Synthetic ETFs: Will full replication survive?

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Abstract

This paper focuses on the replication process of exchange-traded funds (ETFs). It compares the performance of ETFs based on full replication of their benchmark indices to synthetic ETFs. Synthetic ETFs rely on derivatives such as swaps in order to track the index. For ETFs listed at the Frankfurt stock exchange we show that both categories of ETFs suffer from high tracking errors. Contrary to conventional wisdom, synthetic equity ETFs do not have smaller tracking errors than their full replication counterparts. However, in the case of fixed income synthetic ETFs better track their benchmark indices. We identify different factors influencing the tracking errors.

JEL Classification: G11, G12, G19, G23

Keywords: ETF, replication method, synthetic replication, full replication, tracking error, autocorrelation

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1 Introduction

The ability to invest in an index, be it equity or fixed income, is very attractive to an investor looking for diversification. In recent years there has been a surge of exchange-traded funds allowing for such an investment at relatively modest costs. Originally, an ETF is a share of a portfolio of securities, which is listed at an exchange. In most cases, it is designed to track a specific index, thus representing a special passive fund.

Quite recently, a debate has started as to the influence of synthetic ETFs. In practice, there are three possibilities to replicate the index that an ETF is based upon. In the very beginning, ETFs were replicated by holding all securities of the underlying index. This full replication set-up is still used extensively. Because of transaction costs and other frictions, an optimally chosen subset of index securities has also been advocated. The resulting optimal or statistical replication accounts for a relatively small number of ETFs. In contrast to this, synthetic replication is a very popular set-up by now. (cp Newlands (2011)). In Europe, ETFs that rely on derivatives such as swaps and futures are being traded since 2001. Essentially, a synthetic ETF relies on a contract with a counterparty that pays the chosen index in exchange for a portfolio that the ETF is invested in. Usually, the partner of this swap is the financial institution to which the fund belongs. Because of this swap contract, synthetic ETFs face a counterparty risk, which does not exist in the case of full replication ETFs.

What are the effects of the different replication techniques? Will there be a difference in tracking errors of the respective ETFs? It has been argued that synthetic ETFs can perfectly mimic the underlying index. Consequently, the tracking errors of synthetic ETFs should be smaller than those of their full replication counterparts. Which are the factors affecting the tracking errors of ETFs following different replication methods? This paper considers these issues for equity and fixed income ETFs listed at the Frankfurt stock exchange. According to our knowledge it is the first rigorous empirical analysis that addresses these questions.

Right from the start, the performance of ETFs has been a crucial issue both for investors and researchers alike. For the American market, comparisons of ETFs to their benchmark indices and to corresponding index funds yielded mixed results. Elton et al. (2002) were the first to note both an underperformance of the ETF Spiders with respect to its benchmark S&P 500 and to a corresponding index fund. Whereas underperformance with respect to the benchmark index prevails in all studies, Svetina/Wahal (2008), for instance, show no differ-

ence in performance between ETFs and corresponding index funds. Also, Svetina/Wahal (2008) establish that ETFs based on international benchmarks show a much smaller underperformance than ETFs based on national benchmarks. Similar in nature are the studies of Agapova (2011), Blitz/Huij/Swinkels (2010) and Shin/Soydemir (2010). Agapova (2011) focused on the US market, whereas Blitz/Huij/Swinkels (2010) and Shin/Soydemir (2010) analyzed ETFs based on large international indices traded in Europe and worldwide, respectively. National markets are analyzed by Gallagher/Segara (2006), Milona/Rompotis (2006) and Rompotis (2008). Gallagher/Segara (2006) focused on ETFs at the Australian stock exchange, whereas Milona/Rompotis (2006) and Rompotis (2008) considered the Swiss and the German market, respectively.

Apart from performance, the ability to track the underlying index is of great importance. Shin/Soydemir (2010), for instance, find that tracking errors are significantly different from zero when considering 26 ETFs based on major American, Asian and European stock indices for the period July 2004 until June 2007. When compared, US ETFs show smaller tracking errors than Asian and European ETFs. Similar results were provided by Gallagher/Segara (2006), Milona/Rompotis (2006), Rompotis (2008), Svetina/Wahal (2008), Agapova (2011) and Blitz/Huij/Swinkels (2010). Thus it is of interest to find factors that determine the tracking errors. Rompotis (2008) was the first to consider this question for German ETFs for the period 2000-2006. His main findings include a substantial tracking error which is positively affected by the bid-ask spread and management fees. Frino/Gallagher (2001), Kostovetsky (2003), Milonas/Rompotis (2006) and Shin/Soydemir (2010) reveal expenses, spread, fund volume, dividends, changes in index composition and exchange rate risks as factors that affect tracking errors.

Our paper contributes to the existing literature in two ways. First, it analyzes a financial market with close but not perfect substitutes. It explains the coexistence of full replication and synthetic ETFs, two investment vehicles with the same underlying index but different replication structure. Second, it adds to our understanding of product development by analyzing ETFs according to dividends or interest payments being distributed or accumulated.

This paper is organized as follows. Section 2 is devoted to the data and the methodology used. Section 3 presents our empirical findings, whereas Section 4 concludes.

2 Data and methodology

2.1 Data

This study analyzes ETFs listed at the Frankfurt Stock Exchange from 01/01/2010 to 08/31/2011. Overall, 879 ETFs were available for sale in Frankfurt. We take the position of a European investor who trades in euro and does not want to bear exchange rate risks. Thus we eliminate 380 ETFs from the sample because their trading currencies differ from the currency of the underlying index, yielding a sample of 499 ETFs.

ETFs are classified with respect to the index replication method employed. We exclude 20 optimized ETFs from the analyses because they do not fully replicate their indices. Furthermore, the applied test statistics have low explanatory power for such a small group. 24 ETFs are eliminated because their replication method changed and 34 ETFs because of missing, incomplete or incorrect data. Thus we analyze 326 synthetic ETFs and 95 ETFs based on full replication.

We use daily returns of ETFs and their indices based on closing trading prices available on Bloomberg. An alternative would be net asset values. An advantage of closing prices over net asset values is a smaller time-gap between ETF returns and index returns. Furthermore, Blitz/Huij (2012) and Elia (2012) show that pricing deviations of last trading prices and NAV are non-zero using monthly data. Thus the tracking error based on ETFs closing prices can substantially deviate from NAV tracking error.

Funds receive payments from their investments, e.g. dividends or interest payments. This cash flow can either be reinvested in the portfolio of the fund or paid out to the investor. Thus ETFs are either accumulating or distributing funds. The returns of ETFs and their corresponding indices, which accumulate dividends and interest payments, are calculated using gross and net total return indices. Price indices are the basis for returns of distributing ETFs and their corresponding indices.

The information about replication method, asset class, corresponding index and trading/index currency are hand-collected from the websites of ETF providers. Specifications as to income being distributed are directly collected from ETF providers. For example, Lyxor, db x-trackers, PIMCO/Source, UBS and RBS reinvest dividends and interest payments instead of keeping them as liquidity until distributed to investors.

Additional data like daily bid and ask prices, daily trading volume and dividends are collected from Bloomberg. Annualized total expense ratios *(TER)* are gathered from BlackRock.

