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An Empirical Study on the Differences between Synthetic and Physical ETFs

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Abstract

This research focuses on the differences between synthetic and traditional exchange-traded funds in benchmark replication process. It extends previous literature by empirical examining the tracking ability of traditional and synthetic ETFs traded at the Swiss Stock Exchange offered by the leading providers in Europe. 35 equity ETFs are used in the sample. For both types of funds the average tracking error is estimated in four ways. The research demonstrates that both traditional and synthetic ETFs have significant tracking errors. The findings also show that, contrary to popular opinion, synthetic ETFs have higher tracking errors than physical. These facts are of a significant importance to private investors and portfolio managers, especially if the performance of portfolio manager is based on a comparison to the performance of a benchmark.

Additionally, factors that influence tracking errors are estimated. The results suggest that tracking errors are influenced by expense ratio, number of securities in the benchmark and type of replication for all estimation methods. Average daily trading volume doesn't influence dependent variables except for one tracking error estimation method.

Keywords: exchange-traded fund, swap-based ETFs, synthetic replication, physical replication, tracking error

1. Introduction

An exchange-traded fund is an investment company (in form of open-ended fund or unit investment trust), whose shares are traded intraday on stock exchanges at market-determined prices. Investors are able to buy or sell ETF shares through a broker just as they do with the stocks of any publicly traded company, including shorting them and buying with margin. ETF reflects owning a share of assets portfolio, usually representing a market index, sector or industry, commodity group or country company stocks. The amount of ETFs reached 3581 at the end of 2013, created by almost 190 sponsors at more than 40 stock exchanges around the world. Blackrock is the world's largest ETF sponsor and consolidates 40% of ETFs assets under management (AUM) under its brand. Together with other four largest sponsors – State Street Global Advisors, Vanguard, PowerShares, Deutsche Bank AG, the aggregate share of the market composes 79%.

ETFs AUM increased globally from 400 billion dollars in 2005 to 2,254 billion dollars at the end of 2013, which means almost 24% of annual growing. A decrease in asset's growth rate was observed in 2011. The reason is most probably not in losing interest to the new instrument or market saturation, but in general pessimism and uncertainty at financial markets: mutual funds assets increased only negligibly during 2011 (from 23 trillion dollars to 23.8 trillion dollars globally), and the U.S. mutual fund assets even decreased, during 2012-2013 increase in assets also continued. Inspite of these tendencies, ETFs assets constitute only about 8% of mutual funds assets. About 70% of world ETFs AUM are registered under US jurisdiction, 20% – in Europe, 6% in Asia and 2% in Canada. The share of "synthetic" ETFs is the largest in Europe (about 35% of European ETFs).

Assets Under Management: Physical vs Synthetic.

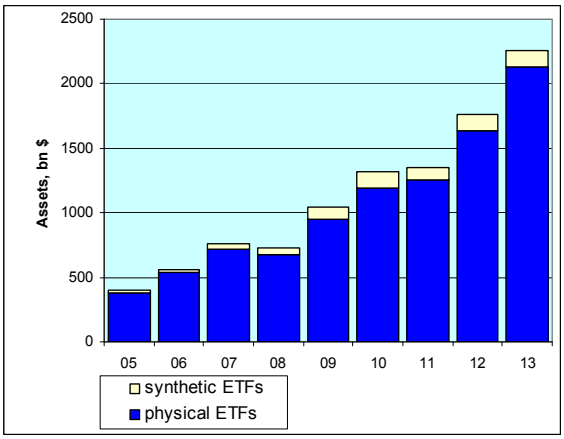

Figure 1. ETFs assets under management globally (2005-2013 yy), in bln of USD

Note. Physical – blue color, synthetic – yellow color.

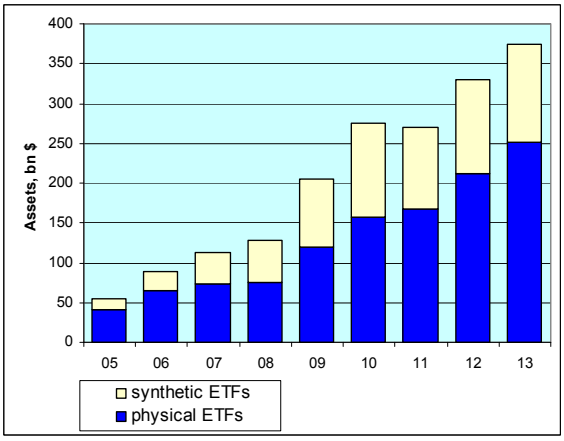

Figure 2. ETFs assets under management in Europe in bln of USD (2005-2013 yy)

Note. Physical – blue color, synthetic – yellow color.

Source: Based on data from Deutsche Bank ETF Annual Review & Outlook (2014).

Synthetic ETFs have become a serious concern for the regulation organizations in recent years, because of the possible risks for stability of financial system they bear. Though during the last three years the tendency of decreasing synthetic ETF proportion is observed in Europe. This research contributes to the discussion of differences between two types of ETF replication schemes – physical and synthetic, in particularly, a difference in their tracking ability, complementing previous literature on this question.

