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Does size matter?

The Effect of Assets under Management on Tracking Error in the American ETF Market

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Abstract

Numerous studies have been conducted on the subject of tracking error of mutual funds and exchange traded funds in respect to their underlying indexes. In this paper we intend to shed some light on the causes of the tracking error and more particularly if the size of assets under management of exchange traded funds have any impact on tracking error. Our working hypothesis is that there might be economies of scales that could lead to lower average expenses for the ETFs and thus lower tracking error. Trading data for a sample of 27 US ETFs during the period 2008-2013 was collected and fails to show any clear negative relationship between assets under management and tracking error. The risk variable on the other hand reveals to be positively related to tracking error for 75 percent of the ETFs and it is by far the single most important factor in explaining the tracking error.

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Introduction

Active versus Passive Management

Should investors invest money into actively or passively managed mutual funds? Countless studies have revealed the inability of active managed funds to consistently beat index funds over time and even more so after expenses have been taken into account. William F. Sharpe comes therefore to the conclusion that index funds or passive funds are superior to actively managed funds (Sharpe, 1991).

'When we buy an actively managed fund, we are like gamblers in Vegas. We know it is likely to be a losing proposition, yet somehow we feel we are getting our money's worth.'

The Wall Street Journal, February 27, 2001

ETFs versus Index Funds

Growing awareness about the flaws in actively managed funds has to some extent sparked the popularity of passively managed investment vehicles. There are two types of passive investment vehicles:

- Index funds
- Exchange Traded Funds (ETFs)

ETFs and index funds do not aim to outperform their benchmark index. Instead, they simply try to replicate its performance. Index funds have been around the longest (since 1976 (Bogle, 2011)) and are simply mutual funds with a passive strategy. Despite that ETFs and index funds are quite similar financial vehicles there are differences which we will write more extensively about in Section *'ETFs versus Index Funds, continued'*.

The interest for ETFs has increased in recent years. Both the number and the amount of money invested in ETFs have grown tremendously, which can be seen in Figure 1 on Page 11.

The amount of academic research on ETFs is in line with its growing popularity. A great deal of research has focused on tracking error of the ETFs.

Gastineau (2001) notes how, at the time of the publication of his paper in 2001, the most popular conventional index funds have higher pre-tax returns compared to ETFs that are tracking the same underlying index. He concludes that structural deficiencies on the part of ETF are the essential cause. By timing their trades and acting in the same way as mutual funds ETFs could narrow this gap in performance.

Going further, Frino and Gallagher (2001) highlight the reasons why tracking error is inherent in index fund performance. They evaluate the magnitude of S&P 500 index fund tracking error and compared the performance of active funds relative to index funds. They find that on average, active funds significantly underperform index funds after expenses. They also find seasonality in S&P 500 index mutual fund tracking error to be demonstrated.

A study conducted by Rompotis (2012) on the performance of 43 German ETF reveals that the benchmark indexes clearly outperform the ETFs. This situation is due to insufficient replication on behalf of the ETFs. In addition, factors such as the bid-ask spread, risk, and premium or discounts reflected in the prices of ETFs contribute to the size of the tracking error. In contrast, the expense ratio fails to show any statistically significant relationship to tracking error which in a way goes against common beliefs and expectations.

An older study by Milonas and Rompotis (2006) reveals that Swiss ETFs are subject to both lower returns and higher risk, as measured by the standard deviation of daily returns, than their benchmark indexes. Reason for the lower returns is among other things that the ETFs deviate from a perfect replication as indicated by their modest beta values. The authors also uncover a negative relationship between expenses and performance.

With the increased popularity of ETFs the size of these has grown. Because of this we find it interesting to investigate if size in terms of assets under management is a factor affecting tracking error and in this way examine if there are economies of scale in the fund management. We have not been able to find any research on this specific subject. If there is evidence of economies of scale then this finding may have implications for the ETF investment decision process. We will examine the American ETF market since it is the biggest ETF market in all categories.

Research Aim

We intend to investigate if there are economies of scale in the American ETF market. By the term economies of scale we mean that the per-ETF-share costs that are deducted on a daily basis from the exchange-traded funds should decrease as the funds' assets under management increase. We will test this hypothesis by looking at whether the ETFs' tracking error is negatively affected by the ETFs' size in terms of its assets under management.

ETFs

Exchange Traded Funds belong to the broader term Exchange Traded Products (ETPs). Exchange Traded Products include Exchange Traded Funds, Exchange Traded Vehicles (ETVs) and Exchange Traded Notes (ETNs). The far most popular ETPs are ETFs. ETVs and ETNs will not be further discussed in this paper.

An Exchange Traded Fund is a fund that tracks an index, but can be traded like a stock. They are traded on stock exchanges and they can be bought and sold at any time during the day. Their price will fluctuate from moment to moment, just like any other stock price. This means that the ETF can be trading at a premium (above) or discount (below) to the ETF's net asset value (NAV). The fact that ETFs can be traded intraday provides an opportunity for speculative investors to bet on the direction of short-term market movements. ETFs can also be used for speculative trading strategies, such as short selling and trading on margin.

There is a large variety of ETFs with different styles and tracking various indexes. ETFs tracking market equity indexes are the most popular but there are also more niched ETFs such as sector and industry ETFs, tracking everything from healthcare to uranium and nuclear energy. Other types of ETFs are: emerging markets ETFs, commodity ETFs, bond ETFs, leveraged ETFs etc.

There are even actively managed ETFs, which may seem a bit contradictive. They are a combination of ETFs and actively managed mutual funds, and they combine the advantages and disadvantages of the two. However, these are actively managed funds and face the same dilemma of underperformance over time as do ordinary actively managed mutual funds.

ETF Characteristics

Expense Ratios

The expense ratio is a measure of what it costs an investment company to operate a fund and is the annual fee that all funds or ETFs charge their shareholders. It expresses the percentage of assets deducted each fiscal year for fund expenses. An expense ratio is determined through an annual calculation, where a fund's operating expenses are divided by the average dollar value of its assets under management.

If the fund's assets are small, its expense ratio can be quite high because the fund must meet its expenses from a restricted asset base. Conversely, as the net assets of the fund grow, the expense percentage should ideally diminish as expenses are spread across the wider base (Morningstar).

Size is not the only factor explaining a low or a high expense ratio. Even if the expense ratio is supposed to be a reflection of the funds costs the expense ratio is arbitrary and the provider can set its expense ratio based on additional factors. Competition seems from a logical point of view to be one important factor affecting the expense ratio since the expense ratio probably is the easiest way to compete between the different providers.

As ETFs and index funds are low cost products they both have lower expense ratios compared to actively managed mutual funds. Index funds have an average expense ratio of 0,64 % and ETFs are averaging 0,50 % (Wild, 2011, p. 30).

Bid-Ask Spread

The bid-ask spread (or simply spread) is the difference between the bid price and the ask price at a specific point in time. Ask price is the price the owner wants to sell for and bid price is the price the buyer is offering. The wider the spread the bigger is the cost of trading.

The spread depends on the liquidity and the volume of the ETF and is generally very low for an ETF with high liquidity and large volume but could be higher for an ETF with low liquidity and small volume. The spread is generally a concern for the more frequent traders. The spread is not an issue for mutual fund investors since mutual funds are bought and sold at the fund’s net asset value.

Commissions

Because ETFs trade like stocks on an exchange the buying and selling are subject to brokerage fees for the investor in contrast to mutual funds where all the transactions are made directly via the fund managers. For the frequent trader the brokerage fees can eliminate the benefit of an ETF's low expense ratio.

Creation and Redemption

The 'creation/redemption' mechanism is one unique feature of ETFs. The process involves two parties; one ETF provider and one authorized participant, AP. The AP (large institutional investor or market maker) acquires the securities that the ETF wants to hold and delivers these to the ETF provider. In exchange, the provider gives the AP a block of equally valued ETF shares, called a creation unit, of typically 50.000 shares (ETF.com).

The exchange is on a one-for-one basis, the AP delivers a certain amount of underlying stocks and gets the exact same value in ETF shares, price based on their NAV, not the market value.

Both the ETF provider and the AP benefit from the transaction: The ETF provider gets the securities it needs to track the index, and the AP gets ETF shares to resell for profit. The process also works in reverse.