Figure 2: Descriptive statistics – ETF issuers

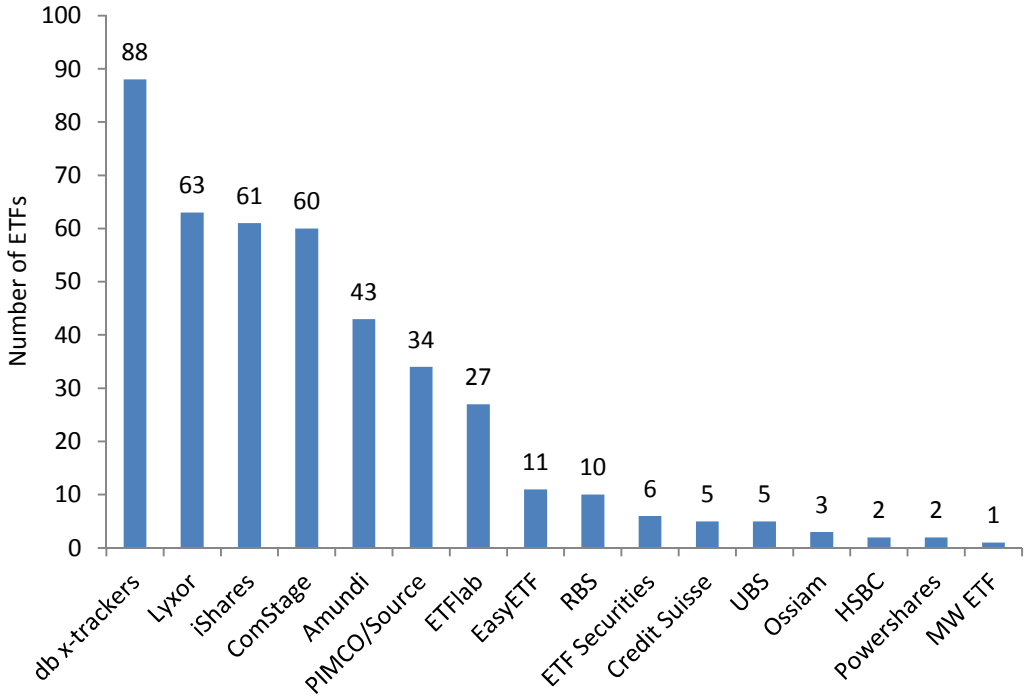

Figure 2.1 shows the number of ETFs in our dataset with regard to issuer. 88 ETFs from db x-trackers represent the largest group followed by 63 ETFs from Lyxor and 61 ETFs from iShares. We cover all ETFs listed at the Frankfurt Stock Exchange in the examination period. Thus compared to previous studies, the problem of survivorship bias is almost circumvented.

We separate ETFs with respect to asset class resulting in 286 equity ETFs, 117 fixed income ETFs and 18 other (commodity/total return) ETFs. Table 2.2 shows that synthetic ETFs mainly accumulate dividends and interest payments whereas full replication ETFs mainly distribute fund income.

Table 2.2: Descriptive statistics

	Synthetic ETFs			Full replication ETFs			
Asset class	**Distr.**	**Acc.**	**Total**	**Distr.**	**Acc.**	**Total**	**Total**
Equity	41	177	218	56	12	68	286
Fixed Income	2	91	93	24	0	24	117
Other	0	15	15	2	1	3	18
Total	43	283	326	82	13	95	421

Our sample contains ETFs on 315 different indices. Only 7 indices are simultaneously covered by both synthetic and full replication ETFs. 78 and 230 different indices are the only benchmarks for full replication ETFs and synthetic ETFs, respectively. Thus there is hardly any competition of issuers on synthetic and full replication ETFs on an identical benchmark. On the contrary, 265 indices are tracked by only one ETF, the majority of which are of the synthetic type. Only 74 indices serve as benchmarks of full replication ETFs.

2.2 Methodology

Tracking errors

How closely is an ETF following its benchmark? The tracking error can be measured in at least four different ways. Frino/Gallagher (2001) and Rompotis (2008), for example, estimate tracking errors by the average absolute difference of returns and the standard error from a regression, respectively. Gallagher/Segara (2006) and Milonas/Rompotis (2006) employ the standard deviation of return differences, whereas Shin/Soydemir (2010) modify this approach by estimating the standard deviation of absolute return differences.

In this study we analyze ETFs using all four methods. Thus our results can easily be compared to other studies. The first tracking error (TE_1) is the average absolute difference of ETF returns and index returns:

$$TE_1 = \frac{\sum_{t=1}^{n} \left| R_t^{ETF} - R_t^{Index} \right|}{n}$$

where R_t^{ETF} and R_t^{Index} denote the day t returns of the ETF considered and the underlying index , respectively. Similarly, the second and third definition of tracking errors are given by

$$TE_2 = \sqrt{\frac{\sum_{t=1}^{n} \left(R_t^{ETF} - R_t^{Index} - \overline{\left(R_t^{ETF} - R_t^{Index} \right)} \right)^2}{n-1}}$$

$$TE_3 = \sqrt{\frac{\sum_{t=1}^{n} \left(\left| R_t^{ETF} - R_t^{Index} \right| - \overline{\left| R_t^{ETF} - R_t^{Index} \right|} \right)^2}{n-1}}$$

with $\overline{R_t^{ETF} - R_t^{Index}}$ denoting the average difference of returns between the ETF and the underlying index *at t.* Note that the third tracking error method is just a modification of the second one using absolute return differences. ETF issuers use the second definition when providing tracking error information. Finally, the fourth method uses the standard error from a one factor model

$$TE_4 = \sqrt{\frac{\sum_{t=1}^{n} \varepsilon_t^2}{n-2}}$$

where ε_t results from estimating

$$R_t^{ETF} = \alpha + \beta\, R_t^{Index} + \varepsilon_t.$$

α measures the excess return which an ETF earns above the index. Since ETFs are primarily passive index vehicles, they should not exhibit α's significantly different from zero. Due to expenses like transaction costs α's can significantly be negative but not positive. β measures the systematic risk and the replication strategy of the ETF considered. Furthermore, the coefficient indicates the sensitivity of the ETF portfolio to the corresponding index. If β is close to unity, the ETF perfectly replicates the index. If this is the case, alpha yields the difference of ETF and index returns. Svetina/Wahal (2008), Blitz/Huij/Swinkels (2010) und Blitz/Huij (2012) use this for measuring performance. The standard deviation of residuals should not significantly be different from zero if the ETF perfectly replicates the corresponding index.

Adjustments due to serial correlation

According to Pope/Yadav (1994) the use of daily returns might result in negative serial correlation of the difference of ETF returns and index returns. Without adjustments, this might lead to an overestimation of tracking errors. Thus return differences are corrected for serial correlation. We use the Cochrane-Orcutt procedure to transform the time series according to an optimal lag configuration for every single ETF.

To obtain the best linear unbiased alpha and beta estimator, we test for autocorrelation in standard errors. When necessary, standard errors are adjusted by the Cochrane-Orcutt

procedure. Hence, our final time series is free of serial correlation. On average, five lags are applied to raw returns. The longest time period of adjustments is three weeks. Some studies use weekly data to overcome the problem of correlated return differences. Our tests show that this procedure does not prevent an overestimating of tracking errors.

Subsamples of ETFs

We form four groups to test whether synthetic ETFs replicate their indices better than full replication ETFs. These groups are synthetic equity ETFs (S_{Syn}) and synthetic fixed income ETFs $\left(B_{Syn}\right)$ as well as full replication equity ETFs (S_{Full}) and full replication fixed income ETFs (B_{Full}).

