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Testing Weak-Form Efficiency of Exchange Traded Funds Market

Gerasimos G. Rompotis

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Abstract

In this paper we assess the weak-form efficiency of Exchange Traded Funds market applying various parametric and non-parametric tests. The parametric tests performed concern serial correlation tests and Augmented Dickey-Fuller (ADF) unit root test while the non-parametric tests used is the Phillips-Peron (PP) unit root test. To assess ETF market efficiency, we employ full daily return historical data of a sample of 66 equity-linked ETFs traded in the U.S. stock over the period 2001-2010. The performed tests provide evidence on the fact that the efficient market hypothesis holds in the ETF market. In particular, the majority of serial correlation tests show the lack of such an issue in the time series of ETF returns, which is a prerequisite in order for the efficient market hypothesis to be verified. Moreover, both the parametric and non-parametric unit root tests adopted reveal the non-existence of such an issue with respect to the pricing of ETFs and, therefore, the weak-form of the efficient market hypothesis seems not to be infringed in the U.S. ETF market.

Keywords:

ETFs, Market efficiency, Weak-forms.

JEL classification:

G14.

Gerasimos G. Rompotis ✉ Senior Auditor-KPMG Greece. Researcher-National and Kapodistrian University of Athens, Greece. 25 Ypsilantou Street. Peristeri, Athens, Greece. GR 12131 +0030 210 5776510. grompotis@kpmg.gr

1. Introduction

Three types of efficiency in capital markets are described in the finance literature; namely operational efficiency, informational efficiency and allocation efficiency. Operational efficiency requires that participants can carry out transactions and receive services at prices which are in line with the actual costs required to provide them. The operationally-efficient market assumption is satisfied when financial intermediaries are competitive enough. The informationally-efficient market hypothesis (or efficient market hypothesis-EMH) asserts that the prices of traded assets already reflect all known information and instantly change to reflect new information. Therefore, theoretically, it is impossible for an investor to consistently outperform the market by using any information that the market already knows and any records of outperformance are attributed to luck. Information or news in the EMH is defined as anything that may affect prices that is unknowable in the present and thus appears randomly in the future. Allocation efficiency implies that capital is allocated in a way that benefits all participants. In order for a market to be allocationally efficient, it must be both informationally and operationally efficient. As a result, the prices of securities are adjusted according to their risk, that is securities with the same level of risk will offer the same expected return.

In general, EMH requires that agents have rational expectations and whenever new relevant information appears, the agents update their expectations appropriately. EMH allows that when faced with new information, some investors may overreact and some may underreact. All that is required by the EMH is that investors' reactions be random and follow a normal distribution pattern so that the net effect on market prices cannot be reliably exploited to make an abnormal profit. Therefore, although there might be individual investors that are wrong about the market, the market as a whole is always right.

When all the available publicly information is reflected in the prices of securities, three patterns must be traced in the relevant securities market. The first trait has to do with the return predictability. In particular, the difference between realized returns and expected returns should not be predictable. Moreover, investors should not be able to predict when markets produce abnormally high or low returns and which stocks will have abnormally high or low returns during a subsequent period. The second trait of an efficient market concerns the link between the capital market and the real economy. More specifically, if an entity's performance and profitability are highly sensitive to a particular macroeconomic variable or a governmental decision, and if this variable or decision affects large segments of the economy, then the company's share should earn a risk premium to compensate investors for this non-diversifiable risk. In other words, the sensitivity to pervasive risks in the real economy should be reflected in stock prices. The third pattern of an efficient capital market regards the lack of persistence in stocks' performance. The lack of performance persistence implies that professional fund managers should not be able to consistently earn high returns by analyzing financial information. In an informationally efficient market all the information is already reflected in securities prices and, therefore, gathering and analyzing the available information should not provide a reliable payoff for investors.

In 1970, Fama proposed three types of informational efficiency for capital markets, i.e., weak-form efficiency, semi-strong-form efficiency and strong-form efficiency. Each of these forms has different implications for how markets work. In weak-form efficiency, the prices of a security perfectly reflect all the information contained in its historical prices and, thus, future prices cannot be predicted by historical prices and excess returns cannot be earned in the long run by applying investment strategies based on historical data. In addition, share prices exhibit no serial dependencies, meaning that there are no "patterns" to asset prices. This implies that future price movements are determined entirely by information not contained in the price series and, hence, prices must follow a random walk. In the semi-strong-form efficiency, share prices adjust to all publicly available new information very rapidly and in an unbiased manner, such that no excess returns can be earned by trading on that information. Semi-strong-form efficiency implies that no analysis (neither fundamental analysis nor technical analysis techniques), will be able to reliably produce excess returns. In the strong-form of efficiency, share prices reflect all information, either it is publicly available or not, and no one can achieve excess returns on the basis of inside knowledge or any other sources of information. Capital markets are difficult to be efficient at the strong-form level because, usually, there are legal barriers and insider trading laws to private information becoming public, except in the cases where the laws are universally ignored. It should be noted that if a market is efficient at the semi-strong level, it will be efficient at the weak-level too. In addition, if a market is efficient at the strong-form, it will be efficient at the semi-strong level. These relationships do not hold vise-versa.

Fama (1991) revised the work of efficient market hypothesis by proposing three alternative categories of efficiency. The weak-form is replaced with the tests for return predictability, in which along with the tests of return predictability using historical data other factors such us dividend yields, interests rates, size effects and seasonal effects such as the January effect are considered too. For the semi-strong and strong form of efficiency, the author proposes new titles without proposing changes to the nature of tests and their coverage. In particular, he uses the title event studies instead of using the semi-strong tests of stock price adjustments to public announcements. Finally, the title tests for private information is a substitute for the strong-form of efficiency.

In this paper we perform various parametric and non-parametric tests to assess the weak-form efficiency of Exchange Traded Funds market (hereafter ETFs). Parametric tests include serial correlation tests and Augmented Dickey-Fuller (ADF) unit root test. Non parametric tests used is the Phillips-Peron (PP) unit root test. All the tests are performed on a sample of 66 equity-linked ETFs traded in the U.S. stock market while the available data covers the full historical daily net asset values (NAV) of the selected ETFs during the period 2001-2010. Overall, the results of the tests reveal strong evidence of efficiency in ETFs market at the weak-form level. In particular, the majority of serial correlation tests used demonstrate that pricing of the majority of the sample's ETFs is efficient while only the autocorrelation test provides evidence of inefficiency for the ETF market. Moreover, both the parametric and non-parametric tests on the existence of unit roots in ETF return time series, which would indicate that there are inefficient patterns in the examined market, reveal the lack of such unit roots and, consequently, the existence of weak-form efficiency in the pricing of U.S. ETFs.

The rest of the paper is organized as follows: Section 2 provides a very brief analysis of the literature's findings with respect to the weak-form efficiency of capital markets. It also describes the main criticism on the efficient market hypothesis and the various findings of the literature in regards of the behavior of investors or stock prices which support the belief of a major part of the investing community that the capital markets are not efficient. Section 3 describes the methodology employed to test the weak-from efficiency of ETF market. Section 4 analyzes the data used in this study and provides information on the profiles of the sample and some descriptive statistics. Section 5 discusses the results of the applied tests on the efficiency of the examined sample of ETFs. Summary and conclusions are offered in the last Section 6.

2. Literature Review

The capital markets efficiency hypothesis is based on the work of Samuelson (1965), who developed the theoretical framework of the Random Walk Model (RWM), which suggests that the successive price changes are independent and identically distributed variables and, therefore, future price movements cannot be predicted on the basis of historical price changes. In addition, the work of Fama (1965) set the start point for studying the efficiency of capital markets.