What makes this process important is that it guarantees that the ETFs will trade close to its NAV. If the ETFs are trading at premium or discount the AP can either sell or buy the ETFs and make arbitrage profits.

Tracking Error

Tracking Error (TE) is a measurement of performance for index funds and ETFs. Tracking error is the deviation of the fund's performance from that of the underlying index and is usually measured in basis points (1 b.p. equals 1/100th of 1%).

Tracking error in index fund/ETF performance is unavoidable. The primary source of the problem comes from the fact that the underlying index is measured as a 'paper' portfolio, which assumes transactions may occur at any time without cost (Frino & Gallagher, 2001).

Other factors affecting tracking error are transaction costs, fund cash flows, differences in timing of the accrual of dividends, the volatility of the benchmark (when the fund does not use a full replication strategy), corporate activity (when a company is subject to a merger or takeover by another company outside the index, a timing delay may exist between the date

when the fund receives the cash settlement and the target firm is removed from the index) and index composition changes (transaction costs are incurred when re-aligning with the "new index") (ibid.).

A trade-off exists between tracking error minimization and transaction costs. The passive portfolio managers have the dual objective of minimizing tracking error in performance and of minimizing the costs incurred in tracking the index as closely as possible (ibid.).

Tracking error may also be due to the fact that the fund incurs fees. Tracking error increases if these additional fees ('hidden costs') are not used for tracking error minimization.

ETFs versus Index Funds, continued

Index funds and ETFs are not perfect substitutes. They both have a place in the industry. Table 1 below compares their respective advantages and disadvantages.

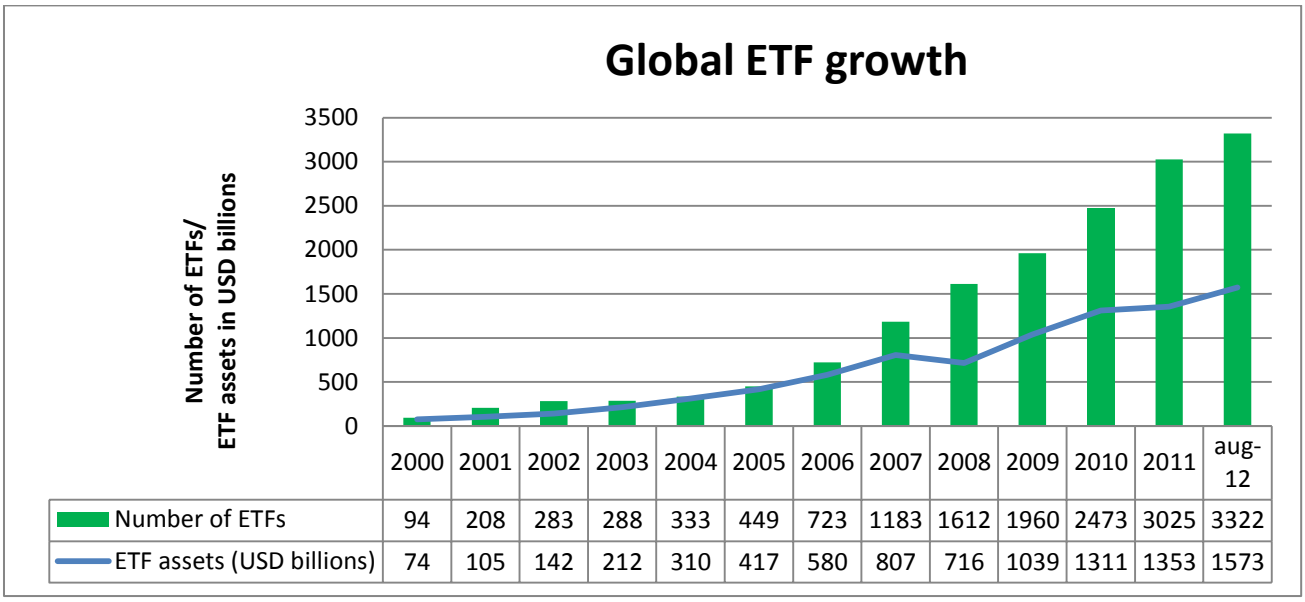
Table 1: Differences between Index funds and ETFs

Index funds		Vs.	ETFs	
Advantages:	**Disadvantages:**		**Advantages:**	**Disadvantages:**
• Old investment vehicle, well known product	• Restrictions on when it can be bought and sold		• Suitable for both passive investors and active traders (due to flexibility to trade throughout the day)	• May not be traded at their "correct value". Might trade at a premium or a discount to NAV
			• Lower average expense ratio	• Bid-Ask spread
			• No minimum investment amount	• Brokerage fee paid when buying and selling

(Wild, 2011)

The ETF Market

The S&P 500 Depository Receipt (called the SPDR or "spider" for short) which launched in January 1993 was the first of its kind and is still one of the most actively-traded ETFs today. Since then the ETF market has seen a tremendous growth and both the number of ETFs and its assets under management have increased dramatically. In less than 20 years, exchange traded funds have become one of the most popular investment vehicles for both institutional and individual investors.



	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	aug-12
Number of ETFs	94	208	283	288	333	449	723	1183	1612	1960	2473	3025	3322
ETF assets (USD billions)	74	105	142	212	310	417	580	807	716	1039	1311	1353	1573

Figure 1: Total number of ETFs and assets as at end of August 2012. **(Deborah, 2013)**

ETFs' success has mainly been driven by two things: they are cheap (low expense ratios) and they are convenient (trading like stocks).

There are a lot of mutual fund providers but this is not the case for ETFs. Fewer providers exist (48 as of 2011 (Wild, 2011, p. 55)) since the profit margin on ETFs is lower. The providers tend to be large companies because of the need of economies of scale to make a profit. As a result the industry is highly concentrated; the top four providers (BlackRock, State Street, Vanguard, and Invesco PowerShares) control 92 percent of the market (as of 2011 (Wild, 2011, p. 55)). Wild also points out that because of the need of economies of scale the exponential growth we have seen in the number of ETFs and ETF providers will start to slow down.

Table 2: Providers of ETFs

Company	Number of ETFs	Average Expense Ratio	Claim to Fame
BlackRock iShares	222	0.42	Biggest variety of funds
State Street Global Advisors	100	0.35	Oldest and single largest ETF
Vanguard	65	0.18	Sensibility and economy
Invesco PowerShares	120	0.65	Quirky indexes
ProShares	119	0.95	High volatility with leveraged and inverse ETFs
Van Eck	35	0.60	Alternative investments galore
WisdomTree	50	0.52	Dividend mania

(Wild, 2011, p. 56)

Data

The 27 ETFs shown in Table 3 below were chosen for this study. 20 of them are stock market ETFs, 5 are commodity ETFs and 2 are real estate ETFs.

These were chosen by sorting, in Bloomberg, all 1079 ETFs incorporated in the U.S. and removing those who are actively managed or those who use leverage. We thereafter have sorted the ETFs on their underlying index and selected the groups where two or more ETFs have the same underlying index ticker.[1] Our ETFs can be divided into 7 categories and 12 sub-categories (each index).

- Value - Large Cap, 2 indexes, 5 ETFs
- Growth - Large Cap, 2 indexes, 5 ETFs
- Value - Mid Cap, 1 index, 2 ETFs
- Value - Small Cap, 2 indexes, 4 ETFs
- Growth - Small Cap, 2 indexes, 4 ETFs
- Commodity, 2 indexes, 5 ETFs
- Sector Fund - Real Estate, 1 index, 2 ETFs

These ETFs all have the aim to closely track the performance of their underlying index and they have not changed their underlying index under the period investigated.

In Bloomberg we have collected data for last price, bid price, ask price, fund net asset value and number of shares outstanding. For the more recent ETFs with inception taking place after 2009 we have collected data from the inception date until 11/27/2013. For the ETFs which have been in existence since prior to 2009 we have collected data from the fiscal year beginning sometime during 2008 until 11/27/2013. We started working with this thesis autumn 2013, hence our end date for the data period. Old expense ratios have been gathered from annual reports from the different ETF providers and current expense ratios have been looked up on Bloomberg's webpage.

