ISCTE Business School
Instituto Universitário de Lisboa

TRACKING ABILITY OF GLOBAL EMERGING MARKETS EXCHANGE TRADED FUNDS

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- Spine -

Resumo

Este estudo tem como objectivo analisar a *tracking ability* dos ETF dos mercados emergentes em replicar 3 dos mais conhecidos e procurados *benchmarks* a nível mundial: MSCI EM Broad, MSCI EM Asia e MSCI Latin America. Para estudar essa capacidade foi utilizada uma amostra de 20 ETF comercializados e domiciliados na Europa por 5 das maiores entidades mundiais. Adicionalmente foram tidas em conta 4 formas de cálculo do *tracking error*, sendo que nesta dissertação se teve um cuidado especial com a volatilidade, uma vez que foram utilizados modelos assimétricos GARCH para ajustamento da volatilidade dos retornos.

Os resultados mostram que os ETF dos mercados emergentes apresentam valores substancialmente elevados para o *tracking error*, e não replicam totalmente os seus *benchmarks*. Destes, os que seguem o índice MSCI EM Broad são os que evidenciam maiores dificuldades no *tracking*. Relativamente aos betas e aos alfas, todos os fundos apresentam valores muito próximos do beta objectivo e alfas não estatisticamente significativos. Por outro lado, os ETF dos mercados desenvolvidos ainda são os que apresentam melhores resultados em termos de replicação.

No que diz respeito ao ajustamento da volatilidade os nossos resultados demonstraram que em 86% dos casos as conclusões sobre o *tracking error* são as mesmas se considerarmos retornos ajustados à volatilidade e retornos não ajustados.

Conclui-se então que, apesar da generalidade dos ETF dos mercados emergentes ainda não estarem totalmente maduros, estes representam oportunidades fantásticas de lucros, por vezes muito superiores às dos mercados maduros. Por isso, é altura de olhar para novos horizontes. É altura de olhar para os mercados emergentes.

Palavras-Chave: *Exchange-traded funds, Ajustamento da volatilidade, Tracking Error; Mercados Emergentes*

Classificação JEL*: C50 – General; G11 – Portfolio Choice, Investment Decisions*

Abstract

This study examines the tracking ability of global emerging markets ETF to replicate 3 of the best known and most popular benchmarks worldwide: MSCI EM Broad, MSCI EM Asia and MSCI Latin America. To study this ability we used a sample of 20 ETF traded and domiciled in Europe by 5 of the largest global management companies. Additionally were taken into account 4 ways to calculate the tracking error, and in this dissertation we took a special care with the volatility, since were used asymmetric GARCH models to adjust the volatility of returns.

The results show that global emerging markets ETF present substantially high values for tracking error and that they do not fully replicate their benchmarks. From these funds we find that the ones that mimic MSCI EM Broad seem to be the worst into track their benchmark. Additionally, all funds present values for beta close to the objective beta and, in most of cases, not statistically alphas.

Regarding volatility adjustment, our results show that in 86% of the cases the results that we reach about tracking error are the same if we consider volatility adjustment returns or unadjusted volatility returns.

We conclude that, despite the majority of emerging market ETF is not yet fully mature, these represent fantastic opportunities for profit, sometimes much higher than those of mature markets. It is time to look to new horizons. It is time to look to emerging markets.

Key words: *Exchange-traded funds, Volatility adjustment, Tracking Error; Emerging Markets*

JEL Classification*: C50 – General; G11 – Portfolio Choice, Investment Decisions*

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Sumário executivo

Desde a sua introdução há apenas duas décadas, os *Exchange Traded Funds* (ETF) têm sido inegavelmente bem-sucedidos, existindo actualmente mais de 5400 produtos listados em mais de 60 bolsas de valores. Ainda que os activos estejam muito concentrados em certos mercados, é expectável que com a globalização os ETF se continuem a difundir nos mercados internacionais, e a endereçar um número cada vez maior de classes de activos.

Em termos globais, o fluxo de activos nos EUA e na Europa vai continuar a dominar o cenário global dos ETF, mas as maiores taxas de crescimento tendem a ser encontrados em mercados menos maduros, como é o caso dos mercados asiáticos e latino-americanos. O crescente número de investidores nestas regiões combinada com o crescimento económico, a rápida criação de riqueza e de serviços financeiros significa que estes mercados são susceptíveis de contribuir de forma significativa para o crescimento destes fundos. Mas até que ponto estes ETF replicam melhor ou pior os ETF dos mercados desenvolvidos? E terá a volatilidade um papel importante no cálculo do *tracking error* destes fundos?

De forma a responder a estas questões, este estudo pretendeu investigar a capacidade dos ETF dos dois maiores mercados em desenvolvimento – asiático e latino-americano – em replicar os seus *benchmarks*. Para o efeito foram analisados um total de 20 ETF domiciliados e comercializados na Europa de 5 entidades diferentes, sendo que dos 20 fundos 5 deles replicam índices de mercados desenvolvidos, e os restantes replicam índices de mercados em desenvolvimento.

Com base em séries diárias de rendibilidades, foi primeiramente analisado o beta e o alfa de cada fundo recorrendo a uma regressão linear, onde a variável dependente era o retorno do ETF e a variável independente era o retorno do seu *benchmark*. Posteriormente, seguindo os estudos de Gallagher (2001), Rompotis (2009) e Milonas e Rompotis (2010), foram calculados os *tracking error* dos fundos de forma a avaliar o desvio médio dos retornos relativamente aos retornos dos seus *benchmarks*. Ainda neste ponto, foi introduzido um cuidado especial ao tratamento da volatilidade: foram tidos em conta retornos ajustados à volatilidade e retornos não ajustados de forma a concluir se este ajustamento tinha impacto na capacidade de replicação dos ETF.

Os resultados empíricos demonstraram que dos ETF estudados apenas 6 deles apresentavam um alfa estatisticamente significativo, embora negativo, o que revela que os gestores alcançaram retornos negativos, independentemente dos retornos dos *benchmarks*. Relativamente ao beta, foi possível demonstrar com base no *Wald-test* que todos os fundos têm um beta muito próximo da unidade, chegando em alguns casos a ser mesmo igual a 1.

Quanto à capacidade de replicação dos fundos foi possível observar que os ETF dos mercados emergentes de diferentes partes do globo[1] são os que apresentam piores resultados e que os ETF dos mercados desenvolvidos ainda apresentam uma capacidade de replicação substancialmente superior à dos mercados em desenvolvimento. Adicionalmente foi possível concluir que os resultados do *tracking error* com base em retornos ajustados à volatilidade e retornos não ajustados são os mesmos em 86% dos casos. Para além disso, foi possível demonstrar com base na *information criteria* que o melhor modelo GARCH para explicar os movimentos dos retornos é, no caso dos ETF dos mercados desenvolvidos, o *student t* EGARCH (1,1), e no caso dos ETF dos mercados em desenvolvimento o *student t* GJR (1,1).

Em suma, para investidores mais avessos e que têm preferência por produtos mais seguros, os ETF dos mercados mais desenvolvidos são os que melhor se adequam, enquanto que os dos mercados menos maduros são mais direccionados para investidores com gosto pelo risco.

[1] São os designados "Emerging markets – Broad".

1. Introduction

1.1. ETF history

Exchange-traded funds (ETF) are open-ended investment funds listed on stock exchanges and traded in different currencies in one or more stock exchanges. Its quotation is associated with the performance of market indexes, and its variation is directly correlated with the variation of the respective index, which is its "benchmark". Unlike a mutual fund that has its net-asset value (NAV) calculated at the end of each trading day, an ETF's price changes throughout the day, changing with supply and demand. By owning an ETF, investor gets the flexibility of a stock plus the diversification of an index fund. Thus, ETF follow a kind of passive management which consists on the replication of a particular market index and dynamic adjust of portfolio, exactly in the same extent of movement of the index.

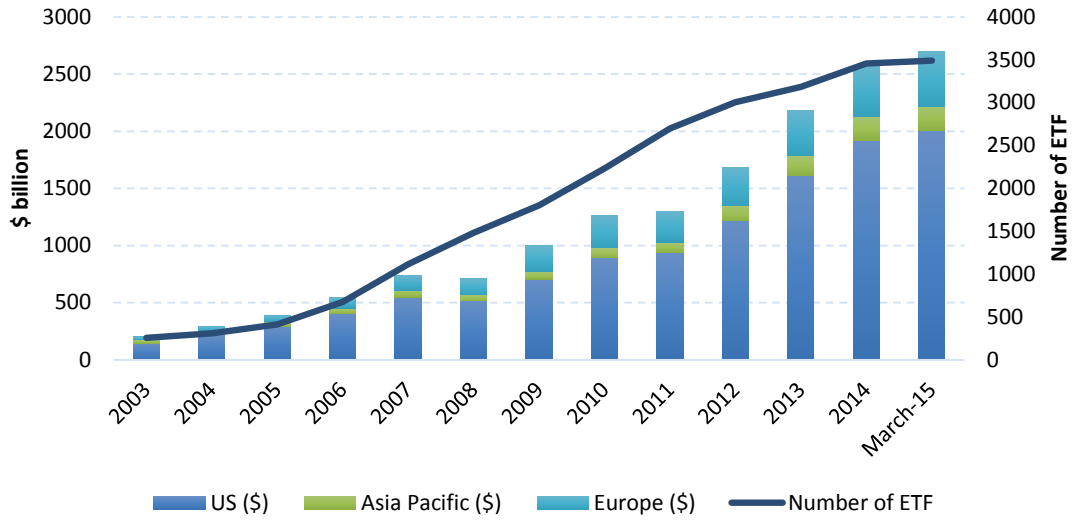
The ETF's structure has its origins in the stock market crash of 1987: institutional investors discovered from this market crash that they had a need to trade large amounts of stock rapidly and preferably on an intraday basis. In 1990, one idea was suggested by an American investment firm that stocks could be assembled together into a basket, traded on an exchange, and traded as a single unit. Basically, they wanted to put a fund on an exchange. However, this first approach didn't go well which resulted in a weak demand, mainly due to its high minimum investment requirements.

In Canada, the Toronto Index Participation Shares (TIPS) tracking the Toronto Stock Exchange 35 (TSE 35) began trading on Toronto Stock Exchange (TSE) in 1990 and became very popular quickly. Following the success of this product, the concept of ETF was recovered in the US. Over the next few years, this product were approved by regulators and ended in 1993 with the creation of Standard & Poor's Depositary Receipts (SPDRs) tracking the S&P 500 index, which many consider to be the first ETF in the US.

In Europe, the first products were launched on April 11th 2014 on the Deutsche Börse and offered exposure to European equities through two ETF: iShares Stoxx Europe 50 UCITS ETF and the iShares Euro Stoxx 50 UCITS ETF. They were followed by the London Stock Exchange (LSE), which launched on April 28th 2014 the iShares Core FTSE 100 UCITS ETF.