In regards of the efficiency of the developed capital markets, the literature has revealed that, in general, these markets are sufficiently efficient, mainly due to the low degree of dependence in the historical return records of securities. In this respect, articles such as these of Fama (1965) and Sharpe (1966) examine the price behaviour of U.S. listed stocks finding that the historical prices are not indicative of future price fluctuations and, therefore, the price changes follow a random walk. Similar findings on U.K. market are offered by Hudson et al. (1994), Evans (2006), and Sung and Johnson (2006). Finally, Hawawini and Michel (1984) examine European stock markets and conclude that these markets are efficient at the weak level.

On the question of efficiency in small and emerging markets, the findings of the literature demonstrate that these markets are easy to control while they suffer from thin trading. Therefore, these markets are basically informationally inefficient. The inefficiency of the developing markets at the weak level has been accentuated by numerous studies, such as these of Barnes (1986), Buttler and Malaikah (1992), Dickinson and Muragu (1994), and Omran and Farrar (2006).

The hypothesis of efficient capital markets has been widely questioned in the finance literature. Malkiel (2003) provides a thorough review of the criticism on stock market efficiency hypothesis and the relationship between predictable stock returns and efficiency. One of the critics described concerns the short-term momentum in stock prices, which suggests that the short-run serial correlations between successive stock prices are not zero and drive to underreaction to new information. This critic is supported by Cootner (1964), Lo and MacKinlay (1999), and Lo et al. (2000). Going further, Malkiel (2003) refers to the research on various psychological patterns such as overconfidence, overreaction, representative bias, information bias, and various other predictable human errors conducted by behavioral economists [e.g. Shiller (2000)] which cause the violation of EMH. These psychological patterns relate to the short-term momentum which results in the investors' under or overreaction to raised news. In Malkiel's analysis, studies such as those of Fama and French (1988), Debondt and Thaler (1995) and Kahneman and Tversky (1973) on long-run "overreaction" and predicted return reversals are referred to. Another key-critic discussed by Malkiel (2003) concerns the seasonal patterns observed in stock returns. More specifically, the author refers to the monthly and day-of-the-week seasonality revealed by Keim (1983), Haugen and Lakonishok (1988), and French (1980). The first two studies find that the low capitalization stocks usually present abnormal equally-weighted returns in January, while the article of French documents that stocks presents higher returns on Mondays.

Apart from the anomalies observed with respect to the efficient market hypothesis described in Malkiel (2003), the records of the literature concerning EMH and the skills of managers to time and beat the market or the performance persistence of traded assets are voluminous. When it comes to the ability of professional money managers to predict the cycle of the market or the stocks that will outperform making the EMH fail, the findings of the literature are mixed. In particular, Carhart (1997) finds no significant evidence of skilled or talented fund managers. On the other hand, Jensen (1969) and Elton et al. (1993) reveal that managers who apply stock selection strategies can produce positive superior returns over long-run periods. In addition, Goetzmann and Ibbotson (1994), Grinblatt et al. (1995) and Wermers (1999) also reveal some evidence on successful stock picking, which partially explains the short-run persistence in mutual fund performance. On the question of managers' timing skills, Treynor and Mazuy (1966), Henriksson and Merton (1981), Chang and Lewellen (1984), Graham and Harvey (1996) report limited or non-existent significant market timing ability while Bollen and Busse (2001) and Chance and Hemler (2001) find such evidence.

Beyond the above-normal average returns attributed to stock picking and market timing skills of managers, the literature focus on the short-run or long-run persistence of mutual funds' performance. A number of studies show that although mutual funds deliver negative abnormal returns, relative performance persists. Hendricks, Patel and Zeckhauser (1993) find that the relative performance of no-load, growth-oriented equity funds persists in an one-year evaluation period. Jegadeesh and Titman (1993) reveal a momentum effect on the return of mutual funds, which is expressed via strategies that buy the stocks that have performed well in the past and sell stocks that have performed poorly in the past. According to the authors, these strategies derive material positive returns over three- to twelve-month holding periods. Carhart (1997) confirms that the superior returns of top funds are subject to the momentum effect of Jegadeesh and Titman (1993). The embedment of a momentum factor in Carhart's model makes performance persistence largely dissipates. The only significant persistence not explained regards the strong underperformance displayed by the worst-performing mutual funds, whose underperformance is driven by the persistence of expenses.

3. Methodology

3.1 Hypothesis Development

The purpose of this study is to assess the efficiency of the U.S. ETF market at the weak level. The null hypothesis states that the prices of ETFs follow a random walk and, thus, ETF market is efficient in the weak-form. The null and the alternative hypotheses are expressed as follows:

H_0: The returns in the U.S. ETF market are random over the period of the study.
H_1: The returns in the U.S. ETF market are not random over the period of the study.

Given the findings of the literature on the developed markets described in the previous section of the study [refer to Fama (1965) and Sharpe (1966)], we expect the null hypothesis to be verified.

We examine efficiency using various types of parametric and non-parametric tests extensively used by literature. These tests include serial correlations, which have been used by Kendall (1953), Fama (1965), Fama and French (1988), Lo and MacKinlay (1988), Worthington and Higgs (2006), and Squalli, (2006), and unit root test adopted among others by Worthington and Higgs (2006), Mishra et al. (2009), and Karadagli and Omay (2010).

3.2 Parametric Tests

3.2.1 Autocorrelation Tests

The autocorrelation of a random process describes the correlation between the values of the process at different points in time, as a function of the two times or of the time difference. The autocorrelation is a test for serial dependence in the time series of stock returns which requires the criteria of normal distribution be met. Statistically, the absences of significance in autocorrelation coefficients imply that the return series follow a random walk, which in turn means that the market is efficient at the weak level. The null hypothesis is that the autocorrelation coefficients are equal to zero (the market is efficient) whereas the alternative is that they deviate from zero (the market is inefficient). We estimate autocorrelation for n =1,2,3 lagged return estimates.

3.2.2 Serial Correlation Tests

A common finding in time series regression analysis is that the residuals are correlated with their own lagged values, especially when data of high frequency is used [Pope and Yadav (1994)]. This serial correlation violates the standard assumption of regression theory that disturbances are not correlated with other disturbances as past residuals are not helpful in the prediction of current residuals. The existence of statistically significant estimates of serial correlation implies that the daily returns of ETFs are not independent to their lagged values and, therefore, this market cannot be considered efficient at the weak-level. The lack of significant serial correlation coefficients verifies the null hypothesis of the random walk and the market is efficient.

In this study, in order to estimate serial correlation we, firstly, estimate a third-order Autoregressive Model [AR(3)] for each ETF of the sample. The AR(3) model incorporates the residual from the three past return observations of the ETF into the regression model for the current observation. The AR(3) is expressed by the following equation (1):

$$R_{i.t}=\beta_0+\beta_1 R_{i.t\text{-}1}+\beta_2 R_{i.t\text{-}2}+\beta_3 R_{i.t\text{-}3}+u_{i.t} \qquad (1)$$

where, $R_{i.t\text{-}1}$ is the return of ETF i on day t, $R_{i.t\text{-}1}$ is the return of ETF i on day t-1, $R_{i.t\text{-}2}$ is the return of ETF i on day t-2 and $R_{i.t\text{-}3}$ is the return of ETF i on day t-3.