22 of the chosen ETFs pay dividends. The 5 commodity ETFs do not because they do not have underlying dividend paying securities. They try to replicate the price movements of gold respectively silver. None of the ETFs issuing dividends reinvest these automatically, they all

[1] This actually gave us 31 ETFs but we had to remove 4 of these. GLD has been removed since it was impossible to find old expense ratios and SCHZ, LAG and AGG have been removed because there was no price index available.

pay cash and it is up to each investor what to do with the dividend. Distributions in cash may be reinvested automatically in additional whole shares only if the broker through whom they purchased shares offers a reinvestment service. Since none of the ETFs automatically reinvest dividends we have used price indexes (PI) instead of the total return indexes (TRI) when conducting our research.

Table 3: The chosen ETFs; ETF Name, ETF Ticker, Underlying Price Index Name, Underlying Price Index Ticker, Bloomberg Category, Inception Date, Expense Ratio (%, as on 11/30/2013), Average Size last year in dataset (Average Assets Under Management, millions US dollar, 11/27/2012 - 11/27/2013) and Average Daily Turnover last year in dataset (millions US dollar, 11/27/2012 - 11/27/2013)

ETF Name	ETF Ticker	Index Name	Index Ticker	ETF Category	Inception Date	Expense Ratio	Average AUM (mln USD)	Average Daily Turnover (mln USD)
Vanguard S&P 500 Value	VOOV	S&P 500 Value	SVX	Value-Large Cap	9/9/2010	0.15	99.33	0.71
iShares S&P 500 Value	IVE	S&P 500 Value	SVX	Value-Large Cap	5/26/2000	0.18	5,772.28	46.90
SPDR S&P 500 Value	SPYV	S&P 500 Value	SVX	Value-Large Cap	9/29/2000	0.20	148.16	0.79
Vanguard Russell 1000 Value	VONV	Russell 1000 Value	RLV	Value-Large Cap	9/22/2010	0.15	126.55	1.34
iShares Russell 1000 Value	IWD	Russell 1000 Value	RLV	Value-Large Cap	5/26/2000	0.21	17,574.33	134.46
iShares S&P 500 Growth	IVW	S&P 500 Growth	SGX	Growth-Large Cap	5/26/2000	0.18	7,382.57	45.17
Vanguard S&P 500 Growth	VOOG	S&P 500 Growth	SGX	Growth-Large Cap	9/9/2010	0.15	134.23	0.71
SPDR S&P 500 Growth	SPYG	S&P 500 Growth	SGX	Growth-Large Cap	9/29/2000	0.20	256.50	0.93
Vanguard Russell 1000 Growth	VONG	Russell 1000 Growth	RLG	Growth-Large Cap	9/22/2010	0.15	144.83	1.34
iShares Russell 1000 Growth	IWF	Russell 1000 Growth	RLG	Growth-Large Cap	5/26/2000	0.20	19,127.43	151.26

Table 3 Continued

ETF Name	ETF Ticker	Index Name	Index Ticker	ETF Category	Inception Date	Expense Ratio	Average AUM (mln USD)	Average Daily Turnover (mln USD)
SPDR S&P 400 Mid Cap Value	MDYV	S&P Mid Cap 400 Value	MIDV	Value-Mid Cap	11/15/2005	0.25	49.11	0.52
Vanguard S&P Mid Cap 400 Value	IVOV	S&P Mid Cap 400 Value	MIDV	Value-Mid Cap	9/9/2010	0.20	22.95	0.33
Vanguard S&P Small Cap 600 Value	VIOV	S&P Small Cap 600 Value	SMLV	Value-Small Cap	9/9/2010	0.20	26.73	0.30
SPDR S&P 600 Small Cap Value	SLYV	S&P Small Cap 600 Value	SMLV	Value-Small Cap	9/29/2000	0.25	175.63	1.05
iShares Russell 2000 Value	IWN	Russell 2000 Value	RUJ	Value-Small Cap	7/28/2000	0.25	5,212.51	94.53
Vanguard Russell 2000 Value	VTWV	Russell 2000 Value	RUJ	Value-Small Cap	9/22/2010	0.20	37.51	0.30
Vanguard S&P Small Cap 600 Growth	VIOG	S&P Small Cap 600 Growth	SMLG	Growth-Small Cap	9/9/2010	0.20	22.43	0.26
SPDR S&P 600 Small Cap Growth	SLYG	S&P Small Cap 600 Growth	SMLG	Growth-Small Cap	9/29/2000	0.25	224.64	1.28
Vanguard Russell 2000 Growth	VTWG	Russell 2000 Growth	RUO	Growth-Small Cap	9/22/2010	0.20	60.91	0.72
iShares Russell 2000 Growth	IWO	Russell 2000 Growth	RUO	Growth-Small Cap	7/28/2000	0.25	5,010.48	111.95

Table 3 Continued

ETF Name	ETF Ticker	Index Name	Index Ticker	ETF Category	Inception Date	Expense Ratio	Average AUM (mln USD)	Average Daily Turnover (mln USD)
ETFS Gold Trust	SGOL	London Gold PM Fix	GOLDLNPM	Commodity	9/9/2009	0.39	1,538.51	10.89
ETFS Asian Gold Trust	AGOL	London Gold PM Fix	GOLDLNPM	Commodity	1/14/2011	0.39	71.13	0.23
iShares Gold Trust	IAU	London Gold PM Fix	GOLDLNPM	Commodity	1/28/2005	0.25	9,140.26	90.58
iShares Silver Trust	SLV	London Silver Fix Price	SLVRLN	Commodity	4/28/2006	0.50	8,296.34	266.36
ETFS Physical Silver Shares	SIVR	London Silver Fix Price	SLVRLN	Commodity	7/24/2009	0.30	458.04	4.85
Schwab US REIT	SCHH	Dow Jones U.S. Select REIT	DWRTF	Sector Fund-Real Estate	1/13/2011	0.07	522.05	4.58
SPDR Dow Jones REIT	RWR	Dow Jones U.S. Select REIT	DWRTF	Sector Fund-Real Estate	1/13/2011	0.25	2,127.80	18.00

We can clearly see that there are large differences in the size of assets under management among the ETFs (making the dataset ideal for this study). Interesting is also the fact that the ETFs with the lowest expense ratio within the indexes (most often Vanguard) are not the ones with the most assets under management (most often iShares). Why is it that the cheapest fund is not also the biggest? It is generally so that the first ETF introduced gets all the inflow. A good example of that is IWD which is more expensive than its competitor VONV. IWD is roughly 139 times bigger than VONV but you should keep in mind that it was introduced ten years earlier. Can it be that the ones with more assets under management have lower tracking error and compensate in this way for a higher expense ratio? Hopefully this study will be able to answer these kinds of questions.

Research Methodology

The first step is to calculate return, risk, premium/discount, spread and assets under management using Equations 1-4.

The percentage daily return of the ETFs and the indexes are given by Equation 1.

$$R_i = \frac{Trading\ price_i - Trading\ price_{i-1}}{Trading\ price_{i-1}} * 100 \quad (1)$$

Where R_i is the percentage return on day i, and Trading price_i reflects the closing price of the ETFs/indexes on day i.

The risk of the ETFs is calculated as the standard deviation of daily percentage return using Equation 2.

$$Risk = \sqrt{\frac{\sum_{i=1}^{N}(R_i - \bar{R})^2}{N-1}} \quad (2)$$

Where R_i is the percentage return on day i, and $\bar{R}$ is the average daily return.

The premium or discount to NAV (Net Asset Value) is calculated using Equation 3.

$$Premium = \frac{Trading\ price_i - NAV_i}{NAV_i} * 100 \quad (3)$$

A positive value denotes that the ETF is traded at a premium to NAV and vice versa.

The spread is calculated using Equation 4 which was suggested by Roll (1984) and also used by (Rompotis, 2012).

$$Spread = \frac{s}{\sqrt{ASK_i BID_i}} \quad (4)$$

Where *s* represents the difference between ask and bid quotes.

And finally the ETF's assets under management are given by multiplying the ETF's net asset values with the number of shares outstanding for each ETF.