Additionally, we distinguish between accumulating and distributing ETFs both for equity and fixed income. This is done to answer the question whether tracking errors differ with respect to profit appropriation. We form groups of synthetic accumulating equity ETFs $\left(S_{Syn}^{Acc.}\right)$, synthetic distributing equity ETFs $\left(S_{Syn}^{Distr.}\right)$, full replication accumulating equity ETFs ($S_{Full}^{Acc.}$) and full replication distributing equity ETFs ($S_{Full}^{Distr.}$), respectively. However, our dataset does not contain full replication accumulating fixed income ETFs. Also, there are only two synthetic distributing fixed income ETFs. Thus in the case of fixed income, we only rely on the groups of synthetic accumulating fixed income ETFs ($B_{Syn}^{Acc.}$) and full replication distributing fixed income ETFs ($B_{Full}^{Distr.}$).

We analyze whether the funds belonging to one of the groups mentioned replicate their indices well. If so, the equally weighted tracking errors and alpha should be close to zero, whereas the equally weighted beta and R^2 should be close to unity. We perform t-tests which are two-sided for checking alpha and beta coefficients and one-sided for R^2 as well as for the four tracking errors.

One-factorial ANOVA

We use a one-factorial ANOVA to compare the groups of ETFs introduced above. With the exception of full replication accumulating equity ETFs and full replication distributing fixed income ETFs, the groups are adequate in size to assume a normal distribution of returns. In addition, we test groups' homogeneity of variances with Levene statistics and find them highly significant. Therefore, we use the Welch test and the Brown-Forsythe test to analyze

group differences. Post-hoc tests are modified using the Games-Howel test to avoid an alpha error accumulation.

Factors influencing tracking errors

The level of risk should affect tracking errors because of the time-gap between the trades of an ETF and the index. Therefore higher risks should be accompanied by higher tracking errors. Since costs are likely to influence the return differences of an ETF and the underlying index, we expect costs and tracking errors to be positively correlated. Additionally, the spread should have a positive influence on the tracking error. Also, high liquidity ETFs should have lower tracking errors. Furthermore, dividends are expected to have an influence on tracking errors. For example, tracking errors should be higher for ETFs which do not immediately distribute income to investors.

In order to overcome the problem of correlated regressors, we first choose to analyze tracking errors with respect to risk measured by the average standard deviation of daily returns, spread measured by the average of daily relative spreads, liquidity measured by the natural logarithm of the average daily trading volume and dividends measured by the ratio of average dividends and average trading price. Thus we obtain

$$TE_i = \alpha + \beta_1 \cdot Risk_i + \beta_2 \cdot Spread_i + \beta_3 \cdot LnVolume_i + \beta_4 \cdot Dividends_i + \varepsilon_i \quad (1)$$

In a second step, costs measured by the average annualized total expense ratio are considered. However, risk and spread had to be dropped from the regression due to high correlation with the total expense ratio, yielding

$$TE_i = \alpha + \beta_1 \cdot TER_i + \beta_2 \cdot LnVolume_i + \beta_3 \cdot Dividends_i + \varepsilon_i \quad (2)$$

Since the variances of the independent variables are not homogeneous, the test statistics are adjusted by the White standard error. As in Shin/Soydemir (2010), we checked a volatility factor measured by the average difference between the highest and lowest trading price in relation to the closing price within one day according to. We do not show the results, because this factor is highly correlated with risk, spread and total expense ratio. In addition, the explanatory power is lower measured by adjusted R^2.

3 Empirical results

3.1 Synthetic vs. full replication ETFs

Tracking errors

In this section, we present the results of cross-sectional regressions. Table 3.1 shows the means of the four types of tracking errors, alpha and beta coefficients as well as R^2 for the overall sample and for synthetic and full replication ETFs, respectively with T-test values in parentheses.

Both synthetic and full replication ETFs suffer from high tracking errors. Thus they do not perfectly replicate their indices. Independent of the replication method, tracking errors are consistently significant at a 1 percent level. Tracking errors of synthetic ETFs have a wider range around their means than full replication ETFs. The standard deviations of synthetic ETFs are roughly twice as high as those full replication ETFs. The highest tracking error (TE_4) for a single synthetic ETF amounts to 0.0313 compared to 0.0156 for the highest value of full replication ETFs. Hence, separating the sample into two subsamples according to the replication method is reasonable.

For comparison, the tracking errors of the primary dataset (without correcting for autocorrelation) are much higher. The average TE_2 amounts to 0.0055 for the whole dataset, to 0.0054 for synthetic and to 0.0057 for full replication ETFs, respectively.

Alpha and beta coefficients are also highly significant except for the alpha coefficient of full replication ETFs, which is significant at a 5 percent level. Although the alpha coefficients are close to zero, t-tests are significant. Moreover, alpha values of synthetic ETFs are significantly negative on average. This could be explained by higher transaction costs that synthetic ETFs face in comparison to their full replication counterparts. In fact, synthetic ETFs are often used to replicate illiquid indices. Beta coefficients also significantly differ from unity verifying the tracking error results.

Table 3.1: All ETFs – Synthetic vs. full replication

	TE_1	TE_2	TE_3	TE_4	Alpha	Beta	R^2
In all ($ETFs$: 421)							
Mean	**0.0025***** (25.152)	**0.0042***** (25.643)	**0.0034***** (24.913)	**0.0053***** (24.973)	**-0.0001***** (-5.672)	**0.9376***** (-11.969)	**0.8411***** (-15.956)
Median	0.0021	0.0037	0.0030	0.0046	0.0000	0.9637	0.9312
St. Deviation	0.0020	0.0034	0.0028	0.0044	0.0002	0.1069	0.2044
Minimum	0.0000	0.0000	0.0000	0.0000	-0.0024	0.1839	0.0003
Maximum	0.0192	0.0264	0.0251	0.0313	0.0010	1.2112	0.9985
Synthetic ($ETFs_{Syn}$: 326)							
Mean	**0.0024***** (20.071)	**0.0041***** (20.084)	**0.0033***** (19.350)	**0.0053***** (19.823)	**-0.0001***** (-5.261)	**0.9418***** (-9.768)	**0.8624***** (-13.059)
Median	0.0019	0.0032	0.0025	0.0040	0.0000	0.9688	0.9438
St. Deviation	0.0022	0.0037	0.0030	0.0048	0.0003	0.1076	0.1903
Minimum	0.0000	0.0000	0.0000	0.0000	-0.0024	0.3851	0.0516
Maximum	0.0192	0.0264	0.0251	0.0313	0.0010	1.2112	0.9985
Full replication ($ETFs_{Full}$: 95)							
Mean	**0.0028***** (18.280)	**0.0047***** (22.761)	**0.0037***** (25.106)	**0.0056***** (22.054)	**0.0000**** (-2.231)	**0.9234***** (-7.196)	**0.7680***** (-9.691)
Median	0.0026	0.0044	0.0035	0.0053	0.0000	0.9489	0.8879
St. Deviation	0.0015	0.0020	0.0014	0.0024	0.0001	0.1037	0.2334
Minimum	0.0005	0.0011	0.0009	0.0013	-0.0006	0.1839	0.0003
Maximum	0.0091	0.0125	0.0085	0.0156	0.0003	1.0632	0.9966

The table represents the results of the cross-sectional regressions for the alpha and the beta coefficients, R^2 and the four tracking errors during the time period from 01/01/2010 to 08/31/2011. The t-values are shown in parentheses. The calculation is done based on historical data in daily terms. The whole sample consists of 421 ETFs and is divided into subsamples of 326 synthetic and 95 full replication ETFs. According to the asset class, the data set consists of 286 equity, 117 fixed income and 18 others ETFs.