Having performed model (1), we estimate serial correlation in two fashions. The first one concerns the preparation of a correlogram and the estimation of the corresponding Q-statistics for $n = 1,2,3$ lagged returns. This is a combination of visual and direct test of serial correlation which gives an idea about the order of serial correlation as well as whether there exists serial correlation in regression equation (1). If the coefficients of Q-statistics are insignificant, we will infer that there is no serial dependence in returns of ETFs and, therefore, the market is efficient at the weak-level.

The second serial correlation test we use regards the Breusch-Godfrey Lagrange Multiplier test (LM test) for high orders of serial correlation. The null hypothesis of the LM test is that there is no serial correlation up to lag order p, where p is equal to 1,2,3 in our case. The LM statistic is computed as the number of observations times the R^2 from the test regression (1). The LM test statistic is asymptotically distributed as a χ^2 with p degrees of freedom (p is equal to 1,2,3 in our case). If the null hypothesis is satisfied, we will infer that the U.S. ETF market is efficient at the weak level.

3.2.3 Augmented Dickey-Fuller Unit Root Test

The last parametric test we apply to examine the efficiency of U.S. ETF market is the Augmented Dickey-Fuller Test (ADF) for the existence of a unit root in the return time series of ETFs. Alternatively, this test is used to asses whether the return time series of ETFs are stationary or not. Non-stationarity implies that the prices do not follow a random walk, namely the market is not efficient. In applying the ADF test a critical issue is whether to include other exogenous variables in the test regression. More specifically, we have to choose whether to include a constant, a constant and a linear time trend, or neither in the test regression.

One approach on this selection problem would be to run the test with both a constant and a linear trend since the other two cases are just special cases of this more general specification. However, including irrelevant regressors in the regression reduces the power of the test, possibly concluding that there is a unit root when, in fact, there is none. The general principle is to choose a specification that is a plausible description of the data under both the null and alternative hypotheses. If the series seems to contain a trend (whether deterministic or stochastic), we should include both a constant and a trend in the test regression. If the series does not exhibit any trend and has a nonzero mean, we should only include a constant in the regression, while if the series seems to be fluctuating around a zero mean, you should include neither a constant nor a trend in the test regression. In order to deal with all these theoretical and practical issues when applying the ADF test, we apply three different ADF tests; that is an ADF with an intercept included in the regression model, an ADF tests with both an intercept and a time trend, and an ADF test without any constant or trend regressors and we compare the results of the three distinct tests. The unit root test is carried out under the null and alternative hypotheses:

H_0: The return series of ETF i has a unit root (inefficiency).
H_1: The return series of ETF i has root outside unit circle (efficiency).

If the ADF coefficient is more negative than the MacKinnon critical values for rejection of the hypothesis of a unit root, at the 95 per cent level the null hypothesis of a unit root will be rejected and, thus, ETF market will be efficient at the weak level.

3.3 Non-Parametric Tests

3.3.1 Phillips-Peron Unit Root Test
Phillips-Perron (PP) test is a non-parametric method of controlling for higher-order serial correlation in a series. While the ADF test described above corrects for higher order serial correlation by adding lagged differenced terms on the right-hand side, the PP test makes a correction to the t-statistic of the coefficients from the AR(3) regression mentioned above to account for the serial correlation. The correction is non-parametric since we use an estimate of the spectrum of AR(3) residuals (u) at frequency zero that is robust to heteroskedasticity and autocorrelation of unknown form.

The main similarities between the ADF and PP tests are that they have the same asymptotic distribution and they are compared to the MacKinnon critical values for the rejection of the hypothesis of a unit root. As with the ADF test, we face the same problem about specifying whether to include a constant, a constant and a linear trend, or neither in the test regression. We deal with this dilemma by following the same approach as with the ADF test. Moreover, the PP test requires the specification of the truncation lags for the Newey-West correction, that is, the number of periods of serial correlation to include. We face this problem by using a number of lags which is consistent with the suggestions of Newey-West. The unit root test is carried out under the null and alternative hypotheses:

H_0: The return series of ETF i has a unit root (inefficiency).
H_1: The return series of ETF l has root outside unit circle (efficiency).

If the PP coefficient is more negative than the MacKinnon critical values for rejection of the hypothesis of a unit root, at the 95 per cent level the null hypothesis of a unit root will be rejected and, thus, ETF market will be efficient at the weak level.

4. Data and Statistics

In this paper we examine the efficiency of U.S. ETF market with the view of covering the maximum possible time interval so as to capture both bear and bull trends in the market. The period satisfying this criterion is the ten-year period 2001-2010. It should be pointed out that ETFs experienced a spectacular flourish during the period we examine as before 2001 both the population of ETFs and the assets invested in the ETF market were relatively low as compared to traditional open-ended mutual funds. Going further, we also wanted to spread our investigation on various categories of equity-linked ETFs. That is, the sample should include ETFs invested both in domestic and international capital indexes. Finally, we desired our sample to contain ETFs having sound trading activity. Sound trading activity first reflects the proliferation among investors and second make the respective ETFs be representative enough of the entire ETF market.

The requirements just described were absolutely met by a sample of 66 ETFs invested either in local broad market and sector indexes or indexes from foreign stock markets. In particular, Table 1 shows that the sample consists of 25 broad market ETFs, 19 sector ETFs and 22 internationally allocated ETFs. As the inception dates of ETFs in Table 1 imply, the sample includes the ETFs having the longer trading history among all the ETFs currently available in the entire U.S. market. More specifically, the well-known SPDRS (SPY), which is invested in the S&P 500 Index and was the first ETF to be launched in the States in January 1993, is included in the sample. The most tradable ETF, the Qubes (QQQQ) invested in the Nasdaq-100 index, is also included in the sample of the study. Two other significant ETFs in terms of assets under management and trading activity, the DIAMONDS (DIA) and Mid Cap SPDRS (MDY) invested in the Dow Jones Industrial Average index and S&P 400 index, respectively, are contained in the sample as well. The sector SPDRS are also examined in this study while the majority of the sample's ETFs belong to the family of iShares, which is one of the biggest ETF families. Among iShares there are the progenitor of iShares, the ex-World Equity Benchmark Shares (WEBs) single country funds initially created in 1996 by Morgan Stanley and managed by Barclays under a sub-advisory agreement. When Barclays entered the ETF business on a large scale, Morgan Stanley transferred responsibility for the WEBs, which were renamed iShares MSCI Series upon the transfer to Barclays.

Table A1. **Profiles of ETFs**

Symbol	Name	Category	Inception Date	Expense Ratio
IJJ	iShares S&P MidCap 400/Barra Value Index Fund	Broad	7/24/2000	0.25
DIA	DIAMONDS Trust Series I	Broad	1/13/1998	0.17
IJH	iShares S&P MidCap 400 Index Fund	Broad	5/22/2000	0.20
IJK	iShares S&P MidCap 400/BARRA Growth Index Fund	Broad	7/24/2000	0.25
IJR	iShares S&P SmallCap 600 Index Fund	Broad	5/22/2000	0.20
IJS	iShares Small Cap 600/BARRA Value Index Fund	Broad	7/24/2000	0.25
IJT	iShares Small Cap 600/BARRA Growth Index Fund	Broad	7/24/2000	0.25
IOO	iShares S&P Global 100 Index Fund	Broad	12/05/2000	0.40

