LUND UNIVERSITY
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The Importance of Size

An examination of the effect of size and the prevalence of skill in Swedish mutual funds

by

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Abstract

In this thesis, I examine the relation between size and performance in Swedish equity mutual funds during the period 2010 – 2017. The thesis is divided into two main parts with the first part investigating the relation between size and performance by dividing the sample of 107 mutual funds into three groups according to the size of the funds. The funds are then analyzed with three different performance measures. The differences between the performance measures of the three groups are tested for statistical significance to give an indication of the relation between size and performance. The results show no clear relation between size and performance although the largest fund size show overall better results compared to the other sizes. The second part of the thesis examines the distribution of skilled fund managers among the different fund sizes. The results show an improbable high proportion of skilled fund managers in the sample compared to previous research. When analyzing the differences in the proportion of skilled fund managers between the fund sizes it is discovered that the smallest fund size has the smallest proportion of skilled fund managers among the groups.

Keywords: mutual funds, size, performance, luck, skill, Sweden

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1 Introduction

There has been a long discussion regarding the effect of size on the performance of mutual funds. Results have been varied among different studies with both positive and negative relationships between size and performance reported (Bodson, Cavenalle & Sougné, 2011). Researchers who find that size erodes performance have often mentioned diseconomies of scale in active management stemming from the increase of costs associated with either larger transactions (Perold & Salomon, 1991) or the organizational structure (Yan, 2008) as a possible explanation. On the other hand, a positive relationship implies that growth in funds is preferable. The causes behind a positive relationship have been argued, one example is Zera and Madura (2001) who find that a larger fund size is associated with smaller expense percentages. With size being a factor which is easy to grasp for even an uninitiated investor, it is easy to understand why there has been much focus on the subject among researchers. If a concise way to attribute size to performance were to be found it would give a valuable insight for amateurs and professionals alike.

1.1 Background

Mutual funds are one of the most common ways of saving in today's society. It is an attractive alternative for both amateurs and professional investors (Thune, 2018). A mutual fund is an investment company, a trust or a corporation whose business is to make investments on behalf of individuals and institutions with similar investment goals. The main idea behind the concept is that a fund endeavors to outperform individual investors in managing investments (Madlem & Sykes, 2000). Mutual funds are controlled by an assigned fund manager or a manager group who uses the pool of money, stemming from the individual investors of the fund, to buy a portfolio of securities to achieve the mutual funds' financial objectives (Madlem & Sykes, 2000). There are several different types of mutual funds based on what type of securities the fund invests in: equity funds invest in stocks, fixed income funds focus on investments that pay a fixed rate of return such as government bonds, corporate bonds, or other debt instruments. A very common type of fund is the index fund which tries to mimic a major market index, thus acting according to the strategy that it is too difficult and expensive to try to beat the market themselves. Other types of funds include money market funds, sector funds, and fund of funds (Hayes, n.d.).

For an individual, investing in mutual funds is similar to buying shares of a stock of any large corporation. The investor purchases shares of the fund but instead of owning an interest in one company, as is the case with stocks, the investor of mutual funds purchases shares in a company which owns shares of other companies (Madlem & Sykes, 2000). The costs of purchasing shares in mutual funds are not as straightforward as for other assets. When purchasing stock for instance you simply pay the broker the agreed upon commission. Since mutual funds are professionally managed there are other expenses involved as well. The fees can vary widely between different types of funds and are one of the biggest drawbacks of mutual funds as an investment type. Generally, the fees can be broken down into two broad categories: ongoing annual fees and transaction fees (Hayes, n.d.). The ongoing annual fees are summarized in the expense ratio which is reported once a year and include among others management fees and administrative expenses. Transaction fees, often referred to as loads, are equivalent to sales commissions. They cover the costs associated with buying or selling shares in a mutual fund (Hayes, n.d.).

One of the main appeals of mutual funds is that they provide simplicity for investors with lack of knowledge, time or money. The individual investor does not need to spend the amount of money or time that would have been required for them to get the same diversity in their own portfolio as they receive in a mutual fund (Kennon, 2018). The advantage of diversification seems to imply that larger mutual funds, funds with a higher value of total assets invested, would gain an advantage through diversification compared to smaller funds. Although, with an increase in size follows an increase in costs attributed to administration and research. With these factors in mind, it is difficult to attribute a succinct relation between size and performance. There are good arguments for the relation between size and performance to be both positive and negative, or if the scope is lifted and we considered if the effect not necessarily has to be linear but instead quadratic. With the effect of size described by a quadratic concave function the arguments for both positive and negative effects of the size can be incorporated in the same model. In a quadratic concave model the performance would increase with size at smaller sizes but after a point decrease as the drawbacks from size becomes more severe. This would imply that there is an optimal size for mutual funds where the performance is maximized.

One important aspect in evaluating the performance of mutual funds is how you consider the notions of luck and skill. From an investment perspective, to be able to locate skilled funds maximizes the chances of outperforming the market when investing in mutual funds. There is however difficult to discern if fund managers possess true stock-picking skill or if their success depends mainly on luck. If a fund outperforms the market is that indicative of a good fund manager or a lucky one?

If there was a way to distinguish a skilled fund manager from a manager who attains good results mainly due to luck, it would be a major advantage for investors. According to Chen, Cliff and Zhao (2017) there is no way to observe “true skill” for individual funds. There is however possible to find differences in the proportion of skilled fund managers between different groups of funds (Barras, Scaillet & Wermers, 2010). If skill were to be found to be more prevalent in a certain type of fund it would give investors further insight of the composition of fund types in the market increasing investors odds at being successful.

1.2 Aim and Objectives

The aim of the thesis is to investigate if and how the size of a mutual fund affects the performance of the fund. Furthermore, the intention is to examine the notion that the size is related to the performance of the fund in a quadratic concave manner. The other main part of the thesis consists of investigating if skill is prevalent among mutual fund managers and how the presence of skill is distributed between different sized funds.

Since there seem to be an issue with different performance measures giving varied results (Bodson, Cavenalle & Sougné, 2011), the objectives of the thesis consist in part of evaluating the effect of the size on three different performance measures: returns, the Sharpe ratio and the four-factor alpha model proposed by Carhart (1997). The other objective of the thesis consists of estimating the proportion of skilled funds in mutual funds for the complete sample as well as for different sized funds.

1.3 Research Purpose

The purpose of this study is to advance understanding of the underlying factors determining success in mutual funds. More specifically, the study will examine the relationship between size and performance in Swedish equity mutual funds. The purpose can be summarized into three main focal points.

- Expand the research about the relationship between size and performance in mutual funds, including newer data on Swedish equity mutual funds.
- Give further insight in an important factor underlying performance of mutual funds to the average investor.
- Examine the prevalence of skill among different fund sizes

The first two are in some regards self-explanatory, but being so no less important. The focus of previous research has been overwhelmingly on American based mutual funds. With limited research performed on Swedish data in recent times this study will contribute to the existing field. The third focal point is as far as I know a new approach of examining the relationship between size and performance and thus giving further insight in the relationship between size and performance in mutual funds.