Performance Regression Analysis

We use the following regression model for estimating key variables:

$$R_{pt} = \alpha_i + \beta_i R_{bt} + \varepsilon_{pt} \quad (5)$$

The dependent variable R_{pt} signifies the daily return on the ETF, the explanatory variable R_{bt} stands for the daily return of the underlying index and ε_{pt} represents a random, also called stochastic, error term. If the alpha term α_i is bigger than zero then you have a situation with the return of the ETF surpassing that of its underlying index (Rompotis 2012). A priori we consider it unlikely to find positive alphas for our ETFs since they are constructed to mirror their benchmark index. The beta coefficient β_i should be interpreted as the rate of change of the conditional mean (of daily returns) when the benchmark index changes with one unit (i.e. percent in our study). An ETF that adopts a perfect replication strategy towards its underlying index will have a beta of one.

Tracking Error

We use three methods to estimate tracking error. The first method, TE_1, uses the root MSE (mean squared error) of regression (5).

TE_2 is the average of the absolute return difference between the ETF and the index (6).

$$TE_{2,p} = \frac{\sum_{t=1}^{n} |e_p|}{n} \quad (6)$$

Where $|e_p|$ is the absolute return difference.

TE_3 is the standard deviation of the daily return difference between the ETF and the index (7).

$$TE_{3,p} = \sqrt{\frac{\sum_{t=1}^{n} (e_{pt} - \bar{e}_p)^2}{n-1}} \quad (7)$$

Where e_{pt} is the difference of returns in day *t* and $\bar{e}_p$ is the average return's difference over *n* days.

Factors that affect Tracking Error

The regression model used by Rompotis (Rompotis, 2012) has been extended with an additional variable, the natural log of assets under management "LnAssets", in order to see if this is a factor that has an impact on tracking error. The regression model we use is (8):

$$TE = \alpha_0 + \alpha_1 Risk + \alpha_2 Abs.Premium + \alpha_3 Spread + \alpha_4 Exp.Ratio + \alpha_5 LnAssets + \varepsilon \quad (8)$$

We divide the complete time-series of daily observations into intervals of three months. Every interval consisting of the daily values for the different variables is considered as one observation. For the dependent variable tracking error, we use the average value for the interval obtained from the three different methods of computing the tracking error (Equation 5-7). The variable risk is derived using the standard deviation of daily returns for the interval. For the rest of the explanatory variables we use the average for the three month period.

Expected results

Performance Regression Analysis

Since our ETFs aim to closely track the performance of their respectively underlying index we expect to see beta values close to 1. We consider it unlikely to find positive alphas for our ETFs since they are constructed to mirror their benchmark indexes.

Tracking Error

We have just mentioned that we expect to find beta values close to unity. If that hypothesis proves to be true then we are likely to obtain nearly identical estimations of tracking error using method 1 (TE_1) and method 3 (TE_3) as stated by Pope and Yadav (Pope & Yadav, 1994).

Factors that affect Tracking Error

Rompotis (2012) finds that tracking error is positively related to risk, premium and spread, whereas there is no statistically significant relationship between tracking error and expense ratio.

We expect to find similar results to those obtained by Rompotis. Since the expense ratios for the ETFs do not change that often (and sometimes not at all) during the data period investigated we should not expect to find a statistically significant relationship between tracking error and expense ratio (the expense ratio will in fact be omitted for a number of ETFs because of collinearity). In addition we expect to find a negative relationship between ETF size and tracking error. We expect to get higher R square values than Rompotis because of the addition of one extra explanatory variable, LnAssets.

Empirical Results

Performance Regression Analysis

Table 4: Results of the performance regression

Results of the performance regression $R_{pt} = \alpha_i + \beta_i R_{bt} + \varepsilon_{pt} \quad (5)$							
ETF Name	**Ticker**	**α**	**t-Test**	**β**	**t-Test**	**R^2**	**Obs.**
Vanguard S&P 500 Value	VOOV	0.01	0.62	0.84	56.61^{A}	0.82	724
iShares S&P 500 Value	IVE	0.00	0.14	0.98	422.48^{A}	0.99	1317
SPDR S&P 500 Value	SPYV	0.00	0.18	0.88	106.76^{A}	0.90	1249
Vanguard Russell 1000 Value	VONV	0.00	0.41	0.95	90.36^{A}	0.91	772
iShares Russell 1000 Value	IWD	0.00	0.16	0.99	429.60^{A}	0.99	1307
iShares S&P 500 Growth	IVW	0.00	0.10	0.99	394.80^{A}	0.99	1324
Vanguard S&P 500 Growth	VOOG	0.00	0.37	0.95	94.78^{A}	0.92	752
SPDR S&P 500 Growth	SPYG	0.00	0.37	0.96	142.40^{A}	0.94	1286
Vanguard Russell 1000 Growth	VONG	0.00	0.25	0.95	91.59^{A}	0.92	775
iShares Russell 1000 Growth	IWF	0.00	0.12	0.99	348.73^{A}	0.99	1323
SPDR S&P 400 Mid Cap Value	MDYV	0.01	0.34	0.81	60.45^{A}	0.77	1098
Vanguard S&P Mid Cap 400 Value	IVOV	0.02	0.63	0.84	44.17^{A}	0.78	561
Vanguard S&P Small Cap 600 Value	VIOV	0.02	0.81	0.78	44.41^{A}	0.76	639
SPDR S&P 600 Small Cap Value	SLYV	0.01	0.49	0.92	121.14^{A}	0.92	1274

Table 4 Continued

ETF Name	Ticker	α	t-Test	β	t-Test	R^2	Obs.
iShares Russell 2000 Value	IWN	-0.00	-0.13	0.96	326.93^A	0.99	1313
Vanguard Russell 2000 Value	VTWV	0.02	0.70	0.80	55.13^A	0.81	718
Vanguard S&P Small Cap 600 Growth	VIOG	0.02	0.75	0.82	48.32^A	0.78	666
SPDR S&P 600 Small Cap Growth	SLYG	0.01	0.39	0.97	108.00^A	0.90	1266
Vanguard Russell 2000 Growth	VTWG	0.01	0.43	0.92	96.42^A	0.92	781
iShares Russell 2000 Growth	IWO	0.00	0.02	0.97	389.07^A	0.99	1320
ETFS Gold Trust	SGOL	0.01	0.37	0.57	23.12^A	0.35	1006
ETFS Asian Gold Trust	AGOL	-0.00	-0.06	0.76	24.16^A	0.57	435
iShares Gold Trust	IAU	0.01	0.47	0.58	27.13^A	0.34	1426
iShares Silver Trust	SLV	0.03	0.53	0.32	14.42^A	0.13	1437
ETFS Physical Silver Shares	SIVR	0.04	0.64	0.34	13.91^A	0.16	1052
Schwab US REIT	SCHH	0.01	1.07	0.97	247.63^A	0.99	685
SPDR Dow Jones REIT	RWR	0.00	0.20	0.95	240.17^A	0.98	1279
Average		0.01	0.38	0.84	150.47	0.80	1029
t-Test		4.16^A		-4.38^A		-4.10^A	

Note: The t-tests of the entire α, β and R^2 columns test the hypothesis whether the average α is different from zero and whether the average β and R^2 are statistically different from unity. A indicate statistical significance at 1% level.

In Table 4 above are depicted the results from the 'performance' regression. Let us take a closer look at the alpha values. The mean alpha value for the 27 ETFs is 0.01 and a t-test of hypothesis shows that this value is statistically different from zero at the 0.01 significance level. Hence, the ETFs display an excess return compared to their benchmark indexes.

The beta values are an indicator of the degree of similarity between the ETFs and their underlying indexes in terms of daily returns. An ETF that is made up of the same assets as those belonging to the index it aims to reflect will have a beta of unity. Since it on a cost effective basis may be hard to defend a full replication strategy many ETF providers

deliberately opt for a basket of assets for their ETF that diverge somewhat from that of the index. The result is a beta that is less than 1. The set of 27 ETFs in our sample has a beta mean of 0.84. That figure is somewhat misleading due to a couple of outliers with very low beta values which can be find first and foremost among the commodities ETFs such as those trading in gold and silver. In addition, it is easy to identify another category, or more precisely provider since we are talking about Vanguard, that stands out for its lower beta value when compared to other ETFs with identical underlying indexes. Vanguard has apparently settled on a different plan for mirroring indexes than their rivals when it comes to the degree of replication. Rompotis demonstrates that there is a negative correlation between the degree of replication and tracking error (Rompotis, 2012). This is clearly the case for the ETFs in this study as well. For instance, we conclude that the ETFs from Vanguard that display a lower beta value than those of the other ETFs with the same underlying index at the same time have a higher tracking error.