The importance gained over the past two decades by ETF in the capital market, explained by its ease of implementation and its ability to diversify, conducted to an increase of the transactions of these funds, having their value and number increased more than 10 times since 2003 as it is possible to see in figure 1.

Figure 1 – Global ETF regional asset growth.

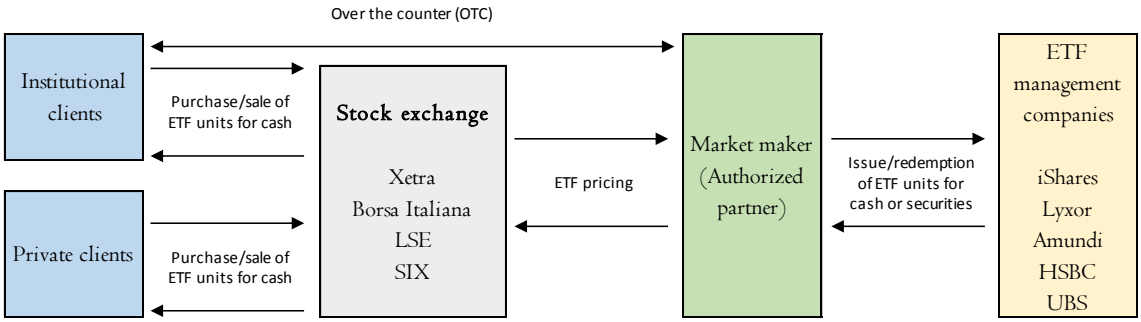


Source: Deutsche Bank, Bloomberg Finance LP, Reuters.

1.2. Trading and liquidity

ETF offer two types of liquidity: in the first one, liquidity is caused by trading volumes on stock exchange (or secondary market); in the second one, liquidity in generated by the creation and redemption of ETF units on the primary market – known as the creation/redemption process. Figure 2 shows this process:

Figure 2 – Creation/redemption process.



This process consists on the exchange of ETF units between a market maker (or authorized participant) and an ETF management company in return for securities or cash. When ETF units are issued (creation process), market makers deliver either a basket of securities or cash to ETF company and receive in exchange the equivalent

amount of ETF units, which they make accessible on the secondary market for individual investors, banks, brokers, etc. On the other hand, when ETF units are redeemed, the market makers exchange a fixed number of ETF units to the ETF company in return for a corresponding basket of securities or cash amount. Therefore, these two processes differentiate ETF from all other kind of financial products: existing ETF units can be redeemed if demand decreases, as well as new units can be created as demand increases.

As a result, the prices at which ETF trade rarely differ from the value of the security it tracks (or NAV): because market makers are allowed to trade directly with ETF companies on the primary market, they will buy shares in the secondary market at market price and redeem their shares at NAV with ETF companies if the market price of ETF is below its NAV, and they will do the opposite if the market price of ETF is above its NAV.

1.3. Advantages and risks of ETF

There are several factors by which investors are tempted to invest in ETF and justify such high popularity of this asset class:

1. Diversification: ETF provide an opportunity to diversify in an inexpensive and efficient way by distributing risk over multiple risk carriers. These funds can cover an index no matter how big or small that index is.
2. Flexibility: are easy to buy and sell, even on an intraday basis. Since investors can act on market views within seconds, these funds can be used on several investment strategies: long-term growth, short-term and for hedging of portfolio.
3. Transparency: ETF holdings are transparent. The management company posts the fund's holdings daily, which should mimic the index. All key information can be viewed on an intraday basis or in real time.
4. Cost efficiency: they do not incur any subscription/redemption surcharges. Just the transaction costs of buying and selling and ETF, and a minimal management fee is charged.
5. Security: ETF are not affected by any insolvency of the ETF provider or custodian bank as the fund’s assets are not included in the bankruptcy estate.

However, an investor must take into account the risks associated with this financial product when he chooses an ETF. There are some risks that affect all ETF, like equity risk (funds are exposed to the market risks related to fluctuations in the value of stocks that make up the index), capital risk (initial capital invested is not guaranteed) and tracking error risk (fund may not be able to exactly replicate the performance of the index because of numerous factors like discrepancies between NAV and market price or fees and fund expenses) , and others that are specifically related with a specific type of ETF, like currency risk (if ETF is denominated in a currency different to that of the underlying index they are tracking, exchange rate fluctuations can have a negative or positive effect on returns), country risk, replication risk (synthetic or physical), counterparty risk (results from the use of derivative financial instruments executed with a credit institution in the case of synthetic replication) and underlying index risk.

1.4. Why invest in emerging markets?

Emerging markets can be defined as countries that have large and investable financial markets but are still at a relatively early stage of economic development, with indicators like GDP per capita far below the levels of advanced economies. These markets often offer extraordinary opportunities for profit, much higher than those of advanced and mature markets. On the other hand, is more commonly observed high growth rates in these countries, so that the largest companies' gains will match higher valuations of securities. Increases of 10% of GDP per year and 100% stock valuation only happen on emerging markets. In table 1 it is possible to see that:

Table 1 – Performance of some emerging markets since 03/01/2000.

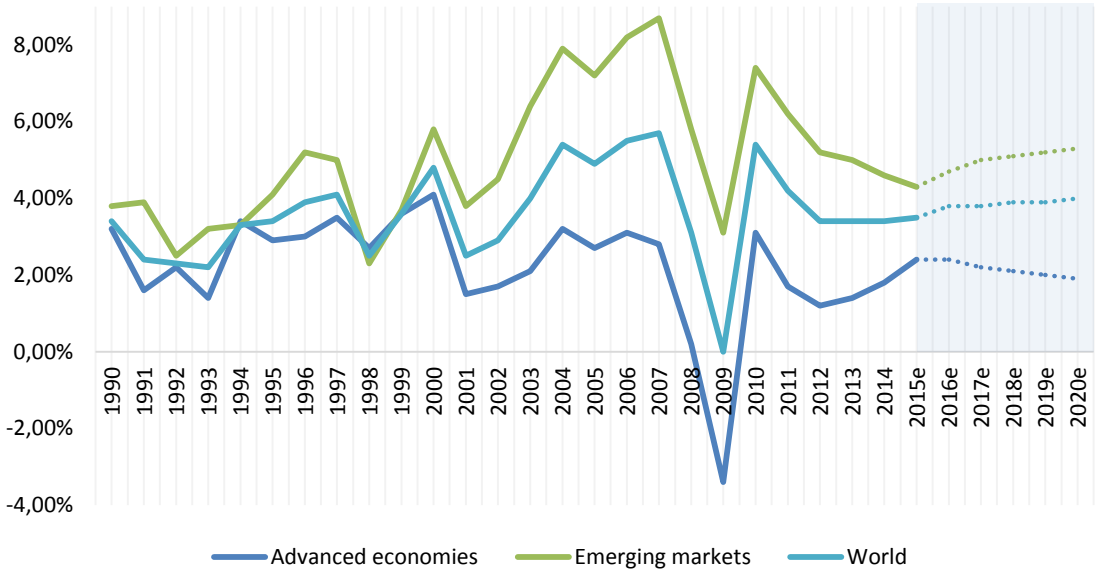
Country	Index	03/01/2000	19/09/2015	Δ%
China	SSE	1367	2329	+ 70%
India	Sensex	5375	27090	+ 404%
Mexico	Mexbol	7078	45742	+ 546%
Brazil	Bovespa	16930	57789	+ 241%
Russia	RTS	178	1170	+ 559%
South Africa	JSE	8516	51462	+ 504%

Source: Bloomberg.

Recent years, with an increasing global economic growth, globalization, market liberalization, internet and the increasingly wide range of financial services, are changing the world for a great backdrop for these markets. For instance, emerging economies are expected to grow two to three times faster than developed markets, and

around 70% of world growth over the next few years will come from emerging markets as shown in Figure 3, with China and India accounting for 40% of that growth according to International Monetary Fund (IMF).

Figure 3 – Contributions to global GDP growth.



Source: IMF, Bloomberg.

Moreover, emerging economies have sound balance sheets that provide a solid base for the continued economic outperformance over developed markets. China will post a current account surplus of over $450 billion and rising into 2016, and Russia will have an account surplus in 2016 of over $86 billion, according to the IMF.

However, we have to keep in mind that these opportunities are associated with a huge increase in risk. It's important to know all the risks of investments in emerging markets and the different ways to mitigate these risks, such as exposure to currencies and commodities. Additionally, the difficulty to track efficiently emerging markets may also be due to the fact that underlying markets being located in time zones which aren't the same from the ones where titles trade: for example, the Asian market is closed during the hours of trading of XETRA.

As more and more we can easily think on international investment, investors will be interested in detecting where will be the next ascension. Therefore, we recommend the book of Fernando Braga de Matos "*Ganhar em Bolsa*", where the author explains the roller coaster of emerging markets, presenting his arguments and data in a very convincing way.

1.5. Overview of the dissertation

There are numerous types of ETF, but the focus of our analysis are the ETF that are domiciled in Europe, traded on the Deutsche Börse Xetra – Frankfurt Stock Exchange and with exposure to the global emerging markets (GEM). Although they are still considered emerging economies, countries like China, Brazil, India or Russia have been approximated to developed countries, with higher GDP growth rates and with better social, environmental and human rights qualitative indicators than ever before.

Taking this into account, since the purpose of passive management funds is the replication of its benchmark returns', the main focus of our dissertation is the analysis of the tracking ability of GEM ETF. This is relevant for an investor perspective, once in his point of view it's necessary to know the accuracy and the reliability of this kind of financial products, in order to be able to classify if the they are in accordance with his risk profile or not. Moreover, there are several studies about ETF's performance, mainly comparative studies with traditional mutual funds (see, e.g, Dellva, 2001; Harper *et al.*, 2006; Agapova, 2011), but no study has explored the capacity of ETF domiciled in Europe to track GEM equity indexes.

Thus, to investigate the previous goal we will take into account the behavior of the tracking error of GEM ETF. However, is in the analysis of the tracking error that our thesis will be different from other works: we will have a special care in the treatment of volatility using two types of asymmetric GARCH models (EGARCH and GJR) and 2 alternative distributional functions for the error term (student's *t* and normal distribution). Since most part of empirical papers in literature deal only with the type of (1,1) asymmetric GARCH models, and because of its notable success in the financial volatility modelling, we only use the basics EGARCH (1,1) and GJR (1,1) in our paper. With this we want to understand which model is the best to explain volatility based on information criteria, and to study the second topic of our dissertation: are the conclusions about tracking error the same if we consider unadjusted-volatility returns and adjusted-volatility returns by GARCH models?

The assumption of independent and identically distributed returns (i.i.d) is very unrealistic (see, e.g., Mandelbrot, 1967; Rachev & Mittnik, 2000; Rachev *et al.*, 2005), since it assumes that volatility of financial asset returns is constant over time and that there is no autocorrelation between returns. This assumption is very often violated by

the characteristics of returns: its volatility changes throughout time, with periods where volatility is high followed by periods where the volatility is low (volatility clustering). Moreover, without the i.i.d assumption we can not use the square-root-of-time scaling rule to annualize the tracking error.