1.4 Research Limitations

There are several different types of mutual funds, classified according to the type of assets it invests in. In this study, I will look at actively managed equity funds on the Swedish market. With Swedish equity funds a uniform sample is attained that is suitable for this type of study. The fact that the funds are actively managed is a vital aspect in the study. By choosing to only examine actively managed funds index funds are excluded from the sample. The importance of excluding index funds lies in that index funds do not suffer the same drawbacks as actively managed funds. Index funds strive to match a major market index thus reducing the need for research- and other costs as many of the funds functions can be more or less automated.

The time period which is investigated in the paper is between 2010 and 2017. The period is chosen in such a way that the amount of data is manageable under the time restriction as well as it fills the criteria of being current and captures the present state of today. The time frame was also limited by the availability of the data needed to calculate the performance measures which only were available up to the start of 2017.

1.5 Outline of the Thesis

This paper consists of five main parts. The first part provides a background for the thesis, including descriptions of the aims and objectives of the thesis and its limitations. The second part describes previous studies in the field to give an overview of the subject matter and to try to find the place for this study in the existing field. The third part first describes in short the data being used in the study. The third part also details the methods being used. In the fourth part the results of the study is presented, analyzed and discussed. Finally, in the fifth part the conclusion of the study is presented.

2 Literature Review

In this chapter, previous research is presented and discussed. The chapter is divided into three parts. First, research regarding size and performance is discussed with the previous studies structured in such a way that similar approaches and conclusions are grouped together. In the second part, research regarding separating luck and skill is discussed. In the third and final part the previous research is summarized and discussed to show how this thesis fit in the current field of research.

2.1 Performance and Size

There has been plenty of research conducted on the impact of size on the performance of mutual funds. However, there is no clear consensus in the literature on the direction the size impact performance or even if size has an effect at all. Chen, Hong, Huang, and Kubik (2004) find that fund returns, both before and after fees and expenses, decline with lagged fund size. They find that the effect is more prominent with funds that invest in small cap stocks, suggesting that liquidity is an important factor. Consistent with these findings Yan (2008), using several different one- and multi-factor alpha models to measure performance, finds an inverse relation between fund size and performance and that the relation is stronger among funds that hold less liquid portfolios.

Other previous research has argued that a negative relationship can be attributed to diseconomies of scale. Chen et al. (2004) argues that organizational diseconomies, in that the administration of a large fund is more expensive, has a negative effect of the performance of larger funds. In contrast, Reuter and Zitzewitz (2010) who investigate diseconomies of scale in mutual funds find that possible downward bias from diseconomies of scale is too small to be significant and find little to no evidence that fund size erode performance.

Several other studies find no link or an inconclusive relationship between size and performance in mutual funds. Basso and Funari (2017) looking at European equity mutual funds using various statistical tests find no linear relationship between size and performance. They do however find that there is a significant difference in performance between small and large mutual funds in that larger funds on average tend to perform better than smaller funds. They argue that this indicates that size indeed has a positive impact on the performance and that the relationship between fund size and performance might be non-linear. Furthermore, they find indications of an optimal size where beyond a negative effect could erode performance. Dahlquist, Engström and Söderlind (2000) looking at Swedish equity funds finds that large funds tend to perform less well than smaller equity funds, however they find that the advantage of smaller funds does not seem to persist over time. Sing (2007), investigating equity funds in Singapore, find that there exists a positive relationship between size and performance but, similarly to Dahlquist, Engström and Söderlind (2010), the relationship does not hold up when examined during several continuing time periods.

Phillips, Pukthuanthong and Rau (2018) argue in a recent study that previous difficulties of reaching a conclusion might stem from the possibility that size and performance of mutual funds are endogenous. They identify a set of instrumental variables that influence fund size but are unrelated to the performance of the funds. Using these instruments, they find no significant evidence that size affect performance. They also fail to find any significant evidence of diseconomies of scale in mutual fund performance.

Some studies find an existence of a positive relationship between size and performance. Indro, Jiang, Hu and Lee (1999) finds that actively managed mutual funds need to attain a minimum size before they achieve high enough returns to cover the costs of operating the fund. Tang, Wang and Hu (2011) looking at Chinese open end equity funds finds the relationship to be explained by an inverted U-shape. They cite economy of scale and liquidity constraints as the main factors behind the relationship. Indro et al. (1999) also describe the relationship in a quadratic manner. They find diminishing marginal returns in information activities and find an optimal size after which the marginal returns become negative. Bodson, Cavenalle and Sougné (2011) argue that the different results in research in the subject can be attributed to the use of different measurements for the performance of the funds. They investigate the relationship between size and performance using various measurements and find evidence of a quadratic concave relationship between fund size and performance in the majority of their chosen performance measures.

2.2 Luck Versus Skill

Several of the previous mentioned studies, regardless of the manner of the relationship they find between size and performance has one thing in common. The persistence of results over time does not seem to be stable. For example, Dahlquist, Engström and Söderlind (2000) as well as Sing (2007), although with the relationship being in opposite directions, find that the result does not stand when investigating in different time periods. There seems to be a problem in analyzing results in mutual funds stemming from an inconsistency over time in producing market beating returns. One possible explanation to the problem is the notion of luck versus skill, namely that one important often omitted factor behind the success of mutual funds is luck. One would expect that funds with skilled managers would outperform the market regularly. With the notion of luck added, the reason behind the lack of persistence in success of mutual funds can be argued to originate from skilled managers suffering spells of bad luck. Similarly, for unskilled fund managers, there is a possibility of performing well during a particularly lucky period before receding to a performance level corresponding to the actual skill level of the manager.

Previous research has had two main approaches when estimating the impact of luck and skill. The "no luck" approach, where it is assumed that luck does not have an effect on the results and the only important thing is the observed number of significant funds (Ferson & Schadt, 1996). The other approach proposed by Jensen (1968) assumes that all funds are neither skilled or unskilled, thus for a given significance level, γ, it would be expected that merely because of random chance the estimate of skilled and unskilled funds would be equal to $\gamma/2$. Fama and French (2010) examine actively managed U.S. equity mutual funds. They find that in aggregate, mutual fund investors realize net returns which underperform compared to the market. Furthermore, they find no significant proof of fund managers with enough skill to cover costs, although they suggest that the presence of skill can be hidden by the amount of unskilled fund managers. Barras, Scaillet and Wermers (2010) develop a simple technique to control for luck in mutual funds. They argue that luck is present in all funds, regardless their level of skill. By assuming that luck is normally distributed they find a way to distinguish the truly skilled and unskilled funds. Chen, Cliff and Zhao (2017) suggests a new performance measure building on the model created by Barra, Scaillet and Wermers (2010) to evaluate mutual funds where luck plays an integral part, influencing both presumed skilled and unskilled fund managers. In their method, they include a step which determines the number of different skill-levels present in the sample. They find that their constructed performance measure outperforms traditional measures such as estimated alpha in identifying skilled funds.

2.3 Chapter Summary

It is clear by previous research that there is no consensus on how performance of mutual funds is related to the size of the funds. Different studies find different results, with both negative and positive relationships being put forth. Some researchers find evidence of a quadratic relationship while a few do not find any evidence of a relation at all. One notion that seems to be re-occurring is that the relationship does not seem to be stable over multiple periods. The majority of research has been performed on the U.S. mutual fund market, with fewer studies on other markets. There appear then to be a gap in previous research for research on other countries to examine if they exhibit similar attributes as the U.S. market. In accordance to the findings of Bodson, Cavenalle and Sougné (2011) different approaches in measuring performance among mutual funds need to be used for any discovered relation to be robust.