IVE	iShares S&P 500/BARRA Value Index Fund	Broad	5/22/2000	0.18
IVV	iShares S&P 500 Index Fund	Broad	5/15/2000	0.09
IVW	iShares S&P 500/BARRA Growth Index Fund	Broad	5/22/2000	0.18
IWB	iShares Russell 1000 Index Fund	Broad	5/15/2000	0.15
IWD	iShares Russell 1000 Value Index Fund	Broad	5/22/2000	0.20
IWF	iShares Russell 1000 Growth Index Fund	Broad	5/22/2000	0.20
IWM	iShares Russell 2000 Index Fund	Broad	5/22/2000	0.20
IWN	iShares Russell 2000 Value Index Fund	Broad	7/24/2000	0.25
IWO	iShares Russell 2000 Growth Index Fund	Broad	7/24/2000	0.25
IWV	iShares Russell 3000 Index Fund	Broad	5/22/2000	0.20
IWW	iShares Russell 3000 Value Index Fund	Broad	7/24/2000	0.25
IWZ	iShares Russell 3000 Growth Index Fund	Broad	7/24/2000	0.25
IYY	iShares Dow Jones U.S. Total Market Index Fund	Broad	06/12/2000	0.20
MDY	MidCap SPDR Trust Series I	Broad	4/27/1995	0.25
OEF	iShares S&P 100 Index Fund	Broad	10/23/2000	0.20
QQQQ	PowerShares QQQ Trust, Series 1	Broad	03/10/1999	0.20
SPY	SPDR Trust Series I	Broad	1/22/1993	0.09
EWA	iShares MSCI Australia Index Fund	International	03/12/1996	0.52
EWC	iShares MSCI Canada Index Fund	International	03/12/1996	0.52
EWD	iShares MSCI Sweden Index Fund	International	03/12/1996	0.51
EWG	iShares MSCI Germany Index Fund	International	03/12/1996	0.52
EWH	iShares MSCI Hong Kong Index Fund	International	03/12/1996	0.52
EWI	iShares MSCI Italy Index Fund	International	03/12/1996	0.52
EWJ	iShares MSCI Japan Index Fund	International	03/12/1996	0.52
EWK	iShares MSCI Belgium Index Fund	International	03/12/1996	0.52
EWL	iShares MSCI Switzerland Index Fund	International	03/12/1996	0.52
EWM	iShares MSCI Malaysia Index Fund	International	03/12/1996	0.52
EWN	iShares MSCI Netherlands Index Fund	International	03/12/1996	0.52
EWO	iShares MSCI Austria Index Fund	International	03/12/1996	0.52
EWP	iShares MSCI Spain Index Fund	International	03/12/1996	0.52
EWQ	iShares MSCI France Index Fund	International	03/12/1996	0.52
EWS	iShares MSCI Singapore Index Fund	International	03/12/1996	0.52
EWT	iShares MSCI Taiwan Index Fund	International	6/20/2000	0.73
EWU	iShares MSCI United Kingdom Index Fund	International	03/12/1996	0.52
EWW	iShares MSCI Mexico Index Fund	International	03/12/1996	0.52
EWY	iShares MSCI South Korea Index Fund	International	05/09/2000	0.63
EWZ	iShares MSCI Brazil Index Fund	International	07/10/2000	0.63
EZU	iShares MSCI EMU Index Fund	International	7/25/2000	0.52
IEV	iShares S&P Europe 350 Index Fund	International	7/25/2000	0.60
IDU	iShares Dow Jones U.S. Utilities Index Fund	Sector	06/12/2000	0.48
IYC	iShares Dow Jones U.S. Consumer Index Fund	Sector	06/12/2000	0.48
IYE	iShares Dow Jones U.S. Oil and Gas Fund	Sector	12/16/1998	0.48

IYF	iShares Dow Jones U.S. Financials Index Fund	Sector	5/22/2000	0.48
IYG	iShares Dow Jones U.S. Financial Services Index Fund	Sector	06/12/2000	0.48
IYH	iShares Dow Jones U.S. Health Care Index Fund	Sector	06/12/2000	0.48
IYJ	iShares Dow Jones U.S. Industrials Index Fund	Sector	06/12/2000	0.48
IYK	iShares Dow Jones U.S. Consumer Goods Index Fund	Sector	06/12/2000	0.48
IYM	iShares Dow Jones U.S. Basic Materials Index	Sector	12/16/1998	0.47
IYR	iShares Dow Jones U.S. Real Estate Index Fund	Sector	12/16/1998	0.48
IYW	iShares Dow Jones U.S. Technology Index Fund	Sector	5/15/2000	0.48
IYZ	iShares Dow Jones U.S. Telecommunications Index Fund	Sector	5/22/2000	0.48
XLB	Select Sector SPDR Fund - Basic Industries	Sector	12/16/1998	0.22
XLF	Select Sector SPDR Fund - Financial	Sector	12/16/1998	0.22
XLI	Select Sector SPDR Fund - Industrial	Sector	12/16/1998	0.22
XLK	Select Sector SPDR Fund - Technology	Sector	12/16/1998	0.22
XLP	Select Sector SPDR Fund - Consumer Staples	Sector	12/16/1998	0.22
XLU	Select Sector SPDR Fund - Utilities	Sector	12/16/1998	0.22
XLV	Select Sector SPDR Fund - Health Care	Sector	12/16/1998	0.22
Average				**0.37**

Date used concerns the daily net asset values of ETFs. The historical net asset values of iShares were gathered from the website of iShares (www.ishares.com). The net asset values of non-iShares ETFs included in the sample are not available on the web. However, the daily closing trading values of these ETFs are available on Nasdaq.com. To estimate their net asset values, we firstly collected the closing trading prices along with the expense ratio of the specific ETFs and we then adjusted these prices to net asset values by subtracting the percentage of expenses described in expense ratio. This adjustment is reasonable as expenses are accounted for by ETFs on a daily basis.

When it comes to the managerial expenses charged by the selected ETFs, Table 1 reports an average expense ratio of 37 basis points (b.p.), which is considered sufficiently low and reflects the cost advantage of passively managed ETFs in general as compared to other active investing products such as open-ended equity mutual funds. Scanning though the individual expense ratios of the sample, we see that the broad market ETFs are the cheapest ones while the ETFs allocated in stocks of foreign capital markets charge the greater costs among the three ETF classes considered.

Table 2 offers the descriptive statistics of the sample. More specifically, the table presents the average and median daily returns of ETFs, the standard deviation of returns, which is a measure of the risk an ETF investor is exposed to, the maximum return scores, and the kurtosis and skewness coefficients of ETFs' return distributions.

Table 2. Descriptives Statistics (in %)