So, we pretend to capture the volatility clustering of returns by adjusting the series of ETF's returns so that the whole sample reflects the current market conditions. The volatility adjustment makes our sample much more like i.i.d and because of that the square-root-of-time rule is not as inappropriate as it is when we have volatility clustering.

About the structure, this dissertation is divided in 6 chapters. In the first chapter of this dissertation we elucidate readers about the choice of global emerging markets ETF and what we are going to study, and it is divided into 5 parts: the first part presents a brief overview of the evolution of these funds since its appearance; the second part shows how they are traded in the market; in the third part are cited some advantages and some risks that the investor is subject; the fourth part explains why we chose the ETF of emerging markets; the fifth part of the first chapter presents the main objectives of this thesis. The second chapter presents a literature review of studies and scientific articles which provides a theoretical support for the discussion of the topic and for the research question. The third chapter presents the data used as well as the reasons of your choice. In the fourth and fifth chapters are presented the methods used and results obtained respectively, and in the sixth and final chapter are presented the conclusions and the final results.

2. Review of literature

With the increasing popularity over the years, the number of studies performed about this kind of investment vehicle also increased, what allowed the existence of a great variety of published articles and academic studies about it in the current literature.

Gastineau (2001) is one of the most important and first authors writing about ETF. He provides a general overview of exchange-traded funds, where he traces their origin, lists some advantages, describes their main types and explains how it work and how the creation and redemption processes provide tax-efficiency.

2.1. ETF advantages

At the beginning as ETF weren't as well-known as today, some authors started to focus their attention on the advantages of ETF over other products, such as similar mutual funds or futures.

Dellva (2001) performs a comparison between two S&P 500 Index ETF and one S&P 500 index mutual fund and finds that ETF have advantages in terms of annual expenses (which increase in long-holding periods), even supporting transaction costs and bid-ask spread unlike index mutual funds, and in terms of tax efficiency, because of the "in-kind" creation/redemption processes. He also points out that ETF can not be attractive for small investors due to the transaction costs associated in each trade. Similarly, Fuhr (2001) lists some attractive ETF applications for individual and institutional investors, and suggests that investors interested in increase or reduce their exposure to different market indices, countries, sectors or investment styles should ponder ETF as a substitute of futures, because of its advantages.

Poterba and Shoven (2002) compare the pre-tax and after-tax returns between the largest ETF, SPDR trust, and the largest equity index fund, Vanguard Index 500 and they find that both funds present a similar performance during the period 1994 - 2000. They also refer that ETF are more tax-efficiency than other similar products because of its creation/redemption processes and their flexibility. Also Kostovetsky (2003) refers that the main differences between index mutual funds and ETF are tax efficiency, management fees, transaction fees and some qualitative differences such as simplicity (for index funds) and convenience (for ETF). He also argues that there is no reason for

small investors to invest in ETF, since they invest for a short period of time, and that ETF become a better investment tool than index funds for larger invested amounts.

Gastineau (2004) shows that conventional index funds outperform ETF for the S&P 500 and Russell 2000 indexes. Gastineau refers that the ETF performance problem is due to the incapacity of ETF managers to modify the portfolio in order to minimize transaction costs associated with the index adjustment, since they do not change the index fund portfolio as soon as possible after an official index change.

2.2. ETF tracking ability

The ability of passive index funds to track their benchmark has been one of the most studied issues over the years.

Frino and Gallagher (2001) study the tracking error of 42 S&P 500 index mutual funds between December 1993 and February 1999 and point out that tracking error is unavoidable in index fund performance due to the presence of market frictions. They explain that, because of this inevitability, index managers face a trade-off between the minimization of tracking error and transaction costs.

Elton *et al.* (2002) apply a comparison between the tracking ability of Spiders[2] and conventional S&P 500 index fund. They suggest that SPDR underperforms the S&P 500 by 28.4 basis points per year and the conventional index funds by 18 basis points per year because of the management fees and the loss of return from dividend reinvestment.

Gallagher and Segara (2006) analyze the capacity of the Australian index ETF to follow the performance of its underlying indexes. They find that tracking error is inevitable on performance, and that tracking error of ETF is considerably smaller than conventional index funds due some problems such as liquidity costs, higher costs and dividend policies.

Milonas and Rompotis (2006) investigate the trading and performance characteristics of 36 Swiss ETF during 2001-2006 and conclude that Swiss ETF underperform their benchmarks. They also report that Swiss ETF expose investors to a higher risk than the

[2] Is a short form of Standard & Poor's depositary receipt (SPDR), is managed by State Street Global Advisors and designed to track the S&P 500 index.

standard deviation of indexes and that tracking error is positively related with the risk of ETF and management fees.

Chu (2011) examines the tracking error of 18 ETF traded in Hong Kong stock market during 2004-2008 and finds that it's higher than those in Australia and US. He points out that this situation is due to higher cost of trading stocks in Honk Kong and/or to the use of synthetic investment tools instead of holding the underlying stocks. He also refers that tracking error is positively related to the expense ratio of ETF and negatively related with the size.

Elia (2012) compares the tracking ability of 48 European ETF that track 20 different benchmarks and finds that ETF in Europe have a substantial tracking error. He concludes that synthetic replication ETF have a smaller tracking error and higher tax efficiency than physical replication ETF, and that synthetic ETF underperform its benchmark and physical ETF competitors. Additionally, he argues that synthetic ETF are more efficient in tracking emerging market benchmarks.

2.3. Asymmetric GARCH models

Engle (1982) suggests to model time-varying conditional variance and corresponding volatility with the AutoRegressive Conditional Heteroskedasticity (ARCH) model, where the conditional variance is a linear function of the square of past errors. Despite being an easy model to determine, this model has some drawbacks such as the necessity of many parameters to adequately describe the evolution of volatility.

The generalized ARCH (GARCH) model of Bollerslev (1986) is an extension of ARCH model. In this model the linear function of the conditional variance also includes past variances. Thus, the conditional variance depends on the square of the previous innovations as well as its own conditional variances in earlier periods[3]. This model requires some restrictions and assumes that the response of the conditional variance to positive market shocks is the same as its response to negative market shocks of same scale. Therefore, since we are considering the square of errors, we are eliminating the "financial leverage effect" noted by Black (1976), which consists in the fact that

[3] For more details about ARCH and GARCH models we refer to Alexander (2009).

volatility increases more after a negative shock than after a positive shock of the same magnitude.[4]

In order to overcome these problems, alternative models known as asymmetric GARCH models have been proposed. One example is Nelson (1991) who proposes the exponential GARCH model (EGARCH). Unlike the symmetric GARCH, this model specifies the logarithm of the conditional volatility and does not imply restrictions on the parameters to ensure that variance is positive. Moreover, positive and negative shocks have a different impact on volatility. Another example are Glosten *et al.* (1993) who propose the GJR-GARCH model, which also has an asymmetric reaction to market shocks, because of its extra leverage parameter to capture the leverage effect.

Since normal GARCH models, which assume that conditional distribution of returns in normally distributed, usually can not explain the heavy tails that are present in financial asset returns when they are measured at daily frequency, some non-normal distributions have been proposed. Bollerslev (1987), for example, suggests using the student's *t* distribution.

[4] This effect commonly occurs in equity markets (Alexander, 2009).

3. Data

Blackrock (2011) provides a complete overview of all ETF available in various markets. From there we selected 20 regional[5] ETF domiciled and listed in Europe, wherein 5 ETF replicate the MSCI developed markets equity index of Europe and 15 ETF track the most important MSCI emerging market equity indexes: MSCI EM Asia, MSCI EM Latin America and MSCI EM Broad. All these indexes are net total return indexes, i.e., the return of all of them is calculated assuming the reinvestment of dividends after the deduction of withholding taxes. In all indexes we have 5 of the most important providers of ETF present in Europe: iShares, Lyxor, Amundi, db x-trackers and HSBC.

Since ETF can be traded in different exchanges, and we are interested in European funds, we selected ETF that are traded on Deutsche Börse Xetra – Frankfurt Stock Exchange[6], once all the providers have ETF for the different studied indexes in this exchange.

All ETF have Euro as trading currency. However, all indexes except the MSCI developed markets have USD as trading currency. Through Bloomberg we convert all the values for the same currency (i.e. euros), in order to have all variables in the same currency to be able to compare them.

We use Bloomberg to gather the time series of daily prices and NAV of the funds from its inception until September 19th 2014, as well as additional information such as inception date, total expense ratio (TER), currency, market capitalization, average traded volume of the last 6 months and replication technique[7].

Since ETF NAV and ETF closing price can not be the same, we can find for the same fund different levels of tracking error, depending whether deviations are calculated based on one of them or on the other. The return of the indexes is calculated using their daily closing prices, unlike funds return. Following Davidson *et al.* (2013), we used NAV to measure funds returns, since great part of the European negotiation of ETF is done over-the-counter (OTC), where investors usually prefer to trade at NAV.

[5] Regional ETF offer exposure to different countries.
[6] The Bloomberg ticker of this exchange is "GY".
[7] We eliminated from our sample the values for any days where an ETF didn't have NAV but the index have a price or vice-versa.

Moreover, all the providers that we are considering calculate funds tracking error based on NAV on its factsheets.

On Table 2 we present all descriptive information regarding our funds. Starting by the third column, we can see that all funds have different numbers of observations. This may have two reasons: the first one, because different funds have different inceptions dates; the second one, because some funds started to track its current benchmarks after its inception[8]. About the forth column, we see that the ETF from "Lyxor" that tracks developed markets has the oldest inception date, and that ETF from "HSBC" that track Emerging markets of Asia and Latin America are the most recent funds. The next column presents the total expense ratio of each fund that, as it's possible to understand, is always smaller for ETF from developed markets than for ETF from emerging markets, with the exception of "Amundi" funds. Notice that investors should remember that they have to look beyond TER because, since this type of funds is traded on exchanges, this can add additional costs for investors wishing to adjust their portfolio holdings. The costs of buying/selling ETF, like brokerage commissions and bid/offer spreads, can be significant, especially for smaller investors, and depending on the investment horizon could negate any benefit gained by moving assets to a fund with a lower TER.[9]

In the seventh and eighth columns it is also presented the average trading volume in the last 6 months and the current capitalization of the equity index ETF. Through these two variables we confirm that the liquidity of all these funds is substantially high, since there is a secondary stock market where it's possible to negotiate them freely. In addition to this fact, management companies act as market makers ensuring always on stock exchange a price to buy or to sell a certain units of an ETF, providing constant liquidity to the market.

Finally, the last column presents the replication technique: only ETF from "db x-trackers" and "HSBC" of developed markets present different type of replication when compared with other funds from the same provider.