The paper is organized as follows. the second section contains a brief overview of synthetic ETFs structure compared to physical ETFs, with the aim to highlight the specifities of each type, which can lead to the difference in performance. Also possible reasons for using the synthetic scheme are presented, as well as risks for financial stability that are created, which were discussed in the literature in recent years. Referring to securities' market regulation, it is showed why synthetic scheme is more common in Europe – to explain the choice of the market for investigation. Section 3 reviews the research literature on ETFs. The fourth section describes in details the sample of 35 ETFs traded on the Swiss Stock Exchange during the period from August of 2012 to August of 2014, as well as methodologies implemented in this research. Several methods of calculating the tracking error (the deviation from the benchmark return) are used and a multivariate regressions for determining the factors that influence the tracking errors are built. Section 5 presents the empirical results, and conclusion is made further.

2. Structure, Advantages and Risks of Synthetic Funds

In Europe, ETFs are regulated by UCITS (The Undertakings for Collective Investment in Transferable Securities). One of the distinctive features describing the European market but not common in the U.S. market because of the regulatory constraints, is the usage of sythethic replication method. This method firstly was introduced in French market in 2001. Synthetic replication scheme, related risks as well as motives for using it were investigated in BIS Working paper by Ramaswamy (2011).

Instead of owning physical assets synthetic ETFs replicate the benchmark index using derivatives. One of the reasons for using synthetic structures is reducing costs. Narrow or sector index that is actively traded can be replicated effectively in terms of cost by holding underlying assets, but it can be expensive for a broad market index, emerging market stocks or bond index, or just less liquid index. In illiquid markets a difference between the bid and ask prices can lead to increasing costs, especially when a large turnover is present. Also, significant deviations from index return in the period of market volatility can occur, if only a subset of underlying assets, which contribute mainly to the index performance, is included in the ETF for physical replication. This deviations are known as tracking errors.

The other possible reason proposed by Ramaswamy (2011), that induces development of synthetic structure, is the use of synergy effect between derivative counterparty bank practice of using collateral and opportunity to attract funding secured by this collateral.

One of the ways to create synthetic structure of ETF is by using total return swap (sometimes called unfunded swap structure). Under synthetic scheme authorized participants receive creation units from the ETF sponsor in the exchange for cash, rather than in the exchange for a portfolio of index securities like under traditional (physical) ETF scheme. The ETF sponsor enters swap with some financial institution, often with its related party, to receive return according to the benchmark index. This is one side of the swap. Cash is transferred to the swap counterparty, and, in return, counterparty transfers a basket of collateral assets to the ETF sponsor. These collateral assets can be significantly different from the composition of the benchmark. The second side of the swap consists of the return from the collateral basket transferred back to the swap counterparty.

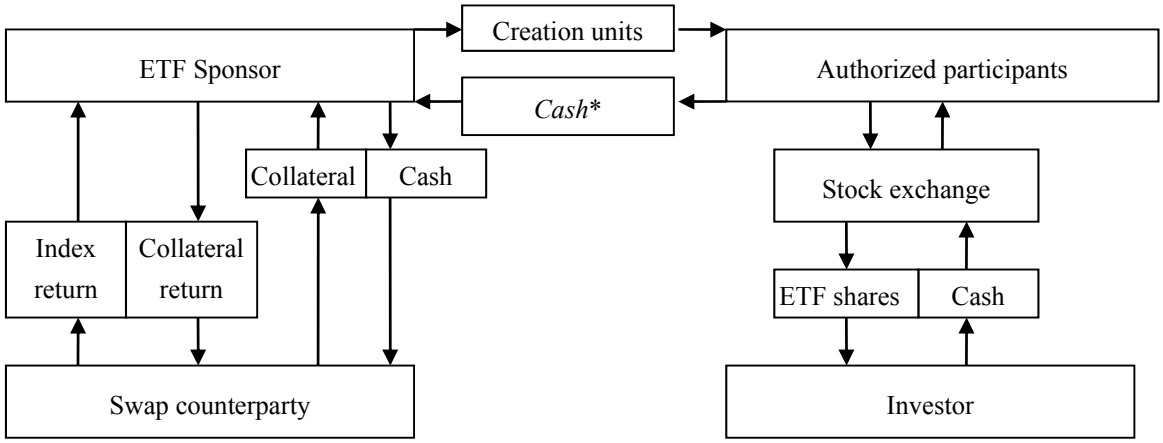

Figure 3. Synthetic replication scheme and role of swap counterparty

Source: Based on Ramaswamy (2011).

* In traditional scheme (physical ETFs) sponsor of ETF receives securities according to the benchmark index.

