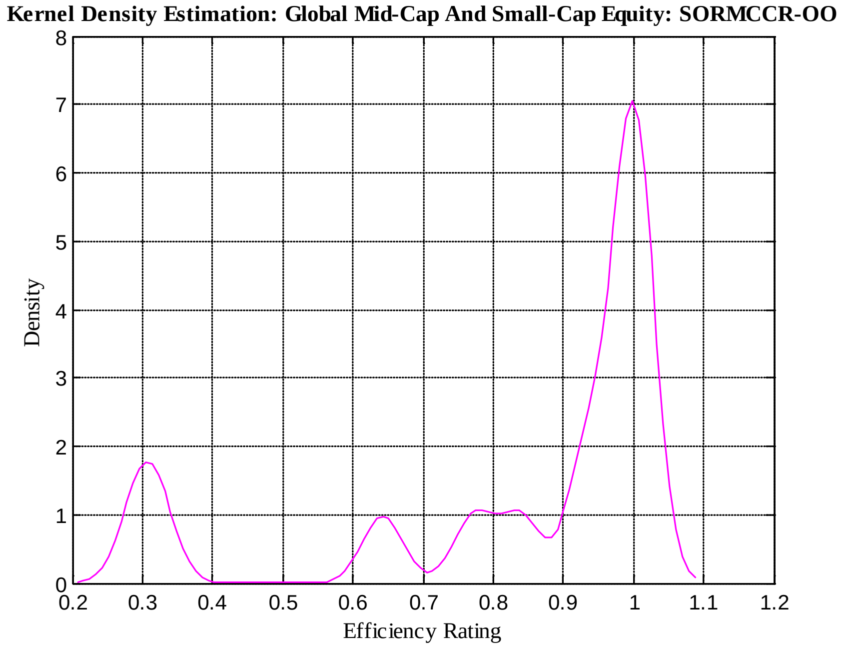

These results from the 118 global large-cap blend equity OEICs/UTs and the benchmark ETF, the iShares MSCI World, provide a number of results that are worth highlighting. The efficiency ratings results for the OEICs/UTs in this category indicate that when the three-stage DEA-SFA-DEA model, combined with the SORMCCR-OO DEA model, is employed to eliminate the influence of environmental factors and statistical noise from the OEIC/UT efficiency ratings to obtain the ‘true’ managerial performance, there is no difference in the efficiency ratings results that are produced compared against those obtained from the standalone DEA model, thus implying that the variation seen in the performance of the OEICs/UTs is caused in its entirety by differences in the managerial performance between the funds. However, this is in contrast to the efficiency ratings results for the OEICs/UTs in this category that are produced when the DEA model utilised in the three-stage DEA-SFA-DEA model is switched to the SORMSBM(CRS)-OO DEA model, where the efficiency ratings are markedly different to those obtained from the corresponding standalone DEA model, with all 118 of the OEICs/UTs and the benchmark iShares MSCI World ETF attaining the maximum efficiency rating of 1.000 under evaluation, thus implying that the variation in the performance of the OEICs/UTs that is seen can be entirely explained by environmental factors and statistical noise/luck.

The most plausible reason for these opposing conclusions that arise depending on which of the two DEA models is utilised in the three-stage model is that it is as a result of the differing way in which the two DEA models characterise the optimal adjustments of the inputs and outputs, with the SORMCCR-OO model treating them as being radial in nature and the SORMSBM(CRS)-OO model treating them as being non-radial in nature. In relation to the managerial performance of the OEICs/UTs which is the focus of this thesis, the most appropriate DEA model for use in the three-stage model appears likely to be the non-radial SORMSBM(CRS)-OO DEA model. Therefore, for the OEICs/UTs in this category evaluated using the three-stage DEA-SFA-DEA model, combined with the SORMSBM(CRS)-OO DEA model, to eliminate the influence of environmental factors and statistical noise/luck, the conclusion to be drawn is that the managers of these OEICs/UTs fail to outperform the low-cost market index tracker, with all 118 of the OEICs/UTs appearing to replicate the performance of the market index tracker which mimics the return that can be earned from the relevant market index.

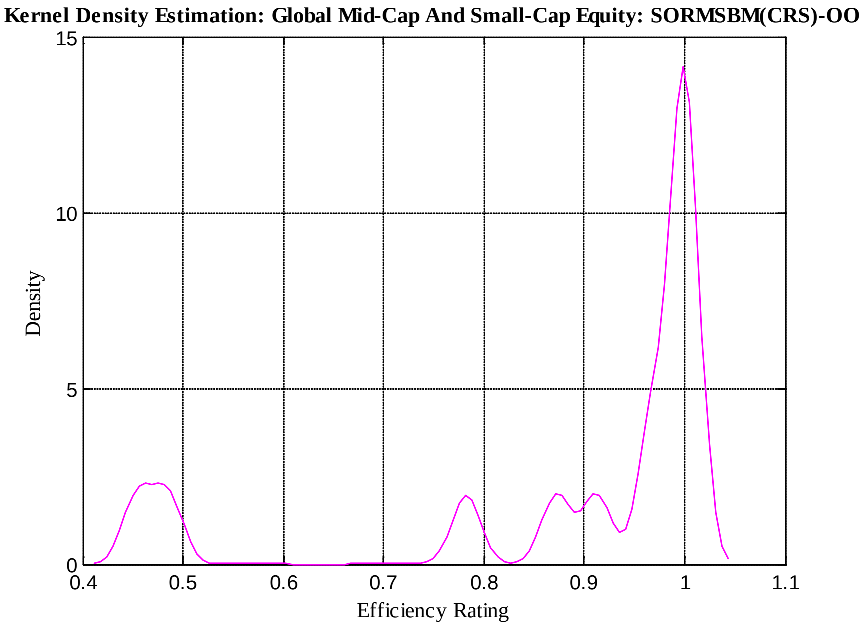
### *Global Mid-Cap And Small-Cap Equity (1st January 2008 – 31st December 2010)*

The detailed breakdown of the results from the individual OEICs/UTs in this category across both the two standalone DEA models and the two three-stage DEA-SFA-DEA models can be found in Results Appendix 4 Table RA4.12, with a summary of the results provided in the table below, along with a kernel density estimation graph for each of the four model variations.

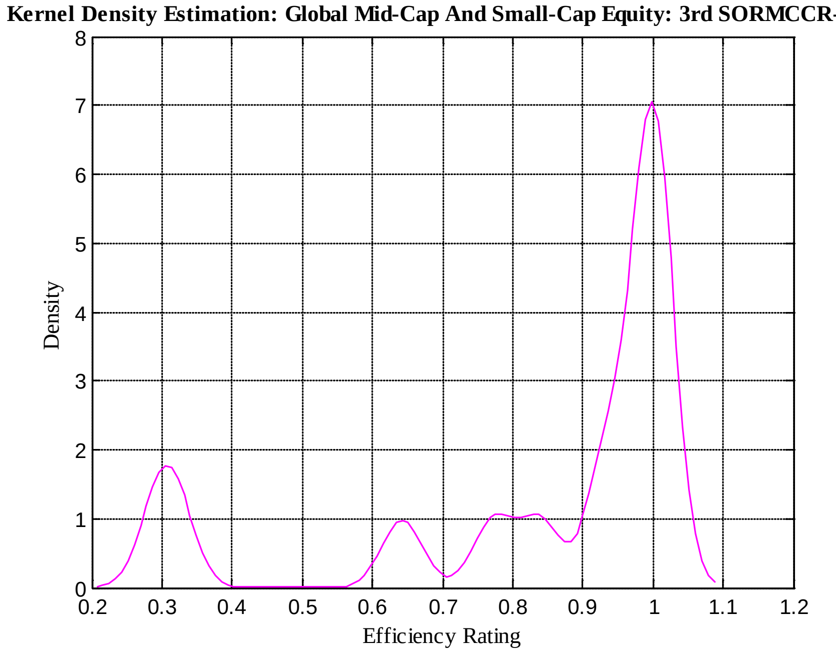
| Summary Results | SORMCCR-OO | Three-Stage SORMCCR-OO | SORMSBM-OO | Three-Stage SORMSBM-OO |
|---|---|---|---|---|
| **Maximum Efficiency Rating** (Number Of OEICs/UTs) | **1.000** (6) | **1.000** (6) | **1.000** (6) | **1.000** (13) |
| **Minimum Efficiency Rating** (Number Of OEICs/UTs) | **0.294** (1) | **0.294** (1) | **0.455** (1) | **1.000** (13) |
| **Mean Efficiency Rating** | **0.839** | **0.839** | **0.889** | **1.000** |
| **Standard Deviation Of Efficiency Ratings** | **0.250** | **0.250** | **0.189** | **0.000** |
| **Number Of OEICs/UTs Outperforming The Benchmark ETF** | **0** (0.00%) | **0** (0.00%) | **0** (0.00%) | **0** (0.00%) |
| **Number Of OEICs/UTs Underperforming The Benchmark ETF** | **7** (53.85%) | **7** (53.85%) | **7** (53.85%) | **0** (0.00%) |

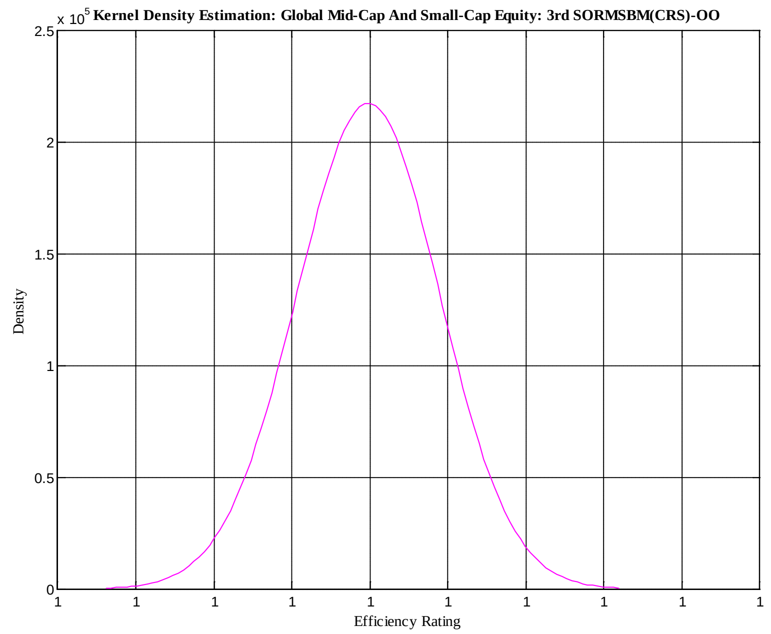


Kernel Density Estimation: Global Mid-Cap And Small-Cap Equity: SORMCCR-OO
Density
Efficiency Rating
0
1
2
3
4
5
6
7
8
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
1.1
1.2

Kernel Density Estimation: Global Mid-Cap And Small-Cap Equity: SORMSBM(CRS)-OO
Density
Efficiency Rating
0
5
10
15
0.4
0.5
0.6
0.7
0.8
0.9
1
1.1



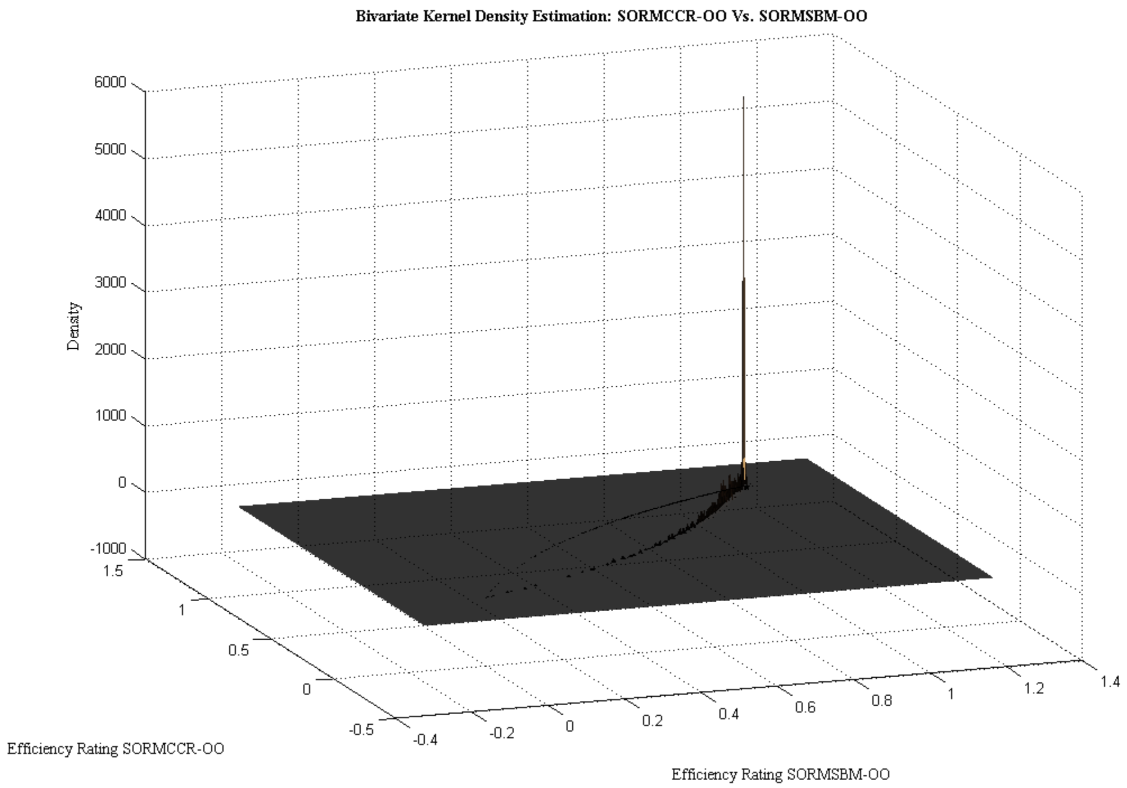



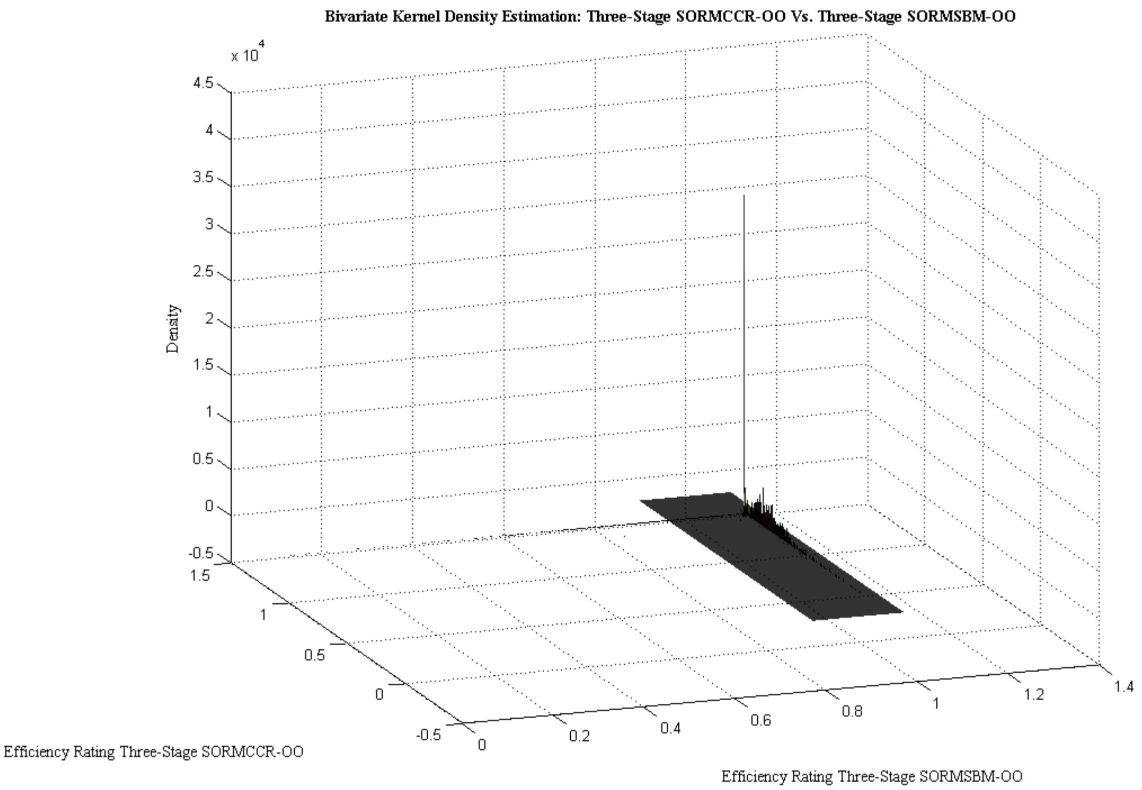

These results from the 13 global mid-cap and small-cap equity OEICs/UTs and the benchmark ETF, the iShares MSCI World, provide a number of results that are worth highlighting. These results for this category of OEIC/UT indicate that when the SORMCCR-OO DEA model is employed in the three-stage DEA-SFA-DEA method to remove the effects of environmental factors and statistical noise from the efficiency ratings of the OEICs/UTs to obtain the 'true' managerial performance, there is no difference between the efficiency ratings obtained and those obtained from the standalone DEA model, suggesting that the variation in the performance of the OEICs/UTs is entirely as a result of differences in the managerial performance between the funds. However, when the SORMSBM(CRS)-OO DEA model is employed in the three-stage model instead, the efficiency ratings of the OEICs/UTs that are produced are significantly different to those from the standalone DEA model, with all 13 of the OEICs/UTs and the benchmark iShares MSCI World ETF achieving the maximum efficiency rating of 1.000, suggesting that the variation in the performance of the OEICs/UTs is explained in its entirety by environmental factors and statistical noise/luck.

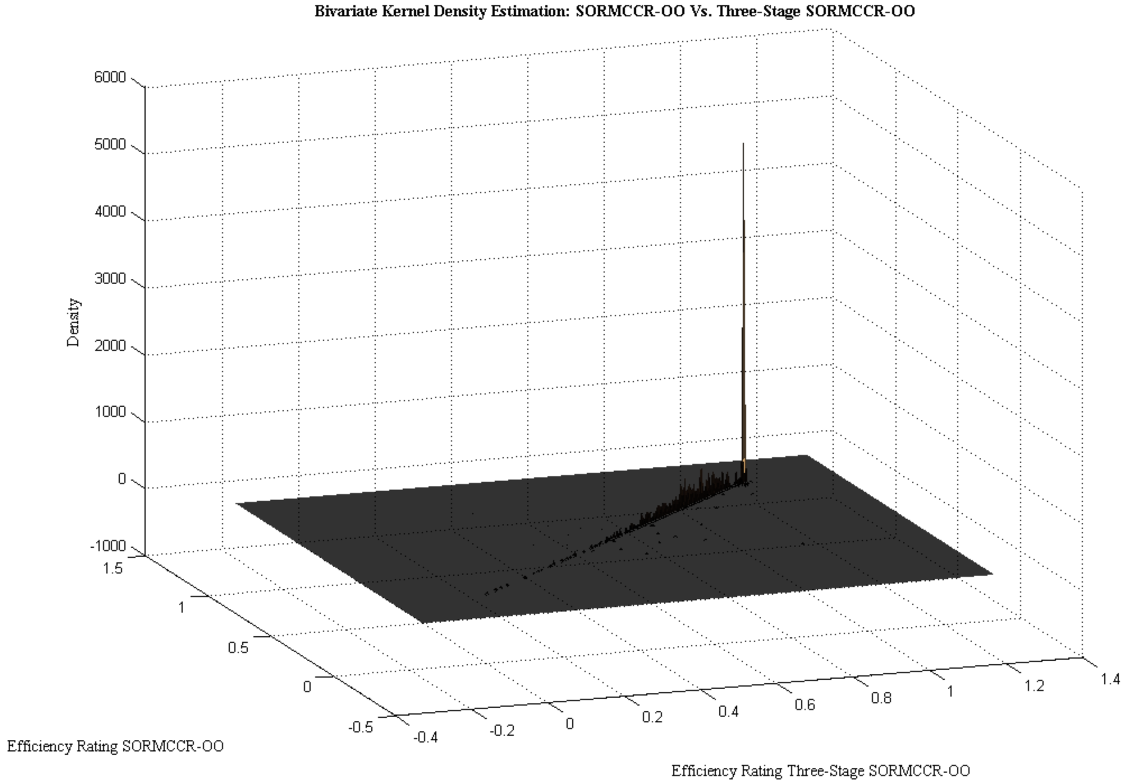
For this thesis, focused on assessing the managerial performance of the OEICs/UTs, the most appropriate DEA model for use in the three-stage model appears to be the non-radial SORMSBM(CRS)-OO DEA model. Consequently therefore, after employing the three-stage DEA-SFA-DEA model, in combination with the SORMSBM(CRS)-OO DEA model, to remove the effects of environmental factors and statistical noise/luck from the efficiency ratings of the OEICs/UTs, the conclusion that results is that the managers of these OEICs/UTs are unable to outperform the market in terms of the low-cost market index tracker.

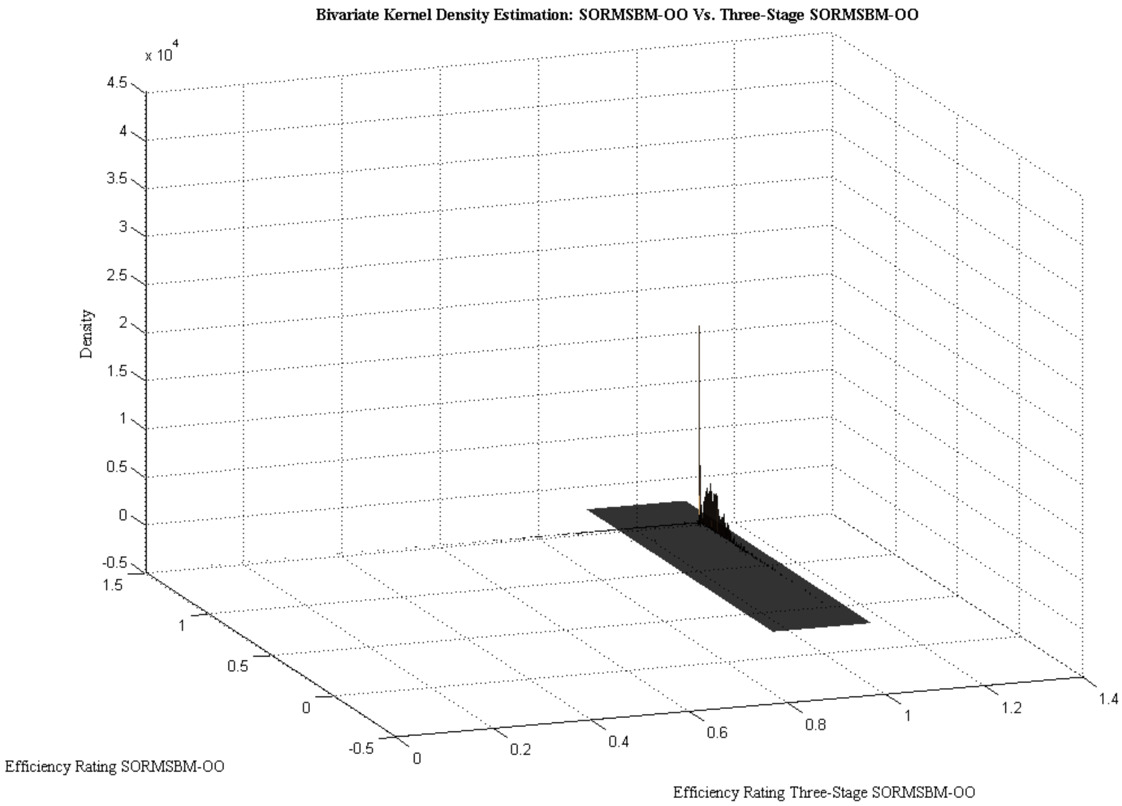
## *10.4: Summary Conclusions*

To provide a graphical summary of the results for the managerial performance of the OEICs/UTs under assessment from this section of results for the three-stage DEA-SFA-DEA model using the SORMCCR-OO DEA model and the three-stage DEA-SFA-DEA model using the SORMSBM(CRS)-OO DEA model, there are four bivariate kernel density estimation graphs below.


Bivariate Kernel Density Estimation: SORMCCR-OO Vs. SORMSBM-OO
Density
Efficiency Rating SORMCCR-OO
Efficiency Rating SORMSBM-OO


Bivariate Kernel Density Estimation: Three-Stage SORMCCR-OO Vs. Three-Stage SORMSBM-OO
Density
Efficiency Rating Three-Stage SORMCCR-OO
Efficiency Rating Three-Stage SORMSBM-OO


Bivariate Kernel Density Estimation: SORMCCR-OO Vs. Three-Stage SORMCCR-OO
Density
6000
5000
4000
3000
2000
1000
0
-1000
1.5
1
0.5
0
-0.5
-0.4
-0.2
0
0.2
0.4
0.6
0.8
1
1.2
1.4
Efficiency Rating SORMCCR-OO
Efficiency Rating Three-Stage SORMCCR-OO


Bivariate Kernel Density Estimation: SORMSBM-OO Vs. Three-Stage SORMSBM-OO
x 10^4
Density
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
-0.5
1.5
1
0.5
0
-0.5
0
0.2
0.4
0.6
0.8
1
1.2
1.4
Efficiency Rating SORMSBM-OO
Efficiency Rating Three-Stage SORMSBM-OO

To conclude this section of results it is possible to emphasise the following points. Firstly, when the SORMCCR-OO DEA model is being utilised in the three-stage DEA-SFA-DEA model, the radial nature of the optimal adjustments of the inputs and outputs in the SORMCCR-OO DEA model and the neglection of the non-radial input and output slacks, make this three-stage model appear unsuitable for the OEIC/UT dataset used in this thesis. The non-radial optimal adjustments of the inputs and outputs in the SORMSBM(CRS)-OO DEA model appear more suitable for the OEIC/UT dataset used in this thesis when the three-stage DEA-SFA-DEA model is being employed to evaluate the managerial performance of the OEICs/UTs, and thus this DEA model is preferred for use in the three-stage model. Furthermore, the criticality of the removal of the influence exerted by environmental factors and statistical noise/luck from the managerial efficiency ratings of the OEICs/UTs to obtain the 'true' managerial performance is highlighted by the sharply differing results from the three-stage DEA-SFA-DEA model utilising the SORMSBM(CRS)-OO DEA model when compared against those from the one-stage standalone SORMSBM(CRS)-OO DEA model. Finally, for the mutual fund universe of 565 OEICs/UTs, across the 12 investment categories of OEIC/UT, under the evaluation of the three-stage DEA-SFA-DEA model, combined with the SORMSBM(CRS)-OO DEA model, there are no categories in which any of the OEICs/UTs outperform the benchmark iShares ETF index tracker, and thus this implies that there are no OEIC/UT managers that are showing an ability to generate consistent superior returns and outperform the market in terms of their 'true' managerial performance.

There are some linkages between the empirical results in this chapter and the existing research literature. Whilst there are no large studies of UK mutual fund performance using DEA, and no research studies at all of mutual funds that use the three-stage DEA-SFA-DEA methodology to remove the influence of environmental factors and statistical noise/luck to obtain the 'true' managerial performance, there are some large research studies of UK mutual funds that make use of the traditional measures. In particular, Cuthbertson et al (2008) conclude from their evaluation of

UK mutual fund performance that very few actively managed UK mutual funds demonstrate real stock picking skill that would allow them to outperform the market and they are extremely difficult to identify, and thus most investors would be better off investing in low-cost, passively managed index trackers. This appears broadly consistent with the empirical results in this chapter which imply that there are no OEIC/UT managers exhibiting an ability to select stocks and outperform the market in terms of their ‘true’ managerial performance. Cuthbertson et al (2010) conduct a review of the empirical findings from numerous studies using the traditional measures to assess the performance of mutual funds, mainly US and UK mutual funds, and find they all generally come to this same conclusion, and thus investors should invest in low-cost, passively managed index trackers and avoid actively managed funds. Again this is broadly consistent with the empirical results in this chapter.

# Chapter 11: Conclusions And Further Work

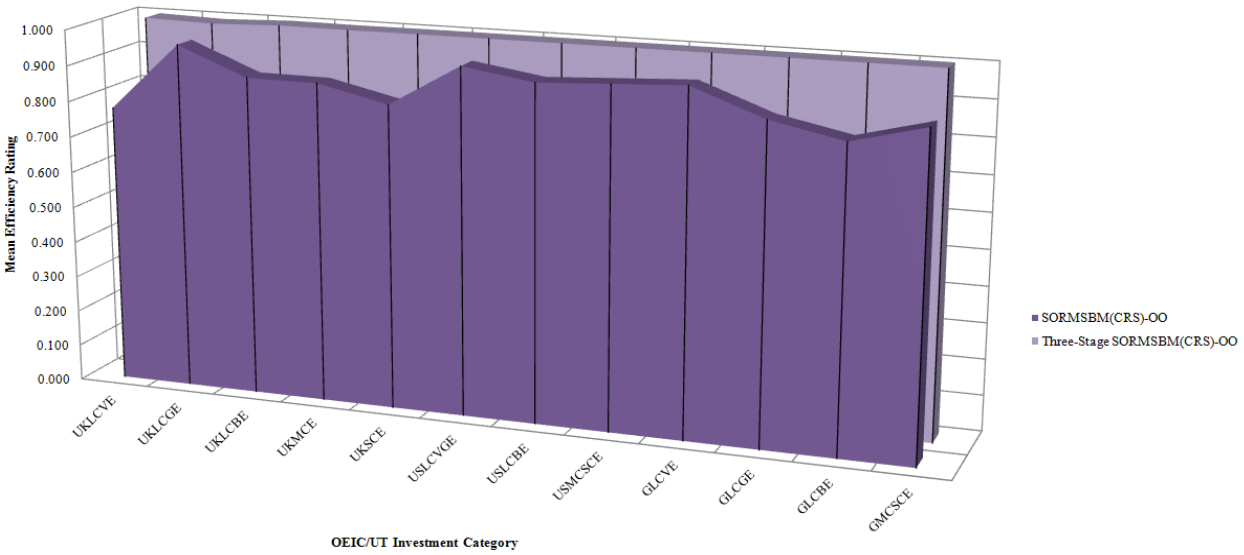
## *11.1: Conclusions*

From the results that have been generated and analysed in the course of undertaking this thesis which has investigated the managerial performance of UK domiciled OEICs/UTs, the following summary conclusions can be drawn. Firstly, this thesis implements a novel approach to the evaluation of the managerial performance of the UK domiciled OEICs/UTs which involves utilising a three-stage DEA-SFA-DEA model methodology to eliminate the influence of environmental factors and statistical noise/luck from the efficiency ratings results of the OEICs/UTs, thus obtaining the 'true' managerial performance. Prior to this, this thesis also performs a detailed standalone DEA analysis of the managerial performance of the OEICs/UTs which employs a number of different DEA models encompassing radial and non-radial models, constant and variable returns-to-scale models, and models that implement the SORM procedure to deal with the problematic issue of negative data. The seminal question that drives the interest in evaluating the managerial performance of mutual funds is whether the actively managed mutual funds can justify their higher costs through superior performance over a matched low-cost index tracker, and to investigate this question this thesis compares the performance of the actively managed OEICs/UTs to an appropriately matched iShares ETF index tracker.

With regard to the standalone DEA models and their evaluation of the managerial performance of the UK domiciled OEICs/UTs, the results and subsequent analysis indicate that the selection of an appropriate DEA model is a key decision due to the differences in the efficiency ratings for individual OEICs/UTs across the various DEA models used. Two clear conclusions this thesis makes with regard to this are that firstly, due to the prevalence of negative data in the underlying dataset for the OEICs/UTs, it is essential that the DEA model utilised is able to deal with negative data as the SORM variant models are, and secondly this study finds that the most appropriate returns-to-scale metric for the DEA models applied to the evaluation of the managerial performance of the UK domiciled OEICs/UTs is a constant returns-to-scale metric. Selecting the most appropriate DEA model to employ in this thesis for the assessment of the managerial efficiency of the UK domiciled OEICs/UTs on this basis resulted in the conclusion that the most appropriate DEA models were the SORMCCR-OO DEA model and the SORMSBM(CRS)-OO DEA model, and thus the analysis and conclusion drawn from the results of these models with regard to the managerial performance of the OEICs/UTs under assessment will be the most reliable and valid. Furthermore, when analysing the standalone DEA efficiency ratings results for the OEICs/UTs to determine whether they are able to justify their generally higher cost through superior performance over an appropriately matched low-cost index tracker, the conclusion to be drawn is that the results show a mixed pattern across the categories of OEIC/UT, with some categories containing a large number of actively managed OEICs/UTs which outperform the matched iShares ETF index tracker and some categories where all of the actively managed OEICs/UTs fail to outperform the matched iShares ETF index tracker.

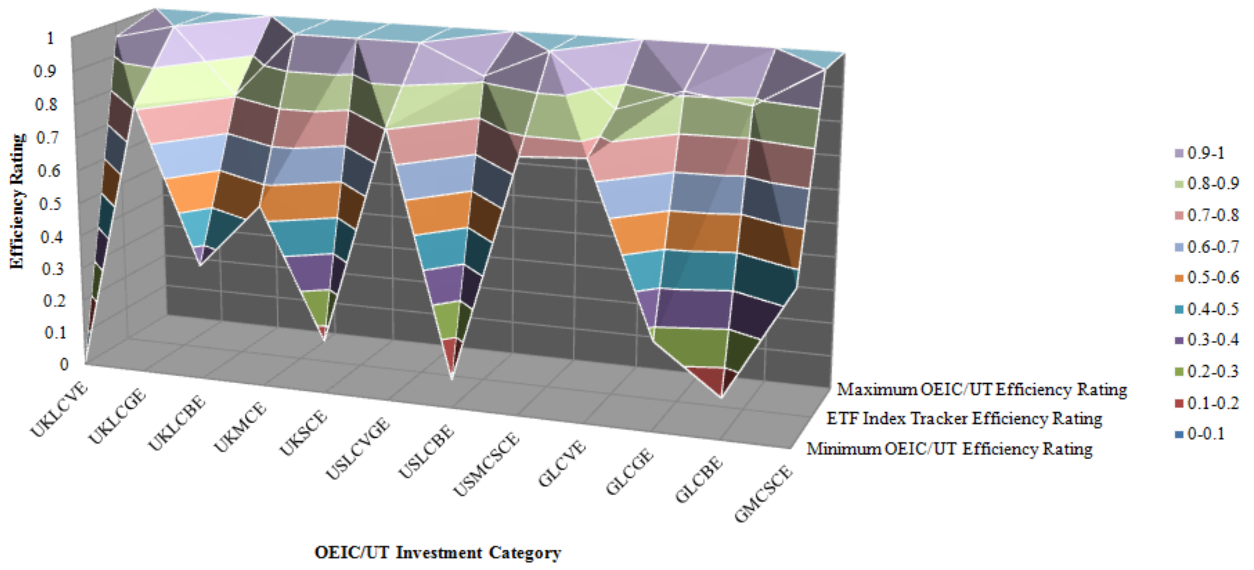
Finally, the results from the three-stage DEA-SFA-DEA model in this thesis with regard to the evaluation of the managerial performance of the UK domiciled OEICs/UTs support a particularly definitive conclusion. As mentioned in Chapter 10 which contains the results for the three-stage model, of the two DEA models utilised within the three-stage DEA-SFA-DEA procedure, the SORMSBM(CRS)-OO DEA model is the most appropriate DEA model to employ, and thus the conclusion that follows is based on the results from the three-stage model using this SORMSBM(CRS)-OO DEA model. These results indicate that across the universe of 565 UK domiciled OEICs/UTs, split in to their appropriate investment categories, none of the actively managed OEICs/UTs produce a superior performance over that of the relevant iShares ETF index tracker, thus supporting the definitive conclusion that the actively managed OEICs/UTs fail to justify their higher cost through superior performance above that of the market in the form of the low-cost market index tracker. This conclusion is analogous with a majority of the previous research that has examined the performance of actively managed mutual funds using a variety of methodologies which has found that mutual funds are unable to persistently earn an abnormal return above that of the underlying market. This conclusion also calls in to doubt the *raison d'être* for actively managed mutual funds and the claimed 'star performance' of mutual fund managers, and indicates that a low-cost, passively managed market index tracker is likely to deliver an investor a level of performance at least as good as that from an actively managed mutual fund.

**A Graphical Comparison Of The Mean Efficiency Ratings Between Standalone SORMSBM(CRS)-OO DEA And Three-Stage DEA-SFA-DEA Using SORMSBM(CRS)-OO DEA**

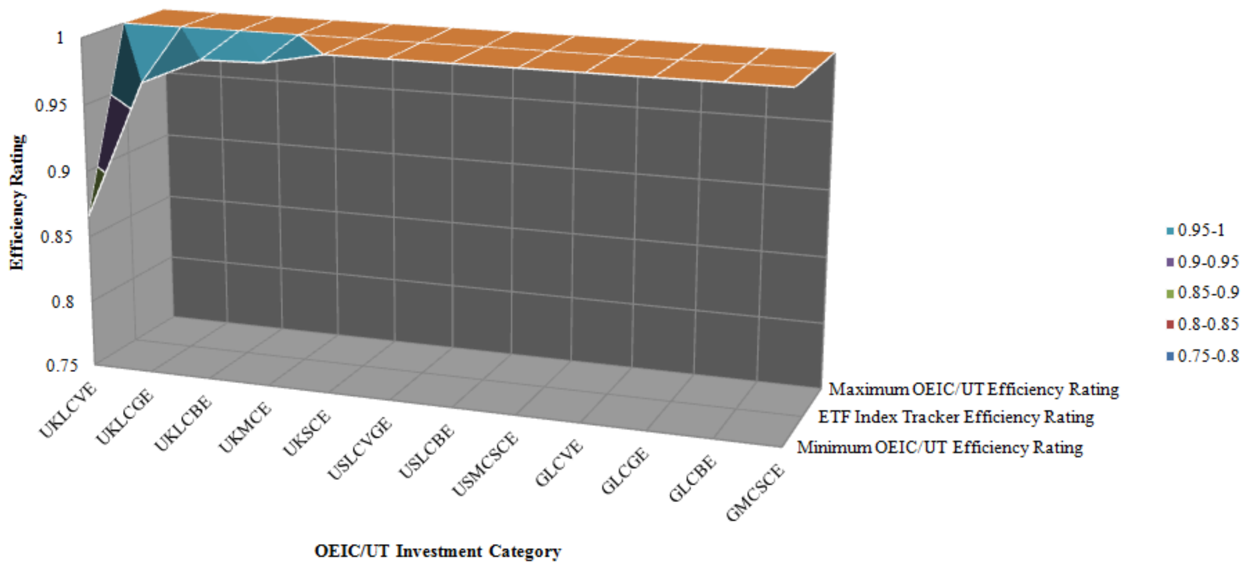



| | UKLCVE | UKLCGE | UKLCBE | UKMCE | UKSCE | USLCVGE | USLCBE | USMCSCE | GLCVE | GLCGE | GLCBE | GMCSCE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SORMSBM(CRS)-OO | 0.779 | 0.968 | 0.890 | 0.889 | 0.845 | 0.962 | 0.932 | 0.942 | 0.952 | 0.878 | 0.837 | 0.889 |
| Three-Stage SORMSBM(CRS)-OO | 0.998 | 0.993 | 1.000 | 0.999 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 |

**A Graphical Representation Of The Minimum And Maximum OEIC/UT Efficiency Ratings, And The ETF Index Tracker Efficiency Rating, Under The SORMSBM(CRS)-OO DEA Model**




**A Graphical Representation Of The Minimum And Maximum OEIC/UT Efficiency Ratings, And The ETF Index Tracker Efficiency Rating, Under The Three-Stage DEA-SFA-DEA Model Using The SORMSBM(CRS)-OO DEA Model**



The results and conclusions of this thesis indicate that the one-stage, standalone DEA models give the fund managers the best chance of looking good in performance terms because they do not systematically remove the idiosyncratic errors which the three-stage DEA-SFA-DEA model does, and thus the three-stage model is more robust for measuring performance because it does treat these errors in a defensible way. Consequently therefore, the three-stage DEA-SFA-DEA model produces the more robust results as well as supporting the stronger conclusions. To conclude and close this thesis, it has employed a novel methodology to extend support to the premise of the Efficient Market Hypothesis (EMH) that financial markets are 'information efficient', and thus it is not possible, given the information available when the investment is made, to consistently obtain returns in excess of the average market return on a risk-adjusted basis.

There are some important policy implications for both investors and mutual fund managers that emanate from the empirical results and subsequent conclusions of this thesis which investigated the managerial performance of mutual funds. For investors the clear policy implication that arises from this thesis is that because the expensive actively managed mutual funds are unable to deliver superior returns in excess of the return that can be earned from the market, they should be avoided, and instead investors should invest in a suitable low-cost market index tracker which is likely to deliver a level of return at least as good as, and in many cases better than, that from an actively managed mutual fund. For mutual fund managers the clear policy implication that is manifested here is that they need to clearly present to investors what benefits investing in their actively managed mutual fund offers them that justifies incurring the high cost of investment because justification on the grounds of a higher return than the market and the 'star ability' of managers to select stocks appears unfounded.

## 11.2: Further Work

The work that was produced in this thesis can be further developed in the future in a number of ways. Firstly, it can be developed by changing the factors used in the DEA models and/or adding additional factors in to the DEA models to improve the accuracy of the managerial efficiency ratings obtained for the OEICs/UTs under evaluation. In particular, the inclusion of additional risk factors could be beneficial in terms of producing more accurate results, for example, by using a downside risk measure to incorporate in to the DEA model a more realistic representation of the risk preferences of investors through the recognition of their preference for upside volatility over downside volatility. The downside risk measures that could be utilised include semi-deviation, other lower partial moment degrees and value at risk (VaR). It can also be developed by including bivariate kernel density estimation graphs at the investment category level in the results to aid the analytical comparison of the efficiency ratings from different models. The contribution of this thesis can also be enhanced by expanding the work to evaluate financial funds from other geographical domiciles and also to evaluate other types of financial funds such as hedge funds.

It could also be further developed by looking at using other DEA models, both in standalone terms and in the three-stage DEA-SFA-DEA model, to assess whether another model may be more appropriate in accurately assessing the managerial performance of the OEICs/UTs. In particular, given the markedly opposing results of the three-stage DEA-SFA-DEA model depending on whether the radial SORMCCR-OO DEA model or the non-radial SORMSBM(CRS)-OO DEA model is used, it is likely to be prudent to look at results produced from the Hybrid DEA model which is able to combine both radial and non-radial characterisations in to a single DEA model, and analyse the additional information this Hybrid DEA model provides.

Also, given that the results for the managerial performance of the OEICs/UTs from the three-stage DEA-SFA-DEA model in combination with the SORMSBM(CRS)-OO DEA model show that almost all of the OEICs/UTs are evaluated at the maximum efficiency rating of 1.000, the work of this thesis could be developed and enhanced by implementing super-efficiency in the form of a Super-Efficient SORMSBM(CRS)-OO DEA model. This would attempt to disseminate these efficiency ratings results for the OEICs/UTs that achieve the maximum efficiency rating of 1.000, thus allowing more accurate and valid conclusions to be drawn from the results.

Further, the work of this thesis could be further developed by carrying out the evaluation of the managerial performance of the OEICs/UTs across different time horizons. In particular, it would be enlightening to compare the managerial performance of the same OEICs/UTs over, for example, a one-year time period and a three-year time period to determine whether the actively managed OEICs/UTs are able to outperform the low-cost market index tracker in the short-term, but lack long-term persistence.

Finally, the work of this thesis could be extended by employing other techniques for efficiency measurement in the assessment of the managerial performance of mutual funds such as other non-parametric frontier methods like Free Disposal Hull (FDH) (De Prins et al 1984), non-parametric partial frontier methods like Order-*m* (Cazals et al 2002) and Order-α (Aragon et al 2005, Daouia and Simar 2007), Artificial Neural Networks (ANNs) (Stern 1996, Athanassopoulos and Curram 1996, Liao et al 2007) and Stochastic Non-Parametric Envelopment Of Data (StoNED) (Kuosmanen 2006).

# References

Abbott, M. And Doucouliagos, C. (2003), ‘The Efficiency Of Australian Universities: A Data Envelopment Analysis’, *Economics Of Education Review*, Volume 22, Pg 89-97.

Abdelsalam, O., Fethi, M. D., Matallin, J. C. And Tortosa-Ausina, E., ‘On The Comparative Performance Of Socially Responsible And Islamic Mutual Funds’, *Journal Of Economic Behaviour & Organisation (2013)*, http://dx.doi.org/10.1016/j.jebo.2013.06.011.

Abdelsalam, O., Fethi, M. D., Matallin, J. C. And Tortosa-Ausina, E. (2014), ‘Do Ethics Imply Persistence? The Case Of Islamic And Socially Responsible Funds’, *Journal Of Banking & Finance*, Volume 40, Pg 182-194.

Ackermann, C., McEnally, R. And Ravenscraft, D. (1999), ‘The Performance Of Hedge Funds: Risk, Return And Incentives’, *The Journal Of Finance*, Volume 54, Pg 833-874.

Admati, A., Bhattacharya, S., Pfleiderer, P. And Ross, S. (1986), ‘On Timing And Selectivity’, *The Journal Of Finance*, Volume 41, Pg 715-730.

Ahn, T. And Seiford, L. M. (1993), ‘Sensitivity Of DEA Results To Models And Variable Sets In A Hypothesis Test Setting: The Efficiency Of University Operations’, In *Creative And Innovative Approaches To The Science Of Management*, Ijiri, Y. (Editor), New York, Quorum Books.

Aigner, D., Lovell, C. A. K. And Schmidt, P. (1977), ‘Formulation And Estimation Of Stochastic Frontier Production Function Models’, *Journal Of Econometrics*, Volume 6, Pg 21-37.

Ali, A. I. And Seiford, L. M. (1990), ‘Translation Invariance In Data Envelopment Analysis’, *Operations Research Letters*, Volume 9, Pg 403-405.

Ali, A. I. And Seiford, L. M. (1993), 'The Mathematical Programming Approach To Efficiency Analysis', In *The Measurement Of Productive Efficiency: Techniques And Applications*, Fried, H., Knox Lovell, C. A. And Schmidt, S. (Editors), Oxford, Oxford University Press.

Andersen, P. And Petersen, N. C. (1993), 'A Procedure For Ranking Efficient Units In Data Envelopment Analysis', *Management Science*, Volume 39, Pg 1261-1264.

Aragon, Y., Daouia, A. And Thomas-Agnan, C. (2005), 'Non-Parametric Frontier Estimation: A Conditional Quantile-Based Approach', *Econometric Theory*, Volume 21, Pg 358-389.

Athanassopoulos, A. D. And Curram, S. P. (1996), 'A Comparison Of Data Envelopment Analysis And Artificial Neural Networks As Tools For Assessing The Efficiency Of Decision Making Units', *The Journal Of The Operational Research Society*, Volume 47, Pg 1000-1016.

Athanassopoulos, A. D. And Shale, E. (1997), 'Assessing The Comparative Efficiency Of Higher Education Institutions In The UK By The Means Of Data Envelopment Analysis', *Education Economics*, Volume 5, Pg 117-134.

Avkiran, N. K. (2009), 'Removing The Impact Of The Environment With Units Invariant Efficient Frontier Analysis: An Illustrative Case Study With Intertemporal Panel Data', *Omega*, Volume 37, Pg 535-544.

Avkiran, N. K. And Rowlands, T. (2008), 'How To Better Identify The True Managerial Performance: State Of The Art Using DEA', *The International Journal Of Management Science*, Volume 36, Pg 317-324.

Avkiran, N. K., Tone, K. And Tsutsui, M. (2008), 'Bridging Radial And Non-Radial Measures Of Efficiency In DEA', *Annals Of Operations Research*, Volume 164, Pg 127-138.

Banker, R. D. (1996), 'Hypothesis Tests Using Data Envelopment Analysis', *The Journal Of Productivity Analysis*, Volume 7, Pg 139-159.

Banker, R. D., Charnes, A. And Cooper, W. W. (1984), 'Some Models For Estimating Technical And Scale Inefficiencies In Data Envelopment Analysis', *Management Science*, Volume 30, Pg 1078-1092.

Banker, R. D., Conrad, R. F. And Strauss, R. P. (1986), 'A Comparative Application Of Data Envelopment Analysis And Translog Methods: An Illustrative Study Of Hospital Production', *Management Science*, Volume 32, Pg 30-44.

Banker, R. D. And Morey, R. C. (1986), 'Efficiency Analysis For Exogenously Fixed Inputs And Outputs', *Operations Research*, Volume 34, Pg 513-521.

Basso, A. And Funari, S. (2001), 'A Data Envelopment Analysis Approach To Measure The Mutual Fund Performance', *European Journal Of Operational Research*, Volume 135, Pg 477-492.

Basso, A. And Funari, S. (2003), 'Measuring The Performance Of Ethical Mutual Funds: A DEA Approach', *Journal Of The Operational Research Society*, Volume 54, Pg 521-531.

Basso, A. And Funari, S. (2005a), 'A Generalised Performance Attribution Technique For Mutual Funds', *Central European Journal Of Operational Research*, Volume 13, Pg 65-84.

Basso, A. And Funari, S. (2005b), 'Performance Evaluation Of Ethical Mutual Funds In Slump Periods', *EconWPA 0511001*.

Basso, A. And Funari, S. (2007), 'DEA Models For Ethical And Non-Ethical Mutual Funds With Negative Data', *Working Paper N. 153/2007*.

Bawa, V. S. (1975), 'Optimal Rules For Ordering Uncertain Prospects', *Journal Of Financial Economics*, Volume 2, Pg 95-121.

Beccalli, E., Casu, B. And Girardone, C. (2006), 'Efficiency And Stock Performance In European Banking', *Journal Of Business Finance And Accounting*, Volume 33, Pg 245-262.

Berger, A. N. And Humphrey, D. B. (1997), 'Efficiency Of Financial Institutions: International Survey And Directions For Future Research', *European Journal Of Operational Research*, Volume 98, Pg 175-212.

Bessent, A., Bessent, W., Charnes, A., Cooper, W. W. And Thorogood, N. (1983), 'Evaluation Of Educational Program Proposals By Means Of Data Envelopment Analysis', *Educational Administration Quarterly*, Volume 19, Pg 82-107.

Bhattacharyya, A., Lovell, C. A. K. And Sahay, P. (1997), 'The Impact Of Liberalisation On The Productive Efficiency Of Indian Commercial Banks', *European Journal Of Operational Research*, Volume 98, Pg 332-347.

Brandouy, O., Kerstens, K. And Van De Woestyne, I. (2012), 'Backtesting Super-Fund Portfolio Strategies Founded On Frontier-Based Mutual Fund Ratings', In *Efficiency And Productivity Growth In The Financial Services Industry*, Pasiouras, F. (Editor), New York, Wiley.

Bulla, S., Cooper, W. W., Wilson, D. And Park, K. S. (2000), 'Evaluating Efficiencies Of Turbofan Jet Engines: A Data Envelopment Analysis Approach', *Journal Of Propulsion And Power*, Volume 16, Pg 431-439.

Carhart, M. M. (1997), 'On Persistence In Mutual Fund Performance', *Journal Of Finance*, Volume 52, Pg 57-82.

Casu, B. And Molyneux, P. (2003), 'A Comparative Study Of Efficiency In European Banking', *Applied Economics*, Volume 35, Pg 1865-1876.

Cazals, C., Florens, J.-P. And Simar, L. (2002), 'Non-Parametric Frontier Estimation: A Robust Approach', *Journal Of Econometrics*, Volume 106, Pg 1-25.

Chambers, R. G., Chung, Y. And Fare, R. (1996), 'Benefit And Distance Functions', *Journal Of Economic Theory*, Volume 70, Pg 407-419.

Chambers, R. G., Chung, Y. And Fare, R. (1998), 'Profit, Directional Distance Functions And Nerlovian Efficiency', *Journal Of Optimisation Theory And Applications*, Volume 98, Pg 351-364.

Chang, E. C. And Lewellen, W. G. (1984), 'Market Timing And Mutual Fund Investment Performance', *The Journal Of Business*, Volume 57, Pg 57-72.

Charnes, A., Clark, C. T., Cooper, W. W. And Golany, B. (1985a), 'A Developmental Study Of Data Envelopment Analysis In Measuring The Efficiency Of Maintenance Units In The U.S. Air Force', *Annals Of Operations Research*, Volume 2, Pg 95-112.

Charnes, A. And Cooper, W. W. (1962), 'Programming With Linear Fractional Functions', *Naval Research Logistics Quarterly*, Volume 9, Pg 181-186.

Charnes, A., Cooper, W. W., Golany, B., Seiford, L. M. And Stutz, J. (1985b), 'Foundations Of Data Envelopment Analysis For Pareto-Koopmans Efficient Empirical Production Functions', *Journal Of Econometrics*, Volume 30, Pg 91-107.

Charnes, A., Cooper, W. W. And Li, S. (1989), 'Using Data Envelopment Analysis To Evaluate Efficiency In The Economic Performance Of Chinese Cities', *Socio-Economic Planning Sciences*, Volume 23, Pg 325-344.

Charnes, A., Cooper, W. W. And Rhodes, E. (1978), 'Measuring The Efficiency Of Decision Making Units', *European Journal Of Operational Research*, Volume 2, Pg 429-444.

Charnes, A., Cooper, W. W., Seiford, L. M. And Stutz, J. (1982), 'A Multiplicative Model For Efficiency Analysis', *Socio-Economic Planning Sciences*, Volume 16, Pg 223-224.

Choi, Y. K. And Murthi, B. P. S. (2001), 'Relative Performance Evaluation Of Mutual Funds: A Non-Parametric Approach', *Journal Of Business Finance And Accounting*, Volume 28, Pg 853-876.

Coelli, T. J., Prasada Rao, D. S., O'Donnell, C. J. And Battese, G. E. (2005), *An Introduction To Efficiency And Productivity Analysis (2nd Edition)*, New York, Springer.

Coggin, D., Fabozzi, F. J. And Rahman, S. (1993), 'The Investment Performance Of US Equity Pension Fund Managers: An Empirical Investigation', *The Journal Of Finance*, Volume 48, Pg 1039-1055.

Cohn, E., Rhine, S. And Santos, M. C. (1989), 'Institutions Of Higher Education As Multi-Product Firms: Economies Of Scale And Scope', *Review Of Economics And Statistics*, Volume 71, Pg 284-290.

Cook, W. D. And Seiford, L. M. (2009), 'Data Envelopment Analysis (DEA) – Thirty Years On', *European Journal Of Operational Research*, Volume 192, Pg 1-17.

Cooper, W. W., Seiford, L. M. And Tone, K. (2007), *Data Envelopment Analysis: A Comprehensive Text With Models, Applications, References And DEA-Solver Software (2nd Edition)*, Boston, Kluwer Academic Publishers.

Cuthbertson, K., Nitzsche, D. And O'Sullivan, N. (2008), 'UK Mutual Fund Performance: Skill Or Luck?', *Journal Of Empirical Finance*, Volume 15, Pg 613-634.

Cuthbertson, K., Nitzsche, D. And O'Sullivan, N. (2010), 'Mutual Fund Performance: Measurement And Evidence', *Journal Of Financial Markets, Instruments And Institutions*, Volume 19, Pg 95-187.

Daouia, A. And Simar, L. (2007), 'Non-Parametric Efficiency Analysis: A Multivariate Conditional Quantile Approach', *Journal Of Econometrics*, Volume 140, Pg 375-400.

Dellva, W. L., DeMaskey, A. L. And Smith, C. A. (2001), 'Selectivity And Market Timing Performance Of Fidelity Sector Mutual Funds', *The Financial Review*, Volume 36, Pg 39-54.

De Prins, D., Simar, L. And Tulkens, H. (1984), 'Measuring Labour Efficiency In Post Offices', In *The Performance Of Public Enterprises: Concepts And Measurement*, Marchand, M., Pestieau, P. And Tulkens, H. (Editors), Amsterdam, North-Holland.

Desai, A., Haynes, K. And Storbeck, J. E. (1994), 'A Spatial Efficiency Framework For The Support Of Location Decisions', In *Data Envelopment Analysis: Theory, Methodology And Applications*, Charnes, A., Cooper, W. W., Lewin, A. Y. And Seiford, L. M. (Editors), Boston, Kluwer Academic Publishers.

Dowd, K. (2000), 'Adjusting For Risk: An Improved Sharpe Ratio', *International Review Of Economics And Finance*, Volume 9, Pg 209-222.

Drake, L., Hall, M. J. B. And Simper, R. (2006), 'The Impact Of Macroeconomic And Regulatory Factors On Bank Efficiency: A Non-Parametric Analysis Of Hong Kong's Banking System', *Journal Of Banking And Finance*, Volume 30, Pg 1443-1466.

Drake, L. And Howcroft, B. (1994), 'Relative Efficiency In The Branch Network Of A UK Bank: An Empirical Study', *Omega*, Volume 22, Pg 83-90.

Drake, L. And Simper, R. (2000), 'Productivity Estimation And The Size-Efficiency Relationship In English And Welsh Police Forces: An Application Of Data Envelopment Analysis And Multiple Discriminant Analysis', *International Review Of Law And Economics*, Volume 20, Pg 53-73.

Efron, B. (1979), 'Bootstrap Methods: Another Look At The Jackknife', *The Annals Of Statistics*, Volume 7, Pg 1-26.

Elton, E. J., Gruber, M. J., Das, S. And Hlavka, M. (1993), 'Efficiency With Costly Information: A Reinterpretation Of Evidence From Managed Portfolios', *The Review Of Financial Studies*, Volume 6, Pg 1-22.

Emrouznejad, A., Anouze, A. L. And Thanassoulis, E. (2010), 'A Semi-Oriented Radial Measure For Measuring The Efficiency Of Decision Making Units With Negative Data Using DEA', *European Journal Of Operational Research*, Volume 200, Pg 297-304.

European Fund And Asset Management Association (2012), *Asset Management In Europe (5th Annual Review)*, Brussels, European Fund And Asset Management Association (EFAMA).

Fama, E. F. And French, K. R. (1993), 'Common Risk Factors In The Returns On Stocks And Bonds', *Journal Of Financial Economics*, Volume 33, Pg 3-56.

Fare, R., Grosskopf, S., Kirkley, J. L. And Squires, D. (2001), 'Data Envelopment Analysis (DEA): A Framework For Assessing Capacity In Fisheries When Data Are Limited, In *Microbehaviour And Macroresults: Proceedings Of The Tenth Biennial Conference Of The International Institute Of Fisheries, Economics And Trade, 10th-14th July 2000, Corvallis, Oregon, USA*, Johnston, R. S. And Shriver, A. L. (Editors), Corvallis, International Institute Of Fisheries, Economics And Trade.

Fare, R., Grosskopf, S., Lovell, C. A. K. And Pasurka, C. (1989), 'Multilateral Productivity Comparisons When Some Outputs Are Undesirable: A Nonparametric Approach', *The Review Of Economics And Statistics*, Volume 71, Pg 90-98.

Fare, R. And Lovell, C. A. K. (1978), 'Measuring The Technical Efficiency Of Production', *Journal Of Economic Theory*, Volume 19, Pg 150-162.

Farrell, M. J. (1957), 'The Measurement Of Productive Efficiency', *Journal Of The Royal Statistical Society*, Volume 120, Pg 253-290.

Fethi, M. D. And Pasiouras, F. (2010), 'Assessing Bank Efficiency And Performance With Operational Research And Artificial Intelligence Techniques: A Survey', *European Journal Of Operational Research*, Volume 204, Pg 189-198.

Fishburn, P. C. (1977), 'Mean-Risk Analysis With Risk Associated With Below-Target Returns', *The American Economic Review*, Volume 67, Pg 116-126.

Forbes (2008), 'World's Most Economically Powerful Cities', *Forbes.com*, [Online], [Accessed 4th December 2013], Available From: www.forbes.com/2008/07/15/economic-growth-gdp-biz-cx_jz_0715powercities.html.

Fried, H. O., Lovell, C. A. K., Schmidt, S. S. And Yaisawarng, S. (2002), 'Accounting For Environmental Effects And Statistical Noise In Data Envelopment Analysis', *Journal Of Productivity Analysis*, Volume 17, Pg 157-174.

Fried, H. O., Lovell, C. A. K. And Vanden Eeckaut, P. (1993), 'Evaluating The Performance Of US Credit Unions', *Journal Of Banking And Finance*, Volume 17, Pg 251-265.

Fried, H. O., Schmidt, S. S. And Yaisawarng, S. (1999), 'Incorporating The Operating Environment Into A Non-Parametric Measure Of Technical Efficiency', *Journal Of Productivity Analysis*, Volume 12, Pg 249-267.

Galagedera, D. U. A. And Silvapulle, P. (2002), 'Australian Mutual Fund Performance Appraisal Using Data Envelopment Analysis', *Managerial Finance*, Volume 28, Pg 60-73.

Gillen, D. And Lall, A. (1997), 'Developing Measures Of Airport Productivity And Performance: An Application Of Data Envelopment Analysis', *Transportation Research Part E: Logistics And Transportation Review*, Volume 33, Pg 261-273.