[8] In our dissertation we just considered data from current benchmarks (we ignored the previous benchmarks).
[9] Longer term investors are likely to benefit most from such a switch, as lower fees over many years will offset the one-off trading costs.

Table 2 – Funds description.
This table presents the ETF providers, the Bloomberg ticker for each ETF, the benchmark, the number of observations, the inception date, i.e., the date on which the fund began its operations, the total expense ratio of the fund (TER), the market capitalization of each ETF and the number of shares traded on average on the past 6 months on December 2nd 2015 and, finally, the replication technique of each fund (physical ETF hold individual securities or physical assets (such as commodities); synthetic ETFs use derivatives to replicate the exposure of physical ETFs).

Provider	Ticker Bloomberg	Index (Bloomberg ticker)	# obs.	Inception date	TER (%)	Current market capitalization (10^6 €)	Average vol. 6 months	Replication technique
iShares	EUNK GY	MSCI Developed Markets Europe (MSDEE15N)	1026	20/10/2009	0,33	662	9627	Optimized
Lyxor[10, 14]	LYY5 GY		896	30/05/2006	0,30	1547	10891	Swap-based
Amundi	CEUGR GY		1269	23/02/2010	0,28	1033	1664	Swap-based
db x-trackers	XMEU GY		1870	10/01/2007	0,30	2564	97875	Full
HSBC[14]	H4ZE GY		988	12/10/2010	0,30	262	2411	Full
iShares	EUNM GY	MSCI EM Broad (NDUEEGF)	532	20/10/2009	0,68	301	10248	Optimized
Lyxor[11]	LYXLEM GY		852	29/08/2007	0,55	1205	73279	Swap-based
Amundi	AMEM GY		973	15/03/2011	0,20	437	210448	Swap-based
db x-trackers	XMEM GY		1789	09/07/2007	0,65	2071	142021	Swap-based
HSBC[14]	H410 GY		751	27/09/2013	0,60	294	36032	Optimized
iShares	CEBL GY	MSCI Asia Pacific (NDUEEGFA)	1030	26/08/2010	0,65	227	1401	Optimized
Lyxor[12]	LYXAPX GY		645	05/11/2008	0,50	50	659	Swap-based
Amundi[14]	AMEA GY		447	29/11/2011	0,20	524	22668	Swap-based
db x-trackers	XMAS GY		1821	09/07/2007	0,65	809	57905	Swap-based
HSBC[14]	H4ZI GY		964	14/10/2010	0,60	24	1141	Optimized
iShares	CEBD GY	MSCI EM Latin America (NDUEEGFL)	1011	26/08/2010	0,65	11	87	Optimized
Lyxor[13, 14]	LYXLTM GY		887	29/08/2007	0,65	67	3372	Swap-based
Amundi[14]	AMEL GY		447	29/11/2011	0,20	47	15690	Swap-based
db x-trackers	XMLA GY		1819	09/07/2007	0,65	145	9736	Swap-based
HSBC	H4ZW GY		856	27/09/2013	0,60	12	2133	Optimized

[10] The fund started to track its current benchmark on 01/04/2011.
[11] The fund started to track its current benchmark on 06/06/2011.
[12] The fund started to track its current benchmark on 21/03/2012.
[13] The fund started to track its current benchmark on 15/04/2011.
[14] Distribute dividends.

On Table 3, we present the most important descriptive statistics of our funds. Notice that the only 3 ETF that present negative means for the returns over the entire sample replicate MSCI Latin America Index. On the other hand, the fund for developed markets from iShares is the one with the highest mean of the returns. Regarding standard deviation, we can see that this measure varies considerably, presenting values between 0.338% and 0.991%.

Table 3 – Summary statistics.
This table contains the descriptive statistics for each of the 20 ETF based on their returns.

Provider	Ticker Bloomberg	Mean	Standard deviation	Minimum	Maximum
iShares	EUNK GY	0,040%	0,991%	-4,834%	4,267%
Lyxor	LYY5 GY	0,015%	0,434%	-2,102%	1,856%
Amundi	CEUGR GY	0,017%	0,449%	-2,100%	2,968%
db x-trackers	XMEU GY	0,004%	0,590%	-3,436%	4,155%
HSBC	H4ZE GY	0,017%	0,432%	-2,097%	1,851%
iShares	EUNM GY	0,007%	0,338%	-1,084%	1,039%
Lyxor	LYXLEM GY	0,005%	0,400%	-2,168%	1,566%
Amundi	AMEM GY	0,003%	0,399%	-2,162%	1,567%
db x-trackers	XMEM GY	0,004%	0,602%	-3,768%	4,310%
HSBC	H410 GY	0,013%	0,401%	-2,059%	1,664%
iShares	CEBL GY	0,010%	0,473%	-2,124%	2,202%
Lyxor	LYXAPX GY	0,013%	0,360%	-1,513%	1,084%
Amundi	AMEA GY	0,015%	0,372%	-1,233%	1,179%
db x-trackers	XMAS GY	0,006%	0,671%	-3,721%	5,413%
HSBC	H4ZI GY	0,011%	0,512%	-2,626%	2,321%
iShares	CEBD GY	-0,004%	0,508%	-3,678%	1,849%
Lyxor	LYXLTM GY	-0,006%	0,515%	-3,754%	1,824%
Amundi	AMEL GY	0,001%	0,479%	-1,526%	1,569%
db x-trackers	XMLA GY	0,002%	0,826%	-6,180%	6,543%
HSBC	H4ZW GY	-0,004%	0,533%	-3,679%	2,123%

4. Methodology

In this section we present the methods that have been used to study a number of issues surrounding the tracking ability of the GEM, like linear regression analysis, tracking error, symmetric GARCH models, asymmetric GARCH models, volatility adjusted returns and mispricing.

4.1. Returns

To be able to assess the capacity of the ETF to track the performance of its benchmarks, we need first to compute the daily log returns of the series using the following formulas:

$$R_{i,t}^{ETF} = \log\left(NAV_{i,t}^{ETF}\right) - \log\left(NAV_{i,t-1}^{ETF}\right) = \log\left(\frac{NAV_{i,t}^{ETF} + Dividend_{i,t}}{NAV_{i,t-1}^{ETF}}\right) \quad (1)$$

$$R_{j,t}^{Bench} = \log\left(P_{j,t}^{Bench}\right) - \log\left(P_{j,t-1}^{Bench}\right) = \log\left(\frac{P_{j,t}^{Bench}}{P_{j,t-1}^{Bench}}\right) \quad (2)$$

Equation (1) represents the daily return of ETF *i* on day *t*, where $NAV_{i,t}^{ETF}$ is the net asset value of ETF *i* on day *t*, $Dividend_t$ is the dividend paid by ETF *i* on day *t*, and $NAV_{i,t-1}^{ETF}$ is the net asset value of ETF *i* on day *t-1*. Equation (2) represents the daily return of benchmark *j* on day *t*, where $P_{j,t}^{Bench}$ is the price of benchmark *j* on day *t* and $P_{j,t-1}^{Bench}$ is the price of benchmark *j* on day *t-1*.

4.2. Linear regression (CAPM)

After the calculation of returns, we perform the linear regression presented in equation (3) to compare the daily ETF return variation to that of the index:

$$R_{i,t}^{ETF} = \alpha_i + \beta_i R_{j,t}^{Bench} + \varepsilon_t \quad (3)$$

where $R_{i,t}^{ETF}$ is the daily return of ETF *i* on day *t*, $R_{j,t}^{Bench}$ is the daily return of benchmark *j* on day *t*, and ε_t is the error term[15]. The alpha (α_i) coefficient corresponds to the return that a manager can achieve independently of index return, and the beta (β_i) coefficient corresponds to the portion of the ETF *i* return variation common to it benchmark return, and is an estimation of the systematic risk that a fund manager face.

[15] Error term corresponds to the part of the ETF return that is not explained by the benchmark return.

Beta coefficient is also a suggestion of ETF's replication strategy: if beta is higher than one means that fund moves more aggressively when compared to the benchmark, whereas when beta is lower than one means that fund follows a more conservative investing policy. In addition, a beta of one indicates a full replication strategy, where manager purchases all the underlying assets of the benchmark index in the same weights, and a beta different from one represents another type of strategy, where manager opts for other selection methods, leaving certain stocks as they might be too illiquid or to small, for example.

For the estimation of linear regression model we used the statistical software EVIEWS 7 and we consider OLS results and Wald test to investigate the following hypotheses:

$$\begin{cases} H_0: \beta_i = \beta_{obj} = 1 \\ H_1: \beta_i \neq \beta_{obj} = 1 \end{cases} \qquad \begin{cases} H_0: \alpha_i = \alpha_{obj} = 0 \\ H_1: \alpha_i \neq \alpha_{obj} = 0 \end{cases}$$

Since we are leading with ETF that follow a passive management strategy, we expect to have a statistically and significant estimate $\beta_i = 1$ and a statistically and insignificant estimate for α_i, or a statistically and significant estimator $\alpha_i = 0$.

Cresson *et al.* (2002) suggest the coefficient of determination (or R^2) as another measure that indicates the nearness to which ETF follows its benchmark. They also argue that this is a more straightforward measure.

4.3. Tracking error

The most common concern in passive portfolio management is the failure of fund managers to accurately replicate the return of their benchmarks (i.e. tracking error) and, consequently, meet their investment objectives. Roll (1992), for example, suggests that the level of tracking error is an important criterion to evaluate an ETF performance.

Among the several methods suggested by the literature, in this section we present the four different measures to calculate tracking error that were used in other studies.

4.3.1. Average of the absolute differences in returns

The first method of tracking error, suggested by Roll (1992), Frino and Gallagher (2001), Gallagher and Segara (2006) and Rompotis (2009) is defined as the mean of the

absolute daily return difference between the fund and its benchmark and is represented in equation 4:

$$TE_1 = \frac{\sum_{t=1}^{n} \left| R_{i,t}^{ETF} - R_{j,t}^{Bench} \right|}{n} \quad (4)$$

where $R_{i,t}^{ETF}$ is the daily return of ETF *i* on day *t*, $R_{j,t}^{Bench}$ is the daily return of benchmark *j* on day *t*, and n is the number of days.

In this method we use the absolute values of returns differences since either a negative or positive difference reflects a non-similar performance (Rompotis, 2009).

4.3.2. Standard deviation of returns differences

The second method, suggested by Roll (1992), Frino and Gallagher (2001) and Aber *et al.* (2009), is the standard deviation of the difference between the fund's and benchmark's returns over time and is represented in equation 5:

$$TE_2 = \sqrt{\frac{\sum_{t=1}^{n} (R_{i,t}^{ETF} - R_{j,t}^{Bench})^2}{n-1}} \quad (5)$$

where $R_{i,t}^{ETF}$ is the daily return of ETF *i* on day *t*, $R_{j,t}^{Bench}$ is the daily return of benchmark *j* on day *t*, and n is the number of days.