With regard to the gold and silver ETFs we find that their tracking error is substantial which in turn may be due to a low degree of replication.

In Table 4 there is a column for R squared values. One can think of the R squared values as being closely related to the beta values since they reflect the quality of the regression. The average R square amounts to 0.80 which is not far from the average beta of 0.84. Once again we are reminded of the divergence from a full replication strategy.

Tracking Error

Table 5: Tracking Error Estimates

ETF Name	Ticker	TE_1	TE_2	TE_3	Average $TE_{(1+2+3)}$	Obs.
Vanguard S&P 500 Value	VOOV	0.46	0.27	0.50	0.41	724
iShares S&P 500 Value	IVE	0.13	0.07	0.13	0.11	1317
SPDR S&P 500 Value	SPYV	0.48	0.30	0.52	0.43	1249
Vanguard Russell 1000 Value	VONV	0.32	0.21	0.32	0.28	772
iShares Russell 1000 Value	IWD	0.13	0.08	0.13	0.12	1307
iShares S&P 500 Growth	IVW	0.12	0.07	0.12	0.11	1324
Vanguard S&P 500 Growth	VOOG	0.28	0.19	0.29	0.25	752
SPDR S&P 500 Growth	SPYG	0.35	0.21	0.35	0.30	1286
Vanguard Russell 1000 Growth	VONG	0.31	0.20	0.31	0.27	775
iShares Russell 1000 Growth	IWF	0.15	0.09	0.15	0.13	1323
SPDR S&P 400 Mid Cap Value	MDYV	0.84	0.55	0.92	0.77	1098
Vanguard S&P Mid Cap 400 Value	IVOV	0.66	0.43	0.70	0.60	561
Vanguard S&P Small Cap 600 Value	VIOV	0.72	0.53	0.80	0.69	639
SPDR S&P 600 Small Cap Value	SLYV	0.52	0.32	0.55	0.47	1274
iShares Russell 2000 Value	IWN	0.21	0.14	0.22	0.19	1313
Vanguard Russell 2000 Value	VTWV	0.59	0.40	0.66	0.55	718

Table 5 Continued

ETF Name	Ticker	TE_1	TE_2	TE_3	Average $TE_{(1+2+3)}$	Obs.
Vanguard S&P Small Cap 600 Growth	VIOG	0.63	0.40	0.68	0.57	666
SPDR S&P 600 Small Cap Growth	SLYG	0.56	0.32	0.56	0.48	1266
Vanguard Russell 2000 Growth	VTWG	0.40	0.26	0.41	0.36	781
iShares Russell 2000 Growth	IWO	0.18	0.12	0.18	0.16	1320
ETFS Gold Trust	SGOL	0.97	0.78	1.10	0.95	1006
ETFS Asian Gold Trust	AGOL	1.07	0.79	1.13	1.00	435
iShares Gold Trust	IAU	1.14	0.87	1.28	1.09	1426
iShares Silver Trust	SLV	2.31	2.11	2.95	2.46	1437
ETFS Physical Silver Shares	SIVR	2.07	1.96	2.68	2.24	1052
Schwab US REIT	SCHH	0.14	0.09	0.15	0.13	685
SPDR Dow Jones REIT	RWR	0.38	0.17	0.40	0.32	1279
Average		**0.60**	**0.44**	**0.67**	**0.57**	1029
Min.		**0.12**	**0.07**	**0.12**	**0.11**	435
Max.		**2.31**	**2.11**	**2.95**	**2.46**	1437

Note: TE1 refers to the standard error of the regression; TE2 is the average of the absolute return difference between the ETF and the index; and TE3 is the standard deviation of the return difference between the ETF and the index.

The average tracking error ranges from 0.44 to 0.67 depending on the formula used for the calculation. The first method gives an average tracking error of 0.60, the second method gives 0.44 and finally the third method gives 0.67. The mean tracking error of the three methods equals 0.57 % or 57 bp.

The minimum tracking error ranges from 0.07 to 0.12 and the maximum tracking error ranges from 2.11 to 2.95 depending on the formula used. The lowest average tracking error (0.11), and by that the best trackers, have iShares S&P 500 Value ETF (IVE) and iShares S&P 500 Growth ETF (IVW).

The worst trackers are the commodity ETFs and especially the silver ETFs. The average tracking error in category 'Commodity' ranges from 0.95 to 2.46. And in sub-category

‘Silver’ the tracking error ranges from 2.24 to 2.46. It is not that surprising that the commodity ETFs have the highest tracking error since these store physical gold or silver in a vault and by that have larger costs than the other ETFs. The gold and silver ETFs also have the highest average expense ratios among the ETFs as seen in Table 3. The beta values are, as mentioned earlier, also lowest in category ‘Commodity’ and especially among the two silver ETFs.

Again by looking at Table 4 and 5 simultaneously we notice that there is a strong negative relationship between replication strategy and tracking error. In 11 of the 12 sub-categories the ETFs with the highest β-values also have the lowest tracking error. The one sub-category where this in not true is ‘Gold’. Here AGOL has the highest beta value, 0.76, but SGOL has the lowest tracking error, 0.95.

If we now look at Table 3 and Table 5 simultaneously we notice another interesting fact. In 8 of the sub-categories the largest ETF also have the smallest tracking error. This suggests that there is a negative relationship between size and tracking error.

This relationship seems to be strongest in the categories ‘Value - Large Cap’ and ‘Growth - Large Cap’ with large differences in both size and tracking error within the sub-categories.

For example iShares Russell 1000 Value (IWD) has 17,574.33 million US dollar in average AUM and a tracking error of 0.12 compared to Vanguard Russell 1000 Value (VONV) in the same sub-category with just 126.55 million in AUM and a tracking error of 0.28.

The best trackers IVE and IVW are by far the biggest within their sub-category, with AUM of 5,772.28 and 7,382.57 million respectively.

There does not seem to be a negative relationship between size and tracking error in the category ‘Value - Mid Cap’ but the difference in assets under management among the two ETFs in this category is not huge which makes it difficult to draw any conclusions from this group.

The relationship does not seem to exist in the categories ‘Commodity’ and ‘Sector Fund - Real Estate’ either, in spite of large differences in assets under management within the sub-categories.

Factors that affect Tracking Error

Table 6: Regression results

Regression Results – Factors that affect Tracking Error

$$TE = \alpha_0 + \alpha_1 Risk + \alpha_2 Abs.Premium + \alpha_3 Spread + \alpha_4 Exp.Ratio + \alpha_5 LnAssets + \varepsilon \quad (8)$$

ETF Name	Ticker	Constant	t-Test	Risk	t-Test	Abs. Premium	t-Test	Spread	t-Test	Expense Ratio	t-Test	LnAssets	t-Test	R^2
Vanguard S&P 500 Value	VOOV	0.75	1.06	0.53	6.29^{A}	-0.45	-0.31	1.35	0.07	0		-0.05	-1.40	0.88
iShares S&P 500 Value	IVE	1.02	1.17	0.04	3.89^{A}	0.83	1.58	0.98	2.20^{B}	0		-0.04	-1.15	0.90
SPDR S&P 500 Value	SPYV	4.00	1.25	0.21	3.62^{A}	2.52	1.80^{C}	0.86	0.29	-0.10	-0.03	-0.21	-1.20	0.87
Vanguard Russell 1000 Value	VONV	1.20	2.74^{B}	0.07	1.49	0.13	0.12	606.25	2.71^{B}	0		-0.08	-3.09^{B}	0.76
iShares Russell 1000 Value	IWD	-0.28	-0.13	0.03	1.80^{C}	0.18	0.30	-0.19	-0.24	11.82	0.97	-0.09	-2.44^{B}	0.78

Note: Risk is the standard deviation of ETFs' daily returns. TE is the tracking error estimated by the average of the three different methods applied to estimate the daily tracking error of ETFs. Expense ratio is the average expense ratio of the ETFs collected from annual reports. Absolute premium is the absolute value of ETFs' average daily premium/discount. Spread is the average daily percentage bid-ask spread of ETFs. Ln Assets is the natural logarithm of ETFs' daily assets. A, B and C indicate statistical significance at 1%, 5% and 10% levels, respectively. This applies to Tables 6-18.