Glawischnig, M. And Sommersguter-Reichmann, M. (2010), 'Assessing The Performance Of Alternative Investments Using Non-Parametric Efficiency Measurement Approaches: Is It Convincing?', *Journal Of Banking & Finance*, Volume 34, Pg 295-303.

Hadad, M. D., Hall, M. J. B., Kenjegalieva, K. A., Santoso, W. And Simper, R. (2012), 'A New Approach To Dealing With Negative Numbers In Efficiency Analysis: An Application To The Indonesian Banking Sector', *Expert Systems With Applications*, Volume 39, Pg 8212-8219.

Hendricks, D., Patel, J. And Zeckhauser, R. (1993), 'Hot Hands In Mutual Funds: Short-Run Persistence Of Relative Performance: 1974-1988', *The Journal Of Finance*, Volume 48, Pg 93-130.

Henriksson, R. D. (1984), 'Market Timing And Mutual Fund Performance: An Empirical Investigation', *The Journal Of Business*, Volume 57, Pg 73-96.

Henriksson, R. D. And Merton, R. C. (1981), 'On Market Timing And Investment Performance: II: Statistical Procedures For Evaluating Forecasting Skills', *Journal Of Business*, Volume 54, Pg 513-533.

Investment Company Institute (2011), *2011 Investment Company Fact Book (51st Edition)*, Washington DC, Investment Company Institute (ICI).

Investment Management Association (2011), *IMA Asset Management Survey 2010-2011*, London, Investment Management Association (IMA).

Ippolito, R. A. (1989), 'Efficiency With Costly Information: A Study Of Mutual Fund Performance 1965-1984', *The Quarterly Journal Of Economics*, Volume 104, Pg 1-23.

Jacobs, R. (2001), 'Alternative Methods To Examine Hospital Efficiency: Data Envelopment Analysis And Stochastic Frontier Analysis', *Health Care Management Science*, Volume 4, Pg 103-115.

Jegadeesh, N. And Titman, S. (1993), 'Returns To Buying Winners And Selling Losers: Implications For Stock Market Efficiency', *The Journal Of Finance*, Volume 48, Pg 65-91.

Jensen, M. C. (1968), 'The Performance Of Mutual Funds In The Period 1945-1964', *The Journal Of Finance*, Volume 23, Pg 389-416.

Jondrow, J., Knox Lovell, C. A., Materov, I. S. And Schmidt, P. (1982), 'On The Estimation Of Technical Inefficiency In The Stochastic Frontier Production Function Model', *Journal Of Econometrics*, Volume 19, Pg 233-238.

Kaplan, P. And Knowles, J. A. (2004), 'Kappa: A Generalised Downside Risk-Adjusted Performance Measure', *Journal Of Performance Measurement*, Volume 8, Pg 42-54.

Kerstens, K., Mounir, A. And Van De Woestyne, I. (2011), 'Non-Parametric Frontier Estimates Of Mutual Fund Performance Using C- And L- Moments: Some Specification Tests', *Journal Of Banking & Finance*, Volume 35, Pg 1190-1201.

Kestner, L. N. (1996), 'Getting A Handle On True Performance', *Futures*, Volume 25, Pg 44-47.

Korhonen, P. And Luptacik, M. (2004), 'Eco-Efficiency Analysis Of Power Plants: An Extension Of Data Envelopment Analysis', *European Journal Of Operational Research*, Volume 154, Pg 437-446.

Korostelev, A., Simar, L. And Tsybakov, A. (1995a), 'Efficient Estimation Of Monotone Boundaries', *The Annals Of Statistics*, Volume 23, Pg 476-489.

Korostelev, A., Simar, L. And Tsybakov, A. (1995b), 'On Estimation Of Monotone And Convex Boundaries', *Publications ISUP*, XXXIX, Pg 3-18.

Kreander, N., Gray, R. H., Power, D. M. And Sinclair, C. D. (2005), 'Evaluating The Performance Of Ethical And Non-Ethical Funds: A Matched Pair Analysis', *Journal Of Business Finance & Accounting*, Volume 32, Pg 1465-1493.

Kuosmanen, T. (2006), 'Stochastic Non-Parametric Envelopment Of Data: Combining Virtues Of SFA And DEA In A Unified Framework', *MTT Discussion Paper No. 3/2006*.

Leger, L. A. (1997), 'UK Investment Trusts: Performance, Timing And Selectivity', *Applied Economics Letters*, Volume 4, Pg 207-210.

Liao, H., Wang, B. And Weyman-Jones, T. (2007), 'Neural Network Based Models For Efficiency Frontier Analysis: An Application To East Asian Economies' Growth Decomposition', *Global Economic Review*, Volume 36, Pg 361-384.

Liu, J. And Tone, K. (2008), 'A Multistage Method To Measure Efficiency And Its Application To The Japanese Banking Industry', *Socio-Economic Planning Sciences*, Volume 42, Pg 75-91.

Lovell, C. A. K. (1995), 'Measuring The Macroeconomic Performance Of The Taiwanese Economy', *International Journal Of Production Economics*, Volume 39, Pg 165-178.

Lovell, C. A. K., Walters, L. C. And Wood, L. L. (1994), 'Stratified Models Of Education Production Using Modified DEA And Regression Analysis', In *Data Envelopment Analysis: Theory, Methodology And Applications*, Charnes, A., Cooper, W. W., Lewin, A. Y. And Seiford, L. M. (Editors), Boston, Kluwer.

Lozano-Vivas, A., Pastor, J. T. And Pastor, J. M. (2002), 'An Efficiency Comparison Of European Banking Systems Operating Under Different Environmental Conditions', *Journal Of Productivity Analysis*, Volume 18, Pg 59-77.

Markowitz, H. (1952), 'Portfolio Selection', *The Journal Of Finance*, Volume 7, Pg 77-91.

Matallin, J. C., Soler-Dominguez, A. And Tortosa-Ausina, E. (2014), 'On The Informativeness Of Persistence For Evaluating Mutual Fund Performance Using Partial Frontiers', *Omega*, Volume 42, Pg 47-64.

McCarty, T. And Yaisawarng, S. (1993), 'Technical Efficiency In New Jersey School Districts', In *The Measurement Of Productive Efficiency: Techniques And Applications*, Fried, H. O., Lovell, C. A. K. And Schmidt, S. S. (Editors), New York, Oxford University Press.

McDonald, J. G. (1974), 'Objectives And Performance Of Mutual Funds: 1960-1969', *The Journal Of Financial And Quantitative Analysis*, Volume 9, Pg 311-333.

Meeusen, W. And Van Den Broeck, J. (1977), 'Efficiency Estimation From Cobb-Douglas Production Functions With Composed Error', *International Economic Review*, Volume 18, Pg 435-444.

Modigliani, F. And Modigliani, L. (1997), 'Risk-Adjusted Performance: How To Measure It And Why', *The Journal Of Portfolio Management*, Volume 23, Pg 45-54.

Morey, M. R. And Morey, R. C. (1999), 'Mutual Fund Performance Appraisals: A Multi-Horizon Perspective With Endogenous Benchmarking', *Omega*, Volume 27, Pg 241-258.

Murthi, B. P. S., Choi, Y. K. And Desai, P. (1997), 'Efficiency Of Mutual Funds And Portfolio Performance Measurement: A Non-Parametric Approach', *European Journal Of Operational Research*, Volume 98, Pg 408-418.

Pastor, J. M. (2002), 'Credit Risk And Efficiency In The European Banking System: A Three-Stage Analysis', *Applied Financial Economics*, Volume 12, Pg 895-911.

Pastor, J. T., Ruiz, J. L. And Sirvent, I. (1999), 'An Enhanced DEA Russell Graph Efficiency Measure', *European Journal Of Operational Research*, Volume 115, Pg 596-607.

Portela, M. C. A. S., Thanassoulis, E. And Simpson, G. (2004), 'A Directional Distance Approach To Deal With Negative Data In DEA: An Application To Bank Branches', *Journal Of Operational Research Society*, Volume 55, Pg 1111-1121.

Roll, R. (1977), 'A Critique Of The Asset Pricing Theory's Tests Part 1: On Past And Potential Testability Of The Theory', *Journal Of Financial Economics*, Volume 4, Pg 129-176.

Rom, B. M. And Ferguson, K. W. (1993), 'Post-Modern Portfolio Theory Comes Of Age', *The Journal Of Investing*, Volume 2, Pg 27-33.

Ross, S. A. (1976), 'The Arbitrage Theory Of Capital Asset Pricing', *Journal Of Economic Theory*, Volume 13, Pg 341-360.

Scheel, H. (2001), 'Undesirable Outputs In Efficiency Valuations', *European Journal Of Operational Research*, Volume 132, Pg 400-410.

Schefczyk, M. (1993), 'Operational Performance Of Airlines: An Extension Of Traditional Measurement Paradigms', *Strategic Management Journal*, Volume 14, Pg 301-317.

Scheraga, C. A. (2004), 'Operational Efficiency Versus Financial Mobility In The Global Airline Industry: A Data Envelopment And Tobit Analysis', *Transportation Research Part A: Policy And Practice*, Volume 38, Pg 383-404.

Scholz, H. And Wilkens, M. (2005), 'A Jigsaw Puzzle Of Basic Risk-Adjusted Performance Measures', *The Journal Of Performance Measurement*, Volume 9, Pg 57-64.

Seiford, L. M. (1996), 'Data Envelopment Analysis: The Evolution Of The State Of The Art (1978-1995)', *The Journal Of Productivity Analysis*, Volume 7, Pg 99-137.

Seiford, L. M. And Zhu, J. (2002), 'Modelling Undesirable Factors In Efficiency Evaluation', *European Journal Of Operational Research*, Volume 142, Pg 16-20.

Shadwick, W. And Keating, C. (2002), 'A Universal Performance Measure', *Journal Of Performance Measurement*, Volume 6, Pg 59-84.

Sharp, J. A., Liu, W. B. And Meng, W. (2006), 'A Modified Slacks-Based Measure Model For Data Envelopment Analysis With Natural Negative Outputs And Inputs', *Journal Of Operational Research Society*, Volume 57, Pg 1-6.

Sharpe, W. F. (1966), 'Mutual Fund Performance', *The Journal Of Business*, Volume 39, Pg 119-138.

Sharpe, W. F. (1994), 'The Sharpe Ratio', *The Journal Of Portfolio Management*, Volume 21, Pg 49-58.

Sherman, D. H. (1984), ‘Hospital Efficiency Measurement And Evaluation: Empirical Test Of A New Technique’, *Medical Care*, Volume 22, Pg 922-938.

Sherman, D. H. And Gold, F. (1985), ‘Bank Branch Operating Efficiency: Evaluation With Data Envelopment Analysis’, *Journal Of Banking & Finance*, Volume 9, Pg 297-315.

Shukla, R. K. And Van Inwegen, G. B. (1995), ‘Do Locals Perform Better Than Foreigners?: An Analysis Of UK And US Mutual Fund Managers’, *Journal Of Economics And Business*, Volume 47, Pg 241-254.

Simar, L. And Wilson, W. P. (1998), ‘Sensitivity Analysis Of Efficiency Scores: How To Bootstrap In Non-Parametric Frontier Models’, *Management Science*, Volume 44, Pg 49-61.

Simar, L. And Wilson, W. P. (2000), ‘Statistical Inference In Non-Parametric Frontier Models: The State Of The Art’, *Journal Of Productivity Analysis*, Volume 13, Pg 49-78.

Sortino, F. A. And Van Der Meer, R. (1991), ‘Downside Risk’, *The Journal Of Portfolio Management*, Volume 17, Pg 27-31.

Sortino, F. A., Van Der Meer, R. And Plantinga, A. (1999), ‘The Dutch Triangle’, *The Journal Of Portfolio Management*, Volume 26, Pg 50-57.

Stern, H. S. (1996), ‘Neural Networks In Applied Statistics’, *Technometrics*, Volume 38, Pg 205-214.

Talluri, S., Huq, F. And Pinney, W. E. (1997), 'Application Of Data Envelopment Analysis For Cell Performance Evaluation And Process Improvement In Cellular Manufacturing', *International Journal Of Production Research*, Volume 35, Pg 2157-2170.

Thanassoulis, E. (1995), 'Assessing Police Forces In England And Wales Using Data Envelopment Analysis', *European Journal Of Operational Research*, Volume 87, Pg 641-657.

Thompson, R. G., Dharmapala, P. S. And Thrall, R. M. (1994), 'Sensitivity Analysis Of Efficiency Measures With Applications To Kansas Farming And Illinois Coal Mining', In *Data Envelopment Analysis: Theory, Methodology And Applications*, Charnes, A., Cooper, W. W., Lewin, A. Y. And Seiford, L. M. (Editors), Boston, Kluwer Academic Publishers.

Thompson, R. G., Singleton, F. D., Thrall, R. M. And Smith, B. A. (1986), 'Comparative Site Evaluations For Locating A High-Energy Physics Lab In Texas', *Interfaces*, Volume 16, Pg 35-49.

Timmer, C. P. (1971), 'Using A Probabilistic Frontier Production Function To Measure Technical Efficiency', *The Journal Of Political Economy*, Volume 79, Pg 776-794.

Tone, K. (2001), 'A Slacks-Based Measure Of Efficiency In Data Envelopment Analysis', *European Journal Of Operational Research*, Volume 130, Pg 498-509.

Tone, K. (2002), 'A Slacks-Based Measure Of Super-Efficiency In Data Envelopment Analysis', *European Journal Of Operational Research*, Volume 143, Pg 32-41.

Tone, K. (2004), 'A Hybrid Measure Of Efficiency In DEA', *GRIPS Research Report Series*, Research Report I-2004-0003.

Tone, K. And Tsutsui, M. (2009), 'Tuning Regression Results For Use In Multi-Stage Data Adjustment Approach Of DEA', *Journal Of The Operational Research Society Of Japan*, Volume 52, Pg 76-85.

Treynor, J. L. (1965), 'How To Rate Management Of Investment Funds', *Harvard Business Review*, Volume 43, Pg 63-75.

Treynor, J. L. And Black, F. (1973), 'How To Use Security Analysis To Improve Portfolio Selection', *The Journal Of Business*, Volume 46, Pg 66-86.

Treynor, J. L. And Mazuy, K. (1966), 'Can Mutual Funds Outguess The Market?', *Harvard Business Review*, Volume 44, Pg 131-136.

Webb, R. M. (2003), 'Levels Of Efficiency In UK Retail Banks: A DEA Window Analysis', *International Journal Of The Economics Of Business*, Volume 10, Pg 305-322.

Weyman-Jones, T. G., Boucinha, J. M. And Inacio, C. F. (2010), 'Quality Of Supply And Efficiency: An Analysis Of Portuguese Electricity Distribution Networks', *Sosyo Ekonomi*, Volume 6, Pg 177-209.

Yeandle, M. And Danev, N. (2013), *Global Financial Centres Index (GFCI) 14*, London, Z/Yen Group.

# Appendices

# Data Appendix

# Data Appendix Section 1:

# UK Domiciled OEICs And UTs With A UK Investment Focus

**Category 1:** UK Large-Cap Value Equity (1st January 2008 – 31st December 2010)

ETF Index Tracking Fund – iShares FTSE 100

**Category 2:** UK Large-Cap Growth Equity (1st January 2008 – 31st December 2010)

ETF Index Tracking Fund – iShares FTSE 100

**Category 3:** UK Large-Cap Blend Equity (1st January 2008 – 31st December 2010)

ETF Index Tracking Fund – iShares FTSE 100

**Category 4:** UK Mid-Cap Equity (1st January 2008 – 31st December 2010)

ETF Index Tracking Fund – iShares FTSE 250

**Category 5:** UK Small-Cap Equity (1st January 2008 – 31st December 2010)

ETF Index Tracking Fund – iShares FTSE 250

## UK Large-Cap Value Equity (1st January 2008 – 31st December 2010)

Input 1 (3-Yr SD) → 3-Year Standard Deviation (%)

Input 2 (3-Yr SR) → 3-Year Sharpe Ratio

Input 3 (TER) → Total Expense Ratio (%)

Input 4 (Fund Size) → Total Fund Size (GBP Millions)

Output 1 (3-Yr AR) → 3-Year Annualised Return (%)

| Name Of OEIC/UT | Input 1 3-Yr SD | Input 2 3-Yr SR | Input 3 TER | Input 4 Fund Size | Output 1 3-Yr AR |
|---|---|---|---|---|---|
| Aberdeen Charity Select UK Equity Fund | 21.47 | 0.22 | 0.59 | 22.59 | 3.93 |
| Aberdeen Multi-Manager UK Income Portfolio | 17.20 | 0.19 | 2.24 | 8.55 | 3.63 |
| Aberdeen Responsible UK Equity Fund | 20.93 | 0.21 | 1.57 | 13.12 | 3.58 |
| Aberdeen UK Equity Fund | 21.38 | 0.18 | 1.63 | 136.52 | 2.96 |
| Aberdeen UK Equity Income Fund | 21.26 | 0.17 | 1.60 | 101.20 | 2.64 |
| Artemis Income Fund | 16.80 | 0.24 | 1.55 | 3654.30 | 4.11 |
| Cazenove UK Growth & Income Fund | 20.56 | 0.25 | 1.10 | 512.80 | 4.48 |
| Capita Financial Taylor Young Equity Income Fund | 19.44 | 0.22 | 1.69 | 20.00 | 3.61 |
| Capita Financial Walker Crips UK Growth Fund | 18.46 | 0.29 | 1.58 | 164.00 | 5.69 |
| Dimensional UK Core Equity Fund | 21.52 | 0.21 | 0.38 | 216.02 | 3.67 |
| Dimensional UK Value Fund | 27.72 | 0.05 | 0.61 | 96.41 | -1.33 |
| Elite Henderson Rowe Dogs FTSE 100 Fund | 20.62 | -0.45 | 2.40 | 0.43 | -10.22 |
| F&C UK Equity Income Fund | 18.26 | 0.14 | 1.82 | 14.92 | 2.27 |
| F&C UK Growth & Income Fund | 18.57 | 0.07 | 1.88 | 14.99 | 1.34 |
| Family Asset Trust | 20.89 | -0.02 | 1.02 | 86.55 | -0.80 |
| Fidelity Special Situations Fund | 22.99 | 0.26 | 1.69 | 3108.98 | 5.15 |
| Gartmore UK Alpha Fund | 28.01 | -0.21 | 1.48 | 33.91 | -8.61 |
| Gartmore UK Equity Income Fund | 18.81 | 0.12 | 1.68 | 98.77 | 1.73 |
| Gartmore UK Growth Fund | 23.54 | -0.08 | 1.70 | 180.34 | -3.54 |
| GLG UK Growth Fund | 22.85 | -0.05 | 1.66 | 114.80 | -2.41 |
| GLG UK Income Fund | 21.47 | 0.07 | 1.67 | 86.60 | 0.83 |

| | | | | | |
|---|---|---|---|---|---|
| HL Multi-Manager Income & Growth Portfolio Trust | 16.07 | 0.11 | 1.91 | 7.21 | 2.36 |
| HSBC Income Fund | 18.74 | 0.18 | 1.65 | 41.35 | 2.88 |
| Ignis UK Equity Income Fund | 19.70 | 0.17 | 1.66 | 105.40 | 2.80 |
| Insight Investment Equity High Income Fund | 20.56 | 0.18 | 1.69 | 147.43 | 3.04 |
| Investec UK Special Situations Fund | 19.96 | 0.49 | 1.61 | 190.65 | 9.62 |
| Invesco Perpetual Children's Fund | 18.69 | 0.06 | 1.74 | 144.94 | 1.17 |
| Invesco Perpetual High Income Fund | 14.25 | 0.09 | 1.69 | 6801.40 | 1.98 |
| Invesco Perpetual Income & Growth Fund | 18.96 | 0.06 | 1.69 | 72.37 | 0.66 |
| Invesco Perpetual Income Fund | 14.34 | 0.08 | 1.68 | 4499.22 | 1.86 |
| Invesco Perpetual UK Aggressive Fund | 17.55 | 0.05 | 1.69 | 111.53 | 0.98 |
| Invesco Perpetual UK Enhanced Index Fund | 20.46 | 0.21 | 0.40 | 40.18 | 3.64 |
| Invesco Perpetual UK Growth Fund | 20.00 | -0.04 | 1.69 | 660.47 | -1.65 |
| JoHambro Capital Management UK Equity Income Fund | 21.59 | 0.51 | 1.39 | 118.49 | 10.70 |
| J. P. Morgan Premier Equity Income Fund | 21.11 | 0.16 | 1.67 | 174.08 | 2.43 |
| J. P. Morgan UK Managed Equity Fund | 20.96 | 0.15 | 1.67 | 257.38 | 2.19 |
| J. P. Morgan UK Strategic Equity Income Fund | 25.06 | 0.19 | 1.67 | 151.61 | 2.76 |
| Jupiter Undervalued Assets Fund | 19.75 | -0.04 | 1.78 | 124.27 | -1.42 |
| L&G (Barclays) MM UK Equity Income Fund | 16.00 | 0.19 | 1.73 | 72.80 | 3.64 |
| Lazard UK Income Fund | 21.30 | 0.15 | 1.30 | 28.50 | 2.43 |
| Legg Mason UK Equity Fund | 20.15 | 0.16 | 1.87 | 52.47 | 2.49 |
| M&G Charifund | 18.54 | -0.01 | 0.47 | 983.30 | -0.59 |
| M&G Dividend Fund | 18.10 | 0.17 | 1.66 | 83.41 | 2.92 |
| M&G Income Fund | 21.02 | 0.24 | 1.66 | 46.98 | 4.58 |
| Neptune Income Fund | 18.69 | 0.18 | 1.61 | 223.71 | 3.61 |
| Neptune Quarterly Income Fund | 17.93 | 0.16 | 1.72 | 21.60 | 2.59 |
| Neptune UK Equity Fund | 21.16 | 0.26 | 1.70 | 34.54 | 5.09 |
| Neptune UK Special Situations Fund | 20.78 | 0.39 | 1.91 | 2.79 | 7.93 |
| Old Mutual Equity Income Fund | 20.41 | 0.18 | 1.74 | 4.85 | 3.26 |
| Old Mutual Extra Income Fund | 17.54 | 0.18 | 1.77 | 9.00 | 3.47 |
| Premier UK Strategic Growth Fund | 24.24 | 0.12 | 1.21 | 0.46 | 1.17 |
| Prudential Ethical Trust Fund | 23.32 | -0.07 | 1.75 | 0.56 | -3.21 |
| PSigma Income Fund | 18.71 | 0.04 | 1.78 | 122.29 | 0.02 |
| PSigma UK Growth Fund | 23.11 | 0.08 | 1.91 | 0.31 | 0.07 |

| | | | | | |
|---|---|---|---|---|---|
| Rathbone Blue Chip Income & Growth Fund | 17.56 | 0.18 | 1.63 | 60.73 | 3.26 |
| Rathbone Income Fund | 20.04 | 0.06 | 1.56 | 499.78 | 0.01 |
| River & Mercantile UK Equity High Alpha Fund | 25.93 | 0.36 | 0.15 | 135.24 | 8.22 |
| S&W Church House Balanced Value & Income Fund | 16.58 | 0.16 | 1.58 | 57.70 | 3.30 |
| S&W Church House UK Managed Growth Fund | 19.84 | 0.29 | 1.58 | 41.80 | 5.42 |
| S&W FTIM Munro Fund | 19.15 | 0.06 | 2.80 | 0.20 | 0.46 |
| Schroder Charity Equity Fund | 22.38 | 0.31 | 0.60 | 7.03 | 7.06 |
| Schroder Income Fund | 22.92 | 0.36 | 1.65 | 726.09 | 7.66 |
| Schroder Income Maximiser Fund | 21.14 | 0.31 | 1.66 | 240.36 | 6.37 |
| Schroder Recovery Fund | 25.93 | 0.46 | 1.52 | 91.46 | 10.93 |
| Schroder Specialist Value UK Equity Fund | 22.07 | 0.33 | 0.77 | 85.33 | 7.30 |
| Scottish Widows Ethical Fund | 20.83 | -0.19 | 1.62 | 2.40 | -3.56 |
| Scottish Widows UK Equity Income Fund | 19.27 | 0.00 | 1.36 | 262.19 | 1.00 |
| Scottish Widows UK Growth Fund | 19.98 | 0.05 | 1.61 | 1330.27 | 1.68 |
| Skandia Multi-Manager UK Equity Fund | 23.62 | 0.21 | 1.59 | 129.60 | 3.49 |
| St James's Place Equity Income Fund | 23.31 | 0.32 | 1.63 | 527.00 | 6.51 |
| St James's Place UK Growth Fund | 25.13 | 0.25 | 2.19 | 75.00 | 5.90 |
| St James's Place UK High Income Fund | 13.08 | 0.14 | 1.82 | 949.00 | 4.20 |
| Standard Life UK Equity High Income Fund | 20.57 | 0.09 | 1.59 | 848.70 | 1.08 |
| Standard Life UK Equity Manager Of Managers Fund | 19.50 | 0.10 | 1.97 | 2.85 | 3.05 |
| SWIP Multi-Manager UK Equity Income Fund | 19.44 | 0.06 | 1.81 | 86.30 | 2.08 |
| SWIP UK Income Fund | 19.79 | 0.02 | 1.62 | 0.14 | 1.35 |
| TB Wise Income Fund | 19.50 | 0.13 | 2.13 | 2.01 | 3.07 |
| Templeton UK Equity Fund | 25.43 | -0.01 | 1.75 | 2.93 | -0.33 |
| Troy Trojan Income Fund | 12.61 | 0.39 | 1.07 | 234.00 | 7.09 |
| UBS UK Select Fund | 20.38 | -0.02 | 1.60 | 2.25 | 0.54 |
| **iShares FTSE 100** | **19.24** | **0.15** | **0.40** | **3793.97** | **3.34** |

Source: Morningstar UK

Total Number Of OEICs/UTs = 80 (+1 ETF)

## UK Large-Cap Growth Equity (1st January 2008 – 31st December 2010)

Input 1 (3-Yr SD) → 3-Year Standard Deviation (%)

Input 2 (3-Yr SR) → 3-Year Sharpe Ratio

Input 3 (TER) → Total Expense Ratio (%)

Input 4 (Fund Size) → Total Fund Size (GBP Millions)

Output 1 (3-Yr AR) → 3-Year Annualised Return (%)

| Name Of OEIC/UT | Input 1 3-Yr SD | Input 2 3-Yr SR | Input 3 TER | Input 4 Fund Size | Output 1 3-Yr AR |
|---|---|---|---|---|---|
| AEGON UK Opportunities Fund | 21.65 | 0.24 | 1.58 | 30.42 | 5.64 |
| BlackRock UK Fund | 22.80 | 0.08 | 1.67 | 613.60 | 1.91 |
| BlackRock UK Dynamic Fund | 23.57 | 0.08 | 1.66 | 1522.80 | 2.07 |
| FF&P Concentrated UK Equity Fund | 22.25 | 0.20 | 2.19 | 77.69 | 5.12 |
| Fidelity UK Growth Fund | 22.42 | 0.33 | 1.70 | 543.99 | 7.50 |
| L&G (N) UK Growth Fund | 22.34 | 0.18 | 1.67 | 469.86 | 4.68 |
| Mirabaud Mir GB Fund | 20.66 | 0.23 | 1.83 | 40.10 | 3.99 |
| Royal London UK Opportunities Fund | 23.06 | 0.38 | 1.42 | 364.35 | 9.42 |
| SVM UK Growth Fund | 22.02 | 0.40 | 1.80 | 16.61 | 10.04 |
| **iShares FTSE 100** | **19.24** | **0.15** | **0.40** | **3793.97** | **3.34** |

Source: Morningstar UK

Total Number Of OEICs/UTs = 9 (+1 ETF)

## UK Large-Cap Blend Equity (1st January 2008 – 31st December 2010)

Input 1 (3-Yr SD) → 3-Year Standard Deviation (%)

Input 2 (3-Yr SR) → 3-Year Sharpe Ratio

Input 3 (TER) → Total Expense Ratio (%)

Input 4 (Fund Size) → Total Fund Size (GBP Millions)

Output 1 (3-Yr AR) → 3-Year Annualised Return (%)

| Name Of OEIC/UT | Input 1 3-Yr SD | Input 2 3-Yr SR | Input 3 TER | Input 4 Fund Size | Output 1 3-Yr AR |
|---|---|---|---|---|---|
| Aberdeen Multi-Manager UK Growth Portfolio | 17.54 | 0.14 | 2.56 | 6.35 | 4.20 |
| AEGON UK Equity Fund | 20.83 | 0.25 | 1.61 | 90.70 | 6.11 |
| Allianz RCM UK Equity Fund | 22.83 | 0.13 | 1.59 | 1.05 | 3.18 |
| Allianz RCM UK Growth Fund | 22.94 | 0.09 | 1.43 | 61.21 | 2.39 |
| Allianz RCM UK Index Fund | 20.94 | 0.21 | 0.70 | 20.97 | 5.45 |
| Allianz RCM UK Unconstrained Fund | 24.96 | 0.02 | 1.96 | 11.08 | -0.32 |
| Architas Multi-Manager UK Equity Portfolio | 21.30 | 0.02 | 1.89 | 153.88 | 2.22 |
| Artemis Capital Fund | 24.50 | 0.02 | 1.66 | 389.20 | 0.61 |
| Artemis UK Growth Fund | 20.43 | 0.23 | 1.61 | 376.10 | 5.81 |
| Aviva Investors UK Equity Fund | 19.20 | 0.36 | 0.72 | 208.70 | 8.73 |
| Aviva Investors UK Focus Fund | 24.12 | 0.27 | 1.55 | 120.30 | 7.57 |
| Aviva Investors UK Growth Fund | 20.63 | 0.38 | 1.00 | 190.60 | 9.03 |
| AXA Framlington UK Growth Fund | 22.64 | 0.28 | 1.55 | 206.50 | 7.81 |
| AXA General Trust | 23.11 | 0.12 | 1.03 | 177.90 | 3.95 |
| Baillie Gifford British 350 Fund | 20.69 | 0.30 | 1.50 | 100.55 | 8.29 |
| Baillie Gifford UK Equity Alpha Fund | 20.66 | 0.23 | 1.55 | 106.37 | 6.70 |
| Bank Of Scotland FTSE 100 Tracker Fund | 20.52 | 0.16 | 1.00 | 10.72 | 4.48 |
| BlackRock Armed Forces Common Investment Fund | 16.77 | 0.16 | 0.65 | 196.02 | 4.15 |
| BlackRock Charishare Fund | 21.49 | 0.19 | 1.05 | 102.00 | 4.76 |
| BlackRock UK Equity Fund | 20.89 | 0.37 | 0.52 | 962.00 | 8.84 |
| BlackRock UK Income Fund | 19.21 | 0.43 | 1.67 | 641.00 | 10.53 |

| | | | | | |
|---|---|---|---|---|---|
| Cazenove Multi-Manager UK Growth Fund | 16.61 | 0.10 | 1.78 | 152.70 | 3.31 |
| Cazenove UK Opportunities Fund | 19.94 | 0.58 | 1.23 | 56.30 | 14.04 |
| CF Canada Life General Trust | 19.71 | 0.11 | 1.55 | 87.18 | 2.31 |
| CF Canada Life Growth Fund | 18.58 | 0.08 | 1.53 | 396.16 | 2.91 |
| CF GHC Multi-Manager UK Equity OEIC | 19.03 | 0.16 | 2.69 | 15.18 | 4.33 |
| CF JM Finn UK Portfolio Fund | 20.17 | 0.13 | 1.81 | 10.00 | 3.22 |
| CF Lindsell Train UK Equity Fund | 18.19 | 0.59 | 0.92 | 256.60 | 13.25 |
| CF Taylor Young Growth & Income Fund | 17.28 | 0.22 | 1.65 | 20.70 | 5.51 |
| CF Walker Crips UK High Alpha Fund | 19.17 | 0.36 | 1.57 | 46.00 | 8.94 |
| Chariguard UK Equity Fund | 19.88 | 0.26 | 0.80 | 129.40 | 5.71 |
| CIS UK FTSE4Good Tracker Trust | 19.96 | 0.10 | 1.50 | 54.09 | 3.45 |
| EFA OPM UK Equity Fund | 20.93 | -0.07 | 2.03 | 0.77 | -0.86 |
| Engage Investment Growth Fund | 20.27 | 0.17 | 1.00 | 0.07 | 5.26 |
| Epworth Affirmative Equity Fund | 19.00 | 0.04 | 0.39 | 41.00 | 1.13 |
| F&C FTSE All-Share Tracker Fund | 20.82 | 0.22 | 0.40 | 102.56 | 5.74 |
| F&C UK Equity Fund | 20.58 | 0.27 | 1.78 | 66.44 | 7.20 |
| Family Charities Ethical Trust | 22.51 | -0.12 | 1.48 | 43.00 | -1.99 |
| Fidelity MoneyBuilder UK Index Fund | 20.96 | 0.20 | 0.30 | 842.42 | 5.40 |
| Fidelity UK Aggressive Fund | 19.96 | 0.36 | 1.71 | 263.79 | 8.18 |
| GAM MP UK Equity Unit Trust | 19.35 | 0.22 | 1.15 | 10.40 | 5.92 |
| Gartmore UK Index Fund | 20.92 | 0.20 | 0.67 | 239.30 | 5.42 |
| Gartmore UK Tracker Fund | 20.55 | 0.16 | 1.20 | 100.13 | 4.47 |
| HBOS UK FTSE 100 Index Track Fund | 20.72 | 0.16 | 1.50 | 317.02 | 4.15 |
| Henderson UK Equity Tracker Trust | 21.05 | 0.04 | 1.03 | 78.46 | 1.89 |
| Henderson UK High Alpha Fund | 19.65 | 0.01 | 0.73 | 27.68 | 2.20 |
| HSBC FTSE 100 Index Fund | 20.48 | 0.18 | 0.27 | 185.20 | 5.49 |
| HSBC FTSE All Share Index Fund | 20.78 | 0.22 | 0.27 | 48.19 | 6.21 |
| HSBC MERIT UK Equity Fund | 21.10 | 0.18 | 0.52 | 13.68 | 5.37 |
| HSBC UK Focus Fund | 20.58 | 0.24 | 1.02 | 2.59 | 5.01 |
| HSBC UK Freestyle Fund | 19.67 | -0.02 | 1.65 | 44.57 | 0.93 |
| HSBC UK Growth & Income Fund | 19.76 | 0.18 | 1.65 | 108.29 | 5.45 |
| IFDS Brown Shipley UK Flagship Fund | 19.24 | 0.24 | 1.66 | 12.81 | 5.87 |

| | | | | | |
|---|---|---|---|---|---|
| Ignis Balanced Growth Fund | 21.67 | 0.04 | 1.59 | 185.80 | 1.46 |
| Ignis Cartesian UK Opportunities Fund | 17.60 | -0.05 | 1.80 | 73.90 | 0.78 |
| Ignis UK Focus Fund | 22.12 | 0.16 | 1.53 | 105.00 | 4.27 |
| Insight Investment UK Dynamic Managed Fund | 20.43 | 0.12 | 2.42 | 19.03 | 3.64 |
| Investec UK Alpha Fund | 22.80 | 0.27 | 1.61 | 28.52 | 6.35 |
| Investec UK Blue Chip Fund | 20.21 | 0.24 | 1.61 | 135.30 | 5.91 |
| Invesco Perpetual UK Strategic Income Fund | 14.65 | 0.16 | 1.74 | 28.85 | 5.02 |
| Jessop Gartmore UK Index Fund | 20.86 | 0.18 | 1.03 | 2.47 | 4.79 |
| JoHambro Capital Management UK Opportunities Fund | 15.97 | 0.24 | 0.84 | 334.26 | 5.57 |
| J. P. Morgan Premier Equity Growth Fund | 22.65 | 0.04 | 1.67 | 275.40 | 1.12 |
| J. P. Morgan UK Active Index Plus Fund | 21.77 | 0.20 | 0.40 | 65.95 | 5.10 |
| J. P. Morgan UK Dynamic Fund | 22.24 | 0.18 | 1.67 | 125.85 | 4.66 |
| J. P. Morgan UK Focus Fund | 21.97 | 0.26 | 1.67 | 54.21 | 6.47 |
| Jupiter UK Alpha Fund | 19.31 | 0.30 | 1.60 | 15.32 | 7.12 |
| L&G (Barclays) Market Track 350 Trust | 20.59 | 0.19 | 1.00 | 75.47 | 5.02 |
| L&G (Barclays) Multi-Manager UK Alpha Fund | 22.08 | 0.12 | 1.70 | 759.20 | 3.41 |
| L&G (Barclays) Multi-Manager UK Alpha (Series 2) Fund | 22.67 | 0.10 | 1.72 | 122.50 | 2.93 |
| L&G (Barclays) Multi-Manager UK Core Fund | 20.41 | 0.13 | 1.70 | 375.20 | 4.35 |
| L&G (Barclays) Multi-Manager UK Opportunities Fund | 16.65 | 0.31 | 1.80 | 103.70 | 7.72 |
| L&G Capital Growth Fund | 20.55 | 0.18 | 1.50 | 179.20 | 4.77 |
| L&G (N) UK Tracker Trust | 20.78 | 0.18 | 1.15 | 945.84 | 4.93 |
| L&G CAF UK Equitrack Fund | 20.68 | 0.39 | 0.32 | 232.08 | 9.69 |
| L&G Equity Trust | 19.65 | 0.02 | 1.17 | 39.11 | 1.22 |
| L&G Ethical Trust | 23.48 | 0.06 | 1.15 | 67.03 | 2.29 |
| L&G Growth Trust | 20.03 | 0.19 | 1.67 | 28.29 | 4.44 |
| L&G UK 100 Index Trust | 20.28 | 0.18 | 0.82 | 119.15 | 4.70 |
| L&G UK Active Opportunities Trust | 20.24 | 0.11 | 1.67 | 172.37 | 3.08 |
| L&G UK Index Trust | 20.51 | 0.21 | 0.55 | 1693.37 | 5.62 |
| Lazard UK Alpha Fund | 21.78 | 0.14 | 1.53 | 6.35 | 3.92 |
| Lazard UK Omega Fund | 23.04 | 0.24 | 1.70 | 0.17 | 6.41 |
| LV UK Growth Fund | 21.71 | 0.13 | 1.14 | 8.82 | 3.04 |
| M&G Index Tracker Fund | 20.58 | 0.22 | 0.46 | 116.01 | 5.37 |
| M&G Recovery Fund | 20.92 | 0.41 | 1.66 | 2960.02 | 9.76 |
| M&G UK Growth Fund | 19.41 | 0.29 | 1.66 | 233.05 | 6.47 |
| M&G UK Select Fund | 20.09 | 0.17 | 1.66 | 53.43 | 4.89 |
| Majedie AM UK Equity Fund | 18.19 | 0.46 | 1.03 | 385.00 | 10.22 |

| | | | | | |
|---|---|---|---|---|---|
| Majedie AM UK Focus Fund | 19.32 | 0.44 | 2.03 | 6.12 | 9.94 |
| M&S Ethical Fund | 19.59 | 0.04 | 1.68 | 13.50 | 2.36 |
| M&S UK 100 Companies Fund | 20.22 | 0.14 | 1.04 | 214.90 | 4.39 |
| M&S UK Selection Portfolio | 20.88 | 0.09 | 1.64 | 108.80 | 2.73 |
| Morgan Stanley UK Equity Alpha Fund | 18.95 | 0.10 | 1.75 | 0.06 | 3.10 |
| Old Mutual UK Select Equity Fund | 22.11 | 0.26 | 1.60 | 76.09 | 6.41 |
| Premier Castlefield UK Alpha Fund | 28.23 | -0.02 | 4.42 | 0.01 | -2.04 |
| Premier Castlefield UK Equity Fund | 20.42 | 0.14 | 1.59 | 0.08 | 3.87 |
| Prudential UK Growth Trust | 21.32 | 0.14 | 1.64 | 12.54 | 4.08 |
| Prudential UK Index Tracker Trust | 20.77 | 0.20 | 0.50 | 9.32 | 5.24 |
| RBS FTSE 100 Tracker Fund | 20.53 | 0.18 | 1.00 | 38.32 | 4.46 |
| Royal London FTSE 350 Tracker Fund | 20.28 | 0.12 | 0.12 | 2711.17 | 3.43 |
| Royal London UK Equity Fund | 20.26 | 0.34 | 1.30 | 331.24 | 8.18 |
| Santander Premium Fund UK Equity | 19.85 | 0.20 | 1.02 | 652.36 | 5.39 |
| Santander Stockmarket 100 Tracker Trust | 20.34 | 0.21 | 0.35 | 70.55 | 5.47 |
| Santander UK Growth Trust | 20.13 | 0.24 | 1.27 | 910.88 | 6.06 |
| Schroder Specialist UK Equity Fund | 22.18 | 0.28 | 0.77 | 96.55 | 8.51 |
| Schroder Prime UK Equity Fund | 20.09 | 0.34 | 0.50 | 124.37 | 9.95 |
| Schroder UK Alpha Plus Fund | 26.58 | 0.33 | 1.65 | 1747.33 | 8.81 |
| Schroder UK Equity Fund | 22.95 | 0.29 | 1.64 | 455.20 | 7.56 |
| Scottish Friendly UK Growth Fund | 21.54 | 0.25 | 1.42 | 7.40 | 5.82 |
| Scottish Mutual UK All-Share Index Trust | 20.74 | 0.24 | 0.04 | 27.14 | 5.52 |
| Scottish Mutual UK Equity Trust | 21.05 | 0.15 | 1.02 | 76.89 | 3.71 |
| Scottish Widows UK All-Share Tracker Fund | 21.15 | 0.21 | 0.36 | 1290.30 | 5.08 |
| Scottish Widows UK Select Growth Fund | 20.06 | 0.26 | 1.58 | 174.88 | 7.00 |
| Scottish Widows UK Tracker Fund | 20.53 | 0.16 | 1.00 | 66.58 | 4.27 |
| Skandia Multi-Manager UK Index Fund | 20.92 | 0.18 | 0.46 | 363.48 | 4.90 |
| Skandia Multi-Manager UK Opportunities Fund | 27.04 | -0.16 | 1.61 | 108.94 | -4.88 |
| Standard Life TM UK General Equity Fund | 22.00 | 0.15 | 0.83 | 1302.99 | 3.71 |
| SSGA UK Equity Enhanced Fund | 19.40 | 0.14 | 0.90 | 92.50 | 4.58 |
| SSGA UK Equity Tracker Fund | 19.74 | 0.18 | 0.90 | 177.30 | 5.27 |

| | | | | | |
|---|---|---|---|---|---|
| St James's Place UK & General Progressive Fund | 21.94 | -0.04 | 1.87 | 541.00 | -0.80 |
| Standard Life UK Equity Growth Fund | 22.17 | 0.13 | 1.59 | 427.60 | 3.70 |
| SWIP Multi-Manager UK Equity Focus Fund | 21.54 | 0.06 | 1.81 | 179.63 | 1.69 |
| SWIP Multi-Manager UK Equity Growth Fund | 21.13 | 0.17 | 1.82 | 174.31 | 3.88 |
| SWIP UK Opportunities Fund | 20.26 | 0.32 | 1.64 | 33.82 | 7.73 |
| Threadneedle Navigator UK Index Tracker Fund | 20.92 | 0.20 | 1.17 | 79.00 | 5.17 |
| Threadneedle UK Extended Alpha Fund | 20.98 | 0.08 | 1.49 | 3.50 | 1.91 |
| Troy Trojan Capital Fund | 12.20 | 0.57 | 1.15 | 59.00 | 9.17 |
| UBS UK Equity Income Find | 19.72 | -0.09 | 1.61 | 10.34 | -1.05 |
| Wesleyan Growth Trust | 20.40 | 0.21 | 1.47 | 66.15 | 5.04 |
| **iShares FTSE 100** | **19.24** | **0.15** | **0.40** | **3793.97** | **3.34** |

Source: Morningstar UK

Total Number Of OEICs/UTs = 130 (+1 ETF)

## UK Mid-Cap Equity (1st January 2008 – 31st December 2010)

Input 1 (3-Yr SD) → 3-Year Standard Deviation (%)

Input 2 (3-Yr SR) → 3-Year Sharpe Ratio

Input 3 (TER) → Total Expense Ratio (%)

Input 4 (Fund Size) → Total Fund Size (GBP Millions)

Output 1 (3-Yr AR) → 3-Year Annualised Return (%)

| Name Of OEIC/UT | Input 1 3-Yr SD | Input 2 3-Yr SR | Input 3 TER | Input 4 Fund Size | Output 1 3-Yr AR |
|---|---|---|---|---|---|
| Aberdeen UK Mid-Cap Fund | 24.50 | 0.26 | 1.63 | 33.21 | 6.58 |
| AEGON Ethical Equity Fund | 19.44 | 0.24 | 1.58 | 146.77 | 4.95 |
| Allianz RCM UK Mid-Cap Fund | 26.05 | 0.32 | 1.74 | 58.14 | 7.40 |
| Artemis UK Special Situations Fund | 18.42 | 0.31 | 1.56 | 1175.50 | 7.18 |
| Aviva Investors SF UK Growth Fund | 19.65 | 0.07 | 1.52 | 137.80 | 2.59 |
| Aviva Investors UK Ethical Fund | 20.32 | 0.06 | 1.00 | 236.30 | 2.63 |
| Aviva Investors UK Special Situations Fund | 25.38 | 0.30 | 1.72 | 306.50 | 6.93 |
| AXA Framlington Equity Income Fund | 22.35 | -0.05 | 1.59 | 197.90 | -1.20 |
| AXA Framlington Monthly Income Fund | 21.00 | -0.17 | 1.61 | 124.30 | -3.64 |
| AXA Framlington UK Select Opportunities Fund | 20.35 | 0.43 | 1.56 | 2380.40 | 9.46 |
| BlackRock UK Special Situations Fund | 21.70 | 0.50 | 1.67 | 1322.60 | 11.98 |
| Cazenove UK Dynamic Fund | 24.26 | 0.33 | 1.67 | 69.00 | 9.01 |
| CF Cornelian British Opportunities Fund | 20.56 | 0.09 | 2.17 | 7.37 | 2.44 |
| CF OLIM UK Equity Trust | 19.62 | 0.27 | 2.20 | 8.40 | 5.47 |
| CF Taylor Young Growth Fund | 25.65 | 0.16 | 1.64 | 36.90 | 2.80 |
| CF Taylor Young Opportunistic Fund | 21.87 | 0.07 | 2.15 | 2.80 | 1.67 |
| Ecclesiastical Amity UK Fund | 19.54 | 0.20 | 1.37 | 34.50 | 4.88 |
| F&C Stewardship Growth Fund | 20.28 | -0.01 | 1.74 | 205.79 | 1.03 |
| F&C Stewardship Income Fund | 18.17 | -0.07 | 1.63 | 132.56 | 0.09 |
| F&C UK Mid-Cap Fund | 24.65 | 0.46 | 1.59 | 27.67 | 11.26 |

| | | | | | |
|---|---|---|---|---|---|
| F&C UK Opportunities Fund | 22.71 | 0.02 | 1.57 | 29.59 | 0.56 |
| GAM UK Diversified Fund | 19.89 | 0.25 | 1.61 | 214.10 | 7.59 |
| Henderson UK Alpha Fund | 24.48 | 0.21 | 1.76 | 344.37 | 4.00 |
| HSBC FTSE 250 Index Fund | 24.75 | 0.34 | 0.27 | 142.17 | 7.73 |
| L&G (Barclays) Multi-Manager UK Lower-Cap Fund | 23.13 | 0.41 | 1.73 | 74.30 | 9.54 |
| Majedie UK Opportunities Fund | 29.61 | 0.14 | 1.06 | 15.96 | 1.99 |
| Marlborough Ethical Fund | 20.47 | 0.21 | 1.57 | 6.80 | 5.05 |
| Marlborough UK Primary Opportunities Fund | 25.58 | 0.26 | 1.75 | 3.65 | 6.24 |
| Melchior UK Opportunities Fund | 22.21 | -0.12 | 2.77 | 1.43 | -1.56 |
| MFM Bowland Fund | 23.85 | 0.50 | 2.12 | 10.15 | 13.62 |
| MFM Slater Recovery Fund | 22.09 | 0.55 | 1.54 | 52.17 | 13.70 |
| Old Mutual UK Select Mid-Cap Fund | 23.20 | 0.39 | 1.68 | 665.69 | 9.39 |
| Rathbone Recovery Fund | 24.82 | -0.47 | 1.66 | 71.10 | -11.77 |
| Real Life Fund | 18.14 | -0.05 | 3.56 | 2.63 | 0.08 |
| Rensburg UK Managers' Focus Trust | 21.10 | 0.39 | 1.57 | 46.96 | 8.32 |
| Royal London UK Mid-Cap Growth Fund | 23.77 | 0.70 | 1.50 | 73.72 | 17.20 |
| Saracen Growth Fund | 24.88 | -0.06 | 1.77 | 47.90 | -2.11 |
| Schroder UK Mid 250 Fund | 27.50 | 0.15 | 1.65 | 1360.23 | 2.56 |
| Skandia UK Best Ideas Fund | 24.77 | -0.05 | 2.35 | 142.97 | -1.29 |
| Standard Life UK Equity High Alpha Fund | 32.18 | 0.47 | 1.61 | 63.30 | 13.30 |
| Standard Life UK Equity Income Unconstrained Fund | 27.45 | 0.15 | 1.94 | 21.50 | 2.43 |
| Standard Life UK Equity Unconstrained Fund | 35.34 | 0.66 | 1.90 | 315.50 | 20.68 |
| Standard Life UK Ethical Fund | 24.60 | 0.19 | 1.61 | 122.70 | 4.14 |
| SVM UK Opportunities Fund | 36.38 | 0.38 | 1.80 | 64.56 | 9.42 |
| Threadneedle UK Mid 250 Fund | 23.44 | 0.40 | 1.67 | 32.77 | 9.23 |
| **iShares FTSE 250** | **24.55** | **0.37** | **0.40** | **523.67** | **9.26** |

Source: Morningstar UK

Total Number Of OEICs/UTs = 45 (+1 ETF)

## UK Small-Cap Equity (1st January 2008 – 31st December 2010)

Input 1 (3-Yr SD) → 3-Year Standard Deviation (%)

Input 2 (3-Yr SR) → 3-Year Sharpe Ratio

Input 3 (TER) → Total Expense Ratio (%)

Input 4 (Fund Size) → Total Fund Size (GBP Millions)

Output 1 (3-Yr AR) → 3-Year Annualised Return (%)

| Name Of OEIC/UT | Input 1 3-Yr SD | Input 2 3-Yr SR | Input 3 TER | Input 4 Fund Size | Output 1 3-Yr AR |
|---|---|---|---|---|---|
| Aberdeen UK Smaller Companies Fund | 20.97 | 0.41 | 1.62 | 113.86 | 8.52 |
| Aberforth UK Small Companies Fund | 24.03 | 0.35 | 0.82 | 261.57 | 8.22 |
| AEGON UK Smaller Companies Fund | 20.38 | 0.64 | 1.64 | 11.88 | 14.00 |
| Artemis UK Smaller Companies Fund | 25.97 | 0.01 | 1.62 | 338.60 | -2.40 |
| Aviva Investors UK Smaller Companies Fund | 23.24 | 0.54 | 1.29 | 73.90 | 12.92 |
| AXA Framlington UK Smaller Companies Fund | 25.84 | 0.22 | 1.60 | 59.50 | 5.31 |
| Baillie Gifford British Smaller Companies Fund | 20.41 | 0.56 | 1.56 | 222.72 | 12.64 |
| BlackRock Growth And Recovery Fund | 28.95 | 0.29 | 1.04 | 101.40 | 5.84 |
| BlackRock UK Smaller Companies Fund | 22.96 | 0.56 | 1.67 | 453.30 | 12.57 |
| Cazenove UK Smaller Companies Fund | 25.73 | 0.48 | 1.29 | 46.80 | 12.84 |
| CF Amati UK Smaller Companies Fund | 22.90 | 0.74 | 2.19 | 7.60 | 17.50 |
| CF Canada Life UK Smaller Companies Fund | 22.07 | 0.15 | 1.64 | 35.55 | 3.86 |
| CF Chelverton UK Equity Income Fund | 23.05 | 0.21 | 1.25 | 19.20 | 4.52 |
| CF Octopus UK Micro Cap Growth Fund | 21.20 | 0.09 | 1.60 | 19.03 | 2.84 |
| Close Special Situations Fund | 36.01 | 0.79 | 1.62 | 19.71 | 25.04 |
| Dimensional UK Small Companies Fund | 24.86 | 0.39 | 0.72 | 100.11 | 9.65 |
| Discretionary Fund | 29.10 | 0.12 | 1.11 | 24.66 | 1.98 |
| F&C UK Smaller Companies Fund | 22.85 | 0.38 | 2.01 | 13.90 | 8.53 |
| Gartmore UK & Irish Smaller Companies Fund | 25.47 | 0.23 | 1.68 | 154.61 | 5.31 |
| Henderson UK Smaller Companies Fund | 27.80 | 0.41 | 1.79 | 45.37 | 10.01 |

| | | | | | |
|---|---|---|---|---|---|
| Henderson UK Strategic Capital Trust | 24.99 | 0.06 | 1.55 | 43.27 | 0.78 |
| HSBC UK Smaller Companies Fund | 26.18 | 0.20 | 1.44 | 4.39 | 4.72 |
| Ignis Smaller Companies Fund | 24.67 | 0.39 | 1.57 | 109.20 | 7.49 |
| Investec UK Smaller Companies Fund | 24.47 | 0.73 | 1.61 | 171.12 | 18.63 |
| Invesco Perpetual UK Smaller Companies Equity Fund | 21.32 | 0.31 | 1.69 | 311.68 | 6.28 |
| Invesco Perpetual UK Smaller Companies Growth Fund | 24.12 | -0.04 | 1.71 | 65.04 | -2.14 |
| J. P. Morgan UK Smaller Companies Fund | 26.69 | 0.34 | 1.67 | 101.83 | 7.53 |
| Jupiter UK Smaller Companies Fund | 23.09 | 0.27 | 1.79 | 57.05 | 5.79 |
| L&G UK Alpha Trust | 24.35 | 0.84 | 1.72 | 110.52 | 22.02 |
| L&G UK Smaller Companies Trust | 21.90 | 0.54 | 1.69 | 181.39 | 12.22 |
| M&G Smaller Companies Fund | 26.00 | 0.39 | 1.67 | 40.73 | 10.21 |
| Majedie Asset Special Situations Investment Fund | 33.43 | 0.21 | 1.02 | 0.21 | 3.78 |
| Manek Growth Fund | 23.88 | -0.04 | 2.22 | 37.22 | -5.29 |
| Marlborough Special Situations Fund | 20.55 | 0.63 | 1.54 | 343.43 | 14.49 |
| Marlborough UK Micro Cap Growth Fund | 21.78 | 0.76 | 1.55 | 43.82 | 17.25 |
| MFM Techinvest Special Situations Fund | 22.20 | -0.35 | 2.21 | 2.13 | -7.15 |
| Newton UK Smaller Companies Fund | 20.10 | 0.56 | 0.79 | 71.86 | 13.08 |
| Old Mutual UK Select Smaller Companies Fund | 22.15 | 0.48 | 1.93 | 361.54 | 10.47 |
| Premier Castlefield UK Smaller Companies Fund | 22.01 | 0.26 | 3.47 | 0.01 | 5.85 |
| Prudential Small Companies Trust | 25.88 | 0.40 | 1.62 | 5.49 | 8.90 |
| River & Mercantile UK Equity Smaller Companies Fund | 21.44 | 0.51 | 1.50 | 0.69 | 11.10 |
| Royal London UK Smaller Companies Fund | 20.24 | 0.39 | 1.43 | 56.99 | 7.58 |
| Schroder UK Smaller Companies Fund | 21.54 | 0.35 | 1.67 | 280.30 | 7.63 |
| Scottish Widows UK Smaller Companies Fund | 24.63 | 0.19 | 1.62 | 164.50 | 4.08 |
| SF T1PS Smaller Companies Growth Fund | 23.54 | 0.91 | 2.45 | 17.80 | 24.26 |
| Standard Life UK Opportunities Fund | 25.91 | 0.35 | 1.60 | 259.50 | 8.30 |
| Standard Life UK Smaller Companies Fund | 21.10 | 0.74 | 1.59 | 954.20 | 16.29 |
| SWIP UK Smaller Companies Fund | 24.08 | 0.21 | 1.65 | 49.20 | 4.46 |
| UBS UK Smaller Companies Fund | 25.28 | -0.14 | 1.60 | 25.00 | -4.29 |

| | | | | | |
|---|---|---|---|---|---|
| Unicorn Outstanding British Companies Fund | 18.27 | 0.78 | 2.20 | 2.60 | 15.12 |
| **iShares FTSE 250** | **24.55** | **0.37** | **0.40** | **523.67** | **9.26** |

Source: Morningstar UK

Total Number Of OEICs/UTs = 50 (+1 ETF)

# Data Appendix Section 2:

# UK Domiciled OEICs And UTs With A US Investment Focus

**Category 6:** US Large-Cap Value And Growth Equity (1st January 2008 – 31st December 2010)

ETF Index Tracking Fund – iShares S&P 500

**Category 7:** US Large-Cap Blend Equity (1st January 2008 – 31st December 2010)

ETF Index Tracking Fund – iShares S&P 500

**Category 8:** US Mid-Cap And Small-Cap Equity (1st January 2008 – 31st December 2010)

ETF Index Tracking Fund – iShares S&P 500

## US Large-Cap Value And Growth Equity (1st January 2008 – 31st December 2010)

Input 1 (3-Yr SD) → 3-Year Standard Deviation (%)

Input 2 (3-Yr SR) → 3-Year Sharpe Ratio

Input 3 (TER) → Total Expense Ratio (%)

Input 4 (Fund Size) → Total Fund Size (GBP Millions)

Output 1 (3-Yr AR) → 3-Year Annualised Return (%)

| Name Of OEIC/UT | Input 1 3-Yr SD | Input 2 3-Yr SR | Input 3 TER | Input 4 Fund Size | Output 1 3-Yr AR |
|---|---|---|---|---|---|
| Franklin Mutual Shares Fund | 22.67 | -0.02 | 1.75 | 15.74 | -0.58 |
| GLG US Relative Value Fund | 23.83 | 0.34 | 1.64 | 30.50 | 8.95 |
| J. P. Morgan US Fund | 19.69 | 0.34 | 1.67 | 168.00 | 7.75 |
| M&G North American Value Fund | 28.00 | 0.20 | 1.68 | 94.76 | 5.34 |
| Old Mutual North American Equity Fund | 21.14 | 0.25 | 1.60 | 72.50 | 5.72 |
| Prudential North American Trust | 22.56 | 0.26 | 1.55 | 327.00 | 6.65 |
| AXA Framlington American Growth Fund | 19.03 | 0.47 | 1.58 | 197.30 | 11.31 |
| Baillie Gifford American Fund | 19.07 | 0.44 | 1.51 | 164.41 | 9.09 |
| CF The Westchester Fund | 18.68 | 0.38 | 2.11 | 25.26 | 9.11 |
| Fidelity American Special Situations Fund | 20.31 | 0.29 | 1.71 | 271.00 | 6.93 |
| Gartmore US Opportunities Fund | 22.74 | 0.22 | 1.66 | 208.10 | 5.82 |
| GLG American Growth Fund | 22.23 | 0.35 | 1.64 | 151.70 | 8.15 |
| Ignis American Growth Fund | 19.04 | 0.30 | 1.56 | 111.20 | 6.78 |
| Martin Currie North American Fund | 20.52 | 0.21 | 1.64 | 736.00 | 4.12 |
| Martin Currie North American Alpha Fund | 22.71 | 0.23 | 1.68 | 87.00 | 4.10 |
| Neptune US Opportunities Fund | 18.39 | 0.46 | 1.58 | 695.50 | 10.75 |
| PSigma American Growth Fund | 19.27 | 0.28 | 1.87 | 11.30 | 6.56 |
| Standard Life TM North American Trust | 21.20 | 0.41 | 0.84 | 361.73 | 9.47 |

| | | | | | |
|---|---|---|---|---|---|
| Standard Life North American Equity Manager Of Managers Fund | 19.88 | 0.27 | 1.97 | 99.90 | 6.55 |
| Threadneedle American Extended Alpha Fund | 18.18 | 0.58 | 1.64 | 110.60 | 11.41 |
| Threadneedle American Fund | 19.07 | 0.49 | 1.68 | 1491.00 | 10.22 |
| Threadneedle American Select Fund | 20.01 | 0.39 | 1.68 | 1220.20 | 8.69 |
| **iShares S&P 500** | **19.25** | **0.33** | **0.40** | **4565.00** | **7.41** |

Source: Morningstar UK

Total Number Of OEICs/UTs = 22 (+1 ETF)

## US Large-Cap Blend Equity (1st January 2008 – 31st December 2010)

Input 1 (3-Yr SD) → 3-Year Standard Deviation (%)

Input 2 (3-Yr SR) → 3-Year Sharpe Ratio

Input 3 (TER) → Total Expense Ratio (%)

Input 4 (Fund Size) → Total Fund Size (GBP Millions)