Luck and skill appears to be difficult to separate when examining mutual funds. Different approaches exist where recent attempts to account for luck is an interesting development. If luck is accounted for and it is possible to distinguish lucky funds from skilled ones it could be a possible explanation to why the relationship between size and performance is hard to find and why the relation does not tend to hold over multiple periods.

The recent study by Phillips, Pukthuanthong and Rau (2018) highlights an important issue in the problem with endogeneity by omitted variable bias. This unfortunately falls outside the time frame and scope of this study but would be interesting to investigate further in the future on Swedish data. In this study, the problem is averted by not examining size affecting performance in a causal manner and instead trying to find the correlating relationship.

3 Methodology

3.1 Research Approach

The study is divided into two parts with the first part investigating the relation between size and performance in mutual funds. The second part of the study explores the presence of skill in mutual funds in an attempt to see if the distribution of skill among different sized funds might explain the difference in performance.

3.2 Research Design

The study will focus on Swedish equity mutual funds during seven years between 2010 and 2017. The study includes data on 107 Swedish mutual funds. These funds are the available funds after adjusting for index funds, and other types of funds. Using equity funds has the advantage of it being a homogenous sample of mutual funds giving more weight to the findings of the study. Index funds are weeded out since they do not fulfill the requisite of being actively managed. The data of the funds used is collected from Thomas Reuters Eikon, a software product provided by Thomson Reuters to aid financial professionals to monitor and analyze financial information. The data of the mutual funds consists of monthly observations of the funds' net asset value (NAV) and their total net asset value (TNA). Also included in the data is the expense ratio of the funds as well as the date of the funds inception. The total net asset value is the total market value of a fund's investments subtracted its liabilities. The liabilities of the fund consist of different expenses the fund has including for example research costs, trading costs and management fees. The NAV is calculated by dividing the TNA with the number of outstanding shares. The expenses that are subtracted to calculate the net asset value is reported once a year as the total percentage of fund assets used for administrative, management and other expenses. An expense ratio of 1% per annum means that each year the fund company uses 1% of the fund's total assets to cover expenses. The expense ratio does not however include sales loads or brokerage commissions. These costs are however included in the net asset value of the funds.

The funds are sorted according to the size of their total net assets. The mutual funds are then divided into terciles according to the monetary limit of the average total net asset value of the funds. The delimitations for the groups are chosen to achieve an even distribution of funds in the different groups. This procedure is performed for the whole sample period as well as for three sub periods. The sub periods are the whole seven-year period divided into three equal parts consisting of 28 months per period. The sub periods are analyzed to investigate the persistence of the funds' performance over time and to distinguish potential trends in the different sub periods. Worth noting is that when sorting the funds into the groups for each period, the funds move freely among the groups according to the average TNA of the funds for that specific period. One fund can for example be in the largest group in period one and in the next have dropped down to the second group. This approach is similar to the one used by Ciccotello and Grant (1996), Indro et al. (1999) and Bodson, Cavenalle and Sougné (2011). A significant difference from previous research in this study is the number of size groups that are used. Since previous research has focused on mutual funds in the U.S. the sample size is larger than with Swedish funds, giving researchers the possibility of using a larger number of groups to conduct their study. Especially Bodson, Cavenalle and Sougné (2011) takes advantage of this by dividing their funds into percentiles and plotting the results of various common performance measures against the logged size of the percentiles and the square of logged asset size. This method has the advantage of simplifying the comparison between the smallest and largest funds to test if there is significance in the difference of performance. With only three different size groups it is not possible to use the brute force of numbers to examine the relationship between size and performance, and to investigate the notion of non-linearity.

To be able to perform an analysis on the available data the method needs some form of modification. For all funds in the dataset performance is measured in three different ways for the full sample period from January 2010 to December 2016 as well as for the three sub periods. The measures that are used in the study to evaluate performance of the funds are first the average monthly excess returns after subtracting the risk-free rate which is assumed to be equal to the Swedish 1-month T bill. The second performance measure is the Sharpe ratio which is based on the single factor Capital Asset Pricing model (CAPM). The Sharpe ratio measures the performance of an investment adjusted for its risk measured by its standard deviation. By computing the risk adjusted performance the Sharpe ratio is comparable among funds with different levels of risk making it a good choice for this study (Sharpe, 1966). The third performance measure is the Carhart (1997) four-factor alpha model. This multifactor model is an extension of the previous Fama-French three-factor model (1996). The multifactor model uses several factors to compare performance in contrast to a single factor model (CAPM). The factors in the Fama-French model are market risk, the outperformance of small companies versus big companies, and the outperformance of high book to market ratio companies compared to low book to market companies (Fama & French, 1996). The Carhart model has in addition to the three factors used by the Fama-French model a momentum factor which describes the tendency for the price of an asset to continue rising when it is going up and to continue declining when going down (Carhart, 1997). Since it has been shown that the factors used in the Fama-French and the Carhart model are country specific, data on the factors needs to be taken from the Swedish market (Griffin, 2002). This data has been provided by the Swedish House of Finance. To evaluate how the size of the funds affect the performance the average of each performance measure of the individual funds in the three different groups are calculated for the whole period and the three sub periods. The performance measures for the three size groups are then analyzed with t-tests and a one way ANOVA to see if there exist statistically significant differences between the different sizes.

The second part of the study examines the aspect of how luck and skill influences the performance of funds. In a similar way as Barras, Scaillet and Wermers (2010) I assume three different skill groups among the sample: skilled, unskilled and skill-neutral. Skill in this instance is measured as the fund managers' ability to cover their costs. This is measured by the alpha value of the different funds for the whole sample period from 2010 to 2017. The skilled managers in the sample will thus have a positive alpha for the period, the unskilled managers will have a negative alpha and the skill-neutral fund managers will be what Barras, Scaillet and Wermers (2010) refers to as zero-alpha managers. The alpha value for these skill-neutral managers is approximately zero; the term zero-alpha will henceforth be used to describe the skill-neutral managers. Unskilled managers will thus not be able to cover the costs of the funds. This however is not a "true" measurement of managers' skill. It is possible to imagine a manager with more than sufficient skill to achieve a positive alpha after adjusting for trading costs, but where the fund managing company overcharges fees or inefficiently generates costs attributed to administration or research.

Barras, Scaillet and Wermers (2010) infer the prevalence of each of the skill groups from performance estimates for the individual funds by using the t-statistic $\hat{t}_i = \hat{\alpha}_i / \hat{\sigma}_{\hat{\alpha}_i}$ as their performance estimate. They observe whether $\hat{t}_i$ lies outside the threshold implied by a chosen significance level, γ, and label it "significant" if it does. The procedure is simultaneously applied across all funds. The authors show that the proportion of funds that display positive and significant t-statistic simply cannot be labeled as skilled as there is a chance that some of the funds in that particular group are zero-alpha funds that just got lucky. The method that the authors use to account for these issues is the one used in this study, and is described in further detail in the next part.