4.3.3. Standard error of regression

The third method, proposed by Frino and Gallagher (2001), Rompotis (2009) and Milonas and Rompotis (2010), is the standard error of regression computed previously (equation 3).

4.3.4. Semi-standard deviation

Nowadays it's recognized that investors do not understand risk as the returns above the minimum set as target for an investment. Investors only feel penalized as loss if the investment can not beat the benchmark. Therefore, since the previous methods treat negative and positive tracking errors equally, and once investors prefer positive to negative tracking errors, we complement our analysis with a fourth method suggested by Milonas and Rompotis (2010). This last method, which is represented in equation 6, is known as semi-standard deviation, and is only applied for the days where the fund does not beat the benchmark index:

$$TE_4 = \sqrt{\frac{\sum_{t=1}^{n} Min\left[\left(R_{i,t}^{ETF} - R_{j,t}^{Bench}\right); 0\right]^2}{n}} \quad (6)$$

where $R_{i,t}^{ETF}$ is the daily return of ETF *i* on day *t*, $R_{j,t}^{Bench}$ is the daily return of benchmark *j* on day *t*, and n is the number of days with negative excess returns.

4.4. Asymmetric GARCH models

The comprehension and modeling of volatility of a time series are important since they allow the improvement of the estimation of the parameters of a model that expresses the behavior of the data, and improve the quality of the adjustment of returns that will be made later.

A GARCH model consists of 2 equations: a conditional mean equation[16], which specifies the behavior of the returns, and a conditional variance equation. Regarding the conditional variance equation, in this section we present the two asymmetric GARCH models used to express it: EGARCH and GJR-GARCH.

4.4.1. Exponential GARCH – EGARCH

Nelson (1991) recommends EGARCH (p,q) as an alternative model to symmetric GARCH models, once the last do not allow to deal with the leverage effect and, because of that, is not suitable to predict conditional volatility of financial asset returns. The model is present in equations 8 and 9[17]:

$$\ln \sigma_t^2 = \alpha_0 + \sum_{i=1}^{q} \alpha_i \, g(z_{t-i}) + \sum_{j=1}^{p} \beta_i \ln \sigma_{t-j}^2 \quad (7)$$

$$g(z_t) = \theta_1 \, z_t + \theta_2 [|z_t| - E|z_t|] \quad (8)$$

where σ_t^2 is the conditional variance, $z_t = \frac{\varepsilon_t}{\sigma_t}$ is the standardized residual and $|z_t| - E|z_t|$ is the deviation of a realization of $|z_t|$ from its expected value. The parameter θ_1 represents the asymmetric effect or the leverage effect, θ_2 represents the symmetric

[16] Usually the choice of return model has little impact on GARCH estimates. Following Alexander (2009) we assume an AR (1) - $r_t = c + \rho r_{t-1} + \varepsilon_t$ - as our conditional mean equation.
[17] Since we are using an EGARCH (1,1), the parameter α_i can be set to 1.

effect or the GARCH effect[18] and β_i represents the persistence in conditional volatility, regardless of what happen in the market (Alexander, 2009).

To consider the leverage effect, θ_1 must be negative: negative shocks ($\varepsilon_t < 0$) will have a greater positive impact on future volatility than positive shocks ($\varepsilon_t > 0$).[19]

To guarantee that the relation between returns and volatility is asymmetric $g(z_t)$ should be a function of two effects: both the magnitude ($\theta_2[|z_t - E|z_t||]$) and sign of z_t ($\theta_1 z_t$) (Nelson, 1991). Equation 9 shows that $g(z_t)$ permits the conditional variance σ_t^2 to respond asymmetrically to falls and rises of funds price:

$$g(z_t) = \begin{cases} (\theta_1 + \theta_2)z_t - \theta_2 E|z_t|, if\ z_t > 0 \\ (\theta_1 - \theta_2)z_t - \theta_2 E|z_t|, if\ z_t < 0 \end{cases} \quad (9)$$

Therefore there is a variety of asymmetric effects resulting from positive or negative shocks because, when $z_t > 0$ $g(z_t)$ has slope $(\theta_1 + \theta_2)$ and is linear, and when $z_t < 0$ $g(z_t)$ has slope $(\theta_1 - \theta_2)$ and is linear once again. Thus, we can have an effect to only negative shocks ($z_t < 0$) if $\theta_1 = -\theta_2$ and we can also have an effect to only positive shocks ($z_t > 0$) if θ_1 and θ_2 are equal.

Note also that $E|z_t|$ depends on the conditional density assumption[20]. Equations 11 and 12 present the values for $E|z_t|$ if we consider a normal distribution or a student *t* distribution for the errors respectively:

$$E|z_t| = \sqrt{\frac{2}{\pi}},\ z_t \sim \mathrm{N}(0,1) \quad (10)$$

$$E|z_t| = \frac{\sqrt{v}\,\Gamma[0.5(v-1)]}{\sqrt{\pi}\,\Gamma(0.5v)},\ z_t \sim t_{(v)},\ v > 2 \quad (11)$$

where v are the degrees of freedom.

With this model, unlike symmetric GARCH model, since we use the logarithm of the conditional volatility we do not need to impose any parameter constraints to ensure the non-negativity of the conditional variance: the logarithm can be negative, but the variance will be always positive.

[18] If $\theta_1 = 0$, then model is symmetric.
[19] Negative (positive) shocks can be interpreted as unexpected decreases (increases) in returns.
[20] For more details about conditional density function we refer to Alexander (2009).

4.4.2. GJR-GARCH

Another alternative model to symmetric GARCH models is the GJR-GARCH model of Glosten *et al.* (1993) represented in equation 13:

$$\sigma_t^2 = \omega + \alpha\varepsilon_{t-1}^2 + \lambda 1_{\{\varepsilon_{t-1}<0\}}\varepsilon_{t-1}^2 + \beta\sigma_{t-1}^2 \quad (12)$$

where σ_t^2 is the conditional variance and λ is an extra parameter used to capture the leverage effect. In this model it's supposed that the impact of ε_{t-1}^2 on the conditional variance is different when ε_t is negative or positive. Because of this assumption the dummy variable $1_{\{\varepsilon_{t-1}<0\}}$ takes the value one (zero) when ε_t is negative (positive), i.e., when there is negative (positive) news.

Note that, in the situation where we have negative news on the market, or $\varepsilon_t < 0$, there is only an asymmetric effect on volatility (or a leverage effect) when the estimate for the coefficient λ is positive and statistically significant. If we have positive news, the GJR-GARCH is simply the **symmetric GARCH model.**

4.5. Volatility adjusted returns

To capture the volatility clustering of returns we use a volatility weighting method that is suggested by Alexander (2009). The volatility adjusted returns series is presented in equation 14:

$$\tilde{r}_{t,T} = \left(\frac{\hat{\sigma}_T}{\hat{\sigma}_t}\right) r_t \quad (13)$$

where r_t is the unadjusted return on day t and $\hat{\sigma}_T$ and $\hat{\sigma}_t$ are the time series of the statistical (EGARCH or GJR-GARCH) volatility of returns, wherein T is the last day of the sample. Note that T is fixed but t varies, i.e., $t = \{1, \dots, T\}$.

Accordingly to this formula, if we compute the series of variance estimates for the adjusted returns, it will be approximately constant and equal to $\hat{\sigma}_T$. Thus, the entire series reflects the current market conditions.

5. Empirical Results

In this section we will present all the results obtained based on the tests and methods shown in previous section.

5.1. Linear regression analysis

Table 4 shows the results for the different studied measures for each equity index ETF under the linear regression analysis.

Starting by the alpha coefficient, we can see that all the 20 ETF present values very close to zero, and that, with the exception of EUNK GY, XMEM GY, XMAS GY, CEBD GY, H4ZW GY and XMLA GY, they are all statistically insignificant, presenting values for p-value higher than 5% as we expected. For those ETF for which we do not reject the null hypothesis "$\alpha_i = \alpha_{obj} = 0$", the values for alpha are negative for all of them, meaning that managers, on average, achieve negative returns independently of index returns.

Concerning the beta coefficient, all the ETF have a statistically and significant beta, presenting a range of values very close to the unity (between 0,945 and 1,002), as we expected. Moreover, Wald test allows us to say that just 6 ETF have betas exactly equal to the unity, since we don't reject the null hypotheses of "$\beta_i = \beta_{obj} = 1$". From our sample of ETF, the GEM ETF are the ones that are less sensitive to the variations of its benchmark, since they present the smallest estimates for betas.

Regarding the coefficient of determination (R^2), it is possible to see that the performance of all the funds is totally explained by the evolution of its benchmark, since there is no fund that presents a value for this coefficient smaller than 99,6% and that all ETF are fully invested on the benchmark index constituents. Once again, the developed markets ETF are the ones that present the best results.

Lastly, the F-test shows that the conclusions from t-tests are correct, because we reject the null hypothesis "$\beta_i = \cdots = \beta_k = 0$" for all the funds, which allow us to conclude that the model is statistically significant.

Table 4 – Results from linear regression analysis.
This table contains the linear regression results for the different coefficients and tests: alpha coefficient (α_i), beta coefficient (β_i) and Wald test, coefficient of determination (R^2), t-test and p-values for all the coefficients and, finally, the p-value for the F-test.
* Coefficients significant at 10%.
** Coefficients significant at 5%.
*** Coefficients significant at 1%.

Provider	Ticker Bloomberg	α_i (%)	t-test	p-value	β_i	Wald test t-test (β=1)	Wald test p-value	F-test (p-value)	R^2
iShares	EUNK GY	- 0,0348**	-2,235	0,027	0,997***	-2,376**	0,0177	0,000	1,000
Lyxor	LYY5 GY	0,0001	1,543	0,123	0,999***	-0,618	0,5366	0,000	0,999
Amundi	CEUGR GY	0,0000	-0,344	0,731	0,999***	-1,907*	0,0567	0,000	0,999
db x-trackers	XMEU GY	0,0000	0,198	0,843	1,000***	0,711	0,4770	0,000	0,999
HSBC	H4ZE GY	0,0001	1,014	0,311	0,999***	-1,077	0,2816	0,000	1,000
iShares	EUNM GY	- 0,0017	-0,485	0,628	0,945***	-5,207***	0,000	0,000	0,972
Lyxor	LYXLEM GY	- 0,0011	-0,367	0,714	0,957***	-5,519***	0,000	0,000	0,974
Amundi	AMEM GY	- 0,0012	-0,388	0,698	0,954***	-5,852***	0,000	0,000	0,969
db x-trackers	XMEM GY	- 0,0014***	-11,59	0,000	1,003***	-4,200***	0,000	0,000	0,999
HSBC	H410 GY	- 0,0004	-0,448	0,654	0,997***	-1,354	0,1762	0,000	0,998
iShares	CEBL GY	- 0,0016	-1,604	0,109	0,991***	-4,201***	0,000	0,000	0,998
Lyxor	LYXAPX GY	- 0,0006	-0,207	0,836	0,961***	-4,693***	0,000	0,000	0,977
Amundi	AMEA GY	- 0,0008	-0,217	0,828	0,965***	-3,744***	0,000	0,000	0,979
db x-trackers	XMAS GY	- 0,0014***	-45,36	0,000	1,001***	18,095***	0,000	0,000	1,000
HSBC	H4ZI GY	- 0,0009	-0,932	0,352	0,999***	-0,211	0,833	0,000	0,998
iShares	CEBD GY	-0,0012***	-5,163	0,000	0,999***	-2,192**	0,029	0,000	0,999
Lyxor	LYXLTM GY	- 0,0018	-0,561	0,575	0,983***	-2,658***	0,008	0,000	0,982
Amundi	AMEL GY	- 0,0013	-0,354	0,723	0,976***	-3,269***	0,001	0,000	0,988
db x-trackers	XMLA GY	- 0,0014***	-11,48	0,000	1,002***	10,001***	0,000	0,000	1,000
HSBC	H4ZW GY	- 0,0011***	-4,407	0,000	1,000***	0,466	0,6413	0,000	0,999

5.2. Tracking error analysis

Tables 5, 6, 7 and 8 show us the results of each method used to measure the tracking errors and the values of information criteria for each equity index ETF and its respective index in 5 different situations: without volatility adjusted returns and with volatility adjusted returns based on normal or *student t* EGARCH (1,1) and GJR (1,1) models.