Output 1 (3-Yr AR) → 3-Year Annualised Return (%)

| Name Of OEIC/UT | Input 1 3-Yr SD | Input 2 3-Yr SR | Input 3 TER | Input 4 Fund Size | Output 1 3-Yr AR |
|---|---|---|---|---|---|
| Aberdeen American Equity Fund | 19.44 | 0.38 | 1.63 | 137.00 | 8.54 |
| AEGON American Equity Fund | 23.25 | 0.03 | 1.63 | 25.10 | 0.05 |
| Allianz RCM US Equity Fund | 20.45 | 0.47 | 1.67 | 97.30 | 10.32 |
| AXA Rosenberg American Fund | 19.28 | 0.21 | 1.51 | 141.30 | 4.02 |
| BlackRock US Dynamic Fund | 20.12 | 0.22 | 1.67 | 132.60 | 4.82 |
| CF Canada Life North American Fund | 19.54 | 0.50 | 1.55 | 124.90 | 10.30 |
| F&C North American Fund | 19.60 | 0.37 | 2.02 | 276.85 | 9.78 |
| FF&P US Large-Cap Equity Fund | 20.23 | 0.26 | 1.64 | 68.97 | 5.36 |
| Fidelity American Special Situations Fund | 20.31 | 0.30 | 1.71 | 278.42 | 8.27 |
| Franklin US Equity Fund | 18.93 | 0.31 | 1.61 | 14.09 | 8.39 |
| Gartmore US Growth Fund | 18.09 | 0.49 | 1.69 | 309.05 | 12.07 |
| Henderson American Portfolio Fund | 18.89 | 0.06 | 2.83 | 10.05 | 2.27 |
| Henderson North American Enhanced Equity Fund | 19.16 | 0.33 | 1.68 | 367.54 | 7.86 |
| HSBC American Index Fund | 19.94 | 0.33 | 0.25 | 207.80 | 8.05 |
| Investec American Fund | 21.51 | 0.45 | 1.66 | 865.49 | 11.93 |
| Invesco Perpetual US Equity Fund | 19.20 | 0.23 | 1.67 | 374.99 | 5.82 |
| J. P. Morgan US Select Fund | 19.00 | 0.44 | 1.68 | 71.43 | 10.26 |
| Jupiter North American Income Fund | 17.65 | 0.48 | 1.81 | 291.01 | 10.41 |
| L&G (Barclays) Multi-Manager US Alpha Fund | 21.30 | 0.13 | 1.78 | 128.27 | 4.21 |
| L&G North American Trust | 19.28 | 0.30 | 1.68 | 103.72 | 6.83 |

| | | | | | |
|---|---|---|---|---|---|
| L&G US Index Trust | 19.71 | 0.38 | 0.78 | 493.22 | 8.41 |
| Legg Mason US Equity Fund | 26.31 | -0.07 | 1.71 | 97.70 | -0.58 |
| M&G American Fund | 20.72 | 0.35 | 1.66 | 2378.93 | 9.69 |
| Royal London US Index Tracker Trust | 19.46 | 0.38 | 0.22 | 1117.58 | 9.88 |
| Santander Premium Fund US Equity Fund | 19.60 | 0.27 | 1.04 | 128.14 | 7.61 |
| Schroder QEP US Core Fund | 19.33 | 0.49 | 0.45 | 204.31 | 12.30 |
| Scottish Mutual North American Trust | 18.49 | 0.33 | 1.05 | 25.84 | 8.72 |
| Scottish Widows American Growth Fund | 19.19 | 0.42 | 1.63 | 72.91 | 10.39 |
| Scottish Widows American Select Growth Fund | 18.53 | 0.32 | 2.04 | 2.61 | 8.33 |
| SSGA North American Equity Tracker Fund | 19.95 | 0.40 | 0.90 | 78.70 | 8.44 |
| St James's Place North American Fund | 25.25 | 0.28 | 1.56 | 111.18 | 9.05 |
| Standard Life American Equity Unconstrained Fund | 21.98 | 0.34 | 1.64 | 12.10 | 9.21 |
| Standard Life US Equity Index Tracker Fund | 20.37 | 0.33 | 1.60 | 189.80 | 8.44 |
| SWIP North American Fund | 18.26 | 0.32 | 1.69 | 22.77 | 8.45 |
| UBS US 130/30 Equity Fund | 23.33 | 0.26 | 1.69 | 40.81 | 8.02 |
| UBS US Equity Fund | 21.56 | 0.27 | 1.58 | 416.09 | 7.86 |
| **iShares S&P 500** | **19.25** | **0.33** | **0.40** | **4565.00** | **7.41** |

Source: Morningstar UK

Total Number Of OEICs/UTs = 36 (+1 ETF)

## US Mid-Cap And Small-Cap Equity (1st January 2008 – 31st December 2010)

Input 1 (3-Yr SD) → 3-Year Standard Deviation (%)

Input 2 (3-Yr SR) → 3-Year Sharpe Ratio

Input 3 (TER) → Total Expense Ratio (%)

Input 4 (Fund Size) → Total Fund Size (GBP Millions)

Output 1 (3-Yr AR) → 3-Year Annualised Return (%)

| Name Of OEIC/UT | Input 1 3-Yr SD | Input 2 3-Yr SR | Input 3 TER | Input 4 Fund Size | Output 1 3-Yr AR |
|---|---|---|---|---|---|
| CF Greenwich Fund | 24.22 | 0.38 | 2.48 | 2.88 | 7.93 |
| FF&P US All-Cap Value Equity Fund | 22.17 | 0.39 | 2.10 | 38.95 | 8.10 |
| GAM North American Growth Fund | 20.14 | 0.73 | 1.72 | 94.47 | 16.80 |
| Melchior North American Opportunities Fund | 22.96 | 0.43 | 2.43 | 97.86 | 11.86 |
| Schroder US Mid-Cap Fund | 20.00 | 0.60 | 1.66 | 815.21 | 15.20 |
| Scottish Widows American Smaller Companies Fund | 21.50 | 0.59 | 1.65 | 41.98 | 15.42 |
| SWIP North American Smaller Companies Fund | 21.05 | 0.59 | 1.70 | 17.65 | 15.97 |
| Threadneedle American Smaller Companies Fund | 21.43 | 0.82 | 1.70 | 316.84 | 22.54 |
| FF&P US Small-Cap Equity Fund | 25.05 | 0.51 | 2.15 | 27.69 | 12.09 |
| J. P. Morgan US Smaller Companies Fund | 26.60 | 0.55 | 1.68 | 27.55 | 18.90 |
| Legg Mason US Smaller Companies Fund | 25.52 | 0.53 | 1.74 | 104.29 | 16.48 |
| Schroder US Smaller Companies Fund | 22.24 | 0.55 | 1.66 | 586.43 | 16.12 |
| **iShares S&P 500** | **19.25** | **0.33** | **0.40** | **4565.00** | **7.41** |

Source: Morningstar UK

Total Number Of OEICs/UTs = 12 (+1 ETF)

# Data Appendix Section 3:

# UK Domiciled OEICs And UTs With A Global Investment Focus

**Category 9:** Global Large-Cap Value Equity (1st January 2008 – 31st December 2010)

ETF Index Tracking Fund – iShares MSCI World

**Category 10:** Global Large-Cap Growth Equity (1st January 2008 – 31st December 2010)

ETF Index Tracking Fund – iShares MSCI World

**Category 11:** Global Large-Cap Blend Equity (1st January 2008 – 31st December 2010)

ETF Index Tracking Fund – iShares MSCI World

**Category 12:** Global Mid-Cap And Small-Cap Equity (1st January 2008 – 31st December 2010)

ETF Index Tracking Fund – iShares MSCI World

## Global Large-Cap Value Equity (1st January 2008 – 31st December 2010)

Input 1 (3-Yr SD) → 3-Year Standard Deviation (%)

Input 2 (3-Yr SR) → 3-Year Sharpe Ratio

Input 3 (TER) → Total Expense Ratio (%)

Input 4 (Fund Size) → Total Fund Size (GBP Millions)

Output 1 (3-Yr AR) → 3-Year Annualised Return (%)

| Name Of OEIC/UT | Input 1 3-Yr SD | Input 2 3-Yr SR | Input 3 TER | Input 4 Fund Size | Output 1 3-Yr AR |
|---|---|---|---|---|---|
| Aberdeen Charity Select Global Equity Fund | 22.18 | 0.33 | 0.93 | 48.28 | 8.91 |
| Aberdeen Ethical World Fund | 23.03 | 0.25 | 1.62 | 299.94 | 6.59 |
| Aberdeen World Equity Fund | 21.43 | 0.28 | 1.65 | 767.40 | 7.39 |
| AXA Rosenberg Global Fund | 21.22 | 0.07 | 1.48 | 390.53 | 2.75 |
| Baillie Gifford Global Income Fund | 19.82 | 0.07 | 1.73 | 13.10 | 2.28 |
| CF Stewart Ivory Investment Markets Fund | 17.98 | 0.05 | 1.13 | 14.91 | 2.00 |
| Dimensional International Value Fund | 25.64 | 0.17 | 0.61 | 182.44 | 5.49 |
| GAM Global Diversified Fund | 17.90 | 0.31 | 1.55 | 505.90 | 7.35 |
| Gartmore Long-Term Balanced Fund | 15.72 | 0.08 | 0.85 | 56.16 | 2.94 |
| GLG Stockmarket Managed Fund | 20.42 | 0.15 | 1.66 | 117.17 | 4.22 |
| Ignis Global Growth Fund | 28.32 | 0.28 | 1.60 | 40.31 | 7.66 |
| Investec Global Special Situations Fund | 18.64 | 0.54 | 1.61 | 41.60 | 12.32 |
| Invesco Perpetual Global Core Equity Index Fund | 19.76 | 0.25 | 0.71 | 36.72 | 6.85 |
| J. P. Morgan Global Equity Income Fund | 16.39 | 0.09 | 1.66 | 115.29 | 2.69 |
| L&G Global 100 Index Trust | 19.24 | 0.27 | 1.15 | 76.05 | 6.22 |
| Lazard Global Equity Income Fund | 20.60 | 0.24 | 1.58 | 154.88 | 6.93 |
| M&G Global Leaders Fund | 23.78 | 0.15 | 1.67 | 1172.01 | 4.12 |
| Newton Global Higher Income Fund | 19.45 | 0.24 | 0.20 | 1718.95 | 7.71 |
| Old Mutual Global Equity Fund | 21.85 | 0.17 | 1.83 | 32.45 | 4.22 |
| Prudential International Growth Trust | 22.01 | 0.24 | 1.72 | 93.07 | 6.81 |

| | | | | | |
|---|---|---|---|---|---|
| Sarasin International Equity Income Fund | 17.98 | 0.30 | 1.74 | 254.73 | 7.06 |
| Schroder Global Equity Income Fund | 18.08 | 0.22 | 1.67 | 73.63 | 6.05 |
| St James's Place Recovery Fund | 18.72 | 0.21 | 2.26 | 337.65 | 3.85 |
| Templeton Growth Fund | 22.30 | 0.13 | 1.58 | 285.46 | 3.58 |
| Threadneedle Global Equity Income Fund | 18.34 | 0.31 | 1.72 | 40.92 | 8.07 |
| **iShares MSCI World** | **20.28** | **0.25** | **0.50** | **2036.43** | **5.89** |

Source: Morningstar UK

Total Number Of OEICs/UTs = 25 (+1 ETF)

## Global Large-Cap Growth Equity (1st January 2008 – 31st December 2010)

Input 1 (3-Yr SD) → 3-Year Standard Deviation (%)

Input 2 (3-Yr SR) → 3-Year Sharpe Ratio

Input 3 (TER) → Total Expense Ratio (%)

Input 4 (Fund Size) → Total Fund Size (GBP Millions)

Output 1 (3-Yr AR) → 3-Year Annualised Return (%)

| Name Of OEIC/UT | Input 1 3-Yr SD | Input 2 3-Yr SR | Input 3 TER | Input 4 Fund Size | Output 1 3-Yr AR |
|---|---|---|---|---|---|
| AEGON Global Equity Fund | 24.73 | -0.20 | 2.10 | 8.91 | -3.90 |
| Aviva Investors World Leaders Fund | 19.45 | 0.11 | 1.57 | 54.23 | 3.15 |
| AXA Framlington Global Opportunities Fund | 22.25 | 0.02 | 1.55 | 257.34 | 0.16 |
| Baillie Gifford International Fund | 22.40 | 0.31 | 1.53 | 264.18 | 9.13 |
| Baillie Gifford Long-Term Global Growth Fund | 26.04 | 0.36 | 0.81 | 167.01 | 10.78 |
| CF JM Finn Global Opportunities Fund | 26.75 | 0.11 | 1.63 | 81.47 | 4.26 |
| Discovery Managed Growth Fund | 14.62 | -0.28 | 2.59 | 5.67 | -1.84 |
| EFA Ursa Major Growth Portfolio Fund | 16.60 | 0.08 | 1.66 | 7.87 | 3.21 |
| F&C Global Growth Fund | 21.21 | 0.06 | 2.40 | 40.66 | 2.99 |
| F&C International Heritage Fund | 19.61 | 0.44 | 0.65 | 8.75 | 10.79 |
| F&C Stewardship International Fund | 19.50 | 0.30 | 1.70 | 353.08 | 7.73 |
| Fidelity Global Focus Fund | 21.67 | 0.32 | 1.68 | 396.39 | 8.39 |
| Henderson International Fund | 20.51 | 0.20 | 1.75 | 53.13 | 5.35 |
| Margetts Greystone Global Growth Fund | 18.70 | 0.28 | 1.27 | 66.82 | 6.68 |
| Martin Currie Global Alpha Fund | 21.40 | 0.06 | 1.78 | 69.00 | 0.69 |
| NatWest International Growth Fund | 19.21 | 0.30 | 1.59 | 25.23 | 6.86 |
| Neptune Global Equity Fund | 22.00 | 0.10 | 1.75 | 1345.01 | 4.41 |
| PFS Taube Global Fund | 13.12 | 0.25 | 1.66 | 18.41 | 6.74 |
| RBS International Growth Fund | 19.21 | 0.30 | 1.61 | 25.85 | 6.86 |
| Sheldon Equity Growth Fund | 21.13 | -0.30 | 1.23 | 10.62 | -5.56 |

| | | | | | |
|---|---|---|---|---|---|
| Sheldon Financial Growth Fund | 21.18 | -0.31 | 1.38 | 7.23 | -5.78 |
| St James's Place Worldwide Opportunities Fund | 24.49 | 0.24 | 2.03 | 1298.57 | 6.75 |
| Thesis Lion Growth Fund | 11.96 | 0.07 | 1.93 | 28.23 | 3.70 |
| Threadneedle Global Select Fund | 19.57 | 0.24 | 1.69 | 637.56 | 6.83 |
| Zenith International Growth Fund | 24.39 | 0.05 | 1.00 | 2.92 | 0.55 |
| **iShares MSCI World** | **20.28** | **0.25** | **0.50** | **2036.43** | **5.89** |

Source: Morningstar UK

Total Number Of OEICs/UTs = 25 (+1 ETF)

## Global Large-Cap Blend Equity (1st January 2008 – 31st December 2010)

Input 1 (3-Yr SD) → 3-Year Standard Deviation (%)

Input 2 (3-Yr SR) → 3-Year Sharpe Ratio

Input 3 (TER) → Total Expense Ratio (%)

Input 4 (Fund Size) → Total Fund Size (GBP Millions)

Output 1 (3-Yr AR) → 3-Year Annualised Return (%)

| Name Of OEIC/UT | Input 1 3-Yr SD | Input 2 3-Yr SR | Input 3 TER | Input 4 Fund Size | Output 1 3-Yr AR |
|---|---|---|---|---|---|
| Aberdeen Multi-Manager Constellation Portfolio | 18.33 | 0.12 | 2.48 | 99.43 | 4.28 |
| Aberdeen Multi-Manager International Growth Portfolio | 18.92 | 0.17 | 2.44 | 32.56 | 4.97 |
| Architas Multi-Manager Diversified Share Portfolio | 21.67 | -0.05 | 2.07 | 10.51 | -0.27 |
| Architas Multi-Manager Global Equity Portfolio | 21.54 | 0.07 | 2.03 | 2.71 | 2.34 |
| Artemis Global Growth Fund | 23.54 | -0.10 | 1.66 | 140.76 | -0.91 |
| Aviva Investors Fund Of Funds Balanced Fund | 14.89 | 0.28 | 1.70 | 139.67 | 6.91 |
| Aviva Investors Fund Of Funds Growth Fund | 16.38 | 0.22 | 2.70 | 54.29 | 6.13 |
| Aviva Investors International Index Tracking Fund | 20.32 | 0.28 | 0.96 | 355.94 | 7.09 |
| Aviva Investors SF Global Growth Fund | 19.94 | 0.02 | 1.54 | 128.22 | 1.32 |
| Baillie Gifford Managed Fund | 17.36 | 0.32 | 1.51 | 496.43 | 8.24 |
| Bank Of Scotland International Managed Fund | 19.94 | 0.14 | 0.99 | 15.73 | 4.71 |
| BCIF Balanced Managed Fund | 18.07 | 0.15 | 1.51 | 481.54 | 3.96 |
| BlackRock Active Managed Portfolio Fund | 20.03 | 0.19 | 1.79 | 14.85 | 4.88 |
| BlackRock Global Equity Fund | 22.07 | 0.28 | 1.68 | 179.89 | 7.99 |
| BlackRock International Equity Fund | 20.68 | 0.19 | 0.99 | 121.41 | 5.67 |
| BlackRock Overseas Fund | 21.38 | 0.25 | 1.58 | 60.59 | 7.13 |
| Cazenove Multi-Manager Global Fund | 17.14 | 0.29 | 1.93 | 192.37 | 6.45 |
| CF Adam Worldwide Fund | 17.00 | 0.45 | 1.24 | 30.79 | 10.14 |

| | | | | | |
|---|---|---|---|---|---|
| CF Aquarius Fund | 16.52 | 0.04 | 1.42 | 48.47 | 1.21 |
| CF Broden Fund | 16.00 | 0.17 | 1.19 | 12.24 | 3.44 |
| CF Canada Life International Growth Fund | 19.86 | 0.35 | 1.56 | 202.00 | 8.70 |
| CF FundQuest Global Select Fund | 18.22 | 0.24 | 2.23 | 8.73 | 5.67 |
| CF FundQuest Select Opportunities Fund | 16.26 | 0.15 | 2.54 | 5.88 | 4.06 |
| CF FundQuest Select Fund | 16.88 | 0.18 | 2.54 | 36.11 | 5.23 |
| CF Helm Investment Fund | 21.46 | 0.03 | 0.78 | 16.53 | 2.85 |
| CF Lacomp World Fund | 18.88 | 0.08 | 1.07 | 9.38 | 2.74 |
| CF The Aurinko Fund | 13.40 | 0.30 | 1.43 | 28.89 | 5.80 |
| CF Taylor Young International Equity Fund | 20.06 | 0.09 | 1.89 | 6.78 | 3.51 |
| Chariguard Overseas Equity Fund | 21.84 | 0.35 | 0.59 | 41.03 | 8.04 |
| City Financial Multi-Manager Growth Fund | 17.71 | 0.13 | 1.82 | 47.83 | 0.40 |
| Deutsche Bank PWM Capital Growth Portfolio | 22.86 | 0.35 | 1.61 | 90.00 | 9.20 |
| Ecclesiastical Amity International Fund | 16.88 | 0.51 | 1.35 | 117.90 | 11.15 |
| F&C Lifestyle Growth Fund | 16.63 | 0.19 | 2.24 | 46.67 | 5.38 |
| Family Investments Child Trust Fund | 17.86 | 0.16 | 1.48 | 394.31 | 3.80 |
| FF&P Global Equities II Fund | 19.91 | 0.17 | 2.15 | 348.82 | 4.61 |
| Fidelity Global Special Situations Fund | 26.41 | 0.09 | 1.71 | 1909.05 | 2.97 |
| Fidelity International Fund | 20.32 | 0.19 | 1.72 | 288.24 | 4.91 |
| Fidelity MoneyBuilder Global Trust | 19.51 | 0.22 | 2.31 | 553.66 | 6.05 |
| Fidelity WealthBuilder Fund | 19.50 | 0.25 | 1.69 | 1003.15 | 6.65 |
| First State Global Growth Fund | 20.13 | 0.08 | 1.87 | 4.90 | 3.08 |
| First State Global Opportunities Fund | 20.20 | 0.15 | 1.81 | 38.17 | 4.86 |
| GAM Composite Absolute Return OEIC | 7.59 | -0.34 | 1.09 | 146.55 | -1.05 |
| GAM Portfolio Unit Trust | 16.76 | 0.27 | 1.25 | 17.02 | 6.56 |
| Gartmore Global Focus Fund | 19.82 | 0.14 | 1.42 | 278.06 | 4.13 |
| Gartmore Multi-Manager Active Fund | 17.21 | 0.24 | 2.75 | 5.89 | 6.62 |
| Henderson Global Dividend Income Fund | 19.35 | 0.04 | 1.64 | 25.44 | 5.18 |
| Henderson Multi-Manager Active Fund | 17.69 | 0.06 | 2.68 | 427.68 | 2.26 |
| Henderson Multi-Manager Tactical Fund | 19.85 | -0.44 | 2.39 | 55.67 | -5.81 |
| HSBC Global Growth Fund Of Funds | 18.65 | 0.26 | 2.32 | 48.60 | 6.94 |
| HSBC Portfolio Fund | 19.21 | 0.09 | 1.04 | 14.51 | 3.41 |
| IFDS Brown Shipley Multi-Manager International Fund | 20.58 | 0.18 | 2.35 | 21.27 | 5.70 |

| | | | | | |
|---|---|---|---|---|---|
| Investec Global Dynamic Fund | 20.83 | 0.28 | 1.61 | 219.12 | 9.09 |
| Investec Global Equity Fund | 20.33 | 0.20 | 1.61 | 425.72 | 6.66 |
| Investec Global Free Enterprise Fund | 20.88 | 0.11 | 1.61 | 437.86 | 4.99 |
| Invesco Perpetual Global Equity Fund | 21.29 | 0.24 | 1.69 | 1235.87 | 6.24 |
| Invesco Perpetual Global Enhanced Index Fund | 19.37 | 0.33 | 0.48 | 196.16 | 8.51 |
| Invesco Perpetual Global Opportunities Fund | 18.47 | 0.20 | 1.71 | 59.97 | 5.28 |
| Invesco Perpetual Managed Growth Fund | 18.93 | 0.21 | 1.89 | 243.65 | 5.86 |
| Jessop (GAR) Global Equity Quant Fund | 19.77 | 0.24 | 1.12 | 9.39 | 6.74 |
| J. P. Morgan Global Fund | 21.49 | 0.17 | 1.67 | 188.97 | 5.81 |
| J. P. Morgan Portfolio Fund | 20.63 | 0.22 | 1.97 | 51.22 | 5.95 |
| Jupiter Merlin Growth Portfolio Fund | 15.12 | 0.41 | 2.63 | 1419.49 | 9.13 |
| Jupiter Merlin Worldwide Portfolio Fund | 16.76 | 0.38 | 2.53 | 714.35 | 9.52 |
| L&G (Barclays) Adventurous Growth Portfolio Trust | 21.05 | 0.02 | 2.25 | 76.01 | 1.52 |
| L&G Global Growth Trust | 20.27 | 0.12 | 1.64 | 32.88 | 4.00 |
| L&G Worldwide Trust | 17.74 | 0.15 | 1.70 | 105.35 | 4.41 |
| Liberation No. VIII Fund | 17.68 | 0.02 | 2.92 | 13.54 | 2.68 |
| M&G Global Growth Fund | 20.52 | 0.32 | 1.68 | 980.20 | 8.28 |
| Margetts International Strategy Fund | 19.33 | 0.28 | 2.46 | 47.67 | 7.68 |
| Margetts Venture Strategy Fund | 19.89 | 0.37 | 2.60 | 62.91 | 10.54 |
| Marlborough Global Fund | 16.77 | 0.04 | 2.81 | 10.73 | 2.13 |
| Martin Currie Global Fund | 20.04 | 0.03 | 1.75 | 48.00 | 1.92 |
| Neptune Global Max Alpha Fund | 17.64 | 0.07 | 2.50 | 0.62 | 2.94 |
| Newton 50/50 Global Equity Fund | 19.79 | 0.24 | 0.55 | 737.31 | 6.52 |
| Newton Falcon Fund | 17.92 | 0.34 | 1.59 | 128.84 | 8.41 |
| Newton Global Balanced Fund | 15.45 | 0.46 | 0.55 | 554.87 | 9.98 |
| Newton Global Opportunities Fund | 20.28 | 0.15 | 1.64 | 436.29 | 5.92 |
| Newton International Growth Fund | 19.97 | 0.15 | 0.65 | 1182.94 | 5.39 |
| Newton Managed Fund | 18.40 | 0.06 | 1.62 | 1464.84 | 3.15 |
| Newton Overseas Equity Fund | 20.89 | 0.24 | 0.57 | 346.61 | 7.67 |
| Premier Castlefield Managed Multi-Asset Fund | 19.99 | 0.20 | 2.55 | 17.90 | 5.68 |
| Prudential (Invesco Perpetual) Managed Trust | 17.14 | 0.27 | 2.03 | 122.94 | 5.27 |
| S&W Endurance Global Opportunities Fund | 13.41 | 0.22 | 2.01 | 18.10 | 4.00 |

| | | | | | |
|---|---|---|---|---|---|
| Santander Multi-Manager Equity Fund | 19.71 | 0.23 | 1.85 | 178.55 | 4.60 |
| Sarasin Alpha CIF Income & Reserves Fund | 8.05 | 0.30 | 1.13 | 41.39 | 4.71 |
| Sarasin EquiSar Global Thematic Fund | 19.35 | 0.20 | 1.73 | 486.53 | 5.25 |
| Sarasin EquiSar IIID Fund | 12.64 | 0.01 | 1.92 | 124.61 | 0.25 |
| Schroder Global Equity Fund | 19.81 | 0.44 | 0.52 | 291.48 | 11.01 |
| Schroder Growth Fund | 6.28 | -0.51 | 0.48 | 35.74 | -1.17 |
| Schroder QEP Global Quant Core Equity Fund | 20.18 | 0.38 | 0.48 | 583.18 | 9.35 |
| Scottish Mutual International Growth Trust | 25.63 | 0.27 | 1.04 | 62.54 | 7.00 |
| Scottish Mutual Opportunity Trust | 23.18 | 0.29 | 0.55 | 162.75 | 5.90 |
| Scottish Widows Global Growth Fund | 19.25 | 0.25 | 1.62 | 540.63 | 4.72 |
| Scottish Widows Global Select Growth Fund | 18.46 | 0.21 | 1.63 | 204.43 | 4.38 |
| Scottish Widows International Equity Tracker Fund | 22.25 | 0.28 | 0.61 | 890.97 | 4.87 |
| Skandia Ethical Fund | 21.27 | 0.16 | 1.98 | 76.02 | 2.00 |
| Skandia Global Best Ideas Fund | 23.51 | 0.28 | 2.34 | 328.20 | 5.71 |
| Skandia Newton Managed Fund | 15.14 | 0.25 | 1.57 | 375.98 | 3.81 |
| Standard Life TM Global Equity Trust | 22.91 | 0.27 | 0.15 | 329.38 | 4.85 |
| Standard Life TM International Trust | 21.28 | 0.30 | 0.14 | 1692.93 | 5.51 |
| St James's Place Ethical Fund | 23.37 | 0.27 | 1.58 | 235.52 | 4.62 |
| St James's Place International Fund | 20.05 | 0.20 | 1.70 | 590.97 | 3.16 |
| Standard Life Global Equity Fund | 25.70 | 0.32 | 1.64 | 26.30 | 6.61 |
| SVM Global Opportunities Fund | 16.76 | -0.45 | 1.73 | 34.48 | -6.95 |
| SWIP Global Fund | 17.93 | 0.21 | 1.73 | 21.15 | 3.59 |
| SWIP Multi-Manager International Equity Fund | 20.78 | 0.43 | 1.84 | 1593.14 | 7.89 |
| SWIP Multi-Manager Select Boutiques Fund | 16.47 | 0.32 | 2.53 | 20.26 | 5.79 |
| T. Bailey Growth Fund | 19.78 | 0.20 | 2.42 | 162.95 | 3.24 |
| Thames River Equity Managed Fund | 15.61 | 0.27 | 3.01 | 14.97 | 4.89 |
| Thames River Global Boutiques Fund | 15.69 | 0.37 | 2.97 | 54.53 | 6.60 |
| Threadneedle Global Equity Fund | 18.83 | 0.35 | 1.92 | 232.85 | 6.22 |
| Threadneedle Navigator Adventurous Managed Trust | 18.99 | 0.40 | 1.60 | 17.64 | 7.10 |
| THS International Growth & Value Fund | 21.00 | 0.24 | 1.16 | 707.99 | 4.10 |
| UBS Global Optimal Fund | 22.40 | 0.35 | 1.63 | 20.51 | 6.09 |
| UBS Global Optimal Thirds Fund | 22.29 | 0.37 | 0.95 | 9.06 | 6.31 |

| | | | | | |
|---|---|---|---|---|---|
| WAY Global Red Active Portfolio Fund | 15.95 | 0.31 | 2.93 | 56.81 | 5.36 |
| Wesleyan International Trust | 21.22 | 0.23 | 1.97 | 15.39 | 3.47 |
| Williams De Broe Global Fund | 20.58 | 0.43 | 2.41 | 26.22 | 7.87 |
| **iShares MSCI World** | **20.28** | **0.25** | **0.50** | **2036.43** | **5.89** |

Source: Morningstar UK

Total Number Of OEICs/UTs = 118 (+1 ETF)

## Global Mid-Cap And Small-Cap Equity (1st January 2008 – 31st December 2010)

Input 1 (3-Yr SD) → 3-Year Standard Deviation (%)

Input 2 (3-Yr SR) → 3-Year Sharpe Ratio

Input 3 (TER) → Total Expense Ratio (%)

Input 4 (Fund Size) → Total Fund Size (GBP Millions)

Output 1 (3-Yr AR) → 3-Year Annualised Return (%)

| Name Of OEIC/UT | Input 1 3-Yr SD | Input 2 3-Yr SR | Input 3 TER | Input 4 Fund Size | Output 1 3-Yr AR |
|---|---|---|---|---|---|
| AXA Framlington Talents Fund | 27.04 | 0.38 | 1.86 | 12.77 | 8.18 |
| Baillie Gifford Phoenix Global Growth Fund | 21.39 | 0.46 | 0.68 | 25.43 | 10.05 |
| Hargreaves Lansdown Multi-Manager Special Situations Trust | 18.98 | 0.28 | 2.11 | 404.13 | 5.44 |
| Invesco Perpetual Global Smaller Companies Fund | 22.74 | 0.64 | 1.69 | 369.06 | 14.48 |
| J. P. Morgan Multi-Manager Growth Fund | 21.34 | 0.14 | 1.42 | 362.90 | 2.19 |
| L&G (Barclays) Multi-Manager Global Core Fund | 21.75 | 0.01 | 1.74 | 49.75 | 0.56 |
| M&G Fund Of Investment Trust Shares | 23.34 | 0.11 | 1.19 | 31.96 | 0.76 |
| M&G Global Basics Fund | 25.91 | 0.38 | 1.67 | 6536.73 | 8.25 |
| Neptune Green Planet Fund | 23.28 | -0.02 | 2.11 | 6.62 | -0.58 |
| Rathbone Global Opportunities Fund | 21.04 | 0.28 | 1.57 | 125.70 | 4.95 |
| S&W Aubrey Global Conviction Fund | 22.85 | 0.26 | 1.82 | 33.70 | 5.45 |
| SF Adventurous Portfolio Fund | 16.85 | 0.20 | 1.97 | 1.99 | 4.01 |
| St James's Place Global Fund | 18.77 | 0.05 | 1.88 | 891.64 | 0.45 |
| **iShares MSCI World** | **20.28** | **0.25** | **0.50** | **2036.43** | **5.89** |

Source: Morningstar UK

Total Number Of OEICs/UTs = 13 (+1 ETF)

# Data Appendix Section 4:

# FTSE 100, FTSE 250, S&P 500 And MSCI World Stock Market Indices

**FTSE 100:** 3-Year Annualised Return (1st January 2008 – 31st December 2010)

**FTSE 250:** 3-Year Annualised Return (1st January 2008 – 31st December 2010)

**S&P 500:** 3-Year Annualised Return (1st January 2008 – 31st December 2010)

**MSCI World:** 3-Year Annualised Return (1st January 2008 – 31st December 2010)

## FTSE 100 3-Year Annualised Return (1st January 2008 – 31st December 2010)

| Month/Year | Index Value | Percentage Change |
|---|---|---|
| January 2008 | 5,879.80 | 1.02 |
| February 2008 | 5,884.30 | 1.00 |
| March 2008 | 5,702.10 | 0.97 |
| April 2008 | 6,087.30 | 1.07 |
| May 2008 | 6,053.50 | 0.99 |
| June 2008 | 5,625.90 | 0.93 |
| July 2008 | 5,411.90 | 0.96 |
| August 2008 | 5,636.60 | 1.04 |
| September 2008 | 4,902.50 | 0.87 |
| October 2008 | 4,377.30 | 0.89 |
| November 2008 | 4,288.00 | 0.98 |
| December 2008 | 4,434.20 | 1.03 |
| January 2009 | 4,149.60 | 0.94 |
| February 2009 | 3,830.10 | 0.92 |
| March 2009 | 3,926.10 | 1.03 |
| April 2009 | 4,243.70 | 1.08 |
| May 2009 | 4,417.90 | 1.04 |
| June 2009 | 4,249.20 | 0.96 |
| July 2009 | 4,608.40 | 1.08 |
| August 2009 | 4,908.90 | 1.07 |
| September 2009 | 5,133.90 | 1.05 |
| October 2009 | 5,044.50 | 0.98 |
| November 2009 | 5,190.70 | 1.03 |
| December 2009 | 5,412.90 | 1.04 |
| January 2010 | 5,188.50 | 0.96 |
| February 2010 | 5,354.50 | 1.03 |
| March 2010 | 5,679.60 | 1.06 |
| April 2010 | 5,553.30 | 0.98 |
| May 2010 | 5,188.40 | 0.93 |
| June 2010 | 4,916.90 | 0.95 |
| July 2010 | 5,258.00 | 1.07 |
| August 2010 | 5,225.20 | 0.99 |
| September 2010 | 5,548.60 | 1.06 |
| October 2010 | 5,675.20 | 1.02 |
| November 2010 | 5,528.30 | 0.97 |
| December 2010 | 5,899.90 | 1.07 |

| FTSE 100 3-Year Annualised Return (%) |
|---|
| **0.82** |

Source: DataStream

## FTSE 250 3-Year Annualised Return (1st January 2008 – 31st December 2010)

| Month/Year | Index Value | Percentage Change |
|---|---|---|
| January 2008 | 9,881.80 | 0.93 |
| February 2008 | 10,067.90 | 1.02 |
| March 2008 | 10,013.20 | 0.99 |
| April 2008 | 10,122.30 | 1.01 |
| May 2008 | 10,049.30 | 0.99 |
| June 2008 | 9,145.80 | 0.91 |
| July 2008 | 8,856.70 | 0.97 |
| August 2008 | 9,381.80 | 1.06 |
| September 2008 | 7,888.21 | 0.84 |
| October 2008 | 6,282.55 | 0.80 |
| November 2008 | 6,093.32 | 0.97 |
| December 2008 | 6,360.85 | 1.04 |
| January 2009 | 6,250.76 | 0.98 |
| February 2009 | 6,049.14 | 0.97 |
| March 2009 | 6,373.89 | 1.05 |
| April 2009 | 7,528.95 | 1.18 |
| May 2009 | 7,572.00 | 1.01 |
| June 2009 | 7,414.56 | 0.98 |
| July 2009 | 7,999.96 | 1.08 |
| August 2009 | 8,817.51 | 1.10 |
| September 2009 | 9,142.31 | 1.04 |
| October 2009 | 8,885.77 | 0.97 |
| November 2009 | 8,918.44 | 1.00 |
| December 2009 | 9,306.89 | 1.04 |
| January 2010 | 9,237.30 | 0.99 |
| February 2010 | 9,344.39 | 1.01 |
| March 2010 | 10,165.28 | 1.09 |
| April 2010 | 10,366.00 | 1.02 |
| May 2010 | 9,637.14 | 0.93 |
| June 2010 | 9,366.12 | 0.97 |
| July 2010 | 9,948.72 | 1.06 |
| August 2010 | 9,825.14 | 0.99 |
| September 2010 | 10,531.80 | 1.07 |
| October 2010 | 10,843.50 | 1.03 |
| November 2010 | 10,607.75 | 0.98 |
| December 2010 | 11,558.80 | 1.09 |

| FTSE 250 3-Year Annualised Return (%) |
|---|
| **2.74** |

Source: DataStream

## S&P 500 3-Year Annualised Return (1st January 2008 – 31st December 2010)

| Month/Year | Index Value | Percentage Change |
|---|---|---|
| January 2008 | 1,378.55 | 0.94 |
| February 2008 | 1,330.63 | 0.97 |
| March 2008 | 1,322.70 | 0.99 |
| April 2008 | 1,385.59 | 1.05 |
| May 2008 | 1,400.38 | 1.01 |
| June 2008 | 1,280.00 | 0.91 |
| July 2008 | 1,267.38 | 0.99 |
| August 2008 | 1,282.83 | 1.01 |
| September 2008 | 1,166.36 | 0.91 |
| October 2008 | 968.75 | 0.83 |
| November 2008 | 896.24 | 0.93 |
| December 2008 | 903.25 | 1.01 |
| January 2009 | 825.88 | 0.91 |
| February 2009 | 735.09 | 0.89 |
| March 2009 | 797.87 | 1.09 |
| April 2009 | 872.81 | 1.09 |
| May 2009 | 919.14 | 1.05 |
| June 2009 | 919.32 | 1.00 |
| July 2009 | 987.48 | 1.07 |
| August 2009 | 1,020.62 | 1.03 |
| September 2009 | 1,057.08 | 1.04 |
| October 2009 | 1,036.19 | 0.98 |
| November 2009 | 1,095.63 | 1.06 |
| December 2009 | 1,115.10 | 1.02 |
| January 2010 | 1,073.87 | 0.96 |
| February 2010 | 1,104.49 | 1.03 |
| March 2010 | 1,169.43 | 1.06 |
| April 2010 | 1,186.69 | 1.01 |
| May 2010 | 1,089.41 | 0.92 |
| June 2010 | 1,030.71 | 0.95 |
| July 2010 | 1,101.60 | 1.07 |
| August 2010 | 1,049.33 | 0.95 |
| September 2010 | 1,141.20 | 1.09 |
| October 2010 | 1,183.26 | 1.04 |
| November 2010 | 1,180.55 | 1.00 |
| December 2010 | 1,257.64 | 1.07 |

| S&P 500 3-Year Annualised Return (%) |
|---|
| **-5.03** |

Source: DataStream

## MSCI World 3-Year Annualised Return (1st January 2008 – 31st December 2010)

| Month/Year | Index Value | Percentage Change |
|---|---|---|
| January 2008 | 1,466.35 | 0.92 |
| February 2008 | 1,455.56 | 0.99 |
| March 2008 | 1,437.40 | 0.99 |
| April 2008 | 1,508.99 | 1.05 |
| May 2008 | 1,525.73 | 1.01 |
| June 2008 | 1,402.13 | 0.92 |
| July 2008 | 1,366.70 | 0.97 |
| August 2008 | 1,344.87 | 0.98 |
| September 2008 | 1,182.44 | 0.88 |
| October 2008 | 957.25 | 0.81 |
| November 2008 | 892.93 | 0.93 |
| December 2008 | 920.23 | 1.03 |
| January 2009 | 838.83 | 0.91 |
| February 2009 | 750.86 | 0.90 |
| March 2009 | 805.22 | 1.07 |
| April 2009 | 893.03 | 1.11 |
| May 2009 | 970.00 | 1.09 |
| June 2009 | 964.05 | 0.99 |
| July 2009 | 1,044.75 | 1.08 |
| August 2009 | 1,085.60 | 1.04 |
| September 2009 | 1,126.98 | 1.04 |
| October 2009 | 1,106.17 | 0.98 |
| November 2009 | 1,149.01 | 1.04 |
| December 2009 | 1,168.47 | 1.02 |
| January 2010 | 1,119.54 | 0.96 |
| February 2010 | 1,133.35 | 1.01 |
| March 2010 | 1,200.53 | 1.06 |
| April 2010 | 1,198.56 | 1.00 |
| May 2010 | 1,079.80 | 0.90 |
| June 2010 | 1,041.32 | 0.96 |
| July 2010 | 1,124.83 | 1.08 |
| August 2010 | 1,080.70 | 0.96 |
| September 2010 | 1,179.19 | 1.09 |
| October 2010 | 1,222.23 | 1.04 |
| November 2010 | 1,193.56 | 0.98 |
| December 2010 | 1,280.07 | 1.07 |

| MSCI World 3-Year Annualised Return (%) |
|---|
| **-6.95** |

Source: MSCI

# MATLAB Coding Appendix

## CCR DEA Model MATLAB Code

The MATLAB coding in the following section performs a number of CCR DEA model variations, namely CCR DEA with either an input-orientation or an output-orientation, and SORMCCR DEA with either an input-orientation or an output-orientation.

```
% ***********************
% Coded By T. J. Burrows
% 2013
% Loughborough University
% ***********************


% ****************************************************
% ====================================================
% CCR DEA Model (Normal/SORM) -- Input/Output-Oriented
% ====================================================
% ****************************************************


% ==> This MATLAB code is able to perform the following DEA model
%     variations:
%
%     ==> CCR DEA Input-Oriented
%     ==> CCR DEA Output-Oriented
%     ==> SORMCCR DEA Input-Oriented
%     ==> SORMCCR DEA Output-Oriented


% ---------------
% Model Selection
% ---------------

model = menu('Model','CCR-IO','CCR-OO','SORMCCR-IO','SORMCCR-OO');

if (model == 1);
    typ='NORM';
    var='CCRIO';
elseif (model == 2);
    typ='NORM';
    var='CCROO';
elseif (model == 3);
    typ='SORM';
    var='SORMCCRIO';
elseif (model == 4);
    typ='SORM';
    var='SORMCCROO';
end

% --------------------------------------
% Selection Of Data For Use In The Model
% --------------------------------------
```

```
data =
menu('Data','UKLCVE','UKLCGE','UKLCBE','UKMCE','UKSCE','USLCVGE','USLCBE','USMCS
CE','GLCVE','GLCGE','GLCBE','GMCSCE','(3rd)UKLCVE','(3rd)UKLCGE','(3rd)UKLCBE','
(3rd)UKMCE','(3rd)UKSCE','(3rd)USLCVGE','(3rd)USLCBE','(3rd)USMCSCE','(3rd)GLCVE
','(3rd)GLCGE','(3rd)GLCBE','(3rd)GMCSCE');

if (data == 1);
    load('C:\Users\Tim\Desktop\Tim''s PhD\MATLAB\PhD Original Data\UKLCVE.mat')
elseif (data == 2);
    load('C:\Users\Tim\Desktop\Tim''s PhD\MATLAB\PhD Original Data\UKLCGE.mat')
elseif (data == 3);
    load('C:\Users\Tim\Desktop\Tim''s PhD\MATLAB\PhD Original Data\UKLCBE.mat')
elseif (data == 4);
    load('C:\Users\Tim\Desktop\Tim''s PhD\MATLAB\PhD Original Data\UKMCE.mat')
elseif (data == 5);
    load('C:\Users\Tim\Desktop\Tim''s PhD\MATLAB\PhD Original Data\UKSCE.mat')
elseif (data == 6);
    load('C:\Users\Tim\Desktop\Tim''s PhD\MATLAB\PhD Original Data\USLCVGE.mat')
elseif (data == 7);
    load('C:\Users\Tim\Desktop\Tim''s PhD\MATLAB\PhD Original Data\USLCBE.mat')
elseif (data == 8);
    load('C:\Users\Tim\Desktop\Tim''s PhD\MATLAB\PhD Original Data\USMCSCE.mat')
elseif (data == 9);
    load('C:\Users\Tim\Desktop\Tim''s PhD\MATLAB\PhD Original Data\GLCVE.mat')
elseif (data == 10);
    load('C:\Users\Tim\Desktop\Tim''s PhD\MATLAB\PhD Original Data\GLCGE.mat')
elseif (data == 11);
    load('C:\Users\Tim\Desktop\Tim''s PhD\MATLAB\PhD Original Data\GLCBE.mat')
elseif (data == 12);
    load('C:\Users\Tim\Desktop\Tim''s PhD\MATLAB\PhD Original Data\GMCSCE.mat')
elseif (data == 13);
    load('C:\Users\Tim\Desktop\Tim''s PhD\MATLAB\PhD 3rd Stage
Data\(3rd)UKLCVE.mat')
elseif (data == 14);
    load('C:\Users\Tim\Desktop\Tim''s PhD\MATLAB\PhD 3rd Stage
Data\(3rd)UKLCGE.mat')
elseif (data == 15);
    load('C:\Users\Tim\Desktop\Tim''s PhD\MATLAB\PhD 3rd Stage
Data\(3rd)UKLCBE.mat')
elseif (data == 16);
    load('C:\Users\Tim\Desktop\Tim''s PhD\MATLAB\PhD 3rd Stage
Data\(3rd)UKMCE.mat')
elseif (data == 17);
    load('C:\Users\Tim\Desktop\Tim''s PhD\MATLAB\PhD 3rd Stage
Data\(3rd)UKSCE.mat')
elseif (data == 18);
    load('C:\Users\Tim\Desktop\Tim''s PhD\MATLAB\PhD 3rd Stage
Data\(3rd)USLCVGE.mat')
elseif (data == 19);
    load('C:\Users\Tim\Desktop\Tim''s PhD\MATLAB\PhD 3rd Stage
Data\(3rd)USLCBE.mat')
elseif (data == 20);
    load('C:\Users\Tim\Desktop\Tim''s PhD\MATLAB\PhD 3rd Stage
Data\(3rd)USMCSCE.mat')
elseif (data == 21);
    load('C:\Users\Tim\Desktop\Tim''s PhD\MATLAB\PhD 3rd Stage
Data\(3rd)GLCVE.mat')
elseif (data == 22);
    load('C:\Users\Tim\Desktop\Tim''s PhD\MATLAB\PhD 3rd Stage
Data\(3rd)GLCGE.mat')
elseif (data == 23);
    load('C:\Users\Tim\Desktop\Tim''s PhD\MATLAB\PhD 3rd Stage
Data\(3rd)GLCBE.mat')
elseif (data == 24);
```

```
    load('C:\Users\Tim\Desktop\Tim''s PhD\MATLAB\PhD 3rd Stage
Data\(3rd)GMCSCE.mat')
end

% -------------------
% Identify Dimensions
% -------------------

% Input Matrix (One Column Per DMU)

X;

% Output Matrix (One Column Per DMU)

Y;

% Extracts The Number Of DMUs, Inputs And Outputs

[I,J] = size (X);
[R,J] = size (Y);

% --------------
% SORM Procedure
% --------------

% Extracts The Negative Data Variables

Xk = X(2,:);
Yk = Y(1,:);

% Extracts The Input Matrix Minus The Negative Variable

Xp = [X(1,:);X(3,:);X(4,:)];

% Constructs The Variables Xk1 And Xk2

for j=1:J
    Xkj = Xk(:,j);
    if Xkj >= 0;
        Xka = Xkj;
        Xkb = 0;
        Xk1(:,j) = Xka;
        Xk2(:,j) = Xkb;
    else Xkj < 0;
        Xka = 0;
        Xkb = -Xkj;
        Xk1(:,j) = Xka;
        Xk2(:,j) = Xkb;
    end
end

% Constructs The Variables Yk1 And Yk2

for j=1:J
    Ykj = Yk(:,j);
    if Ykj >= 0;
        Yka = Ykj;
        Ykb = 0;
        Yk1(:,j) = Yka;
        Yk2(:,j) = Ykb;
    else Ykj < 0;
```

```
            Yka = 0;
            Ykb = -Ykj;
            Yk1(:,j) = Yka;
            Yk2(:,j) = Ykb;
        end
    end

% ====================================
% Computes The Results From The Models
% ====================================

if strcmp('NORM',typ)

    epsilon = 0.000001;     % Epsilon (Non-Archimedean Number)

    Ei = epsilon*ones(1,I);
    Er = epsilon*ones(1,R);

    Z = zeros(J,J+I+R+1);     % Structure For Storing The Results

    effx = zeros(J,1);     % Structure For Storing The Results

    lb = [zeros(1,J+I+R),0];

    if strcmp('CCRIO',var)     % Input-Oriented CCR DEA Model

        for j=1:J
            f = [zeros(1,J) Ei Er 1];
            Xj = X(:,j);
            Yj = Y(:,j);
            Aeq = [-X,-eye(I,I),zeros(I,R),Xj;Y,zeros(R,I),-
eye(R,R),zeros(R,1)];
            beq = [zeros(I,1);Yj];
            [x,fval,exitflag,output,lambda] =
linprog(f,[],[],Aeq,beq,lb,[],[],optimset('LargeScale','Off','Simplex','On','Dis
play','Final'));
            Z(j,:) = x;     % Accumulates x For Each DMU In Matrix Z
            A = x'*f';
            if A < 0
                A = 1;
            end
            effx(j,:) = A;     % Accumulates Efficiency Rating For Each DMU
        end

    elseif strcmp('CCROO',var)     % Output-Oriented CCR DEA Model

        for j=1:J
            f = [zeros(1,J) Ei Er -1];
            Xj = X(:,j);
            Yj = Y(:,j);
            Aeq = [X,eye(I,I),zeros(I,R),zeros(I,1);-Y,zeros(R,I),eye(R,R),Yj];
            beq = [Xj;zeros(R,1)];
            [x,fval,exitflag,output,lambda] =
linprog(f,[],[],Aeq,beq,lb,[],[],optimset('LargeScale','Off','Simplex','On','Dis
play','Final'));
            Z(j,:) = x;     % Accumulates x For Each DMU In Matrix Z
            A = -1/(x'*f');
            if A < 0
                A = 1;
            end
            effx(j,:) = A;     % Accumulates Efficiency Rating For Each DMU
        end
```

```
    end

elseif strcmp('SORM',typ)

    epsilon = 0.000001;     % Epsilon (Non-Archimedean Number)

    Ei = epsilon*ones(1,I+1);
    Er = epsilon*ones(1,R+1);

    Z = zeros(J,J+I+1+R+1+1);     % Structure For Storing The Results

    effx = zeros(J,1);     % Structure For Storing The Results

    lb = [zeros(1,J+I+1+R+1),0];

    if strcmp('SORMCCRIO',var)     % Input-Oriented SORMCCR DEA Model

        for j=1:J
            f = [zeros(1,J) Ei Er 1];
            Xpj = Xp(:,j);
            Xk1j = Xk1(:,j);
            Xk2j = Xk2(:,j);
            Yk1j = Yk1(:,j);
            Yk2j = Yk2(:,j);
            Aeq = [[-Xp;-Xk1;-Yk2],-
eye(5,I+1),zeros(5,R+1),[Xpj;Xk1j;Yk2j];[Yk1;Xk2],zeros(2,I+1),-
eye(2,R+1),zeros(2,1)];
            beq = [zeros(3,1);zeros(1,1);zeros(1,1);Yk1j;Xk2j];
            [x,fval,exitflag,output,lambda] =
linprog(f,[],[],Aeq,beq,lb,[],[],optimset('LargeScale','Off','Simplex','On','Dis
play','Final'));
            Z(j,:) = x;     % Accumulates x For Each DMU In Matrix Z
            A = x'*f';
            if A < 0
                A = 1;
            end
            effx(j,:) = A;     % Accumulates Efficiency Rating For Each DMU
        end

    elseif strcmp('SORMCCROO',var)     % Output-Oriented SORMCCR DEA Model

        for j=1:J
            f = [zeros(1,J) Ei Er -1];
            Xpj = Xp(:,j);
            Xk1j = Xk1(:,j);
            Xk2j = Xk2(:,j);
            Yk1j = Yk1(:,j);
            Yk2j = Yk2(:,j);
            Aeq = [[Xp;Xk1;Yk2],eye(5,I+1),zeros(5,R+1),zeros(5,1);[-Yk1;-
Xk2],zeros(2,I+1),eye(2,R+1),[Yk1j;Xk2j]];
            beq = [Xpj;Xk1j;Yk2j;zeros(1,1);zeros(1,1)];
            [x,fval,exitflag,output,lambda] =
linprog(f,[],[],Aeq,beq,lb,[],[],optimset('LargeScale','Off','Simplex','On','Dis
play','Final'));
            Z(j,:) = x;     % Accumulates x For Each DMU In Matrix Z
            A = -1/(x'*f');
            if A < 0
                A = 1;
            end
            effx(j,:) = A;     % Accumulates Efficiency Rating For Each DMU
        end
    end
```

```
end

% ============================================
% Extracts The Efficiency Rating For Each DMU
% ============================================

EfficiencyRatings = effx(1:J,1);

% --------------------
% Displays The Results
% --------------------

if (model == 1);
    fprintf('\n=================================\n');
    fprintf('\nCCR DEA Model -- Input-Oriented\n');
    fprintf('\n=================================\n\n');
    LabelC = 'CCR-IO';
elseif (model == 2);
    fprintf('\n==================================\n');
    fprintf('\nCCR DEA Model -- Output-Oriented\n');
    fprintf('\n==================================\n\n');
    LabelC = 'CCR-OO';
elseif (model == 3);
    fprintf('\n=====================================\n');
    fprintf('\nSORMCCR DEA Model -- Input-Oriented\n');
    fprintf('\n=====================================\n\n');
    LabelC = 'SORMCCR-IO';
elseif (model == 4);
    fprintf('\n======================================\n');
    fprintf('\nSORMCCR DEA Model -- Output-Oriented\n');
    fprintf('\n======================================\n\n');
    LabelC = 'SORMCCR-OO';
end

if (data == 1);
    fprintf('-------------------------\n')
    fprintf('UK Large-Cap Value Equity\n')
    fprintf('-------------------------\n\n')
    LabelB = 'UK Large-Cap Value Equity: ';
elseif (data == 2);
    fprintf('--------------------------\n')
    fprintf('UK Large-Cap Growth Equity\n')
    fprintf('--------------------------\n\n')
    LabelB = 'UK Large-Cap Growth Equity: ';
elseif (data == 3);
    fprintf('-------------------------\n')
    fprintf('UK Large-Cap Blend Equity\n')
    fprintf('-------------------------\n\n')
    LabelB = 'UK Large-Cap Blend Equity: ';
elseif (data == 4);
    fprintf('-----------------\n')
    fprintf('UK Mid-Cap Equity\n')
    fprintf('-----------------\n\n')
    LabelB = 'UK Mid-Cap Equity: ';
elseif (data == 5);
    fprintf('-------------------\n')
    fprintf('UK Small-Cap Equity\n')
    fprintf('-------------------\n\n')
    LabelB = 'UK Small-Cap Equity: ';
elseif (data == 6);
    fprintf('-----------------------------------\n')
    fprintf('US Large-Cap Value And Growth Equity\n')
```

```
    fprintf('------------------------------------\n\n')
    LabelB = 'US Large-Cap Value And Growth Equity: ';
elseif (data == 7);
    fprintf('-------------------------\n')
    fprintf('US Large-Cap Blend Equity\n')
    fprintf('-------------------------\n\n')
    LabelB = 'US Large-Cap Blend Equity: ';
elseif (data == 8);
    fprintf('-------------------------------\n')
    fprintf('US Mid-Cap And Small-Cap Equity\n')
    fprintf('-------------------------------\n\n')
    LabelB = 'US Mid-Cap And Small-Cap Equity: ';
elseif (data == 9);
    fprintf('-----------------------------\n')
    fprintf('Global Large-Cap Value Equity\n')
    fprintf('-----------------------------\n\n')
    LabelB = 'Global Large-Cap Value Equity: ';
elseif (data == 10);
    fprintf('------------------------------\n')
    fprintf('Global Large-Cap Growth Equity\n')
    fprintf('------------------------------\n\n')
    LabelB = 'Global Large-Cap Growth Equity: ';
elseif (data == 11);
    fprintf('-----------------------------\n')
    fprintf('Global Large-Cap Blend Equity\n')
    fprintf('-----------------------------\n\n')
    LabelB = 'Global Large-Cap Blend Equity: ';
elseif (data == 12);
    fprintf('-----------------------------------\n')
    fprintf('Global Mid-Cap And Small-Cap Equity\n')
    fprintf('-----------------------------------\n\n')
    LabelB = 'Global Mid-Cap And Small-Cap Equity: ';
elseif (data == 13);
    fprintf('-------------------------------\n')
    fprintf('(3rd) UK Large-Cap Value Equity\n')
    fprintf('-------------------------------\n\n')
    LabelB = 'UK Large-Cap Value Equity: 3rd ';
elseif (data == 14);
    fprintf('--------------------------------\n')
    fprintf('(3rd) UK Large-Cap Growth Equity\n')
    fprintf('--------------------------------\n\n')
    LabelB = 'UK Large-Cap Growth Equity: 3rd ';
elseif (data == 15);
    fprintf('-------------------------------\n')
    fprintf('(3rd) UK Large-Cap Blend Equity\n')
    fprintf('-------------------------------\n\n')
    LabelB = 'UK Large-Cap Blend Equity: 3rd ';
elseif (data == 16);
    fprintf('-----------------------\n')
    fprintf('(3rd) UK Mid-Cap Equity\n')
    fprintf('-----------------------\n\n')
    LabelB = 'UK Mid-Cap Equity: 3rd ';
elseif (data == 17);
    fprintf('-------------------------\n')
    fprintf('(3rd) UK Small-Cap Equity\n')
    fprintf('-------------------------\n\n')
    LabelB = 'UK Small-Cap Equity: 3rd ';
elseif (data == 18);
    fprintf('------------------------------------------\n')
    fprintf('(3rd) US Large-Cap Value And Growth Equity\n')
    fprintf('------------------------------------------\n\n')
    LabelB = 'US Large-Cap Value And Growth Equity: 3rd ';
elseif (data == 19);
    fprintf('-------------------------------\n')
```

```
    fprintf('(3rd) US Large-Cap Blend Equity\n')
    fprintf('------------------------------\n\n')
    LabelB = 'US Large-Cap Blend Equity: 3rd ';
elseif (data == 20);
    fprintf('-------------------------------------\n')
    fprintf('(3rd) US Mid-Cap And Small-Cap Equity\n')
    fprintf('-------------------------------------\n\n')
    LabelB = 'US Mid-Cap And Small-Cap Equity: 3rd ';
elseif (data == 21);
    fprintf('-----------------------------------\n')
    fprintf('(3rd) Global Large-Cap Value Equity\n')
    fprintf('-----------------------------------\n\n')
    LabelB = 'Global Large-Cap Value Equity: 3rd ';
elseif (data == 22);
    fprintf('------------------------------------\n')
    fprintf('(3rd) Global Large-Cap Growth Equity\n')
    fprintf('------------------------------------\n\n')
    LabelB = 'Global Large-Cap Growth Equity: 3rd ';
elseif (data == 23);
    fprintf('-----------------------------------\n')
    fprintf('(3rd) Global Large-Cap Blend Equity\n')
    fprintf('-----------------------------------\n\n')
    LabelB = 'Global Large-Cap Blend Equity: 3rd ';
elseif (data == 24);
    fprintf('-----------------------------------------\n')
    fprintf('(3rd) Global Mid-Cap And Small-Cap Equity\n')
    fprintf('-----------------------------------------\n\n')
    LabelB = 'Global Mid-Cap And Small-Cap Equity: 3rd ';
end

for j=1:J
    fprintf('Efficiency Rating DMU %d --> %.3f\n', j, EfficiencyRatings(j));
end

% =======================================================================
% Calculates And Displays - Mean Efficiency Rating And Standard Deviation
% Of Efficiency Ratings
% =======================================================================

fprintf('\n==================================================\n\n');

Mean = mean(EfficiencyRatings);

fprintf('Mean Efficiency Rating ==> %.3f\n\n', Mean);

SD = std(EfficiencyRatings);

fprintf('Standard Deviation Of Efficiency Ratings ==> %.3f\n\n', SD);

fprintf('==================================================\n\n');

% =======================================================================
% Calculates And Displays - Maximum Efficiency Rating, Minimum Efficiency
% Rating, Outperformance Of The Benchmark And Underperformance Of The
% Benchmark
% =======================================================================

EfficiencyRatingsX = ((round(EfficiencyRatings*1000))/1000);

EfficiencyRatingsX2 = EfficiencyRatingsX(1:J-1,1);
MM = quantile(EfficiencyRatingsX2,[0,1]);
MaxRat = MM(1,2);
```

```
MinRat = MM(1,1);

MaxRN = find(EfficiencyRatingsX2 == MaxRat);
MinRN = find(EfficiencyRatingsX2 == MinRat);
[MaN,Wa] = size(MaxRN);
[MiN,Wi] = size(MinRN);

fprintf('--------------------------------------------------------------------
\n\n');
fprintf('Maximum Efficiency Rating ==> %.3f\n', MaxRat);
fprintf('Number Of OEICs/UTs At Maximum Efficiency Rating ==> %.0f\n\n', MaN);
fprintf('Minimum Efficiency Rating ==> %.3f\n', MinRat);
fprintf('Number Of OEICs/UTs At Minimum Efficiency Rating ==> %.0f\n\n', MiN);

ETF = EfficiencyRatingsX(J,1);

OP = (EfficiencyRatingsX(1:J-1,1) > ETF);
OPX = tabulate(OP);
UP = (EfficiencyRatingsX(1:J-1,1) < ETF);
UPX = tabulate(UP);

Ov = (J-1)-(cell2mat(OPX(1,2)));
OvP = (Ov/(J-1))*100;
Un = cell2mat(UPX(2,2));
UnP = cell2mat(UPX(2,3));

fprintf('Number Of OEICs/UTs Outperforming The Benchmark ETF ==> %.0f\n', Ov);
fprintf('Percentage Of OEICs/UTs Outperforming The Benchmark ETF ==>
%.2f%%\n\n', OvP);
fprintf('Number Of OEICs/UTs Underperforming The Benchmark ETF ==> %.0f\n', Un);
fprintf('Percentage Of OEICs/UTs Underperforming The Benchmark ETF ==>
%.2f%%\n\n', UnP);
fprintf('--------------------------------------------------------------------
\n\n');

fprintf('\n********************************************************************\
n');
fprintf('****************** Coded By T. J. Burrows © 2013
******************\n');
fprintf('********************* Loughborough University
*********************\n');
fprintf('********************************************************************\n\
n');

LabelA = 'Kernel Density Estimation: ';
LabelM = [LabelA LabelB LabelC];

% ----------------------------------------
% Kernel Smoothing Density Estimate (KSDE)
% ----------------------------------------

[b,xi] = ksdensity(EfficiencyRatings);
plot(xi,b,'m');

title(LabelM,'FontName','Times New Roman','FontWeight','Bold');
xlabel('Efficiency Rating','FontName','Times New Roman');
ylabel('Density','FontName','Times New Roman');
grid on;
```