Symbol	Category	Average	Median	Stdev	Min	Max	Kurtosis	Skewness
IJJ	Broad	0.036	0.089	1.495	-11.672	10.111	7.148	-0.169
DIA	Broad	0.012	0.054	1.307	-9.395	13.556	13.521	0.626
IJH	Broad	0.033	0.083	1.484	-10.853	10.455	6.183	-0.135
IJK	Broad	0.031	0.088	1.511	-9.946	10.849	5.119	-0.072
IJR	Broad	0.038	0.083	1.576	-10.961	8.445	4.234	-0.128
IJS	Broad	0.039	0.077	1.649	-12.034	8.849	4.692	-0.101
IJT	Broad	0.036	0.066	1.526	-9.723	8.389	3.670	-0.144
IOO	Broad	0.003	0.040	1.222	-7.091	10.425	7.192	0.055
IVE	Broad	0.008	0.057	1.458	-9.727	11.099	7.529	-0.023
IVV	Broad	0.008	0.062	1.374	-9.009	11.556	8.385	0.095
IVW	Broad	0.007	0.071	1.349	-9.522	12.810	9.241	0.260
IWB	Broad	0.009	0.060	1.380	-9.087	11.647	8.189	0.064
IWD	Broad	0.013	0.055	1.424	-9.708	11.239	9.036	-0.041
IWF	Broad	0.005	0.063	1.420	-9.061	12.046	7.476	0.252
IWM	Broad	0.033	0.066	1.658	-11.818	9.255	4.312	-0.117
IWN	Broad	0.038	0.082	1.670	-12.868	9.111	5.602	-0.129
IWO	Broad	0.027	0.064	1.697	-10.641	10.134	3.196	-0.076
IWV	Broad	0.011	0.060	1.391	-9.239	11.452	7.761	0.036
IWW	Broad	0.015	0.057	1.432	-9.958	10.976	8.671	-0.063
IWZ	Broad	0.007	0.063	1.431	-9.118	11.898	7.007	0.210
IYY	Broad	0.011	0.059	1.387	-9.151	11.490	7.909	0.046
MDY	Broad	0.034	0.091	1.523	-11.656	12.000	8.125	-0.082
OEF	Broad	0.002	0.050	1.366	-8.757	11.210	8.010	0.148
QQQQ	Broad	0.015	0.090	1.888	-8.956	16.842	6.431	0.388
SPY	Broad	0.008	0.063	1.379	-9.845	14.520	11.527	0.320
EWA	International	0.054	0.104	1.697	-14.734	9.177	9.011	-0.810
EWC	International	0.046	0.111	1.553	-13.228	10.782	9.349	-0.557
EWD	International	0.042	0.050	2.065	-10.000	15.073	4.759	0.297
EWG	International	0.023	0.074	1.743	-9.123	12.158	5.226	0.153
EWH	International	0.030	0.000	1.459	-11.681	10.928	8.434	-0.216
EWI	International	0.001	0.053	1.627	-10.247	12.867	8.627	0.186
EWJ	International	0.011	0.000	1.510	-9.013	11.969	4.057	-0.016
EWK	International	0.012	0.088	1.552	-11.324	10.499	6.352	-0.239
EWL	International	0.024	0.046	1.313	-6.991	9.744	5.399	0.123
EWM	International	0.047	0.000	1.085	-12.835	5.737	14.860	-1.173
EWN	International	0.010	0.048	1.633	-10.793	10.722	6.159	0.044
EWO	International	0.056	0.102	1.694	-13.060	12.703	8.759	-0.249
EWP	International	0.032	0.042	1.687	-9.812	15.673	8.435	0.300
EWQ	International	0.014	0.051	1.695	-10.918	12.674	6.974	0.274

EWS	International	0.039	0.072	1.471	-11.788	8.922	5.977	-0.280
EWT	International	0.032	0.000	1.737	-12.749	13.341	4.575	-0.038
EWU	International	0.010	0.055	1.531	-9.864	13.005	9.100	0.167
EWW	International	0.076	0.137	1.751	-10.121	16.980	7.999	0.133
EWY	International	0.087	0.088	2.171	-18.519	28.237	16.646	0.245
EWZ	International	0.092	0.138	2.516	-15.657	23.370	7.835	0.245
EZU	International	0.012	0.057	1.621	-9.939	11.597	6.284	0.154
IEV	International	0.013	0.055	1.519	-9.604	11.450	7.457	0.174
IDU	Sector	0.003	0.094	1.341	-8.270	14.120	11.491	0.339
IYC	Sector	0.018	0.045	1.434	-10.077	11.598	6.395	0.171
IYE	Sector	0.048	0.116	1.906	-15.761	18.800	10.386	-0.070
IYF	Sector	0.006	0.000	2.132	-16.447	16.580	12.301	0.356
IYG	Sector	0.006	-0.007	2.331	-17.613	18.747	13.713	0.556
IYH	Sector	0.003	0.032	1.176	-7.003	12.091	8.289	0.101
IYJ	Sector	0.017	0.053	1.515	-9.275	9.628	5.000	-0.096
IYK	Sector	0.021	0.044	1.017	-7.041	9.249	9.293	0.080
IYM	Sector	0.046	0.081	1.941	-13.303	14.879	6.484	-0.204
IYR	Sector	0.041	0.080	2.262	-19.273	18.706	14.592	0.428
IYW	Sector	0.014	0.104	1.978	-9.224	17.793	6.413	0.529
IYZ	Sector	-0.006	0.000	1.692	-9.270	15.052	6.994	0.268
XLB	Sector	0.038	0.091	1.701	-12.412	14.058	5.904	0.021
XLF	Sector	0.001	0.000	2.266	-16.667	16.400	12.183	0.467
XLI	Sector	0.015	0.060	1.488	-9.405	10.705	5.576	-0.006
XLK	Sector	0.008	0.083	1.809	-8.654	16.102	7.096	0.607
XLP	Sector	0.006	0.040	0.961	-6.024	6.886	4.540	-0.132
XLU	Sector	0.007	0.069	1.338	-8.529	12.073	10.073	0.399
XLV	Sector	0.013	0.030	1.194	-9.783	12.055	10.123	0.027
Average		**0.023**	**0.062**	**1.593**	**-10.846**	**12.629**	**7.868**	**0.060**

The average daily return of the sample during the study period 2001-2010 is slightly higher than zero being equal to approximately 2 b.p. The corresponding median return is superior to average return and equal to 6.2 b.p. The average risk calculation is equal to 1.593%. It is interesting to point out that the maximum risk among all standard deviations concerns an international ETF (the iShares MSCI Brazil Index Fund). In addition, if we calculate the average risk of the three categories, we will see that the average risk of broad market ETFs is equal to 1.480%, the corresponding risk estimate of sector ETFs is equal to 1.657% while the average standard deviation of international ETFs is superior to the two average risks aforementioned and equal to 1.665% (these calculations are not clearly reported in Table 2). This analysis indicates that the investors who seek opportunities of global assets allocation are usually exposed to greater risk (along with the greater costs mentioned above) than those investors choosing from locally invested ETFs. However, in our case the international ETFs compensate investors for the higher jeopardy they run with higher average daily returns. The average return of broad market, sector and international ETFs is equal to 1.9, 1.6 and 3.5 b.p., respectively (these calculates are not clearly presented in Table 2 as well).

With respect to extreme returns, Table 2 exhibits an average minimum and maximum return of about -11% and 13%, respectively. These extreme scores imply that the U.S. ETF market was significantly volatile during the period under examination. Volatility was especially high over the first three years of the study after the severe recession in stock prices that followed the collapse of dot.com companies in 2000. Volatility was also great in the last three years of the examined period, as the effects of the US subprime mortgage crisis, characterized by a rise in subprime mortgage delinquencies and foreclosures and the resulting decline of securities backing said mortgages, started to spread to the entire so-called real economy resulting in the financial and economic crisis currently experienced by the economies worldwide.

Finally, on the question of kurtosis and skewness bias in ETF returns, the relevant average calculations in Table 2 are 7.868 and 0.60, respectively. Whereas the average skewness estimate indicates that there is no such problem in ETF return distributions, the average kurtosis coefficient implies that there is an issue of leptokurtosis for the sample's ETFs.

5. Empirical Results

5.1 Parametric Tests

5.1.1 Autocorrelation Tests

Table 3 reports the results of the time series autocorrelation test used to examine the efficiency of U.S. ETF market. Presented in the table are the autocorrelation coefficient of each ETF of the sample, the corresponding Q-statistics, which assess the statistical significance of the calculated autocorrelations, and the P-values which indicate the significance of autocorrelations. Autocorrelations are calculated by successively taking into account one, two and three lagged return observations. We follow this approach so as to have a broader view of dependency among the return records of each single ETF.