*** 10 % significance level, ** 5 % significance level, *** 1 % significance level**

The results of equity and fixed income ETFs are presented in Tables 3.2 and 3.3, respectively. Tracking errors as well as beta coefficients and R^2s are highly significant independent of asset class and replication method. This implies that neither equity nor fixed income ETFs can perfectly replicate their underlying indices. On average, the tracking errors of fixed income ETFs, varying between 0.0011 and 0.0038, are smaller than those of equity ETFs, which are in the range of 0.0029 to 0.0066. Additionally, the tracking errors of full replication equity ETFs and fixed income ETFs as well as synthetic fixed income ETFs similarly vary around their mean. Only synthetic equity ETFs exhibit higher standard deviations.

Table 3.2: Equity ETFs – Synthetic vs. full replication

	TE_1	TE_2	TE_3	TE_4	Alpha	Beta	R^2
In all (S: 286)							
Mean	**0.0030***** (25.793)	**0.0051***** (25.771)	**0.0041***** (24.541)	**0.0065***** (25.178)	**-0.0001***** (-5.198)	**0.9431***** (-12.628)	**0.9085***** (-12.288)
Median	0.0024	0.0044	0.0035	0.0057	0.0000	0.9608	0.9460
St. Deviation	0.0019	0.0033	0.0028	0.0044	0.0003	0.0761	0.1259
Minimum	0.0005	0.0007	0.0005	0.0010	-0.0024	0.4449	0.2695
Maximum	0.0114	0.0255	0.0251	0.0313	0.0010	1.1794	0.9985
Synthetic (S_{Syn}: 218)							
Mean	**0.0029***** (20.638)	**0.0050***** (20.248)	**0.0041***** (19.201)	**0.0066***** (20.145)	**-0.0001***** (-4.943)	**0.9479***** (-9.595)	**0.9167***** (-9.345)
Median	0.0022	0.0040	0.0034	0.0056	0.0000	0.9659	0.9556
St. Deviation	0.0020	0.0037	0.0031	0.0048	0.0003	0.0802	0.1317
Minimum	0.0005	0.0007	0.0005	0.0010	-0.0024	0.4449	0.2695
Maximum	0.0114	0.0255	0.0251	0.0313	0.0010	1.1794	0.9985
Full replication (S_{Full}: 68)							
Mean	**0.0033***** (17.777)	**0.0053***** (22.090)	**0.0041***** (24.156)	**0.0063***** (21.412)	**-0.0000*** (-1.686)	**0.9279***** (-9.998)	**0.8825***** (-9.527)
Median	0.0029	0.0048	0.0038	0.0058	0.0000	0.9401	0.9165
St. Deviation	0.0015	0.0020	0.0014	0.0024	0.0002	0.0595	0.1017
Minimum	0.0007	0.0011	0.0009	0.0013	-0.0006	0.6934	0.4556
Maximum	0.0091	0.0125	0.0085	0.0156	0.0003	1.0017	0.9966

The table represents the results of the cross-sectional regressions for the alpha and the beta coefficients, R^2 and the four tracking errors during the time period from 01/01/2010 to 08/31/2011. The t-values are shown in parentheses. The calculation is done based on historical data in daily terms. The group of equity ETFs is furthermore divided into subsamples containing of 218 synthetic and 68 full replication ETFs.

*** 10 % significance level, ** 5 % significance level, *** 1 % significance level**

Compared to this, the alpha coefficient of full replication fixed income ETFs is insignificant. This implies that replicating fixed income ETFs do not generate negative abnormal returns. The highest negative abnormal returns are measured for synthetic equity ETFs. However, the betas of fixed income ETFs vary to a larger extent than the betas calculated for equity ETFs. In the case of equity ETFs, the regressions have high explanatory power.

Table 3.3: Fixed income ETFs – Synthetic vs. full replication

	TE_1	TE_2	TE_3	TE_4	Alpha	Beta	R^2
In all (B: 117)							
Mean	**0.0012***** (15.766)	**0.0019***** (15.829)	**0.0015***** (14.989)	**0.0023***** (15.133)	**0.0000***** (-2.657)	**0.9242***** (-5.098)	**0.6951***** (-12.403)
Median	0.0010	0.0016	0.0012	0.0017	0.0000	0.9750	0.7686
St. Deviation	0.0008	0.0013	0.0011	0.0016	0.0001	0.1609	0.2659
Minimum	0.0000	0.0000	0.0000	0.0000	-0.0003	0.1839	0.0003
Maximum	0.0039	0.0061	0.0054	0.0075	0.0004	1.2112	0.9894
Synthetic (B_{Syn}: 93)							
Mean	**0.0011***** (12.900)	**0.0016***** (13.050)	**0.0012***** (12.465)	**0.0019***** (12.770)	**0.0000**** (-2.160)	**0.9246***** (-4.598)	**0.7481***** (-9.756)
Median	0.0009	0.0014	0.0010	0.0016	0.0000	0.9791	0.8641
St. Deviation	0.0008	0.0012	0.0009	0.0014	0.0001	0.1581	0.2490
Minimum	0.0000	0.0000	0.0000	0.0000	-0.0003	0.3851	0.0516
Maximum	0.0039	0.0061	0.0054	0.0075	0.0004	1.2112	0.9894
Full replication (B_{Full}: 24)							
Mean	**0.0017***** (11.509)	**0.0031***** (14.619)	**0.0026***** (15.607)	**0.0038***** (12.338)	0.0000 (-1.704)	**0.9225**** (-2.173)	**0.4898***** (-10.838)
Median	0.0019	0.0035	0.0030	0.0045	0.0000	0.9607	0.5345
St. Deviation	0.0007	0.0011	0.0008	0.0015	0.0001	0.1747	0.2306
Minimum	0.0005	0.0014	0.0012	0.0015	-0.0002	0.1839	0.0003
Maximum	0.0032	0.0048	0.0037	0.0059	0.0001	1.0632	0.7829

The table represents the results of the cross-sectional regressions for the alpha and the beta coefficients, R^2 and the four tracking errors during the time period from 01/01/2010 to 08/31/2011. The t-values are shown in parentheses. The calculation is done based on historical data in daily terms. The group of fixed income ETFs is furthermore divided into subsamples containing of 93 synthetic and 24 full replication ETFs.
*** 10 % significance level, ** 5 % significance level, *** 1 % significance level**

One- factorial ANOVA

To answer the question whether synthetic ETFs are superior in terms of following their benchmarks, a comparison of tracking errors, alpha, beta coefficients and R^2 is not sufficient. We use a one-factorial ANOVA to check differences between groups. Furthermore, we examine whether equity and fixed income ETFs differ in their replication quality.

Table 3.4 provides the results of the one-factorial ANOVA. The highly significant Levene statistics show that the groups considered do not have homogeneous variances. Therefore, we apply the Welch test and the Brown-Forsythe test. Their values are highly significant indicating that at least one group differs from the other three groups with regard to tracking errors, alpha coefficient and R^2s. However, the beta coefficients are statistically identical for all four groups. Consequently, all groups similarly replicate their indices in terms of the linear regression. By contrast, the tracking errors differ significantly. Thus alpha values could be

responsible for those deviations. If the abnormal returns between groups do not vary significantly, factors not covered by the linear regression model have to be considered. This is most probably the case, since R^2s significantly differ from unity.