## BCC DEA Model MATLAB Code

The MATLAB coding in the following section performs a number of BCC DEA model variations, namely BCC DEA with either an input-orientation or an output-orientation, and SORMBCC DEA with either an input-orientation or an output-orientation.

```
% ***********************
% Coded By T. J. Burrows
% 2013
% Loughborough University
% ***********************


% ****************************************************
% ====================================================
% BCC DEA Model (Normal/SORM) -- Input/Output-Oriented
% ====================================================
% ****************************************************


% ==> This MATLAB code is able to perform the following DEA model
%     variations:
%
%     ==> BCC DEA Input-Oriented
%     ==> BCC DEA Output-Oriented
%     ==> SORMBCC DEA Input-Oriented
%     ==> SORMBCC DEA Output-Oriented


% ---------------
% Model Selection
% ---------------

model = menu('Model','BCC-IO','BCC-OO','SORMBCC-IO','SORMBCC-OO');

if (model == 1);
    typ='NORM';
    var='BCCIO';
elseif (model == 2);
    typ='NORM';
    var='BCCOO';
elseif (model == 3);
    typ='SORM';
    var='SORMBCCIO';
elseif (model == 4);
    typ='SORM';
    var='SORMBCCOO';
end

% --------------------------------------
% Selection Of Data For Use In The Model
% --------------------------------------
```

```
data =
menu('Data','UKLCVE','UKLCGE','UKLCBE','UKMCE','UKSCE','USLCVGE','USLCBE','USMCS
CE','GLCVE','GLCGE','GLCBE','GMCSCE','(3rd)UKLCVE','(3rd)UKLCGE','(3rd)UKLCBE','
(3rd)UKMCE','(3rd)UKSCE','(3rd)USLCVGE','(3rd)USLCBE','(3rd)USMCSCE','(3rd)GLCVE
','(3rd)GLCGE','(3rd)GLCBE','(3rd)GMCSCE');

if (data == 1);
    load('C:\Users\Tim\Desktop\Tim''s PhD\MATLAB\PhD Original Data\UKLCVE.mat')
elseif (data == 2);
    load('C:\Users\Tim\Desktop\Tim''s PhD\MATLAB\PhD Original Data\UKLCGE.mat')
elseif (data == 3);
    load('C:\Users\Tim\Desktop\Tim''s PhD\MATLAB\PhD Original Data\UKLCBE.mat')
elseif (data == 4);
    load('C:\Users\Tim\Desktop\Tim''s PhD\MATLAB\PhD Original Data\UKMCE.mat')
elseif (data == 5);
    load('C:\Users\Tim\Desktop\Tim''s PhD\MATLAB\PhD Original Data\UKSCE.mat')
elseif (data == 6);
    load('C:\Users\Tim\Desktop\Tim''s PhD\MATLAB\PhD Original Data\USLCVGE.mat')
elseif (data == 7);
    load('C:\Users\Tim\Desktop\Tim''s PhD\MATLAB\PhD Original Data\USLCBE.mat')
elseif (data == 8);
    load('C:\Users\Tim\Desktop\Tim''s PhD\MATLAB\PhD Original Data\USMCSCE.mat')
elseif (data == 9);
    load('C:\Users\Tim\Desktop\Tim''s PhD\MATLAB\PhD Original Data\GLCVE.mat')
elseif (data == 10);
    load('C:\Users\Tim\Desktop\Tim''s PhD\MATLAB\PhD Original Data\GLCGE.mat')
elseif (data == 11);
    load('C:\Users\Tim\Desktop\Tim''s PhD\MATLAB\PhD Original Data\GLCBE.mat')
elseif (data == 12);
    load('C:\Users\Tim\Desktop\Tim''s PhD\MATLAB\PhD Original Data\GMCSCE.mat')
elseif (data == 13);
    load('C:\Users\Tim\Desktop\Tim''s PhD\MATLAB\PhD 3rd Stage
Data\(3rd)UKLCVE.mat')
elseif (data == 14);
    load('C:\Users\Tim\Desktop\Tim''s PhD\MATLAB\PhD 3rd Stage
Data\(3rd)UKLCGE.mat')
elseif (data == 15);
    load('C:\Users\Tim\Desktop\Tim''s PhD\MATLAB\PhD 3rd Stage
Data\(3rd)UKLCBE.mat')
elseif (data == 16);
    load('C:\Users\Tim\Desktop\Tim''s PhD\MATLAB\PhD 3rd Stage
Data\(3rd)UKMCE.mat')
elseif (data == 17);
    load('C:\Users\Tim\Desktop\Tim''s PhD\MATLAB\PhD 3rd Stage
Data\(3rd)UKSCE.mat')
elseif (data == 18);
    load('C:\Users\Tim\Desktop\Tim''s PhD\MATLAB\PhD 3rd Stage
Data\(3rd)USLCVGE.mat')
elseif (data == 19);
    load('C:\Users\Tim\Desktop\Tim''s PhD\MATLAB\PhD 3rd Stage
Data\(3rd)USLCBE.mat')
elseif (data == 20);
    load('C:\Users\Tim\Desktop\Tim''s PhD\MATLAB\PhD 3rd Stage
Data\(3rd)USMCSCE.mat')
elseif (data == 21);
    load('C:\Users\Tim\Desktop\Tim''s PhD\MATLAB\PhD 3rd Stage
Data\(3rd)GLCVE.mat')
elseif (data == 22);
    load('C:\Users\Tim\Desktop\Tim''s PhD\MATLAB\PhD 3rd Stage
Data\(3rd)GLCGE.mat')
elseif (data == 23);
    load('C:\Users\Tim\Desktop\Tim''s PhD\MATLAB\PhD 3rd Stage
Data\(3rd)GLCBE.mat')
elseif (data == 24);
```

```
    load('C:\Users\Tim\Desktop\Tim''s PhD\MATLAB\PhD 3rd Stage
Data\(3rd)GMCSCE.mat')
end

% -------------------
% Identify Dimensions
% -------------------

% Input Matrix (One Column Per DMU)

X;

% Output Matrix (One Column Per DMU)

Y;

% Extracts The Number Of DMUs, Inputs And Outputs

[I,J] = size (X);
[R,J] = size (Y);

% --------------
% SORM Procedure
% --------------

% Extracts The Negative Data Variables

Xk = X(2,:);
Yk = Y(1,:);

% Extracts The Input Matrix Minus The Negative Variable

Xp = [X(1,:);X(3,:);X(4,:)];

% Constructs The Variables Xk1 And Xk2

for j=1:J
    Xkj = Xk(:,j);
    if Xkj >= 0;
        Xka = Xkj;
        Xkb = 0;
        Xk1(:,j) = Xka;
        Xk2(:,j) = Xkb;
    else Xkj < 0;
        Xka = 0;
        Xkb = -Xkj;
        Xk1(:,j) = Xka;
        Xk2(:,j) = Xkb;
    end
end

% Constructs The Variables Yk1 And Yk2

for j=1:J
    Ykj = Yk(:,j);
    if Ykj >= 0;
        Yka = Ykj;
        Ykb = 0;
        Yk1(:,j) = Yka;
        Yk2(:,j) = Ykb;
    else Ykj < 0;
```

```
        Yka = 0;
        Ykb = -Ykj;
        Yk1(:,j) = Yka;
        Yk2(:,j) = Ykb;
    end
end

% ====================================
% Computes The Results From The Models
% ====================================

if strcmp('NORM',typ)

    epsilon = 0.000001;     % Epsilon (Non-Archimedean Number)

    Ei = epsilon*ones(1,I);
    Er = epsilon*ones(1,R);

    Z = zeros(J,J+I+R+1);     % Structure For Storing The Results

    effx = zeros(J,1);     % Structure For Storing The Results

    lb = [zeros(1,J+I+R),0];

    if strcmp('BCCIO',var)     % Input-Oriented BCC DEA Model

        for j=1:J
            f = [zeros(1,J) Ei Er 1];
            Xj = X(:,j);
            Yj = Y(:,j);
            Aeq = [-X,-eye(I,I),zeros(I,R),Xj;Y,zeros(R,I),-
eye(R,R),zeros(R,1);ones(1,J),zeros(1,I),zeros(1,R),0];
            beq = [zeros(I,1);Yj;1];
            [x,fval,exitflag,output,lambda] =
linprog(f,[],[],Aeq,beq,lb,[],[],optimset('LargeScale','Off','Simplex','On','Dis
play','Final'));
            Z(j,:) = x;     % Accumulates x For Each DMU In Matrix Z
            A = x'*f';
            if A < 0
                A = 1;
            end
            effx(j,:) = A;     % Accumulates Efficiency Rating For Each DMU
        end

    elseif strcmp('BCCOO',var)     % Output-Oriented BCC DEA Model

        for j=1:J
            f = [zeros(1,J) Ei Er -1];
            Xj = X(:,j);
            Yj = Y(:,j);
            Aeq = [X,eye(I,I),zeros(I,R),zeros(I,1);-
Y,zeros(R,I),eye(R,R),Yj;ones(1,J),zeros(1,I),zeros(1,R),0];
            beq = [Xj;zeros(R,1);1];
            [x,fval,exitflag,output,lambda] =
linprog(f,[],[],Aeq,beq,lb,[],[],optimset('LargeScale','Off','Simplex','On','Dis
play','Final'));
            Z(j,:) = x;     % Accumulates x For Each DMU In Matrix Z
            A = -1/(x'*f');
            if A < 0
                A = 1;
            end
            effx(j,:) = A;     % Accumulates Efficiency Rating For Each DMU
```

```
            end
        end

    elseif strcmp('SORM',typ)

        epsilon = 0.000001;     % Epsilon (Non-Archimedean Number)

        Ei = epsilon*ones(1,I+1);
        Er = epsilon*ones(1,R+1);

        Z = zeros(J,J+I+1+R+1+1);     % Structure For Storing The Results

        effx = zeros(J,1);     % Structure For Storing The Results

        lb = [zeros(1,J+I+1+R+1),0];

        if strcmp('SORMBCCIO',var)     % Input-Oriented SORMBCC DEA Model

            for j=1:J
                f = [zeros(1,J) Ei Er 1];
                Xpj = Xp(:,j);
                Xk1j = Xk1(:,j);
                Xk2j = Xk2(:,j);
                Yk1j = Yk1(:,j);
                Yk2j = Yk2(:,j);
                Aeq = [[-Xp;-Xk1;-Yk2],-
eye(5,I+1),zeros(5,R+1),[Xpj;Xk1j;Yk2j];[Yk1;Xk2],zeros(2,I+1),-
eye(2,R+1),zeros(2,1);ones(1,J),zeros(1,I+1),zeros(1,R+1),0];
                beq = [zeros(3,1);zeros(1,1);zeros(1,1);Yk1j;Xk2j;1];
                [x,fval,exitflag,output,lambda] =
linprog(f,[],[],Aeq,beq,lb,[],[],optimset('LargeScale','Off','Simplex','On','Dis
play','Final'));
                Z(j,:) = x;     % Accumulates x For Each DMU In Matrix Z
                A = x'*f';
                if A < 0
                    A = 1;
                end
                effx(j,:) = A;     % Accumulates Efficiency Rating For Each DMU
            end

        elseif strcmp('SORMBCCOO',var)     % Output-Oriented SORMBCC DEA Model

            for j=1:J
                f = [zeros(1,J) Ei Er -1];
                Xpj = Xp(:,j);
                Xk1j = Xk1(:,j);
                Xk2j = Xk2(:,j);
                Yk1j = Yk1(:,j);
                Yk2j = Yk2(:,j);
                Aeq = [[Xp;Xk1;Yk2],eye(5,I+1),zeros(5,R+1),zeros(5,1);[-Yk1;-
Xk2],zeros(2,I+1),eye(2,R+1),[Yk1j;Xk2j];ones(1,J),zeros(1,I+1),zeros(1,R+1),0];
                beq = [Xpj;Xk1j;Yk2j;zeros(1,1);zeros(1,1);1];
                [x,fval,exitflag,output,lambda] =
linprog(f,[],[],Aeq,beq,lb,[],[],optimset('LargeScale','Off','Simplex','On','Dis
play','Final'));
                Z(j,:) = x;     % Accumulates x For Each DMU In Matrix Z
                A = -1/(x'*f');
                if A < 0
                    A = 1;
                end
                effx(j,:) = A;     % Accumulates Efficiency Rating For Each DMU
            end
```

```
    end

end

% ===========================================
% Extracts The Efficiency Rating For Each DMU
% ===========================================

EfficiencyRatings = effx(1:J,1);

% --------------------
% Displays The Results
% --------------------

if (model == 1);
    fprintf('\n==============================\n');
    fprintf('\nBCC DEA Model -- Input-Oriented\n');
    fprintf('\n==============================\n\n');
    LabelC = 'BCC-IO';
elseif (model == 2);
    fprintf('\n===============================\n');
    fprintf('\nBCC DEA Model -- Output-Oriented\n');
    fprintf('\n===============================\n\n');
    LabelC = 'BCC-OO';
elseif (model == 3);
    fprintf('\n==================================\n');
    fprintf('\nSORMBCC DEA Model -- Input-Oriented\n');
    fprintf('\n==================================\n\n');
    LabelC = 'SORMBCC-IO';
elseif (model == 4);
    fprintf('\n===================================\n');
    fprintf('\nSORMBCC DEA Model -- Output-Oriented\n');
    fprintf('\n===================================\n\n');
    LabelC = 'SORMBCC-OO';
end

if (data == 1);
    fprintf('-------------------------\n')
    fprintf('UK Large-Cap Value Equity\n')
    fprintf('-------------------------\n\n')
    LabelB = 'UK Large-Cap Value Equity: ';
elseif (data == 2);
    fprintf('--------------------------\n')
    fprintf('UK Large-Cap Growth Equity\n')
    fprintf('--------------------------\n\n')
    LabelB = 'UK Large-Cap Growth Equity: ';
elseif (data == 3);
    fprintf('-------------------------\n')
    fprintf('UK Large-Cap Blend Equity\n')
    fprintf('-------------------------\n\n')
    LabelB = 'UK Large-Cap Blend Equity: ';
elseif (data == 4);
    fprintf('-----------------\n')
    fprintf('UK Mid-Cap Equity\n')
    fprintf('-----------------\n\n')
    LabelB = 'UK Mid-Cap Equity: ';
elseif (data == 5);
    fprintf('-------------------\n')
    fprintf('UK Small-Cap Equity\n')
    fprintf('-------------------\n\n')
    LabelB = 'UK Small-Cap Equity: ';
elseif (data == 6);
    fprintf('------------------------------------\n')
```

```
    fprintf('US Large-Cap Value And Growth Equity\n')
    fprintf('------------------------------------\n\n')
    LabelB = 'US Large-Cap Value And Growth Equity: ';
elseif (data == 7);
    fprintf('-------------------------\n')
    fprintf('US Large-Cap Blend Equity\n')
    fprintf('-------------------------\n\n')
    LabelB = 'US Large-Cap Blend Equity: ';
elseif (data == 8);
    fprintf('-------------------------------\n')
    fprintf('US Mid-Cap And Small-Cap Equity\n')
    fprintf('-------------------------------\n\n')
    LabelB = 'US Mid-Cap And Small-Cap Equity: ';
elseif (data == 9);
    fprintf('-----------------------------\n')
    fprintf('Global Large-Cap Value Equity\n')
    fprintf('-----------------------------\n\n')
    LabelB = 'Global Large-Cap Value Equity: ';
elseif (data == 10);
    fprintf('------------------------------\n')
    fprintf('Global Large-Cap Growth Equity\n')
    fprintf('------------------------------\n\n')
    LabelB = 'Global Large-Cap Growth Equity: ';
elseif (data == 11);
    fprintf('-----------------------------\n')
    fprintf('Global Large-Cap Blend Equity\n')
    fprintf('-----------------------------\n\n')
    LabelB = 'Global Large-Cap Blend Equity: ';
elseif (data == 12);
    fprintf('-----------------------------------\n')
    fprintf('Global Mid-Cap And Small-Cap Equity\n')
    fprintf('-----------------------------------\n\n')
    LabelB = 'Global Mid-Cap And Small-Cap Equity: ';
elseif (data == 13);
    fprintf('-------------------------------\n')
    fprintf('(3rd) UK Large-Cap Value Equity\n')
    fprintf('-------------------------------\n\n')
    LabelB = 'UK Large-Cap Value Equity: 3rd ';
elseif (data == 14);
    fprintf('--------------------------------\n')
    fprintf('(3rd) UK Large-Cap Growth Equity\n')
    fprintf('--------------------------------\n\n')
    LabelB = 'UK Large-Cap Growth Equity: 3rd ';
elseif (data == 15);
    fprintf('-------------------------------\n')
    fprintf('(3rd) UK Large-Cap Blend Equity\n')
    fprintf('-------------------------------\n\n')
    LabelB = 'UK Large-Cap Blend Equity: 3rd ';
elseif (data == 16);
    fprintf('-----------------------\n')
    fprintf('(3rd) UK Mid-Cap Equity\n')
    fprintf('-----------------------\n\n')
    LabelB = 'UK Mid-Cap Equity: 3rd ';
elseif (data == 17);
    fprintf('-------------------------\n')
    fprintf('(3rd) UK Small-Cap Equity\n')
    fprintf('-------------------------\n\n')
    LabelB = 'UK Small-Cap Equity: 3rd ';
elseif (data == 18);
    fprintf('------------------------------------------\n')
    fprintf('(3rd) US Large-Cap Value And Growth Equity\n')
    fprintf('------------------------------------------\n\n')
    LabelB = 'US Large-Cap Value And Growth Equity: 3rd ';
elseif (data == 19);
```

```
    fprintf('-------------------------------\n')
    fprintf('(3rd) US Large-Cap Blend Equity\n')
    fprintf('-------------------------------\n\n')
    LabelB = 'US Large-Cap Blend Equity: 3rd ';
elseif (data == 20);
    fprintf('-------------------------------------\n')
    fprintf('(3rd) US Mid-Cap And Small-Cap Equity\n')
    fprintf('-------------------------------------\n\n')
    LabelB = 'US Mid-Cap And Small-Cap Equity: 3rd ';
elseif (data == 21);
    fprintf('-----------------------------------\n')
    fprintf('(3rd) Global Large-Cap Value Equity\n')
    fprintf('-----------------------------------\n\n')
    LabelB = 'Global Large-Cap Value Equity: 3rd ';
elseif (data == 22);
    fprintf('------------------------------------\n')
    fprintf('(3rd) Global Large-Cap Growth Equity\n')
    fprintf('------------------------------------\n\n')
    LabelB = 'Global Large-Cap Growth Equity: 3rd ';
elseif (data == 23);
    fprintf('-----------------------------------\n')
    fprintf('(3rd) Global Large-Cap Blend Equity\n')
    fprintf('-----------------------------------\n\n')
    LabelB = 'Global Large-Cap Blend Equity: 3rd ';
elseif (data == 24);
    fprintf('-----------------------------------------\n')
    fprintf('(3rd) Global Mid-Cap And Small-Cap Equity\n')
    fprintf('-----------------------------------------\n\n')
    LabelB = 'Global Mid-Cap And Small-Cap Equity: 3rd ';
end

for j=1:J
    fprintf('Efficiency Rating DMU %d --> %.3f\n', j, EfficiencyRatings(j));
end

% =======================================================================
% Calculates And Displays - Mean Efficiency Rating And Standard Deviation
% Of Efficiency Ratings
% =======================================================================

fprintf('\n==================================================\n\n');

Mean = mean(EfficiencyRatings);

fprintf('Mean Efficiency Rating ==> %.3f\n\n', Mean);

SD = std(EfficiencyRatings);

fprintf('Standard Deviation Of Efficiency Ratings ==> %.3f\n\n', SD);

fprintf('==================================================\n\n');

% =======================================================================
% Calculates And Displays - Maximum Efficiency Rating, Minimum Efficiency
% Rating, Outperformance Of The Benchmark And Underperformance Of The
% Benchmark
% =======================================================================

EfficiencyRatingsX = ((round(EfficiencyRatings*1000))/1000);

EfficiencyRatingsX2 = EfficiencyRatingsX(1:J-1,1);
MM = quantile(EfficiencyRatingsX2,[0,1]);
```

```
MaxRat = MM(1,2);
MinRat = MM(1,1);

MaxRN = find(EfficiencyRatingsX2 == MaxRat);
MinRN = find(EfficiencyRatingsX2 == MinRat);
[MaN,Wa] = size(MaxRN);
[MiN,Wi] = size(MinRN);

fprintf('---------------------------------------------------------------------
\n\n');
fprintf('Maximum Efficiency Rating ==> %.3f\n', MaxRat);
fprintf('Number Of OEICs/UTs At Maximum Efficiency Rating ==> %.0f\n\n', MaN);
fprintf('Minimum Efficiency Rating ==> %.3f\n', MinRat);
fprintf('Number Of OEICs/UTs At Minimum Efficiency Rating ==> %.0f\n\n', MiN);

ETF = EfficiencyRatingsX(J,1);

OP = (EfficiencyRatingsX(1:J-1,1) > ETF);
OPX = tabulate(OP);
UP = (EfficiencyRatingsX(1:J-1,1) < ETF);
UPX = tabulate(UP);

Ov = (J-1)-(cell2mat(OPX(1,2)));
OvP = (Ov/(J-1))*100;
Un = cell2mat(UPX(2,2));
UnP = cell2mat(UPX(2,3));

fprintf('Number Of OEICs/UTs Outperforming The Benchmark ETF ==> %.0f\n', Ov);
fprintf('Percentage Of OEICs/UTs Outperforming The Benchmark ETF ==>
%.2f%%\n\n', OvP);
fprintf('Number Of OEICs/UTs Underperforming The Benchmark ETF ==> %.0f\n', Un);
fprintf('Percentage Of OEICs/UTs Underperforming The Benchmark ETF ==>
%.2f%%\n\n', UnP);
fprintf('---------------------------------------------------------------------
\n\n');

fprintf('\n*******************************************************************\
n');
fprintf('******************* Coded By T. J. Burrows © 2013
******************\n');
fprintf('********************** Loughborough University
*********************\n');
fprintf('*********************************************************************\n\
n');

LabelA = 'Kernel Density Estimation: ';
LabelM = [LabelA LabelB LabelC];

% ----------------------------------------
% Kernel Smoothing Density Estimate (KSDE)
% ----------------------------------------

[b,xi] = ksdensity(EfficiencyRatings);
plot(xi,b,'m');

title(LabelM,'FontName','Times New Roman','FontWeight','Bold');
xlabel('Efficiency Rating','FontName','Times New Roman');
ylabel('Density','FontName','Times New Roman');
grid on;
```

## SBM DEA Model MATLAB Code

The MATLAB coding in the following section performs a number of SBM DEA model variations, namely CRS SBM DEA, either non-oriented, input-oriented or output-oriented, and VRS SBM DEA, either non-oriented, input-oriented or output-oriented.

```
% **********************
% Coded By T. J. Burrows
% 2013
% Loughborough University
% **********************


% ***************************************************
% ===================================================
% SBM DEA Model (CRS/VRS) -- Non/Input/Output-Oriented
% ===================================================
% ***************************************************


% ==> This MATLAB code is able to perform the following DEA model
%     variations:
%
%     ==> SBM DEA (CRS) Non-Oriented
%     ==> SBM DEA (CRS) Input-Oriented
%     ==> SBM DEA (CRS) Output-Oriented
%     ==> SBM DEA (VRS) Non-Oriented
%     ==> SBM DEA (VRS) Input-Oriented
%     ==> SBM DEA (VRS) Output-Oriented


% ---------------
% Model Selection
% ---------------

model = menu('Model','SBM(CRS)-NO','SBM(CRS)-IO','SBM(CRS)-OO','SBM(VRS)-
NO','SBM(VRS)-IO','SBM(VRS)-OO');

if (model == 1);
    rts='CRS';
    ori='NO';
elseif (model == 2);
    rts='CRS';
    ori='IO';
elseif (model == 3);
    rts='CRS';
    ori='OO';
elseif (model == 4);
    rts='VRS';
    ori='NO';
elseif (model == 5);
    rts='VRS';
    ori='IO';
```

```
elseif (model == 6);
    rts='VRS';
    ori='OO';
end

% -------------------------------------
% Selection Of Data For Use In The Model
% -------------------------------------

data =
menu('Data','UKLCVE','UKLCGE','UKLCBE','UKMCE','UKSCE','USLCVGE','USLCBE','USMCS
CE','GLCVE','GLCGE','GLCBE','GMCSCE','(3rd)UKLCVE','(3rd)UKLCGE','(3rd)UKLCBE','
(3rd)UKMCE','(3rd)UKSCE','(3rd)USLCVGE','(3rd)USLCBE','(3rd)USMCSCE','(3rd)GLCVE
','(3rd)GLCGE','(3rd)GLCBE','(3rd)GMCSCE');

if (data == 1);
    load('C:\Users\Tim\Desktop\Tim''s PhD\MATLAB\PhD Original Data\UKLCVE.mat')
elseif (data == 2);
    load('C:\Users\Tim\Desktop\Tim''s PhD\MATLAB\PhD Original Data\UKLCGE.mat')
elseif (data == 3);
    load('C:\Users\Tim\Desktop\Tim''s PhD\MATLAB\PhD Original Data\UKLCBE.mat')
elseif (data == 4);
    load('C:\Users\Tim\Desktop\Tim''s PhD\MATLAB\PhD Original Data\UKMCE.mat')
elseif (data == 5);
    load('C:\Users\Tim\Desktop\Tim''s PhD\MATLAB\PhD Original Data\UKSCE.mat')
elseif (data == 6);
    load('C:\Users\Tim\Desktop\Tim''s PhD\MATLAB\PhD Original Data\USLCVGE.mat')
elseif (data == 7);
    load('C:\Users\Tim\Desktop\Tim''s PhD\MATLAB\PhD Original Data\USLCBE.mat')
elseif (data == 8);
    load('C:\Users\Tim\Desktop\Tim''s PhD\MATLAB\PhD Original Data\USMCSCE.mat')
elseif (data == 9);
    load('C:\Users\Tim\Desktop\Tim''s PhD\MATLAB\PhD Original Data\GLCVE.mat')
elseif (data == 10);
    load('C:\Users\Tim\Desktop\Tim''s PhD\MATLAB\PhD Original Data\GLCGE.mat')
elseif (data == 11);
    load('C:\Users\Tim\Desktop\Tim''s PhD\MATLAB\PhD Original Data\GLCBE.mat')
elseif (data == 12);
    load('C:\Users\Tim\Desktop\Tim''s PhD\MATLAB\PhD Original Data\GMCSCE.mat')
elseif (data == 13);
    load('C:\Users\Tim\Desktop\Tim''s PhD\MATLAB\PhD 3rd Stage
Data\(3rd)UKLCVE.mat')
elseif (data == 14);
    load('C:\Users\Tim\Desktop\Tim''s PhD\MATLAB\PhD 3rd Stage
Data\(3rd)UKLCGE.mat')
elseif (data == 15);
    load('C:\Users\Tim\Desktop\Tim''s PhD\MATLAB\PhD 3rd Stage
Data\(3rd)UKLCBE.mat')
elseif (data == 16);
    load('C:\Users\Tim\Desktop\Tim''s PhD\MATLAB\PhD 3rd Stage
Data\(3rd)UKMCE.mat')
elseif (data == 17);
    load('C:\Users\Tim\Desktop\Tim''s PhD\MATLAB\PhD 3rd Stage
Data\(3rd)UKSCE.mat')
elseif (data == 18);
    load('C:\Users\Tim\Desktop\Tim''s PhD\MATLAB\PhD 3rd Stage
Data\(3rd)USLCVGE.mat')
elseif (data == 19);
    load('C:\Users\Tim\Desktop\Tim''s PhD\MATLAB\PhD 3rd Stage
Data\(3rd)USLCBE.mat')
elseif (data == 20);
    load('C:\Users\Tim\Desktop\Tim''s PhD\MATLAB\PhD 3rd Stage
Data\(3rd)USMCSCE.mat')
```

```
elseif (data == 21);
    load('C:\Users\Tim\Desktop\Tim''s PhD\MATLAB\PhD 3rd Stage
Data\(3rd)GLCVE.mat')
elseif (data == 22);
    load('C:\Users\Tim\Desktop\Tim''s PhD\MATLAB\PhD 3rd Stage
Data\(3rd)GLCGE.mat')
elseif (data == 23);
    load('C:\Users\Tim\Desktop\Tim''s PhD\MATLAB\PhD 3rd Stage
Data\(3rd)GLCBE.mat')
elseif (data == 24);
    load('C:\Users\Tim\Desktop\Tim''s PhD\MATLAB\PhD 3rd Stage
Data\(3rd)GMCSCE.mat')
end

% -------------------
% Identify Dimensions
% -------------------

% Input Matrix (One Column Per DMU)

X;

% Output Matrix (One Column Per DMU)

Y;

% Extracts The Number Of DMUs, Inputs And Outputs

[I,J] = size (X);
[R,J] = size (Y);

% Constructs The Matrices TX And TY

for j=1:J
    for i=1:I
        TX(i,j) = -1/(X(i,j)*I);
    end
end

for j=1:J
    for r=1:R
        TY(r,j) = 1/(Y(r,j)*R);
    end
end

% ===================================
% Computes The Results From The Model
% ===================================

epsilon = 0.000001;     % Epsilon (Non-Archimedean Number)

Ei = epsilon*ones(1,I);
Er = epsilon*ones(1,R);

Z = zeros(J,J+I+R+1);     % Structure For Storing The Results

effx = zeros(J,1);     % Structure For Storing The Results

lb = [zeros(1,J+I+R),1];
ub = [inf(1,J+I+R),1];
```

```
if strcmp('CRS',rts)

    if strcmp('NO',ori) % Non-Oriented SBM DEA Model (CRS)

        for j=1:J
            TXj = TX(:,j);
            TYj = TY(:,j);
            f = [zeros(1,J) TXj' Er 1];
            Xj = X(:,j);
            Yj = Y(:,j);
            Aeq = [zeros(1,J),zeros(1,I),TYj',1;-X,-
eye(I,I),zeros(I,R),Xj;Y,zeros(R,I),-eye(R,R),zeros(R,1)];
            beq = [1;zeros(I,1);Yj];
            [x,fval,exitflag,output,lambda] =
linprog(f,[],[],Aeq,beq,lb,ub,[],optimset('LargeScale','Off','Simplex','On','Dis
play','Final'));
            Z(j,:) = x;     % Accumulates x For Each DMU In Matrix Z
            A = x'*f';
            if A < 0
                A = 1;
            end
            effx(j,:) = A;     % Accumulates Efficiency Rating For Each DMU
        end

    elseif strcmp('IO',ori) % Input-Oriented SBM DEA Model (CRS)

        for j=1:J
            TXj = TX(:,j);
            f = [zeros(1,J) TXj' Er 1];
            Xj = X(:,j);
            Yj = Y(:,j);
            Aeq = [-X,-eye(I,I),zeros(I,R),Xj;Y,zeros(R,I),-
eye(R,R),zeros(R,1)];
            beq = [zeros(I,1);Yj];
            [x,fval,exitflag,output,lambda] =
linprog(f,[],[],Aeq,beq,lb,ub,[],optimset('LargeScale','Off','Simplex','On','Dis
play','Final'));
            Z(j,:) = x;     % Accumulates x For Each DMU In Matrix Z
            A = x'*f';
            if A < 0
                A = 1;
            end
            effx(j,:) = A;     % Accumulates Efficiency Rating For Each DMU
        end

    elseif strcmp('OO',ori) % Output-Oriented SBM DEA Model (CRS)

        for j=1:J
            TYj = TY(:,j);
            f = [zeros(1,J) Ei -TYj' -1];
            Xj = X(:,j);
            Yj = Y(:,j);
            Aeq = [X,eye(I,I),zeros(I,R),zeros(I,1);-Y,zeros(R,I),eye(R,R),Yj];
            beq = [Xj;zeros(R,1)];
            [x,fval,exitflag,output,lambda] =
linprog(f,[],[],Aeq,beq,lb,ub,[],optimset('LargeScale','Off','Simplex','On','Dis
play','Final'));
            Z(j,:) = x;     % Accumulates x For Each DMU In Matrix Z
            A = -1/(x'*f');
            if A < 0
                A = 1;
```

```
            end
            effx(j,:) = A;     % Accumulates Efficiency Rating For Each DMU
        end
    end

elseif strcmp('VRS',rts)

    if strcmp('NO',ori) % Non-Oriented SBM DEA Model (VRS)

        for j=1:J
            TXj = TX(:,j);
            TYj = TY(:,j);
            f = [zeros(1,J) TXj' Er 1];
            Xj = X(:,j);
            Yj = Y(:,j);
            Aeq = [zeros(1,J),zeros(1,I),TYj',1;-X,-
eye(I,I),zeros(I,R),Xj;Y,zeros(R,I),-
eye(R,R),zeros(R,1);ones(1,J),zeros(1,I),zeros(1,R),0];
            beq = [1;zeros(I,1);Yj;1];
            [x,fval,exitflag,output,lambda] =
linprog(f,[],[],Aeq,beq,lb,ub,[],optimset('LargeScale','Off','Simplex','On','Dis
play','Final'));
            Z(j,:) = x;     % Accumulates x For Each DMU In Matrix Z
            A = x'*f';
            if A < 0
                A = 1;
            end
            effx(j,:) = A;     % Accumulates Efficiency Rating For Each DMU
        end

    elseif strcmp('IO',ori) % Input-Oriented SBM DEA Model (VRS)

        for j=1:J
            TXj = TX(:,j);
            f = [zeros(1,J) TXj' Er 1];
            Xj = X(:,j);
            Yj = Y(:,j);
            Aeq = [-X,-eye(I,I),zeros(I,R),Xj;Y,zeros(R,I),-
eye(R,R),zeros(R,1);ones(1,J),zeros(1,I),zeros(1,R),0];
            beq = [zeros(I,1);Yj;1];
            [x,fval,exitflag,output,lambda] =
linprog(f,[],[],Aeq,beq,lb,ub,[],optimset('LargeScale','Off','Simplex','On','Dis
play','Final'));
            Z(j,:) = x;     % Accumulates x For Each DMU In Matrix Z
            A = x'*f';
            if A < 0
                A = 1;
            end
            effx(j,:) = A;     % Accumulates Efficiency Rating For Each DMU
        end

    elseif strcmp('OO',ori) % Output-Oriented SBM DEA Model (VRS)

        for j=1:J
            TYj = TY(:,j);
            f = [zeros(1,J) Ei -TYj' -1];
            Xj = X(:,j);
            Yj = Y(:,j);
            Aeq = [X,eye(I,I),zeros(I,R),zeros(I,1);-
Y,zeros(R,I),eye(R,R),Yj;ones(1,J),zeros(1,I),zeros(1,R),0];
            beq = [Xj;zeros(R,1);1];
```

```
            [x,fval,exitflag,output,lambda] =
linprog(f,[],[],Aeq,beq,lb,ub,[],optimset('LargeScale','Off','Simplex','On','Dis
play','Final'));
            Z(j,:) = x;     % Accumulates x For Each DMU In Matrix Z
            A = -1/(x'*f');
            if A < 0
                A = 1;
            end
            effx(j,:) = A;     % Accumulates Efficiency Rating For Each DMU
        end
    end

end

% ===========================================
% Extracts The Efficiency Rating For Each DMU
% ===========================================

EfficiencyRatings = effx(1:J,1);

% --------------------
% Displays The Results
% --------------------

if (model == 1);
    fprintf('\n===================================\n');
    fprintf('\nSBM DEA Model (CRS) -- Non-Oriented\n');
    fprintf('\n===================================\n\n');
    LabelC = 'SBM(CRS)-NO';
elseif (model == 2);
    fprintf('\n=====================================\n');
    fprintf('\nSBM DEA Model (CRS) -- Input-Oriented\n');
    fprintf('\n=====================================\n\n');
    LabelC = 'SBM(CRS)-IO';
elseif (model == 3);
    fprintf('\n======================================\n');
    fprintf('\nSBM DEA Model (CRS) -- Output-Oriented\n');
    fprintf('\n======================================\n\n');
    LabelC = 'SBM(CRS)-OO';
elseif (model == 4);
    fprintf('\n===================================\n');
    fprintf('\nSBM DEA Model (VRS) -- Non-Oriented\n');
    fprintf('\n===================================\n\n');
    LabelC = 'SBM(VRS)-NO';
elseif (model == 5);
    fprintf('\n=====================================\n');
    fprintf('\nSBM DEA Model (VRS) -- Input-Oriented\n');
    fprintf('\n=====================================\n\n');
    LabelC = 'SBM(VRS)-IO';
elseif (model == 6);
    fprintf('\n======================================\n');
    fprintf('\nSBM DEA Model (VRS) -- Output-Oriented\n');
    fprintf('\n======================================\n\n');
    LabelC = 'SBM(VRS)-OO';
end

if (data == 1);
    fprintf('-------------------------\n')
    fprintf('UK Large-Cap Value Equity\n')
    fprintf('-------------------------\n\n')
    LabelB = 'UK Large-Cap Value Equity: ';
elseif (data == 2);
    fprintf('--------------------------\n')
```

```
    fprintf('UK Large-Cap Growth Equity\n')
    fprintf('--------------------------\n\n')
    LabelB = 'UK Large-Cap Growth Equity: ';
elseif (data == 3);
    fprintf('-------------------------\n')
    fprintf('UK Large-Cap Blend Equity\n')
    fprintf('-------------------------\n\n')
    LabelB = 'UK Large-Cap Blend Equity: ';
elseif (data == 4);
    fprintf('-----------------\n')
    fprintf('UK Mid-Cap Equity\n')
    fprintf('-----------------\n\n')
    LabelB = 'UK Mid-Cap Equity: ';
elseif (data == 5);
    fprintf('-------------------\n')
    fprintf('UK Small-Cap Equity\n')
    fprintf('-------------------\n\n')
    LabelB = 'UK Small-Cap Equity: ';
elseif (data == 6);
    fprintf('------------------------------------\n')
    fprintf('US Large-Cap Value And Growth Equity\n')
    fprintf('------------------------------------\n\n')
    LabelB = 'US Large-Cap Value And Growth Equity: ';
elseif (data == 7);
    fprintf('-------------------------\n')
    fprintf('US Large-Cap Blend Equity\n')
    fprintf('-------------------------\n\n')
    LabelB = 'US Large-Cap Blend Equity: ';
elseif (data == 8);
    fprintf('-------------------------------\n')
    fprintf('US Mid-Cap And Small-Cap Equity\n')
    fprintf('-------------------------------\n\n')
    LabelB = 'US Mid-Cap And Small-Cap Equity: ';
elseif (data == 9);
    fprintf('-----------------------------\n')
    fprintf('Global Large-Cap Value Equity\n')
    fprintf('-----------------------------\n\n')
    LabelB = 'Global Large-Cap Value Equity: ';
elseif (data == 10);
    fprintf('------------------------------\n')
    fprintf('Global Large-Cap Growth Equity\n')
    fprintf('------------------------------\n\n')
    LabelB = 'Global Large-Cap Growth Equity: ';
elseif (data == 11);
    fprintf('-----------------------------\n')
    fprintf('Global Large-Cap Blend Equity\n')
    fprintf('-----------------------------\n\n')
    LabelB = 'Global Large-Cap Blend Equity: ';
elseif (data == 12);
    fprintf('-----------------------------------\n')
    fprintf('Global Mid-Cap And Small-Cap Equity\n')
    fprintf('-----------------------------------\n\n')
    LabelB = 'Global Mid-Cap And Small-Cap Equity: ';
elseif (data == 13);
    fprintf('-------------------------------\n')
    fprintf('(3rd) UK Large-Cap Value Equity\n')
    fprintf('-------------------------------\n\n')
    LabelB = 'UK Large-Cap Value Equity: 3rd ';
elseif (data == 14);
    fprintf('--------------------------------\n')
    fprintf('(3rd) UK Large-Cap Growth Equity\n')
    fprintf('--------------------------------\n\n')
    LabelB = 'UK Large-Cap Growth Equity: 3rd ';
elseif (data == 15);
```

```
    fprintf('-------------------------------\n')
    fprintf('(3rd) UK Large-Cap Blend Equity\n')
    fprintf('-------------------------------\n\n')
    LabelB = 'UK Large-Cap Blend Equity: 3rd ';
elseif (data == 16);
    fprintf('-----------------------\n')
    fprintf('(3rd) UK Mid-Cap Equity\n')
    fprintf('-----------------------\n\n')
    LabelB = 'UK Mid-Cap Equity: 3rd ';
elseif (data == 17);
    fprintf('-------------------------\n')
    fprintf('(3rd) UK Small-Cap Equity\n')
    fprintf('-------------------------\n\n')
    LabelB = 'UK Small-Cap Equity: 3rd ';
elseif (data == 18);
    fprintf('------------------------------------------\n')
    fprintf('(3rd) US Large-Cap Value And Growth Equity\n')
    fprintf('------------------------------------------\n\n')
    LabelB = 'US Large-Cap Value And Growth Equity: 3rd ';
elseif (data == 19);
    fprintf('-------------------------------\n')
    fprintf('(3rd) US Large-Cap Blend Equity\n')
    fprintf('-------------------------------\n\n')
    LabelB = 'US Large-Cap Blend Equity: 3rd ';
elseif (data == 20);
    fprintf('-------------------------------------\n')
    fprintf('(3rd) US Mid-Cap And Small-Cap Equity\n')
    fprintf('-------------------------------------\n\n')
    LabelB = 'US Mid-Cap And Small-Cap Equity: 3rd ';
elseif (data == 21);
    fprintf('-----------------------------------\n')
    fprintf('(3rd) Global Large-Cap Value Equity\n')
    fprintf('-----------------------------------\n\n')
    LabelB = 'Global Large-Cap Value Equity: 3rd ';
elseif (data == 22);
    fprintf('------------------------------------\n')
    fprintf('(3rd) Global Large-Cap Growth Equity\n')
    fprintf('------------------------------------\n\n')
    LabelB = 'Global Large-Cap Growth Equity: 3rd ';
elseif (data == 23);
    fprintf('-----------------------------------\n')
    fprintf('(3rd) Global Large-Cap Blend Equity\n')
    fprintf('-----------------------------------\n\n')
    LabelB = 'Global Large-Cap Blend Equity: 3rd ';
elseif (data == 24);
    fprintf('-----------------------------------------\n')
    fprintf('(3rd) Global Mid-Cap And Small-Cap Equity\n')
    fprintf('-----------------------------------------\n\n')
    LabelB = 'Global Mid-Cap And Small-Cap Equity: 3rd ';
end

for j=1:J
    fprintf('Efficiency Rating DMU %d --> %.3f\n', j, EfficiencyRatings(j));
end

% ======================================================================
% Calculates And Displays - Mean Efficiency Rating And Standard Deviation
% Of Efficiency Ratings
% ======================================================================

fprintf('\n==================================================\n\n');

Mean = mean(EfficiencyRatings);
```

```
fprintf('Mean Efficiency Rating ==> %.3f\n\n', Mean);

SD = std(EfficiencyRatings);

fprintf('Standard Deviation Of Efficiency Ratings ==> %.3f\n\n', SD);

fprintf('==================================================\n\n');

% ======================================================================
% Calculates And Displays - Maximum Efficiency Rating, Minimum Efficiency
% Rating, Outperformance Of The Benchmark And Underperformance Of The
% Benchmark
% ======================================================================

EfficiencyRatingsX = ((round(EfficiencyRatings*1000))/1000);

EfficiencyRatingsX2 = EfficiencyRatingsX(1:J-1,1);
MM = quantile(EfficiencyRatingsX2,[0,1]);
MaxRat = MM(1,2);
MinRat = MM(1,1);

MaxRN = find(EfficiencyRatingsX2 == MaxRat);
MinRN = find(EfficiencyRatingsX2 == MinRat);
[MaN,Wa] = size(MaxRN);
[MiN,Wi] = size(MinRN);

fprintf('--------------------------------------------------------------------
\n\n');
fprintf('Maximum Efficiency Rating ==> %.3f\n', MaxRat);
fprintf('Number Of OEICs/UTs At Maximum Efficiency Rating ==> %.0f\n\n', MaN);
fprintf('Minimum Efficiency Rating ==> %.3f\n', MinRat);
fprintf('Number Of OEICs/UTs At Minimum Efficiency Rating ==> %.0f\n\n', MiN);

ETF = EfficiencyRatingsX(J,1);

OP = (EfficiencyRatingsX(1:J-1,1) > ETF);
OPX = tabulate(OP);
UP = (EfficiencyRatingsX(1:J-1,1) < ETF);
UPX = tabulate(UP);

Ov = (J-1)-(cell2mat(OPX(1,2)));
OvP = (Ov/(J-1))*100;
Un = cell2mat(UPX(2,2));
UnP = cell2mat(UPX(2,3));

fprintf('Number Of OEICs/UTs Outperforming The Benchmark ETF ==> %.0f\n', Ov);
fprintf('Percentage Of OEICs/UTs Outperforming The Benchmark ETF ==>
%.2f%%\n\n', OvP);
fprintf('Number Of OEICs/UTs Underperforming The Benchmark ETF ==> %.0f\n', Un);
fprintf('Percentage Of OEICs/UTs Underperforming The Benchmark ETF ==>
%.2f%%\n\n', UnP);
fprintf('--------------------------------------------------------------------
\n\n');

fprintf('\n*******************************************************************\
n');
fprintf('******************** Coded By T. J. Burrows © 2013
******************\n');
fprintf('********************** Loughborough University
*********************\n');
```

```
fprintf('********************************************************************\n\
n');

LabelA = 'Kernel Density Estimation: ';
LabelM = [LabelA LabelB LabelC];

% ----------------------------------------
% Kernel Smoothing Density Estimate (KSDE)
% ----------------------------------------

[b,xi] = ksdensity(EfficiencyRatings);
plot(xi,b,'m');

title(LabelM,'FontName','Times New Roman','FontWeight','Bold');
xlabel('Efficiency Rating','FontName','Times New Roman');
ylabel('Density','FontName','Times New Roman');
grid on;
```