3.3 Data Analysis

3.3.1 Performance and Size

The Sharpe ratio is calculated for all the individual funds in the dataset as

$$SR_i = \frac{E(R_{it} - r_{ft})}{\sqrt{Var(R_{it} - r_{ft})}} \tag{1}$$

Where R_{it} is the return of percentile i at time t and r_{ft} is the risk-free rate at time t. The risk-free rate is given by the 1 month Swedish T-Bill. The Sharpe ratio is calculated for all individual funds for the whole sample period as well as for the three sub periods.

The alpha value (Carhart) used in both parts of the study is calculated as

$$R_{it} - r_{ft} = \alpha_i + \beta_{1i} * R_{m,t} + \beta_{2i} SMB_t + \beta_3 HML_t + \beta_4 MOM_t + \varepsilon_{it} \tag{2}$$

Where the α_i is the model alpha of percentile i, $R_{m,t}$ is the excess market return at time t after subtracting the risk-free rate, SMB_t is the small (market cap) versus big factor at time t, HML_t is the high (book to market ratio) versus low factor at time t, and MOM_t is the momentum factor at time t.

3.3.2 Luck Versus Skill

There is no way to observe the true alphas for the individual funds. To infer the prevalence of each of the skill groups from performance estimates for the individual funds the procedure used by Barras, Scaillet and Wermers (2010) is implemented. First the t-statistic $\hat{t}_i = \hat{\alpha}_i / \hat{\sigma}_{\hat{\alpha}_i}$ is used as the performance measure, where $\hat{\alpha}_i$ is the estimated alpha for fund i and $\hat{\sigma}_{\hat{\alpha}_i}$ is its estimated standard deviation. Second, after choosing a significance level, γ, if the observed $\hat{t}_i$ for each fund lies outside the threshold set by the significance level it is labeled as significant. The proportions of significant values are denoted by $E(S^+)$ and $E(S^-)$, meaning that they are the expected proportion of significant values either positive or negative. Since it is assumed that luck is normally distributed for each of the groups there exists zero-alpha funds in both the skilled and the unskilled groups. The challenge is then to measure the frequency of false discoveries in the tails of the cross-sectional t-distribution. The significance level γ is the probability that a zero-alpha fund is lucky or unlucky in such a way that their t-statistic assigns them to a different skill group than they belong to. This means that the expected proportion of zero-alpha funds that by luck is in the skilled group equals

$$E(F^+) = \pi_0 * \gamma/2 \tag{3}$$

Where π_0 is the proportion of zero-alpha funds in the population and F^+ stands for false positive. Since luck is assumed to be normally distributed the expected proportion of unlucky zero-alpha funds, $E(F^-)$, is equal to $E(F^+)$. To determine the expected proportion of truly skilled funds, $E(T^+)$, the expected proportion of significant positive funds are adjusted by the expected proportion of lucky funds

$$E(T^+) = E(S^+) - E(F^+) = E(S^+) - \pi_0 * \gamma/2 \tag{4}$$

Similarly, for the unskilled funds, the expected proportion of truly unskilled funds is given by

$$E(T^-) = E(S^-) - E(F^-) = E(S^-) - \pi_0 * \gamma/2 \tag{5}$$

To be able to measure luck the proportion of zero-alpha funds, π_0, need to be known. To estimate the proportion an approach called the "False Discovery Rate" (FDR) developed by Storey (2002) is used. The FDR approach only inputs are the two-sided p-values associated with the alpha t-statistics from each of the funds. By definition, the zero-alpha funds have p-values that are uniformly distributed over the interval [0,1] (Barras, Scaillet & Wermers, 2010). The p-values of the skilled and unskilled funds on the other hand, tend to be small as their estimated t-statistics is far from zero. This knowledge is exploited in the FDR to estimate the π_0 without having to know the exact distribution of the p-values of the skilled and unskilled funds. According to Storey (2002) a viable estimation of π_0 is

$$\hat{\pi}_0(\lambda^*) = \frac{W(\lambda^*)}{(1-\lambda^*)m} \quad (6)$$

Where m is the number of funds, λ^* is some well-chosen constant and $W(\lambda^*)$ equals the number of funds with p-values exceeding λ^*. To select λ^*, a bootstrap method proposed by Storey (2002) and Storey, Taylor, and Siegmund (2004) is used. The method of choosing λ^* is described in Appendix A.

The resulting estimate $\hat{\pi}_0(\lambda^*)$ is substituted into equations (3), (4) and (5). By using the observed proportion of significant positive funds in the sample (S^+) as a proxy for $E(S^+)$ it is possible to calculate estimations of $E(F^+)$ and $E(T^+)$. The same approach is used to find estimations of $E(F^-)$ and $E(T^-)$. This implies that the estimates of the proportion of lucky and unlucky funds are

$$\hat{F}^+ = \hat{F}^- = \hat{\pi}_0 * \gamma/2 \quad (7)$$

Using equation (7) the estimated proportions of unskilled and skilled funds at a certain significance level, γ, is

$$\begin{aligned} \hat{T}^+ &= \hat{S}^+ - \hat{F}^+ = \hat{S}^+ - \hat{\pi}_0 * \gamma/2 \\ \hat{T}^- &= \hat{S}^- - \hat{F}^- = \hat{S}^- - \hat{\pi}_0 * \gamma/2 \end{aligned} \quad (8)$$

Finally, the proportions of skilled and unskilled funds of the entire population is estimated as

$$\hat{\pi}^+ = \hat{T}^+, \qquad \hat{\pi}^- = \hat{T}^- \quad (9)$$

Barras, Scaillet and Wermers (2010) use a similar bootstrap method as the one used to choose λ^* to find the optimal significance value γ^*. However, the authors also suggest that simply setting γ^* to a pre-specified value such as 0.35 or 0.45 produces similar results. It is necessary for the γ^* to be high, as too low values result in too low estimates of the proportion of skilled and unskilled funds. In this study, the value of γ^* is assumed to be 0.35.

3.4 Validity and Reliability

A problem in investigating mutual funds over a period of time is how to avoid potential survivorship bias. When looking at mutual funds attrition is problematic for the researcher since funds that disappear tend to do so either as a result of poor performance or because their total market value is sufficiently small that the management decides that it is no longer justified to maintain the fund (Elton, Gruber & Blake, 1996). To mitigate this issue the database of funds being used contains both active funds and dead funds, with all funds being active at the beginning of the analyzed period. By including funds that disappear during the analyzed period, the result does not get skewed from the success of the surviving funds and potential survivorship bias is avoided.

As the study is using secondary data it is important to be careful of the shortcomings of the information. Although there is no reason to question the validity of the sources used beforehand, precautions in the form of controlling the data with different external sources has been made to assure the quality of the data.

4 Analysis and Discussion

In this section, the results are presented, analyzed and discussed. The chapter is divided into three sections with the first section presenting the descriptive statistics of the data. The two subsequent sections present, analyze and discuss the two main parts of the study.