Table 3. Autocorrelation of ETF Daily Returns

Symbol	Category	Autocorrelation (1 lag)			Autocorrelation (2 lags)			Autocorrelation (3 lags)		
		Coef.	Q-Sat	P-value	Coef.	Q-Sat	P-value	Coef.	Q-Sat	P-value
IJJ	Broad	-0.061	9.257	0.002	-0.050	15.564	0.000	0.041	19.756	0.000
DIA	Broad	-0.088	19.647	0.000	-0.063	29.684	0.000	0.056	37.640	0.000
IJH	Broad	-0.039	3.773	0.052	-0.058	12.121	0.002	0.036	15.452	0.001
IJK	Broad	-0.015	0.559	0.455	-0.063	10.704	0.005	0.029	12.803	0.005
IJR	Broad	-0.058	8.437	0.004	-0.040	12.426	0.002	0.039	16.268	0.001
IJS	Broad	-0.081	16.545	0.000	-0.035	19.565	0.000	0.043	24.166	0.000
IJT	Broad	-0.030	2.319	0.128	-0.045	7.468	0.024	0.033	10.162	0.017
IOO	Broad	0.055	7.750	0.005	-0.069	19.837	0.000	0.005	19.904	0.000
IVE	Broad	-0.076	14.464	0.000	-0.057	22.555	0.000	0.044	27.420	0.000
IVV	Broad	-0.094	22.381	0.000	-0.071	35.242	0.000	0.057	43.414	0.000
IVW	Broad	-0.109	30.187	0.000	-0.084	48.118	0.000	0.066	58.945	0.000
IWB	Broad	-0.087	19.238	0.000	-0.072	32.250	0.000	0.057	40.456	0.000
IWD	Broad	-0.092	21.529	0.000	-0.061	30.770	0.000	0.050	37.049	0.000
IWF	Broad	-0.073	13.264	0.000	-0.083	30.781	0.000	0.058	39.184	0.000
IWM	Broad	-0.078	15.160	0.000	-0.037	18.650	0.000	0.042	23.186	0.000
IWN	Broad	-0.113	32.076	0.000	-0.031	34.489	0.000	0.044	39.371	0.000
IWO	Broad	-0.034	2.912	0.088	-0.043	7.463	0.024	0.040	11.415	0.010
IWV	Broad	-0.086	18.705	0.000	-0.068	30.424	0.000	0.056	38.304	0.000
IWW	Broad	-0.094	22.453	0.000	-0.057	30.517	0.000	0.050	36.772	0.000
IWZ	Broad	-0.069	12.150	0.000	-0.080	28.437	0.000	0.057	36.505	0.000
IYY	Broad	-0.083	17.509	0.000	-0.071	30.268	0.000	0.058	38.604	0.000
MDY	Broad	-0.050	6.176	0.013	-0.059	14.824	0.001	0.022	16.001	0.001
OEF	Broad	-0.101	25.501	0.000	-0.072	38.405	0.000	0.053	45.586	0.000
QQQQ	Broad	-0.037	3.517	0.061	-0.086	22.215	0.000	0.037	25.586	0.000
SPY	Broad	-0.077	14.739	0.000	-0.082	31.827	0.000	0.041	36.154	0.000
EWA	International	-0.009	0.204	0.652	0.004	0.240	0.887	-0.062	10.000	0.019
EWC	International	0.044	4.883	0.027	-0.087	23.836	0.000	0.081	40.542	0.000
EWD	International	0.026	1.753	0.185	-0.060	10.885	0.004	-0.037	14.381	0.002
EWG	International	-0.006	0.088	0.767	-0.020	1.079	0.583	-0.014	1.572	0.666
EWH	International	-0.004	0.041	0.839	0.022	1.273	0.529	-0.005	1.340	0.720
EWI	International	0.015	0.536	0.464	-0.027	2.330	0.312	-0.025	3.923	0.270
EWJ	International	-0.068	11.779	0.001	-0.067	23.170	0.000	-0.014	23.642	0.000
EWK	International	0.095	22.765	0.000	-0.013	23.165	0.000	-0.018	24.018	0.000
EWL	International	0.009	0.188	0.665	-0.054	7.612	0.022	-0.032	10.158	0.017
EWM	International	0.120	36.037	0.000	-0.025	37.668	0.000	0.042	42.116	0.000
EWN	International	0.007	0.111	0.739	-0.028	2.146	0.342	-0.045	7.301	0.063
EWO	International	0.059	8.779	0.003	-0.024	10.251	0.006	0.002	10.261	0.016

EWP	International	0.012	0.369	0.544	-0.043	5.014	0.082	-0.029	7.146	0.067
EWQ	International	-0.017	0.695	0.404	-0.053	7.645	0.022	-0.047	13.166	0.004
EWS	International	0.017	0.690	0.406	0.024	2.147	0.342	-0.004	2.180	0.536
EWT	International	0.033	2.774	0.096	0.049	8.903	0.012	0.005	8.969	0.030
EWU	International	-0.033	2.673	0.102	-0.054	9.951	0.007	-0.069	21.936	0.000
EWW	International	0.093	21.891	0.000	-0.022	23.104	0.000	-0.007	23.229	0.000
EWY	International	0.027	1.785	0.182	0.007	1.907	0.385	-0.027	3.805	0.283
EWZ	International	0.043	4.550	0.033	-0.076	19.265	0.000	0.016	19.916	0.000
EZU	International	0.008	0.158	0.691	-0.041	4.371	0.112	-0.034	7.312	0.063
IEV	International	-0.006	0.104	0.747	-0.053	7.207	0.027	-0.041	11.405	0.010
IDU	Sector	-0.054	7.395	0.007	-0.056	15.221	0.000	0.059	23.874	0.000
IYC	Sector	-0.027	1.871	0.171	-0.075	16.195	0.000	0.041	20.465	0.000
IYE	Sector	-0.084	17.767	0.000	-0.107	46.601	0.000	0.063	56.457	0.000
IYF	Sector	-0.119	35.769	0.000	-0.024	37.182	0.000	-0.004	37.222	0.000
IYG	Sector	-0.094	22.237	0.000	-0.022	23.444	0.000	-0.021	24.553	0.000
IYH	Sector	-0.024	1.477	0.224	-0.088	21.170	0.000	0.042	25.684	0.000
IYJ	Sector	-0.041	4.172	0.041	-0.047	9.700	0.008	0.049	15.795	0.001
IYK	Sector	-0.064	10.254	0.001	-0.088	29.972	0.000	0.066	41.055	0.000
IYM	Sector	-0.056	7.970	0.005	-0.048	13.655	0.001	0.036	16.839	0.001
IYR	Sector	-0.201	101.510	0.000	-0.018	102.310	0.000	0.010	102.560	0.000
IYW	Sector	-0.026	1.663	0.197	-0.083	19.142	0.000	0.027	20.977	0.000
IYZ	Sector	-0.034	2.849	0.091	-0.061	12.121	0.002	-0.004	12.161	0.007
XLB	Sector	-0.033	2.799	0.094	-0.046	8.183	0.017	0.014	8.696	0.034
XLF	Sector	-0.104	27.021	0.000	-0.012	27.377	0.000	-0.014	27.899	0.000
XLI	Sector	-0.033	2.760	0.097	-0.042	7.120	0.028	0.039	10.949	0.012
XLK	Sector	-0.046	5.435	0.020	-0.078	20.849	0.000	0.045	25.858	0.000
XLP	Sector	-0.089	19.947	0.000	-0.038	23.589	0.000	0.010	23.838	0.000
XLU	Sector	-0.080	15.951	0.000	-0.025	17.506	0.000	0.006	17.607	0.001
XLV	Sector	-0.009	0.205	0.650	-0.094	22.587	0.000	0.010	22.848	0.000
Average		**-0.037**	**11.699**	**0.151**	**-0.049**	**20.026**	**0.057**	**0.019**	**24.148**	**0.043**

With respect to 1st-order autocorrelation, the respective average coefficient is equal to -0.037. Moreover, there are 40 ETFs, whose first order autocorrelation is significant at the 5% level or better. The individual autocorrelations are either positive or negative. Given these results, we conclude that the pricing of the majority of the examined ETFs is not efficient at the weak level, when the 1st-order autocorrelation is taken into consideration. In other words, the ETF returns as a whole cannot be considered independent to their lagged values and, thus, the random walk hypothesis tends to be rejected. This finding implies that past returns affect future returns either in a positive or a negative fashion.