## SORMSBM DEA Model MATLAB Code

The MATLAB coding in the following section performs a number of SORMSBM DEA model variations, namely CRS SORMSBM DEA, either non-oriented, input-oriented or output-oriented, and VRS SORMSBM DEA, either non-oriented, input-oriented or output-oriented.

```
% ***********************
% Coded By T. J. Burrows
% 2013
% Loughborough University
% ***********************


% ********************************************************
% ========================================================
% SORMSBM DEA Model (CRS/VRS) -- Non/Input/Output-Oriented
% ========================================================
% ********************************************************


% ==> This MATLAB code is able to perform the following DEA model
%     variations:
%
%     ==> SORMSBM DEA (CRS) Non-Oriented
%     ==> SORMSBM DEA (CRS) Input-Oriented
%     ==> SORMSBM DEA (CRS) Output-Oriented
%     ==> SORMSBM DEA (VRS) Non-Oriented
%     ==> SORMSBM DEA (VRS) Input-Oriented
%     ==> SORMSBM DEA (VRS) Output-Oriented


% ---------------
% Model Selection
% ---------------

model = menu('Model','SORMSBM(CRS)-NO','SORMSBM(CRS)-IO','SORMSBM(CRS)-
OO','SORMSBM(VRS)-NO','SORMSBM(VRS)-IO','SORMSBM(VRS)-OO');

if (model == 1);
    rts='CRS';
    ori='NO';
elseif (model == 2);
    rts='CRS';
    ori='IO';
elseif (model == 3);
    rts='CRS';
    ori='OO';
elseif (model == 4);
    rts='VRS';
    ori='NO';
elseif (model == 5);
    rts='VRS';
    ori='IO';
```

```
elseif (model == 6);
    rts='VRS';
    ori='OO';
end

% -------------------------------------
% Selection Of Data For Use In The Model
% -------------------------------------

data =
menu('Data','UKLCVE','UKLCGE','UKLCBE','UKMCE','UKSCE','USLCVGE','USLCBE','USMCS
CE','GLCVE','GLCGE','GLCBE','GMCSCE','(3rd)UKLCVE','(3rd)UKLCGE','(3rd)UKLCBE','
(3rd)UKMCE','(3rd)UKSCE','(3rd)USLCVGE','(3rd)USLCBE','(3rd)USMCSCE','(3rd)GLCVE
','(3rd)GLCGE','(3rd)GLCBE','(3rd)GMCSCE');

if (data == 1);
    load('C:\Users\Tim\Desktop\Tim''s PhD\MATLAB\PhD Original Data\UKLCVE.mat')
elseif (data == 2);
    load('C:\Users\Tim\Desktop\Tim''s PhD\MATLAB\PhD Original Data\UKLCGE.mat')
elseif (data == 3);
    load('C:\Users\Tim\Desktop\Tim''s PhD\MATLAB\PhD Original Data\UKLCBE.mat')
elseif (data == 4);
    load('C:\Users\Tim\Desktop\Tim''s PhD\MATLAB\PhD Original Data\UKMCE.mat')
elseif (data == 5);
    load('C:\Users\Tim\Desktop\Tim''s PhD\MATLAB\PhD Original Data\UKSCE.mat')
elseif (data == 6);
    load('C:\Users\Tim\Desktop\Tim''s PhD\MATLAB\PhD Original Data\USLCVGE.mat')
elseif (data == 7);
    load('C:\Users\Tim\Desktop\Tim''s PhD\MATLAB\PhD Original Data\USLCBE.mat')
elseif (data == 8);
    load('C:\Users\Tim\Desktop\Tim''s PhD\MATLAB\PhD Original Data\USMCSCE.mat')
elseif (data == 9);
    load('C:\Users\Tim\Desktop\Tim''s PhD\MATLAB\PhD Original Data\GLCVE.mat')
elseif (data == 10);
    load('C:\Users\Tim\Desktop\Tim''s PhD\MATLAB\PhD Original Data\GLCGE.mat')
elseif (data == 11);
    load('C:\Users\Tim\Desktop\Tim''s PhD\MATLAB\PhD Original Data\GLCBE.mat')
elseif (data == 12);
    load('C:\Users\Tim\Desktop\Tim''s PhD\MATLAB\PhD Original Data\GMCSCE.mat')
elseif (data == 13);
    load('C:\Users\Tim\Desktop\Tim''s PhD\MATLAB\PhD 3rd Stage
Data\(3rd)UKLCVE.mat')
elseif (data == 14);
    load('C:\Users\Tim\Desktop\Tim''s PhD\MATLAB\PhD 3rd Stage
Data\(3rd)UKLCGE.mat')
elseif (data == 15);
    load('C:\Users\Tim\Desktop\Tim''s PhD\MATLAB\PhD 3rd Stage
Data\(3rd)UKLCBE.mat')
elseif (data == 16);
    load('C:\Users\Tim\Desktop\Tim''s PhD\MATLAB\PhD 3rd Stage
Data\(3rd)UKMCE.mat')
elseif (data == 17);
    load('C:\Users\Tim\Desktop\Tim''s PhD\MATLAB\PhD 3rd Stage
Data\(3rd)UKSCE.mat')
elseif (data == 18);
    load('C:\Users\Tim\Desktop\Tim''s PhD\MATLAB\PhD 3rd Stage
Data\(3rd)USLCVGE.mat')
elseif (data == 19);
    load('C:\Users\Tim\Desktop\Tim''s PhD\MATLAB\PhD 3rd Stage
Data\(3rd)USLCBE.mat')
elseif (data == 20);
    load('C:\Users\Tim\Desktop\Tim''s PhD\MATLAB\PhD 3rd Stage
Data\(3rd)USMCSCE.mat')
```

```
elseif (data == 21);
    load('C:\Users\Tim\Desktop\Tim''s PhD\MATLAB\PhD 3rd Stage
Data\(3rd)GLCVE.mat')
elseif (data == 22);
    load('C:\Users\Tim\Desktop\Tim''s PhD\MATLAB\PhD 3rd Stage
Data\(3rd)GLCGE.mat')
elseif (data == 23);
    load('C:\Users\Tim\Desktop\Tim''s PhD\MATLAB\PhD 3rd Stage
Data\(3rd)GLCBE.mat')
elseif (data == 24);
    load('C:\Users\Tim\Desktop\Tim''s PhD\MATLAB\PhD 3rd Stage
Data\(3rd)GMCSCE.mat')
end

% -------------------
% Identify Dimensions
% -------------------

% Input Matrix (One Column Per DMU)

X;

% Output Matrix (One Column Per DMU)

Y;

% Extracts The Number Of DMUs, Inputs And Outputs

[I,J] = size (X);
[R,J] = size (Y);

% --------------
% SORM Procedure
% --------------

% Extracts The Negative Data Variables

Xk = X(2,:);
Yk = Y(1,:);

% Extracts The Input Matrix Minus The Negative Variable

Xp = [X(1,:);X(3,:);X(4,:)];

% Constructs The Variables Xk1 And Xk2

for j=1:J
    Xkj = Xk(:,j);
    if Xkj >= 0;
        Xka = Xkj;
        Xkb = 0;
        Xk1(:,j) = Xka;
        Xk2(:,j) = Xkb;
    else Xkj < 0;
        Xka = 0;
        Xkb = -Xkj;
        Xk1(:,j) = Xka;
        Xk2(:,j) = Xkb;
    end
end
```

```
% Constructs The Variables Yk1 And Yk2

for j=1:J
    Ykj = Yk(:,j);
    if Ykj >= 0;
        Yka = Ykj;
        Ykb = 0;
        Yk1(:,j) = Yka;
        Yk2(:,j) = Ykb;
    else Ykj < 0;
        Yka = 0;
        Ykb = -Ykj;
        Yk1(:,j) = Yka;
        Yk2(:,j) = Ykb;
    end
end

% Constructs The Matrices TX And TY

WXp = [Xp;Xk1;Yk2];

for j=1:J
    for i=1:5
        ZXp(i,j) = -1/(WXp(i,j)*(I+1));
    end
end

for j=1:J
    for i=1:5
        SXp(i,j) = ZXp(i,j);
        if ZXp(i,j) ~= -inf;
            SXp(i,j) = ZXp(i,j);
        elseif ZXp(i,j) == -inf;
            SXp(i,j) = 0;
        end
    end
end

TX = [SXp];

WYp = [Yk1;Xk2];

for j=1:J
    for i=1:2
        ZYp(i,j) = 1/(WYp(i,j)*(R+1));
    end
end

for j=1:J
    for i=1:2
        SYp(i,j) = ZYp(i,j);
        if ZYp(i,j) ~= inf;
            SYp(i,j) = ZYp(i,j);
        elseif ZYp(i,j) == inf;
            SYp(i,j) = 0;
        end
    end
end

TY = [SYp];

% ===================================
```

```
% Computes The Results From The Model
% ====================================

epsilon = 0.000001;     % Epsilon (Non-Archimedean Number)

Ei = epsilon*ones(1,I+1);
Er = epsilon*ones(1,R+1);

Z = zeros(J,J+I+1+R+1+1);     % Structure For Storing The Results

effx = zeros(J,1);     % Structure For Storing The Results

lb = [zeros(1,J+I+1+R+1),1];
ub = [inf(1,J+I+1+R+1),1];

if strcmp('CRS',rts)

    if strcmp('NO',ori) % Non-Oriented SORMSBM DEA Model (CRS)

        for j=1:J
            TXj = TX(:,j);
            TYj = TY(:,j);
            f = [zeros(1,J) TXj' Er 1];
            Xpj = Xp(:,j);
            Xk1j = Xk1(:,j);
            Xk2j = Xk2(:,j);
            Yk1j = Yk1(:,j);
            Yk2j = Yk2(:,j);
            Aeq = [zeros(1,J),zeros(1,I+1),TYj',1;[-Xp;-Xk1;-Yk2],-
eye(5,I+1),zeros(5,R+1),[Xpj;Xk1j;Yk2j];[Yk1;Xk2],zeros(2,I+1),-
eye(2,R+1),zeros(2,1)];
            beq = [1;zeros(3,1);zeros(1,1);zeros(1,1);Yk1j;Xk2j];
            [x,fval,exitflag,output,lambda] =
linprog(f,[],[],Aeq,beq,lb,ub,[],optimset('LargeScale','Off','Simplex','On','Dis
play','Final'));
            Z(j,:) = x;     % Accumulates x For Each DMU In Matrix Z
            A = x'*f';
            if A < 0
                A = 1;
            end
            effx(j,:) = A;     % Accumulates Efficiency Rating For Each DMU
        end

    elseif strcmp('IO',ori) % Input-Oriented SORMSBM DEA Model (CRS)

        for j=1:J
            TXj = TX(:,j);
            f = [zeros(1,J) TXj' Er 1];
            Xpj = Xp(:,j);
            Xk1j = Xk1(:,j);
            Xk2j = Xk2(:,j);
            Yk1j = Yk1(:,j);
            Yk2j = Yk2(:,j);
            Aeq = [[-Xp;-Xk1;-Yk2],-
eye(5,I+1),zeros(5,R+1),[Xpj;Xk1j;Yk2j];[Yk1;Xk2],zeros(2,I+1),-
eye(2,R+1),zeros(2,1)];
            beq = [zeros(3,1);zeros(1,1);zeros(1,1);Yk1j;Xk2j];
            [x,fval,exitflag,output,lambda] =
linprog(f,[],[],Aeq,beq,lb,ub,[],optimset('LargeScale','Off','Simplex','On','Dis
play','Final'));
            Z(j,:) = x;     % Accumulates x For Each DMU In Matrix Z
            A = x'*f';
```

```
            if A < 0
                A = 1;
            end
            effx(j,:) = A;     % Accumulates Efficiency Rating For Each DMU
        end

    elseif strcmp('OO',ori) % Output-Oriented SORMSBM DEA Model (CRS)

        for j=1:J
            TYj = TY(:,j);
            f = [zeros(1,J) Ei -TYj' -1];
            Xpj = Xp(:,j);
            Xk1j = Xk1(:,j);
            Xk2j = Xk2(:,j);
            Yk1j = Yk1(:,j);
            Yk2j = Yk2(:,j);
            Aeq = [[Xp;Xk1;Yk2],eye(5,I+1),zeros(5,R+1),zeros(5,1);[-Yk1;-
Xk2],zeros(2,I+1),eye(2,R+1),[Yk1j;Xk2j]];
            beq = [Xpj;Xk1j;Yk2j;zeros(2,1)];
            [x,fval,exitflag,output,lambda] =
linprog(f,[],[],Aeq,beq,lb,ub,[],optimset('LargeScale','Off','Simplex','On','Dis
play','Final'));
            Z(j,:) = x;     % Accumulates x For Each DMU In Matrix Z
            A = -1/(x'*f');
            if A < 0
                A = 1;
            end
            effx(j,:) = A;     % Accumulates Efficiency Rating For Each DMU
        end
    end

elseif strcmp('VRS',rts)

    if strcmp('NO',ori) % Non-Oriented SORMSBM DEA Model (VRS)

        for j=1:J
            TXj = TX(:,j);
            TYj = TY(:,j);
            f = [zeros(1,J) TXj' Er 1];
            Xpj = Xp(:,j);
            Xk1j = Xk1(:,j);
            Xk2j = Xk2(:,j);
            Yk1j = Yk1(:,j);
            Yk2j = Yk2(:,j);
            Aeq = [zeros(1,J),zeros(1,I+1),TYj',1;[-Xp;-Xk1;-Yk2],-
eye(5,I+1),zeros(5,R+1),[Xpj;Xk1j;Yk2j];[Yk1;Xk2],zeros(2,I+1),-
eye(2,R+1),zeros(2,1);ones(1,J),zeros(1,I+1),zeros(1,R+1),0];
            beq = [1;zeros(3,1);zeros(1,1);zeros(1,1);Yk1j;Xk2j;1];
            [x,fval,exitflag,output,lambda] =
linprog(f,[],[],Aeq,beq,lb,ub,[],optimset('LargeScale','Off','Simplex','On','Dis
play','Final'));
            Z(j,:) = x;     % Accumulates x For Each DMU In Matrix Z
            A = x'*f';
            if A < 0
                A = 1;
            end
            effx(j,:) = A;     % Accumulates Efficiency Rating For Each DMU
        end

    elseif strcmp('IO',ori) % Input-Oriented SORMSBM DEA Model (VRS)

        for j=1:J
```

```
            TXj = TX(:,j);
            f = [zeros(1,J) TXj' Er 1];
            Xpj = Xp(:,j);
            Xk1j = Xk1(:,j);
            Xk2j = Xk2(:,j);
            Yk1j = Yk1(:,j);
            Yk2j = Yk2(:,j);
            Aeq = [[-Xp;-Xk1;-Yk2],-
eye(5,I+1),zeros(5,R+1),[Xpj;Xk1j;Yk2j];[Yk1;Xk2],zeros(2,I+1),-
eye(2,R+1),zeros(2,1);ones(1,J),zeros(1,I+1),zeros(1,R+1),0];
            beq = [zeros(3,1);zeros(1,1);zeros(1,1);Yk1j;Xk2j;1];
            [x,fval,exitflag,output,lambda] =
linprog(f,[],[],Aeq,beq,lb,ub,[],optimset('LargeScale','Off','Simplex','On','Dis
play','Final'));
            Z(j,:) = x;      % Accumulates x For Each DMU In Matrix Z
            A = x'*f';
            if A < 0
                A = 1;
            end
            effx(j,:) = A;      % Accumulates Efficiency Rating For Each DMU
        end

    elseif strcmp('OO',ori) % Output-Oriented SORMSBM DEA Model (VRS)

        for j=1:J
            TYj = TY(:,j);
            f = [zeros(1,J) Ei -TYj' -1];
            Xpj = Xp(:,j);
            Xk1j = Xk1(:,j);
            Xk2j = Xk2(:,j);
            Yk1j = Yk1(:,j);
            Yk2j = Yk2(:,j);
            Aeq = [[Xp;Xk1;Yk2],eye(5,I+1),zeros(5,R+1),zeros(5,1);[-Yk1;-
Xk2],zeros(2,I+1),eye(2,R+1),[Yk1j;Xk2j];ones(1,J),zeros(1,I+1),zeros(1,R+1),0];
            beq = [Xpj;Xk1j;Yk2j;zeros(2,1);1];
            [x,fval,exitflag,output,lambda] =
linprog(f,[],[],Aeq,beq,lb,ub,[],optimset('LargeScale','Off','Simplex','On','Dis
play','Final'));
            Z(j,:) = x;      % Accumulates x For Each DMU In Matrix Z
            A = -1/(x'*f');
            if A < 0
                A = 1;
            end
            effx(j,:) = A;      % Accumulates Efficiency Rating For Each DMU
        end
    end

end

% ============================================
% Extracts The Efficiency Rating For Each DMU
% ============================================

EfficiencyRatings = effx(1:J,1);

% --------------------
% Displays The Results
% --------------------

if (model == 1);
    fprintf('\n=====================================\n');
    fprintf('\nSORMSBM DEA Model (CRS) -- Non-Oriented\n');
```

```
    fprintf('\n=======================================\n\n');
    LabelC = 'SORMSBM(CRS)-NO';
elseif (model == 2);
    fprintf('\n=========================================\n');
    fprintf('\nSORMSBM DEA Model (CRS) -- Input-Oriented\n');
    fprintf('\n=========================================\n\n');
    LabelC = 'SORMSBM(CRS)-IO';
elseif (model == 3);
    fprintf('\n==========================================\n');
    fprintf('\nSORMSBM DEA Model (CRS) -- Output-Oriented\n');
    fprintf('\n==========================================\n\n');
    LabelC = 'SORMSBM(CRS)-OO';
elseif (model == 4);
    fprintf('\n=======================================\n');
    fprintf('\nSORMSBM DEA Model (VRS) -- Non-Oriented\n');
    fprintf('\n=======================================\n\n');
    LabelC = 'SORMSBM(VRS)-NO';
elseif (model == 5);
    fprintf('\n=========================================\n');
    fprintf('\nSORMSBM DEA Model (VRS) -- Input-Oriented\n');
    fprintf('\n=========================================\n\n');
    LabelC = 'SORMSBM(VRS)-IO';
elseif (model == 6);
    fprintf('\n==========================================\n');
    fprintf('\nSORMSBM DEA Model (VRS) -- Output-Oriented\n');
    fprintf('\n==========================================\n\n');
    LabelC = 'SORMSBM(VRS)-OO';
end

if (data == 1);
    fprintf('-------------------------\n')
    fprintf('UK Large-Cap Value Equity\n')
    fprintf('-------------------------\n\n')
    LabelB = 'UK Large-Cap Value Equity: ';
elseif (data == 2);
    fprintf('--------------------------\n')
    fprintf('UK Large-Cap Growth Equity\n')
    fprintf('--------------------------\n\n')
    LabelB = 'UK Large-Cap Growth Equity: ';
elseif (data == 3);
    fprintf('-------------------------\n')
    fprintf('UK Large-Cap Blend Equity\n')
    fprintf('-------------------------\n\n')
    LabelB = 'UK Large-Cap Blend Equity: ';
elseif (data == 4);
    fprintf('-----------------\n')
    fprintf('UK Mid-Cap Equity\n')
    fprintf('-----------------\n\n')
    LabelB = 'UK Mid-Cap Equity: ';
elseif (data == 5);
    fprintf('-------------------\n')
    fprintf('UK Small-Cap Equity\n')
    fprintf('-------------------\n\n')
    LabelB = 'UK Small-Cap Equity: ';
elseif (data == 6);
    fprintf('------------------------------------\n')
    fprintf('US Large-Cap Value And Growth Equity\n')
    fprintf('------------------------------------\n\n')
    LabelB = 'US Large-Cap Value And Growth Equity: ';
elseif (data == 7);
    fprintf('-------------------------\n')
    fprintf('US Large-Cap Blend Equity\n')
    fprintf('-------------------------\n\n')
    LabelB = 'US Large-Cap Blend Equity: ';
```

```
elseif (data == 8);
    fprintf('-------------------------------\n')
    fprintf('US Mid-Cap And Small-Cap Equity\n')
    fprintf('-------------------------------\n\n')
    LabelB = 'US Mid-Cap And Small-Cap Equity: ';
elseif (data == 9);
    fprintf('-----------------------------\n')
    fprintf('Global Large-Cap Value Equity\n')
    fprintf('-----------------------------\n\n')
    LabelB = 'Global Large-Cap Value Equity: ';
elseif (data == 10);
    fprintf('------------------------------\n')
    fprintf('Global Large-Cap Growth Equity\n')
    fprintf('------------------------------\n\n')
    LabelB = 'Global Large-Cap Growth Equity: ';
elseif (data == 11);
    fprintf('-----------------------------\n')
    fprintf('Global Large-Cap Blend Equity\n')
    fprintf('-----------------------------\n\n')
    LabelB = 'Global Large-Cap Blend Equity: ';
elseif (data == 12);
    fprintf('-----------------------------------\n')
    fprintf('Global Mid-Cap And Small-Cap Equity\n')
    fprintf('-----------------------------------\n\n')
    LabelB = 'Global Mid-Cap And Small-Cap Equity: ';
elseif (data == 13);
    fprintf('-------------------------------\n')
    fprintf('(3rd) UK Large-Cap Value Equity\n')
    fprintf('-------------------------------\n\n')
    LabelB = 'UK Large-Cap Value Equity: 3rd ';
elseif (data == 14);
    fprintf('--------------------------------\n')
    fprintf('(3rd) UK Large-Cap Growth Equity\n')
    fprintf('--------------------------------\n\n')
    LabelB = 'UK Large-Cap Growth Equity: 3rd ';
elseif (data == 15);
    fprintf('-------------------------------\n')
    fprintf('(3rd) UK Large-Cap Blend Equity\n')
    fprintf('-------------------------------\n\n')
    LabelB = 'UK Large-Cap Blend Equity: 3rd ';
elseif (data == 16);
    fprintf('-----------------------\n')
    fprintf('(3rd) UK Mid-Cap Equity\n')
    fprintf('-----------------------\n\n')
    LabelB = 'UK Mid-Cap Equity: 3rd ';
elseif (data == 17);
    fprintf('-------------------------\n')
    fprintf('(3rd) UK Small-Cap Equity\n')
    fprintf('-------------------------\n\n')
    LabelB = 'UK Small-Cap Equity: 3rd ';
elseif (data == 18);
    fprintf('------------------------------------------\n')
    fprintf('(3rd) US Large-Cap Value And Growth Equity\n')
    fprintf('------------------------------------------\n\n')
    LabelB = 'US Large-Cap Value And Growth Equity: 3rd ';
elseif (data == 19);
    fprintf('-------------------------------\n')
    fprintf('(3rd) US Large-Cap Blend Equity\n')
    fprintf('-------------------------------\n\n')
    LabelB = 'US Large-Cap Blend Equity: 3rd ';
elseif (data == 20);
    fprintf('-------------------------------------\n')
    fprintf('(3rd) US Mid-Cap And Small-Cap Equity\n')
    fprintf('-------------------------------------\n\n')
```

```
    LabelB = 'US Mid-Cap And Small-Cap Equity: 3rd ';
elseif (data == 21);
    fprintf('-----------------------------------\n')
    fprintf('(3rd) Global Large-Cap Value Equity\n')
    fprintf('-----------------------------------\n\n')
    LabelB = 'Global Large-Cap Value Equity: 3rd ';
elseif (data == 22);
    fprintf('------------------------------------\n')
    fprintf('(3rd) Global Large-Cap Growth Equity\n')
    fprintf('------------------------------------\n\n')
    LabelB = 'Global Large-Cap Growth Equity: 3rd ';
elseif (data == 23);
    fprintf('-----------------------------------\n')
    fprintf('(3rd) Global Large-Cap Blend Equity\n')
    fprintf('-----------------------------------\n\n')
    LabelB = 'Global Large-Cap Blend Equity: 3rd ';
elseif (data == 24);
    fprintf('-----------------------------------------\n')
    fprintf('(3rd) Global Mid-Cap And Small-Cap Equity\n')
    fprintf('-----------------------------------------\n\n')
    LabelB = 'Global Mid-Cap And Small-Cap Equity: 3rd ';
end

for j=1:J
    fprintf('Efficiency Rating DMU %d --> %.3f\n', j, EfficiencyRatings(j));
end

% =======================================================================
% Calculates And Displays - Mean Efficiency Rating And Standard Deviation
% Of Efficiency Ratings
% =======================================================================

fprintf('\n==================================================\n\n');

Mean = mean(EfficiencyRatings);

fprintf('Mean Efficiency Rating ==> %.3f\n\n', Mean);

SD = std(EfficiencyRatings);

fprintf('Standard Deviation Of Efficiency Ratings ==> %.3f\n\n', SD);

fprintf('==================================================\n\n');

% =======================================================================
% Calculates And Displays - Maximum Efficiency Rating, Minimum Efficiency
% Rating, Outperformance Of The Benchmark And Underperformance Of The
% Benchmark
% =======================================================================

EfficiencyRatingsX = ((round(EfficiencyRatings*1000))/1000);

EfficiencyRatingsX2 = EfficiencyRatingsX(1:J-1,1);
MM = quantile(EfficiencyRatingsX2,[0,1]);
MaxRat = MM(1,2);
MinRat = MM(1,1);

MaxRN = find(EfficiencyRatingsX2 == MaxRat);
MinRN = find(EfficiencyRatingsX2 == MinRat);
[MaN,Wa] = size(MaxRN);
[MiN,Wi] = size(MinRN);
```

```
fprintf('------------------------------------------------------------------
\n\n');
fprintf('Maximum Efficiency Rating ==> %.3f\n', MaxRat);
fprintf('Number Of OEICs/UTs At Maximum Efficiency Rating ==> %.0f\n\n', MaN);
fprintf('Minimum Efficiency Rating ==> %.3f\n', MinRat);
fprintf('Number Of OEICs/UTs At Minimum Efficiency Rating ==> %.0f\n\n', MiN);

ETF = EfficiencyRatingsX(J,1);

OP = (EfficiencyRatingsX(1:J-1,1) > ETF);
OPX = tabulate(OP);
UP = (EfficiencyRatingsX(1:J-1,1) < ETF);
UPX = tabulate(UP);

Ov = (J-1)-(cell2mat(OPX(1,2)));
OvP = (Ov/(J-1))*100;
Un = cell2mat(UPX(2,2));
UnP = cell2mat(UPX(2,3));

fprintf('Number Of OEICs/UTs Outperforming The Benchmark ETF ==> %.0f\n', Ov);
fprintf('Percentage Of OEICs/UTs Outperforming The Benchmark ETF ==>
%.2f%%\n\n', OvP);
fprintf('Number Of OEICs/UTs Underperforming The Benchmark ETF ==> %.0f\n', Un);
fprintf('Percentage Of OEICs/UTs Underperforming The Benchmark ETF ==>
%.2f%%\n\n', UnP);
fprintf('------------------------------------------------------------------
\n\n');

fprintf('\n*******************************************************************\
n');
fprintf('******************* Coded By T. J. Burrows © 2013
******************\n');
fprintf('********************** Loughborough University
*********************\n');
fprintf('******************************************************************\n\
n');

LabelA = 'Kernel Density Estimation: ';
LabelM = [LabelA LabelB LabelC];

% ----------------------------------------
% Kernel Smoothing Density Estimate (KSDE)
% ----------------------------------------

[b,xi] = ksdensity(EfficiencyRatings);
plot(xi,b,'m');

title(LabelM,'FontName','Times New Roman','FontWeight','Bold');
xlabel('Efficiency Rating','FontName','Times New Roman');
ylabel('Density','FontName','Times New Roman');
grid on;
```

# Results Appendix 1 – CCR & SORMCCR DEA Models

## UK Domiciled OEICs And UTs With A UK Investment Focus

***Table RA1.1:*** *UK Large-Cap Value Equity (1st January 2008 – 31st December 2010)*

CCR-IO → CCR DEA Model Input-Oriented

CCR-OO → CCR DEA Model Output-Oriented

SORMCCR-IO → SORMCCR DEA Model Input-Oriented

SORMCCR-OO → SORMCCR DEA Model Output-Oriented

| Name Of OEIC/UT | CCR-IO | CCR-OO | SORMCCR-IO | SORMCCR-OO |
|---|---|---|---|---|
| Aberdeen Charity Select UK Equity Fund | 0.762 | 0.762 | 0.763 | 0.763 |
| Aberdeen Multi-Manager UK Income Portfolio | 0.791 | 0.791 | 0.791 | 0.791 |
| Aberdeen Responsible UK Equity Fund | 0.684 | 0.684 | 0.684 | 0.684 |
| Aberdeen UK Equity Fund | 0.607 | 0.607 | 0.607 | 0.607 |
| Aberdeen UK Equity Income Fund | 0.569 | 0.569 | 0.570 | 0.570 |
| Artemis Income Fund | 0.665 | 0.664 | 0.665 | 0.664 |
| Cazenove UK Growth & Income Fund | 0.714 | 0.714 | 0.714 | 0.714 |
| Capita Financial Taylor Young Equity Income Fund | 0.668 | 0.668 | 0.668 | 0.668 |
| Capita Financial Walker Crips UK Growth Fund | 0.805 | 0.805 | 0.805 | 0.805 |
| Dimensional UK Core Equity Fund | 0.733 | 0.733 | 0.733 | 0.733 |
| Dimensional UK Value Fund | 0.000 | 0.000 | 0.704 | 0.704 |
| Elite Henderson Rowe Dogs FTSE 100 Fund | 0.000 | 0.000 | 1.000 | 1.000 |
| F&C UK Equity Income Fund | 0.593 | 0.593 | 0.593 | 0.593 |
| F&C UK Growth & Income Fund | 0.564 | 0.564 | 0.565 | 0.565 |
| Family Asset Trust | 0.000 | 0.000 | 0.393 | 0.393 |
| Fidelity Special Situations Fund | 0.753 | 0.752 | 0.753 | 0.752 |
| Gartmore UK Alpha Fund | 0.000 | 0.000 | 0.757 | 0.757 |
| Gartmore UK Equity Income Fund | 0.496 | 0.496 | 0.497 | 0.497 |
| Gartmore UK Growth Fund | 0.000 | 0.000 | 0.421 | 0.421 |
| GLG UK Growth Fund | 0.000 | 0.000 | 0.369 | 0.369 |
| GLG UK Income Fund | 0.327 | 0.327 | 0.329 | 0.329 |
| HL Multi-Manager Income & Growth Portfolio Trust | 0.770 | 0.770 | 0.770 | 0.770 |
| HSBC Income Fund | 0.612 | 0.612 | 0.612 | 0.612 |
| Ignis UK Equity Income Fund | 0.612 | 0.612 | 0.612 | 0.612 |
| Insight Investment Equity High Income Fund | 0.626 | 0.626 | 0.627 | 0.627 |
| Investec UK Special Situations Fund | 0.956 | 0.956 | 0.956 | 0.956 |
| Invesco Perpetual Children’s Fund | 0.520 | 0.520 | 0.521 | 0.521 |

| | | | | |
|---|---|---|---|---|
| Invesco Perpetual High Income Fund | 0.661 | 0.660 | 0.663 | 0.662 |
| Invesco Perpetual Income & Growth Fund | 0.298 | 0.298 | 0.299 | 0.299 |
| Invesco Perpetual Income Fund | 0.674 | 0.673 | 0.677 | 0.677 |
| Invesco Perpetual UK Aggressive Fund | 0.499 | 0.499 | 0.501 | 0.501 |
| Invesco Perpetual UK Enhanced Index Fund | 0.746 | 0.746 | 0.747 | 0.747 |
| Invesco Perpetual UK Growth Fund | 0.000 | 0.000 | 0.408 | 0.407 |
| JoHambro Capital Management UK Equity Income Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| J. P. Morgan Premier Equity Income Fund | 0.544 | 0.544 | 0.544 | 0.544 |
| J. P. Morgan UK Managed Equity Fund | 0.509 | 0.509 | 0.510 | 0.510 |
| J. P. Morgan UK Strategic Equity Income Fund | 0.528 | 0.528 | 0.530 | 0.530 |
| Jupiter Undervalued Assets Fund | 0.000 | 0.000 | 0.460 | 0.460 |
| L&G (Barclays) MM UK Equity Income Fund | 0.758 | 0.758 | 0.758 | 0.758 |
| Lazard UK Income Fund | 0.598 | 0.598 | 0.602 | 0.602 |
| Legg Mason UK Equity Fund | 0.570 | 0.570 | 0.570 | 0.570 |
| M&G Charifund | 0.000 | 0.000 | 0.294 | 0.294 |
| M&G Dividend Fund | 0.650 | 0.650 | 0.650 | 0.650 |
| M&G Income Fund | 0.754 | 0.754 | 0.754 | 0.754 |
| Neptune Income Fund | 0.750 | 0.750 | 0.750 | 0.750 |
| Neptune Quarterly Income Fund | 0.612 | 0.612 | 0.612 | 0.612 |
| Neptune UK Equity Fund | 0.796 | 0.796 | 0.796 | 0.796 |
| Neptune UK Special Situations Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Old Mutual Equity Income Fund | 0.713 | 0.713 | 0.713 | 0.713 |
| Old Mutual Extra Income Fund | 0.782 | 0.782 | 0.782 | 0.782 |
| Premier UK Strategic Growth Fund | 0.627 | 0.627 | 0.627 | 0.627 |
| Prudential Ethical Trust Fund | 0.000 | 0.000 | 0.474 | 0.474 |
| PSigma Income Fund | 0.011 | 0.011 | 0.011 | 0.011 |
| PSigma UK Growth Fund | 0.036 | 0.036 | 0.036 | 0.036 |
| Rathbone Blue Chip Income & Growth Fund | 0.700 | 0.700 | 0.700 | 0.700 |
| Rathbone Income Fund | 0.004 | 0.004 | 0.004 | 0.004 |
| River & Mercantile UK Equity High Alpha Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| S&W Church House Balanced Value & Income Fund | 0.787 | 0.787 | 0.787 | 0.787 |
| S&W Church House UK Managed Growth Fund | 0.782 | 0.782 | 0.782 | 0.782 |
| S&W FTIM Munro Fund | 0.314 | 0.314 | 0.314 | 0.314 |
| Schroder Charity Equity Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Schroder Income Fund | 0.863 | 0.863 | 0.863 | 0.863 |
| Schroder Income Maximiser Fund | 0.831 | 0.831 | 0.831 | 0.831 |
| Schroder Recovery Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Schroder Specialist Value UK Equity Fund | 0.942 | 0.942 | 0.942 | 0.942 |
| Scottish Widows Ethical Fund | 0.000 | 0.000 | 1.000 | 1.000 |
| Scottish Widows UK Equity Income Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Scottish Widows UK Growth Fund | 0.754 | 0.754 | 0.754 | 0.754 |
| Skandia Multi-Manager UK Equity Fund | 0.625 | 0.625 | 0.626 | 0.626 |

| | | | | |
|---|---|---|---|---|
| St James's Place Equity Income Fund | 0.809 | 0.809 | 0.809 | 0.809 |
| St James's Place UK Growth Fund | 0.907 | 0.907 | 0.907 | 0.907 |
| St James's Place UK High Income Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Standard Life UK Equity High Income Fund | 0.349 | 0.349 | 0.349 | 0.349 |
| Standard Life UK Equity Manager Of Managers Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| SWIP Multi-Manager UK Equity Income Fund | 0.925 | 0.925 | 0.927 | 0.927 |
| SWIP UK Income Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| TB Wise Income Fund | 0.895 | 0.895 | 0.895 | 0.895 |
| Templeton UK Equity Fund | 0.000 | 0.000 | 0.266 | 0.266 |
| Troy Trojan Income Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| UBS UK Select Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| **iShares FTSE 100** | **0.913** | **0.912** | **0.913** | **0.912** |

***Table RA1.2:* UK Large-Cap Growth Equity (1st January 2008 – 31st December 2010)**

CCR-IO → CCR DEA Model Input-Oriented

CCR-OO → CCR DEA Model Output-Oriented

SORMCCR-IO → SORMCCR DEA Model Input-Oriented

SORMCCR-OO → SORMCCR DEA Model Output-Oriented

| Name Of OEIC/UT | CCR-IO | CCR-OO | SORMCCR-IO | SORMCCR-OO |
|---|---|---|---|---|
| AEGON UK Opportunities Fund | 0.932 | 0.932 | 0.932 | 0.932 |
| BlackRock UK Fund | 0.919 | 0.919 | 0.919 | 0.919 |
| BlackRock UK Dynamic Fund | 0.997 | 0.997 | 0.997 | 0.997 |
| FF&P Concentrated UK Equity Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Fidelity UK Growth Fund | 0.901 | 0.901 | 0.901 | 0.901 |
| L&G (N) UK Growth Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Mirabaud Mir GB Fund | 0.686 | 0.686 | 0.686 | 0.686 |
| Royal London UK Opportunities Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| SVM UK Growth Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| **iShares FTSE 100** | **1.000** | **1.000** | **1.000** | **1.000** |

***Table RA1.3:* UK Large-Cap Blend Equity (1st January 2008 – 31st December 2010)**

CCR-IO → CCR DEA Model Input-Oriented

CCR-OO → CCR DEA Model Output-Oriented

SORMCCR-IO → SORMCCR DEA Model Input-Oriented

SORMCCR-OO → SORMCCR DEA Model Output-Oriented

| Name Of OEIC/UT | CCR-IO | CCR-OO | SORMCCR-IO | SORMCCR-OO |
|---|---|---|---|---|
| Aberdeen Multi-Manager UK Growth Portfolio | 0.935 | 0.935 | 0.935 | 0.935 |
| AEGON UK Equity Fund | 0.775 | 0.775 | 0.775 | 0.775 |
| Allianz RCM UK Equity Fund | 0.726 | 0.726 | 0.774 | 0.774 |
| Allianz RCM UK Growth Fund | 0.541 | 0.541 | 0.544 | 0.544 |
| Allianz RCM UK Index Fund | 0.884 | 0.884 | 0.884 | 0.884 |
| Allianz RCM UK Unconstrained Fund | 0.000 | 0.000 | 0.600 | 0.600 |
| Architas Multi-Manager UK Equity Portfolio | 0.798 | 0.798 | 0.854 | 0.854 |
| Artemis Capital Fund | 0.200 | 0.200 | 0.209 | 0.209 |
| Artemis UK Growth Fund | 0.777 | 0.777 | 0.784 | 0.784 |
| Aviva Investors UK Equity Fund | 0.863 | 0.863 | 0.863 | 0.863 |
| Aviva Investors UK Focus Fund | 0.865 | 0.865 | 0.868 | 0.868 |
| Aviva Investors UK Growth Fund | 0.840 | 0.840 | 0.840 | 0.840 |
| AXA Framlington UK Growth Fund | 0.882 | 0.882 | 0.887 | 0.887 |
| AXA General Trust | 0.766 | 0.766 | 0.772 | 0.772 |
| Baillie Gifford British 350 Fund | 0.920 | 0.920 | 0.920 | 0.920 |
| Baillie Gifford UK Equity Alpha Fund | 0.896 | 0.896 | 0.901 | 0.901 |
| Bank Of Scotland FTSE 100 Tracker Fund | 0.863 | 0.863 | 0.863 | 0.863 |
| BlackRock Armed Forces Common Investment Fund | 0.763 | 0.763 | 0.767 | 0.767 |
| BlackRock Charishare Fund | 0.717 | 0.717 | 0.723 | 0.723 |
| BlackRock UK Equity Fund | 0.845 | 0.845 | 0.845 | 0.845 |
| BlackRock UK Income Fund | 0.931 | 0.931 | 0.931 | 0.931 |
| Cazenove Multi-Manager UK Growth Fund | 0.808 | 0.808 | 0.828 | 0.828 |
| Cazenove UK Opportunities Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| CF Canada Life General Trust | 0.499 | 0.499 | 0.509 | 0.509 |
| CF Canada Life Growth Fund | 0.755 | 0.755 | 0.781 | 0.781 |
| CF GHC Multi-Manager UK Equity OEIC | 0.838 | 0.838 | 0.838 | 0.838 |
| CF JM Finn UK Portfolio Fund | 0.709 | 0.709 | 0.709 | 0.709 |
| CF Lindsell Train UK Equity Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| CF Taylor Young Growth & Income Fund | 0.877 | 0.877 | 0.877 | 0.877 |
| CF Walker Crips UK High Alpha Fund | 0.937 | 0.937 | 0.937 | 0.937 |
| Chariguard UK Equity Fund | 0.705 | 0.705 | 0.708 | 0.708 |

| | | | | |
|---|---|---|---|---|
| CIS UK FTSE4Good Tracker Trust | 0.796 | 0.796 | 0.796 | 0.796 |
| EFA OPM UK Equity Fund | 0.000 | 0.000 | 1.000 | 1.000 |
| Engage Investment Growth Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Epworth Affirmative Equity Fund | 0.543 | 0.543 | 0.543 | 0.543 |
| F&C FTSE All-Share Tracker Fund | 0.860 | 0.860 | 0.860 | 0.860 |
| F&C UK Equity Fund | 0.884 | 0.884 | 0.884 | 0.884 |
| Family Charities Ethical Trust | 0.000 | 0.000 | 1.000 | 1.000 |
| Fidelity MoneyBuilder UK Index Fund | 0.891 | 0.891 | 0.891 | 0.891 |
| Fidelity UK Aggressive Fund | 0.797 | 0.797 | 0.797 | 0.797 |
| GAM MP UK Equity Unit Trust | 0.939 | 0.939 | 0.939 | 0.939 |
| Gartmore UK Index Fund | 0.801 | 0.801 | 0.801 | 0.801 |
| Gartmore UK Tracker Fund | 0.761 | 0.761 | 0.772 | 0.772 |
| HBOS UK FTSE 100 Index Track Fund | 0.702 | 0.702 | 0.714 | 0.714 |
| Henderson UK Equity Tracker Trust | 0.612 | 0.612 | 0.622 | 0.622 |
| Henderson UK High Alpha Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| HSBC FTSE 100 Index Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| HSBC FTSE All Share Index Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| HSBC MERIT UK Equity Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| HSBC UK Focus Fund | 0.861 | 0.861 | 0.861 | 0.861 |
| HSBC UK Freestyle Fund | 0.622 | 0.622 | 1.000 | 1.000 |
| HSBC UK Growth & Income Fund | 0.870 | 0.870 | 0.882 | 0.882 |
| IFDS Brown Shipley UK Flagship Fund | 0.874 | 0.874 | 0.874 | 0.874 |
| Ignis Balanced Growth Fund | 0.451 | 0.451 | 0.471 | 0.471 |
| Ignis Cartesian UK Opportunities Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Ignis UK Focus Fund | 0.707 | 0.707 | 0.718 | 0.718 |
| Insight Investment UK Dynamic Managed Fund | 0.812 | 0.812 | 0.812 | 0.812 |
| Investec UK Alpha Fund | 0.806 | 0.806 | 0.806 | 0.806 |
| Investec UK Blue Chip Fund | 0.769 | 0.769 | 0.775 | 0.775 |
| Invesco Perpetual UK Strategic Income Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Jessop Gartmore UK Index Fund | 0.865 | 0.865 | 0.865 | 0.865 |
| JoHambro Capital Management UK Opportunities Fund | 0.772 | 0.772 | 0.774 | 0.773 |
| J. P. Morgan Premier Equity Growth Fund | 0.335 | 0.335 | 0.350 | 0.350 |
| J. P. Morgan UK Active Index Plus Fund | 0.835 | 0.835 | 0.835 | 0.835 |
| J. P. Morgan UK Dynamic Fund | 0.713 | 0.713 | 0.725 | 0.725 |
| J. P. Morgan UK Focus Fund | 0.818 | 0.818 | 0.818 | 0.818 |
| Jupiter UK Alpha Fund | 0.906 | 0.906 | 0.906 | 0.906 |
| L&G (Barclays) Market Track 350 Trust | 0.776 | 0.776 | 0.776 | 0.776 |
| L&G (Barclays) Multi-Manager UK Alpha Fund | 0.663 | 0.663 | 0.681 | 0.681 |
| L&G (Barclays) Multi-Manager UK Alpha (Series 2) Fund | 0.616 | 0.616 | 0.636 | 0.636 |
| L&G (Barclays) Multi-Manager UK Core Fund | 0.838 | 0.838 | 0.857 | 0.857 |
| L&G (Barclays) Multi-Manager UK Opportunities Fund | 0.884 | 0.884 | 0.884 | 0.884 |
| L&G Capital Growth Fund | 0.751 | 0.751 | 0.762 | 0.762 |
| L&G (N) UK Tracker Trust | 0.775 | 0.775 | 0.785 | 0.785 |
| L&G CAF UK Equitrack Fund | 1.000 | 1.000 | 1.000 | 1.000 |

| | | | | |
|---|---|---|---|---|
| L&G Equity Trust | 0.496 | 0.496 | 0.501 | 0.501 |
| L&G Ethical Trust | 0.602 | 0.602 | 0.611 | 0.611 |
| L&G Growth Trust | 0.734 | 0.734 | 0.734 | 0.734 |
| L&G UK 100 Index Trust | 0.750 | 0.750 | 0.754 | 0.754 |
| L&G UK Active Opportunities Trust | 0.653 | 0.653 | 0.670 | 0.670 |
| L&G UK Index Trust | 0.825 | 0.825 | 0.825 | 0.825 |
| Lazard UK Alpha Fund | 0.817 | 1.099 | 0.818 | 0.818 |
| Lazard UK Omega Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| LV UK Growth Fund | 0.656 | 0.656 | 0.656 | 0.656 |
| M&G Index Tracker Fund | 0.783 | 0.783 | 0.783 | 0.783 |
| M&G Recovery Fund | 0.865 | 0.864 | 0.865 | 0.864 |
| M&G UK Growth Fund | 0.741 | 0.741 | 0.743 | 0.743 |
| M&G UK Select Fund | 0.833 | 0.833 | 0.833 | 0.833 |
| Majedie AM UK Equity Fund | 0.880 | 0.880 | 0.880 | 0.880 |
| Majedie AM UK Focus Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| M&S Ethical Fund | 0.978 | 0.978 | 1.000 | 1.000 |
| M&S UK 100 Companies Fund | 0.819 | 0.819 | 0.830 | 0.830 |
| M&S UK Selection Portfolio | 0.630 | 0.630 | 0.651 | 0.651 |
| Morgan Stanley UK Equity Alpha Fund | 0.992 | 0.992 | 1.000 | 1.000 |
| Old Mutual UK Select Equity Fund | 0.787 | 0.787 | 0.787 | 0.787 |
| Premier Castlefield UK Alpha Fund | 0.000 | 0.000 | 1.000 | 1.000 |
| Premier Castlefield UK Equity Fund | 0.886 | 0.886 | 0.893 | 0.893 |
| Prudential UK Growth Trust | 0.835 | 0.835 | 0.835 | 0.835 |
| Prudential UK Index Tracker Trust | 1.000 | 1.000 | 1.000 | 1.000 |
| RBS FTSE 100 Tracker Fund | 0.757 | 0.757 | 0.757 | 0.757 |
| Royal London FTSE 350 Tracker Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Royal London UK Equity Fund | 0.821 | 0.821 | 0.821 | 0.821 |
| Santander Premium Fund UK Equity | 0.802 | 0.801 | 0.810 | 0.810 |
| Santander Stockmarket 100 Tracker Trust | 0.877 | 0.877 | 0.877 | 0.877 |
| Santander UK Growth Trust | 0.790 | 0.790 | 0.796 | 0.796 |
| Schroder Specialist UK Equity Fund | 0.985 | 0.985 | 0.985 | 0.985 |
| Schroder Prime UK Equity Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Schroder UK Alpha Plus Fund | 0.846 | 0.846 | 0.851 | 0.851 |
| Schroder UK Equity Fund | 0.829 | 0.829 | 0.834 | 0.834 |
| Scottish Friendly UK Growth Fund | 0.830 | 0.830 | 0.830 | 0.830 |
| Scottish Mutual UK All-Share Index Trust | 1.000 | 1.000 | 1.000 | 1.000 |
| Scottish Mutual UK Equity Trust | 0.659 | 0.659 | 0.661 | 0.661 |
| Scottish Widows UK All-Share Tracker Fund | 0.790 | 0.789 | 0.790 | 0.789 |
| Scottish Widows UK Select Growth Fund | 0.862 | 0.862 | 0.867 | 0.867 |
| Scottish Widows UK Tracker Fund | 0.741 | 0.741 | 0.741 | 0.741 |
| Skandia Multi-Manager UK Index Fund | 0.831 | 0.831 | 0.831 | 0.831 |
| Skandia Multi-Manager UK Opportunities Fund | 0.000 | 0.000 | 1.000 | 1.000 |
| Standard Life TM UK General Equity Fund | 0.649 | 0.649 | 0.651 | 0.651 |
| SSGA UK Equity Enhanced Fund | 0.871 | 0.871 | 0.879 | 0.879 |
| SSGA UK Equity Tracker Fund | 0.846 | 0.846 | 0.853 | 0.853 |

| | | | | |
|---|---|---|---|---|
| St James's Place UK & General Progressive Fund | 0.000 | 0.000 | 0.463 | 0.463 |
| Standard Life UK Equity Growth Fund | 0.687 | 0.687 | 0.704 | 0.704 |
| SWIP Multi-Manager UK Equity Focus Fund | 0.454 | 0.454 | 0.475 | 0.475 |
| SWIP Multi-Manager UK Equity Growth Fund | 0.627 | 0.627 | 0.638 | 0.638 |
| SWIP UK Opportunities Fund | 0.887 | 0.887 | 0.887 | 0.887 |
| Threadneedle Navigator UK Index Tracker Fund | 0.768 | 0.768 | 0.768 | 0.768 |
| Threadneedle UK Extended Alpha Fund | 0.614 | 0.614 | 0.690 | 0.690 |
| Troy Trojan Capital Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| UBS UK Equity Income Find | 0.000 | 0.000 | 1.000 | 1.000 |
| Wesleyan Growth Trust | 0.737 | 0.737 | 0.737 | 0.737 |
| **iShares FTSE 100** | **0.672** | **0.671** | **0.672** | **0.671** |

***Table RA1.4:* UK Mid-Cap Equity (1st January 2008 – 31st December 2010)**

CCR-IO → CCR DEA Model Input-Oriented

CCR-OO → CCR DEA Model Output-Oriented

SORMCCR-IO → SORMCCR DEA Model Input-Oriented

SORMCCR-OO → SORMCCR DEA Model Output-Oriented

| Name Of OEIC/UT | CCR-IO | CCR-OO | SORMCCR-IO | SORMCCR-OO |
|---|---|---|---|---|
| Aberdeen UK Mid-Cap Fund | 0.854 | 0.854 | 0.895 | 0.895 |
| AEGON Ethical Equity Fund | 0.608 | 0.608 | 0.644 | 0.644 |
| Allianz RCM UK Mid-Cap Fund | 0.777 | 0.777 | 0.804 | 0.804 |
| Artemis UK Special Situations Fund | 0.726 | 0.726 | 0.733 | 0.733 |
| Aviva Investors SF UK Growth Fund | 0.696 | 0.696 | 0.951 | 0.951 |
| Aviva Investors UK Ethical Fund | 0.903 | 0.903 | 1.000 | 1.000 |
| Aviva Investors UK Special Situations Fund | 0.668 | 0.668 | 0.702 | 0.702 |
| AXA Framlington Equity Income Fund | 0.000 | 0.000 | 0.459 | 0.459 |
| AXA Framlington Monthly Income Fund | 0.000 | 0.000 | 0.883 | 0.883 |
| AXA Framlington UK Select Opportunities Fund | 0.755 | 0.755 | 0.755 | 0.755 |
| BlackRock UK Special Situations Fund | 0.862 | 0.862 | 0.862 | 0.862 |
| Cazenove UK Dynamic Fund | 0.917 | 0.917 | 0.942 | 0.942 |
| CF Cornelian British Opportunities Fund | 0.712 | 0.712 | 0.964 | 0.964 |

| | | | | |
|---|---|---|---|---|
| CF OLIM UK Equity Trust | 0.700 | 0.700 | 0.739 | 0.739 |
| CF Taylor Young Growth Fund | 0.534 | 0.534 | 0.598 | 0.598 |
| CF Taylor Young Opportunistic Fund | 0.664 | 0.664 | 0.857 | 0.857 |
| Ecclesiastical Amity UK Fund | 0.802 | 0.802 | 0.851 | 0.851 |
| F&C Stewardship Growth Fund | 0.555 | 0.555 | 1.000 | 1.000 |
| F&C Stewardship Income Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| F&C UK Mid-Cap Fund | 0.925 | 0.925 | 0.925 | 0.925 |
| F&C UK Opportunities Fund | 0.347 | 0.347 | 0.744 | 0.744 |
| GAM UK Diversified Fund | 0.892 | 0.892 | 0.930 | 0.930 |
| Henderson UK Alpha Fund | 0.503 | 0.503 | 0.552 | 0.552 |
| HSBC FTSE 250 Index Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| L&G (Barclays) Multi-Manager UK Lower-Cap Fund | 0.804 | 0.804 | 0.811 | 0.811 |
| Majedie UK Opportunities Fund | 0.472 | 0.472 | 0.505 | 0.505 |
| Marlborough Ethical Fund | 0.828 | 0.828 | 0.878 | 0.878 |
| Marlborough UK Primary Opportunities Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Melchior UK Opportunities Fund | 0.000 | 0.000 | 1.000 | 1.000 |
| MFM Bowland Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| MFM Slater Recovery Fund | 0.969 | 0.969 | 0.969 | 0.969 |
| Old Mutual UK Select Mid-Cap Fund | 0.754 | 0.754 | 0.761 | 0.761 |
| Rathbone Recovery Fund | 0.000 | 0.000 | 1.000 | 1.000 |
| Real Life Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Rensburg UK Managers' Focus Trust | 0.756 | 0.756 | 0.758 | 0.758 |
| Royal London UK Mid-Cap Growth Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Saracen Growth Fund | 0.000 | 0.000 | 0.472 | 0.472 |
| Schroder UK Mid 250 Fund | 0.412 | 0.412 | 0.457 | 0.457 |
| Skandia UK Best Ideas Fund | 0.000 | 0.000 | 0.374 | 0.374 |
| Standard Life UK Equity High Alpha Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Standard Life UK Equity Income Unconstrained Fund | 0.488 | 0.488 | 0.568 | 0.568 |
| Standard Life UK Equity Unconstrained Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Standard Life UK Ethical Fund | 0.609 | 0.609 | 0.676 | 0.676 |
| SVM UK Opportunities Fund | 0.845 | 0.845 | 0.866 | 0.866 |
| Threadneedle UK Mid 250 Fund | 0.825 | 0.825 | 0.830 | 0.830 |
| **iShares FTSE 250** | **1.000** | **1.000** | **1.000** | **1.000** |

***Table RA1.5:* UK Small-Cap Equity (1st January 2008 – 31st December 2010)**

CCR-IO → CCR DEA Model Input-Oriented

CCR-OO → CCR DEA Model Output-Oriented

SORMCCR-IO → SORMCCR DEA Model Input-Oriented

SORMCCR-OO → SORMCCR DEA Model Output-Oriented

| Name Of OEIC/UT | CCR-IO | CCR-OO | SORMCCR-IO | SORMCCR-OO |
|---|---|---|---|---|
| Aberdeen UK Smaller Companies Fund | 0.644 | 0.644 | 0.656 | 0.656 |
| Aberforth UK Small Companies Fund | 0.732 | 0.732 | 0.741 | 0.741 |
| AEGON UK Smaller Companies Fund | 0.807 | 0.807 | 0.807 | 0.807 |
| Artemis UK Smaller Companies Fund | 0.000 | 0.000 | 0.085 | 0.085 |
| Aviva Investors UK Smaller Companies Fund | 0.771 | 0.771 | 0.771 | 0.771 |
| AXA Framlington UK Smaller Companies Fund | 0.623 | 0.623 | 0.762 | 0.762 |
| Baillie Gifford British Smaller Companies Fund | 0.769 | 0.769 | 0.769 | 0.769 |
| BlackRock Growth And Recovery Fund | 0.596 | 0.596 | 0.635 | 0.635 |
| BlackRock UK Smaller Companies Fund | 0.736 | 0.736 | 0.736 | 0.736 |
| Cazenove UK Smaller Companies Fund | 0.822 | 0.822 | 0.844 | 0.844 |
| CF Amati UK Smaller Companies Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| CF Canada Life UK Smaller Companies Fund | 0.610 | 0.610 | 0.812 | 0.812 |
| CF Chelverton UK Equity Income Fund | 0.582 | 0.582 | 0.679 | 0.679 |
| CF Octopus UK Micro Cap Growth Fund | 0.615 | 0.615 | 0.996 | 0.996 |
| Close Special Situations Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Dimensional UK Small Companies Fund | 0.825 | 0.825 | 0.825 | 0.825 |
| Discretionary Fund | 0.399 | 0.399 | 0.521 | 0.521 |
| F&C UK Smaller Companies Fund | 0.676 | 0.676 | 0.708 | 0.708 |
| Gartmore UK & Irish Smaller Companies Fund | 0.601 | 0.601 | 0.729 | 0.728 |
| Henderson UK Smaller Companies Fund | 0.718 | 0.718 | 0.770 | 0.770 |
| Henderson UK Strategic Capital Trust | 0.204 | 0.204 | 0.410 | 0.410 |
| HSBC UK Smaller Companies Fund | 0.772 | 0.772 | 0.772 | 0.772 |
| Ignis Smaller Companies Fund | 0.573 | 0.573 | 0.606 | 0.606 |
| Investec UK Smaller Companies Fund | 0.909 | 0.909 | 0.909 | 0.909 |
| Invesco Perpetual UK Smaller Companies Equity Fund | 0.594 | 0.594 | 0.639 | 0.639 |
| Invesco Perpetual UK Smaller Companies Growth Fund | 0.000 | 0.000 | 0.382 | 0.382 |
| J. P. Morgan UK Smaller Companies Fund | 0.631 | 0.631 | 0.699 | 0.699 |
| Jupiter UK Smaller Companies Fund | 0.599 | 0.599 | 0.677 | 0.677 |
| L&G UK Alpha Trust | 1.000 | 1.000 | 1.000 | 1.000 |
| L&G UK Smaller Companies Trust | 0.744 | 0.744 | 0.744 | 0.744 |
| M&G Smaller Companies Fund | 0.773 | 0.773 | 0.826 | 0.826 |
| Majedie Asset Special Situations Investment Fund | 0.877 | 0.877 | 0.877 | 0.877 |
| Manek Growth Fund | 0.000 | 0.000 | 0.154 | 0.154 |

| | | | | |
|---|---|---|---|---|
| Marlborough Special Situations Fund | 0.812 | 0.812 | 0.812 | 0.812 |
| Marlborough UK Micro Cap Growth Fund | 0.914 | 0.914 | 0.914 | 0.914 |
| MFM Techinvest Special Situations Fund | 0.000 | 0.000 | 1.000 | 1.000 |
| Newton UK Smaller Companies Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Old Mutual UK Select Smaller Companies Fund | 0.687 | 0.687 | 0.688 | 0.688 |
| Premier Castlefield UK Smaller Companies Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Prudential Small Companies Trust | 0.819 | 0.819 | 0.819 | 0.819 |
| River & Mercantile UK Equity Smaller Companies Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Royal London UK Smaller Companies Fund | 0.601 | 0.601 | 0.613 | 0.613 |
| Schroder UK Smaller Companies Fund | 0.654 | 0.654 | 0.688 | 0.688 |
| Scottish Widows UK Smaller Companies Fund | 0.532 | 0.532 | 0.678 | 0.678 |
| SF T1PS Smaller Companies Growth Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Standard Life UK Opportunities Fund | 0.685 | 0.685 | 0.748 | 0.748 |
| Standard Life UK Smaller Companies Fund | 0.838 | 0.838 | 0.838 | 0.838 |
| SWIP UK Smaller Companies Fund | 0.547 | 0.547 | 0.670 | 0.670 |
| UBS UK Smaller Companies Fund | 0.000 | 0.000 | 0.667 | 0.667 |
| Unicorn Outstanding British Companies Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| **iShares FTSE 250** | **1.000** | **1.000** | **1.000** | **1.000** |

## UK Domiciled OEICs And UTs With A US Investment Focus

***Table RA1.6:*** ***US Large-Cap Value And Growth Equity (1st January 2008 – 31st December 2010)***

CCR-IO → CCR DEA Model Input-Oriented

CCR-OO → CCR DEA Model Output-Oriented

SORMCCR-IO → SORMCCR DEA Model Input-Oriented

SORMCCR-OO → SORMCCR DEA Model Output-Oriented

| Name Of OEIC/UT | CCR-IO | CCR-OO | SORMCCR-IO | SORMCCR-OO |
|---|---|---|---|---|
| Franklin Mutual Shares Fund | 0.000 | 0.000 | 1.000 | 1.000 |
| GLG US Relative Value Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| J. P. Morgan US Fund | 0.898 | 0.898 | 0.898 | 0.898 |
| M&G North American Value Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Old Mutual North American Equity Fund | 0.867 | 0.867 | 0.867 | 0.867 |
| Prudential North American Trust | 0.969 | 0.969 | 0.969 | 0.969 |
| AXA Framlington American Growth Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Baillie Gifford American Fund | 0.866 | 0.866 | 0.866 | 0.866 |
| CF The Westchester Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Fidelity American Special Situations Fund | 0.908 | 0.908 | 0.908 | 0.908 |
| Gartmore US Opportunities Fund | 0.998 | 0.998 | 0.998 | 0.998 |
| GLG American Growth Fund | 0.902 | 0.902 | 0.902 | 0.902 |
| Ignis American Growth Fund | 0.875 | 0.875 | 0.875 | 0.875 |
| Martin Currie North American Fund | 0.742 | 0.741 | 0.742 | 0.741 |
| Martin Currie North American Alpha Fund | 0.673 | 0.673 | 0.673 | 0.673 |
| Neptune US Opportunities Fund | 0.982 | 0.982 | 0.982 | 0.982 |
| PSigma American Growth Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Standard Life TM North American Trust | 1.000 | 1.000 | 1.000 | 1.000 |
| Standard Life North American Equity Manager Of Managers Fund | 0.921 | 0.921 | 0.921 | 0.921 |
| Threadneedle American Extended Alpha Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Threadneedle American Fund | 0.896 | 0.896 | 0.896 | 0.896 |
| Threadneedle American Select Fund | 0.896 | 0.896 | 0.896 | 0.896 |
| **iShares S&P 500** | **1.000** | **1.000** | **1.000** | **1.000** |

***Table RA1.7:*** ***US Large-Cap Blend Equity (1st January 2008 – 31st December 2010)***

CCR-IO → CCR DEA Model Input-Oriented

CCR-OO → CCR DEA Model Output-Oriented

SORMCCR-IO → SORMCCR DEA Model Input-Oriented

SORMCCR-OO → SORMCCR DEA Model Output-Oriented

| Name Of OEIC/UT | CCR-IO | CCR-OO | SORMCCR-IO | SORMCCR-OO |
|---|---|---|---|---|
| Aberdeen American Equity Fund | 0.845 | 0.845 | 0.845 | 0.845 |
| AEGON American Equity Fund | 0.036 | 0.036 | 0.044 | 0.044 |
| Allianz RCM US Equity Fund | 0.909 | 0.909 | 0.909 | 0.909 |
| AXA Rosenberg American Fund | 0.591 | 0.591 | 0.592 | 0.592 |
| BlackRock US Dynamic Fund | 0.677 | 0.676 | 0.677 | 0.677 |
| CF Canada Life North American Fund | 0.912 | 0.912 | 0.912 | 0.912 |
| F&C North American Fund | 0.976 | 0.976 | 0.976 | 0.976 |
| FF&P US Large-Cap Equity Fund | 0.684 | 0.684 | 0.684 | 0.684 |
| Fidelity American Special Situations Fund | 0.944 | 0.944 | 0.944 | 0.944 |
| Franklin US Equity Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Gartmore US Growth Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Henderson American Portfolio Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Henderson North American Enhanced Equity Fund | 0.855 | 0.855 | 0.855 | 0.855 |
| HSBC American Index Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Investec American Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Invesco Perpetual US Equity Fund | 0.806 | 0.806 | 0.806 | 0.806 |
| J. P. Morgan US Select Fund | 0.999 | 0.999 | 0.999 | 0.999 |
| Jupiter North American Income Fund | 0.888 | 0.888 | 0.888 | 0.888 |
| L&G (Barclays) Multi-Manager US Alpha Fund | 0.897 | 0.897 | 0.970 | 0.970 |
| L&G North American Trust | 0.800 | 0.800 | 0.800 | 0.800 |
| L&G US Index Trust | 0.824 | 0.824 | 0.824 | 0.824 |
| Legg Mason US Equity Fund | 0.000 | 0.000 | 1.000 | 1.000 |
| M&G American Fund | 0.988 | 0.988 | 0.988 | 0.988 |
| Royal London US Index Tracker Trust | 1.000 | 1.000 | 1.000 | 1.000 |
| Santander Premium Fund US Equity Fund | 0.949 | 0.949 | 0.949 | 0.949 |
| Schroder QEP US Core Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Scottish Mutual North American Trust | 1.000 | 1.000 | 1.000 | 1.000 |
| Scottish Widows American Growth Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Scottish Widows American Select Growth Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| SSGA North American Equity Tracker Fund | 0.846 | 0.846 | 0.846 | 0.846 |

| | | | | |
|---|---|---|---|---|
| St James's Place North American Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Standard Life American Equity Unconstrained Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Standard Life US Equity Index Tracker Fund | 0.904 | 0.904 | 0.904 | 0.904 |
| SWIP North American Fund | 0.995 | 0.995 | 0.995 | 0.995 |
| UBS US 130/30 Equity Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| UBS US Equity Fund | 0.942 | 0.942 | 0.942 | 0.942 |
| **iShares S&P 500** | **0.841** | **0.840** | **0.841** | **0.840** |

***Table RA1.8:*** ***US Mid-Cap And Small-Cap Equity (1st January 2008 – 31st December 2010)***

CCR-IO → CCR DEA Model Input-Oriented

CCR-OO → CCR DEA Model Output-Oriented

SORMCCR-IO → SORMCCR DEA Model Input-Oriented

SORMCCR-OO → SORMCCR DEA Model Output-Oriented

| Name Of OEIC/UT | CCR-IO | CCR-OO | SORMCCR-IO | SORMCCR-OO |
|---|---|---|---|---|
| CF Greenwich Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| FF&P US All-Cap Value Equity Fund | 0.604 | 0.604 | 0.604 | 0.604 |
| GAM North American Growth Fund | 0.993 | 0.993 | 0.993 | 0.993 |
| Melchior North American Opportunities Fund | 0.803 | 0.803 | 0.803 | 0.803 |
| Schroder US Mid-Cap Fund | 0.853 | 0.853 | 0.853 | 0.853 |
| Scottish Widows American Smaller Companies Fund | 0.931 | 0.931 | 0.931 | 0.931 |
| SWIP North American Smaller Companies Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Threadneedle American Smaller Companies Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| FF&P US Small-Cap Equity Fund | 0.690 | 0.690 | 0.690 | 0.690 |
| J. P. Morgan US Smaller Companies Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Legg Mason US Smaller Companies Fund | 0.907 | 0.907 | 0.907 | 0.907 |
| Schroder US Smaller Companies Fund | 0.919 | 0.919 | 0.919 | 0.919 |
| **iShares S&P 500** | **1.000** | **1.000** | **1.000** | **1.000** |

## UK Domiciled OEICs And UTs With A Global Investment Focus

***Table RA1.9:* Global Large-Cap Value Equity (1st January 2008 – 31st December 2010)**

CCR-IO → CCR DEA Model Input-Oriented

CCR-OO → CCR DEA Model Output-Oriented

SORMCCR-IO → SORMCCR DEA Model Input-Oriented

SORMCCR-OO → SORMCCR DEA Model Output-Oriented

| Name Of OEIC/UT | CCR-IO | CCR-OO | SORMCCR-IO | SORMCCR-OO |
|---|---|---|---|---|
| Aberdeen Charity Select Global Equity Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Aberdeen Ethical World Fund | 0.890 | 0.890 | 0.890 | 0.890 |
| Aberdeen World Equity Fund | 0.902 | 0.902 | 0.902 | 0.902 |
| AXA Rosenberg Global Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Baillie Gifford Global Income Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| CF Stewart Ivory Investment Markets Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Dimensional International Value Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| GAM Global Diversified Fund | 0.893 | 0.893 | 0.893 | 0.893 |
| Gartmore Long-Term Balanced Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| GLG Stockmarket Managed Fund | 0.865 | 0.865 | 0.865 | 0.865 |
| Ignis Global Growth Fund | 0.993 | 0.993 | 0.993 | 0.993 |
| Investec Global Special Situations Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Invesco Perpetual Global Core Equity Index Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| J. P. Morgan Global Equity Income Fund | 0.829 | 0.829 | 0.829 | 0.829 |
| L&G Global 100 Index Trust | 0.840 | 0.840 | 0.840 | 0.840 |
| Lazard Global Equity Income Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| M&G Global Leaders Fund | 0.780 | 0.780 | 0.780 | 0.780 |
| Newton Global Higher Income Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Old Mutual Global Equity Fund | 0.832 | 0.832 | 0.832 | 0.832 |
| Prudential International Growth Trust | 0.978 | 0.978 | 0.978 | 0.978 |
| Sarasin International Equity Income Fund | 0.889 | 0.889 | 0.889 | 0.889 |
| Schroder Global Equity Income Fund | 0.973 | 0.973 | 0.973 | 0.973 |
| St James's Place Recovery Fund | 0.619 | 0.619 | 0.619 | 0.619 |
| Templeton Growth Fund | 0.770 | 0.770 | 0.770 | 0.770 |
| Threadneedle Global Equity Income Fund | 1.000 | 1.000 | 1.000 | 1.000 |

| | | | | |
|---|---|---|---|---|
| **iShares MSCI World** | **0.733** | **0.733** | **0.733** | **0.733** |

***Table RA1.10:*** ***Global Large-Cap Growth Equity (1st January 2008 – 31st December 2010)***

CCR-IO → CCR DEA Model Input-Oriented

CCR-OO → CCR DEA Model Output-Oriented

SORMCCR-IO → SORMCCR DEA Model Input-Oriented

SORMCCR-OO → SORMCCR DEA Model Output-Oriented

| Name Of OEIC/UT | CCR-IO | CCR-OO | SORMCCR-IO | SORMCCR-OO |
|---|---|---|---|---|
| AEGON Global Equity Fund | 0.000 | 0.000 | 0.639 | 0.639 |
| Aviva Investors World Leaders Fund | 0.579 | 0.579 | 0.701 | 0.701 |
| AXA Framlington Global Opportunities Fund | 0.044 | 0.044 | 0.151 | 0.151 |
| Baillie Gifford International Fund | 0.969 | 0.969 | 0.969 | 0.969 |
| Baillie Gifford Long-Term Global Growth Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| CF JM Finn Global Opportunities Fund | 0.729 | 0.729 | 0.937 | 0.937 |
| Discovery Managed Growth Fund | 0.000 | 0.000 | 1.000 | 1.000 |
| EFA Ursa Major Growth Portfolio Fund | 0.730 | 0.730 | 1.000 | 1.000 |
| F&C Global Growth Fund | 0.589 | 0.589 | 0.943 | 0.943 |
| F&C International Heritage Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| F&C Stewardship International Fund | 0.884 | 0.884 | 0.884 | 0.884 |
| Fidelity Global Focus Fund | 0.886 | 0.886 | 0.886 | 0.886 |
| Henderson International Fund | 0.741 | 0.741 | 0.789 | 0.789 |
| Margetts Greystone Global Growth Fund | 0.815 | 0.815 | 0.815 | 0.815 |
| Martin Currie Global Alpha Fund | 0.141 | 0.141 | 0.218 | 0.218 |
| NatWest International Growth Fund | 0.793 | 0.793 | 0.795 | 0.795 |
| Neptune Global Equity Fund | 0.760 | 0.760 | 1.000 | 1.000 |
| PFS Taube Global Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| RBS International Growth Fund | 0.792 | 0.792 | 0.793 | 0.793 |
| Sheldon Equity Growth Fund | 0.000 | 0.000 | 1.000 | 1.000 |
| Sheldon Financial Growth Fund | 0.000 | 0.000 | 1.000 | 1.000 |
| St James's Place Worldwide Opportunities Fund | 0.772 | 0.772 | 0.791 | 0.791 |
| Thesis Lion Growth Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Threadneedle Global Select Fund | 0.876 | 0.876 | 0.876 | 0.876 |
| Zenith International Growth Fund | 0.263 | 0.263 | 0.342 | 0.342 |
| **iShares MSCI World** | **0.837** | **0.837** | **0.837** | **0.837** |