Hence, we present pairwise comparisons of the four groups to show the significant differences. The differences between the betas are illustrated for the sake of completeness. According to Games-Howel, post-hoc tests are used to correct for the accumulation of alpha errors.

The results show that synthetic and full replication equity ETFs are not different in terms of tracking errors and coefficients of the regressions. Thus, an investor is indifferent between both groups. The large difference in numbers of synthetic equity ETFs and full replication equity ETFs cannot be explained by the tracking errors and the one factor model. Other factors such as investors' demand and issuers' convenience could be possible reasons.

Table 3.4: ANOVA results

		TE_1	TE_2	TE_3	TE_4	Alpha	Beta	R^2
ANOVA statistics								
Levene statistic		**14.6576*** **	**14.5490*** **	**15.6827*** **	**18.7480*** **	**9.6810*** **	**19.7716*** **	**39.9066*** **
Welch test		**67.8199*** **	**105.857*** **	**93.5480*** **	**98.0587*** **	**5.6749*** **	1.9821	**36.4993*** **
Brown-Forsythe test		**58.3437*** **	**80.1927*** **	**76.1432*** **	**81.5661*** **	**9.5666*** **	0.9428	**44.7576*** **
Post-hoc tests								
(1)	(2)	(1)-(2)	(1)-(2)	(1)-(2)	(1)-(2)	(1)-(2)	(1)-(2)	(1)-(2)
S_{Syn}	S_{Full}	-0.0004	-0.0003	-0.0001	0.0003	-0.0001	0.0200	0.0342
	B_{Syn}	**0.0018*** **	**0.0034*** **	**0.0029*** **	**0.0047*** **	**-0.0001*** **	0.0233	**0.1686*** **
	B_{Full}	**0.0012*** **	**0.0019*** **	**0.0014*** **	**0.0028*** **	**-0.0001*** **	0.0254	**0.4268*** **
S_{Full}	B_{Syn}	**0.0022*** **	**0.0037*** **	**0.0029*** **	**0.0044*** **	0.0000	0.0033	**0.1344*** **
	B_{Full}	**0.0016*** **	**0.0021*** **	**0.0015*** **	**0.0025*** **	0.0000	0.0054	**0.3926*** **
B_{Syn}	B_{Full}	**-0.0006*** **	**-0.0015*** **	**-0.0015*** **	**-0.0019*** **	0.0000	0.0021	**0.2583*** **

The table represents the differences of the mean values of the alpha and the beta coefficients, R^2 and the four tracking errors for the ETF groups (S_{Syn}, S_{Full}, B_{Syn} and B_{Full}) introduced in table 3.2 and 3.3. The significance is calculated using post-hoc tests according to Games-Howel. A comparison between groups leads normally to an accumulation of alpha errors and weakens the explanation power of the results. The procedure we use overcomes this problem.
*** 10 % significance level, ** 5 % significance level, *** 1 % significance level**

In contrast to equity ETFs, our analysis shows different results in the case of fixed income ETFs. Synthetic fixed income ETFs have smaller tracking errors than full replication fixed income ETFs. However, like in the case of equity ETFs, alpha and beta coefficients (except of R^2) do not differ. With alpha and beta being insignificant, the variation of tracking errors between the two groups cannot be explained by the linear regression.

Our results on asset class comparisons are remarkable. Fixed income ETFs have smaller tracking errors than equity ETFs independent of the replication method. The differences in tracking errors can partly be explained by the linear regression in terms of negative abnormal returns. Our results of alpha coefficients are mixed. The alphas of synthetic equity ETFs are significantly smaller than the alphas of fixed income synthetic and full replication ETFs. This confirms the results of tracking errors: It also indicates higher costs for synthetic equity ETFs. Apart from that, the alphas of full replication equity ETFs do not differ from those of fixed income ETFs.

3.2 Replication method and profit appropriation

Tracking errors

Are distributing ETFs or accumulating ETFs superior in tracking their benchmark indices? To answer this question, we separate the four groups with regard to profit appropriation. Table 3.5 gives a first overview. Here we do not distinguish between equity and fixed income ETFs.

Table 3.5: All ETFs (profit appropriation) – Synthetic vs. full replication

(ETFs: 421)	TE_1	TE_2	TE_3	TE_4	Alpha	Beta	R^2
Distributing ($ETFs^{Distr.}$: 125)	**0.0026*** ** (17.071)	**0.0045*** ** (21.496)	**0.0036*** ** (23.667)	**0.0052*** ** (20.554)	**-0.0001*** ** (-6.339)	**0.9297*** ** (-7.454)	**0.7948*** ** (-10.060)
Accumulating ($ETFs^{Acc.}$: 296)	**0.0024*** ** (19.496)	**0.0041*** ** (18.935)	**0.0032*** ** (17.983)	**0.0054*** ** (18.931)	**-0.0001*** ** (-3.544)	**0.9410*** ** (-9.435)	**0.8606*** ** (-12.573)
Synthetic (distr.) ($ETFs_{Syn}^{Distr.}$: 43)	**0.0023*** ** (7.385)	**0.0042*** ** (9.348)	**0.0035*** ** (10.214)	**0.0046*** ** (8.833)	**-0.0002*** ** (-11.036)	**0.9402*** ** (-3.698)	**0.8702*** ** (-4.464)
Synthetic (acc.) ($ETFs_{Syn}^{Acc.}$: 283)	**0.0024*** ** (18.649)	**0.0041*** ** (18.124)	**0.0032*** ** (17.227)	**0.0054*** ** (18.153)	**-0.0001*** ** (-3.410)	**0.9420*** ** (-9.028)	**0.8612*** ** (-12.256)
Full replication (distr.) ($ETFs_{Full}^{Distr.}$: 82)	**0.0028*** ** (16.845)	**0.0046*** ** (21.691)	**0.0037*** ** (24.551)	**0.0054*** ** (20.654)	**-0.0000*** (-1.873)	**0.9242*** ** (-6.534)	**0.7552*** ** (-9.371)
Full replication (acc.) ($ETFs_{Full}^{Acc.}$: 13)	**0.0032*** ** (7.038)	**0.0049*** ** (7.179)	**0.0037*** ** (7.007)	**0.0058*** ** (7.574)	-0.0001 (-1.271)	**0.9185** (-2.975)	**0.8485** (-2.705)

The table represents the results of the alpha and the beta coefficients, R^2 and the four tracking errors. The t-values are shown in parentheses. The calculation is done based on historical data in daily terms. The whole sample consists of 421 ETFs and is divided into subsamples of 125 distributing and 296 accumulating ETFs. The 326 synthetic ETFs from table 3.1 are divided into a group of 42 distributing and a group of 283 accumulating ETFs. The remaining 95 full replication ETFs are formed by 82 distributing and 13 accumulating ETFs.

*** 10 % significance level, ** 5 % significance level, *** 1 % significance level**

Similar to the last section, tracking errors are significant at a 1 percent level. Regardless of profit appropriation, the ETFs considered do not perfectly track their benchmark indices. Full replication ETFs exhibit lower abnormal returns independent of profit appropriation.