4.1 Descriptive Statistics

The number of funds for which data was gathered after excluding for index funds was 143. To avoid survivorship bias only funds which were alive at the start of the period, January 2010, was used leading to the final number of mutual funds to be 107. Of these 107 funds only 64 was alive at the end of the sample period. Figure 1 presents the evolution of the percentage of

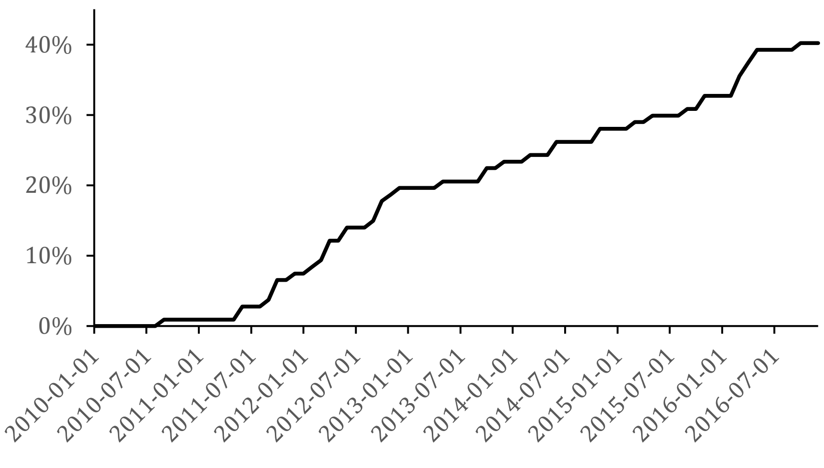

Figure 1: Percentage of dead funds in the dataset

dead funds in the dataset. The amount of dead funds during the period is higher than expected. In the study by Bodson, Cavenalle and Sougné (2011) the percentage of dead funds is only 12.3%. Their study stretches for a similar amount of time, ten years, and is performed between 2000 and 2010. Dahlquist, Engström and Söderlind (2000) who measures Swedish funds between 1993 and 1997 reports that the annual attrition rates among equity funds, including bond and money market funds, ranges from 2% to 21%. They find that these attrition rates are similar to the ones found in the U.S. mutual fund market although more volatile. A more volatile attrition rate in Swedish funds could explain some of the discrepancy between previous studies and the results here. The majority (69%) of the funds in the dataset which exit the market were merged with other funds. This is comparable with the findings of Dahlquist, Engström and Söderlind (2000) who find that 80% of the Swedish funds which left the market did so through mergers.

For the remaining 107 funds the three different performance measures were calculated for the whole period as well as for the three sub periods. The funds were then divided into terciles for all periods. Table 1 shows summary statistics for average total net asset value in million SEK, number of funds, average age in years, and expense ratio in percent. The age reported in panel A is the total average for the entire sample over the full period, the age reported in panel B through D is the average age at the beginning of the sample period. Since expense ratio only is reported once a year and the sub periods in the study covers incomplete years, the average expense ratio is only calculated and reported for the entire sample period.

The average TNA for all sample funds is 3173.66 million SEK for the entire period. The average fund in the smallest fund group only has total net assets in the value of 195.83 million SEK while the average large fund has total net assets valuing over 8 billion SEK. In panel B through D it is shown that the average total net asset value increases with time. The TNA of group one and two more than doubled their average TNA from period 1 to period 3. The average age of the funds in panel A is 14.94 years for the entire sample. The average age for the different groups is 13.34 years for the smallest group, 12.45 years for the second, and 19.17 years for the largest group. The difference between the two smaller groups is limited and the group with highest average age among the two varies over the different time periods. The largest group is also the oldest with a substantial margin. This is in line with previous research; see for example Yan (2008) and Chen et al. (2004). The expense ratio declines with size with the smallest group having an average expense ratio of 1.19%, the second group a ratio of 1.17% and the largest group a ratio of 1.04%, while the average for the entire sample is 1.14%. This is also as expected according to previous studies (Zera & Madura, 2001).

Table 1: Summary statistics on the Swedish equity mutual funds in the dataset.

		Fund Size Tercile		
Data Item	All Funds	1 (small)	2	3 (large)
Panel A. Full Sample Period (2010-2016)				
Number of Funds	107	35	37	35
Total Net Assets (mil SEK)	3173.66	195.83	1104.76	8368.55
Age (Year)	14.94	13.34	12.45	19.17
Expense Ratio (%)	1.14	1.19	1.17	1.06
Panel B. Period 1 (2010/01–2012/04)				
Number of Funds	107	35	37	35
Total Net Assets (mil SEK)	2585.84	162.48	863.15	6830.35
Age (Year)	11.30	9.93	7.92	16.24
Panel C. Period 2 (2012/05–2014/08)				
Number of Funds	92	31	30	31
Total Net Assets (mil SEK)	3250.52	215.24	1213.07	8257.53
Age (Year)	13.00	10.44	10.53	17.93
Panel D. Period 3 (2014/09–2016/12)				
Number of Funds	79	26	27	26
Total Net Assets (mil SEK)	4681.81	332.01	1923.24	11896.29
Age (Year)	15.08	12.30	12.86	20.17

4.2 Performance and Size

Performance is measured for all individual funds with three different measures. The funds are measured for the entire period as well as for the three sub periods. The three performance measures are: excess returns after subtracting the risk-free rate, the Sharpe ratio, and the Carhart four-factor alpha model. The averages of the different performance measure for the individual funds in the three terciles are calculated. To assess how the performance is affected by size the differences of the averages is analyzed with separate t-tests. A t-test performed with a significance level of 5% has by definition a 5% risk of giving a spurious significance (type I error). When performing three t-tests to evaluate the difference between the terciles the risk of getting a false positive result rises to 14.3% (Sheskin, 2003). To account for this risk a one way ANOVA test is performed for each performance measure and period. The ANOVA is used to determine if there are any statistically significant differences between the mean of the performance measures. If the t-tests for a performance measure suggests that one group outperform another but the ANOVA fail to reject the null-hypothesis that the means between the groups are identical there is a high probability that the result from the t-test is a false positive.

Table 1 presents the performance measured by the excess returns in percent. Included in the table are the returns for all funds as well as the three size groups for all periods. The results from the t-tests are included for all periods. The numbers in the parenthesis is the t-statistics. The ANOVA is the F-statistic measuring the probability of any difference between the groups.

*Table 2: Average monthly returns measured in percent. Differences are analyzed with separate t-tests and a one-way ANOVA. * indicates significance at the 10% level, ** indicates significance at the 5% level, and *** indicates significance at the 1% level.*

		Fund Size Tercile			Difference			
Excess Returns (%)	All Funds	1	2	3	3 – 1	3 – 2	2 – 1	ANOVA
Full period	0.73	0.51	0.63	1.06	0.55*	0.43	0.12	2.74*
					(1.84)	(1.44)	(1.31)	
Period 1	0.35	0.39	0.27	0.40	0.01	0.13**	-0.12	2.06
					(0.15)	(2.02)	(-1.56)	
Period 2	1.29	0.85	1.05	1.96	1.11	0.91	0.20**	1.21
					(1.20)	(0.99)	(2.37)	
Period 3	0.91	0.90	0.87	0.95	0.05	0.07	-0.02	0.20
					(0.37)	(0.87)	(-0.18)	

The averages of the individual returns for all funds are positive. The first period ranging from January 2010 to April 2012 sees the smallest returns regardless of size group. The size group with the largest average TNA (group 3) has the highest average return for all periods. The one-way ANOVA however only shows a significant difference between the groups in the full sample period. The average returns of the largest group are statistically significantly larger than the average returns of the smallest group. There is also a statistically significant difference between group 3 and group 2 in the first period as well as between group 2 and group 1 in the second period. The ANOVA for these periods however are not statistically significant making inferring relations from these results unreliable. For every period except period 3 there is a seemingly linear positive relation between size and average return but the differences between the groups are rarely statistically significant. A possible explanation for this might be the higher standard deviation of the largest group.