By unanimity of all tracking error measures and GARCH models we find, as expected, that ETF that track developed markets indexes present smaller values for tracking error when compared with GEM ETF. The only exceptions are ETF from db x-trackers, where the funds that track emerging markets from Asia are the ones with the smallest values for tracking error when compared with all the other funds. Moreover, ETF that mimic the emerging markets from different parts of the world (emerging markets – broad) seem to be the worst into track their benchmark.[21]

More specifically, we can also say that the fund from "Amundi" presents the lowest TE for the developed market index, while the fund from "Deutsche Bank" presents the highest value of TE. About the emerging markets indexes, the conclusions are not the same: if the investor wants to buy an ETF from different emerging markets, he should be aware that the fund from "Amundi" is the one with the highest value for TE. However, if he wants to invest in one of the other two markets (Asia and Latin America) he should be advice that the funds from "Lyxor" are the ones with the highest TE's. Notice that funds from "Deutsche Bank" present the smallest TEs for all emerging markets.

Regarding information criteria we can conclude that the best model to modeling the conditional distribution of returns in the case of developed markets ETF is the *student t* EGARCH (1,1) model. On the other hand, all emerging markets considered in this dissertation have in common the fact that the best model to explain volatility is *student t* GJR (1,1) model[22]. Conversely, the results show that, in all the considered markets, the normal EGARCH (1,1) is the worst model.

[21] See annex 1.
[22] The lower the information criteria, the better the model.

Table 5 – Tracking errors – Developed Markets.
This table contains the results from the four methods used to calculate tracking error – the average of the absolute differences in returns (TE1), the standard deviation of returns differences (TE2), the standard error of regression (TE3) and the semi-standard deviation (TE4) – using unadjusted volatility returns and adjusted volatility returns through two types of asymmetric GARCH models (EGARCH and GJR) and 2 alternative distributional functions for the error term (student's t and normal distribution). In order to select the best model, we present the 3 most used information criteria: Akaike info criterion, Schwarz criterion and Hannan.Quinn criterion. To facilitate the analysis, green is for the best model and red is for the worst model.

		TE1	TE2	TE3	TE4	Akaike info criterion		Schwarz criterion		Hannan-Quinn criterion	
						Fund	Index	Fund	Index	Fund	Index
1. EUNK GY iShares	**GJR - Normal**	0,038%	0,061%	0,060%	0,039%	-6,6688	-6,6679	-6,6399	-6,6390	-6,6578	-6,6569
	GJR - Student t	0,037%	0,060%	0,059%	0,039%	-6,6910	-6,6901	-6,6573	-6,6564	-6,6782	-6,6773
	EGARCH - Normal	0,045%	0,073%	0,070%	0,048%	-6,6658	-6,6651	-6,6369	-6,6362	-6,6548	-6,6541
	EGARCH - Student t	0,045%	0,079%	0,076%	0,056%	-6,6963	-6,6953	-6,6626	-6,6616	-6,6835	-6,6825
	Without adjustment	0,052%	0,079%	0,079%	0,052%						
2. LYY5 GY Lyxor	**GJR - Normal**	0,013%	0,017%	0,017%	0,011%	-8,3505	-8,3502	-8,3184	-8,3180	-8,3382	-8,3379
	GJR - Student t	0,012%	0,017%	0,016%	0,010%	-8,3760	-8,3758	-8,3385	-8,3383	-8,3617	-8,3614
	EGARCH - Normal	0,016%	0,021%	0,020%	0,013%	-8,3454	-8,3450	-8,3133	-8,3129	-8,3331	-8,3327
	EGARCH - Student t	0,036%	0,056%	0,053%	0,045%	-8,3799	-8,3801	-8,3424	-8,3426	-8,3656	-8,3658
	Without adjustment	0,019%	0,025%	0,025%	0,015%						
3. CEUGR GY Amundi	**GJR - Normal**	0,008%	0,015%	0,015%	0,008%	-8,2482	-8,2481	-8,2239	-8,2238	-8,2391	-8,2390
	GJR - Student t	0,008%	0,015%	0,015%	0,009%	-8,2706	-8,2705	-8,2422	-8,2421	-8,2599	-8,2598
	EGARCH - Normal	0,010%	0,017%	0,017%	0,010%	-8,2472	-8,2474	-8,2228	-8,2231	-8,2380	-8,2383
	EGARCH - Student t	0,010%	0,019%	0,019%	0,013%	-8,2762	-8,2762	-8,2478	-8,2478	-8,2656	-8,2655
	Without adjustment	0,012%	0,023%	0,023%	0,013%						
4. XMEU GY db x-trackers	**GJR - Normal**	0,018%	0,112%	0,111%	0,081%	-7,8890	-7,8916	-7,8712	-7,8738	-7,8824	-7,8851
	GJR - Student t	0,018%	0,109%	0,109%	0,080%	-7,9016	-7,9045	-7,8808	-7,8838	-7,8939	-7,8969
	EGARCH - Normal	0,020%	0,113%	0,113%	0,084%	-7,8922	-7,8949	-7,8744	-7,8771	-7,8856	-7,8883
	EGARCH - Student t	0,019%	0,112%	0,112%	0,085%	-7,9056	-7,9085	-7,8849	-7,8877	-7,8980	-7,9008
	Without adjustment	0,025%	0,169%	0,169%	0,118%						
5. H4ZE GY HSBC	**GJR - Normal**	0,029%	0,042%	0,042%	0,028%	-8,3339	-8,3344	-8,3042	-8,3046	-8,3226	-8,3230
	GJR - Student t	0,027%	0,040%	0,040%	0,026%	-8,3580	-8,3584	-8,3232	-8,3237	-8,3448	-8,3452
	EGARCH - Normal	0,032%	0,047%	0,046%	0,031%	-8,3255	-8,3258	-8,2957	-8,2960	-8,3142	-8,3145
	EGARCH - Student t	0,030%	0,047%	0,047%	0,032%	-8,3609	-8,3612	-8,3262	-8,3265	-8,3477	-8,3480
	Without adjustment	0,040%	0,056%	0,056%	0,035%						

Table 6 – Tracking errors – Emerging Markets Broad.
This table contains the results from the four methods used to calculate tracking error – the average of the absolute differences in returns (TE1), the standard deviation of returns differences (TE2), the standard error of regression (TE3) and the semi-standard deviation (TE4) – using unadjusted volatility returns and adjusted volatility returns through two types of asymmetric GARCH models (EGARCH and GJR) and 2 alternative distributional functions for the error term (student's t and normal distribution). In order to select the best model, we present the 3 most used information criteria: Akaike info criterion, Schwarz criterion and Hannan.Quinn criterion. To facilitate the analysis, green is for the best model and red is for the worst model.

		TE1	TE2	TE3	TE4	Akaike info criterion		Schwarz criterion		Hannan-Quinn criterion	
						Fund	Index	Fund	Index	Fund	Index
1. EUNM GY iShares	**GJR - Normal**	0,979%	1,317%	1,230%	0,969%	-8,6424	-8,6013	-8,5941	-8,5530	-8,6235	-8,5824
	GJR - Student t	0,999%	1,349%	1,245%	0,997%	-8,6399	-8,6049	-8,5836	-8,5485	-8,6179	-8,5828
	EGARCH - Normal	1,006%	1,363%	1,260%	0,997%	-8,6356	-8,5855	-8,5873	-8,5372	-8,6167	-8,5666
	EGARCH - Student t	1,038%	1,418%	1,281%	1,050%	-8,6333	-8,5923	-8,5770	-8,5360	-8,6113	-8,5703
	Without adjustment	0,955%	1,293%	1,262%	0,946%						
2. LYXLEM GY Lyxor	**GJR - Normal**	0,980%	1,323%	1,200%	0,950%	-8,4239	-8,3788	-8,3904	-8,3453	-8,4111	-8,3659
	GJR - Student t	0,969%	1,317%	1,214%	0,948%	-8,4262	-8,3851	-8,3872	-8,3461	-8,4113	-8,3702
	EGARCH - Normal	1,091%	1,478%	1,297%	1,074%	-8,4084	-8,3635	-8,3749	-8,3300	-8,3955	-8,3506
	EGARCH - Student t	1,074%	1,471%	1,319%	1,075%	-8,4131	-8,3740	-8,3741	-8,3349	-8,3982	-8,3590
	Without adjustment	1,075%	1,470%	1,445%	1,055%						
3. AMEM GY Amundi	**GJR - Normal**	0,996%	1,338%	1,237%	0,958%	-8,3998	-8,3616	-8,3697	-8,3315	-8,3883	-8,3502
	GJR - Student t	0,992%	1,336%	1,241%	0,960%	-8,4026	-8,3661	-8,3674	-8,3310	-8,3892	-8,3528
	EGARCH - Normal	1,096%	1,472%	1,293%	1,057%	-8,3908	-8,3509	-8,3607	-8,3207	-8,3793	-8,3394
	EGARCH - Student t	1,085%	1,465%	1,304%	1,055%	-8,3949	-8,3580	-8,3598	-8,3228	-8,3815	-8,3446
	Without adjustment	1,170%	1,596%	1,569%	1,132%						
4. XMEM GY db x-trackers	**GJR - Normal**	0,023%	0,058%	0,055%	0,044%	-7,8113	-7,8141	-7,7928	-7,7956	-7,8045	-7,8073
	GJR - Student t	0,022%	0,055%	0,052%	0,043%	-7,8399	-7,8426	-7,8184	-7,8211	-7,8320	-7,8347
	EGARCH - Normal	0,024%	0,059%	0,056%	0,046%	-7,8072	-7,8072	-7,7887	-7,7915	-7,8004	-7,8031
	EGARCH - Student t	0,022%	0,069%	0,053%	0,050%	-7,8397	-7,8425	-7,8182	-7,8210	-7,8318	-7,8345
	Without adjustment	0,032%	0,085%	0,080%	0,067%						
5. H410 GY HSBC	**GJR - Normal**	0,239%	0,332%	0,332%	0,248%	-8,3720	-8,3752	-8,3351	-8,3382	-8,3578	-8,3609
	GJR - Student t	0,242%	0,338%	0,338%	0,253%	-8,3733	-8,3768	-8,3302	-8,3337	-8,3567	-8,3602
	EGARCH - Normal	0,238%	0,331%	0,327%	0,249%	-8,3646	-8,3668	-8,3277	-8,3298	-8,3504	-8,3526
	EGARCH - Student t	0,249%	0,348%	0,341%	0,262%	-8,3669	-8,3698	-8,3238	-8,3267	-8,3503	-8,3532
	Without adjustment	0,266%	0,366%	0,366%	0,264%						