Detailed results for equity ETFs are presented in Table 36. The estimated values are very similar to those given in Table 3.5. These results do not come at a surprise because equity ETFs amount to roughly two thirds of all ETFs in the dataset. Therefore, equity ETFs strongly influence the overall ETF results in Table 3.5.

Table 3.6: Equity ETFs (profit appropriation) – Synthetic vs. full replication

(S: 286)	TE_1	TE_2	TE_3	TE_4	Alpha	Beta	R^2
Distributing	**0.0029*** **	**0.0049*** **	**0.0040*** **	**0.0057*** **	**-0.0001*** **	**0.9311*** **	**0.8814*** **
($S^{Distr.}$: 97)	(15.845)	(20.079)	(22.156)	(19.052)	(-6.083)	(-8.214)	(-8.474)
Accumulating	**0.0030*** **	**0.0052*** **	**0.0041*** **	**0.0069*** **	**-0.0001*** **	**0.9493*** **	**0.9225*** **
($S^{Acc.}$: 189)	(20.438)	(19.051)	(17.649)	(19.415)	(-3.133)	(-9.664)	(-9.076)
Synthetic (distr.)	**0.0024*** **	**0.0044*** **	**0.0036*** **	**0.0048*** **	**-0.0002*** **	**0.9386*** **	**0.8845*** **
($S_{Syn}^{Distr.}$: 41)	(7.474)	(9.452)	(10.326)	(8.924)	(-11.081)	(-3.625)	(-4.217)
Synthetic (acc.)	**0.0030*** **	**0.0052*** **	**0.0042*** **	**0.0070*** **	**-0.0001*** **	**0.9501*** **	**0.9241*** **
($S_{Syn}^{Acc.}$: 177)	(19.410)	(18.125)	(16.831)	(18.566)	(-3.030)	(-9.189)	(-8.507)
Full replication (distr.)	**0.0033*** **	**0.0054*** **	**0.0042*** **	**0.0063*** **	0.0000	**0.9257*** **	**0.8792*** **
($S_{Full}^{Distr.}$: 56)	(16.273)	(21.559)	(24.869)	(20.372)	(-1.395)	(-9.732)	(-8.788)
Full replication (acc.)	**0.0033*** **	**0.0050*** **	**0.0037*** **	**0.0059*** **	0.0000	**0.9383** **	**0.8980*** **
($S_{Full}^{Acc.}$: 12)	(6.892)	(6.850)	(6.584)	(7.165)	(-0.997)	(-3.004)	(-3.577)

The table represents the results of the alpha and the beta coefficients, R^2 and the four tracking errors. The t-values are shown in parentheses. The calculation is done based on historical data in daily terms. The equity ETFs are divided into 97 distributing and 189 accumulating ETFs. The 218 synthetic ETFs from table 3.2 are a combination of 41 distributing and 177 accumulating ETFs. The 68 full replication ETFs are formed by 56 distributing and 12 accumulating ETFs.
*** 10 % significance level, ** 5 % significance level, *** 1 % significance level**

Table 3.7 reports the results of fixed income ETFs which roughly amount to 28 percent of all ETFs in our study. Synthetic accumulating ETFs as well as full replication distributing ETFs have highly significant tracking errors. Thus fixed income ETFs cannot perfectly replicate their indices irrespective of profit appropriation. Accumulating ETFs seem to have lower tracking errors compared to distributing ETFs. Tracking errors of accumulating ETFs are between 0.0011 and 0.0019, whereas distributing ETFs exhibit tracking errors between 0.0016 and 0.0036. Hence, the subdivision of fixed income ETFs into an accumulating and distributing group proves to be beneficial.

All beta coefficients significantly differ from unity. However, distributing ETFs show a less powerful differentiation at a 5 percent level. Alpha values are significant for the distributing and accumulating group. Synthetic accumulating ETFs exhibit abnormal returns at a 10 per-

cent level only. On the contrary, the alpha coefficient of full replication distributing ETFs is not significantly different from zero. Hence, the two synthetic distributing ETFs that are included in the overall distributing group must have a significant negative influence on the alpha coefficient. Table 3.7 shows that all R^2 are clearly smaller for distributing ETFs than for accumulating ETFs.

Table 3.7: Fixed income ETFs (profit appropriation) – Synthetic vs. full replication

(B: 117)	TE_1	TE_2	TE_3	TE_4	Alpha	Beta	R^2
Distributing	**0.0016*** **	**0.0030*** **	**0.0025*** **	**0.0036*** **	**0.0000** **	**0.9263** **	**0.4966*** **
($B^{Distr.}$: 26)	(10.542)	(13.493)	(14.514)	(11.523)	(-2.213)	(-2.235)	(-11.029)
Accumulating	**0.0011*** **	**0.0016*** **	**0.0012*** **	**0.0019*** **	**0.0000***	**0.9236*** **	**0.7518*** **
($B^{Acc.} = B^{Acc.}_{Syn}$: 91)	(12.879)	(12.844)	(12.201)	(12.604)	(-1.918)	(-4.565)	(-9.551)
Full replication (distr.)	**0.0017*** **	**0.0031*** **	**0.0026*** **	**0.0039*** **	0.0000	**0.9225** **	**0.4898*** **
($B^{Distr.}_{Full}$: 24)	(11.509)	(14.619)	(15.607)	(12.338)	(-1.704)	(-2.173)	(-10.838)

The table represents the results of the sectional regressions for the 117 fixed income ETFs over the alpha and the beta coefficients, R^2 and the four tracking errors. The t-values are shown in parentheses. The calculation is done based on historical data in daily terms. The fixed income ETFs are divided into 26 distributing and 91 accumulating ETFs. The 93 synthetic ETFs from table 3.3 are a combination of 91 accumulating and two distributing ETFs. The group of these two ETFs is not shown in the table. The 24 full replication ETFs from table 3.3 are all distributing ETFs.
*** 10 % significance level, ** 5 % significance level, *** 1 % significance level**

Accumulating vs. distributing ETFs

The previous results show that ETFs do not perfectly replicate the returns of the underlying index, independent of replication method, share class and profit appropriation. Hence, we compare the six remaining groups with each other employing a one-factorial ANOVA. The results are presented in Table 3.8.

The Levene statistics are highly significant at a 1 percent level, showing that group variances differ from each other. The Welch test and the Brown-Forsythe test are highly significant except for the beta coefficient. Thus, at least one group differs from the other groups with regard to the four tracking errors and the alpha coefficient.

Subsequently, the six groups are compared pairwise to detect group variations. It is remarkable that the results differ from the previous findings. Group differences depend on tracking error measurement. For example, synthetic distributing equity ETFs exhibit a significantly lower tracking error TE_4 when compared to synthetic accumulating equity ETFs. Tracking errors $TE_1, TE_2,$ and TE_3 are not different for these two groups. Furthermore, the group of full replication accumulating equity ETFs significantly deviates from the full replication distributing fixed income ETFs in terms of tracking error TE_1. This is not the case for all

other tracking errors. The difference in tracking error TE_1 between these two groups is only significant at a 10 percent level.