Synergy effect can arise between the investment banking department of the parent bank, acting as a swap counterparty, and its subsidiary, acting as an ETF sponsor. It occurs as a result of the market-maker activities of investment banking, which is often associated with funding large holdings of stocks and bonds. For illiquid stocks and bonds the funding can be found either in the unsecured markets or in repo market, but with a significant impairment. By transferring these securities to subsidiary ETF sponsors as collateral, the investment department of the parent bank may reduce the cost of warehousing them. Savings can be used to reduce the subsidiary ETF management costs.

Amount of savings depends on quality of collateral transferred to ETF sponsor, so there could exist an aspiration

to transfer illiquid assets as a collateral. By posting them as a collateral, investment bank department can raise funding for this assets at lower costs for its market-making activities, comparing to funding at unsecured borrowing rates as usually.

If, comparing to the benchmark index, lower credit quality and less liquid securities are used as collateral, than the bank providing the total return swap may benefit from the reduction in regulatory capital charges.

Another way of organizing a synthetic structure, used by ETF sponsors, is called funded swap structure. The difference is that the operation is secured by a collateral which is transferred by counterparty to a third party – custodian, to which the ETF sponsor has legal claims. But as opposed to unfunded swap structure, the ETF sponsor is not the beneficial owner of the collateral asset. This can lead to delays in realizing the value of collateral assets in case of the swap counterparty bankruptcy.

In Ramaswamy (2011), separately among synthetic ETFs are highlighted those that provide exposure to the commodity markets. Here, the lack of index diversification does not allow to create ETF on the principle of a mutual fund, so different types of trust structures are used, and ETF is called ETC (exchange-traded commodities). Sponsors use physical replication of the index return by owning the relevant assets (gold, copper), as well as synthetic replication scheme using forwards and futures, which is more common.

Most of ETFs registered in the USA are governed by the Investment Company Act 1940 (ICA), compose about 70% of global AUM of ETFs and cannot be organized by using synthetic structure. However, synthetic ETFs compose almost half of the funds market in Europe, which, in turn, is 20% of the global assets of ETFs.

The ICA has appeared as a part of the reforms conducted as counteraction to the Great Depression financial crisis of the 1930s. It provided significant protection for fund investors, including prohibitions on transactions between fund and its affiliate and other forms of self-dealing, strict conditions on leverage, daily pricing of fund shares, requirements to redeem shares (for open-ended funds and trusts) and extensive disclosure requirements.

On the other hand, it is allowable to use exchange-traded derivatives as well as OTC derivatives to achieve investment objectives under the UCITS which regulates funds in Europe. Funds in Asia and emerging markets are also UCITS compliant – more than 70% of authorized investment funds in Singapore and Hong Kong meet these rules.

It is a popular opinion that synthetic ETF scheme provides no return deviation from benchmark return, because it is imlpemented by a swap with a counterparty, that guarantees paying return according to the benchmark index performance. Thus, the risk of return deviation transfers to the swap counterparty, and investor doesn't bear tracking error risk that is present in the case of physical replication scheme. However there is an opposed side: tracking error risk is replaced by insolvency risk of the swap counterparty. ETF sponsors tend to emphasize the lower tracking error of synthetic ETFs, less costs comparing to traditional ETFs, and downplay the insolvency counterparty risk, in order to popularize this ETF structure.

Based on the experience of the financial crisis with other structured products, Ramaswamy (2011) in detail describes several channels through which ETFs risks can disrupt systems financial stability:

- substitution of tracking error risk by risk of counterparty insolvency in the swap transaction compromises risk management;
- the risk of collateral impairment leads to investors run on ETFs in the period of increased counterparty risk;
- realization of the liquidity risk during unanticipated and large investor redemptions of ETF shares;
- decreasing ability to monitor risks because of increased product complexity and availability of option ETFs.

Taking into account possible threats to financial stability, it is necessary to continue study of synthetic ETFs, both in the direction of systematic risks, as well as in the direction of the characteristics, that distinguish them from traditional ETFs, in particular, those, that justify their existence from the investors' point of view.

3. Literature Review

ETFs attract substantial research interest. First studies were dedicated to the performance of ETFs compared to the benchmarks as well as to their competitors – mutual funds. For example Elton, Gruber, Comer, and Li (2002) found that the S&P 500 index and the corresponding index mutual funds outperform SPDR (ETF). Poterba and Shoven (2002) by comparing pre-tax and after-tax rate of the return in 1994-2000 years of the largest ETFs – SPDR and Vanguard Index 500 Fund (both are tied to S&P 500), came to the conclusion that these funds have almost the same performance.

In addition to studies of performance, the ability to track underlying index was also investigated in numerous

studies. For example Rompotis (2006) studied the performance, trading characteristics and tracking errors of Swiss ETFs for the period 2001-2006 years. It was determined that ETFs underperfomed the corresponding benchmark indeces, while ETFs burdened their investors with greater risk. He also determined that Swiss ETFs did not follow full replication strategy, the magnitude of tracking error was approximately 1.02% and the value of the tracking error was positively related to the management fees and the risk of ETF.