Table 6 Continued

ETF Name	Ticker	Constant	t-Test	Risk	t-Test	Abs. Premium	t-Test	Spread	t-Test	Expense Ratio	t-Test	LnAssets	t-Test	R^2
iShares S&P 500 Growth	IVW	0.22	0.18	0.04	4.06^{A}	3.59	4.60^{A}	0.40	0.60	0		-0.01	-0.17	0.92
Vanguard S&P 500 Growth	VOOG	0.72	0.62	0.20	2.69^{B}	-0.09	-0.04	0.55	0.05	0		-0.04	-0.61	0.60
SPDR S&P 500 Growth	SPYG	-5.06	-2.25^{B}	0.23	8.07^{A}	1.36	1.92^{C}	0.23	0.15	2.04	0.97	0.24	2.24^{B}	0.93
Vanguard Russell 1000 Growth	VONG	0.20	0.34	0.08	1.23	1.75	1.44	360.95	2.12^{C}	0		-0.02	-0.56	0.71
iShares Russell 1000 Growth	IWF	2.80	2.83^{B}	0.02	1.15	3.57	3.27^{A}	0.50	0.42	0		-0.12	-2.79^{B}	0.87
SPDR S&P 400 Mid Cap Value	MDYV	1.85	0.58	0.47	4.32^{A}	-0.84	-1.02	3.79	1.30	0.56	0.26	-0.12	-0.74	0.84
Vanguard S&P Mid Cap 400 Value	IVOV	3.22	2.04^{C}	0.40	4.32^{A}	2.21	1.26	-725.30	-1.16	0		-0.18	-1.99^{C}	0.81
Vanguard S&P Small Cap 600 Value	VIOV	3.59	3.69^{A}	0.37	6.50^{A}	0.86	1.45	-2.22	-0.32	0		-0.21	-3.69^{A}	0.93
SPDR S&P 600 Small Cap Value	SLYV	6.30	2.34^{B}	0.23	5.04^{A}	-1.85	-2.13^{C}	1.34	0.89	-0.49	-0.16	-0.33	-2.70^{B}	0.92

Table 6 Continued

ETF Name	Ticker	Constant	t-Test	Risk	t-Test	Abs. Premium	t-Test	Spread	t-Test	Expense Ratio	t-Test	LnAssets	t-Test	R^2
iShares Russell 2000 Value	IWN	5.40	3.81^{A}	0.02	1.63	1.63	3.87^{A}	0.01	0.03	0		-0.24	-3.77^{A}	0.94
Vanguard Russell 2000 Value	VTWV	-0.53	-0.38	0.45	4.43^{A}	-2.82	-1.49	89.64	0.50	0		0.03	0.39	0.79
Vanguard S&P Small Cap 600 Growth	VIOG	2.44	1.55	0.52	8.16^{A}	-0.88	-0.84	-12.23	-1.82	0		-0.15	-1.60	0.90
SPDR S&P 600 Small Cap Growth	SLYG	-2.90	-1.14	0.34	6.14^{A}	0.59	0.77	0.73	0.45	-5.57	-1.66	0.22	1.88^{C}	0.90
Vanguard Russell 2000 Growth	VTWG	3.23	2.22^{C}	0.08	0.54	-0.47	-0.16	258.20	1.49	0		-0.19	-2.17^{C}	0.50
iShares Russell 2000 Growth	IWO	6.38	4.11^{A}	0.03	3.00^{A}	-0.53	-0.46	-0.05	-0.06	0		-0.29	-4.09^{A}	0.81
ETFS Gold Trust	SGOL	0.74	0.73	0.66	6.37^{A}	0.22	0.36	9.10	0.36	0		-0.03	-0.59	0.84
ETFS Asian Gold Trust	AGOL	14.60	1.67	0.28	2.25^{C}	-0.32	-0.76	44.02	1.94	0		-0.79	-1.62	0.74
iShares Gold Trust	IAU	1.81	0.57	0.80	10.42^{A}	-0.00	-0.00	-10.91	-0.31	-0.71	-0.54	-0.07	-0.56	0.93

Table 6 Continued

ETF Name	Ticker	Constant	t-Test	Risk	t-Test	Abs. Premium	t-Test	Spread	t-Test	Expense Ratio	t-Test	LnAssets	t-Test	R^2
iShares Silver Trust	SLV	-3.67	-1.34	0.79	11.68^{A}	0.35	1.26	63.30	2.37^{B}	0		0.18	1.48	0.95
ETFS Physical Silver Shares	SIVR	-0.98	-0.49	0.75	6.74^{A}	0.02	0.05	2.71	0.05	0		0.08	0.74	0.84
Schwab US REIT	SCHH	-0.66	-2.04^{C}	0.05	2.72^{B}	-0.39	-0.77	-1.01	-0.86	1.29	2.01	0.03	2.14^{C}	0.94
SPDR Dow Jones REIT	RWR	-2.34	-0.50	0.03	0.80	3.01	1.97^{C}	33.11	3.97^{A}	0.42	0.05	0.11	0.65	0.85

Table 6 on Page 28-31 shows the results of the multiple regression function (8). Judging by the results of the regressions there seems to be only partial evidence of a relationship between tracking error on one hand and the size of assets under management on the other hand. In total we conclude that in 9 of the 27 ETFs tracking error actually decreases as an effect of the increase of assets under management. For 3 of the 27 ETFs we find the opposite relationship.

Among the explanatory variables there is one that stands out for its statistically significant relationship to tracking error and that is risk. The risk variable reveals to be positively related to tracking error for 21 of the 27 ETFs. At the same time we discover a clear negative relationship between the beta and the risk variable. When the beta is high the less impact the risk variable has in explaining the tracking error that exists, which translates into small coefficients of the risk variable. This is logical since the beta is a measure of the degree of similarity between the fund and the index. Remembering that the risk is defined as the standard deviation of daily returns, the tracking error will only be affected to a very little extent if the ETF and the index closely mirror each other in terms of the magnitude and the direction of the daily returns. Hence, other factors must do a better job in explaining the tracking error.

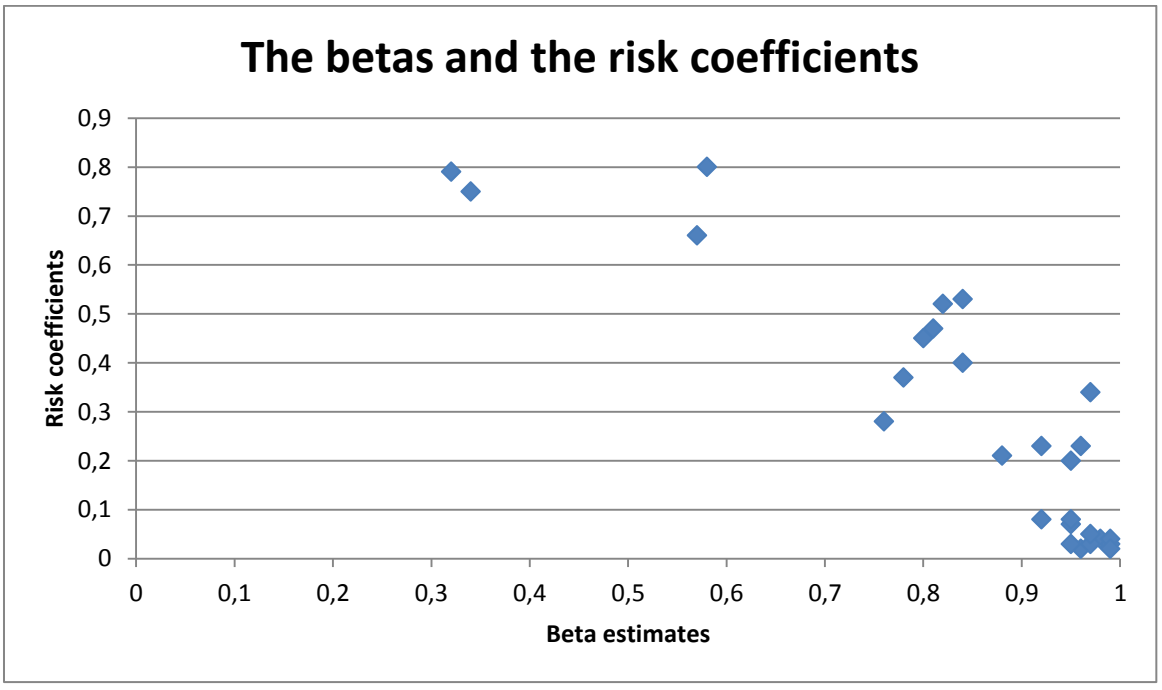


Figure 2: The relationship between the beta and the risk. The beta estimates are found in Table 4 and the risk coefficients are found in Table 6 or Tables 7-18.