Table 7 – Tracking errors – Emerging Markets Asia.
This table contains the results from the four methods used to calculate tracking error – the average of the absolute differences in returns (TE1), the standard deviation of returns differences (TE2), the standard error of regression (TE3) and the semi-standard deviation (TE4) – using unadjusted volatility returns and adjusted volatility returns through two types of asymmetric GARCH models (EGARCH and GJR) and 2 alternative distributional functions for the error term (student's t and normal distribution). In order to select the best model, we present the 3 most used information criteria: Akaike info criterion, Schwarz criterion and Hannan.Quinn criterion. To facilitate the analysis, green is for the best model and red is for the worst model.

		TE1	TE2	TE3	TE4	Akaike info criterion		Schwarz criterion		Hannan-Quinn criter.	
						Fund	Index	Fund	Index	Fund	Index
1. CEBL GY iShares	**GJR - Normal**	0,327%	0,466%	0,423%	0,336%	-8,0394	-8,0224	-8,0106	-7,9936	-8,0285	-8,0114
	GJR - Student t	0,331%	0,470%	0,426%	0,339%	-8,0409	-8,0241	-8,0073	-7,9905	-8,0282	-8,0113
	EGARCH - Normal	0,316%	0,467%	0,441%	0,336%	-8,0360	-8,0185	-8,0072	-7,9897	-8,0251	-8,0076
	EGARCH - Student t	0,326%	0,477%	0,447%	0,343%	-8,0380	-8,0206	-8,0044	-7,9870	-8,0252	-8,0079
	Without adjustment	0,310%	0,507%	0,502%	0,367%						
2. LYXAPX GY Lyxor	**GJR - Normal**	0,837%	1,122%	1,105%	0,805%	-8,4704	-8,4482	-8,4287	-8,4066	-8,4542	-8,4321
	GJR - Student t	0,842%	1,133%	1,111%	0,818%	-8,4747	-8,4566	-8,4261	-8,4080	-8,4558	-8,4378
	EGARCH - Normal	0,853%	1,148%	1,123%	0,826%	-8,4700	-8,4429	-8,4284	-8,4013	-8,4539	-8,4268
	EGARCH - Student t	0,879%	1,182%	1,143%	0,853%	-8,4725	-8,4512	-8,4239	-8,4026	-8,4536	-8,4324
	Without adjustment	0,919%	1,236%	1,216%	0,887%						
3. AMEA GY Amundi	**GJR - Normal**	0,875%	1,216%	1,197%	0,868%	-8,4100	-8,3853	-8,3549	-8,3301	-8,3883	-8,3635
	GJR - Student t	0,876%	1,221%	1,202%	0,874%	-8,4074	-8,3871	-8,3431	-8,3227	-8,3820	-3,3617
	EGARCH - Normal	0,899%	1,278%	1,279%	0,900%	-8,4201	-8,3937	-8,3650	-8,3385	-8,3984	-8,3719
	EGARCH - Student t	0,907%	1,286%	1,282%	0,906%	-8,4165	-8,3955	-8,3522	-8,3311	-8,3912	-8,3701
	Without adjustment	0,876%	1,211%	1,193%	0,882%						
4. XMAS GY db x-trackers	**GJR - Normal**	0,018%	0,024%	0,016%	0,024%	-7,5487	-7,5510	-7,5306	-7,5329	-7,5420	-7,5443
	GJR - Student t	0,018%	0,024%	0,016%	0,024%	-7,5575	-7,5597	-7,5363	-7,5386	-7,5497	-7,5519
	EGARCH - Normal	0,019%	0,025%	0,017%	0,024%	-7,5453	-7,5476	-7,5272	-7,5294	-7,5386	-7,5409
	EGARCH - Student t	0,019%	0,025%	0,017%	0,024%	-7,5552	-7,5575	-7,5340	-7,5363	-7,5474	-7,5496
	Without adjustment	0,025%	0,032%	0,021%	0,031%						
5. H4ZI GY HSBC	**GJR - Normal**	0,161%	0,453%	0,452%	0,333%	-7,9244	-7,9387	-7,8940	-7,9084	-7,9128	-7,9272
	GJR - Student t	0,161%	0,455%	0,455%	0,335%	-7,9292	-7,9420	-7,8938	-7,9066	-7,9157	-7,9286
	EGARCH - Normal	0,168%	0,453%	0,453%	0,337%	-7,9192	-7,9317	-7,8888	-7,9014	-7,9076	-7,9202
	EGARCH - Student t	0,171%	0,459%	0,459%	0,343%	-7,9247	-7,9362	-7,8893	-7,9008	-7,9112	-7,9227
	Without adjustment	0,182%	0,477%	0,477%	0,343%						

Table 8 – Tracking errors – Emerging Markets Latin America.
This table contains the results from the four methods used to calculate tracking error – the average of the absolute differences in returns (TE1), the standard deviation of returns differences (TE2), the standard error of regression (TE3) and the semi-standard deviation (TE4) – using unadjusted volatility returns and adjusted volatility returns through two types of asymmetric GARCH models (EGARCH and GJR) and 2 alternative distributional functions for the error term (student's t and normal distribution). In order to select the best model, we present the 3 most used information criteria: Akaike info criterion, Schwarz criterion and Hannan.Quinn criterion. To facilitate the analysis, green is for the best model and red is for the worst model.

		TE1	TE2	TE3	TE4	Akaike info criterion		Schwarz criterion		Hannan-Quinn criter.	
						Fund	Index	Fund	Index	Fund	Index
1. CEBD GY iShares	**GJR - Normal**	0,050%	0,204%	0,117%	0,188%	-7,8376	-7,8357	-7,8084	-7,8064	-7,8265	-7,8246
	GJR - Student t	0,046%	0,184%	0,182%	0,168%	-7,8541	-7,8522	-7,8200	-7,8182	-7,8412	-7,8393
	EGARCH - Normal	0,044%	0,121%	0,119%	0,092%	-7,8370	-7,8348	-7,8078	-7,8056	-7,8260	-7,8237
	EGARCH - Student t	0,045%	0,124%	0,114%	0,094%	-7,8518	-7,8496	-7,8177	-7,8156	-7,8388	-7,8367
	Without adjustment	0,039%	0,117%	0,115%	0,087%						
2. LYXLTM GY Lyxor	**GJR - Normal**	1,302%	1,735%	1,666%	1,248%	-7,8195	-7,8354	-7,7871	-7,8030	-7,8071	-7,8230
	GJR - Student t	1,165%	1,540%	1,436%	1,104%	-7,8344	-7,8519	-7,7966	-7,8141	-7,8200	-7,8374
	EGARCH - Normal	1,320%	1,789%	1,726%	1,301%	-7,8211	-7,8316	-7,7887	-7,7992	-7,8087	-7,8192
	EGARCH - Student t	1,207%	1,635%	1,579%	1,186%	-7,8326	-7,8476	-7,7948	-7,8098	-7,8182	-7,8332
	Without adjustment	1,113%	1,532%	1,528%	1,095%						
3. AMEL GY Amundi	**GJR - Normal**	0,869%	1,153%	1,070%	0,829%	-7,8791	-7,8472	-7,8239	-7,7921	-7,8573	-7,8255
	GJR - Student t	0,969%	1,256%	1,041%	0,907%	-7,8760	-7,8451	-7,8116	-7,7808	-7,8506	-7,8198
	EGARCH - Normal	0,860%	1,177%	1,155%	0,862%	-7,8308	-7,8056	-7,7757	-7,7505	-7,8091	-7,7839
	EGARCH - Student t	0,868%	1,187%	1,159%	0,868%	-7,8302	-7,8064	-7,7659	-7,7420	-7,8049	-7,7810
	Without adjustment	0,867%	1,200%	1,187%	0,875%						
4. XMLA GY db x-trackers	**GJR - Normal**	0,031%	0,086%	0,082%	0,066%	-7,2865	-7,2895	-7,2683	-7,2714	-7,2798	-7,2828
	GJR - Student t	0,030%	0,086%	0,081%	0,066%	-7,3027	-7,3058	-7,2815	-7,2846	-7,2949	-7,2980
	EGARCH - Normal	0,031%	0,088%	0,083%	0,069%	-7,2784	-7,2813	-7,2603	-7,2631	-7,2717	-7,2746
	EGARCH - Student t	0,031%	0,088%	0,082%	0,068%	-7,2972	-7,3002	-7,2760	-7,2790	-7,2894	-7,2923
	Without adjustment	0,029%	0,087%	0,082%	0,066%						
5. H4ZW GY HSBC	**GJR - Normal**	0,065%	0,142%	0,140%	0,109%	-7,7558	-7,7574	-7,7224	-7,7240	-7,7430	-7,7446
	GJR - Student t	0,059%	0,131%	0,130%	0,101%	-7,7702	-7,7721	-7,7313	-7,7332	-7,7553	-7,7572
	EGARCH - Normal	0,066%	0,146%	0,144%	0,112%	-7,7551	-7,7562	-7,7217	-7,7229	-7,7423	-7,7435
	EGARCH - Student t	0,064%	0,141%	0,139%	0,109%	-7,7677	-7,7691	-7,7288	-7,7302	-7,7528	-7,7542
	Without adjustment	0,054%	0,117%	0,116%	0,088%						

6. Conclusions

In this dissertation we analyze the tracking ability of Exchange Traded Funds that are domiciled in Europe, traded on the Deutsche Börse Xetra – Frankfurt Stock Exchange and offer exposure to the global emerging markets.

Overall, the empirical findings on this dissertation are in line with those reported in the literature for other ETF markets. Like Frino and Galagher (2001), Kostovetsky (2003) and Elia (2012), we can conclude that GEM ETF present substantially high values for tracking error and that they do not fully replicate their benchmarks. From these funds we find, based on TE measures that the ones that mimic the emerging markets from different parts of the world seem to be the worst into track their benchmark.