Svetina and Wahal (2008) analyzed the sample of more than 500 U.S. international stock and bond ETFs from the moment of their introduction until 2007, trying to examine the performance and tracking errors of ETFs and to find out, what kind of competitors they are to index funds. As a result, they concluded that for individual investors, ETF performance based on gross returns is not statistically distinguishable from the corresponding performance of mutual funds.

Barnhart and Rosenstein (2010) tested whether ETF were substitutes for corresponding closed-end funds. Agapova (2009, 2010) has also investigated the competition between traditional mutual index funds and ETFs. It was shown that these two types of financial instruments were substitutes but not perfect substitutes. The coexistence of these essentially relative funds can be explained by the clientele effect, which classifies these two instruments in different market niches.

In 2011 three influential international organizations – the International Monetary Fund, the Bank for International Settlements and the Financial Stability Board, have published articles on the risks of synthetic ETFs and their negative impact on the financial system. On the other side the Investment Company Institute (2011), as well as major ETF sponsors have spoken out in defense of their products. But, to our best knowledge, empirical studies for estimation risk of synthetic funds for financial stability have not been conducted.

As it was already mentioned, it is believed, that important advantage of synthetic funds to investors is a lower tracking error comparing to traditional funds. This statement was investigated by Meinhardt et al. (2014). Meinhardt et al. (2014), based on the sample of 421 ETFs (equity and fixed income) for the period of 2010-2011 years, listed on the Frankfurt Stock Exchange using daily closing prices came to the conclusion that, in general, synthetic and full replication equity ETFs do not differ in tracking errors. Although, in case of studying the group of fixed income ETFs separately, synthetic ETFs demonstrated smaller tracking errors.

Influence of replication method on tracking error was also studied in Elia (2012) research work. Based on the sample of 48 ETFs from the leading providers that track major European and global stock market indices using net asset value (NAV) instead of closing prices for the period 2007-2011 yy, it was obtained that synthetic replication method rewarded the investor with smaller tracking errors, especially with respect to emerging market indices, which is not totally consistent with previous research.

This paper complements previous studies by estimating tracking ability of physical and synthetic ETFs on the sample of ETFs traded at the Swiss Stock Exchange. It is a valuable question for investors seeking for an appropriate passive investment, because the smaller tracking error is one of the arguments for the creation and using this scheme, which bears systematic risks in its essence.

4. Data and Methodology

The sample of 35 ETFs listed at the Swiss Stock Exchange was used for the purpose of this research. Swiss SE takes the 4th place in the ranking by turnover volumes of European ETFs after LSE, Deutsche Borse and NYSE Euronext with a share of approximately 13,5% in 2012-2013 yy (according to Deutsche Bank ETF Annual Review & Outlook, 2014). The period starts from August 2012 and ends in August 2014, producing 526 observations for each fund, except two funds that have a slightly shorter period ended in August 2014 (276 and 416 observations accordingly).

Overall, 340 ETFs were observable at the stock exchange in Zurich. They differ by asset classes (equity developed, fixed income, equity emerging, equity themes, commodities, equity strategy, funds), by fund sponsors, by domicile of fund and of course by replication method. Only equity ETFs are chosen for the sample; 3 of them represent emerging markets and the remaining are for the developed ones. 17 ETFs in the sample have physical replication scheme, 18 have synthetic.

Descriptive statistics of the sample.

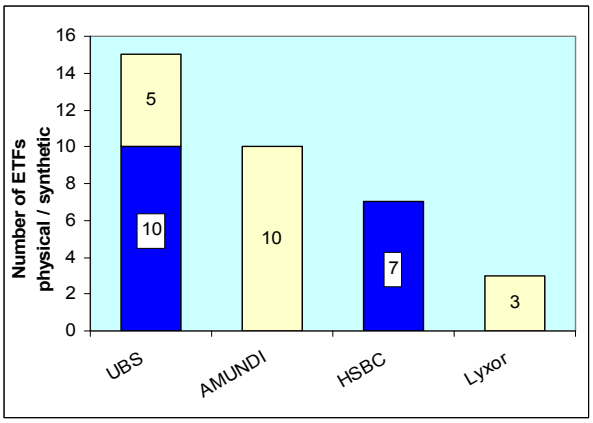

Figure 4. Number of ETFs by sponsor

Note. Physical – blue color, synthetic – yellow color.

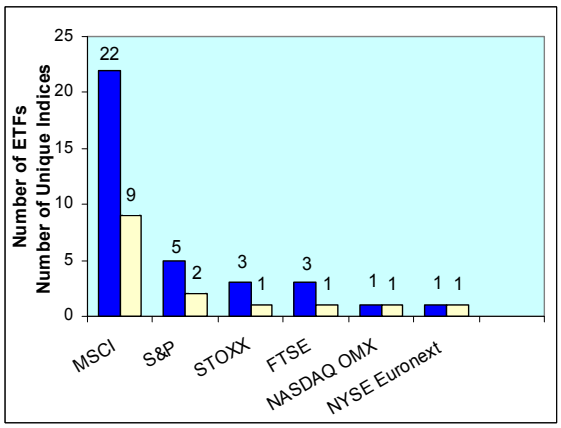

Figure 5. Number of ETFs and unique indices by index provider

Note. Number of ETFs – blue color, number of unique indices – yellow color.