Absolute premium results to be positively correlated with tracking error in 6 cases. Finally a positive relationship exists between the variable spread and tracking error for 5 ETFs. These findings are in accordance with previous studies and with what we expected to discover.

As expected we do not find a statistically significant relationship between tracking error and expense ratio and the expense ratio is omitted in most cases since it is being held constant over long periods of time.

R square ranges from 0.50 to 0.95 and will of course be somewhat smaller if we use the adjusted R squared since the regression model consists of 5 independent variables.

The results will now be discussed in a more detailed way, splitting Table 6 into 12 tables with one table for each index.

Table 7: Regression results for VOOV, IVE and SPYV

Results for Value – Large Cap, S&P 500 Value

VOOV		
Variables	**Coefficient**	**t-Test**
Constant	0.75	1.06
Risk	0.53	6.29^{A}
Absolute Premium	-0.45	-0.31
Spread	1.35	0.07
Expense Ratio	0	
LnAssets	-0.05	-1.40
R^2	0.88	

IVE		
Variables	**Coefficient**	**t-Test**
Constant	1.02	1.17
Risk	0.04	3.89^{A}
Absolute Premium	0.83	1.58
Spread	0.98	2.20^{B}
Expense Ratio	0	
LnAssets	-0.04	-1.15
R^2	0.90	

SPYV		
Variables	**Coefficient**	**t-Test**
Constant	4.00	1.25
Risk	0.21	3.62^{A}
Absolute Premium	2.52	1.80^{C}
Spread	0.86	0.29
Expense Ratio	-0.10	-0.03
LnAssets	-0.21	-1.20
R^2	0.87	

For this group we have one contributive factor that is statistically significant for all three ETFs at the 1 percent alpha level, namely *risk*, which is positively related to tracking error. The magnitude of the coefficient for this dependent variable ranges from 0.04 to 0.53. For one of the three ETFs in this category, SPYV, the independent variable *absolute premium* is statistically significant at the 0.10 level displaying a positive relationship to tracking error. Finally, the variable *spread* is positively correlated to tracking error and statistically significant at the 5 percent level. Just by judging by size and tracking error we anticipated finding a negative relationship between *LnAssets* and tracking error for IVE but the regression shows no statistically significant evidence of such a relationship.

Table 8: Regression results for VONV and IWD

Results for Value – Large Cap, Russell 1000 Value

VONV		
Variables	**Coefficient**	**t-Test**
Constant	1.20	2.74^{B}
Risk	0.07	1.49
Absolute Premium	0.13	0.12
Spread	606.25	2.71^{B}
Expense Ratio	0	
LnAssets	-0.08	-3.09^{B}
R^2	0.76	

IWD		
Variables	**Coefficient**	**t-Test**
Constant	-0.28	-0.13
Risk	0.03	1.80^{C}
Absolute Premium	0.18	0.30
Spread	-0.19	-0.24
Expense Ratio	11.82	0.97
LnAssets	-0.09	-2.44^{B}
R^2	0.78	

For both ETFs we see that there is a negative relationship between *LnAssets* and tracking error that is statistically significant at the 5 percent level. The independent variable *spread* reveals to be positively related to tracking error for VONV. The magnitude of the coefficient for *spread* is quite important with a value of 606.25. The possible impact of this regressor is nevertheless limited considering that the average *spread* is in the neighborhood of 0.0005. In the case of IWD, *risk* shows a positive relationship to tracking error which is statistically significant at the 10 percent level.

Table 9: Regression results for IVW, VOOG and SPYG

Results for Growth – Large Cap, S&P 500 Growth

IVW		
Variables	**Coefficient**	**t-Test**
Constant	0.22	0.18
Risk	0.04	4.06^{A}
Absolute Premium	3.59	4.60^{A}
Spread	0.40	0.60
Expense Ratio	0	
LnAssets	-0.01	-0.17
R^2	0.92	

VOOG		
Variables	**Coefficient**	**t-Test**
Constant	0.72	0.62
Risk	0.20	2.69^{B}
Absolute Premium	-0.09	-0.04
Spread	0.55	0.05
Expense Ratio	0	
LnAssets	-0.04	-0.61
R^2	0.60	

SPYG		
Variables	**Coefficient**	**t-Test**
Constant	-5.06	-2.25^{B}
Risk	0.23	8.07^{A}
Absolute Premium	1.36	1.92^{C}
Spread	0.23	0.15
Expense Ratio	2.04	0.97
LnAssets	0.24	2.24^{B}
R^2	0.93	

Table 9 exhibits a positive correlation between *risk* and tracking error for each ETF in this subgroup. For IVW there is a positive relationship between *absolute premium* and tracking error at the 1 percent level and the same relationship holds for SPYG but this time at the 10 percent level. The explanatory variable *LnAssets* is positively related to tracking error at the 5 percent level.

Table 10: Regression results for VONG and IWF

Results for Value – Large Cap, Russel 1000 Growth

VONG		
Variables	**Coefficient**	**t-Test**
Constant	0.20	0.34
Risk	0.08	1.23
Absolute Premium	1.75	1.44
Spread	360.95	2.12^{C}
Expense Ratio	0	
LnAssets	-0.02	-0.56
R^2	0.71	

IWF		
Variables	**Coefficient**	**t-Test**
Constant	2.80	2.83^{B}
Risk	0.02	1.15
Absolute Premium	3.57	3.27^{A}
Spread	0.50	0.42
Expense Ratio	0	
LnAssets	-0.12	-2.79^{B}
R^2	0.87	

At the 1 percent significance level we find a positive relationship between *absolute premium* and tracking error for IWF. At the 5 percent level a negative relationship exists between *LnAssets* and tracking error for the same ETF. Concerning VONG the independent variable *spread* is positively related to tracking error at the 10 percent significance level.

Table 11: Regression results for MDYV and IVOV

Results for Value – Mid Cap, S&P Mid Cap 400 Value

MDYV		
Variables	**Coefficient**	**t-Test**
Constant	1.85	0.58
Risk	0.47	4.32^{A}
Absolute Premium	-0.84	-1.02
Spread	3.79	1.30
Expense Ratio	0.56	0.26
LnAssets	-0.12	-0.74
R^2	0.84	

IVOV		
Variables	**Coefficient**	**t-Test**
Constant	3.22	2.04^{C}
Risk	0.40	4.32^{A}
Absolute Premium	2.21	1.26
Spread	-725.30	-1.16
Expense Ratio	0	
LnAssets	-0.18	-1.99^{C}
R^2	0.81	

For both ETFs a positive relationship exists between *risk* and tracking error at the 0.01 level. In addition, *LnAssets* is negatively related to tracking error at the 10 percent significance level for IVOV.

Table 12: Regression results for VIOV and SLYV

Results for Value – Small Cap, S&P Small Cap 600 Value

VIOV		
Variables	**Coefficient**	**t-Test**
Constant	3.59	3.69^{A}
Risk	0.37	6.50^{A}
Absolute Premium	0.86	1.45
Spread	-2.22	-0.32
Expense Ratio	0	
LnAssets	-0.21	-3.69^{A}
R^2	0.93	

SLYV		
Variables	**Coefficient**	**t-Test**
Constant	6.30	2.34^{B}
Risk	0.23	5.04^{A}
Absolute Premium	-1.85	-2.13^{C}
Spread	1.34	0.89
Expense Ratio	-0.49	-0.16
LnAssets	-0.33	-2.70^{B}
R^2	0.92	

At the 1 percent significance level we find for both ETFs in this category a positive relationship between *risk* and tracking error. *LnAssets* reveals to be negatively related to tracking error with a statistical significance at the 1 percent level for VIOV and at the 5 percent level for SLYV. Furthermore, we see that *absolute premium* is adversely related to tracking error at the 10 percent significance level for SLYV.