Moreover, like Maister *et al.* (2010), Chu (2011) and Blitz *et al.* (2012), we also conclude that ETF that follow developed markets indexes present better tracking abilities than the ones that track global emerging markets indexes: the first funds exhibit always values for TE smaller than 0.2% unlike the second funds, which present values between 0.016% and 1.789%. The only exceptions are the funds from "db x-trackers", where the conclusion is the opposite, which we relate with the replication method of developed market ETF (is the only with full replication method between Deutsch Bank funds considered in this dissertation). Applying regression analysis, we also find that GEM ETF present values for beta close to the objective beta and, in most of cases, not statistically alphas (although five funds present statistically negative alphas, these are very close to zero).

From the developed markets ETF, "Amundi" is the provider that presents the smallest values for TE, unlike "db x-trackers" which presents the highest values. The conclusions about emerging markets ETF are exactly the opposite: the funds from "Deutsche Bank" present the smallest values for TE in contrast to funds from "Amundi" and "Lyxor", which have the higher values.

The inclusion of four different models to study the volatility allow us to say that the best models to explain the movements of returns according to information criteria are, in the case of developed markets ETF the *student t* EGARCH (1,1) model and, in the case of emerging markets, the *student t* GJR (1,1) model.

However, our results contribute new evidence about the adjustment of volatility on ETF: in 86% of the cases the results that we reach about TE are the same if we consider volatility adjustment returns or unadjusted volatility returns[23]. This allows us to say that, if we want to make a correct analysis of returns, we should always consider the volatility adjustment but, if we are only interested on the results, the conclusions of unadjusted returns are sufficient.

As a final note, the sample period of the data used is different for all ETF which is justified by different inceptions dates and also by the fact that some funds started to track its current benchmarks (total return indexes) after its inception. This has limited our study in terms of homogeneity since our conclusions may be different if we had the same lifetime for each ETF. With this in mind, we suggest a future investigation about this topic, but using the same sample period for all funds, and if it is possible with a higher number of observations.

Additionally, as topic for a new empirical investigation we suggest an analysis of actively managed ETF commercialized in Europe. This type of funds has been growing in recent years, suggesting that investors want to obtain higher returns than the market. With the excess of supply of passively managed products, it makes sense to study whether it is worth investing in this type of product or not.

[23] The conclusions are not the same in 14 situations: see annex 2.

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Annex 1 – Conclusions about tracking error based on different measurers and different GARCH models. This table should be analyzed horizontally. In each situation we have first the fund from a specific provider with the smallest TE and lastly the fund from the same provider with the highest TE (in the first case, Latin ETF are the ones with smallest TE followed by DM, Asia and Broad for iShares ETF). We have in red all 15 situations where the conclusions that we have taking into account a specific TE measure is different from other conclusions if we assume other measures (for instance, for iShares ETF using "without adjustment", we see that we have always the same result for TE2, TE3 and TE4; however, the result with TE1 is different).

		TE1		TE2		TE3		TE4
Without adj.	iShares	LATIN, DM,ASIA,BROAD	iShares	DM,LATIN,ASIA,BROAD	iShares	DM,LATIN,ASIA,BROAD	iShares	DM,LATIN,ASIA,BROAD
	Lyxor	DM,ASIA,BROAD,LATIN	Lyxor	DM,ASIA,BROAD,LATIN	Lyxor	DM,ASIA,BROAD,LATIN	Lyxor	DM,ASIA,BROAD,LATIN
	Amundi	DM,LATIN,ASIA,BROAD	Amundi	DM,LATIN,ASIA,BROAD	Amundi	DM,LATIN,ASIA,BROAD	Amundi	DM,LATIN,ASIA,BROAD
	DB	DM,ASIA,LATIN,BROAD	DB	ASIA,BROAD,LATIN,DM	DB	ASIA,BROAD,LATIN,DM	DB	ASIA,LATIN,BROAD,DM
	HSBC	DM,LATIN,ASIA,BROAD	HSBC	DM,LATIN,BROAD,ASIA	HSBC	DM,LATIN,BROAD,ASIA	HSBC	DM,LATIN,BROAD,ASIA

		TE1		TE2		TE3		TE4
GJR Normal	iShares	DM,LATIN,ASIA,BROAD	iShares	DM,LATIN,ASIA,BROAD	iShares	DM,LATIN,ASIA,BROAD	iShares	DM,LATIN,ASIA,BROAD
	Lyxor	DM,ASIA,BROAD,LATIN	Lyxor	DM,ASIA,BROAD,LATIN	Lyxor	DM,ASIA,BROAD,LATIN	Lyxor	DM,ASIA,BROAD,LATIN
	Amundi	DM,LATIN,ASIA,BROAD	Amundi	DM,LATIN,ASIA,BROAD	Amundi	DM,LATIN,ASIA,BROAD	Amundi	DM,LATIN,ASIA,BROAD
	DB	DM,ASIA,BROAD,LATIN	DB	ASIA,BROAD,LATIN,DM	DB	ASIA,BROAD,LATIN,DM	DB	ASIA,BROAD,LATIN,DM
	HSBC	DM,LATIN,ASIA,BROAD	HSBC	DM,LATIN,BROAD,ASIA	HSBC	DM,LATIN,BROAD,ASIA	HSBC	DM,LATIN,BROAD,ASIA

		TE1		TE2		TE3		TE4
GJR - Student t	iShares	DM,LATIN,ASIA,BROAD	iShares	DM,LATIN,ASIA,BROAD	iShares	DM,LATIN,ASIA,BROAD	iShares	DM,LATIN,ASIA,BROAD
	Lyxor	DM,ASIA,BROAD,LATIN	Lyxor	DM,ASIA,BROAD,LATIN	Lyxor	DM,ASIA,BROAD,LATIN	Lyxor	DM,ASIA,BROAD,LATIN
	Amundi	DM,ASIA,BROAD,LATIN	Amundi	DM,ASIA,BROAD,LATIN	Amundi	DM,LATIN,ASIA,BROAD	Amundi	DM,ASIA,LATIN,BROAD
	DB	ASIA,DM,BROAD,LATIN	DB	ASIA,BROAD,LATIN,DM	DB	ASIA,BROAD,LATIN,DM	DB	ASIA,BROAD,LATIN,DM
	HSBC	DM,LATIN,ASIA,BROAD	HSBC	DM,LATIN,BROAD,ASIA	HSBC	DM,LATIN,BROAD,ASIA	HSBC	DM,LATIN,BROAD,ASIA

		TE1		TE2		TE3		TE4
EGARCH - Normal	iShares	LATIN, DM,ASIA,BROAD	iShares	DM,LATIN,ASIA,BROAD	iShares	DM,LATIN,ASIA,BROAD	iShares	DM,LATIN,ASIA,BROAD
	Lyxor	DM,ASIA,BROAD,LATIN	Lyxor	DM,ASIA,BROAD,LATIN	Lyxor	DM,ASIA,BROAD,LATIN	Lyxor	DM,ASIA,BROAD,LATIN
	Amundi	DM,LATIN,ASIA,BROAD	Amundi	DM,LATIN,ASIA,BROAD	Amundi	DM,LATIN,ASIA,BROAD	Amundi	DM,LATIN,ASIA,BROAD
	DB	ASIA,DM,BROAD,LATIN	DB	ASIA,BROAD,LATIN,DM	DB	ASIA,BROAD,LATIN,DM	DB	ASIA,BROAD,LATIN,DM
	HSBC	DM,LATIN,ASIA,BROAD	HSBC	DM,LATIN,BROAD,ASIA	HSBC	DM,LATIN,BROAD,ASIA	HSBC	DM,LATIN,BROAD,ASIA

		TE1		TE2		TE3		TE4
EGARCH - Student t	iShares	DM,LATIN,ASIA,BROAD	iShares	DM,LATIN,ASIA,BROAD	iShares	DM,LATIN,ASIA,BROAD	iShares	DM,LATIN,ASIA,BROAD
	Lyxor	DM,ASIA,BROAD,LATIN	Lyxor	DM,ASIA,BROAD,LATIN	Lyxor	DM,ASIA,BROAD,LATIN	Lyxor	DM,ASIA,BROAD,LATIN
	Amundi	DM,LATIN,ASIA,BROAD	Amundi	DM,LATIN,ASIA,BROAD	Amundi	DM,LATIN,ASIA,BROAD	Amundi	DM,LATIN,ASIA,BROAD
	DB	DM,ASIA,BROAD,LATIN	DB	ASIA,BROAD,LATIN,DM	DB	ASIA,BROAD,LATIN,DM	DB	ASIA,BROAD,LATIN,DM
	HSBC	DM,LATIN,ASIA,BROAD	HSBC	DM,LATIN,BROAD,ASIA	HSBC	DM,LATIN,BROAD,ASIA	HSBC	DM,LATIN,BROAD,ASIA

Annex 2 – Comparison between results if we use volatility unadjusted returns Vs volatility adjusted returns. To understand this annex, we should analyze annex 1 vertically. The TRUE means that the conclusions that we reach with volatility unadjusted returns are the same if we assume the adjustment of volatility. The FALSE means the opposite. For instance, for the case of **TE1 – GJR Normal** for iShares we have a FALSE because for **unadjusted returns** we have LATIN, DM, ASIA, BROAD, and for **adjusted returns - GJR normal model** we have DM, LATIN, ASIA, BROAD.

Unajus. Ret. Vs GJR Normal	TE1	TE2	TE3	TE4
iShares	FALSE	TRUE	TRUE	TRUE
Lyxor	TRUE	TRUE	TRUE	TRUE
Amundi	TRUE	TRUE	TRUE	TRUE
DB	FALSE	TRUE	TRUE	FALSE
HSBC	TRUE	TRUE	TRUE	TRUE

Unajus. Ret. Vs GJR Student t	TE1	TE2	TE3	TE4
iShares	FALSE	TRUE	TRUE	TRUE
Lyxor	TRUE	TRUE	TRUE	TRUE
Amundi	FALSE	FALSE	TRUE	FALSE
DB	FALSE	TRUE	TRUE	FALSE
HSBC	TRUE	TRUE	TRUE	TRUE

Unajus. Ret. Vs EGARCH - Normal	TE1	TE2	TE3	TE4
iShares	TRUE	TRUE	TRUE	TRUE
Lyxor	TRUE	TRUE	TRUE	TRUE
Amundi	TRUE	TRUE	TRUE	TRUE
DB	FALSE	TRUE	TRUE	FALSE
HSBC	TRUE	TRUE	TRUE	TRUE

Unajus. Ret. Vs EGARCH - Student	TE1	TE2	TE3	TE4
iShares	FALSE	TRUE	TRUE	TRUE
Lyxor	TRUE	TRUE	TRUE	TRUE
Amundi	TRUE	TRUE	TRUE	TRUE
DB	FALSE	TRUE	TRUE	FALSE
HSBC	TRUE	TRUE	TRUE	TRUE