Table 3 presents the performance measured by the Sharpe ratio. The Sharpe ratio is calculated for the individual funds for all periods. The average for the different group sizes is calculated and presented in the table.

*Table 3: Average Sharpe ratio for the different size groups. Differences are analyzed with separate t-tests and a one-way ANOVA. Numbers in parenthesis are t-statistics. * indicates significance at the 10% level, ** indicates significance at the 5% level, and *** indicates significance at the 1% level.*

Sharpe Ratio	All Funds	Fund Size Tercile 1	2	3	Difference 3 – 1	3 – 2	2 – 1	ANOVA
Full period	0.15	0.12	0.15	0.17	0.06***	0.03	0.03	5.00***
					(3.30)	(1.61)	(1.57)	
Period 1	0.07	0.08	0.05	0.07	0.00	0.02**	-0.03*	2.42*
					(-0.28)	(2.06)	(-1.83)	
Period 2	0.30	0.27	0.31	0.32	0.05	0.01	0.04	1.43
					(1.39)	(0.24)	(1.41)	
Period 3	0.24	0.27	0.22	0.24	-0.03	0.02	-0.05	0.53
					(-0.50)	(0.76)	(-0.89)	

For all periods the largest size group performs better than group 2. Only the full period and period 1 has a statistically significant ANOVA. In the full period the largest funds average Sharpe ratio is larger at the 1% significance level. For the first period, the second group performs statistically significantly worse than the other two groups. This indicates that the best performance of this period is made by the largest and smallest groups. For the second and third period, there are no significant differences between the size groups indicating that size does not affect performance in these periods.

Table 4 presents the performance measured by the Carhart four-factor alpha model. In accordance to the other performance measures the table includes the differences between the groups for all periods as well as the one-way ANOVA for all periods.

Surprisingly all alpha values for the groups and periods are positive. Furthermore, the alpha values are all statistically significant on at least the 5% level (t-statistics for the alpha values are not included in the table). There is no apparent relation between the alpha value and size. Only time period 1 show statistically significant differences between the groups with the medium sized group 2 performing worse than the other two groups. There is no significant difference between the smallest and largest groups. With no other significant difference between the groups no inference can be drawn of the relation between size and performance from the alpha values. The fact that all size groups show an average of positive alphas is an interesting occurrence which will be further discussed in the next chapter.

*Table 4: Carhart four-factor alphas for the different size groups. Differences are analyzed with separate t-tests and a one-way ANOVA. Numbers in parenthesis are t-statistics. * indicates significance at the 10% level, ** indicates significance at the 5% level, and *** indicates significance at the 1% level.*

		Fund Size Tercile			Difference			
α	All Funds	1	2	3	3 – 1	3 – 2	2 – 1	ANOVA
Full period	0.011	0.012	0.008	0.012	0.000 (-0.05)	0.003 (1.28)	-0.004 (-1.14)	0.768
Period 1	0.007	0.009	0.006	0.007	-0.002 (-1.17)	0.002** (2.37)	-0.003** (-2.20)	3.435**
Period 2	0.025	0.021	0.022	0.033	0.012 (1.21)	0.010 (1.08)	0.001 (1.00)	1.264
Period 3	0.006	0.006	0.006	0.005	-0.001 (-0.28)	0.000 (-0.36)	0.000 (-0.15)	0.060

When looking at all three performance measures there are not much evidence of a clear relationship between size and performance. Only the full sample period and period 1 has a statistically significant result from the one-way ANOVA. Period 3 has no significant results from either the ANOVA or the t-tests while period 2 only has one statistically significant test according to the t-test between group 2 and group 1 stating that the average return of group 2 is larger than the one of group 1. A possible explanation of these results might stem from the attrition rate of funds in the later periods. With more funds exiting the market as a result of unsatisfactory results, the differences between the group-sizes might be reduced with time since no new funds enter the market in the sample. Further indication of this is that differences are found in the full sample suggesting that differences exists between size groups but with time those differences are diluted.

The different performance measures account for different aspects concerning the performance of the funds. The excess returns only measure the empirical results of the funds taking account of the risk-free rate. From table 2 it can be see that the largest funds have the best performance. When taking account for the risk of the funds as is done with the Sharpe ratio the performance of the groups becomes more even, indicating that the larger funds are riskier than the other size groups but still equal to or better performing than the other groups. The alpha value compares the results of the funds with broad market factors taking account for the overall market conditions. With these factors the performance of all funds in the sample seems to be good, with positive alphas across the board. The differences between the size groups also becomes less apparent when measuring performance with the alpha value indicating that the funds are performing similarly well compared with a broader market. Comparing the results for the different periods, the best results according to all three performance measures comes in period 2 with the worst performing period being period 1. For the alpha values, there are next to no difference between the second and third period. The difference in results from the different performance measures is in line with the findings of Bodson, Cavenalle and Sougné (2011). They find a quadratic concave relationship for all their measures except for their alpha values for which they find no relation between size and performance. There is no evidence in any of the performance measure indicating of a quadratic concave relation between size and performance in this study. For this to be the case the middle size group should exhibit a better performance than the other two groups. Regardless of performance measure or period this is never the case. In all but one period the differences between the groups indicate a positive or a quadratic convex relationship between size and performance. The hypothesis of a quadratic concave relationship between size and performance as suggested by Indro et al. (1999) and Bodson, Cavenalle and Sougné (2011) are thus not supported by the data from the Swedish market.

Comparing the composition of the third and the second size group, the largest group both has a higher average age and a lower average expense ratio. Large funds with lower expense ratios which exhibits a better performance is in line with the findings of Zera and Madura (2001). It can be argued that the higher average age of the funds brings experience to the largest group size which might explain some of the differences between the groups. Another possible explanation behind the better performance of the larger funds might be the diversity that follows from size. Larger funds have by definition more assets and are thus more diverse than smaller funds which should be an advantage. An explanation behind the difference in performance for the smallest size group must also be found. The smallest group, being the worst performing size group in almost half of all periods and for the other half performing almost as well or better than the largest size group. A possible explanation might be that smaller funds are often more specialized than other funds making them more successful in some periods while showing comparable worse results in others.

4.3 Luck Versus Skill

The first part of the empirical analysis of the prevalence of skill in mutual funds is estimating the alpha values of the individual funds. This was done in the previous part where the monthly Carhart four-factor alpha model of equation (2) was used (see table 4). From the alpha values the proportions of zero-alpha, unskilled and skilled funds in the sample were estimated as defined in the method section. The proportions and the estimated number of funds in the categories are presented in panel A of table 5. Panel B and C in table 5 decomposes the left and the right tail of the funds into respectively unlucky and unskilled and lucky and skilled funds. The numbers in the parenthesis in all the panels of the table are the standard deviations. The procedure of estimating theses point estimates is described in Appendix B. The proportion of lucky and unlucky funds is analyzed using four different significance values (γ).