Table 13: Regression results for IWN and VTWV

Results for Value – Small Cap, Russel 2000 Value

IWN		
Variables	**Coefficient**	**t-Test**
Constant	5.40	3.81^{A}
Risk	0.02	1.63
Absolute Premium	1.63	3.87^{A}
Spread	0.01	0.03
Expense Ratio	0	
LnAssets	-0.24	-3.77^{A}
R^2	0.94	

VTWV		
Variables	**Coefficient**	**t-Test**
Constant	-0.53	-0.38
Risk	0.45	4.43^{A}
Absolute Premium	-2.82	-1.49
Spread	89.64	0.50
Expense Ratio	0	
LnAssets	0.03	0.39
R^2	0.79	

At the 1 percent significance level for IWN we find that *absolute premium* is positively related to tracking error whereas *LnAssets* is negatively related to tracking error. In regards to VTWV, at the 1 percent significance level we see that *risk* has a positive effect on tracking error.

Table 14: Regression results for VIOG and SLYG

Results for Growth – Small Cap, S&P Small Cap 600 Growth

VIOG		
Variables	**Coefficient**	**t-Test**
Constant	2.44	1.55
Risk	0.52	8.16^{A}
Absolute Premium	-0.88	-0.84
Spread	-12.23	-1.82
Expense Ratio	0	
LnAssets	-0.15	-1.60
R^2	0.90	

SLYG		
Variables	**Coefficient**	**t-Test**
Constant	-2.90	-1.14
Risk	0.34	6.14^{A}
Absolute Premium	0.59	0.77
Spread	0.73	0.45
Expense Ratio	-5.57	-1.66
LnAssets	0.22	1.88^{C}
R^2	0.90	

As we have often seen for the preceding ETFs we once again find for both ETFs in this category a positive relationship between *risk* and tracking error at the 0.01 alpha level. In addition, regarding SLYG we see that at the 0.10 alpha level that *LnAssets* is positively related to tracking error.

Table 15: Regression results for VTWG and IWO

Results for Growth – Small Cap, Russel 2000 Growth

VTWG		
Variables	**Coefficient**	**t-Test**
Constant	3.23	2.22^{C}
Risk	0.08	0.54
Absolute Premium	-0.47	-0.16
Spread	258.20	1.49
Expense Ratio	0	
LnAssets	-0.19	-2.17^{C}
R^2	0.50	

IWO		
Variables	**Coefficient**	**t-Test**
Constant	6.38	4.11^{A}
Risk	0.03	3.00^{A}
Absolute Premium	-0.53	-0.46
Spread	-0.05	-0.06
Expense Ratio	0	
LnAssets	-0.29	-4.09^{A}
R^2	0.81	

For both ETFs in this category we see that *LnAssets* is adversely correlated with tracking error with a 1 percent significance level for IWO and a 10 percent significance level for VTWG. In addition, in the case of IWO there is a positive relationship between *risk* and tracking error at the 0.01 alpha level.

Table 16: Regression results for SGOL, AGOL and IAU

Results for Commodity – Gold, London Gold PM Fix

SGOL		
Variables	**Coefficient**	**t-Test**
Constant	0.74	0.73
Risk	0.66	6.37^{A}
Absolute Premium	0.22	0.36
Spread	9.10	0.36
Expense Ratio	0	
LnAssets	-0.03	-0.59
R^2	0.84	

AGOL		
Variables	**Coefficient**	**t-Test**
Constant	14.60	1.67
Risk	0.28	2.25^{C}
Absolute Premium	-0.32	-0.76
Spread	44.02	1.94
Expense Ratio	0	
LnAssets	-0.79	-1.62
R^2	0.74	

IAU		
Variables	**Coefficient**	**t-Test**
Constant	1.81	0.57
Risk	0.80	10.42^{A}
Absolute Premium	-0.00	-0.00
Spread	-10.91	-0.31
Expense Ratio	-0.71	-0.54
LnAssets	-0.07	-0.56
R^2	0.93	

In this category of Gold ETFs there seems to be only one statistically significant dependent variable and that is *risk* which is positively correlated with tracking error at the 1 percent level for SGOL and IAU and at the 10 percent level for AGOL.

Table 17: Regression results for SLV and SIVR

Results for Commodity – Silver, London Silver Fix Price

SLV		
Variables	**Coefficient**	**t-Test**
Constant	-3.67	-1.34
Risk	0.79	11.68^{A}
Absolute Premium	0.35	1.26
Spread	63.30	2.37^{B}
Expense Ratio	0	
LnAssets	0.18	1.48
R^2	0.95	

SIVR		
Variables	**Coefficient**	**t-Test**
Constant	-0.98	-0.49
Risk	0.75	6.74^{A}
Absolute Premium	0.02	0.05
Spread	2.71	0.05
Expense Ratio	0	
LnAssets	0.08	0.74
R^2	0.84	

At the 0.01 alpha level we see that for both ETFs *risk* is positively related to tracking error. Regarding SLV, *spread* displays a positive correlation with tracking error at the 5 percent significance level.

Table 18: Regression results for SCHH and RWR

Results for Sector Fund - Real Estate – Dow Jones U.S. Select REIT

SCHH		
Variables	**Coefficient**	**t-Test**
Constant	-0.66	-2.04^{C}
Risk	0.05	2.72^{B}
Absolute Premium	-0.39	-0.77
Spread	-1.01	-0.86
Expense Ratio	1.29	2.01
LnAssets	0.03	2.14^{C}
R^2	0.94	

RWR		
Variables	**Coefficient**	**t-Test**
Constant	-2.34	-0.50
Risk	0.03	0.80
Absolute Premium	3.01	1.97^{C}
Spread	33.11	3.97^{A}
Expense Ratio	0.42	0.05
LnAssets	0.11	0.65
R^2	0.85	

We are unable to find any common traits among the two ETFs in this category in terms of explaining variables that are statistically significant. For instance, we see that *risk* and *LnAssets* are positively related to tracking error in the case of SCHH at the 5 percent and the 10 percent significance level respectively. As for RWR, a different set of variables affect

tracking error positively namely *absolute premium* and *spread* at the 10 percent and at the 1 percent significance level respectively.

Conclusion

Numerous studies over the last decade focus on the performance of ETFs relative to their benchmark indexes. One way to measure the difference in return between the index and the ETF is called tracking error. In the present study we use the mean value of three different methods to estimate the tracking error for 27 US ETFs of different types such as equities, real estate as well as silver and gold ETFs. Over this broad range of ETFs the average tracking error amounts to 57 basis points though the individual differences or differences from one type of ETF to another reveals to be quite substantial. Both ETFs that operate in the silver market have for instance a tracking error that exceeds 220 basis points.

We knew beforehand that the magnitude of the tracking error is by a large part due to the degree of replication of the ETF with regards to its underlying index. This fact has been proven by numerous researchers. The higher the departure from a full replication strategy the higher the tracking error reveals to be. With the help of a performance regression where we regress the returns of the ETF on its benchmark index we discover that on average the beta value totals 0.84. Once again we obtain big differences in our material with the silver ETFs demonstrating the lowest beta values accompanied by the gold ETFs. Needless to say, these ETFs exhibit an above average tracking error.

We set out this study to investigate whether there is evidence of a negative relationship between the magnitude of assets under management and tracking error. If this would prove to be the case then there would be signs of possible economies of scales in the hidden costs that ETF providers charge or are faced with. Much in the same way that a lot of things point to that there are economies of scale that makes it possible for ETF providers to lower their expense ratios at the same time as they grow bigger. The results turn out to reveal no general trend since there is only a statistically significant relationship between assets under management and tracking error valid for 12 of the 27 ETFs. To our big surprise in 3 out of 12 cases the relationship turns out to be positive and thus working in the opposite direction to that of economies of scale.

Given our results, perhaps the extra income generated by increasing assets under management is not used for tracking error minimization. Perhaps instead the additional income is just kept and in that way giving the provider a higher profit margin on the ETF. This might be tempting for the provider, especially because ETFs are low cost products and the industry is highly competitive with low profit margins as a result.

We observe how other variables have a more important impact in determining tracking error. The risk variable reveals to be positively related to tracking error for 21 of the 27 ETFs and it is by far the single most important factor in explaining the tracking error.

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