***Table RA1.11:*** ***Global Large-Cap Blend Equity (1st January 2008 – 31st December 2010)***

CCR-IO → CCR DEA Model Input-Oriented

CCR-OO → CCR DEA Model Output-Oriented

SORMCCR-IO → SORMCCR DEA Model Input-Oriented

SORMCCR-OO → SORMCCR DEA Model Output-Oriented

| Name Of OEIC/UT | CCR-IO | CCR-OO | SORMCCR-IO | SORMCCR-OO |
|---|---|---|---|---|
| Aberdeen Multi-Manager Constellation Portfolio | 0.495 | 0.495 | 0.689 | 0.689 |
| Aberdeen Multi-Manager International Growth Portfolio | 0.619 | 0.619 | 0.714 | 0.714 |
| Architas Multi-Manager Diversified Share Portfolio | 0.000 | 0.000 | 0.425 | 0.425 |
| Architas Multi-Manager Global Equity Portfolio | 0.765 | 0.765 | 0.793 | 0.793 |
| Artemis Global Growth Fund | 0.000 | 0.000 | 0.252 | 0.252 |
| Aviva Investors Fund Of Funds Balanced Fund | 0.809 | 0.809 | 0.878 | 0.878 |
| Aviva Investors Fund Of Funds Growth Fund | 0.735 | 0.735 | 0.836 | 0.836 |
| Aviva Investors International Index Tracking Fund | 0.676 | 0.676 | 0.809 | 0.809 |
| Aviva Investors SF Global Growth Fund | 0.152 | 0.152 | 0.504 | 0.504 |
| Baillie Gifford Managed Fund | 0.832 | 0.832 | 0.921 | 0.921 |
| Bank Of Scotland International Managed Fund | 0.824 | 0.824 | 0.937 | 0.937 |
| BCIF Balanced Managed Fund | 0.444 | 0.444 | 0.606 | 0.606 |
| BlackRock Active Managed Portfolio Fund | 0.703 | 0.703 | 0.736 | 0.736 |
| BlackRock Global Equity Fund | 0.689 | 0.689 | 0.851 | 0.851 |
| BlackRock International Equity Fund | 0.643 | 0.643 | 0.830 | 0.830 |
| BlackRock Overseas Fund | 0.678 | 0.678 | 0.840 | 0.840 |
| Cazenove Multi-Manager Global Fund | 0.673 | 0.673 | 0.753 | 0.753 |
| CF Adam Worldwide Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| CF Aquarius Fund | 0.173 | 0.173 | 0.268 | 0.268 |
| CF Broden Fund | 0.606 | 0.606 | 0.628 | 0.628 |
| CF Canada Life International Growth Fund | 0.776 | 0.776 | 0.875 | 0.875 |
| CF FundQuest Global Select Fund | 0.831 | 0.831 | 0.836 | 0.836 |
| CF FundQuest Select Opportunities Fund | 0.802 | 0.802 | 0.835 | 0.835 |
| CF FundQuest Select Fund | 0.664 | 0.664 | 0.774 | 0.774 |
| CF Helm Investment Fund | 0.718 | 0.718 | 1.000 | 1.000 |
| CF Lacomp World Fund | 0.691 | 0.691 | 0.785 | 0.785 |
| CF The Aurinko Fund | 0.762 | 0.762 | 0.783 | 0.783 |

| | | | | |
|---|---|---|---|---|
| CF Taylor Young International Equity Fund | 0.848 | 0.848 | 0.919 | 0.919 |
| Chariguard Overseas Equity Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| City Financial Multi-Manager Growth Fund | 0.049 | 0.049 | 0.064 | 0.064 |
| Deutsche Bank PWM Capital Growth Portfolio | 0.775 | 0.775 | 0.895 | 0.895 |
| Ecclesiastical Amity International Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| F&C Lifestyle Growth Fund | 0.660 | 0.660 | 0.777 | 0.777 |
| Family Investments Child Trust Fund | 0.426 | 0.426 | 0.573 | 0.573 |
| FF&P Global Equities II Fund | 0.467 | 0.467 | 0.625 | 0.625 |
| Fidelity Global Special Situations Fund | 0.249 | 0.248 | 0.445 | 0.445 |
| Fidelity International Fund | 0.481 | 0.481 | 0.640 | 0.640 |
| Fidelity MoneyBuilder Global Trust | 0.600 | 0.600 | 0.750 | 0.750 |
| Fidelity WealthBuilder Fund | 0.646 | 0.646 | 0.793 | 0.793 |
| First State Global Growth Fund | 0.862 | 0.862 | 0.919 | 0.919 |
| First State Global Opportunities Fund | 0.579 | 0.579 | 0.695 | 0.695 |
| GAM Composite Absolute Return OEIC | 0.000 | 0.000 | 0.743 | 0.743 |
| GAM Portfolio Unit Trust | 0.911 | 0.911 | 0.922 | 0.922 |
| Gartmore Global Focus Fund | 0.432 | 0.432 | 0.614 | 0.614 |
| Gartmore Multi-Manager Active Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Henderson Global Dividend Income Fund | 0.850 | 0.850 | 1.000 | 1.000 |
| Henderson Multi-Manager Active Fund | 0.280 | 0.280 | 0.443 | 0.443 |
| Henderson Multi-Manager Tactical Fund | 0.000 | 0.000 | 0.554 | 0.554 |
| HSBC Global Growth Fund Of Funds | 0.733 | 0.733 | 0.818 | 0.818 |
| HSBC Portfolio Fund | 0.661 | 0.661 | 0.794 | 0.794 |
| IFDS Brown Shipley Multi-Manager International Fund | 0.748 | 0.748 | 0.808 | 0.808 |
| Investec Global Dynamic Fund | 0.819 | 0.819 | 0.998 | 0.998 |
| Investec Global Equity Fund | 0.648 | 0.648 | 0.855 | 0.854 |
| Investec Global Free Enterprise Fund | 0.508 | 0.508 | 0.762 | 0.761 |
| Invesco Perpetual Global Equity Fund | 0.568 | 0.568 | 0.724 | 0.724 |
| Invesco Perpetual Global Enhanced Index Fund | 0.982 | 0.982 | 1.000 | 1.000 |
| Invesco Perpetual Global Opportunities Fund | 0.585 | 0.585 | 0.715 | 0.715 |
| Invesco Perpetual Managed Growth Fund | 0.601 | 0.601 | 0.759 | 0.759 |
| Jessop (GAR) Global Equity Quant Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| J. P. Morgan Global Fund | 0.551 | 0.551 | 0.764 | 0.764 |
| J. P. Morgan Portfolio Fund | 0.598 | 0.598 | 0.727 | 0.727 |
| Jupiter Merlin Growth Portfolio Fund | 0.949 | 0.949 | 0.966 | 0.966 |
| Jupiter Merlin Worldwide Portfolio Fund | 0.942 | 0.942 | 0.987 | 0.987 |

| | | | | |
|---|---|---|---|---|
| L&G (Barclays) Adventurous Growth Portfolio Trust | 0.173 | 0.173 | 0.573 | 0.573 |
| L&G Global Growth Trust | 0.524 | 0.524 | 0.621 | 0.621 |
| L&G Worldwide Trust | 0.508 | 0.508 | 0.677 | 0.677 |
| Liberation No. VIII Fund | 0.597 | 0.597 | 1.000 | 1.000 |
| M&G Global Growth Fund | 0.735 | 0.735 | 0.857 | 0.857 |
| Margetts International Strategy Fund | 0.778 | 0.778 | 0.867 | 0.867 |
| Margetts Venture Strategy Fund | 0.969 | 0.969 | 1.000 | 1.000 |
| Marlborough Global Fund | 0.506 | 0.506 | 0.681 | 0.681 |
| Martin Currie Global Fund | 0.243 | 0.243 | 0.491 | 0.491 |
| Neptune Global Max Alpha Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Newton 50/50 Global Equity Fund | 0.733 | 0.733 | 0.870 | 0.869 |
| Newton Falcon Fund | 0.816 | 0.816 | 0.897 | 0.897 |
| Newton Global Balanced Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Newton Global Opportunities Fund | 0.599 | 0.599 | 0.841 | 0.841 |
| Newton International Growth Fund | 0.611 | 0.611 | 0.969 | 0.969 |
| Newton Managed Fund | 0.376 | 0.376 | 0.598 | 0.598 |
| Newton Overseas Equity Fund | 0.844 | 0.844 | 1.000 | 1.000 |
| Premier Castlefield Managed Multi-Asset Fund | 0.754 | 0.754 | 0.803 | 0.803 |
| Prudential (Invesco Perpetual) Managed Trust | 0.558 | 0.558 | 0.636 | 0.636 |
| S&W Endurance Global Opportunities Fund | 0.633 | 0.633 | 0.660 | 0.660 |
| Santander Multi-Manager Equity Fund | 0.449 | 0.449 | 0.562 | 0.562 |
| Sarasin Alpha CIF Income & Reserves Fund | 0.917 | 0.917 | 0.917 | 0.917 |
| Sarasin EquiSar Global Thematic Fund | 0.533 | 0.533 | 0.689 | 0.689 |
| Sarasin EquiSar IIID Fund | 0.045 | 0.045 | 0.187 | 0.187 |
| Schroder Global Equity Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Schroder Growth Fund | 0.000 | 0.000 | 1.000 | 1.000 |
| Schroder QEP Global Quant Core Equity Fund | 0.946 | 0.946 | 0.965 | 0.965 |
| Scottish Mutual International Growth Trust | 0.728 | 0.728 | 0.876 | 0.876 |
| Scottish Mutual Opportunity Trust | 0.700 | 0.700 | 0.759 | 0.759 |
| Scottish Widows Global Growth Fund | 0.463 | 0.463 | 0.567 | 0.567 |
| Scottish Widows Global Select Growth Fund | 0.459 | 0.459 | 0.580 | 0.580 |
| Scottish Widows International Equity Tracker Fund | 0.485 | 0.485 | 0.566 | 0.566 |
| Skandia Ethical Fund | 0.202 | 0.202 | 0.267 | 0.267 |
| Skandia Global Best Ideas Fund | 0.466 | 0.466 | 0.578 | 0.578 |
| Skandia Newton Managed Fund | 0.452 | 0.452 | 0.513 | 0.513 |
| Standard Life TM Global Equity Trust | 1.000 | 1.000 | 1.000 | 1.000 |
| Standard Life TM International Trust | 1.000 | 1.000 | 1.000 | 1.000 |
| St James's Place Ethical Fund | 0.387 | 0.387 | 0.487 | 0.487 |
| St James's Place International Fund | 0.311 | 0.311 | 0.407 | 0.407 |
| Standard Life Global Equity Fund | 0.660 | 0.660 | 0.697 | 0.697 |
| SVM Global Opportunities Fund | 0.000 | 0.000 | 0.915 | 0.915 |
| SWIP Global Fund | 0.493 | 0.493 | 0.521 | 0.521 |
| SWIP Multi-Manager International Equity Fund | 0.646 | 0.646 | 0.694 | 0.694 |

| | | | | |
|---|---|---|---|---|
| SWIP Multi-Manager Select Boutiques Fund | 0.713 | 0.713 | 0.723 | 0.723 |
| T. Bailey Growth Fund | 0.323 | 0.323 | 0.414 | 0.414 |
| Thames River Equity Managed Fund | 0.688 | 0.688 | 0.697 | 0.697 |
| Thames River Global Boutiques Fund | 0.717 | 0.717 | 0.727 | 0.727 |
| Threadneedle Global Equity Fund | 0.577 | 0.577 | 0.633 | 0.633 |
| Threadneedle Navigator Adventurous Managed Trust | 0.845 | 0.845 | 0.845 | 0.845 |
| THS International Growth & Value Fund | 0.382 | 0.382 | 0.490 | 0.490 |
| UBS Global Optimal Fund | 0.653 | 0.653 | 0.659 | 0.659 |
| UBS Global Optimal Thirds Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| WAY Global Red Active Portfolio Fund | 0.605 | 0.605 | 0.623 | 0.623 |
| Wesleyan International Trust | 0.454 | 0.454 | 0.470 | 0.470 |
| Williams De Broe Global Fund | 0.751 | 0.751 | 0.755 | 0.755 |
| **iShares MSCI World** | **0.692** | **0.692** | **0.792** | **0.792** |

### *Table RA1.12: Global Mid-Cap And Small-Cap Equity (1st January 2008 – 31st December 2010)*

CCR-IO → CCR DEA Model Input-Oriented

CCR-OO → CCR DEA Model Output-Oriented

SORMCCR-IO → SORMCCR DEA Model Input-Oriented

SORMCCR-OO → SORMCCR DEA Model Output-Oriented

| Name Of OEIC/UT | CCR-IO | CCR-OO | SORMCCR-IO | SORMCCR-OO |
|---|---|---|---|---|
| AXA Framlington Talents Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Baillie Gifford Phoenix Global Growth Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Hargreaves Lansdown Multi-Manager Special Situations Trust | 0.839 | 0.839 | 0.839 | 0.839 |
| Invesco Perpetual Global Smaller Companies Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| J. P. Morgan Multi-Manager Growth Fund | 0.643 | 0.643 | 0.643 | 0.643 |
| L&G (Barclays) Multi-Manager Global Core Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| M&G Fund Of Investment Trust Shares | 0.294 | 0.294 | 0.294 | 0.294 |
| M&G Global Basics Fund | 0.936 | 0.936 | 0.936 | 0.936 |
| Neptune Green Planet Fund | 0.000 | 0.000 | 1.000 | 1.000 |
| Rathbone Global Opportunities Fund | 0.773 | 0.773 | 0.773 | 0.773 |
| S&W Aubrey Global Conviction Fund | 0.937 | 0.937 | 0.937 | 0.937 |

| | | | | |
|---|---|---|---|---|
| SF Adventurous Portfolio Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| St James's Place Global Fund | 0.320 | 0.320 | 0.320 | 0.320 |
| **iShares MSCI World** | **1.000** | **1.000** | **1.000** | **1.000** |

# Results Appendix 2 – BCC & SORMBCC DEA Models

## UK Domiciled OEICs And UTs With A UK Investment Focus

***Table RA2.1:*** ***UK Large-Cap Value Equity (1st January 2008 – 31st December 2010)***

BCC-IO → BCC DEA Model Input-Oriented

BCC-OO → BCC DEA Model Output-Oriented

SORMBCC-IO → SORMBCC DEA Model Input-Oriented

SORMBCC-OO → SORMBCC DEA Model Output-Oriented

| Name Of OEIC/UT | BCC-IO | BCC-OO | SORMBCC-IO | SORMBCC-OO |
|---|---|---|---|---|
| Aberdeen Charity Select UK Equity Fund | 0.999 | 0.867 | 1.000 | 1.000 |
| Aberdeen Multi-Manager UK Income Portfolio | 0.992 | 0.958 | 0.992 | 0.958 |
| Aberdeen Responsible UK Equity Fund | 0.874 | 0.689 | 0.874 | 0.689 |
| Aberdeen UK Equity Fund | 0.801 | 0.607 | 0.810 | 0.609 |
| Aberdeen UK Equity Income Fund | 0.810 | 0.570 | 0.825 | 0.570 |
| Artemis Income Fund | 0.834 | 0.676 | 0.849 | 0.676 |
| Cazenove UK Growth & Income Fund | 0.845 | 0.716 | 0.852 | 0.716 |
| Capita Financial Taylor Young Equity Income Fund | 0.900 | 0.718 | 0.900 | 0.718 |
| Capita Financial Walker Crips UK Growth Fund | 0.919 | 0.880 | 0.919 | 0.880 |
| Dimensional UK Core Equity Fund | 0.977 | 0.888 | 1.000 | 1.000 |
| Dimensional UK Value Fund | 1.000 | 0.000 | 1.000 | 1.000 |
| Elite Henderson Rowe Dogs FTSE 100 Fund | 1.000 | 0.000 | 1.000 | 1.000 |
| F&C UK Equity Income Fund | 0.917 | 0.662 | 0.917 | 0.662 |
| F&C UK Growth & Income Fund | 0.925 | 0.620 | 0.953 | 0.620 |
| Family Asset Trust | 1.000 | 0.000 | 1.000 | 1.000 |
| Fidelity Special Situations Fund | 0.754 | 0.768 | 0.754 | 0.768 |
| Gartmore UK Alpha Fund | 0.999 | 0.000 | 0.999 | 0.998 |
| Gartmore UK Equity Income Fund | 0.881 | 0.522 | 0.913 | 0.522 |
| Gartmore UK Growth Fund | 0.809 | 0.000 | 0.859 | 0.423 |
| GLG UK Growth Fund | 0.829 | 0.000 | 0.888 | 0.370 |
| GLG UK Income Fund | 0.828 | 0.332 | 0.874 | 0.337 |
| HL Multi-Manager Income & Growth Portfolio Trust | 1.000 | 1.000 | 1.000 | 1.000 |
| HSBC Income Fund | 0.894 | 0.667 | 0.894 | 0.667 |
| Ignis UK Equity Income Fund | 0.845 | 0.627 | 0.859 | 0.627 |
| Insight Investment Equity High Income Fund | 0.814 | 0.628 | 0.822 | 0.628 |
| Investec UK Special Situations Fund | 0.958 | 0.958 | 0.958 | 0.958 |
| Invesco Perpetual Children's Fund | 0.909 | 0.522 | 0.939 | 0.522 |

| | | | | |
|---|---|---|---|---|
| Invesco Perpetual High Income Fund | 0.998 | 0.691 | 1.000 | 0.866 |
| Invesco Perpetual Income & Growth Fund | 0.911 | 0.310 | 0.957 | 0.310 |
| Invesco Perpetual Income Fund | 1.000 | 0.720 | 1.000 | 1.000 |
| Invesco Perpetual UK Aggressive Fund | 0.967 | 0.653 | 1.000 | 1.000 |
| Invesco Perpetual UK Enhanced Index Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Invesco Perpetual UK Growth Fund | 0.845 | 0.000 | 0.953 | 0.460 |
| JoHambro Capital Management UK Equity Income Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| J. P. Morgan Premier Equity Income Fund | 0.790 | 0.544 | 0.815 | 0.547 |
| J. P. Morgan UK Managed Equity Fund | 0.783 | 0.513 | 0.813 | 0.515 |
| J. P. Morgan UK Strategic Equity Income Fund | 0.712 | 0.540 | 0.719 | 0.542 |
| Jupiter Undervalued Assets Fund | 0.892 | 0.000 | 1.000 | 1.000 |
| L&G (Barclays) MM UK Equity Income Fund | 0.962 | 0.922 | 0.962 | 0.922 |
| Lazard UK Income Fund | 0.876 | 0.604 | 0.888 | 0.604 |
| Legg Mason UK Equity Fund | 0.828 | 0.574 | 0.837 | 0.574 |
| M&G Charifund | 1.000 | 0.000 | 1.000 | 1.000 |
| M&G Dividend Fund | 0.897 | 0.715 | 0.910 | 0.715 |
| M&G Income Fund | 0.863 | 0.777 | 0.863 | 0.777 |
| Neptune Income Fund | 0.886 | 0.777 | 0.886 | 0.777 |
| Neptune Quarterly Income Fund | 0.935 | 0.701 | 0.935 | 0.701 |
| Neptune UK Equity Fund | 0.889 | 0.822 | 0.889 | 0.822 |
| Neptune UK Special Situations Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Old Mutual Equity Income Fund | 0.918 | 0.718 | 0.918 | 0.718 |
| Old Mutual Extra Income Fund | 0.982 | 0.904 | 0.982 | 0.904 |
| Premier UK Strategic Growth Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Prudential Ethical Trust Fund | 0.935 | 0.000 | 1.000 | 1.000 |
| PSigma Income Fund | 0.889 | 0.011 | 0.965 | 0.011 |
| PSigma UK Growth Fund | 0.853 | 0.040 | 0.853 | 0.040 |
| Rathbone Blue Chip Income & Growth Fund | 0.928 | 0.798 | 0.930 | 0.798 |
| Rathbone Income Fund | 0.818 | 0.004 | 0.890 | 0.004 |
| River & Mercantile UK Equity High Alpha Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| S&W Church House Balanced Value & Income Fund | 0.992 | 0.968 | 0.992 | 0.968 |
| S&W Church House UK Managed Growth Fund | 0.918 | 0.853 | 0.918 | 0.853 |
| S&W FTIM Munro Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Schroder Charity Equity Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Schroder Income Fund | 0.874 | 0.868 | 0.874 | 0.868 |
| Schroder Income Maximiser Fund | 0.891 | 0.844 | 0.891 | 0.844 |
| Schroder Recovery Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Schroder Specialist Value UK Equity Fund | 0.979 | 0.972 | 0.979 | 0.972 |
| Scottish Widows Ethical Fund | 1.000 | 0.000 | 1.000 | 1.000 |
| Scottish Widows UK Equity Income Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Scottish Widows UK Growth Fund | 0.846 | 0.785 | 0.880 | 0.785 |
| Skandia Multi-Manager UK Equity Fund | 0.763 | 0.630 | 0.763 | 0.633 |

| | | | | |
|---|---|---|---|---|
| St James's Place Equity Income Fund | 0.818 | 0.816 | 0.818 | 0.816 |
| St James's Place UK Growth Fund | 0.911 | 0.923 | 0.914 | 0.927 |
| St James's Place UK High Income Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Standard Life UK Equity High Income Fund | 0.774 | 0.357 | 0.846 | 0.357 |
| Standard Life UK Equity Manager Of Managers Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| SWIP Multi-Manager UK Equity Income Fund | 0.964 | 0.926 | 0.964 | 0.930 |
| SWIP UK Income Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| TB Wise Income Fund | 0.993 | 0.943 | 0.993 | 0.943 |
| Templeton UK Equity Fund | 0.814 | 0.000 | 0.912 | 0.280 |
| Troy Trojan Income Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| UBS UK Select Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| **iShares FTSE 100** | **1.000** | **1.000** | **1.000** | **1.000** |

### *Table RA2.2: UK Large-Cap Growth Equity (1st January 2008 – 31st December 2010)*

BCC-IO → BCC DEA Model Input-Oriented

BCC-OO → BCC DEA Model Output-Oriented

SORMBCC-IO → SORMBCC DEA Model Input-Oriented

SORMBCC-OO → SORMBCC DEA Model Output-Oriented

| Name Of OEIC/UT | BCC-IO | BCC-OO | SORMBCC-IO | SORMBCC-OO |
|---|---|---|---|---|
| AEGON UK Opportunities Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| BlackRock UK Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| BlackRock UK Dynamic Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| FF&P Concentrated UK Equity Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Fidelity UK Growth Fund | 0.954 | 0.902 | 0.954 | 0.902 |
| L&G (N) UK Growth Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Mirabaud Mir GB Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Royal London UK Opportunities Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| SVM UK Growth Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| **iShares FTSE 100** | **1.000** | **1.000** | **1.000** | **1.000** |

***Table RA2.3:*** ***UK Large-Cap Blend Equity (1st January 2008 – 31st December 2010)***

BCC-IO → BCC DEA Model Input-Oriented

BCC-OO → BCC DEA Model Output-Oriented

SORMBCC-IO → SORMBCC DEA Model Input-Oriented

SORMBCC-OO → SORMBCC DEA Model Output-Oriented

| Name Of OEIC/UT | BCC-IO | BCC-OO | SORMBCC-IO | SORMBCC-OO |
|---|---|---|---|---|
| Aberdeen Multi-Manager UK Growth Portfolio | 1.000 | 1.000 | 1.000 | 1.000 |
| AEGON UK Equity Fund | 0.795 | 0.784 | 0.795 | 0.784 |
| Allianz RCM UK Equity Fund | 0.865 | 0.744 | 0.905 | 0.774 |
| Allianz RCM UK Growth Fund | 0.753 | 0.586 | 0.760 | 0.586 |
| Allianz RCM UK Index Fund | 0.941 | 0.887 | 0.941 | 0.887 |
| Allianz RCM UK Unconstrained Fund | 0.780 | 0.000 | 1.000 | 1.000 |
| Architas Multi-Manager UK Equity Portfolio | 0.823 | 0.912 | 0.898 | 0.912 |
| Artemis Capital Fund | 0.727 | 0.251 | 0.744 | 0.251 |
| Artemis UK Growth Fund | 0.808 | 0.789 | 0.808 | 0.789 |
| Aviva Investors UK Equity Fund | 0.943 | 0.878 | 0.943 | 0.878 |
| Aviva Investors UK Focus Fund | 0.884 | 0.911 | 0.884 | 0.911 |
| Aviva Investors UK Growth Fund | 0.879 | 0.849 | 0.879 | 0.849 |
| AXA Framlington UK Growth Fund | 0.889 | 0.915 | 0.889 | 0.915 |
| AXA General Trust | 0.807 | 0.826 | 0.807 | 0.826 |
| Baillie Gifford British 350 Fund | 0.923 | 0.930 | 0.923 | 0.930 |
| Baillie Gifford UK Equity Alpha Fund | 0.898 | 0.910 | 0.906 | 0.910 |
| Bank Of Scotland FTSE 100 Tracker Fund | 0.950 | 0.869 | 0.950 | 0.869 |
| BlackRock Armed Forces Common Investment Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| BlackRock Charishare Fund | 0.823 | 0.741 | 0.823 | 0.741 |
| BlackRock UK Equity Fund | 0.924 | 0.864 | 0.924 | 0.864 |
| BlackRock UK Income Fund | 0.952 | 0.940 | 0.952 | 0.940 |
| Cazenove Multi-Manager UK Growth Fund | 0.946 | 0.830 | 0.959 | 0.855 |
| Cazenove UK Opportunities Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| CF Canada Life General Trust | 0.837 | 0.508 | 0.842 | 0.509 |
| CF Canada Life Growth Fund | 0.897 | 0.758 | 0.913 | 0.790 |
| CF GHC Multi-Manager UK Equity OEIC | 0.879 | 0.844 | 0.880 | 0.844 |
| CF JM Finn UK Portfolio Fund | 0.892 | 0.712 | 0.894 | 0.712 |
| CF Lindsell Train UK Equity Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| CF Taylor Young Growth & Income Fund | 0.953 | 0.881 | 0.953 | 0.881 |
| CF Walker Crips UK High Alpha Fund | 0.939 | 0.943 | 0.939 | 0.943 |
| Chariguard UK Equity Fund | 0.879 | 0.708 | 0.879 | 0.709 |

| | | | | |
|---|---|---|---|---|
| CIS UK FTSE4Good Tracker Trust | 0.849 | 0.800 | 0.852 | 0.800 |
| EFA OPM UK Equity Fund | 1.000 | 0.000 | 1.000 | 1.000 |
| Engage Investment Growth Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Epworth Affirmative Equity Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| F&C FTSE All-Share Tracker Fund | 0.942 | 0.861 | 0.942 | 0.861 |
| F&C UK Equity Fund | 0.895 | 0.905 | 0.895 | 0.905 |
| Family Charities Ethical Trust | 1.000 | 0.000 | 1.000 | 1.000 |
| Fidelity MoneyBuilder UK Index Fund | 0.951 | 0.893 | 0.951 | 0.893 |
| Fidelity UK Aggressive Fund | 0.840 | 0.798 | 0.840 | 0.798 |
| GAM MP UK Equity Unit Trust | 0.981 | 0.948 | 0.981 | 0.948 |
| Gartmore UK Index Fund | 0.890 | 0.814 | 0.890 | 0.814 |
| Gartmore UK Tracker Fund | 0.842 | 0.781 | 0.842 | 0.781 |
| HBOS UK FTSE 100 Index Track Fund | 0.793 | 0.725 | 0.793 | 0.725 |
| Henderson UK Equity Tracker Trust | 0.869 | 0.651 | 0.880 | 0.651 |
| Henderson UK High Alpha Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| HSBC FTSE 100 Index Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| HSBC FTSE All Share Index Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| HSBC MERIT UK Equity Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| HSBC UK Focus Fund | 0.971 | 0.865 | 0.971 | 0.865 |
| HSBC UK Freestyle Fund | 0.920 | 0.650 | 1.000 | 1.000 |
| HSBC UK Growth & Income Fund | 0.883 | 0.880 | 0.894 | 0.882 |
| IFDS Brown Shipley UK Flagship Fund | 0.929 | 0.878 | 0.929 | 0.878 |
| Ignis Balanced Growth Fund | 0.803 | 0.503 | 0.820 | 0.503 |
| Ignis Cartesian UK Opportunities Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Ignis UK Focus Fund | 0.765 | 0.746 | 0.765 | 0.746 |
| Insight Investment UK Dynamic Managed Fund | 0.856 | 0.826 | 0.857 | 0.826 |
| Investec UK Alpha Fund | 0.808 | 0.840 | 0.808 | 0.840 |
| Investec UK Blue Chip Fund | 0.808 | 0.778 | 0.808 | 0.778 |
| Invesco Perpetual UK Strategic Income Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Jessop Gartmore UK Index Fund | 0.961 | 0.873 | 0.961 | 0.873 |
| JoHambro Capital Management UK Opportunities Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| J. P. Morgan Premier Equity Growth Fund | 0.769 | 0.386 | 0.784 | 0.386 |
| J. P. Morgan UK Active Index Plus Fund | 0.912 | 0.836 | 0.912 | 0.836 |
| J. P. Morgan UK Dynamic Fund | 0.753 | 0.753 | 0.753 | 0.753 |
| J. P. Morgan UK Focus Fund | 0.823 | 0.846 | 0.823 | 0.846 |
| Jupiter UK Alpha Fund | 0.941 | 0.911 | 0.941 | 0.911 |
| L&G (Barclays) Market Track 350 Trust | 0.870 | 0.784 | 0.870 | 0.784 |
| L&G (Barclays) Multi-Manager UK Alpha Fund | 0.756 | 0.713 | 0.761 | 0.713 |
| L&G (Barclays) Multi-Manager UK Alpha (Series 2) Fund | 0.743 | 0.679 | 0.753 | 0.679 |
| L&G (Barclays) Multi-Manager UK Core Fund | 0.851 | 0.867 | 0.871 | 0.867 |
| L&G (Barclays) Multi-Manager UK Opportunities Fund | 0.957 | 0.933 | 0.957 | 0.933 |
| L&G Capital Growth Fund | 0.810 | 0.770 | 0.810 | 0.770 |
| L&G (N) UK Tracker Trust | 0.844 | 0.797 | 0.844 | 0.797 |
| L&G CAF UK Equitrack Fund | 1.000 | 1.000 | 1.000 | 1.000 |

| | | | | |
|---|---|---|---|---|
| L&G Equity Trust | 0.928 | 0.501 | 0.959 | 0.501 |
| L&G Ethical Trust | 0.777 | 0.679 | 0.781 | 0.679 |
| L&G Growth Trust | 0.825 | 0.749 | 0.825 | 0.749 |
| L&G UK 100 Index Trust | 0.885 | 0.759 | 0.885 | 0.759 |
| L&G UK Active Opportunities Trust | 0.812 | 0.677 | 0.820 | 0.677 |
| L&G UK Index Trust | 0.918 | 0.826 | 0.918 | 0.826 |
| Lazard UK Alpha Fund | 0.877 | 1.011 | 0.880 | 0.835 |
| Lazard UK Omega Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| LV UK Growth Fund | 0.910 | 0.674 | 0.912 | 0.674 |
| M&G Index Tracker Fund | 0.921 | 0.784 | 0.921 | 0.784 |
| M&G Recovery Fund | 0.884 | 0.878 | 0.884 | 0.878 |
| M&G UK Growth Fund | 0.814 | 0.742 | 0.814 | 0.744 |
| M&G UK Select Fund | 0.834 | 0.848 | 0.836 | 0.848 |
| Majedie AM UK Equity Fund | 0.949 | 0.912 | 0.949 | 0.912 |
| Majedie AM UK Focus Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| M&S Ethical Fund | 0.999 | 0.998 | 1.000 | 1.000 |
| M&S UK 100 Companies Fund | 0.887 | 0.836 | 0.887 | 0.836 |
| M&S UK Selection Portfolio | 0.802 | 0.669 | 0.814 | 0.669 |
| Morgan Stanley UK Equity Alpha Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Old Mutual UK Select Equity Fund | 0.790 | 0.813 | 0.790 | 0.813 |
| Premier Castlefield UK Alpha Fund | 1.000 | 0.000 | 1.000 | 1.000 |
| Premier Castlefield UK Equity Fund | 0.951 | 0.888 | 0.951 | 0.893 |
| Prudential UK Growth Trust | 0.865 | 0.857 | 0.868 | 0.857 |
| Prudential UK Index Tracker Trust | 1.000 | 1.000 | 1.000 | 1.000 |
| RBS FTSE 100 Tracker Fund | 0.871 | 0.764 | 0.871 | 0.764 |
| Royal London FTSE 350 Tracker Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Royal London UK Equity Fund | 0.860 | 0.822 | 0.860 | 0.822 |
| Santander Premium Fund UK Equity | 0.883 | 0.809 | 0.883 | 0.810 |
| Santander Stockmarket 100 Tracker Trust | 0.972 | 0.897 | 0.972 | 0.897 |
| Santander UK Growth Trust | 0.845 | 0.798 | 0.845 | 0.798 |
| Schroder Specialist UK Equity Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Schroder Prime UK Equity Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Schroder UK Alpha Plus Fund | 0.885 | 0.908 | 0.885 | 0.908 |
| Schroder UK Equity Fund | 0.831 | 0.862 | 0.837 | 0.862 |
| Scottish Friendly UK Growth Fund | 0.885 | 0.850 | 0.885 | 0.850 |
| Scottish Mutual UK All-Share Index Trust | 1.000 | 1.000 | 1.000 | 1.000 |
| Scottish Mutual UK Equity Trust | 0.834 | 0.676 | 0.834 | 0.676 |
| Scottish Widows UK All-Share Tracker Fund | 0.910 | 0.792 | 0.910 | 0.792 |
| Scottish Widows UK Select Growth Fund | 0.874 | 0.867 | 0.877 | 0.867 |
| Scottish Widows UK Tracker Fund | 0.868 | 0.750 | 0.868 | 0.750 |
| Skandia Multi-Manager UK Index Fund | 0.918 | 0.833 | 0.918 | 0.833 |
| Skandia Multi-Manager UK Opportunities Fund | 1.000 | 0.000 | 1.000 | 1.000 |
| Standard Life TM UK General Equity Fund | 0.805 | 0.677 | 0.805 | 0.677 |
| SSGA UK Equity Enhanced Fund | 0.939 | 0.872 | 0.939 | 0.882 |
| SSGA UK Equity Tracker Fund | 0.916 | 0.851 | 0.916 | 0.854 |

| | | | | |
|---|---|---|---|---|
| St James's Place UK & General Progressive Fund | 0.815 | 0.000 | 0.882 | 0.497 |
| Standard Life UK Equity Growth Fund | 0.761 | 0.738 | 0.761 | 0.738 |
| SWIP Multi-Manager UK Equity Focus Fund | 0.785 | 0.501 | 0.800 | 0.501 |
| SWIP Multi-Manager UK Equity Growth Fund | 0.750 | 0.651 | 0.750 | 0.651 |
| SWIP UK Opportunities Fund | 0.889 | 0.898 | 0.889 | 0.898 |
| Threadneedle Navigator UK Index Tracker Fund | 0.838 | 0.778 | 0.838 | 0.778 |
| Threadneedle UK Extended Alpha Fund | 0.938 | 0.619 | 1.000 | 1.000 |
| Troy Trojan Capital Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| UBS UK Equity Income Find | 1.000 | 0.000 | 1.000 | 1.000 |
| Wesleyan Growth Trust | 0.811 | 0.750 | 0.811 | 0.750 |
| **iShares FTSE 100** | **0.964** | **0.749** | **0.964** | **0.749** |

***Table RA2.4:* UK Mid-Cap Equity (1st January 2008 – 31st December 2010)**

BCC-IO → BCC DEA Model Input-Oriented

BCC-OO → BCC DEA Model Output-Oriented

SORMBCC-IO → SORMBCC DEA Model Input-Oriented

SORMBCC-OO → SORMBCC DEA Model Output-Oriented

| Name Of OEIC/UT | BCC-IO | BCC-OO | SORMBCC-IO | SORMBCC-OO |
|---|---|---|---|---|
| Aberdeen UK Mid-Cap Fund | 0.956 | 0.931 | 0.958 | 0.935 |
| AEGON Ethical Equity Fund | 0.996 | 0.932 | 0.996 | 0.932 |
| Allianz RCM UK Mid-Cap Fund | 0.862 | 0.795 | 0.867 | 0.817 |
| Artemis UK Special Situations Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Aviva Investors SF UK Growth Fund | 0.965 | 0.803 | 1.000 | 1.000 |
| Aviva Investors UK Ethical Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Aviva Investors UK Special Situations Fund | 0.802 | 0.685 | 0.802 | 0.714 |
| AXA Framlington Equity Income Fund | 0.870 | 0.000 | 1.000 | 1.000 |
| AXA Framlington Monthly Income Fund | 0.971 | 0.000 | 1.000 | 1.000 |
| AXA Framlington UK Select Opportunities Fund | 0.973 | 0.901 | 0.973 | 0.901 |
| BlackRock UK Special Situations Fund | 0.974 | 0.947 | 0.974 | 0.947 |
| Cazenove UK Dynamic Fund | 0.971 | 0.956 | 0.983 | 0.976 |
| CF Cornelian British Opportunities Fund | 0.990 | 0.890 | 1.000 | 1.000 |

| | | | | |
|---|---|---|---|---|
| CF OLIM UK Equity Trust | 1.000 | 1.000 | 1.000 | 1.000 |
| CF Taylor Young Growth Fund | 0.841 | 0.614 | 0.849 | 0.621 |
| CF Taylor Young Opportunistic Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Ecclesiastical Amity UK Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| F&C Stewardship Growth Fund | 0.907 | 0.578 | 1.000 | 1.000 |
| F&C Stewardship Income Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| F&C UK Mid-Cap Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| F&C UK Opportunities Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| GAM UK Diversified Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Henderson UK Alpha Fund | 0.786 | 0.505 | 0.786 | 0.556 |
| HSBC FTSE 250 Index Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| L&G (Barclays) Multi-Manager UK Lower-Cap Fund | 0.902 | 0.848 | 0.907 | 0.852 |
| Majedie UK Opportunities Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Marlborough Ethical Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Marlborough UK Primary Opportunities Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Melchior UK Opportunities Fund | 1.000 | 0.000 | 1.000 | 1.000 |
| MFM Bowland Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| MFM Slater Recovery Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Old Mutual UK Select Mid-Cap Fund | 0.893 | 0.828 | 0.893 | 0.828 |
| Rathbone Recovery Fund | 1.000 | 0.000 | 1.000 | 1.000 |
| Real Life Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Rensburg UK Managers' Focus Trust | 0.972 | 0.842 | 0.972 | 0.847 |
| Royal London UK Mid-Cap Growth Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Saracen Growth Fund | 0.873 | 0.000 | 1.000 | 1.000 |
| Schroder UK Mid 250 Fund | 0.717 | 0.414 | 0.717 | 0.469 |
| Skandia UK Best Ideas Fund | 0.746 | 0.000 | 0.768 | 0.439 |
| Standard Life UK Equity High Alpha Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Standard Life UK Equity Income Unconstrained Fund | 0.790 | 0.541 | 0.801 | 0.584 |
| Standard Life UK Equity Unconstrained Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Standard Life UK Ethical Fund | 0.801 | 0.627 | 0.804 | 0.696 |
| SVM UK Opportunities Fund | 0.876 | 0.846 | 0.877 | 0.868 |
| Threadneedle UK Mid 250 Fund | 0.927 | 0.877 | 0.927 | 0.877 |
| **iShares FTSE 250** | **1.000** | **1.000** | **1.000** | **1.000** |

***Table RA2.5:* UK Small-Cap Equity (1st January 2008 – 31st December 2010)**

BCC-IO → BCC DEA Model Input-Oriented

BCC-OO → BCC DEA Model Output-Oriented

SORMBCC-IO → SORMBCC DEA Model Input-Oriented

SORMBCC-OO → SORMBCC DEA Model Output-Oriented

| Name Of OEIC/UT | BCC-IO | BCC-OO | SORMBCC-IO | SORMBCC-OO |
|---|---|---|---|---|
| Aberdeen UK Smaller Companies Fund | 0.959 | 0.832 | 0.960 | 0.832 |
| Aberforth UK Small Companies Fund | 0.963 | 0.910 | 0.968 | 0.910 |
| AEGON UK Smaller Companies Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Artemis UK Smaller Companies Fund | 0.881 | 0.000 | 1.000 | 1.000 |
| Aviva Investors UK Smaller Companies Fund | 0.945 | 0.912 | 0.945 | 0.912 |
| AXA Framlington UK Smaller Companies Fund | 0.865 | 0.709 | 0.865 | 0.763 |
| Baillie Gifford British Smaller Companies Fund | 0.981 | 0.948 | 0.981 | 0.948 |
| BlackRock Growth And Recovery Fund | 0.885 | 0.739 | 0.897 | 0.773 |
| BlackRock UK Smaller Companies Fund | 0.911 | 0.845 | 0.911 | 0.845 |
| Cazenove UK Smaller Companies Fund | 0.968 | 0.948 | 0.968 | 0.948 |
| CF Amati UK Smaller Companies Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| CF Canada Life UK Smaller Companies Fund | 0.953 | 0.833 | 0.953 | 0.835 |
| CF Chelverton UK Equity Income Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| CF Octopus UK Micro Cap Growth Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Close Special Situations Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Dimensional UK Small Companies Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Discretionary Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| F&C UK Smaller Companies Fund | 0.927 | 0.806 | 0.930 | 0.841 |
| Gartmore UK & Irish Smaller Companies Fund | 0.846 | 0.683 | 0.846 | 0.729 |
| Henderson UK Smaller Companies Fund | 0.856 | 0.767 | 0.856 | 0.774 |
| Henderson UK Strategic Capital Trust | 0.923 | 0.282 | 1.000 | 1.000 |
| HSBC UK Smaller Companies Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Ignis Smaller Companies Fund | 0.832 | 0.663 | 0.834 | 0.663 |
| Investec UK Smaller Companies Fund | 0.969 | 0.956 | 0.969 | 0.956 |
| Invesco Perpetual UK Smaller Companies Equity Fund | 0.957 | 0.769 | 0.959 | 0.769 |
| Invesco Perpetual UK Smaller Companies Growth Fund | 0.938 | 0.000 | 1.000 | 1.000 |
| J. P. Morgan UK Smaller Companies Fund | 0.825 | 0.692 | 0.825 | 0.699 |
| Jupiter UK Smaller Companies Fund | 0.895 | 0.722 | 0.895 | 0.727 |
| L&G UK Alpha Trust | 1.000 | 1.000 | 1.000 | 1.000 |
| L&G UK Smaller Companies Trust | 0.939 | 0.870 | 0.939 | 0.870 |
| M&G Smaller Companies Fund | 0.918 | 0.861 | 0.918 | 0.861 |
| Majedie Asset Special Situations Investment Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Manek Growth Fund | 0.891 | 0.000 | 0.963 | 0.170 |

| | | | | |
|---|---|---|---|---|
| Marlborough Special Situations Fund | 0.986 | 0.965 | 0.986 | 0.965 |
| Marlborough UK Micro Cap Growth Fund | 0.982 | 0.965 | 0.982 | 0.965 |
| MFM Techinvest Special Situations Fund | 1.000 | 0.000 | 1.000 | 1.000 |
| Newton UK Smaller Companies Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Old Mutual UK Select Smaller Companies Fund | 0.920 | 0.812 | 0.920 | 0.812 |
| Premier Castlefield UK Smaller Companies Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Prudential Small Companies Trust | 0.931 | 0.840 | 0.934 | 0.877 |
| River & Mercantile UK Equity Smaller Companies Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Royal London UK Smaller Companies Fund | 0.999 | 0.859 | 1.000 | 1.000 |
| Schroder UK Smaller Companies Fund | 0.948 | 0.821 | 0.948 | 0.821 |
| Scottish Widows UK Smaller Companies Fund | 0.858 | 0.635 | 0.868 | 0.679 |
| SF T1PS Smaller Companies Growth Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Standard Life UK Opportunities Fund | 0.869 | 0.769 | 0.869 | 0.769 |
| Standard Life UK Smaller Companies Fund | 0.971 | 0.935 | 0.971 | 0.935 |
| SWIP UK Smaller Companies Fund | 0.869 | 0.656 | 0.872 | 0.671 |
| UBS UK Smaller Companies Fund | 1.000 | 0.000 | 1.000 | 1.000 |
| Unicorn Outstanding British Companies Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| **iShares FTSE 250** | **1.000** | **1.000** | **1.000** | **1.000** |

## UK Domiciled OEICs And UTs With A US Investment Focus

***Table RA2.6:*** ***US Large-Cap Value And Growth Equity (1st January 2008 – 31st December 2010)***

BCC-IO → BCC DEA Model Input-Oriented

BCC-OO → BCC DEA Model Output-Oriented

SORMBCC-IO → SORMBCC DEA Model Input-Oriented

SORMBCC-OO → SORMBCC DEA Model Output-Oriented

| Name Of OEIC/UT | BCC-IO | BCC-OO | SORMBCC-IO | SORMBCC-OO |
|---|---|---|---|---|
| Franklin Mutual Shares Fund | 1.000 | 0.000 | 1.000 | 1.000 |
| GLG US Relative Value Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| J. P. Morgan US Fund | 0.977 | 0.954 | 0.977 | 0.954 |
| M&G North American Value Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Old Mutual North American Equity Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Prudential North American Trust | 0.996 | 0.994 | 0.996 | 0.994 |
| AXA Framlington American Growth Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Baillie Gifford American Fund | 0.993 | 0.934 | 0.993 | 0.934 |
| CF The Westchester Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Fidelity American Special Situations Fund | 0.993 | 0.986 | 0.993 | 0.986 |
| Gartmore US Opportunities Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| GLG American Growth Fund | 0.950 | 0.914 | 0.950 | 0.914 |
| Ignis American Growth Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Martin Currie North American Fund | 0.981 | 0.829 | 1.000 | 1.000 |
| Martin Currie North American Alpha Fund | 0.939 | 0.690 | 1.000 | 1.000 |
| Neptune US Opportunities Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| PSigma American Growth Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Standard Life TM North American Trust | 1.000 | 1.000 | 1.000 | 1.000 |
| Standard Life North American Equity Manager Of Managers Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Threadneedle American Extended Alpha Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Threadneedle American Fund | 0.964 | 0.903 | 0.964 | 0.903 |
| Threadneedle American Select Fund | 0.945 | 0.913 | 0.945 | 0.913 |
| **iShares S&P 500** | **1.000** | **1.000** | **1.000** | **1.000** |

***Table RA2.7:* US Large-Cap Blend Equity (1st January 2008 – 31st December 2010)**

BCC-IO → BCC DEA Model Input-Oriented

BCC-OO → BCC DEA Model Output-Oriented

SORMBCC-IO → SORMBCC DEA Model Input-Oriented

SORMBCC-OO → SORMBCC DEA Model Output-Oriented

| Name Of OEIC/UT | BCC-IO | BCC-OO | SORMBCC-IO | SORMBCC-OO |
|---|---|---|---|---|
| Aberdeen American Equity Fund | 0.936 | 0.855 | 0.936 | 0.855 |
| AEGON American Equity Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Allianz RCM US Equity Fund | 0.924 | 0.960 | 0.924 | 0.960 |
| AXA Rosenberg American Fund | 0.999 | 0.717 | 0.999 | 0.717 |
| BlackRock US Dynamic Fund | 0.951 | 0.743 | 0.951 | 0.743 |
| CF Canada Life North American Fund | 0.954 | 0.924 | 0.954 | 0.924 |
| F&C North American Fund | 0.997 | 0.996 | 0.997 | 0.996 |
| FF&P US Large-Cap Equity Fund | 0.930 | 0.717 | 0.930 | 0.717 |
| Fidelity American Special Situations Fund | 0.984 | 0.978 | 0.984 | 0.978 |
| Franklin US Equity Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Gartmore US Growth Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Henderson American Portfolio Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Henderson North American Enhanced Equity Fund | 0.956 | 0.886 | 0.956 | 0.886 |
| HSBC American Index Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Investec American Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Invesco Perpetual US Equity Fund | 0.979 | 0.893 | 0.979 | 0.893 |
| J. P. Morgan US Select Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Jupiter North American Income Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| L&G (Barclays) Multi-Manager US Alpha Fund | 0.996 | 0.993 | 1.000 | 1.000 |
| L&G North American Trust | 0.956 | 0.829 | 0.956 | 0.829 |
| L&G US Index Trust | 0.956 | 0.840 | 0.956 | 0.840 |
| Legg Mason US Equity Fund | 1.000 | 0.000 | 1.000 | 1.000 |
| M&G American Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Royal London US Index Tracker Trust | 1.000 | 1.000 | 1.000 | 1.000 |
| Santander Premium Fund US Equity Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Schroder QEP US Core Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Scottish Mutual North American Trust | 1.000 | 1.000 | 1.000 | 1.000 |
| Scottish Widows American Growth Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Scottish Widows American Select Growth Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| SSGA North American Equity Tracker Fund | 0.944 | 0.860 | 0.944 | 0.860 |

| | | | | |
|---|---|---|---|---|
| St James's Place North American Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Standard Life American Equity Unconstrained Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Standard Life US Equity Index Tracker Fund | 0.940 | 0.926 | 0.940 | 0.926 |
| SWIP North American Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| UBS US 130/30 Equity Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| UBS US Equity Fund | 0.986 | 0.980 | 0.986 | 0.980 |
| **iShares S&P 500** | **1.000** | **1.000** | **1.000** | **1.000** |

***Table RA2.8:*** ***US Mid-Cap And Small-Cap Equity (1st January 2008 – 31st December 2010)***

BCC-IO → BCC DEA Model Input-Oriented

BCC-OO → BCC DEA Model Output-Oriented

SORMBCC-IO → SORMBCC DEA Model Input-Oriented

SORMBCC-OO → SORMBCC DEA Model Output-Oriented

| Name Of OEIC/UT | BCC-IO | BCC-OO | SORMBCC-IO | SORMBCC-OO |
|---|---|---|---|---|
| CF Greenwich Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| FF&P US All-Cap Value Equity Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| GAM North American Growth Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Melchior North American Opportunities Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Schroder US Mid-Cap Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Scottish Widows American Smaller Companies Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| SWIP North American Smaller Companies Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Threadneedle American Smaller Companies Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| FF&P US Small-Cap Equity Fund | 0.921 | 0.768 | 0.921 | 0.768 |
| J. P. Morgan US Smaller Companies Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Legg Mason US Smaller Companies Fund | 0.990 | 0.955 | 0.990 | 0.955 |
| Schroder US Smaller Companies Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| **iShares S&P 500** | **1.000** | **1.000** | **1.000** | **1.000** |

## UK Domiciled OEICs And UTs With A Global Investment Focus

### *Table RA2.9: Global Large-Cap Value Equity (1st January 2008 – 31st December 2010)*

BCC-IO → BCC DEA Model Input-Oriented

BCC-OO → BCC DEA Model Output-Oriented

SORMBCC-IO → SORMBCC DEA Model Input-Oriented

SORMBCC-OO → SORMBCC DEA Model Output-Oriented

| Name Of OEIC/UT | BCC-IO | BCC-OO | SORMBCC-IO | SORMBCC-OO |
|---|---|---|---|---|
| Aberdeen Charity Select Global Equity Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Aberdeen Ethical World Fund | 0.892 | 0.906 | 0.892 | 0.906 |
| Aberdeen World Equity Fund | 0.905 | 0.907 | 0.905 | 0.907 |
| AXA Rosenberg Global Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Baillie Gifford Global Income Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| CF Stewart Ivory Investment Markets Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Dimensional International Value Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| GAM Global Diversified Fund | 0.956 | 0.915 | 0.956 | 0.915 |
| Gartmore Long-Term Balanced Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| GLG Stockmarket Managed Fund | 0.869 | 0.882 | 0.869 | 0.882 |
| Ignis Global Growth Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Investec Global Special Situations Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Invesco Perpetual Global Core Equity Index Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| J. P. Morgan Global Equity Income Fund | 0.959 | 0.833 | 0.959 | 0.833 |
| L&G Global 100 Index Trust | 0.895 | 0.850 | 0.895 | 0.850 |
| Lazard Global Equity Income Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| M&G Global Leaders Fund | 0.789 | 0.810 | 0.789 | 0.810 |
| Newton Global Higher Income Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Old Mutual Global Equity Fund | 0.838 | 0.848 | 0.838 | 0.848 |
| Prudential International Growth Trust | 0.989 | 0.990 | 0.989 | 0.990 |
| Sarasin International Equity Income Fund | 0.946 | 0.904 | 0.946 | 0.904 |
| Schroder Global Equity Income Fund | 0.983 | 0.981 | 0.983 | 0.981 |
| St James's Place Recovery Fund | 0.855 | 0.622 | 0.855 | 0.622 |
| Templeton Growth Fund | 0.782 | 0.815 | 0.782 | 0.815 |
| Threadneedle Global Equity Income Fund | 1.000 | 1.000 | 1.000 | 1.000 |

| | | | | |
|---|---|---|---|---|
| **iShares MSCI World** | **0.890** | **0.749** | **0.890** | **0.749** |

***Table RA2.10:*** ***Global Large-Cap Growth Equity (1st January 2008 – 31st December 2010)***

BCC-IO → BCC DEA Model Input-Oriented

BCC-OO → BCC DEA Model Output-Oriented

SORMBCC-IO → SORMBCC DEA Model Input-Oriented

SORMBCC-OO → SORMBCC DEA Model Output-Oriented

| Name Of OEIC/UT | BCC-IO | BCC-OO | SORMBCC-IO | SORMBCC-OO |
|---|---|---|---|---|
| AEGON Global Equity Fund | 0.768 | 0.000 | 0.925 | 0.676 |
| Aviva Investors World Leaders Fund | 0.857 | 0.582 | 0.907 | 0.762 |
| AXA Framlington Global Opportunities Fund | 0.808 | 0.045 | 1.000 | 1.000 |
| Baillie Gifford International Fund | 0.976 | 0.977 | 0.976 | 0.977 |
| Baillie Gifford Long-Term Global Growth Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| CF JM Finn Global Opportunities Fund | 0.779 | 0.754 | 0.996 | 0.992 |
| Discovery Managed Growth Fund | 1.000 | 0.000 | 1.000 | 1.000 |
| EFA Ursa Major Growth Portfolio Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| F&C Global Growth Fund | 0.702 | 0.677 | 1.000 | 1.000 |
| F&C International Heritage Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| F&C Stewardship International Fund | 0.886 | 0.892 | 0.886 | 0.892 |
| Fidelity Global Focus Fund | 0.890 | 0.896 | 0.890 | 0.896 |
| Henderson International Fund | 0.795 | 0.767 | 0.825 | 0.822 |
| Margetts Greystone Global Growth Fund | 0.906 | 0.816 | 0.919 | 0.816 |
| Martin Currie Global Alpha Fund | 0.781 | 0.148 | 0.879 | 0.244 |
| NatWest International Growth Fund | 0.820 | 0.811 | 0.821 | 0.837 |
| Neptune Global Equity Fund | 0.840 | 0.781 | 1.000 | 1.000 |
| PFS Taube Global Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| RBS International Growth Fund | 0.816 | 0.811 | 0.817 | 0.836 |
| Sheldon Equity Growth Fund | 1.000 | 0.000 | 1.000 | 1.000 |
| Sheldon Financial Growth Fund | 1.000 | 0.000 | 1.000 | 1.000 |
| St James's Place Worldwide Opportunities Fund | 0.777 | 0.803 | 0.813 | 0.861 |
| Thesis Lion Growth Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Threadneedle Global Select Fund | 0.876 | 0.883 | 0.876 | 0.883 |
| Zenith International Growth Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| **iShares MSCI World** | **1.000** | **1.000** | **1.000** | **1.000** |

***Table RA2.11:* Global Large-Cap Blend Equity (1st January 2008 – 31st December 2010)**

BCC-IO → BCC DEA Model Input-Oriented

BCC-OO → BCC DEA Model Output-Oriented

SORMBCC-IO → SORMBCC DEA Model Input-Oriented

SORMBCC-OO → SORMBCC DEA Model Output-Oriented

| Name Of OEIC/UT | BCC-IO | BCC-OO | SORMBCC-IO | SORMBCC-OO |
|---|---|---|---|---|
| Aberdeen Multi-Manager Constellation Portfolio | 0.535 | 0.593 | 0.842 | 0.710 |
| Aberdeen Multi-Manager International Growth Portfolio | 0.691 | 0.713 | 0.821 | 0.716 |
| Architas Multi-Manager Diversified Share Portfolio | 0.853 | 0.000 | 1.000 | 1.000 |
| Architas Multi-Manager Global Equity Portfolio | 1.000 | 1.000 | 1.000 | 1.000 |
| Artemis Global Growth Fund | 0.288 | 0.000 | 0.780 | 0.265 |
| Aviva Investors Fund Of Funds Balanced Fund | 0.837 | 0.816 | 0.979 | 0.969 |
| Aviva Investors Fund Of Funds Growth Fund | 0.757 | 0.751 | 0.933 | 0.902 |
| Aviva Investors International Index Tracking Fund | 0.688 | 0.783 | 0.877 | 0.818 |
| Aviva Investors SF Global Growth Fund | 0.412 | 0.226 | 0.929 | 0.783 |
| Baillie Gifford Managed Fund | 0.834 | 0.876 | 0.962 | 0.948 |
| Bank Of Scotland International Managed Fund | 0.924 | 0.825 | 0.989 | 0.973 |
| BCIF Balanced Managed Fund | 0.510 | 0.528 | 0.844 | 0.623 |
| BlackRock Active Managed Portfolio Fund | 0.825 | 0.759 | 0.871 | 0.759 |
| BlackRock Global Equity Fund | 0.735 | 0.869 | 0.858 | 0.884 |
| BlackRock International Equity Fund | 0.699 | 0.748 | 0.905 | 0.832 |
| BlackRock Overseas Fund | 0.723 | 0.853 | 0.852 | 0.885 |
| Cazenove Multi-Manager Global Fund | 0.700 | 0.708 | 0.847 | 0.788 |
| CF Adam Worldwide Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| CF Aquarius Fund | 0.589 | 0.208 | 1.000 | 1.000 |
| CF Broden Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| CF Canada Life International Growth Fund | 0.803 | 0.864 | 0.899 | 0.875 |
| CF FundQuest Global Select Fund | 0.940 | 0.842 | 0.940 | 0.842 |
| CF FundQuest Select Opportunities Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| CF FundQuest Select Fund | 0.742 | 0.728 | 0.883 | 0.824 |
| CF Helm Investment Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| CF Lacomp World Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| CF The Aurinko Fund | 0.952 | 0.861 | 0.952 | 0.903 |

| | | | | |
|---|---|---|---|---|
| CF Taylor Young International Equity Fund | 0.925 | 0.854 | 0.952 | 0.938 |
| Chariguard Overseas Equity Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| City Financial Multi-Manager Growth Fund | 0.547 | 0.057 | 0.824 | 0.067 |
| Deutsche Bank PWM Capital Growth Portfolio | 0.917 | 0.951 | 0.945 | 0.962 |
| Ecclesiastical Amity International Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| F&C Lifestyle Growth Fund | 0.707 | 0.698 | 0.891 | 0.837 |
| Family Investments Child Trust Fund | 0.512 | 0.499 | 0.834 | 0.592 |
| FF&P Global Equities II Fund | 0.505 | 0.585 | 0.748 | 0.632 |
| Fidelity Global Special Situations Fund | 0.350 | 0.439 | 0.679 | 0.496 |
| Fidelity International Fund | 0.515 | 0.610 | 0.761 | 0.644 |
| Fidelity MoneyBuilder Global Trust | 0.616 | 0.708 | 0.821 | 0.752 |
| Fidelity WealthBuilder Fund | 0.654 | 0.755 | 0.844 | 0.794 |
| First State Global Growth Fund | 0.990 | 0.969 | 0.997 | 0.994 |
| First State Global Opportunities Fund | 0.655 | 0.699 | 0.791 | 0.711 |
| GAM Composite Absolute Return OEIC | 0.832 | 0.000 | 1.000 | 1.000 |
| GAM Portfolio Unit Trust | 1.000 | 1.000 | 1.000 | 1.000 |
| Gartmore Global Focus Fund | 0.509 | 0.562 | 0.832 | 0.619 |
| Gartmore Multi-Manager Active Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Henderson Global Dividend Income Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Henderson Multi-Manager Active Fund | 0.414 | 0.352 | 0.809 | 0.486 |
| Henderson Multi-Manager Tactical Fund | 0.471 | 0.000 | 0.573 | 0.863 |
| HSBC Global Growth Fund Of Funds | 0.737 | 0.802 | 0.880 | 0.834 |
| HSBC Portfolio Fund | 0.924 | 0.663 | 0.995 | 0.976 |
| IFDS Brown Shipley Multi-Manager International Fund | 0.755 | 0.863 | 0.848 | 0.863 |
| Investec Global Dynamic Fund | 0.976 | 0.990 | 1.000 | 1.000 |
| Investec Global Equity Fund | 0.656 | 0.817 | 0.879 | 0.856 |
| Investec Global Free Enterprise Fund | 0.527 | 0.712 | 0.854 | 0.791 |
| Invesco Perpetual Global Equity Fund | 0.578 | 0.719 | 0.773 | 0.740 |
| Invesco Perpetual Global Enhanced Index Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Invesco Perpetual Global Opportunities Fund | 0.613 | 0.668 | 0.809 | 0.728 |
| Invesco Perpetual Managed Growth Fund | 0.620 | 0.702 | 0.834 | 0.766 |
| Jessop (GAR) Global Equity Quant Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| J. P. Morgan Global Fund | 0.561 | 0.746 | 0.812 | 0.796 |
| J. P. Morgan Portfolio Fund | 0.621 | 0.721 | 0.785 | 0.747 |
| Jupiter Merlin Growth Portfolio Fund | 0.967 | 0.960 | 0.995 | 0.994 |
| Jupiter Merlin Worldwide Portfolio Fund | 0.954 | 0.964 | 1.000 | 1.000 |

| | | | | |
|---|---|---|---|---|
| L&G (Barclays) Adventurous Growth Portfolio Trust | 0.417 | 0.258 | 0.876 | 0.692 |
| L&G Global Growth Trust | 0.666 | 0.627 | 0.828 | 0.639 |
| L&G Worldwide Trust | 0.557 | 0.585 | 0.843 | 0.706 |
| Liberation No. VIII Fund | 0.817 | 0.644 | 1.000 | 1.000 |
| M&G Global Growth Fund | 0.763 | 0.853 | 0.874 | 0.859 |
| Margetts International Strategy Fund | 0.788 | 0.866 | 0.902 | 0.867 |
| Margetts Venture Strategy Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Marlborough Global Fund | 0.883 | 0.526 | 1.000 | 1.000 |
| Martin Currie Global Fund | 0.542 | 0.328 | 0.895 | 0.541 |
| Neptune Global Max Alpha Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Newton 50/50 Global Equity Fund | 0.789 | 0.772 | 0.991 | 0.948 |
| Newton Falcon Fund | 0.820 | 0.865 | 0.942 | 0.922 |
| Newton Global Balanced Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Newton Global Opportunities Fund | 0.604 | 0.787 | 0.874 | 0.849 |
| Newton International Growth Fund | 0.684 | 0.737 | 1.000 | 1.000 |
| Newton Managed Fund | 0.467 | 0.495 | 0.911 | 0.619 |
| Newton Overseas Equity Fund | 0.844 | 0.907 | 1.000 | 1.000 |
| Premier Castlefield Managed Multi-Asset Fund | 0.779 | 0.849 | 0.852 | 0.849 |
| Prudential (Invesco Perpetual) Managed Trust | 0.606 | 0.591 | 0.764 | 0.668 |
| S&W Endurance Global Opportunities Fund | 0.979 | 0.848 | 1.000 | 1.000 |
| Santander Multi-Manager Equity Fund | 0.500 | 0.535 | 0.710 | 0.562 |
| Sarasin Alpha CIF Income & Reserves Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Sarasin EquiSar Global Thematic Fund | 0.562 | 0.642 | 0.786 | 0.691 |
| Sarasin EquiSar IIID Fund | 0.531 | 0.047 | 1.000 | 1.000 |
| Schroder Global Equity Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Schroder Growth Fund | 1.000 | 0.000 | 1.000 | 1.000 |
| Schroder QEP Global Quant Core Equity Fund | 0.949 | 0.948 | 0.983 | 0.976 |
| Scottish Mutual International Growth Trust | 0.772 | 0.858 | 0.879 | 0.906 |
| Scottish Mutual Opportunity Trust | 0.823 | 0.703 | 0.908 | 0.760 |
| Scottish Widows Global Growth Fund | 0.511 | 0.536 | 0.727 | 0.570 |
| Scottish Widows Global Select Growth Fund | 0.524 | 0.528 | 0.767 | 0.589 |
| Scottish Widows International Equity Tracker Fund | 0.653 | 0.543 | 0.840 | 0.581 |
| Skandia Ethical Fund | 0.428 | 0.259 | 0.671 | 0.280 |
| Skandia Global Best Ideas Fund | 0.486 | 0.612 | 0.646 | 0.628 |
| Skandia Newton Managed Fund | 0.563 | 0.462 | 0.779 | 0.564 |
| Standard Life TM Global Equity Trust | 1.000 | 1.000 | 1.000 | 1.000 |
| Standard Life TM International Trust | 1.000 | 1.000 | 1.000 | 1.000 |
| St James's Place Ethical Fund | 0.469 | 0.511 | 0.651 | 0.519 |
| St James's Place International Fund | 0.434 | 0.387 | 0.697 | 0.408 |
| Standard Life Global Equity Fund | 0.674 | 0.783 | 0.723 | 0.783 |
| SVM Global Opportunities Fund | 0.680 | 0.000 | 0.941 | 0.924 |
| SWIP Global Fund | 0.794 | 0.518 | 0.817 | 0.528 |
| SWIP Multi-Manager International Equity Fund | 0.658 | 0.722 | 0.742 | 0.722 |

| | | | | |
|---|---|---|---|---|
| SWIP Multi-Manager Select Boutiques Fund | 0.860 | 0.720 | 0.861 | 0.740 |
| T. Bailey Growth Fund | 0.394 | 0.391 | 0.640 | 0.416 |
| Thames River Equity Managed Fund | 0.927 | 0.732 | 0.937 | 0.737 |
| Thames River Global Boutiques Fund | 0.761 | 0.720 | 0.815 | 0.754 |
| Threadneedle Global Equity Fund | 0.611 | 0.619 | 0.725 | 0.639 |
| Threadneedle Navigator Adventurous Managed Trust | 0.912 | 0.870 | 0.912 | 0.870 |
| THS International Growth & Value Fund | 0.492 | 0.478 | 0.744 | 0.503 |
| UBS Global Optimal Fund | 0.756 | 0.714 | 0.756 | 0.714 |
| UBS Global Optimal Thirds Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| WAY Global Red Active Portfolio Fund | 0.659 | 0.609 | 0.762 | 0.668 |
| Wesleyan International Trust | 0.745 | 0.501 | 0.748 | 0.501 |
| Williams De Broe Global Fund | 0.783 | 0.829 | 0.783 | 0.829 |
| **iShares MSCI World** | **0.769** | **0.697** | **0.962** | **0.848** |