On the question of 2nd-order autocorrelation, Table 3 reports an average autocorrelation coefficient of -0.049. The average estimated P-value is equal to 0.057 while there are 58 ETFs having significant 2nd-order autocorrelations indicating that the efficiency hypothesis is rejected both at the average and the individual level for the majority of the sample's ETFs when the two lagged returns are taken into account.

The essence of results about the 3rd-order autocorrelation is similar to that of 1st- and 2nd-order autocorrelations. More specifically, the relevant average coefficient is equal to 0.019 while the respective average P-value is equal to 0.043. In addition, there are 59 having significant 3rd-order autocorrelations at the 5% level or better. These estimates reconfirm the rejection of the null hypothesis, which assumes that the prices of ETFs are affected by their pricing history.

5.1.2 Serial Correlation Tests

Table 4 reports the results of the correlogram estimated on the residuals of the third-order autoregressive model (1). The table contains the correlation coefficients, the corresponding Q-statistics on the statistical significance of the estimates and the P-values which indicate the significance of the estimates. Following the presentation of autocorrelations in Table 3, correlogram's estimates are presented for the 1st-, 2nd- and 3rd-order serial correlation.

● Table 4. **Serial Correlation of ETF Daily Returns (Q-statistics)**

Symbol	Category	Autocorrelation (1 lag)			Autocorrelation (2 lags)			Autocorrelation (3 lags)		
		Coef.	Q-Sat	P-value	Coef.	Q-Sat	P-value	Coef.	Q-Sat	P-value
IJJ	Broad	0.001	0.002	0.969	0.001	0.002	0.999	-0.004	0.048	0.997
DIA	Broad	0.001	0.002	0.964	0.001	0.006	0.997	-0.003	0.026	0.999
IJH	Broad	0.000	0.000	0.992	0.000	0.000	1.000	-0.004	0.050	0.997
IJK	Broad	-0.001	0.002	0.967	0.000	0.002	0.999	-0.004	0.043	0.998
IJR	Broad	0.000	0.000	0.988	0.002	0.007	0.997	-0.004	0.045	0.998
IJS	Broad	0.000	0.001	0.982	0.002	0.009	0.996	-0.003	0.028	0.999
IJT	Broad	0.000	0.000	0.984	0.001	0.005	0.997	-0.005	0.067	0.996
IOO	Broad	0.000	0.000	0.990	0.002	0.010	0.995	-0.003	0.039	0.998
IVE	Broad	0.001	0.001	0.972	0.002	0.007	0.996	-0.003	0.038	0.998
IVV	Broad	0.001	0.001	0.977	0.002	0.008	0.996	-0.005	0.064	0.996
IVW	Broad	0.000	0.000	0.997	0.002	0.006	0.997	-0.005	0.068	0.995
IWB	Broad	0.001	0.001	0.979	0.002	0.009	0.996	-0.005	0.068	0.995
IWD	Broad	0.000	0.001	0.981	0.001	0.001	0.999	-0.004	0.051	0.997
IWF	Broad	0.000	0.000	0.993	0.005	0.062	0.970	-0.004	0.105	0.991
IWM	Broad	0.000	0.001	0.982	0.002	0.010	0.995	-0.005	0.065	0.996
IWN	Broad	0.001	0.001	0.977	0.002	0.008	0.996	-0.005	0.063	0.996

IWO	Broad	0.000	0.000	0.990	0.003	0.016	0.992	-0.004	0.047	0.997
IWV	Broad	0.001	0.001	0.979	0.002	0.010	0.995	-0.005	0.071	0.995
IWW	Broad	0.001	0.001	0.979	0.001	0.002	0.999	-0.005	0.054	0.997
IWZ	Broad	0.000	0.000	0.995	0.005	0.059	0.971	-0.004	0.105	0.991
IYY	Broad	0.001	0.001	0.976	0.002	0.009	0.995	-0.005	0.070	0.995
MDY	Broad	-0.001	0.001	0.972	0.001	0.005	0.998	-0.006	0.092	0.993
OEF	Broad	0.001	0.001	0.973	0.002	0.014	0.993	-0.004	0.058	0.996
QQQQ	Broad	-0.001	0.004	0.953	0.011	0.281	0.869	-0.006	0.365	0.947
SPY	Broad	0.000	0.000	0.999	0.002	0.010	0.995	-0.005	0.078	0.994
EWA	International	0.002	0.009	0.924	0.000	0.009	0.995	-0.002	0.020	0.999
EWC	International	-0.002	0.015	0.902	0.012	0.349	0.840	-0.006	0.444	0.931
EWD	International	-0.001	0.001	0.971	0.000	0.002	0.999	-0.003	0.020	0.999
EWG	International	0.001	0.001	0.974	0.000	0.001	0.999	-0.001	0.003	1.000
EWH	International	-0.001	0.005	0.946	0.001	0.009	0.995	0.001	0.011	1.000
EWI	International	0.002	0.012	0.912	0.001	0.015	0.992	-0.004	0.052	0.997
EWJ	International	0.001	0.001	0.975	0.002	0.012	0.994	0.002	0.022	0.999
EWK	International	0.000	0.000	0.991	0.000	0.000	1.000	-0.003	0.030	0.999
EWL	International	0.002	0.006	0.937	0.000	0.006	0.997	-0.005	0.069	0.995
EWM	International	0.000	0.000	0.989	-0.002	0.006	0.997	0.006	0.096	0.992
EWN	International	0.003	0.024	0.876	-0.001	0.026	0.987	-0.004	0.069	0.995
EWO	International	-0.001	0.001	0.978	0.001	0.003	0.998	0.000	0.004	1.000
EWP	International	0.001	0.002	0.964	0.001	0.003	0.999	-0.003	0.028	0.999
EWQ	International	0.003	0.025	0.876	0.000	0.025	0.988	-0.004	0.075	0.995
EWS	International	-0.001	0.006	0.941	0.001	0.008	0.996	-0.001	0.010	1.000
EWT	International	-0.002	0.009	0.923	0.005	0.061	0.970	-0.004	0.094	0.993
EWU	International	0.004	0.045	0.832	-0.001	0.050	0.975	-0.006	0.133	0.988
EWW	International	0.002	0.007	0.933	0.000	0.007	0.996	0.001	0.011	1.000
EWY	International	-0.004	0.041	0.839	-0.001	0.044	0.978	-0.001	0.047	0.997
EWZ	International	0.001	0.001	0.979	-0.001	0.003	0.999	0.002	0.011	1.000
EZU	International	0.002	0.011	0.915	0.001	0.014	0.993	-0.004	0.047	0.997
IEV	International	0.002	0.016	0.901	0.000	0.016	0.992	-0.005	0.068	0.995
IDU	Sector	-0.001	0.001	0.973	0.002	0.008	0.996	0.001	0.010	1.000
IYC	Sector	0.002	0.007	0.932	0.003	0.028	0.986	-0.001	0.031	0.999
IYE	Sector	0.002	0.008	0.929	-0.002	0.023	0.989	-0.004	0.074	0.995
IYF	Sector	-0.001	0.001	0.972	-0.002	0.007	0.996	-0.009	0.224	0.974
IYG	Sector	-0.001	0.004	0.952	-0.002	0.012	0.994	-0.009	0.197	0.978
IYH	Sector	0.000	0.001	0.981	-0.006	0.096	0.953	-0.005	0.148	0.986
IYJ	Sector	0.000	0.001	0.982	0.004	0.037	0.981	-0.003	0.063	0.996
IYK	Sector	0.002	0.006	0.938	0.002	0.012	0.994	0.000	0.012	1.000
IYM	Sector	0.001	0.005	0.945	0.000	0.005	0.998	-0.004	0.045	0.998
IYR	Sector	0.000	0.000	0.986	-0.003	0.026	0.987	-0.013	0.472	0.925
IYW	Sector	-0.001	0.002	0.967	0.012	0.336	0.845	-0.003	0.358	0.949