Table 3.8: ANOVA (profit appropriation) – Post-hoc tests

		TE_1	TE_2	TE_3	TE_4	Alpha	Beta	R^2
ANOVA statistics								
Levene statistics		**9.0481*** **	**8.9503*** **	**9.5632*** **	**11.3657*** **	**5.4979*** **	**12.7483*** **	**24.5301*** **
Welch test		**39.3304*** **	**64.9198*** **	**55.0642*** **	**57.4278*** **	**18.2620*** **	1.5716	**22.3288*** **
Brown-Forsythe test		**24.6545*** **	**35.2075*** **	**32.4247*** **	**41.1101*** **	**10.5092*** **	0.8459	**33.5475*** **
Post-hoc tests								
(1)	(2)	(1)-(2)	(1)-(2)	(1)-(2)	(1)-(2)	(1)-(2)	(1)-(2)	(1)-(2)
$S_{Syn}^{Distr.}$	$S_{Syn}^{Acc.}$	-0.0006	-0.0008	-0.0005	**-0.0022** **	**-0.0001*** **	-0.0114	-0.0396
	$S_{Full}^{Distr.}$	-0.0009	-0.0010	-0.0006	-0.0015	**-0.0002*** **	0.0130	0.0053
	$S_{Full}^{Acc.}$	-0.0009	-0.0006	-0.0001	-0.0011	-0.0002	0.0003	-0.0135
	$B_{Syn}^{Acc.}$	**0.0013*** **	**0.0027*** **	**0.0024*** **	**0.0029*** **	**-0.0002*** **	0.0151	**0.1326*** **
	$B_{Full}^{Distr.}$	0.0007	0.0012	0.0010	0.0011	**-0.0002*** **	0.0162	**0.3946*** **
$S_{Syn}^{Acc.}$	$S_{Full}^{Distr.}$	-0.0003	-0.0002	0.0000	0.0006	0.0000	0.0244	**0.0449***
	$S_{Full}^{Acc.}$	-0.0003	0.0002	0.0004	0.0011	0.0000	0.0117	0.0261
	$B_{Syn}^{Acc.}$	**0.0019*** **	**0.0036*** **	**0.0030*** **	**0.0051*** **	-0.0001	0.0265	**0.1723*** **
	$B_{Full}^{Distr.}$	**0.0013*** **	**0.0020*** **	**0.0015*** **	**0.0032*** **	-0.0001	0.0276	**0.4343*** **
$S_{Full}^{Distr.}$	$S_{Full}^{Acc.}$	0.0000	0.0004	0.0005	0.0004	0.0000	-0.0127	-0.0188
	$B_{Syn}^{Acc.}$	**0.0022*** **	**0.0037*** **	**0.0030*** **	**0.0044*** **	0.0000	0.0021	**0.1273*** **
	$B_{Full}^{Distr.}$	**0.0016*** **	**0.0022*** **	**0.0016*** **	**0.0026*** **	0.0000	0.0032	**0.3893*** **
$S_{Full}^{Acc.}$	$B_{Syn}^{Acc.}$	**0.0022*** **	**0.0033*** **	**0.0025*** **	**0.0040*** **	0.0000	0.0148	**0.1461*** **
	$B_{Full}^{Distr.}$	**0.0016***	0.0018	0.0011	0.0022	0.0000	0.0159	**0.4081*** **
$B_{Syn}^{Acc.}$	$B_{Full}^{Distr.}$	**-0.0006*** **	**-0.0015*** **	**-0.0015*** **	**-0.0019*** **	0.0000	0.0011	**0.2620*** **

The table represents the differences between the groups ($S_{Syn}^{Dist.}$, $S_{Syn}^{Acc.}$, $S_{Full}^{Distr.}$, $S_{Full}^{Acc.}$, $B_{Syn}^{Acc.}$ and $B_{Full}^{Distr.}$) concerning the alpha and the beta coefficients, R^2 and the four tracking errors. We apply post-hoc tests according to Games-Howel. A comparison between groups leads normally to an accumulation of alpha errors and weakens the explanation power of the results. We use this procedure to overcome this problem.

*** 10 % significance level, ** 5 % significance level, *** 1 % significance level**

With the exception of TE_4, the tracking errors of equity ETFs are not significantly different from each other. Synthetic distributing ETFs are not different from synthetic accumulating ETFs in terms of tracking errors. The same is true for the groups of full replication ETFs. Thus tracking errors cannot explain the difference in the numbers of synthetic and full replication equity ETFs and in the numbers of distributing and accumulating ETFs.

Additionally, the large number of synthetic accumulating ETFs can partly be explained by differences in alpha values. Synthetic distributing equity ETFs have significantly higher negative abnormal returns than all other equity groups with the exception of full replication ac-

cumulating ETFs. Contrary to this, the alpha values of full replication distributing equity ETFs and full replication accumulating equity ETFs are not different.

We find that synthetic accumulating fixed income ETFs replicate their indices better than full replication distributing fixed income ETFs. This result cannot be explained by the linear regression, because alpha and beta coefficients are statistically identical for both groups.

The results of asset class comparisons are remarkable. Synthetic accumulating fixed income ETFs have significantly lower tracking errors when compared to all equity ETFs. On the contrary, full replication distributing fixed income ETFs only have lower tracking errors with respect to synthetic accumulating equity ETFs and full replication distributing equity ETFs.

The tracking error of synthetic distributing equity ETFs does not differ from all other distributing ETFs. This is in contrast to full replication distributing equity ETFs having significantly higher tracking errors than the full replication distributing fixed income ETFs.

3.3 Factors influencing tracking errors

Tables 3.9 and 3.10 show the results of the cross-sectional regressions (1) and (2). Tracking errors TE_1 to TE_4 are used as dependent variables.

The data set was split up in order to identify possible differences between synthetic and full replication ETFs as to influential factors. The dividends factor, for instance, could be more influential in the case of full replication ETFs. This might be due to the fact, that more than 85 % of all full replication ETFs in our data set distribute income, whereas only roughly 15 % of synthetic ETFs do so.

Table 3.9 presents the influencing factors for the overall sample. Our results suggest that tracking errors are generally influenced by risk, volume and total expense ratio. Besides, the four tracking errors are differently affected by dividends and spread. Tracking error TE_3 is not influenced by the spread whereas this factor positively affect TE_1, TE_2 and TE_4. Dividends only have a positive impact on TE_2 and TE_3. Hence, the selection of the tracking error calculation method seems to be important.

In particular, the coefficients of risk, being significant at the 1 % level, range between 0.163 and 0.4266. The coefficients of the total expense ratio vary between 0.5875 and 1.0622 and are statistically significant at the 1 % level. However, volume negatively affects the tracking errors. In those cases where spreads influence tracking errors, their coefficients fluctuate between 0.1630 and 0.1802. Dividends exhibit coefficients between 0.0224 and

0.0293. The values of R^2 are sufficiently high for both regressions. However, regression (1) suggests a better explanatory power when compared to regression (2).