For estimation of tracking errors daily returns of ETFs and corresponding indices based on closing daily prices are used in this study. In such manner tracking errors are calculated in Elton, Gruber, Comer, and Li (2002), Rompotis (2006), Meinhardt et al. (2014). The alternative method is using NAV, like in Elia (2012). As mentioned in Meinhardt et al. (2014), one of the advantages of closing prices is a shorter time delay between ETF returns and index returns. The choice of the basis for calculating returns can substantially effect the tracking error values, as there are pricing deviations between last trading prices and NAV.

Historical data for the prices of ETFs and indices was obtained from Bloomberg database. Information about total expense ratios (TER), asset class, corresponding index, replication method, volume of trading, was collected from the Swiss Stock Exchange website, and number of securities in the benchmark comes from the index providers websites.

ETFs from the sample correspond to 15 different indices, 9 of which are simultaneously covered by both synthetic and physical replication ETFs. Some of the indices from these 9 are covered more than by one synthetic and one physical ETFs from different providers.

This research uses popular methodology of estimating tracking errors following previous studies such as Frino and Gallagher (2001), Rompotis (2006), Meinhardt et al. (2014), Elia (2012). The first method (TE_1) is to estimate arithmetic mean of absolute differences between ETF returns and benchmark returns:

$$TE_1 = \frac{\sum_{k=1}^{N} \left| R_k^{ETF} - R_k^{ind} \right|}{N}$$

where R_k^{ETF} and R_k^{ind} – day k returns of ETF and corresponding index respectively, N – number of

observations in the sample for the ETF. The second and third methods represent estimation of the standard deviation of the return differences and the absolute return differences between the fund and the index accordingly. Using the same designations, tracking errors are calculated as follows:

$$TE_2 = \sqrt{\frac{\sum_{k=1}^{N}\left(\left(R_k^{ETF} - R_k^{ind}\right) - \overline{\left(R_k^{ETF} - R_k^{ind}\right)}\right)^2}{N-1}}$$

$$TE_3 = \sqrt{\frac{\sum_{k=1}^{N}\left(\left|R_k^{ETF} - R_k^{ind}\right| - \overline{\left|R_k^{ETF} - R_k^{ind}\right|}\right)^2}{N-1}}$$

Another method to estimate the tracking error is to evaluate standard error of the residuals:

$$TE_4 = \sqrt{\frac{\sum_{k=1}^{N}\varepsilon_k^2}{N-2}}$$

from the regression,

$$R_k^{ETF} = \alpha_k + \beta_k R_k^{ind} + \varepsilon_k \tag{1}$$

α_k reflects the value of return that a fund manager reaches regardless of the index performance, or the value of return that an investor can get if there is no relationship between the fund and the index; β_k describes the degree of precision with which the return of the fund replicates the return of the index, or in other words the sensitivity of the fund return to index return; ε_k residual differences of the regression. As these funds are created in order to replicate accurately the movements of the benchmark, it is expected that α_k will be statistically insignificant and β_k close to one and standard deviation of residuals should not significantly be different from zero.

Serial correlation is found for most of the funds in the regression (1). Since serial correlation does not distort the values of the coefficients in the model, but only the standard deviation of the coefficients, the impact of serial correlation was excluded in the standard deviation, t-statistics and, respectively, p-value, using Hansen method, also known as Newey-West method. Thus, the results are relieved from distortions of significance arising from presence of serial correlation.

Tracking errors could be produced by many factors. Here, some of possible factors are checked. Costs are likely to affect the return of ETFs, thus the tracking errors should be positively related to expense rarios. High liquidity ETFs are supposed to have lower tracking errors. Replication scheme also is checked here to confirm or reject results from the previous part. If synthetic ETFs are more efficient in tracking the benchmark, then the coefficient will be negative. Number of securities in the benchmark is also a possible factor influencing the dependent variable. It is supposed to have a positive relationship, since a broader index is more expensive to replicate and sponsors are motivated to use a subset of a whole benchmark basket that could cause an increase in the tracking error.

To determine possible factors that affect tracking errors, the following multivariate regression is estimated:

$$TE_{j,i} = \alpha + \beta_1 TER_i + \beta_2 LnVolume_i + \beta_3 Synth_i + \beta_4 Sec_i + \xi_i \tag{2}$$

Where $TE_{j,i}$ is the tracking error of the j method ($j = \overline{1,4}$) for fund number i, TER_i is the monthly total expense ratio in decimal terms of the fund i, $LnVolume_i$ represents liquidity of the fund measured by natural logarithm of the average daily trading volume, $Synth_i$ is the dummy variable that equals one if the fund has synthetic replication scheme, and zero otherwise, Sec_i is the number of securities in the benchmark index.