Table 5: Proportion and distribution of skill groups

Panel A: Proportion of Unskilled and Skilled Funds

	Zero alpha ($\hat{\pi}_0$)	Unskilled ($\hat{\pi}^-$)	Skilled ($\hat{\pi}^+$)
Proportion (%)	29.6 (6.2)	-5.2 (1.7)	76.1 (4.8)
Number of Funds	32	-6	81

Panel B: Impact of Luck in the Left Tail

Signif. Level (γ)	0.05	0.1	0.15	0.20
Signif. $\hat{S}^-$ (%)	0 (3.7)	0 (4.8)	0 (4.7)	0 (4.4)
Unlucky $\hat{F}^-$ (%)	0.7 (0.2)	1.5 (0.3)	2.2 (0.5)	3.0 (0.6)
Unskilled $\hat{T}^-$ (%)	-0.7 (3.7)	-1.5 (5.0)	-2.2 (5.0)	-3.0 (4.9)

Panel C: Impact of Luck in the Right Tail

Signif. Level (γ)	0.05	0.1	0.15	0.20
Signif. $\hat{S}^+$ (%)	17.8 (3.7)	48.6 (4.8)	59.8 (4.7)	71.0 (4.4)
Lucky $\hat{F}^+$ (%)	0.7 (0.2)	1.5 (0.3)	2.2 (0.5)	3.0 (0.6)
Skilled $\hat{T}^+$ (%)	17.0 (3.7)	47.1 (5.0)	57.6 (5.0)	68.1 (4.9)

Since skill is defined as the ability to recover the costs of the fund the unexpected high proportion of positive alphas seem to have skewed the results. It is unreasonable to believe that the number of skilled funds is more than three quarters of the funds in the sample. That there would be a negative number of unskilled funds is by definition impossible. When analyzing panel B it is clear that the results cannot be trusted. Since in none of the four significance levels there are a proportion of negative significant funds the subsequent decomposition into unlucky and unskilled funds is meaningless. Panel C shows the extremely high proportion of significant positive alphas. When decomposing the right tail it is clear that the proportion of lucky funds in the right tail is relative low, with the highest value being 3% when the significance level is 20%.

According to the method described by Barras, Scaillet and Wermers (2010) the results imply that Swedish equity mutual funds are managed by extremely talented managers. Since these results contrasts with previous research done on mutual funds, see among others Barras, Scaillet and Wermers (2010), Fama and French (2010), and Chen, Cliff and Zhao (2017) no direct inference of the results can be made. The underlying factors behind these novel results are not easily discernible. A possible explanation could be that the analyzed period of 2010 – 2017 has seen an outperformance from Swedish mutual funds compared to the Fama-French factors used to calculate the alpha values. This would be in line with Fama and French (2010), who argues that active investment is a zero-sum game. That if some active investor has positive alpha some other investor must bear the expenses. However, this is unlikely since such a strong performance would be short-lived and the results of the alphas divided into three sub periods as in the previous section show a strong indication of persistence in the results. Another possible explanation is shortcomings in the data. It is possible that the returns calculated from the net asset values do not capture the true performance of the funds. As almost all of the funds shows positive alpha values and the returns of the funds as seen in table 2 are high, there could be a factor of unknown costs in the reported values.

It can be argued that the potential fault in the data is uniform in the sample. When investigating the t-statistics gathered from the alpha values of the funds, a similar distribution as would be expected according to Barras, Scaillet and Wermers (2010) is found, however with the center of the distribution of the t-statistics equal to two instead of the expected zero. The distribution can be seen in figure 2.

With the similar shape of the distribution although with a different mean, it can be argued that

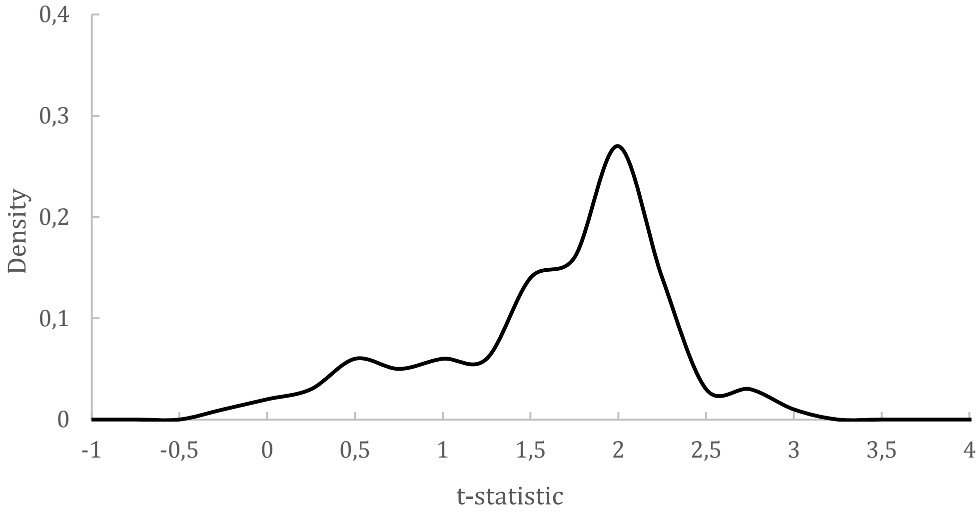

Figure 2: Distribution of t-statistics

despite the exact result from the assessment of luck in mutual funds being flawed it is still possible to compare the distribution of lucky or skilled funds for different sizes of mutual funds. For the same size groups as in the previous section, the proportions of different skill groups were estimated. The resulting estimates are shown in table 6 as well as the difference in estimates between the largest and the smallest size group. Also included are the medium sizes for the different groups. The numbers in the parenthesis are the estimated standard deviations. As in the estimations for the full sample the proportions of unskilled funds are negative for all size groups with relative high standard deviation. There is no clear difference in the prevalence of skill between the largest and the second largest group. The second largest group has the highest proportion but the difference between the two larger groups is smaller than the standard deviation. For the smallest group however, the composition of skill groups contrasts with the other two. The proportion of zero-alpha funds is only slightly higher than the proportion of skilled funds in the group and in fact in range of its standard deviation. This differs from the other two groups where over 85% of the funds are estimated to be skilled. Important to note is once again that the results cannot be trusted directly. The comparison between the size groups is however interesting as it seems to indicate that the funds in the two larger groups are more skilled than the funds in the smallest group. With fewer funds in the smallest group being skilled, size seems to be an indicator for skilled funds. Not necessarily that the largest funds have the most skilled managers but that skill is less prevalent in the smallest funds. A possible explanation might be that skilled managers turn to larger funds in search for a higher fee or more notoriety.