Table 3.9: Factors influencing tracking errors – In all

	TE_1		TE_2		TE_3		TE_4	
	Regr. (1)	Regr. (2)	Regr. (1)	Regr. (2)	Regr. (1)	Regr. (2)	Regr. (1)	Regr. (2)
Alpha	0.0006	**0.0011*** **	**0.0019*** **	**0.0030*** **	**0.0019*** **	**0.0028*** **	**0.0030*** **	**0.0043*** **
	(1.554)	(2.966)	(3.695)	(4.536)	(4.922)	(5.091)	(4.492)	(4.722)
TER		**0.5875*** **		**0.8388*** **		**0.6000*** **		**1.0662*** **
		(7.627)		(7.414)		(7.040)		(7.615)
Risk	**0.1631*** **		**0.3212*** **		**0.2725*** **		**0.4266*** **	
	(10.693)		(9.404)		(8.407)		(10.301)	
Spread	**0.1802*** **		**0.1603*** **		0.0642		**0.1700*** **	
	(4.383)		(2.971)		(1.647)		(2.852)	
LnVolume	**-0.0001*** **	**-0.0001***	**-0.0002*** **	**-0.0002*** **	**-0.0002*** **	**-0.0002*** **	**-0.0004*** **	**-0.0003*** **
	(-3.235)	(-1.789)	(-4.980)	(-2.931)	(-5.442)	(-3.325)	(-5.393)	(-3.157)
Dividends	0.0023	0.0027	**0.0224** **	**0.0255** **	**0.0258*** **	**0.0293*** **	0.0015	0.0060
	(0.330)	(0.385)	(2.047)	(2.391)	(2.980)	(3.571)	(0.113)	(0.457)
Adj. R^2	0.5290	0.2605	0.5563	0.2062	0.5397	0.1713	0.5658	0.2037

The table represents the results of regression (1) and (2) for 412 ETFs based on 318 synthetic and 94 full replication ETFs. We rejected 9 ETFs from our sample because daily volume data are not available in Bloomberg. The coefficients of alpha, total expense ratio, risk, spread, volume (natural logarithm) and dividends are shown as well as the adjusted R^2 for all four tracking errors.

*** 10 % significance level, ** 5 % significance level, *** 1 % significance level**

Table 3.10 represents the influential factors with regard to replication method. The tracking errors of synthetic ETFs are similarly affected by all independent factors when compared to Table 3.9. Dividends have a weaker influence on tracking errors TE_2 and TE_3. This influence vanishes completely in regression (1) when risk and spread are used as independent variables. Apart from TE_1 in (1), alpha values are significant at the 1 % level.

The results of full replication ETFs are similar to synthetic ETFs for total expense ratio, risk and spread. In contrast to synthetic ETFs, volume only negatively affects the tracking errors TE_3 and TE_4 in regression (1). In all other cases, volume does not have an impact. Irrespective of the regression model, dividends are only significant for TE_3. Summing up, tracking errors are differently influenced by the independent variables within the sample of synthetic and full replication ETFs. This confirms our mixed tracking error results already mentioned before.

Table 3.10: Factors influencing tracking errors – Synthetic and full replication ETFs

Synthetic ETFs ($ETFs_{Syn}$: 318)								
	TE_1		TE_2		TE_3		TE_4	
	Regr. (1)	Regr. (2)	Regr. (1)	Regr. (2)	Regr. (1)	Regr. (2)	Regr. (1)	Regr. (2)
Alpha	0.0004	**0.0009****	**0.0017*****	**0.0027*****	**0.0017*****	**0.0026*****	**0.0027*****	**0.0039*****
	(1.087)	(2.045)	(2.933)	(3.467)	(3.997)	(3.988)	(3.651)	(3.661)
TER		**0.6898*****		**1.0354*****		**0.7666*****		**1.3390*****
		(6.742)		(6.736)		(6.518)		(7.034)
Risk	**0.1679*****		**0.3336*****		**0.2840*****		**0.4435*****	
	(10.311)		(9.058)		(8.098)		(9.954)	
Spread	**0.1716*****		**0.1504****		0.0586		**0.1564****	
	(3.515)		(2.407)		(1.308)		(2.330)	
LnVolume	**-0.0001*****	**-0.0001****	**-0.0002*****	**-0.0002*****	**-0.0002*****	**-0.0002*****	**-0.0003*****	**-0.0003*****
	(-2.812)	(-2.005)	(-4.465)	(-3.040)	(-4.922)	(-3.349)	(-4.768)	(-3.193)
Dividends	-0.0078	-0.0015	0.0091	**0.0234***	0.0169	**0.0297*****	-0.0138	0.0054
	(-0.824)	(-0.163)	(0.610)	(1.658)	(1.416)	(2.756)	(-0.742)	(0.309)
Adj. R^2	0.5515	0.2944	0.5748	0.2373	0.5548	0.2003	0.5822	0.2414
Full replication ETFs ($ETFs_{Full}$: 94)								
	TE_1		TE_2		TE_3		TE_4	
	Regr. (1)	Regr. (2)	Regr. (1)	Regr. (2)	Regr. (1)	Regr. (2)	Regr. (1)	Regr. (2)
Alpha	0.0004	**0.0013***	**0.0022***	**0.0032*****	**0.0025*****	**0.0030*****	**0.0031****	**0.0045*****
	(0.379)	(1.779)	(1.812)	(3.323)	(3.153)	(4.561)	(2.057)	(3.798)
TER		**0.3368*****		**0.3720*****		**0.2080****		**0.4307*****
		(3.351)		(2.950)		(2.534)		(2.830)
Risk	**0.1492*****		**0.2384*****		**0.1853*****		**0.2954*****	
	(6.792)		(8.009)		(8.221)		(8.039)	
Spread	**0.1981****		**0.1831***		0.0740		**0.2252***	
	(2.439)		(1.815)		(1.184)		(1.772)	
LnVolume	0.0000	0.0000	-0.0001	0.0000	**-0.0002****	0.0000	**-0.0002***	-0.0001
	(-0.467)	(0.419)	(-1.509)	(-0.210)	(-2.395)	(-0.687)	(-1.972)	(-0.670)
Dividends	0.0062	0.0015	0.0264	0.0252	**0.0263****	**0.0287***	0.0177	0.0160
	(0.484)	(0.101)	(1.481)	(1.201)	(2.011)	(1.806)	(0.841)	(0.644)
Adj. R^2	0.4220	0.1552	0.4125	0.1113	0.3999	0.0904	0.4318	0.1008

The table represents the results of regression (1) and (2) for 412 ETFs based on 318 synthetic and 94 full replication ETFs. We rejected 9 ETFs from our sample because daily volume data are not available in Bloomberg. The coefficients of alpha, total expense ratio, risk, spread, volume (natural logarithm) and dividends are shown as well as the adjusted R^2 for all four tracking errors.

*** 10 % significance level, ** 5 % significance level, *** 1 % significance level**

4 Summary

This paper focuses on the influence of the ETF replication process on tracking errors. It compares the tracking errors of full replication and synthetic ETFs for the German market. We find that German ETFs generally suffer from high tracking errors. This is in line with the extant literature on ETFs for other markets. It has been claimed that synthetic ETFs are superior to full replication ETFs in terms of tracking error. Contrary to this belief, we show that synthetic and full replication equity ETFs do not differ in tracking errors for the German market. However, for fixed income ETFs smaller tracking errors are found for synthetic ETFs in comparison to their full replication counterparts. In any case, fixed income ETFs have smaller tracking errors than equity ETFs, independent of the replication method.

When separating ETFs into distributing and appropriating ETFs (both separately for equity and fixed income) tracking errors are not improved. In fact, regardless of profit appropriation and asset class, tracking errors remain quite high. Tracking errors cannot explain the difference in the number of synthetic and full replication ETFs issued, neither for distributing nor accumulating ETFs. However, synthetic accumulating fixed income ETFs have lower tracking errors compared to all equity ETFs.

The factors that determine tracking errors are risk, volume and the total expense ratio. Dividends and the bid-ask spread influence the tracking errors for the four ETF classes considered in varying degrees.

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