5. Empirical Results

In this section estimations of tracking errors and results of cross-sectional regressions on factors influencing tracking errors are presented. Table A1 in Appendix A contains the list of ETFs analyzed in the sample with corresponding benchmarks, domicile, total expense ratio, replication scheme.

Table 1 presents the results of estimation the tracking errors – the mean, minimum, maximum and median values for the appropriate part of the sample – for the overall sample, and for the physical ETFs and synthetic ETFs separately. Mean of alpha, beta and R^2 from the regression (1) are also in the table.

Both synthetic and full replication ETFs suffer from high tracking errors. Independent of the replication method, tracking errors are significant at 1% level. In Milonas and Rompotis (2006) study for Swiss ETFs, average

tracking error was estimated approximately at 1.02%. Considering all metrics used in the study, the range of tracking errors in Elia (2012) is from 0.004% to 0.617% for different ETFs, with average approximately 0.076% and the average in Meinhardt (2014) is 0.39%. In this study, means of the tracking errors vary from 0.482% to 0.697% according to the method for the whole sample. Considering the researches mentioned above, absolute values indicate that ETFs trading at Swiss Stock Exchange suffer from lower tracking ability comparing to those trading at Frankfurt Stock Exchange or in Europe in general.

The mean of the synthetic ETFs is higher than the mean of the physical ETFs in any of the 4 methods used, and the difference reaches 0.136% for the TE_2. Results on the median also demonstrate, that synthetic ETFs in the sample less accurately replicate the indeces. Synthetic ETFs have higher minimum and maximum tracking errors. Calculation of the mean total expense ratios (equal to 0.27% for both – physical and synthetic funds), indicates that there are some other factors, except management fees, that donate to underperformance of ETFs. Standard deviations of the groups are quite close and it is needed to provide the results of F-test to indetify if they are different. This test is also necessary to determine, which test should be used to find the difference of the means.

Alpha, beta coefficients are also highly significant, although alpha coefficents are close to zero. Beta coefficients, which could also be used to estimate the accuracy of replication method, are closer to unity for physical ETFs, that is consistent with previous findings on tracking errors.

Table 1. Tracking error statistics

	TE_1, %	TE_2, %	TE_3, %	TE_4, %	*Alpha*	*Beta*	R^2
Mean							
All	0.482	0.697	0.508	0.622	0.0002	0.646	0.433
	(17.546)	(20.455)	(20.843)	(21.407)	(9.073)	(21.583)	(13.219)
Physical	0.436	0.627	0.466	0.572	0.0001	0.717	0.500
	(12.328)	(13.631)	(12.462)	(15.162)	(5.348)	(17.447)	(11.556)
Synthetic	0.525	0.763	0.547	0.668	0.0003	0.579	0.370
	(12.772)	(16.151)	(17.941)	(15.529)	(9.500)	(14.805)	(7.989)
Median							
All	0.442	0.674	0.481	0.584	0.0002	0.625	0.388
Physical	0.401	0.592	0.416	0.566	0.0001	0.687	0.453
Synthetic	0.505	0.708	0.529	0.633	0.0003	0.591	0.353
Standard deviation							
All	0.162	0.202	0.144	0.172	0.0001	0.177	0.194
Physical	0.146	0.190	0.154	0.156	0.0001	0.169	0.179
Synthetic	0.169	0.195	0.126	0.177	0.0001	0.161	0.191
Minimum							
All	0.229	0.317	0.265	0.276	-0.0001	0.324	0.112
Physical	0.229	0.317	0.265	0.276	-0.0001	0.507	0.260
Synthetic	0.288	0.504	0.357	0.471	0.0001	0.324	0.112
Maximum							
All	0.961	1.307	0.885	1.183	0.0005	1.083	0.813
Physical	0.806	1.063	0.826	0.914	0.0003	1.083	0.813
Synthetic	0.961	1.307	0.885	1.183	0.0005	0.870	0.682

Note. This table provides summary information on the sample of ETFs. TE_1 is the tracking error measured by the absolute daily return differences between benchmark and index, TE_2 is the standard deviations of return differences, TE_3 is the standard deviations of the absolute return differences, TE_4 is the standard error of the residuals of regression (1). "All" is corresponded to the whole sample, "physical" and "synthetic" – separate the sample in two parts according to replication scheme. Alpha and beta are means of intercept and slope coefficients of the return regression (1), and R^2 shows how well returns of the funds are approximated by index returns. t-values in parenthesis show test results on the hypothesis of equality of the means to zero. According to t-values means are significant at less than 1% level.

To answer the question whether physical ETFs are superior than synthetic ETFs in replicating the return of the benchmark, just visual comparison of the means tracking errros is not enough. A two-sample test should be conducted for differences in the population means, after evaluating whether variances are equal or not.