***Table RA2.12:* Global Mid-Cap And Small-Cap Equity (1st January 2008 – 31st December 2010)**

BCC-IO → BCC DEA Model Input-Oriented

BCC-OO → BCC DEA Model Output-Oriented

SORMBCC-IO → SORMBCC DEA Model Input-Oriented

SORMBCC-OO → SORMBCC DEA Model Output-Oriented

| Name Of OEIC/UT | BCC-IO | BCC-OO | SORMBCC-IO | SORMBCC-OO |
|---|---|---|---|---|
| AXA Framlington Talents Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Baillie Gifford Phoenix Global Growth Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Hargreaves Lansdown Multi-Manager Special Situations Trust | 0.930 | 0.890 | 0.930 | 0.890 |
| Invesco Perpetual Global Smaller Companies Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| J. P. Morgan Multi-Manager Growth Fund | 0.977 | 0.654 | 0.977 | 0.654 |
| L&G (Barclays) Multi-Manager Global Core Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| M&G Fund Of Investment Trust Shares | 1.000 | 1.000 | 1.000 | 1.000 |
| M&G Global Basics Fund | 0.944 | 0.947 | 0.944 | 0.947 |
| Neptune Green Planet Fund | 1.000 | 0.000 | 1.000 | 1.000 |
| Rathbone Global Opportunities Fund | 0.914 | 0.784 | 0.914 | 0.784 |
| S&W Aubrey Global Conviction Fund | 0.942 | 0.939 | 0.943 | 0.939 |

| | | | | |
|---|---|---|---|---|
| SF Adventurous Portfolio Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| St James's Place Global Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| **iShares MSCI World** | **1.000** | **1.000** | **1.000** | **1.000** |

# Results Appendix 3 – SBM & SORMSBM DEA Models

## UK Domiciled OEICs And UTs With A UK Investment Focus

***Table RA3.1:*** ***UK Large-Cap Value Equity (1st January 2008 – 31st December 2010)***

SBM-IO → SBM DEA Model Input-Oriented (CRS)

SBM-OO → SBM DEA Model Output-Oriented (CRS)

SORMSBM-IO → SORMSBM DEA Model Input-Oriented (CRS)

SORMSBM-OO → SORMSBM DEA Model Output-Oriented (CRS)

| Name Of OEIC/UT | SBM-IO | SBM-OO | SORMSBM-IO | SORMSBM-OO |
|---|---|---|---|---|
| Aberdeen Charity Select UK Equity Fund | 0.526 | 0.762 | 0.621 | 0.866 |
| Aberdeen Multi-Manager UK Income Portfolio | 0.508 | 0.791 | 0.606 | 0.883 |
| Aberdeen Responsible UK Equity Fund | 0.439 | 0.684 | 0.551 | 0.812 |
| Aberdeen UK Equity Fund | 0.334 | 0.607 | 0.467 | 0.756 |
| Aberdeen UK Equity Income Fund | 0.310 | 0.569 | 0.448 | 0.726 |
| Artemis Income Fund | 0.397 | 0.664 | 0.518 | 0.799 |
| Cazenove UK Growth & Income Fund | 0.423 | 0.714 | 0.538 | 0.833 |
| Capita Financial Taylor Young Equity Income Fund | 0.418 | 0.668 | 0.534 | 0.801 |
| Capita Financial Walker Crips UK Growth Fund | 0.545 | 0.805 | 0.636 | 0.892 |
| Dimensional UK Core Equity Fund | 0.440 | 0.733 | 0.552 | 0.846 |
| Dimensional UK Value Fund | 0.380 | 1.000 | 0.475 | 0.826 |
| Elite Henderson Rowe Dogs FTSE 100 Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| F&C UK Equity Income Fund | 0.341 | 0.593 | 0.473 | 0.744 |
| F&C UK Growth & Income Fund | 0.305 | 0.564 | 0.444 | 0.722 |
| Family Asset Trust | 0.287 | 1.000 | 0.343 | 0.564 |
| Fidelity Special Situations Fund | 0.414 | 0.752 | 0.531 | 0.859 |
| Gartmore UK Alpha Fund | 0.527 | 1.000 | 0.532 | 0.862 |
| Gartmore UK Equity Income Fund | 0.257 | 0.496 | 0.406 | 0.664 |
| Gartmore UK Growth Fund | 0.352 | 1.000 | 0.384 | 0.593 |
| GLG UK Growth Fund | 0.315 | 1.000 | 0.347 | 0.539 |
| GLG UK Income Fund | 0.174 | 0.327 | 0.339 | 0.495 |
| HL Multi-Manager Income & Growth Portfolio Trust | 0.460 | 0.770 | 0.568 | 0.870 |
| HSBC Income Fund | 0.352 | 0.612 | 0.481 | 0.759 |
| Ignis UK Equity Income Fund | 0.336 | 0.612 | 0.469 | 0.759 |
| Insight Investment Equity High Income Fund | 0.346 | 0.626 | 0.477 | 0.771 |
| Investec UK Special Situations Fund | 0.807 | 0.956 | 0.846 | 0.978 |
| Invesco Perpetual Children's Fund | 0.280 | 0.520 | 0.424 | 0.685 |

| | | | | |
|---|---|---|---|---|
| Invesco Perpetual High Income Fund | 0.355 | 0.660 | 0.484 | 0.799 |
| Invesco Perpetual Income & Growth Fund | 0.159 | 0.298 | 0.327 | 0.460 |
| Invesco Perpetual Income Fund | 0.361 | 0.673 | 0.489 | 0.808 |
| Invesco Perpetual UK Aggressive Fund | 0.274 | 0.499 | 0.419 | 0.667 |
| Invesco Perpetual UK Enhanced Index Fund | 0.547 | 0.746 | 0.638 | 0.855 |
| Invesco Perpetual UK Growth Fund | 0.304 | 1.000 | 0.354 | 0.579 |
| JoHambro Capital Management UK Equity Income Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| J. P. Morgan Premier Equity Income Fund | 0.292 | 0.544 | 0.434 | 0.705 |
| J. P. Morgan UK Managed Equity Fund | 0.273 | 0.509 | 0.418 | 0.676 |
| J. P. Morgan UK Strategic Equity Income Fund | 0.286 | 0.528 | 0.429 | 0.693 |
| Jupiter Undervalued Assets Fund | 0.303 | 1.000 | 0.371 | 0.630 |
| L&G (Barclays) MM UK Equity Income Fund | 0.448 | 0.758 | 0.558 | 0.863 |
| Lazard UK Income Fund | 0.329 | 0.598 | 0.463 | 0.751 |
| Legg Mason UK Equity Fund | 0.309 | 0.570 | 0.447 | 0.726 |
| M&G Charifund | 0.285 | 1.000 | 0.305 | 0.455 |
| M&G Dividend Fund | 0.362 | 0.650 | 0.490 | 0.788 |
| M&G Income Fund | 0.465 | 0.754 | 0.572 | 0.860 |
| Neptune Income Fund | 0.425 | 0.750 | 0.540 | 0.857 |
| Neptune Quarterly Income Fund | 0.354 | 0.612 | 0.483 | 0.759 |
| Neptune UK Equity Fund | 0.506 | 0.796 | 0.605 | 0.887 |
| Neptune UK Special Situations Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Old Mutual Equity Income Fund | 0.499 | 0.713 | 0.599 | 0.833 |
| Old Mutual Extra Income Fund | 0.506 | 0.782 | 0.605 | 0.878 |
| Premier UK Strategic Growth Fund | 0.433 | 0.627 | 0.547 | 0.771 |
| Prudential Ethical Trust Fund | 0.368 | 1.000 | 0.393 | 0.643 |
| PSigma Income Fund | 0.007 | 0.011 | 0.205 | 0.022 |
| PSigma UK Growth Fund | 0.031 | 0.036 | 0.225 | 0.070 |
| Rathbone Blue Chip Income & Growth Fund | 0.402 | 0.700 | 0.521 | 0.823 |
| Rathbone Income Fund | 0.002 | 0.004 | 0.202 | 0.008 |
| River & Mercantile UK Equity High Alpha Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| S&W Church House Balanced Value & Income Fund | 0.443 | 0.787 | 0.554 | 0.881 |
| S&W Church House UK Managed Growth Fund | 0.527 | 0.782 | 0.621 | 0.878 |
| S&W FTIM Munro Fund | 0.225 | 0.314 | 0.380 | 0.478 |
| Schroder Charity Equity Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Schroder Income Fund | 0.567 | 0.863 | 0.654 | 0.926 |
| Schroder Income Maximiser Fund | 0.552 | 0.831 | 0.642 | 0.908 |
| Schroder Recovery Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Schroder Specialist Value UK Equity Fund | 0.759 | 0.942 | 0.807 | 0.970 |
| Scottish Widows Ethical Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Scottish Widows UK Equity Income Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Scottish Widows UK Growth Fund | 0.560 | 0.754 | 0.648 | 0.860 |
| Skandia Multi-Manager UK Equity Fund | 0.353 | 0.625 | 0.482 | 0.770 |

| | | | | |
|---|---|---|---|---|
| St James's Place Equity Income Fund | 0.512 | 0.809 | 0.610 | 0.895 |
| St James's Place UK Growth Fund | 0.587 | 0.907 | 0.670 | 0.951 |
| St James's Place UK High Income Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Standard Life UK Equity High Income Fund | 0.181 | 0.349 | 0.345 | 0.518 |
| Standard Life UK Equity Manager Of Managers Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| SWIP Multi-Manager UK Equity Income Fund | 0.687 | 0.925 | 0.750 | 0.962 |
| SWIP UK Income Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| TB Wise Income Fund | 0.718 | 0.895 | 0.775 | 0.945 |
| Templeton UK Equity Fund | 0.263 | 1.000 | 0.341 | 0.420 |
| Troy Trojan Income Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| UBS UK Select Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| **iShares FTSE 100** | **0.422** | **0.912** | **0.538** | **0.956** |

***Table RA3.2:* UK Large-Cap Growth Equity (1st January 2008 – 31st December 2010)**

SBM-IO → SBM DEA Model Input-Oriented (CRS)

SBM-OO → SBM DEA Model Output-Oriented (CRS)

SORMSBM-IO → SORMSBM DEA Model Input-Oriented (CRS)

SORMSBM-OO → SORMSBM DEA Model Output-Oriented (CRS)

| Name Of OEIC/UT | SBM-IO | SBM-OO | SORMSBM-IO | SORMSBM-OO |
|---|---|---|---|---|
| AEGON UK Opportunities Fund | 0.614 | 0.932 | 0.691 | 0.965 |
| BlackRock UK Fund | 0.336 | 0.919 | 0.469 | 0.958 |
| BlackRock UK Dynamic Fund | 0.481 | 0.997 | 0.584 | 1.000 |
| FF&P Concentrated UK Equity Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Fidelity UK Growth Fund | 0.613 | 0.901 | 0.691 | 0.948 |
| L&G (N) UK Growth Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Mirabaud Mir GB Fund | 0.418 | 0.686 | 0.534 | 0.814 |
| Royal London UK Opportunities Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| SVM UK Growth Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| **iShares FTSE 100** | **1.000** | **1.000** | **1.000** | **1.000** |

***Table RA3.3:* UK Large-Cap Blend Equity (1st January 2008 – 31st December 2010)**

SBM-IO → SBM DEA Model Input-Oriented (CRS)

SBM-OO → SBM DEA Model Output-Oriented (CRS)

SORMSBM-IO → SORMSBM DEA Model Input-Oriented (CRS)

SORMSBM-OO → SORMSBM DEA Model Output-Oriented (CRS)

| Name Of OEIC/UT | SBM-IO | SBM-OO | SORMSBM-IO | SORMSBM-OO |
|---|---|---|---|---|
| Aberdeen Multi-Manager UK Growth Portfolio | 0.553 | 0.935 | 0.643 | 0.966 |
| AEGON UK Equity Fund | 0.513 | 0.775 | 0.611 | 0.873 |
| Allianz RCM UK Equity Fund | 0.437 | 0.726 | 0.550 | 0.873 |
| Allianz RCM UK Growth Fund | 0.388 | 0.541 | 0.511 | 0.704 |
| Allianz RCM UK Index Fund | 0.804 | 0.884 | 0.843 | 0.939 |
| Allianz RCM UK Unconstrained Fund | 0.389 | 1.000 | 0.459 | 0.750 |
| Architas Multi-Manager UK Equity Portfolio | 0.469 | 0.798 | 0.601 | 0.922 |
| Artemis Capital Fund | 1.000 | 0.200 | 0.301 | 0.346 |
| Artemis UK Growth Fund | 0.453 | 0.777 | 0.562 | 0.879 |
| Aviva Investors UK Equity Fund | 0.719 | 0.863 | 0.776 | 0.927 |
| Aviva Investors UK Focus Fund | 0.638 | 0.865 | 0.711 | 0.929 |
| Aviva Investors UK Growth Fund | 0.646 | 0.840 | 0.717 | 0.913 |
| AXA Framlington UK Growth Fund | 0.586 | 0.882 | 0.669 | 0.940 |
| AXA General Trust | 0.526 | 0.766 | 0.621 | 0.872 |
| Baillie Gifford British 350 Fund | 0.728 | 0.920 | 0.782 | 0.958 |
| Baillie Gifford UK Equity Alpha Fund | 0.662 | 0.896 | 0.729 | 0.948 |
| Bank Of Scotland FTSE 100 Tracker Fund | 0.651 | 0.863 | 0.721 | 0.927 |
| BlackRock Armed Forces Common Investment Fund | 0.493 | 0.763 | 0.594 | 0.868 |
| BlackRock Charishare Fund | 0.492 | 0.717 | 0.594 | 0.839 |
| BlackRock UK Equity Fund | 0.660 | 0.845 | 0.728 | 0.916 |
| BlackRock UK Income Fund | 0.603 | 0.931 | 0.682 | 0.965 |
| Cazenove Multi-Manager UK Growth Fund | 0.505 | 0.808 | 0.604 | 0.906 |
| Cazenove UK Opportunities Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| CF Canada Life General Trust | 0.318 | 0.499 | 0.454 | 0.674 |
| CF Canada Life Growth Fund | 0.467 | 0.755 | 0.574 | 0.877 |
| CF GHC Multi-Manager UK Equity OEIC | 0.515 | 0.838 | 0.612 | 0.912 |
| CF JM Finn UK Portfolio Fund | 0.440 | 0.709 | 0.552 | 0.829 |
| CF Lindsell Train UK Equity Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| CF Taylor Young Growth & Income Fund | 0.653 | 0.877 | 0.722 | 0.935 |
| CF Walker Crips UK High Alpha Fund | 0.762 | 0.937 | 0.810 | 0.967 |
| Chariguard UK Equity Fund | 0.529 | 0.705 | 0.623 | 0.829 |

| | | | | |
|---|---|---|---|---|
| CIS UK FTSE4Good Tracker Trust | 0.586 | 0.796 | 0.669 | 0.887 |
| EFA OPM UK Equity Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Engage Investment Growth Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Epworth Affirmative Equity Fund | 0.383 | 0.543 | 0.506 | 0.704 |
| F&C FTSE All-Share Tracker Fund | 0.682 | 0.860 | 0.745 | 0.925 |
| F&C UK Equity Fund | 0.660 | 0.884 | 0.728 | 0.939 |
| Family Charities Ethical Trust | 1.000 | 1.000 | 1.000 | 1.000 |
| Fidelity MoneyBuilder UK Index Fund | 0.597 | 0.891 | 0.678 | 0.943 |
| Fidelity UK Aggressive Fund | 0.516 | 0.797 | 0.613 | 0.887 |
| GAM MP UK Equity Unit Trust | 0.771 | 0.939 | 0.817 | 0.969 |
| Gartmore UK Index Fund | 0.535 | 0.801 | 0.628 | 0.890 |
| Gartmore UK Tracker Fund | 0.525 | 0.761 | 0.620 | 0.871 |
| HBOS UK FTSE 100 Index Track Fund | 0.398 | 0.702 | 0.519 | 0.834 |
| Henderson UK Equity Tracker Trust | 0.482 | 0.612 | 0.586 | 0.767 |
| Henderson UK High Alpha Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| HSBC FTSE 100 Index Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| HSBC FTSE All Share Index Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| HSBC MERIT UK Equity Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| HSBC UK Focus Fund | 0.643 | 0.861 | 0.714 | 0.925 |
| HSBC UK Freestyle Fund | 0.695 | 0.622 | 1.000 | 1.000 |
| HSBC UK Growth & Income Fund | 0.615 | 0.870 | 0.692 | 0.937 |
| IFDS Brown Shipley UK Flagship Fund | 0.664 | 0.874 | 0.731 | 0.933 |
| Ignis Balanced Growth Fund | 0.293 | 0.451 | 0.434 | 0.640 |
| Ignis Cartesian UK Opportunities Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Ignis UK Focus Fund | 0.468 | 0.707 | 0.575 | 0.836 |
| Insight Investment UK Dynamic Managed Fund | 0.489 | 0.812 | 0.591 | 0.896 |
| Investec UK Alpha Fund | 0.633 | 0.806 | 0.707 | 0.893 |
| Investec UK Blue Chip Fund | 0.488 | 0.769 | 0.590 | 0.873 |
| Invesco Perpetual UK Strategic Income Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Jessop Gartmore UK Index Fund | 0.664 | 0.865 | 0.731 | 0.927 |
| JoHambro Capital Management UK Opportunities Fund | 0.510 | 0.772 | 0.608 | 0.872 |
| J. P. Morgan Premier Equity Growth Fund | 0.211 | 0.335 | 0.369 | 0.518 |
| J. P. Morgan UK Active Index Plus Fund | 0.666 | 0.835 | 0.733 | 0.910 |
| J. P. Morgan UK Dynamic Fund | 0.454 | 0.713 | 0.563 | 0.841 |
| J. P. Morgan UK Focus Fund | 0.579 | 0.818 | 0.663 | 0.900 |
| Jupiter UK Alpha Fund | 0.744 | 0.906 | 0.795 | 0.951 |
| L&G (Barclays) Market Track 350 Trust | 0.575 | 0.776 | 0.660 | 0.874 |
| L&G (Barclays) Multi-Manager UK Alpha Fund | 0.360 | 0.663 | 0.488 | 0.810 |
| L&G (Barclays) Multi-Manager UK Alpha (Series 2) Fund | 0.412 | 0.616 | 0.529 | 0.778 |
| L&G (Barclays) Multi-Manager UK Core Fund | 0.505 | 0.838 | 0.604 | 0.923 |
| L&G (Barclays) Multi-Manager UK Opportunities Fund | 0.614 | 0.884 | 0.691 | 0.939 |
| L&G Capital Growth Fund | 0.460 | 0.751 | 0.568 | 0.865 |
| L&G (N) UK Tracker Trust | 0.424 | 0.775 | 0.539 | 0.880 |
| L&G CAF UK Equitrack Fund | 1.000 | 1.000 | 1.000 | 1.000 |

| | | | | |
|---|---|---|---|---|
| L&G Equity Trust | 0.355 | 0.496 | 0.514 | 0.668 |
| L&G Ethical Trust | 0.498 | 0.602 | 0.598 | 0.758 |
| L&G Growth Trust | 0.527 | 0.734 | 0.621 | 0.847 |
| L&G UK 100 Index Trust | 0.525 | 0.750 | 0.620 | 0.860 |
| L&G UK Active Opportunities Trust | 0.395 | 0.653 | 0.516 | 0.803 |
| L&G UK Index Trust | 0.506 | 0.825 | 0.605 | 0.904 |
| Lazard UK Alpha Fund | 0.523 | 0.817 | 0.619 | 0.900 |
| Lazard UK Omega Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| LV UK Growth Fund | 0.452 | 0.656 | 0.561 | 0.792 |
| M&G Index Tracker Fund | 0.600 | 0.783 | 0.680 | 0.878 |
| M&G Recovery Fund | 0.523 | 0.864 | 0.618 | 0.928 |
| M&G UK Growth Fund | 0.462 | 0.741 | 0.570 | 0.852 |
| M&G UK Select Fund | 0.589 | 0.833 | 0.671 | 0.909 |
| Majedie AM UK Equity Fund | 0.673 | 0.880 | 0.738 | 0.936 |
| Majedie AM UK Focus Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| M&S Ethical Fund | 0.873 | 0.978 | 1.000 | 1.000 |
| M&S UK 100 Companies Fund | 0.528 | 0.819 | 0.623 | 0.907 |
| M&S UK Selection Portfolio | 0.429 | 0.630 | 0.543 | 0.789 |
| Morgan Stanley UK Equity Alpha Fund | 0.681 | 0.992 | 1.000 | 1.000 |
| Old Mutual UK Select Equity Fund | 0.541 | 0.787 | 0.632 | 0.881 |
| Premier Castlefield UK Alpha Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Premier Castlefield UK Equity Fund | 0.683 | 0.886 | 0.746 | 0.943 |
| Prudential UK Growth Trust | 0.539 | 0.835 | 0.631 | 0.910 |
| Prudential UK Index Tracker Trust | 1.000 | 1.000 | 1.000 | 1.000 |
| RBS FTSE 100 Tracker Fund | 0.554 | 0.757 | 0.643 | 0.862 |
| Royal London FTSE 350 Tracker Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Royal London UK Equity Fund | 0.554 | 0.821 | 0.644 | 0.902 |
| Santander Premium Fund UK Equity | 0.459 | 0.801 | 0.568 | 0.895 |
| Santander Stockmarket 100 Tracker Trust | 0.733 | 0.877 | 0.786 | 0.935 |
| Santander UK Growth Trust | 0.448 | 0.790 | 0.559 | 0.887 |
| Schroder Specialist UK Equity Fund | 0.927 | 0.985 | 0.941 | 0.992 |
| Schroder Prime UK Equity Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Schroder UK Alpha Plus Fund | 0.478 | 0.846 | 0.583 | 0.920 |
| Schroder UK Equity Fund | 0.499 | 0.829 | 0.599 | 0.910 |
| Scottish Friendly UK Growth Fund | 0.652 | 0.830 | 0.721 | 0.907 |
| Scottish Mutual UK All-Share Index Trust | 1.000 | 1.000 | 1.000 | 1.000 |
| Scottish Mutual UK Equity Trust | 0.452 | 0.659 | 0.562 | 0.796 |
| Scottish Widows UK All-Share Tracker Fund | 0.512 | 0.789 | 0.609 | 0.883 |
| Scottish Widows UK Select Growth Fund | 0.567 | 0.862 | 0.654 | 0.929 |
| Scottish Widows UK Tracker Fund | 0.539 | 0.741 | 0.631 | 0.851 |
| Skandia Multi-Manager UK Index Fund | 0.527 | 0.831 | 0.621 | 0.908 |
| Skandia Multi-Manager UK Opportunities Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Standard Life TM UK General Equity Fund | 0.361 | 0.649 | 0.489 | 0.789 |
| SSGA UK Equity Enhanced Fund | 0.681 | 0.871 | 0.745 | 0.936 |
| SSGA UK Equity Tracker Fund | 0.552 | 0.846 | 0.641 | 0.921 |

| | | | | |
|---|---|---|---|---|
| St James's Place UK & General Progressive Fund | 0.404 | 1.000 | 0.475 | 0.633 |
| Standard Life UK Equity Growth Fund | 0.384 | 0.687 | 0.507 | 0.827 |
| SWIP Multi-Manager UK Equity Focus Fund | 0.314 | 0.454 | 0.451 | 0.644 |
| SWIP Multi-Manager UK Equity Growth Fund | 0.370 | 0.627 | 0.496 | 0.779 |
| SWIP UK Opportunities Fund | 0.717 | 0.887 | 0.774 | 0.940 |
| Threadneedle Navigator UK Index Tracker Fund | 0.548 | 0.768 | 0.638 | 0.869 |
| Threadneedle UK Extended Alpha Fund | 0.343 | 0.614 | 0.475 | 0.817 |
| Troy Trojan Capital Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| UBS UK Equity Income Find | 1.000 | 1.000 | 1.000 | 1.000 |
| Wesleyan Growth Trust | 0.487 | 0.737 | 0.590 | 0.848 |
| **iShares FTSE 100** | **0.385** | **0.671** | **0.508** | **0.804** |

***Table RA3.4:* UK Mid-Cap Equity (1st January 2008 – 31st December 2010)**

SBM-IO → SBM DEA Model Input-Oriented (CRS)

SBM-OO → SBM DEA Model Output-Oriented (CRS)

SORMSBM-IO → SORMSBM DEA Model Input-Oriented (CRS)

SORMSBM-OO → SORMSBM DEA Model Output-Oriented (CRS)

| Name Of OEIC/UT | SBM-IO | SBM-OO | SORMSBM-IO | SORMSBM-OO |
|---|---|---|---|---|
| Aberdeen UK Mid-Cap Fund | 0.544 | 0.854 | 0.635 | 0.945 |
| AEGON Ethical Equity Fund | 0.402 | 0.608 | 0.522 | 0.783 |
| Allianz RCM UK Mid-Cap Fund | 0.526 | 0.777 | 0.621 | 0.892 |
| Artemis UK Special Situations Fund | 0.477 | 0.726 | 0.582 | 0.846 |
| Aviva Investors SF UK Growth Fund | 0.545 | 0.696 | 0.796 | 0.975 |
| Aviva Investors UK Ethical Fund | 0.660 | 0.903 | 1.000 | 1.000 |
| Aviva Investors UK Special Situations Fund | 0.441 | 0.668 | 0.553 | 0.825 |
| AXA Framlington Equity Income Fund | 0.332 | 1.000 | 0.466 | 0.629 |
| AXA Framlington Monthly Income Fund | 0.714 | 1.000 | 0.779 | 0.938 |
| AXA Framlington UK Select Opportunities Fund | 0.521 | 0.755 | 0.617 | 0.861 |
| BlackRock UK Special Situations Fund | 0.601 | 0.862 | 0.681 | 0.926 |
| Cazenove UK Dynamic Fund | 0.654 | 0.917 | 0.723 | 0.970 |
| CF Cornelian British Opportunities Fund | 0.406 | 0.712 | 0.525 | 0.982 |

| | | | | |
|---|---|---|---|---|
| CF OLIM UK Equity Trust | 0.526 | 0.700 | 0.621 | 0.850 |
| CF Taylor Young Growth Fund | 0.289 | 0.534 | 0.431 | 0.749 |
| CF Taylor Young Opportunistic Fund | 0.394 | 0.664 | 0.515 | 0.923 |
| Ecclesiastical Amity UK Fund | 0.498 | 0.802 | 0.599 | 0.919 |
| F&C Stewardship Growth Fund | 0.666 | 0.555 | 1.000 | 1.000 |
| F&C Stewardship Income Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| F&C UK Mid-Cap Fund | 0.823 | 0.925 | 0.858 | 0.961 |
| F&C UK Opportunities Fund | 0.281 | 0.347 | 0.433 | 0.853 |
| GAM UK Diversified Fund | 0.641 | 0.892 | 0.713 | 0.964 |
| Henderson UK Alpha Fund | 0.312 | 0.503 | 0.450 | 0.711 |
| HSBC FTSE 250 Index Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| L&G (Barclays) Multi-Manager UK Lower-Cap Fund | 0.633 | 0.804 | 0.706 | 0.896 |
| Majedie UK Opportunities Fund | 0.256 | 0.472 | 0.405 | 0.671 |
| Marlborough Ethical Fund | 0.592 | 0.828 | 0.674 | 0.935 |
| Marlborough UK Primary Opportunities Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Melchior UK Opportunities Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| MFM Bowland Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| MFM Slater Recovery Fund | 0.925 | 0.969 | 0.940 | 0.984 |
| Old Mutual UK Select Mid-Cap Fund | 0.522 | 0.754 | 0.617 | 0.865 |
| Rathbone Recovery Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Real Life Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Rensburg UK Managers' Focus Trust | 0.608 | 0.756 | 0.686 | 0.862 |
| Royal London UK Mid-Cap Growth Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Saracen Growth Fund | 0.359 | 1.000 | 0.430 | 0.641 |
| Schroder UK Mid 250 Fund | 0.219 | 0.412 | 0.375 | 0.627 |
| Skandia UK Best Ideas Fund | 0.309 | 1.000 | 0.441 | 0.544 |
| Standard Life UK Equity High Alpha Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Standard Life UK Equity Income Unconstrained Fund | 0.257 | 0.488 | 0.406 | 0.724 |
| Standard Life UK Equity Unconstrained Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Standard Life UK Ethical Fund | 0.372 | 0.609 | 0.498 | 0.806 |
| SVM UK Opportunities Fund | 0.572 | 0.845 | 0.657 | 0.928 |
| Threadneedle UK Mid 250 Fund | 0.652 | 0.825 | 0.721 | 0.907 |
| **iShares FTSE 250** | **1.000** | **1.000** | **1.000** | **1.000** |

***Table RA3.5:* UK Small-Cap Equity (1st January 2008 – 31st December 2010)**

SBM-IO → SBM DEA Model Input-Oriented (CRS)

SBM-OO → SBM DEA Model Output-Oriented (CRS)

SORMSBM-IO → SORMSBM DEA Model Input-Oriented (CRS)

SORMSBM-OO → SORMSBM DEA Model Output-Oriented (CRS)

| Name Of OEIC/UT | SBM-IO | SBM-OO | SORMSBM-IO | SORMSBM-OO |
|---|---|---|---|---|
| Aberdeen UK Smaller Companies Fund | 0.410 | 0.644 | 0.528 | 0.792 |
| Aberforth UK Small Companies Fund | 0.477 | 0.732 | 0.581 | 0.851 |
| AEGON UK Smaller Companies Fund | 0.789 | 0.807 | 0.832 | 0.893 |
| Artemis UK Smaller Companies Fund | 0.266 | 1.000 | 0.230 | 0.157 |
| Aviva Investors UK Smaller Companies Fund | 0.585 | 0.771 | 0.668 | 0.871 |
| AXA Framlington UK Smaller Companies Fund | 0.335 | 0.623 | 0.468 | 0.865 |
| Baillie Gifford British Smaller Companies Fund | 0.543 | 0.769 | 0.634 | 0.869 |
| BlackRock Growth And Recovery Fund | 0.334 | 0.596 | 0.467 | 0.777 |
| BlackRock UK Smaller Companies Fund | 0.501 | 0.736 | 0.601 | 0.848 |
| Cazenove UK Smaller Companies Fund | 0.605 | 0.822 | 0.684 | 0.915 |
| CF Amati UK Smaller Companies Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| CF Canada Life UK Smaller Companies Fund | 0.325 | 0.610 | 0.460 | 0.896 |
| CF Chelverton UK Equity Income Fund | 0.345 | 0.582 | 0.476 | 0.809 |
| CF Octopus UK Micro Cap Growth Fund | 0.355 | 0.615 | 0.484 | 0.998 |
| Close Special Situations Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Dimensional UK Small Companies Fund | 0.570 | 0.825 | 0.656 | 0.904 |
| Discretionary Fund | 0.199 | 0.399 | 0.359 | 0.685 |
| F&C UK Smaller Companies Fund | 0.501 | 0.676 | 0.601 | 0.829 |
| Gartmore UK & Irish Smaller Companies Fund | 0.315 | 0.601 | 0.452 | 0.843 |
| Henderson UK Smaller Companies Fund | 0.456 | 0.718 | 0.565 | 0.870 |
| Henderson UK Strategic Capital Trust | 0.125 | 0.204 | 0.300 | 0.582 |
| HSBC UK Smaller Companies Fund | 0.493 | 0.772 | 0.594 | 0.871 |
| Ignis Smaller Companies Fund | 0.351 | 0.573 | 0.481 | 0.755 |
| Investec UK Smaller Companies Fund | 0.698 | 0.909 | 0.758 | 0.953 |
| Invesco Perpetual UK Smaller Companies Equity Fund | 0.330 | 0.594 | 0.464 | 0.780 |
| Invesco Perpetual UK Smaller Companies Growth Fund | 0.314 | 1.000 | 0.328 | 0.553 |
| J. P. Morgan UK Smaller Companies Fund | 0.364 | 0.631 | 0.491 | 0.823 |
| Jupiter UK Smaller Companies Fund | 0.332 | 0.599 | 0.465 | 0.807 |
| L&G UK Alpha Trust | 1.000 | 1.000 | 1.000 | 1.000 |
| L&G UK Smaller Companies Trust | 0.509 | 0.744 | 0.607 | 0.853 |
| M&G Smaller Companies Fund | 0.496 | 0.773 | 0.597 | 0.905 |
| Majedie Asset Special Situations Investment Fund | 0.688 | 0.877 | 0.750 | 0.935 |
| Manek Growth Fund | 0.307 | 1.000 | 0.276 | 0.268 |

| | | | | |
|---|---|---|---|---|
| Marlborough Special Situations Fund | 0.597 | 0.812 | 0.678 | 0.897 |
| Marlborough UK Micro Cap Growth Fund | 0.735 | 0.914 | 0.788 | 0.955 |
| MFM Techinvest Special Situations Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Newton UK Smaller Companies Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Old Mutual UK Select Smaller Companies Fund | 0.435 | 0.687 | 0.548 | 0.816 |
| Premier Castlefield UK Smaller Companies Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Prudential Small Companies Trust | 0.638 | 0.819 | 0.710 | 0.900 |
| River & Mercantile UK Equity Smaller Companies Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Royal London UK Smaller Companies Fund | 0.400 | 0.601 | 0.520 | 0.760 |
| Schroder UK Smaller Companies Fund | 0.379 | 0.654 | 0.503 | 0.815 |
| Scottish Widows UK Smaller Companies Fund | 0.275 | 0.532 | 0.420 | 0.808 |
| SF T1PS Smaller Companies Growth Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Standard Life UK Opportunities Fund | 0.392 | 0.685 | 0.514 | 0.856 |
| Standard Life UK Smaller Companies Fund | 0.631 | 0.838 | 0.705 | 0.912 |
| SWIP UK Smaller Companies Fund | 0.296 | 0.547 | 0.437 | 0.802 |
| UBS UK Smaller Companies Fund | 0.484 | 1.000 | 0.521 | 0.800 |
| Unicorn Outstanding British Companies Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| **iShares FTSE 250** | **1.000** | **1.000** | **1.000** | **1.000** |

## UK Domiciled OEICs And UTs With A US Investment Focus

***Table RA3.6:* US Large-Cap Value And Growth Equity (1st January 2008 – 31st December 2010)**

SBM-IO → SBM DEA Model Input-Oriented (CRS)

SBM-OO → SBM DEA Model Output-Oriented (CRS)

SORMSBM-IO → SORMSBM DEA Model Input-Oriented (CRS)

SORMSBM-OO → SORMSBM DEA Model Output-Oriented (CRS)

| Name Of OEIC/UT | SBM-IO | SBM-OO | SORMSBM-IO | SORMSBM-OO |
|---|---|---|---|---|
| Franklin Mutual Shares Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| GLG US Relative Value Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| J. P. Morgan US Fund | 0.728 | 0.898 | 0.782 | 0.946 |
| M&G North American Value Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Old Mutual North American Equity Fund | 0.628 | 0.867 | 0.703 | 0.929 |
| Prudential North American Trust | 0.645 | 0.969 | 0.716 | 0.984 |
| AXA Framlington American Growth Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Baillie Gifford American Fund | 0.809 | 0.866 | 0.847 | 0.928 |
| CF The Westchester Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Fidelity American Special Situations Fund | 0.645 | 0.908 | 0.716 | 0.952 |
| Gartmore US Opportunities Fund | 0.738 | 0.998 | 0.791 | 0.999 |
| GLG American Growth Fund | 0.739 | 0.902 | 0.791 | 0.948 |
| Ignis American Growth Fund | 0.703 | 0.875 | 0.762 | 0.934 |
| Martin Currie North American Fund | 0.400 | 0.741 | 0.520 | 0.852 |
| Martin Currie North American Alpha Fund | 0.441 | 0.673 | 0.553 | 0.805 |
| Neptune US Opportunities Fund | 0.794 | 0.982 | 0.835 | 0.991 |
| PSigma American Growth Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Standard Life TM North American Trust | 1.000 | 1.000 | 1.000 | 1.000 |
| Standard Life North American Equity Manager Of Managers Fund | 0.658 | 0.921 | 0.726 | 0.959 |
| Threadneedle American Extended Alpha Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Threadneedle American Fund | 0.684 | 0.896 | 0.748 | 0.946 |
| Threadneedle American Select Fund | 0.626 | 0.896 | 0.701 | 0.946 |
| **iShares S&P 500** | **1.000** | **1.000** | **1.000** | **1.000** |

## *Table RA3.7:* ***US Large-Cap Blend Equity (1st January 2008 – 31st December 2010)***

SBM-IO → SBM DEA Model Input-Oriented (CRS)

SBM-OO → SBM DEA Model Output-Oriented (CRS)

SORMSBM-IO → SORMSBM DEA Model Input-Oriented (CRS)

SORMSBM-OO → SORMSBM DEA Model Output-Oriented (CRS)

| Name Of OEIC/UT | SBM-IO | SBM-OO | SORMSBM-IO | SORMSBM-OO |
|---|---|---|---|---|
| Aberdeen American Equity Fund | 0.649 | 0.845 | 0.720 | 0.916 |
| AEGON American Equity Fund | 0.019 | 0.036 | 0.215 | 0.084 |
| Allianz RCM US Equity Fund | 0.784 | 0.909 | 0.827 | 0.953 |
| AXA Rosenberg American Fund | 0.393 | 0.591 | 0.514 | 0.743 |
| BlackRock US Dynamic Fund | 0.448 | 0.676 | 0.558 | 0.808 |
| CF Canada Life North American Fund | 0.768 | 0.912 | 0.814 | 0.954 |
| F&C North American Fund | 0.692 | 0.976 | 0.754 | 0.988 |
| FF&P US Large-Cap Equity Fund | 0.491 | 0.684 | 0.593 | 0.812 |
| Fidelity American Special Situations Fund | 0.679 | 0.944 | 0.743 | 0.971 |
| Franklin US Equity Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Gartmore US Growth Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Henderson American Portfolio Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Henderson North American Enhanced Equity Fund | 0.530 | 0.855 | 0.624 | 0.922 |
| HSBC American Index Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Investec American Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Invesco Perpetual US Equity Fund | 0.472 | 0.806 | 0.578 | 0.893 |
| J. P. Morgan US Select Fund | 0.973 | 0.999 | 0.978 | 1.000 |
| Jupiter North American Income Fund | 0.649 | 0.888 | 0.719 | 0.941 |
| L&G (Barclays) Multi-Manager US Alpha Fund | 0.594 | 0.897 | 0.682 | 0.985 |
| L&G North American Trust | 0.574 | 0.800 | 0.659 | 0.889 |
| L&G US Index Trust | 0.557 | 0.824 | 0.646 | 0.904 |
| Legg Mason US Equity Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| M&G American Fund | 0.645 | 0.988 | 0.716 | 0.995 |
| Royal London US Index Tracker Trust | 1.000 | 1.000 | 1.000 | 1.000 |
| Santander Premium Fund US Equity Fund | 0.824 | 0.949 | 0.859 | 0.974 |
| Schroder QEP US Core Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Scottish Mutual North American Trust | 1.000 | 1.000 | 1.000 | 1.000 |
| Scottish Widows American Growth Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Scottish Widows American Select Growth Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| SSGA North American Equity Tracker Fund | 0.806 | 0.846 | 0.845 | 0.916 |

| | | | | |
|---|---|---|---|---|
| St James's Place North American Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Standard Life American Equity Unconstrained Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Standard Life US Equity Index Tracker Fund | 0.651 | 0.904 | 0.721 | 0.949 |
| SWIP North American Fund | 0.901 | 0.995 | 0.921 | 0.997 |
| UBS US 130/30 Equity Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| UBS US Equity Fund | 0.677 | 0.942 | 0.742 | 0.970 |
| **iShares S&P 500** | **0.551** | **0.840** | **0.641** | **0.915** |

***Table RA3.8:* US Mid-Cap And Small-Cap Equity (1st January 2008 – 31st December 2010)**

SBM-IO → SBM DEA Model Input-Oriented (CRS)

SBM-OO → SBM DEA Model Output-Oriented (CRS)

SORMSBM-IO → SORMSBM DEA Model Input-Oriented (CRS)

SORMSBM-OO → SORMSBM DEA Model Output-Oriented (CRS)

| Name Of OEIC/UT | SBM-IO | SBM-OO | SORMSBM-IO | SORMSBM-OO |
|---|---|---|---|---|
| CF Greenwich Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| FF&P US All-Cap Value Equity Fund | 0.441 | 0.604 | 0.553 | 0.753 |
| GAM North American Growth Fund | 0.933 | 0.993 | 0.946 | 0.997 |
| Melchior North American Opportunities Fund | 0.535 | 0.803 | 0.628 | 0.891 |
| Schroder US Mid-Cap Fund | 0.649 | 0.853 | 0.719 | 0.921 |
| Scottish Widows American Smaller Companies Fund | 0.790 | 0.931 | 0.832 | 0.964 |
| SWIP North American Smaller Companies Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Threadneedle American Smaller Companies Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| FF&P US Small-Cap Equity Fund | 0.626 | 0.690 | 0.701 | 0.816 |
| J. P. Morgan US Smaller Companies Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Legg Mason US Smaller Companies Fund | 0.721 | 0.907 | 0.777 | 0.951 |
| Schroder US Smaller Companies Fund | 0.696 | 0.919 | 0.756 | 0.958 |
| **iShares S&P 500** | **1.000** | **1.000** | **1.000** | **1.000** |

## UK Domiciled OEICs And UTs With A Global Investment Focus

***Table RA3.9:* Global Large-Cap Value Equity (1st January 2008 – 31st December 2010)**

SBM-IO → SBM DEA Model Input-Oriented (CRS)

SBM-OO → SBM DEA Model Output-Oriented (CRS)

SORMSBM-IO → SORMSBM DEA Model Input-Oriented (CRS)

SORMSBM-OO → SORMSBM DEA Model Output-Oriented (CRS)

| Name Of OEIC/UT | SBM-IO | SBM-OO | SORMSBM-IO | SORMSBM-OO |
|---|---|---|---|---|
| Aberdeen Charity Select Global Equity Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Aberdeen Ethical World Fund | 0.557 | 0.890 | 0.645 | 0.942 |
| Aberdeen World Equity Fund | 0.587 | 0.902 | 0.670 | 0.949 |
| AXA Rosenberg Global Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Baillie Gifford Global Income Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| CF Stewart Ivory Investment Markets Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Dimensional International Value Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| GAM Global Diversified Fund | 0.591 | 0.893 | 0.673 | 0.944 |
| Gartmore Long-Term Balanced Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| GLG Stockmarket Managed Fund | 0.551 | 0.865 | 0.641 | 0.928 |
| Ignis Global Growth Fund | 0.890 | 0.993 | 0.912 | 0.996 |
| Investec Global Special Situations Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Invesco Perpetual Global Core Equity Index Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| J. P. Morgan Global Equity Income Fund | 0.525 | 0.829 | 0.620 | 0.907 |
| L&G Global 100 Index Trust | 0.623 | 0.840 | 0.699 | 0.913 |
| Lazard Global Equity Income Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| M&G Global Leaders Fund | 0.440 | 0.780 | 0.552 | 0.877 |
| Newton Global Higher Income Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Old Mutual Global Equity Fund | 0.560 | 0.832 | 0.648 | 0.908 |
| Prudential International Growth Trust | 0.758 | 0.978 | 0.807 | 0.989 |
| Sarasin International Equity Income Fund | 0.571 | 0.889 | 0.657 | 0.941 |
| Schroder Global Equity Income Fund | 0.705 | 0.973 | 0.764 | 0.986 |
| St James's Place Recovery Fund | 0.344 | 0.619 | 0.475 | 0.764 |
| Templeton Growth Fund | 0.445 | 0.770 | 0.556 | 0.870 |
| Threadneedle Global Equity Income Fund | 1.000 | 1.000 | 1.000 | 1.000 |

| | | | | |
|---|---|---|---|---|
| **iShares MSCI World** | **0.604** | **0.733** | **0.683** | **0.846** |

*Table RA3.10: Global Large-Cap Growth Equity (1st January 2008 – 31st December 2010)*

SBM-IO → SBM DEA Model Input-Oriented (CRS)

SBM-OO → SBM DEA Model Output-Oriented (CRS)

SORMSBM-IO → SORMSBM DEA Model Input-Oriented (CRS)

SORMSBM-OO → SORMSBM DEA Model Output-Oriented (CRS)

| Name Of OEIC/UT | SBM-IO | SBM-OO | SORMSBM-IO | SORMSBM-OO |
|---|---|---|---|---|
| AEGON Global Equity Fund | 0.625 | 1.000 | 0.619 | 0.780 |
| Aviva Investors World Leaders Fund | 0.428 | 0.579 | 0.576 | 0.825 |
| AXA Framlington Global Opportunities Fund | 1.000 | 0.044 | 0.247 | 0.263 |
| Baillie Gifford International Fund | 0.726 | 0.969 | 0.781 | 0.984 |
| Baillie Gifford Long-Term Global Growth Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| CF JM Finn Global Opportunities Fund | 0.560 | 0.729 | 0.742 | 0.968 |
| Discovery Managed Growth Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| EFA Ursa Major Growth Portfolio Fund | 0.674 | 0.730 | 1.000 | 1.000 |
| F&C Global Growth Fund | 0.345 | 0.589 | 0.720 | 0.971 |
| F&C International Heritage Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| F&C Stewardship International Fund | 0.545 | 0.884 | 0.636 | 0.939 |
| Fidelity Global Focus Fund | 0.561 | 0.886 | 0.648 | 0.940 |
| Henderson International Fund | 0.492 | 0.741 | 0.625 | 0.882 |
| Margetts Greystone Global Growth Fund | 0.505 | 0.815 | 0.604 | 0.898 |
| Martin Currie Global Alpha Fund | 1.000 | 0.141 | 0.312 | 0.357 |
| NatWest International Growth Fund | 0.515 | 0.793 | 0.612 | 0.886 |
| Neptune Global Equity Fund | 0.564 | 0.760 | 1.000 | 1.000 |
| PFS Taube Global Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| RBS International Growth Fund | 0.513 | 0.792 | 0.611 | 0.884 |
| Sheldon Equity Growth Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Sheldon Financial Growth Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| St James's Place Worldwide Opportunities Fund | 0.478 | 0.772 | 0.582 | 0.884 |
| Thesis Lion Growth Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Threadneedle Global Select Fund | 0.553 | 0.876 | 0.642 | 0.934 |
| Zenith International Growth Fund | 0.169 | 0.263 | 0.335 | 0.510 |
| **iShares MSCI World** | **0.550** | **0.837** | **0.640** | **0.912** |

***Table RA3.11:*** ***Global Large-Cap Blend Equity (1st January 2008 – 31st December 2010)***

SBM-IO → SBM DEA Model Input-Oriented (CRS)

SBM-OO → SBM DEA Model Output-Oriented (CRS)

SORMSBM-IO → SORMSBM DEA Model Input-Oriented (CRS)

SORMSBM-OO → SORMSBM DEA Model Output-Oriented (CRS)

| Name Of OEIC/UT | SBM-IO | SBM-OO | SORMSBM-IO | SORMSBM-OO |
|---|---|---|---|---|
| Aberdeen Multi-Manager Constellation Portfolio | 1.000 | 0.495 | 0.581 | 0.816 |
| Aberdeen Multi-Manager International Growth Portfolio | 0.469 | 0.619 | 0.675 | 0.833 |
| Architas Multi-Manager Diversified Share Portfolio | 0.346 | 1.000 | 0.362 | 0.596 |
| Architas Multi-Manager Global Equity Portfolio | 0.653 | 0.765 | 0.722 | 0.885 |
| Artemis Global Growth Fund | 0.290 | 1.000 | 0.282 | 0.403 |
| Aviva Investors Fund Of Funds Balanced Fund | 0.587 | 0.809 | 0.724 | 0.935 |
| Aviva Investors Fund Of Funds Growth Fund | 0.506 | 0.735 | 0.716 | 0.910 |
| Aviva Investors International Index Tracking Fund | 0.517 | 0.676 | 0.707 | 0.895 |
| Aviva Investors SF Global Growth Fund | 1.000 | 0.152 | 0.416 | 0.670 |
| Baillie Gifford Managed Fund | 0.609 | 0.832 | 0.724 | 0.959 |
| Bank Of Scotland International Managed Fund | 0.778 | 0.824 | 0.863 | 0.967 |
| BCIF Balanced Managed Fund | 1.000 | 0.444 | 0.560 | 0.755 |
| BlackRock Active Managed Portfolio Fund | 0.635 | 0.703 | 0.708 | 0.848 |
| BlackRock Global Equity Fund | 0.470 | 0.689 | 0.754 | 0.919 |
| BlackRock International Equity Fund | 0.456 | 0.643 | 0.766 | 0.907 |
| BlackRock Overseas Fund | 0.583 | 0.678 | 0.784 | 0.913 |
| Cazenove Multi-Manager Global Fund | 0.422 | 0.673 | 0.626 | 0.859 |
| CF Adam Worldwide Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| CF Aquarius Fund | 1.000 | 0.173 | 0.380 | 0.423 |
| CF Broden Fund | 0.556 | 0.606 | 0.645 | 0.771 |
| CF Canada Life International Growth Fund | 0.615 | 0.776 | 0.756 | 0.933 |
| CF FundQuest Global Select Fund | 0.770 | 0.831 | 0.816 | 0.911 |
| CF FundQuest Select Opportunities Fund | 0.727 | 0.802 | 0.782 | 0.910 |
| CF FundQuest Select Fund | 0.512 | 0.664 | 0.700 | 0.872 |
| CF Helm Investment Fund | 0.144 | 0.718 | 1.000 | 1.000 |
| CF Lacomp World Fund | 0.592 | 0.691 | 0.722 | 0.879 |
| CF The Aurinko Fund | 0.672 | 0.762 | 0.738 | 0.878 |

| | | | | |
|---|---|---|---|---|
| CF Taylor Young International Equity Fund | 0.774 | 0.848 | 0.882 | 0.958 |
| Chariguard Overseas Equity Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| City Financial Multi-Manager Growth Fund | 1.000 | 0.049 | 0.244 | 0.121 |
| Deutsche Bank PWM Capital Growth Portfolio | 0.688 | 0.775 | 0.810 | 0.945 |
| Ecclesiastical Amity International Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| F&C Lifestyle Growth Fund | 0.453 | 0.660 | 0.704 | 0.875 |
| Family Investments Child Trust Fund | 1.000 | 0.426 | 0.542 | 0.729 |
| FF&P Global Equities II Fund | 1.000 | 0.467 | 0.564 | 0.770 |
| Fidelity Global Special Situations Fund | 1.000 | 0.248 | 0.446 | 0.616 |
| Fidelity International Fund | 1.000 | 0.481 | 0.595 | 0.781 |
| Fidelity MoneyBuilder Global Trust | 0.120 | 0.600 | 0.618 | 0.857 |
| Fidelity WealthBuilder Fund | 0.276 | 0.646 | 0.618 | 0.885 |
| First State Global Growth Fund | 0.797 | 0.862 | 0.868 | 0.958 |
| First State Global Opportunities Fund | 0.373 | 0.579 | 0.701 | 0.820 |
| GAM Composite Absolute Return OEIC | 0.502 | 1.000 | 0.550 | 0.853 |
| GAM Portfolio Unit Trust | 0.865 | 0.911 | 0.892 | 0.959 |
| Gartmore Global Focus Fund | 1.000 | 0.432 | 0.600 | 0.761 |
| Gartmore Multi-Manager Active Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Henderson Global Dividend Income Fund | 0.436 | 0.850 | 1.000 | 1.000 |
| Henderson Multi-Manager Active Fund | 1.000 | 0.280 | 0.412 | 0.614 |
| Henderson Multi-Manager Tactical Fund | 0.500 | 1.000 | 0.435 | 0.713 |
| HSBC Global Growth Fund Of Funds | 0.609 | 0.733 | 0.742 | 0.900 |
| HSBC Portfolio Fund | 0.589 | 0.661 | 0.775 | 0.885 |
| IFDS Brown Shipley Multi-Manager International Fund | 0.671 | 0.748 | 0.762 | 0.894 |
| Investec Global Dynamic Fund | 0.633 | 0.819 | 0.916 | 0.999 |
| Investec Global Equity Fund | 0.230 | 0.648 | 0.727 | 0.922 |
| Investec Global Free Enterprise Fund | 1.000 | 0.508 | 0.656 | 0.865 |
| Invesco Perpetual Global Equity Fund | 0.119 | 0.568 | 0.581 | 0.840 |
| Invesco Perpetual Global Enhanced Index Fund | 0.957 | 0.982 | 1.000 | 1.000 |
| Invesco Perpetual Global Opportunities Fund | 0.343 | 0.585 | 0.673 | 0.834 |
| Invesco Perpetual Managed Growth Fund | 0.206 | 0.601 | 0.654 | 0.863 |
| Jessop (GAR) Global Equity Quant Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| J. P. Morgan Global Fund | 0.006 | 0.551 | 0.701 | 0.866 |
| J. P. Morgan Portfolio Fund | 0.467 | 0.598 | 0.692 | 0.842 |
| Jupiter Merlin Growth Portfolio Fund | 0.592 | 0.949 | 0.673 | 0.984 |
| Jupiter Merlin Worldwide Portfolio Fund | 0.621 | 0.942 | 0.735 | 0.994 |

| | | | | |
|---|---|---|---|---|
| L&G (Barclays) Adventurous Growth Portfolio Trust | 1.000 | 0.173 | 0.434 | 0.729 |
| L&G Global Growth Trust | 0.242 | 0.524 | 0.669 | 0.766 |
| L&G Worldwide Trust | 1.000 | 0.508 | 0.634 | 0.807 |
| Liberation No. VIII Fund | 1.000 | 0.597 | 1.000 | 1.000 |
| M&G Global Growth Fund | 0.445 | 0.735 | 0.652 | 0.923 |
| Margetts International Strategy Fund | 0.668 | 0.778 | 0.778 | 0.929 |
| Margetts Venture Strategy Fund | 0.791 | 0.969 | 1.000 | 1.000 |
| Marlborough Global Fund | 0.152 | 0.506 | 0.620 | 0.810 |
| Martin Currie Global Fund | 1.000 | 0.243 | 0.479 | 0.659 |
| Neptune Global Max Alpha Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Newton 50/50 Global Equity Fund | 0.568 | 0.733 | 0.735 | 0.930 |
| Newton Falcon Fund | 0.660 | 0.816 | 0.772 | 0.946 |
| Newton Global Balanced Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Newton Global Opportunities Fund | 1.000 | 0.599 | 0.722 | 0.914 |
| Newton International Growth Fund | 0.278 | 0.611 | 0.773 | 0.985 |
| Newton Managed Fund | 1.000 | 0.376 | 0.534 | 0.749 |
| Newton Overseas Equity Fund | 0.751 | 0.844 | 1.000 | 1.000 |
| Premier Castlefield Managed Multi-Asset Fund | 0.665 | 0.754 | 0.734 | 0.890 |
| Prudential (Invesco Perpetual) Managed Trust | 0.309 | 0.558 | 0.566 | 0.777 |
| S&W Endurance Global Opportunities Fund | 0.540 | 0.633 | 0.632 | 0.795 |
| Santander Multi-Manager Equity Fund | 0.045 | 0.449 | 0.532 | 0.720 |
| Sarasin Alpha CIF Income & Reserves Fund | 0.633 | 0.917 | 0.707 | 0.957 |
| Sarasin EquiSar Global Thematic Fund | 0.025 | 0.533 | 0.596 | 0.816 |
| Sarasin EquiSar IIID Fund | 1.000 | 0.045 | 0.264 | 0.314 |
| Schroder Global Equity Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Schroder Growth Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Schroder QEP Global Quant Core Equity Fund | 0.790 | 0.946 | 0.832 | 0.983 |
| Scottish Mutual International Growth Trust | 0.682 | 0.728 | 0.786 | 0.934 |
| Scottish Mutual Opportunity Trust | 0.637 | 0.700 | 0.710 | 0.863 |
| Scottish Widows Global Growth Fund | 0.069 | 0.463 | 0.513 | 0.724 |
| Scottish Widows Global Select Growth Fund | 0.038 | 0.459 | 0.543 | 0.734 |
| Scottish Widows International Equity Tracker Fund | 0.345 | 0.485 | 0.522 | 0.723 |
| Skandia Ethical Fund | 1.000 | 0.202 | 0.379 | 0.421 |
| Skandia Global Best Ideas Fund | 0.036 | 0.466 | 0.533 | 0.733 |
| Skandia Newton Managed Fund | 0.146 | 0.452 | 0.485 | 0.678 |
| Standard Life TM Global Equity Trust | 1.000 | 1.000 | 1.000 | 1.000 |
| Standard Life TM International Trust | 1.000 | 1.000 | 1.000 | 1.000 |
| St James's Place Ethical Fund | 0.032 | 0.387 | 0.502 | 0.655 |
| St James's Place International Fund | 1.000 | 0.311 | 0.429 | 0.579 |
| Standard Life Global Equity Fund | 0.627 | 0.660 | 0.702 | 0.822 |
| SVM Global Opportunities Fund | 0.623 | 1.000 | 0.528 | 0.955 |
| SWIP Global Fund | 0.444 | 0.493 | 0.555 | 0.685 |
| SWIP Multi-Manager International Equity Fund | 0.371 | 0.646 | 0.550 | 0.820 |

| | | | | |
|---|---|---|---|---|
| SWIP Multi-Manager Select Boutiques Fund | 0.615 | 0.713 | 0.692 | 0.839 |
| T. Bailey Growth Fund | 1.000 | 0.323 | 0.444 | 0.586 |
| Thames River Equity Managed Fund | 0.572 | 0.688 | 0.658 | 0.822 |
| Thames River Global Boutiques Fund | 0.534 | 0.717 | 0.627 | 0.842 |
| Threadneedle Global Equity Fund | 0.359 | 0.577 | 0.564 | 0.775 |
| Threadneedle Navigator Adventurous Managed Trust | 0.765 | 0.845 | 0.812 | 0.916 |
| THS International Growth & Value Fund | 1.000 | 0.382 | 0.471 | 0.657 |
| UBS Global Optimal Fund | 0.613 | 0.653 | 0.690 | 0.794 |
| UBS Global Optimal Thirds Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| WAY Global Red Active Portfolio Fund | 0.448 | 0.605 | 0.568 | 0.768 |
| Wesleyan International Trust | 0.406 | 0.454 | 0.525 | 0.639 |
| Williams De Broe Global Fund | 0.685 | 0.751 | 0.748 | 0.861 |
| **iShares MSCI World** | **0.489** | **0.692** | **0.619** | **0.885** |