Table 6: Proportion of skill groups according to fund size

Skill Type	Fund Size Tercile			Difference (3 – 1)
	1 (small)	2	3 (large)	
Zero alpha ($\hat{\pi}_0$)	61.2 (11.9)	13.5 (7.5)	16.3 (7.7)	-44.9
Unskilled ($\hat{\pi}^-$)	-10.7 (10.5)	-2.4 (1.7)	-1.6 (1.5)	9.1
Skilled ($\hat{\pi}^+$)	49.3 (2.0)	89.5 (5.8)	86.9 (6.1)	37.7
Median Size (mil. SEK)	195.8	1,104.8	8,368.5	8,172.7

The relation of a lower proportion of zero-alpha funds in larger fund groups is in line with the findings of Barras, Scaillet and Wermers (2010). They find however that larger funds are populated with far more unskilled funds than the smaller funds while not finding any clear trends in the distribution of skilled funds according to size. This is in contrast to the results in the study, where the proportion of skilled funds increase with fund size and the proportion of unskilled decrease with size. There could be an explanation behind this disparity stemming from the division of groups. Since the sample size is larger in the study of Barras, Scaillet and Wermers (2010) they are able to divide their sample into five different groups and still maintain a large enough sample in each group. With added groups they are able to establish a trend of the composition of skilled and unskilled funds when adjusting for size which is harder when only using three size groups.

5 Conclusion

In this study, I investigate the relationship between size and performance in Swedish equity mutual funds. This is done by examining how funds grouped according to their size perform measured by three common performance measures: returns, Sharpe Ratio and the Carhart four-factor alpha. From the performance measures it is possible to detect an indication of larger funds performing better than smaller funds. The largest fund group measured over the complete period exhibits better performance than the smallest according to both the returns and the Sharpe ratio. The alpha values on the other hand show little to no relation between size and performance. When decomposing the full period into shorter sub periods the effect from the size becomes less apparent signaling that the difference between size groups is small and more prominent when examining longer periods.

There were no evidence supporting the notion of a quadratic concave relationship between size and performance. The funds with net asset value in the middle of the range performs equal to or worse than the other fund sizes in all periods for all performance measures. There seem to be some indications that larger funds have an overall slightly better performance compared to the smaller fund sizes. The results though are both small and inconsistent and give no clear evidence of size having a lasting substantial impact on the performance of Swedish equity mutual funds.

From the investigation of how luck and skill is distributed over different sizes of mutual funds it is difficult to come to a conclusion. The result in its own with an estimated proportion of truly skilled funds of 76.1% is largely inconsistent with previous research making it difficult to assert its reliability. With the assumption of a possible fault in the data being consistent for all funds the comparison of the composition between skill and luck according to the size of the fund show a large difference between the smallest size group and the other groups. The skill level of managers of small funds seems to be subordinate to the one of managers of larger funds. With the proportion of skilled managers being lower in the smaller funds there might be a tendency for skilled managers to move to larger funds.

With a slightly better performance and a higher proportion of skilled fund managers the practical implications for an individual investor seems to be that investing in larger funds might be the best alternative when investing in actively managed Swedish mutual funds. With costs of larger funds generally being smaller than for smaller funds and with the previous mentioned advantages there are multiple good arguments that investing in large mutual funds is the best choice for investors. For future research, I suggest further investigating the prevalence of skill in Swedish mutual funds. Since the results in this thesis are largely inconsistent with previous research there is a need of more studies in the area. For example, a larger sample period and or a larger sample, if available, would be a good place to start. With a larger sample, it would be possible to decompose the sizes of the funds in to additional size groups which might give a better view to the extent size affects performance. Another sample period might shine light on the question that the inconsistency in the results could stem from an abnormally successful period of mutual funds compared to the rest of the Swedish market. Overall more research is needed on the Swedish fund market in general since it appears to in some extent differ from the more studied U.S. market.

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Appendix A

Determining the value of λ^* from the data

To select λ^*, a bootstrap method proposed by Storey (2002) and Storey, Taylor and Siegmund (2004) is used. This approach chooses λ by minimizing the Mean Squared Error (MSE) of $\hat{\pi}_0(\lambda)$, defined as $E(\hat{\pi}_0(\lambda) - \pi_0)^2$. First, for a range of λ values ($\lambda = 0.30, 0.40, \ldots, 0.70$) $\hat{\pi}_0(\lambda)$ is computed using equation (6). The range of values is a simplification of the ones used by Barras, Scaillet and Wermers (2010). Second, for each value of λ, 100 bootstrap versions $\hat{\pi}_0^b$ for b=1,…,100 is formed by drawing with replacement from the sample of the p-values of the funds. Third, for each λ, its respective MSE is estimated as

$$\widehat{MSE}(\lambda) = \frac{1}{100}\sum_{b=1}^{100}\left[\hat{\pi}_0^b(\lambda) - \min_{\lambda}\hat{\pi}_0(\lambda)\right]^2 \qquad (A1)$$

The λ^* is chosen such that $\lambda^* = \arg min_{\lambda}\,\widehat{MSE}(\lambda)$.

Appendix B

Determining Standard Deviations of Estimators

The method of estimating the standard deviation of the estimators used in the thesis are based on the method used by Barras, Scaillet and Wermers (2010) who rely heavily on the large sample theory proposed by Genovese and Wasserman (2004). The idea is that the estimators are stochastic processes that converge to a Gaussian process when the number of funds (m) goes to infinity. Genovese and Wasserman (2004) show that $\hat{\pi}_0(\lambda^*)$ is asymptotically normally distributed when m goes to infinity. The standard deviation of $\hat{\pi}_0(\lambda^*)$ is then $\hat{\sigma}_{\hat{\pi}_0} = \left(\frac{\widehat{W}(\lambda^*)(m-\widehat{W}(\lambda^*))}{m^3(1-\lambda^*)^2}\right)^{\frac{1}{2}}$, where $\widehat{W}(\lambda^*)$ is the number of funds that has p-values exceeding λ^*. Similarly by using the equality $\hat{S}^+ = \hat{F}^+ + \hat{T}^+$, the standard deviation of $\hat{F}^+$, $\hat{S}^+$ and $\hat{T}^+$ is calculated as $\hat{\sigma}_{\hat{F}^+} = (\gamma/2)\hat{\sigma}_{\hat{\pi}_0}$, $\hat{\sigma}_{\hat{S}^+} = \left(\frac{\hat{S}^+(1-\hat{S}^+)}{m}\right)^{\frac{1}{2}}$ and $\hat{\sigma}_{\hat{T}^+} = \left(\hat{\sigma}^2_{\hat{S}^+} + (\gamma/2)^2\hat{\sigma}^2_{\hat{\pi}_0} + 2\frac{(\gamma/2)}{1-\lambda^*}\hat{S}^+\frac{\widehat{W}(\lambda^*)}{m^2}\right)^{\frac{1}{2}}$. Standard deviations for the left tail are obtained by replacing $\hat{S}^+$ with $\hat{S}^-$ in the above formulas. The standard deviations of $\hat{\pi}^+$ and $\hat{\pi}^-$ are given respectively, using the equality $\hat{\pi}^+ = 1 - \hat{\pi}_0 - \hat{\pi}^-$, by $\hat{\sigma}_{\hat{\pi}^+} = \hat{\sigma}_{\hat{T}^+}$ and $\hat{\sigma}_{\hat{\pi}^-} = \left(\hat{\sigma}^2_{\hat{\pi}^+} + \hat{\sigma}^2_{\hat{\pi}_0(\lambda^*)} - 2\left(\frac{1}{1-\lambda^*}\right)\hat{S}^+\frac{\widehat{W}(\lambda^*)}{m^2} - 2(\gamma^*/2)\hat{\sigma}^2_{\hat{\pi}_0}\right)^{\frac{1}{2}}$.