The results are presented in the Table 2. F-test for the differences of population variances shows that variances

are not homogeneous, since the critical value for F-statistics to reject the null hypothesis of variances equality is 2.21 considering degrees of freedom, and an appropriate test for differences in means of two samples with a pooled variance should be used. T-test on the equality of means and the line with p-values shows the significance of the result, which confirms that the means of the two types of funds are not equal with significance about 10%. To be precise, difference between the means of TE_2, TE_3 and TE_4 are significant at less than 10%, using TE_1 – at less than 11%. Beta and R^2 coefficients are also significantly different for the groups. This means that synthetic and full replication ETFs are really different in their ability to replicate the index in terms of tracking errrors and this difference as is presented in Table 1 is not in favor of synthetic scheme.

This conclusion contradicts both mentioned researches on replication schemes.

Table 2. ANOVA results

	TE_1	TE_2	TE_3	TE_4	*Alpha*	*Beta*	R^2
F-test	1.349	0.949	1.507	1.301	1.560	1.102	1.143
t-test	1.654	2.086	1.699	1.700	4.117	-2.456	-2.086
p-value	0.107	0.045	0.099	0.098	0.000	0.019	0.045

Note. Table presents statistics on the F-test of the equality of two subsample variances – synthetic vs physical ETFs. Critical value for F-statistics to reject the null hypothesis of variances equality is 2.21 considering degrees of freedom. Results on F-test don't allow to reject the null hypothesis of equal variances. Table also presents statistics on the t-test – test of equality of two sample means if variances are assumed to be equal. P-value demonstrates the significance of the t-test in decimal form.

Table 3 reports the results of cross-sectional regression for the factors that affect tracking errors of the overall sample. The regressions are built separately for each tracking error, and metric and tracking errors from TE_1 to TE_4 are used as dependent variables. The adjusted R^2 and F-statistic is presented at the bottom of the table, demonstrating how well the model fits the data and significance of the slope coefficients overall.

The results suggest that tracking errors are significantly influenced by expense ratio, number of securities in the benchmark and by type of replication for all metrics, but with different accetable significance level. Average daily trading volume does not influence dependent variables except for one case with TE_1. These findings contradict the results of Meinhardt et al. (2014) in application to trading volume, as in that research volume significantly affects tracking errors. They also contradict Elia (2012), where number of securities is not a valuable determinant of tracking ability. Though, it is consistent in terms of influence of expense ratio and replication scheme.

Table 3. Factors influencing tracking errors

	Dependent variable			
	TE_1	TE_2	TE_3	TE_4
Intercept	0.0006	0.0037**	0.0039***	0.0032**
	(0.471)	(2.3)	(3.286)	(2.431)
TER	0.0069***	0.0076***	0.0045**	0.0073***
	(3.499)	(3.079)	(2.476)	(3.555)
LnVolume	0.0003**	0.0001	0.0000	0.0001
	(2.235)	(0.965)	(0.156)	(1.047)
Synth	0.0011**	0.0014**	0.0007*	0.0010*
	(2.297)	(2.377)	(1.706)	(2.031)
Sec	0.0000*	0.0000**	0.0000**	0.0000**
	(-1.874)	(-2.44)	(-2.73)	(-2.636)
Adj R^2	0.323	0.304	0.250	0.331
F-stat	5.054***	4.717***	3.83***	5.214***

Note. This table presents the results of multiple cross-sectional regressions of model (2). TER is the monthly total expense ratio in decimal terms, LnVolume is liquidity measured by the natural logarithm of the average daily trading volume, Synth is a dummy variable that is equal one if a fund have a synthetic replication scheme and zero otherwise, Sec is a number of securities in the benchmark index.The final rows contain adjusted R^2 and the F-statistics for the test of the null hypothesis that all the coefficients are equal to zero. * - 10% significance level, ** - 5% significance level, *** - 1% significance level.

The coefficient on *Synth* is positive and significant for all four *TE* measures. Thus the tracking errors are higher for synthetic ETFs compared to basic case with physical ETFs. This confirms previous results that synthetic ETFs have higher tracking errors compared to physical ETFs. *Sec*, that represents number of securities in benchmark, appeared to be close to zero but significant for all metrics. Positive value means that returns of more broad benchmarks are less accurately replicated.

There is also a regression for checking influence of the fund sponsor company built with dummy variables that represent organizing the fund by one of the four sponsors from the sample. But the slope coefficients at these dummy variables appear to be insignificant. This means that the absence of the dependence between the fund sponsor and the value of tracking error, i.e. difference in tracking errors couldn't be attributed to the fund provider. The results of these regressions are not presented in the article.

6. Conclusion

This paper is devoted to the study of the differences between synthetic and full replication ETFs. After brief mentioning of the synthetic ETFs nature, motives of creating and using it and risks that it bears for financial system, which were discussed in previous researches, an empirical study is conducted on the tracking ability of synthetic ETFs compared to traditional (physical) ones.

To evaluate and compare tracking errors daily returns from the sample of 35 ETFs traded at the Swiss Stock Exchange are used in four complementary methods. The research demonstrates that both traditional and synthetic ETFs have significant tracking errors. What is more important, synthetic ETFs, despite popular opinion, appeares to be less accurate in replicating benchmark return.