***Table RA3.12:* Global Mid-Cap And Small-Cap Equity (1st January 2008 – 31st December 2010)**

SBM-IO → SBM DEA Model Input-Oriented (CRS)

SBM-OO → SBM DEA Model Output-Oriented (CRS)

SORMSBM-IO → SORMSBM DEA Model Input-Oriented (CRS)

SORMSBM-OO → SORMSBM DEA Model Output-Oriented (CRS)

| Name Of OEIC/UT | SBM-IO | SBM-OO | SORMSBM-IO | SORMSBM-OO |
|---|---|---|---|---|
| AXA Framlington Talents Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Baillie Gifford Phoenix Global Growth Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Hargreaves Lansdown Multi-Manager Special Situations Trust | 0.427 | 0.839 | 0.542 | 0.913 |
| Invesco Perpetual Global Smaller Companies Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| J. P. Morgan Multi-Manager Growth Fund | 0.264 | 0.643 | 0.411 | 0.782 |
| L&G (Barclays) Multi-Manager Global Core Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| M&G Fund Of Investment Trust Shares | 0.122 | 0.294 | 0.298 | 0.455 |
| M&G Global Basics Fund | 0.502 | 0.936 | 0.602 | 0.969 |
| Neptune Green Planet Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Rathbone Global Opportunities Fund | 0.406 | 0.773 | 0.525 | 0.872 |
| S&W Aubrey Global Conviction Fund | 0.520 | 0.937 | 0.616 | 0.968 |

| | | | | |
|---|---|---|---|---|
| SF Adventurous Portfolio Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| St James's Place Global Fund | 0.119 | 0.320 | 0.295 | 0.485 |
| **iShares MSCI World** | **1.000** | **1.000** | **1.000** | **1.000** |

# Results Appendix 4 – Three-Stage DEA-SFA-DEA Models

## UK Domiciled OEICs And UTs With A UK Investment Focus

***Table RA4.1:** UK Large-Cap Value Equity (1st January 2008 – 31st December 2010)*

SORMCCR-OO → SORMCCR DEA Model Output-Oriented

Three-Stage SORMCCR-OO → Three-Stage SORMCCR DEA Model Output-Oriented

SORMSBM-OO → SORMSBM DEA Model Output-Oriented

Three-Stage SORMSBM-OO → Three-Stage SORMSBM DEA Model Output-Oriented

| Name Of OEIC/UT | SORMCCR-OO | Three-Stage SORMCCR-OO | SORMSBM-OO | Three-Stage SORMSBM-OO |
|---|---|---|---|---|
| Aberdeen Charity Select UK Equity Fund | 0.763 | 0.763 | 0.866 | 1.000 |
| Aberdeen Multi-Manager UK Income Portfolio | 0.791 | 0.791 | 0.883 | 1.000 |
| Aberdeen Responsible UK Equity Fund | 0.684 | 0.684 | 0.812 | 1.000 |
| Aberdeen UK Equity Fund | 0.607 | 0.607 | 0.756 | 0.999 |
| Aberdeen UK Equity Income Fund | 0.570 | 0.570 | 0.726 | 0.999 |
| Artemis Income Fund | 0.664 | 0.664 | 0.799 | 1.000 |
| Cazenove UK Growth & Income Fund | 0.714 | 0.714 | 0.833 | 1.000 |
| Capita Financial Taylor Young Equity Income Fund | 0.668 | 0.668 | 0.801 | 1.000 |
| Capita Financial Walker Crips UK Growth Fund | 0.805 | 0.805 | 0.892 | 1.000 |
| Dimensional UK Core Equity Fund | 0.733 | 0.733 | 0.846 | 1.000 |
| Dimensional UK Value Fund | 0.704 | 0.704 | 0.826 | 0.866 |
| Elite Henderson Rowe Dogs FTSE 100 Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| F&C UK Equity Income Fund | 0.593 | 0.593 | 0.744 | 0.999 |
| F&C UK Growth & Income Fund | 0.565 | 0.565 | 0.722 | 0.999 |
| Family Asset Trust | 0.393 | 0.705 | 0.564 | 0.999 |
| Fidelity Special Situations Fund | 0.752 | 0.752 | 0.859 | 1.000 |
| Gartmore UK Alpha Fund | 0.757 | 0.757 | 0.862 | 1.000 |
| Gartmore UK Equity Income Fund | 0.497 | 0.497 | 0.664 | 0.999 |
| Gartmore UK Growth Fund | 0.421 | 0.429 | 0.593 | 0.990 |
| GLG UK Growth Fund | 0.369 | 0.477 | 0.539 | 1.000 |
| GLG UK Income Fund | 0.329 | 0.329 | 0.495 | 0.999 |
| HL Multi-Manager Income & Growth Portfolio Trust | 0.770 | 0.770 | 0.870 | 1.000 |

| | | | | |
|---|---|---|---|---|
| HSBC Income Fund | 0.612 | 0.612 | 0.759 | 0.999 |
| Ignis UK Equity Income Fund | 0.612 | 0.612 | 0.759 | 0.999 |
| Insight Investment Equity High Income Fund | 0.627 | 0.627 | 0.771 | 0.999 |
| Investec UK Special Situations Fund | 0.956 | 0.956 | 0.978 | 1.000 |
| Invesco Perpetual Children's Fund | 0.521 | 0.521 | 0.685 | 0.999 |
| Invesco Perpetual High Income Fund | 0.662 | 0.662 | 0.799 | 1.000 |
| Invesco Perpetual Income & Growth Fund | 0.299 | 0.299 | 0.460 | 0.999 |
| Invesco Perpetual Income Fund | 0.677 | 0.677 | 0.808 | 1.000 |
| Invesco Perpetual UK Aggressive Fund | 0.501 | 0.501 | 0.667 | 0.999 |
| Invesco Perpetual UK Enhanced Index Fund | 0.747 | 0.747 | 0.855 | 1.000 |
| Invesco Perpetual UK Growth Fund | 0.407 | 0.586 | 0.579 | 0.999 |
| JoHambro Capital Management UK Equity Income Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| J. P. Morgan Premier Equity Income Fund | 0.544 | 0.544 | 0.705 | 0.999 |
| J. P. Morgan UK Managed Equity Fund | 0.510 | 0.510 | 0.676 | 0.999 |
| J. P. Morgan UK Strategic Equity Income Fund | 0.530 | 0.530 | 0.693 | 0.999 |
| Jupiter Undervalued Assets Fund | 0.460 | 0.646 | 0.630 | 0.998 |
| L&G (Barclays) MM UK Equity Income Fund | 0.758 | 0.758 | 0.863 | 1.000 |
| Lazard UK Income Fund | 0.602 | 0.602 | 0.751 | 0.999 |
| Legg Mason UK Equity Fund | 0.570 | 0.570 | 0.726 | 0.999 |
| M&G Charifund | 0.294 | 0.514 | 0.455 | 0.999 |
| M&G Dividend Fund | 0.650 | 0.650 | 0.788 | 1.000 |
| M&G Income Fund | 0.754 | 0.754 | 0.860 | 1.000 |
| Neptune Income Fund | 0.750 | 0.750 | 0.857 | 1.000 |
| Neptune Quarterly Income Fund | 0.612 | 0.612 | 0.759 | 0.999 |
| Neptune UK Equity Fund | 0.796 | 0.796 | 0.887 | 1.000 |
| Neptune UK Special Situations Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Old Mutual Equity Income Fund | 0.713 | 0.713 | 0.833 | 1.000 |
| Old Mutual Extra Income Fund | 0.782 | 0.782 | 0.878 | 1.000 |
| Premier UK Strategic Growth Fund | 0.627 | 0.627 | 0.771 | 1.000 |
| Prudential Ethical Trust Fund | 0.474 | 0.474 | 0.643 | 1.000 |
| PSigma Income Fund | 0.011 | 0.011 | 0.022 | 0.999 |
| PSigma UK Growth Fund | 0.036 | 0.036 | 0.070 | 0.999 |
| Rathbone Blue Chip Income & Growth Fund | 0.700 | 0.700 | 0.823 | 1.000 |
| Rathbone Income Fund | 0.004 | 0.004 | 0.008 | 0.999 |
| River & Mercantile UK Equity High Alpha Fund | 1.000 | 1.000 | 1.000 | 1.000 |

| | | | | |
|---|---|---|---|---|
| S&W Church House Balanced Value & Income Fund | 0.787 | 0.787 | 0.881 | 1.000 |
| S&W Church House UK Managed Growth Fund | 0.782 | 0.782 | 0.878 | 1.000 |
| S&W FTIM Munro Fund | 0.314 | 0.314 | 0.478 | 0.999 |
| Schroder Charity Equity Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Schroder Income Fund | 0.863 | 0.863 | 0.926 | 1.000 |
| Schroder Income Maximiser Fund | 0.831 | 0.831 | 0.908 | 1.000 |
| Schroder Recovery Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Schroder Specialist Value UK Equity Fund | 0.942 | 0.942 | 0.970 | 1.000 |
| Scottish Widows Ethical Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Scottish Widows UK Equity Income Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Scottish Widows UK Growth Fund | 0.754 | 0.754 | 0.860 | 1.000 |
| Skandia Multi-Manager UK Equity Fund | 0.626 | 0.626 | 0.770 | 0.999 |
| St James's Place Equity Income Fund | 0.809 | 0.809 | 0.895 | 1.000 |
| St James's Place UK Growth Fund | 0.907 | 0.907 | 0.951 | 1.000 |
| St James's Place UK High Income Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Standard Life UK Equity High Income Fund | 0.349 | 0.349 | 0.518 | 0.999 |
| Standard Life UK Equity Manager Of Managers Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| SWIP Multi-Manager UK Equity Income Fund | 0.927 | 0.927 | 0.962 | 1.000 |
| SWIP UK Income Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| TB Wise Income Fund | 0.895 | 0.895 | 0.945 | 1.000 |
| Templeton UK Equity Fund | 0.266 | 0.914 | 0.420 | 0.999 |
| Troy Trojan Income Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| UBS UK Select Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| **iShares FTSE 100** | **0.912** | **0.912** | **0.956** | **1.000** |

***Table RA4.2:* UK Large-Cap Growth Equity (1st January 2008 – 31st December 2010)**

SORMCCR-OO → SORMCCR DEA Model Output-Oriented

Three-Stage SORMCCR-OO → Three-Stage SORMCCR DEA Model Output-Oriented

SORMSBM-OO → SORMSBM DEA Model Output-Oriented

Three-Stage SORMSBM-OO → Three-Stage SORMSBM DEA Model Output-Oriented

| Name Of OEIC/UT | SORMCCR-OO | Three-Stage SORMCCR-OO | SORMSBM-OO | Three-Stage SORMSBM-OO |
|---|---|---|---|---|
| AEGON UK Opportunities Fund | 0.932 | 0.932 | 0.965 | 0.996 |
| BlackRock UK Fund | 0.919 | 0.919 | 0.958 | 0.971 |
| BlackRock UK Dynamic Fund | 0.997 | 0.997 | 1.000 | 0.970 |
| FF&P Concentrated UK Equity Fund | 1.000 | 1.000 | 1.000 | 0.999 |
| Fidelity UK Growth Fund | 0.901 | 0.901 | 0.948 | 1.000 |
| L&G (N) UK Growth Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Mirabaud Mir GB Fund | 0.686 | 0.686 | 0.814 | 0.996 |
| Royal London UK Opportunities Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| SVM UK Growth Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| **iShares FTSE 100** | **1.000** | **1.000** | **1.000** | **1.000** |

***Table RA4.3:* UK Large-Cap Blend Equity (1st January 2008 – 31st December 2010)**

SORMCCR-OO → SORMCCR DEA Model Output-Oriented

Three-Stage SORMCCR-OO → Three-Stage SORMCCR DEA Model Output-Oriented

SORMSBM-OO → SORMSBM DEA Model Output-Oriented

Three-Stage SORMSBM-OO → Three-Stage SORMSBM DEA Model Output-Oriented

| Name Of OEIC/UT | SORMCCR-OO | Three-Stage SORMCCR-OO | SORMSBM-OO | Three-Stage SORMSBM-OO |
|---|---|---|---|---|
| Aberdeen Multi-Manager UK Growth Portfolio | 0.935 | 0.935 | 0.966 | 1.000 |
| AEGON UK Equity Fund | 0.775 | 0.775 | 0.873 | 1.000 |
| Allianz RCM UK Equity Fund | 0.774 | 0.774 | 0.873 | 1.000 |
| Allianz RCM UK Growth Fund | 0.544 | 0.544 | 0.704 | 1.000 |
| Allianz RCM UK Index Fund | 0.884 | 0.884 | 0.939 | 1.000 |
| Allianz RCM UK Unconstrained Fund | 0.600 | 0.627 | 0.750 | 0.990 |
| Architas Multi-Manager UK Equity Portfolio | 0.854 | 0.854 | 0.922 | 1.000 |
| Artemis Capital Fund | 0.209 | 0.209 | 0.346 | 1.000 |
| Artemis UK Growth Fund | 0.784 | 0.784 | 0.879 | 1.000 |
| Aviva Investors UK Equity Fund | 0.863 | 0.863 | 0.927 | 1.000 |
| Aviva Investors UK Focus Fund | 0.868 | 0.868 | 0.929 | 1.000 |
| Aviva Investors UK Growth Fund | 0.840 | 0.840 | 0.913 | 1.000 |

| | | | | |
|---|---|---|---|---|
| AXA Framlington UK Growth Fund | 0.887 | 0.887 | 0.940 | 1.000 |
| AXA General Trust | 0.772 | 0.772 | 0.872 | 1.000 |
| Baillie Gifford British 350 Fund | 0.920 | 0.920 | 0.958 | 1.000 |
| Baillie Gifford UK Equity Alpha Fund | 0.901 | 0.901 | 0.948 | 1.000 |
| Bank Of Scotland FTSE 100 Tracker Fund | 0.863 | 0.863 | 0.927 | 1.000 |
| BlackRock Armed Forces Common Investment Fund | 0.767 | 0.767 | 0.868 | 1.000 |
| BlackRock Charishare Fund | 0.723 | 0.723 | 0.839 | 1.000 |
| BlackRock UK Equity Fund | 0.845 | 0.845 | 0.916 | 1.000 |
| BlackRock UK Income Fund | 0.931 | 0.931 | 0.965 | 1.000 |
| Cazenove Multi-Manager UK Growth Fund | 0.828 | 0.828 | 0.906 | 1.000 |
| Cazenove UK Opportunities Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| CF Canada Life General Trust | 0.509 | 0.509 | 0.674 | 1.000 |
| CF Canada Life Growth Fund | 0.781 | 0.781 | 0.877 | 1.000 |
| CF GHC Multi-Manager UK Equity OEIC | 0.838 | 0.838 | 0.912 | 1.000 |
| CF JM Finn UK Portfolio Fund | 0.709 | 0.709 | 0.829 | 1.000 |
| CF Lindsell Train UK Equity Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| CF Taylor Young Growth & Income Fund | 0.877 | 0.877 | 0.935 | 1.000 |
| CF Walker Crips UK High Alpha Fund | 0.937 | 0.937 | 0.967 | 1.000 |
| Chariguard UK Equity Fund | 0.708 | 0.708 | 0.829 | 1.000 |
| CIS UK FTSE4Good Tracker Trust | 0.796 | 0.796 | 0.887 | 1.000 |
| EFA OPM UK Equity Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Engage Investment Growth Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Epworth Affirmative Equity Fund | 0.543 | 0.543 | 0.704 | 1.000 |
| F&C FTSE All-Share Tracker Fund | 0.860 | 0.860 | 0.925 | 1.000 |
| F&C UK Equity Fund | 0.884 | 0.884 | 0.939 | 1.000 |
| Family Charities Ethical Trust | 1.000 | 1.000 | 1.000 | 1.000 |
| Fidelity MoneyBuilder UK Index Fund | 0.891 | 0.891 | 0.943 | 1.000 |
| Fidelity UK Aggressive Fund | 0.797 | 0.797 | 0.887 | 1.000 |
| GAM MP UK Equity Unit Trust | 0.939 | 0.939 | 0.969 | 1.000 |
| Gartmore UK Index Fund | 0.801 | 0.801 | 0.890 | 1.000 |
| Gartmore UK Tracker Fund | 0.772 | 0.772 | 0.871 | 1.000 |
| HBOS UK FTSE 100 Index Track Fund | 0.714 | 0.714 | 0.834 | 1.000 |
| Henderson UK Equity Tracker Trust | 0.622 | 0.622 | 0.767 | 1.000 |
| Henderson UK High Alpha Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| HSBC FTSE 100 Index Fund | 1.000 | 1.000 | 1.000 | 1.000 |

| | | | | |
|---|---|---|---|---|
| HSBC FTSE All Share Index Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| HSBC MERIT UK Equity Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| HSBC UK Focus Fund | 0.861 | 0.861 | 0.925 | 1.000 |
| HSBC UK Freestyle Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| HSBC UK Growth & Income Fund | 0.882 | 0.882 | 0.937 | 1.000 |
| IFDS Brown Shipley UK Flagship Fund | 0.874 | 0.874 | 0.933 | 1.000 |
| Ignis Balanced Growth Fund | 0.471 | 0.471 | 0.640 | 1.000 |
| Ignis Cartesian UK Opportunities Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Ignis UK Focus Fund | 0.718 | 0.718 | 0.836 | 1.000 |
| Insight Investment UK Dynamic Managed Fund | 0.812 | 0.812 | 0.896 | 1.000 |
| Investec UK Alpha Fund | 0.806 | 0.806 | 0.893 | 1.000 |
| Investec UK Blue Chip Fund | 0.775 | 0.775 | 0.873 | 1.000 |
| Invesco Perpetual UK Strategic Income Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Jessop Gartmore UK Index Fund | 0.865 | 0.865 | 0.927 | 1.000 |
| JoHambro Capital Management UK Opportunities Fund | 0.773 | 0.773 | 0.872 | 1.000 |
| J. P. Morgan Premier Equity Growth Fund | 0.350 | 0.350 | 0.518 | 1.000 |
| J. P. Morgan UK Active Index Plus Fund | 0.835 | 0.835 | 0.910 | 1.000 |
| J. P. Morgan UK Dynamic Fund | 0.725 | 0.725 | 0.841 | 1.000 |
| J. P. Morgan UK Focus Fund | 0.818 | 0.818 | 0.900 | 1.000 |
| Jupiter UK Alpha Fund | 0.906 | 0.906 | 0.951 | 1.000 |
| L&G (Barclays) Market Track 350 Trust | 0.776 | 0.776 | 0.874 | 1.000 |
| L&G (Barclays) Multi-Manager UK Alpha Fund | 0.681 | 0.681 | 0.810 | 1.000 |
| L&G (Barclays) Multi-Manager UK Alpha (Series 2) Fund | 0.636 | 0.636 | 0.778 | 1.000 |
| L&G (Barclays) Multi-Manager UK Core Fund | 0.857 | 0.857 | 0.923 | 1.000 |
| L&G (Barclays) Multi-Manager UK Opportunities Fund | 0.884 | 0.884 | 0.939 | 1.000 |
| L&G Capital Growth Fund | 0.762 | 0.762 | 0.865 | 1.000 |
| L&G (N) UK Tracker Trust | 0.785 | 0.785 | 0.880 | 1.000 |
| L&G CAF UK Equitrack Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| L&G Equity Trust | 0.501 | 0.501 | 0.668 | 1.000 |
| L&G Ethical Trust | 0.611 | 0.611 | 0.758 | 1.000 |
| L&G Growth Trust | 0.734 | 0.734 | 0.847 | 1.000 |
| L&G UK 100 Index Trust | 0.754 | 0.754 | 0.860 | 1.000 |
| L&G UK Active Opportunities Trust | 0.670 | 0.670 | 0.803 | 1.000 |
| L&G UK Index Trust | 0.825 | 0.825 | 0.904 | 1.000 |
| Lazard UK Alpha Fund | 0.818 | 0.818 | 0.900 | 1.000 |
| Lazard UK Omega Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| LV UK Growth Fund | 0.656 | 0.656 | 0.792 | 1.000 |

| | | | | |
|---|---|---|---|---|
| M&G Index Tracker Fund | 0.783 | 0.783 | 0.878 | 1.000 |
| M&G Recovery Fund | 0.864 | 0.864 | 0.928 | 1.000 |
| M&G UK Growth Fund | 0.743 | 0.743 | 0.852 | 1.000 |
| M&G UK Select Fund | 0.833 | 0.833 | 0.909 | 1.000 |
| Majedie AM UK Equity Fund | 0.880 | 0.880 | 0.936 | 1.000 |
| Majedie AM UK Focus Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| M&S Ethical Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| M&S UK 100 Companies Fund | 0.830 | 0.830 | 0.907 | 1.000 |
| M&S UK Selection Portfolio | 0.651 | 0.651 | 0.789 | 1.000 |
| Morgan Stanley UK Equity Alpha Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Old Mutual UK Select Equity Fund | 0.787 | 0.787 | 0.881 | 1.000 |
| Premier Castlefield UK Alpha Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Premier Castlefield UK Equity Fund | 0.893 | 0.893 | 0.943 | 1.000 |
| Prudential UK Growth Trust | 0.835 | 0.835 | 0.910 | 1.000 |
| Prudential UK Index Tracker Trust | 1.000 | 1.000 | 1.000 | 1.000 |
| RBS FTSE 100 Tracker Fund | 0.757 | 0.757 | 0.862 | 1.000 |
| Royal London FTSE 350 Tracker Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Royal London UK Equity Fund | 0.821 | 0.821 | 0.902 | 1.000 |
| Santander Premium Fund UK Equity | 0.810 | 0.810 | 0.895 | 1.000 |
| Santander Stockmarket 100 Tracker Trust | 0.877 | 0.877 | 0.935 | 1.000 |
| Santander UK Growth Trust | 0.796 | 0.796 | 0.887 | 1.000 |
| Schroder Specialist UK Equity Fund | 0.985 | 0.985 | 0.992 | 1.000 |
| Schroder Prime UK Equity Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Schroder UK Alpha Plus Fund | 0.851 | 0.851 | 0.920 | 1.000 |
| Schroder UK Equity Fund | 0.834 | 0.834 | 0.910 | 1.000 |
| Scottish Friendly UK Growth Fund | 0.830 | 0.830 | 0.907 | 1.000 |
| Scottish Mutual UK All-Share Index Trust | 1.000 | 1.000 | 1.000 | 1.000 |
| Scottish Mutual UK Equity Trust | 0.661 | 0.661 | 0.796 | 1.000 |
| Scottish Widows UK All-Share Tracker Fund | 0.789 | 0.789 | 0.883 | 1.000 |
| Scottish Widows UK Select Growth Fund | 0.867 | 0.867 | 0.929 | 1.000 |
| Scottish Widows UK Tracker Fund | 0.741 | 0.741 | 0.851 | 1.000 |
| Skandia Multi-Manager UK Index Fund | 0.831 | 0.831 | 0.908 | 1.000 |
| Skandia Multi-Manager UK Opportunities Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Standard Life TM UK General Equity Fund | 0.651 | 0.651 | 0.789 | 1.000 |
| SSGA UK Equity Enhanced Fund | 0.879 | 0.879 | 0.936 | 1.000 |

| | | | | |
|---|---|---|---|---|
| SSGA UK Equity Tracker Fund | 0.853 | 0.853 | 0.921 | 1.000 |
| St James's Place UK & General Progressive Fund | 0.463 | 0.488 | 0.633 | 0.993 |
| Standard Life UK Equity Growth Fund | 0.704 | 0.704 | 0.827 | 1.000 |
| SWIP Multi-Manager UK Equity Focus Fund | 0.475 | 0.475 | 0.644 | 1.000 |
| SWIP Multi-Manager UK Equity Growth Fund | 0.638 | 0.638 | 0.779 | 1.000 |
| SWIP UK Opportunities Fund | 0.887 | 0.887 | 0.940 | 1.000 |
| Threadneedle Navigator UK Index Tracker Fund | 0.768 | 0.768 | 0.869 | 1.000 |
| Threadneedle UK Extended Alpha Fund | 0.690 | 0.690 | 0.817 | 1.000 |
| Troy Trojan Capital Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| UBS UK Equity Income Find | 1.000 | 1.000 | 1.000 | 1.000 |
| Wesleyan Growth Trust | 0.737 | 0.737 | 0.848 | 1.000 |
| **iShares FTSE 100** | **0.671** | **0.671** | **0.804** | **1.000** |

***Table RA4.4:* UK Mid-Cap Equity (1st January 2008 – 31st December 2010)**

SORMCCR-OO → SORMCCR DEA Model Output-Oriented

Three-Stage SORMCCR-OO → Three-Stage SORMCCR DEA Model Output-Oriented

SORMSBM-OO → SORMSBM DEA Model Output-Oriented

Three-Stage SORMSBM-OO → Three-Stage SORMSBM DEA Model Output-Oriented

| Name Of OEIC/UT | SORMCCR-OO | Three-Stage SORMCCR-OO | SORMSBM-OO | Three-Stage SORMSBM-OO |
|---|---|---|---|---|
| Aberdeen UK Mid-Cap Fund | 0.895 | 0.900 | 0.945 | 1.000 |
| AEGON Ethical Equity Fund | 0.644 | 0.648 | 0.783 | 1.000 |
| Allianz RCM UK Mid-Cap Fund | 0.804 | 0.809 | 0.892 | 1.000 |
| Artemis UK Special Situations Fund | 0.733 | 0.733 | 0.846 | 1.000 |
| Aviva Investors SF UK Growth Fund | 0.951 | 0.953 | 0.975 | 0.999 |
| Aviva Investors UK Ethical Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Aviva Investors UK Special Situations Fund | 0.702 | 0.704 | 0.825 | 1.000 |
| AXA Framlington Equity Income Fund | 0.459 | 0.485 | 0.629 | 0.997 |
| AXA Framlington Monthly Income Fund | 0.883 | 0.886 | 0.938 | 0.994 |

| | | | | |
|---|---|---|---|---|
| AXA Framlington UK Select Opportunities Fund | 0.755 | 0.755 | 0.861 | 1.000 |
| BlackRock UK Special Situations Fund | 0.862 | 0.862 | 0.926 | 1.000 |
| Cazenove UK Dynamic Fund | 0.942 | 0.943 | 0.970 | 0.997 |
| CF Cornelian British Opportunities Fund | 0.964 | 0.973 | 0.982 | 0.999 |
| CF OLIM UK Equity Trust | 0.739 | 0.844 | 0.850 | 0.999 |
| CF Taylor Young Growth Fund | 0.598 | 0.634 | 0.749 | 1.000 |
| CF Taylor Young Opportunistic Fund | 0.857 | 0.977 | 0.923 | 0.999 |
| Ecclesiastical Amity UK Fund | 0.851 | 0.857 | 0.919 | 1.000 |
| F&C Stewardship Growth Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| F&C Stewardship Income Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| F&C UK Mid-Cap Fund | 0.925 | 0.925 | 0.961 | 1.000 |
| F&C UK Opportunities Fund | 0.744 | 0.799 | 0.853 | 1.000 |
| GAM UK Diversified Fund | 0.930 | 0.930 | 0.964 | 0.998 |
| Henderson UK Alpha Fund | 0.552 | 0.557 | 0.711 | 0.998 |
| HSBC FTSE 250 Index Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| L&G (Barclays) Multi-Manager UK Lower-Cap Fund | 0.811 | 0.812 | 0.896 | 1.000 |
| Majedie UK Opportunities Fund | 0.505 | 0.618 | 0.671 | 0.997 |
| Marlborough Ethical Fund | 0.878 | 0.907 | 0.935 | 0.997 |
| Marlborough UK Primary Opportunities Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Melchior UK Opportunities Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| MFM Bowland Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| MFM Slater Recovery Fund | 0.969 | 0.969 | 0.984 | 1.000 |
| Old Mutual UK Select Mid-Cap Fund | 0.761 | 0.761 | 0.865 | 1.000 |
| Rathbone Recovery Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Real Life Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Rensburg UK Managers' Focus Trust | 0.758 | 0.759 | 0.862 | 1.000 |
| Royal London UK Mid-Cap Growth Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Saracen Growth Fund | 0.472 | 0.481 | 0.641 | 0.991 |
| Schroder UK Mid 250 Fund | 0.457 | 0.462 | 0.627 | 1.000 |
| Skandia UK Best Ideas Fund | 0.374 | 0.408 | 0.544 | 1.000 |
| Standard Life UK Equity High Alpha Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Standard Life UK Equity Income Unconstrained Fund | 0.568 | 0.749 | 0.724 | 0.999 |
| Standard Life UK Equity Unconstrained Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Standard Life UK Ethical Fund | 0.676 | 0.682 | 0.806 | 0.999 |
| SVM UK Opportunities Fund | 0.866 | 0.868 | 0.928 | 1.000 |
| Threadneedle UK Mid 250 Fund | 0.830 | 0.830 | 0.907 | 0.991 |
| **iShares FTSE 250** | **1.000** | **1.000** | **1.000** | **1.000** |

***Table RA4.5:*** ***UK Small-Cap Equity (1st January 2008 – 31st December 2010)***

SORMCCR-OO → SORMCCR DEA Model Output-Oriented

Three-Stage SORMCCR-OO → Three-Stage SORMCCR DEA Model Output-Oriented

SORMSBM-OO → SORMSBM DEA Model Output-Oriented

Three-Stage SORMSBM-OO → Three-Stage SORMSBM DEA Model Output-Oriented

| Name Of OEIC/UT | SORMCCR-OO | Three-Stage SORMCCR-OO | SORMSBM-OO | Three-Stage SORMSBM-OO |
|---|---|---|---|---|
| Aberdeen UK Smaller Companies Fund | 0.656 | 0.656 | 0.792 | 1.000 |
| Aberforth UK Small Companies Fund | 0.741 | 0.741 | 0.851 | 1.000 |
| AEGON UK Smaller Companies Fund | 0.807 | 0.807 | 0.893 | 1.000 |
| Artemis UK Smaller Companies Fund | 0.085 | 0.085 | 0.157 | 1.000 |
| Aviva Investors UK Smaller Companies Fund | 0.771 | 0.771 | 0.871 | 1.000 |
| AXA Framlington UK Smaller Companies Fund | 0.762 | 0.762 | 0.865 | 1.000 |
| Baillie Gifford British Smaller Companies Fund | 0.769 | 0.769 | 0.869 | 1.000 |
| BlackRock Growth And Recovery Fund | 0.635 | 0.635 | 0.777 | 1.000 |
| BlackRock UK Smaller Companies Fund | 0.736 | 0.736 | 0.848 | 1.000 |
| Cazenove UK Smaller Companies Fund | 0.844 | 0.844 | 0.915 | 1.000 |
| CF Amati UK Smaller Companies Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| CF Canada Life UK Smaller Companies Fund | 0.812 | 0.812 | 0.896 | 1.000 |
| CF Chelverton UK Equity Income Fund | 0.679 | 0.679 | 0.809 | 1.000 |
| CF Octopus UK Micro Cap Growth Fund | 0.996 | 0.996 | 0.998 | 1.000 |
| Close Special Situations Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Dimensional UK Small Companies Fund | 0.825 | 0.825 | 0.904 | 1.000 |
| Discretionary Fund | 0.521 | 0.521 | 0.685 | 1.000 |
| F&C UK Smaller Companies Fund | 0.708 | 0.708 | 0.829 | 1.000 |
| Gartmore UK & Irish Smaller Companies Fund | 0.728 | 0.728 | 0.843 | 1.000 |
| Henderson UK Smaller Companies Fund | 0.770 | 0.770 | 0.870 | 1.000 |
| Henderson UK Strategic Capital Trust | 0.410 | 0.410 | 0.582 | 1.000 |

| | | | | |
|---|---|---|---|---|
| HSBC UK Smaller Companies Fund | 0.772 | 0.772 | 0.871 | 1.000 |
| Ignis Smaller Companies Fund | 0.606 | 0.606 | 0.755 | 1.000 |
| Investec UK Smaller Companies Fund | 0.909 | 0.909 | 0.953 | 1.000 |
| Invesco Perpetual UK Smaller Companies Equity Fund | 0.639 | 0.639 | 0.780 | 1.000 |
| Invesco Perpetual UK Smaller Companies Growth Fund | 0.382 | 0.382 | 0.553 | 1.000 |
| J. P. Morgan UK Smaller Companies Fund | 0.699 | 0.699 | 0.823 | 1.000 |
| Jupiter UK Smaller Companies Fund | 0.677 | 0.677 | 0.807 | 1.000 |
| L&G UK Alpha Trust | 1.000 | 1.000 | 1.000 | 1.000 |
| L&G UK Smaller Companies Trust | 0.744 | 0.744 | 0.853 | 1.000 |
| M&G Smaller Companies Fund | 0.826 | 0.826 | 0.905 | 1.000 |
| Majedie Asset Special Situations Investment Fund | 0.877 | 0.877 | 0.935 | 1.000 |
| Manek Growth Fund | 0.154 | 0.154 | 0.268 | 1.000 |
| Marlborough Special Situations Fund | 0.812 | 0.812 | 0.897 | 1.000 |
| Marlborough UK Micro Cap Growth Fund | 0.914 | 0.914 | 0.955 | 1.000 |
| MFM Techinvest Special Situations Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Newton UK Smaller Companies Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Old Mutual UK Select Smaller Companies Fund | 0.688 | 0.688 | 0.816 | 1.000 |
| Premier Castlefield UK Smaller Companies Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Prudential Small Companies Trust | 0.819 | 0.819 | 0.900 | 1.000 |
| River & Mercantile UK Equity Smaller Companies Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Royal London UK Smaller Companies Fund | 0.613 | 0.613 | 0.760 | 1.000 |
| Schroder UK Smaller Companies Fund | 0.688 | 0.688 | 0.815 | 1.000 |
| Scottish Widows UK Smaller Companies Fund | 0.678 | 0.678 | 0.808 | 1.000 |
| SF T1PS Smaller Companies Growth Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Standard Life UK Opportunities Fund | 0.748 | 0.748 | 0.856 | 1.000 |
| Standard Life UK Smaller Companies Fund | 0.838 | 0.838 | 0.912 | 1.000 |
| SWIP UK Smaller Companies Fund | 0.670 | 0.670 | 0.802 | 1.000 |
| UBS UK Smaller Companies Fund | 0.667 | 0.667 | 0.800 | 1.000 |
| Unicorn Outstanding British Companies Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| **iShares FTSE 250** | **1.000** | **1.000** | **1.000** | **1.000** |

## UK Domiciled OEICs And UTs With A US Investment Focus

***Table RA4.6:*** ***US Large-Cap Value And Growth Equity (1st January 2008 – 31st December 2010)***

SORMCCR-OO → SORMCCR DEA Model Output-Oriented

Three-Stage SORMCCR-OO → Three-Stage SORMCCR DEA Model Output-Oriented

SORMSBM-OO → SORMSBM DEA Model Output-Oriented

Three-Stage SORMSBM-OO → Three-Stage SORMSBM DEA Model Output-Oriented

| Name Of OEIC/UT | SORMCCR-OO | Three-Stage SORMCCR-OO | SORMSBM-OO | Three-Stage SORMSBM-OO |
|---|---|---|---|---|
| Franklin Mutual Shares Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| GLG US Relative Value Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| J. P. Morgan US Fund | 0.898 | 0.898 | 0.946 | 1.000 |
| M&G North American Value Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Old Mutual North American Equity Fund | 0.867 | 0.867 | 0.929 | 1.000 |
| Prudential North American Trust | 0.969 | 0.969 | 0.984 | 1.000 |
| AXA Framlington American Growth Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Baillie Gifford American Fund | 0.866 | 0.866 | 0.928 | 1.000 |
| CF The Westchester Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Fidelity American Special Situations Fund | 0.908 | 0.908 | 0.952 | 1.000 |
| Gartmore US Opportunities Fund | 0.998 | 0.998 | 0.999 | 1.000 |
| GLG American Growth Fund | 0.902 | 0.902 | 0.948 | 1.000 |
| Ignis American Growth Fund | 0.875 | 0.875 | 0.934 | 1.000 |
| Martin Currie North American Fund | 0.741 | 0.741 | 0.852 | 1.000 |
| Martin Currie North American Alpha Fund | 0.673 | 0.673 | 0.805 | 1.000 |
| Neptune US Opportunities Fund | 0.982 | 0.982 | 0.991 | 1.000 |
| PSigma American Growth Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Standard Life TM North American Trust | 1.000 | 1.000 | 1.000 | 1.000 |
| Standard Life North American Equity Manager Of Managers Fund | 0.921 | 0.921 | 0.959 | 1.000 |
| Threadneedle American Extended Alpha Fund | 1.000 | 1.000 | 1.000 | 1.000 |

| | | | | |
|---|---|---|---|---|
| Threadneedle American Fund | 0.896 | 0.896 | 0.946 | 1.000 |
| Threadneedle American Select Fund | 0.896 | 0.896 | 0.946 | 1.000 |
| **iShares S&P 500** | **1.000** | **1.000** | **1.000** | **1.000** |

***Table RA4.7:*** ***US Large-Cap Blend Equity (1st January 2008 – 31st December 2010)***

SORMCCR-OO → SORMCCR DEA Model Output-Oriented

Three-Stage SORMCCR-OO → Three-Stage SORMCCR DEA Model Output-Oriented

SORMSBM-OO → SORMSBM DEA Model Output-Oriented

Three-Stage SORMSBM-OO → Three-Stage SORMSBM DEA Model Output-Oriented

| Name Of OEIC/UT | SORMCCR-OO | Three-Stage SORMCCR-OO | SORMSBM-OO | Three-Stage SORMSBM-OO |
|---|---|---|---|---|
| Aberdeen American Equity Fund | 0.845 | 0.845 | 0.916 | 1.000 |
| AEGON American Equity Fund | 0.044 | 0.044 | 0.084 | 1.000 |
| Allianz RCM US Equity Fund | 0.909 | 0.909 | 0.953 | 1.000 |
| AXA Rosenberg American Fund | 0.592 | 0.592 | 0.743 | 1.000 |
| BlackRock US Dynamic Fund | 0.677 | 0.677 | 0.808 | 1.000 |
| CF Canada Life North American Fund | 0.912 | 0.912 | 0.954 | 1.000 |
| F&C North American Fund | 0.976 | 0.976 | 0.988 | 1.000 |
| FF&P US Large-Cap Equity Fund | 0.684 | 0.684 | 0.812 | 1.000 |
| Fidelity American Special Situations Fund | 0.944 | 0.944 | 0.971 | 1.000 |
| Franklin US Equity Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Gartmore US Growth Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Henderson American Portfolio Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Henderson North American Enhanced Equity Fund | 0.855 | 0.855 | 0.922 | 1.000 |
| HSBC American Index Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Investec American Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Invesco Perpetual US Equity Fund | 0.806 | 0.806 | 0.893 | 1.000 |
| J. P. Morgan US Select Fund | 0.999 | 0.999 | 1.000 | 1.000 |
| Jupiter North American Income Fund | 0.888 | 0.888 | 0.941 | 1.000 |
| L&G (Barclays) Multi-Manager US Alpha Fund | 0.970 | 0.970 | 0.985 | 1.000 |

| | | | | |
|---|---|---|---|---|
| L&G North American Trust | 0.800 | 0.800 | 0.889 | 1.000 |
| L&G US Index Trust | 0.824 | 0.824 | 0.904 | 1.000 |
| Legg Mason US Equity Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| M&G American Fund | 0.988 | 0.988 | 0.995 | 1.000 |
| Royal London US Index Tracker Trust | 1.000 | 1.000 | 1.000 | 1.000 |
| Santander Premium Fund US Equity Fund | 0.949 | 0.949 | 0.974 | 1.000 |
| Schroder QEP US Core Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Scottish Mutual North American Trust | 1.000 | 1.000 | 1.000 | 1.000 |
| Scottish Widows American Growth Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Scottish Widows American Select Growth Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| SSGA North American Equity Tracker Fund | 0.846 | 0.846 | 0.916 | 1.000 |
| St James's Place North American Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Standard Life American Equity Unconstrained Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Standard Life US Equity Index Tracker Fund | 0.904 | 0.904 | 0.949 | 1.000 |
| SWIP North American Fund | 0.995 | 0.995 | 0.997 | 1.000 |
| UBS US 130/30 Equity Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| UBS US Equity Fund | 0.942 | 0.942 | 0.970 | 1.000 |
| **iShares S&P 500** | **0.840** | **0.840** | **0.915** | **1.000** |

***Table RA4.8:*** ***US Mid-Cap And Small-Cap Equity (1st January 2008 – 31st December 2010)***

SORMCCR-OO → SORMCCR DEA Model Output-Oriented

Three-Stage SORMCCR-OO → Three-Stage SORMCCR DEA Model Output-Oriented

SORMSBM-OO → SORMSBM DEA Model Output-Oriented

Three-Stage SORMSBM-OO → Three-Stage SORMSBM DEA Model Output-Oriented

| Name Of OEIC/UT | SORMCCR-OO | Three-Stage SORMCCR-OO | SORMSBM-OO | Three-Stage SORMSBM-OO |
|---|---|---|---|---|
| CF Greenwich Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| FF&P US All-Cap Value Equity Fund | 0.604 | 0.604 | 0.753 | 1.000 |
| GAM North American Growth Fund | 0.993 | 0.993 | 0.997 | 1.000 |
| Melchior North American Opportunities Fund | 0.803 | 0.803 | 0.891 | 1.000 |
| Schroder US Mid-Cap Fund | 0.853 | 0.853 | 0.921 | 1.000 |

| | | | | |
|---|---|---|---|---|
| Scottish Widows American Smaller Companies Fund | 0.931 | 0.931 | 0.964 | 1.000 |
| SWIP North American Smaller Companies Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Threadneedle American Smaller Companies Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| FF&P US Small-Cap Equity Fund | 0.690 | 0.690 | 0.816 | 1.000 |
| J. P. Morgan US Smaller Companies Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Legg Mason US Smaller Companies Fund | 0.907 | 0.907 | 0.951 | 1.000 |
| Schroder US Smaller Companies Fund | 0.919 | 0.919 | 0.958 | 1.000 |
| **iShares S&P 500** | **1.000** | **1.000** | **1.000** | **1.000** |

## UK Domiciled OEICs And UTs With A Global Investment Focus

### *Table RA4.9: Global Large-Cap Value Equity (1st January 2008 – 31st December 2010)*

SORMCCR-OO → SORMCCR DEA Model Output-Oriented

Three-Stage SORMCCR-OO → Three-Stage SORMCCR DEA Model Output-Oriented

SORMSBM-OO → SORMSBM DEA Model Output-Oriented

Three-Stage SORMSBM-OO → Three-Stage SORMSBM DEA Model Output-Oriented

| Name Of OEIC/UT | SORMCCR-OO | Three-Stage SORMCCR-OO | SORMSBM-OO | Three-Stage SORMSBM-OO |
|---|---|---|---|---|
| Aberdeen Charity Select Global Equity Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Aberdeen Ethical World Fund | 0.890 | 0.890 | 0.942 | 1.000 |
| Aberdeen World Equity Fund | 0.902 | 0.902 | 0.949 | 1.000 |
| AXA Rosenberg Global Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Baillie Gifford Global Income Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| CF Stewart Ivory Investment Markets Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Dimensional International Value Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| GAM Global Diversified Fund | 0.893 | 0.893 | 0.944 | 1.000 |
| Gartmore Long-Term Balanced Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| GLG Stockmarket Managed Fund | 0.865 | 0.865 | 0.928 | 1.000 |
| Ignis Global Growth Fund | 0.993 | 0.993 | 0.996 | 1.000 |
| Investec Global Special Situations Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Invesco Perpetual Global Core Equity Index Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| J. P. Morgan Global Equity Income Fund | 0.829 | 0.829 | 0.907 | 1.000 |
| L&G Global 100 Index Trust | 0.840 | 0.840 | 0.913 | 1.000 |
| Lazard Global Equity Income Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| M&G Global Leaders Fund | 0.780 | 0.780 | 0.877 | 1.000 |
| Newton Global Higher Income Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Old Mutual Global Equity Fund | 0.832 | 0.832 | 0.908 | 1.000 |
| Prudential International Growth Trust | 0.978 | 0.978 | 0.989 | 1.000 |

| | | | | |
|---|---|---|---|---|
| Sarasin International Equity Income Fund | 0.889 | 0.889 | 0.941 | 1.000 |
| Schroder Global Equity Income Fund | 0.973 | 0.973 | 0.986 | 1.000 |
| St James's Place Recovery Fund | 0.619 | 0.619 | 0.764 | 1.000 |
| Templeton Growth Fund | 0.770 | 0.770 | 0.870 | 1.000 |
| Threadneedle Global Equity Income Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| **iShares MSCI World** | **0.733** | **0.733** | **0.846** | **1.000** |

***Table RA4.10:* Global Large-Cap Growth Equity (1st January 2008 – 31st December 2010)**

SORMCCR-OO → SORMCCR DEA Model Output-Oriented

Three-Stage SORMCCR-OO → Three-Stage SORMCCR DEA Model Output-Oriented

SORMSBM-OO → SORMSBM DEA Model Output-Oriented

Three-Stage SORMSBM-OO → Three-Stage SORMSBM DEA Model Output-Oriented

| Name Of OEIC/UT | SORMCCR-OO | Three-Stage SORMCCR-OO | SORMSBM-OO | Three-Stage SORMSBM-OO |
|---|---|---|---|---|
| AEGON Global Equity Fund | 0.639 | 0.639 | 0.780 | 1.000 |
| Aviva Investors World Leaders Fund | 0.701 | 0.701 | 0.825 | 1.000 |
| AXA Framlington Global Opportunities Fund | 0.151 | 0.151 | 0.263 | 1.000 |
| Baillie Gifford International Fund | 0.969 | 0.969 | 0.984 | 1.000 |
| Baillie Gifford Long-Term Global Growth Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| CF JM Finn Global Opportunities Fund | 0.937 | 0.937 | 0.968 | 1.000 |
| Discovery Managed Growth Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| EFA Ursa Major Growth Portfolio Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| F&C Global Growth Fund | 0.943 | 0.943 | 0.971 | 1.000 |
| F&C International Heritage Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| F&C Stewardship International Fund | 0.884 | 0.884 | 0.939 | 1.000 |
| Fidelity Global Focus Fund | 0.886 | 0.886 | 0.940 | 1.000 |
| Henderson International Fund | 0.789 | 0.789 | 0.882 | 1.000 |
| Margetts Greystone Global Growth Fund | 0.815 | 0.815 | 0.898 | 1.000 |
| Martin Currie Global Alpha Fund | 0.218 | 0.218 | 0.357 | 1.000 |

| | | | | |
|---|---|---|---|---|
| NatWest International Growth Fund | 0.795 | 0.795 | 0.886 | 1.000 |
| Neptune Global Equity Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| PFS Taube Global Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| RBS International Growth Fund | 0.793 | 0.793 | 0.884 | 1.000 |
| Sheldon Equity Growth Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Sheldon Financial Growth Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| St James's Place Worldwide Opportunities Fund | 0.791 | 0.791 | 0.884 | 1.000 |
| Thesis Lion Growth Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Threadneedle Global Select Fund | 0.876 | 0.876 | 0.934 | 1.000 |
| Zenith International Growth Fund | 0.342 | 0.342 | 0.510 | 1.000 |
| **iShares MSCI World** | **0.837** | **0.837** | **0.912** | **1.000** |

***Table RA4.11:*** ***Global Large-Cap Blend Equity (1st January 2008 – 31st December 2010)***

SORMCCR-OO → SORMCCR DEA Model Output-Oriented

Three-Stage SORMCCR-OO → Three-Stage SORMCCR DEA Model Output-Oriented

SORMSBM-OO → SORMSBM DEA Model Output-Oriented

Three-Stage SORMSBM-OO → Three-Stage SORMSBM DEA Model Output-Oriented

| Name Of OEIC/UT | SORMCCR-OO | Three-Stage SORMCCR-OO | SORMSBM-OO | Three-Stage SORMSBM-OO |
|---|---|---|---|---|
| Aberdeen Multi-Manager Constellation Portfolio | 0.689 | 0.689 | 0.816 | 1.000 |
| Aberdeen Multi-Manager International Growth Portfolio | 0.714 | 0.714 | 0.833 | 1.000 |
| Architas Multi-Manager Diversified Share Portfolio | 0.425 | 0.425 | 0.596 | 1.000 |
| Architas Multi-Manager Global Equity Portfolio | 0.793 | 0.793 | 0.885 | 1.000 |
| Artemis Global Growth Fund | 0.252 | 0.252 | 0.403 | 1.000 |
| Aviva Investors Fund Of Funds Balanced Fund | 0.878 | 0.878 | 0.935 | 1.000 |
| Aviva Investors Fund Of Funds Growth Fund | 0.836 | 0.836 | 0.910 | 1.000 |
| Aviva Investors International Index Tracking Fund | 0.809 | 0.809 | 0.895 | 1.000 |
| Aviva Investors SF Global Growth Fund | 0.504 | 0.504 | 0.670 | 1.000 |
| Baillie Gifford Managed Fund | 0.921 | 0.921 | 0.959 | 1.000 |

| | | | | |
|---|---|---|---|---|
| Bank Of Scotland International Managed Fund | 0.937 | 0.937 | 0.967 | 1.000 |
| BCIF Balanced Managed Fund | 0.606 | 0.606 | 0.755 | 1.000 |
| BlackRock Active Managed Portfolio Fund | 0.736 | 0.736 | 0.848 | 1.000 |
| BlackRock Global Equity Fund | 0.851 | 0.851 | 0.919 | 1.000 |
| BlackRock International Equity Fund | 0.830 | 0.830 | 0.907 | 1.000 |
| BlackRock Overseas Fund | 0.840 | 0.840 | 0.913 | 1.000 |
| Cazenove Multi-Manager Global Fund | 0.753 | 0.753 | 0.859 | 1.000 |
| CF Adam Worldwide Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| CF Aquarius Fund | 0.268 | 0.268 | 0.423 | 1.000 |
| CF Broden Fund | 0.628 | 0.628 | 0.771 | 1.000 |
| CF Canada Life International Growth Fund | 0.875 | 0.875 | 0.933 | 1.000 |
| CF FundQuest Global Select Fund | 0.836 | 0.836 | 0.911 | 1.000 |
| CF FundQuest Select Opportunities Fund | 0.835 | 0.835 | 0.910 | 1.000 |
| CF FundQuest Select Fund | 0.774 | 0.774 | 0.872 | 1.000 |
| CF Helm Investment Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| CF Lacomp World Fund | 0.785 | 0.785 | 0.879 | 1.000 |
| CF The Aurinko Fund | 0.783 | 0.783 | 0.878 | 1.000 |
| CF Taylor Young International Equity Fund | 0.919 | 0.919 | 0.958 | 1.000 |
| Chariguard Overseas Equity Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| City Financial Multi-Manager Growth Fund | 0.064 | 0.064 | 0.121 | 1.000 |
| Deutsche Bank PWM Capital Growth Portfolio | 0.895 | 0.895 | 0.945 | 1.000 |
| Ecclesiastical Amity International Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| F&C Lifestyle Growth Fund | 0.777 | 0.777 | 0.875 | 1.000 |
| Family Investments Child Trust Fund | 0.573 | 0.573 | 0.729 | 1.000 |
| FF&P Global Equities II Fund | 0.625 | 0.625 | 0.770 | 1.000 |
| Fidelity Global Special Situations Fund | 0.445 | 0.445 | 0.616 | 1.000 |
| Fidelity International Fund | 0.640 | 0.640 | 0.781 | 1.000 |
| Fidelity MoneyBuilder Global Trust | 0.750 | 0.750 | 0.857 | 1.000 |
| Fidelity WealthBuilder Fund | 0.793 | 0.793 | 0.885 | 1.000 |
| First State Global Growth Fund | 0.919 | 0.919 | 0.958 | 1.000 |
| First State Global Opportunities Fund | 0.695 | 0.695 | 0.820 | 1.000 |
| GAM Composite Absolute Return OEIC | 0.743 | 0.743 | 0.853 | 1.000 |
| GAM Portfolio Unit Trust | 0.922 | 0.922 | 0.959 | 1.000 |
| Gartmore Global Focus Fund | 0.614 | 0.614 | 0.761 | 1.000 |
| Gartmore Multi-Manager Active Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Henderson Global Dividend Income Fund | 1.000 | 1.000 | 1.000 | 1.000 |

| | | | | |
|---|---|---|---|---|
| Henderson Multi-Manager Active Fund | 0.443 | 0.443 | 0.614 | 1.000 |
| Henderson Multi-Manager Tactical Fund | 0.554 | 0.554 | 0.713 | 1.000 |
| HSBC Global Growth Fund Of Funds | 0.818 | 0.818 | 0.900 | 1.000 |
| HSBC Portfolio Fund | 0.794 | 0.794 | 0.885 | 1.000 |
| IFDS Brown Shipley Multi-Manager International Fund | 0.808 | 0.808 | 0.894 | 1.000 |
| Investec Global Dynamic Fund | 0.998 | 0.998 | 0.999 | 1.000 |
| Investec Global Equity Fund | 0.854 | 0.854 | 0.922 | 1.000 |
| Investec Global Free Enterprise Fund | 0.761 | 0.761 | 0.865 | 1.000 |
| Invesco Perpetual Global Equity Fund | 0.724 | 0.724 | 0.840 | 1.000 |
| Invesco Perpetual Global Enhanced Index Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Invesco Perpetual Global Opportunities Fund | 0.715 | 0.715 | 0.834 | 1.000 |
| Invesco Perpetual Managed Growth Fund | 0.759 | 0.759 | 0.863 | 1.000 |
| Jessop (GAR) Global Equity Quant Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| J. P. Morgan Global Fund | 0.764 | 0.764 | 0.866 | 1.000 |
| J. P. Morgan Portfolio Fund | 0.727 | 0.727 | 0.842 | 1.000 |
| Jupiter Merlin Growth Portfolio Fund | 0.966 | 0.966 | 0.984 | 1.000 |
| Jupiter Merlin Worldwide Portfolio Fund | 0.987 | 0.987 | 0.994 | 1.000 |
| L&G (Barclays) Adventurous Growth Portfolio Trust | 0.573 | 0.573 | 0.729 | 1.000 |
| L&G Global Growth Trust | 0.621 | 0.621 | 0.766 | 1.000 |
| L&G Worldwide Trust | 0.677 | 0.677 | 0.807 | 1.000 |
| Liberation No. VIII Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| M&G Global Growth Fund | 0.857 | 0.857 | 0.923 | 1.000 |
| Margetts International Strategy Fund | 0.867 | 0.867 | 0.929 | 1.000 |
| Margetts Venture Strategy Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Marlborough Global Fund | 0.681 | 0.681 | 0.810 | 1.000 |
| Martin Currie Global Fund | 0.491 | 0.491 | 0.659 | 1.000 |
| Neptune Global Max Alpha Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Newton 50/50 Global Equity Fund | 0.869 | 0.869 | 0.930 | 1.000 |
| Newton Falcon Fund | 0.897 | 0.897 | 0.946 | 1.000 |
| Newton Global Balanced Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Newton Global Opportunities Fund | 0.841 | 0.841 | 0.914 | 1.000 |
| Newton International Growth Fund | 0.969 | 0.969 | 0.985 | 1.000 |
| Newton Managed Fund | 0.598 | 0.598 | 0.749 | 1.000 |
| Newton Overseas Equity Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Premier Castlefield Managed Multi-Asset Fund | 0.803 | 0.803 | 0.890 | 1.000 |
| Prudential (Invesco Perpetual) Managed Trust | 0.636 | 0.636 | 0.777 | 1.000 |

| | | | | |
|---|---|---|---|---|
| S&W Endurance Global Opportunities Fund | 0.660 | 0.660 | 0.795 | 1.000 |
| Santander Multi-Manager Equity Fund | 0.562 | 0.562 | 0.720 | 1.000 |
| Sarasin Alpha CIF Income & Reserves Fund | 0.917 | 0.917 | 0.957 | 1.000 |
| Sarasin EquiSar Global Thematic Fund | 0.689 | 0.689 | 0.816 | 1.000 |
| Sarasin EquiSar IIID Fund | 0.187 | 0.187 | 0.314 | 1.000 |
| Schroder Global Equity Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Schroder Growth Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Schroder QEP Global Quant Core Equity Fund | 0.965 | 0.965 | 0.983 | 1.000 |
| Scottish Mutual International Growth Trust | 0.876 | 0.876 | 0.934 | 1.000 |
| Scottish Mutual Opportunity Trust | 0.759 | 0.759 | 0.863 | 1.000 |
| Scottish Widows Global Growth Fund | 0.567 | 0.567 | 0.724 | 1.000 |
| Scottish Widows Global Select Growth Fund | 0.580 | 0.580 | 0.734 | 1.000 |
| Scottish Widows International Equity Tracker Fund | 0.566 | 0.566 | 0.723 | 1.000 |
| Skandia Ethical Fund | 0.267 | 0.267 | 0.421 | 1.000 |
| Skandia Global Best Ideas Fund | 0.578 | 0.578 | 0.733 | 1.000 |
| Skandia Newton Managed Fund | 0.513 | 0.513 | 0.678 | 1.000 |
| Standard Life TM Global Equity Trust | 1.000 | 1.000 | 1.000 | 1.000 |
| Standard Life TM International Trust | 1.000 | 1.000 | 1.000 | 1.000 |
| St James's Place Ethical Fund | 0.487 | 0.487 | 0.655 | 1.000 |
| St James's Place International Fund | 0.407 | 0.407 | 0.579 | 1.000 |
| Standard Life Global Equity Fund | 0.697 | 0.697 | 0.822 | 1.000 |
| SVM Global Opportunities Fund | 0.915 | 0.915 | 0.955 | 1.000 |
| SWIP Global Fund | 0.521 | 0.521 | 0.685 | 1.000 |
| SWIP Multi-Manager International Equity Fund | 0.694 | 0.694 | 0.820 | 1.000 |
| SWIP Multi-Manager Select Boutiques Fund | 0.723 | 0.723 | 0.839 | 1.000 |
| T. Bailey Growth Fund | 0.414 | 0.414 | 0.586 | 1.000 |
| Thames River Equity Managed Fund | 0.697 | 0.697 | 0.822 | 1.000 |
| Thames River Global Boutiques Fund | 0.727 | 0.727 | 0.842 | 1.000 |
| Threadneedle Global Equity Fund | 0.633 | 0.633 | 0.775 | 1.000 |
| Threadneedle Navigator Adventurous Managed Trust | 0.845 | 0.845 | 0.916 | 1.000 |
| THS International Growth & Value Fund | 0.490 | 0.490 | 0.657 | 1.000 |
| UBS Global Optimal Fund | 0.659 | 0.659 | 0.794 | 1.000 |
| UBS Global Optimal Thirds Fund | 1.000 | 1.000 | 1.000 | 1.000 |

| | | | | |
|---|---|---|---|---|
| WAY Global Red Active Portfolio Fund | 0.623 | 0.623 | 0.768 | 1.000 |
| Wesleyan International Trust | 0.470 | 0.470 | 0.639 | 1.000 |
| Williams De Broe Global Fund | 0.755 | 0.755 | 0.861 | 1.000 |
| **iShares MSCI World** | **0.792** | **0.792** | **0.885** | **1.000** |

***Table RA4.12:* Global Mid-Cap And Small-Cap Equity (1st January 2008 – 31st December 2010)**

SORMCCR-OO → SORMCCR DEA Model Output-Oriented

Three-Stage SORMCCR-OO → Three-Stage SORMCCR DEA Model Output-Oriented

SORMSBM-OO → SORMSBM DEA Model Output-Oriented

Three-Stage SORMSBM-OO → Three-Stage SORMSBM DEA Model Output-Oriented

| Name Of OEIC/UT | SORMCCR-OO | Three-Stage SORMCCR-OO | SORMSBM-OO | Three-Stage SORMSBM-OO |
|---|---|---|---|---|
| AXA Framlington Talents Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Baillie Gifford Phoenix Global Growth Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Hargreaves Lansdown Multi-Manager Special Situations Trust | 0.839 | 0.839 | 0.913 | 1.000 |
| Invesco Perpetual Global Smaller Companies Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| J. P. Morgan Multi-Manager Growth Fund | 0.643 | 0.643 | 0.782 | 1.000 |
| L&G (Barclays) Multi-Manager Global Core Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| M&G Fund Of Investment Trust Shares | 0.294 | 0.294 | 0.455 | 1.000 |
| M&G Global Basics Fund | 0.936 | 0.936 | 0.969 | 1.000 |
| Neptune Green Planet Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| Rathbone Global Opportunities Fund | 0.773 | 0.773 | 0.872 | 1.000 |
| S&W Aubrey Global Conviction Fund | 0.937 | 0.937 | 0.968 | 1.000 |
| SF Adventurous Portfolio Fund | 1.000 | 1.000 | 1.000 | 1.000 |
| St James's Place Global Fund | 0.320 | 0.320 | 0.485 | 1.000 |
| **iShares MSCI World** | **1.000** | **1.000** | **1.000** | **1.000** |