Portfolio managers and private investors, who purchase these passive management instruments to obtain the return of the index, should be aware of this specificity of two ETF types, especially if the performance of portfolio manager is based on a comparison to the performance of a benchmark. This is also a valuable knowledge in the context of the situation when better tracking ability of synthetic ETFs is often used as an argument of its superiority over physical ETFs, that covers their disadvantages related to systemic risks. This research demonstrates that such statements at least should be examined first in particularly cases, especially if there are present comparable proposals of different types at the market.

In the last part of the research regressions to determine factors influencing tracking errors are built. The results suggest that tracking errors are influenced by expense ratio, number of securities in the benchmark and type of replication for all estimation methods. Average daily trading volume doesn't influence dependent variables except for one tracking error estimation method.

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Appendix A

Table A1. ETFs used in the data set

No	Name of ETF	Underlying Index	Domicile of fund	Replication method	TER, %
1	UBS ETF - FTSE 100 UCITS ETF	FTSE 100	Luxembourg	physical	0.20
2	UBS ETF - MSCI Canada UCITS ETF	MSCI Canada	Luxembourg	physical	0.33
3	UBS ETF - MSCI Emerging Markets UCITS ETF	MSCI Emerging Markets Index	Luxembourg	physical	0.45
4	UBS ETF - MSCI EMU UCITS ETF	MSCI EMU	Luxembourg	physical	0.23
5	UBS ETF - MSCI Europe UCITS ETF	MSCI Europe	Luxembourg	physical	0.20
6	UBS ETF - MSCI Japan UCITS ETF	MSCI Japan	Luxembourg	physical	0.35
7	UBS ETF - MSCI United Kingdom UCITS ETF	MSCI UK	Luxembourg	physical	0.20
8	UBS ETF - MSCI USA UCITS ETF	MSCI USA	Luxembourg	physical	0.20
9	UBS ETF - MSCI World UCITS ETF	MSCI World	Luxembourg	physical	0.30
10	UBS ETF - EURO STOXX 50 UCITS ETF	EURO STOXX 50® NR	Luxembourg	physical	0.15
11	HSBC EURO STOXX 50 ETF	EURO STOXX 50® NR	Ireland	physical	0.15
12	HSBC MSCI CANADA ETF	MSCI Canada	Ireland	physical	0.35
13	HSBC MSCI EUROPE ETF	MSCI Europe	Ireland	physical	0.30
14	HSBC MSCI JAPAN ETF	MSCI Japan	Ireland	physical	0.40
15	HSBC MSCI WORLD ETF	MSCI World	Ireland	physical	0.35
16	HSBC S&P 500 ETF	S&P 500	Ireland	physical	0.15
17	HSBC FTSE 100 ETF	FTSE 100	Ireland	physical	0.35
18	AMUNDI ETF S&P 500 UCITS ETF	S&P 500	France	synthetic	0.15
19	AMUNDI ETF NASDAQ-100 UCITS ETF	NASDAQ 100	France	synthetic	0.23
20	AMUNDI ETF MSCI EMERGING MARKETS UCITS ETF	MSCI Emerging Markets Index	France	synthetic	0.45
21	AMUNDI ETF MSCI BRAZIL UCITS ETF	MSCI Brazil	France	synthetic	0.55
22	AMUNDI ETF FTSE 100 UCITS ETF	FTSE 100	France	synthetic	0.25
23	AMUNDI ETF CAC 40 UCITS ETF	CAC 40®	France	synthetic	0.25
24	AMUNDI ETF MSCI JAPAN UCITS ETF	MSCI Japan	France	synthetic	0.45
25	AMUNDI ETF MSCI USA UCITS ETF	MSCI USA	France	synthetic	0.28
26	AMUNDI ETF MSCI WORLD UCITS ETF	MSCI World	France	synthetic	0.38
27	AMUNDI ETF EURO STOXX 50 UCITS ETF	EURO STOXX 50® NR	France	synthetic	0.15
28	Lyxor ETF MSCI EMU	MSCI EMU	France	synthetic	0.35
29	Lyxor ETF S&P 500	S&P 500	Luxembourg	synthetic	0.20
30	Lyxor ETF Australia S&P ASX 200	S&P/ASX 200	Luxembourg	synthetic	0.40
31	UBS ETFs plc - MSCI Canada SF UCITS ETF	MSCI Canada	Ireland	synthetic	0.28
32	UBS ETFs plc - MSCI EMU SF UCITS ETF	MSCI EMU	Ireland	synthetic	0.02
33	UBS ETFs plc - MSCI Japan SF UCITS ETF	MSCI Japan	Ireland	synthetic	0.33
34	UBS ETFs plc - MSCI USA SF UCITS ETF	MSCI USA	Ireland	synthetic	0.15
35	UBS ETFs plc - S&P 500 Index SF UCITS	S&P 500	Ireland	synthetic	0.05

Note. Table A1 contains a list of ETFs in the sample from Swiss Stock Exchange, analysed in the research – particularly name of ETF, benchmark index, domicile of the fund, replication scheme and total expense ratio in pps.