IYZ	Sector	0.001	0.004	0.949	0.003	0.034	0.983	-0.001	0.037	0.998
XLB	Sector	0.001	0.003	0.957	-0.001	0.004	0.998	0.000	0.004	1.000
XLF	Sector	-0.001	0.003	0.959	-0.001	0.008	0.996	-0.007	0.136	0.987
XLI	Sector	0.001	0.001	0.974	0.002	0.009	0.996	-0.001	0.013	1.000
XLK	Sector	0.001	0.004	0.948	0.008	0.154	0.926	-0.001	0.157	0.984
XLP	Sector	0.000	0.000	0.999	0.001	0.005	0.998	0.001	0.010	1.000
XLU	Sector	-0.001	0.001	0.980	0.000	0.001	0.999	0.002	0.007	1.000
XLV	Sector	0.001	0.005	0.944	0.006	0.096	0.953	-0.003	0.125	0.989
Average		**0.000**	**0.005**	**0.958**	**0.002**	**0.032**	**0.985**	**-0.003**	**0.080**	**0.992**

No matter what the order of the serial correlation taken into consideration is, the results in Table 4 lead to a unique inference. More specifically, all the 1st-, 2nd- and 3rd-order serial correlation estimates derived from the preparation of the correlogram are insignificant at any acceptable statistical level whereas the average serial correlations do not materially differ from zero. This is also the case for all the individual estimates. Based on the results in Table 4, we draw the conclusion that the returns of ETFs follow a random walk and, therefore, the underlying market efficiently incorporates all the already known information.

The results of the second method employed for the estimation of the serial correlation in the returns of ETF, that is the Breusch-Godfrey Lagrange Multiplier test, are furnished in Table 5. This table presents the coefficients of LM test and the corresponding P-values on the statistical significance of the estimated Breusch-Godfrey statistics. Furthermore, the table presents the 1st-, 2nd- and 3rd-order serial correlations.

Table 5. Breusch-Godfrey Serial Correlation LM Test

Symbol	Category	1st Order Serial Correlation		2nd Order Serial Correlation		3rd Order Serial Correlation	
		LM statistic	P-value	LM statistic	P-value	LM statistic	P-value
IJJ	Broad	1.087	0.297	5.960	0.051	5.960	0.051
DIA	Broad	1.031	0.310	5.912	0.052	6.815	0.078
IJH	Broad	0.056	0.813	0.635	0.728	4.870	0.182
IJK	Broad	0.674	0.412	2.503	0.286	2.503	0.286
IJR	Broad	0.148	0.701	5.336	0.069	5.570	0.135
IJS	Broad	0.369	0.543	5.299	0.071	6.142	0.105
IJT	Broad	0.151	0.698	0.757	0.685	4.657	0.199
IOO	Broad	0.662	0.416	3.816	0.148	3.864	0.276
IVE	Broad	1.032	0.310	6.161	0.046	6.207	0.102
IVV	Broad	0.412	0.521	5.473	0.065	6.461	0.091
IVW	Broad	0.004	0.949	2.005	0.367	2.054	0.561

IWB	Broad	0.307	0.580	5.594	0.061	6.958	0.073
IWD	Broad	0.358	0.550	3.312	0.191	3.952	0.267
IWF	Broad	0.032	0.857	6.848	0.033	9.097	0.028
IWM	Broad	0.316	0.574	6.900	0.032	7.397	0.060
IWN	Broad	0.629	0.428	7.794	0.020	8.325	0.040
IWO	Broad	0.066	0.797	3.478	0.176	3.739	0.291
IWV	Broad	0.306	0.580	5.920	0.052	7.232	0.065
IWW	Broad	0.402	0.526	4.111	0.128	4.474	0.215
IWZ	Broad	0.013	0.908	6.826	0.033	9.200	0.027
IYY	Broad	0.388	0.533	5.838	0.054	7.189	0.066
MDY	Broad	1.110	0.292	1.240	0.538	7.732	0.052
OEF	Broad	0.806	0.369	5.751	0.056	5.751	0.056
QQQQ	Broad	2.185	0.139	9.680	0.008	10.791	0.013
SPY	Broad	0.001	0.970	6.556	0.038	7.361	0.061
EWA	International	1.880	0.170	1.880	0.391	5.263	0.154
EWC	International	1.784	0.182	21.952	0.000	26.341	0.000
EWD	International	0.200	0.655	0.238	0.888	2.094	0.553
EWG	International	4.592	0.032	9.474	0.009	9.474	0.024
EWH	International	1.022	0.312	1.299	0.522	1.552	0.670
EWI	International	14.287	0.000	14.624	0.001	23.705	0.000
EWJ	International	1.365	0.243	1.877	0.391	1.967	0.579
EWK	International	0.413	0.521	0.430	0.807	7.041	0.071
EWL	International	6.520	0.011	23.046	0.000	23.168	0.000
EWM	International	0.064	0.800	1.279	0.528	6.060	0.109
EWN	International	11.267	0.001	16.952	0.000	24.412	0.000
EWO	International	2.509	0.113	2.516	0.284	3.358	0.340
EWP	International	0.745	0.388	0.746	0.689	6.449	0.092
EWQ	International	8.574	0.003	10.621	0.005	18.029	0.000
EWS	International	3.791	0.052	3.803	0.149	7.604	0.055
EWT	International	3.194	0.074	9.819	0.007	11.285	0.010
EWU	International	8.029	0.005	14.727	0.001	23.340	0.000
EWW	International	3.181	0.074	5.546	0.062	6.291	0.098
EWY	International	7.062	0.008	7.479	0.024	7.488	0.058
EWZ	International	1.264	0.261	1.695	0.429	2.110	0.550
EZU	International	6.606	0.010	6.677	0.035	13.617	0.003
IEV	International	6.967	0.008	8.552	0.014	17.377	0.001
IDU	Sector	0.084	0.771	0.520	0.771	0.521	0.914
IYC	Sector	3.557	0.059	4.707	0.095	4.736	0.192
IYE	Sector	2.200	0.138	2.279	0.320	3.115	0.374
IYF	Sector	7.324	0.007	7.706	0.021	12.461	0.006
IYG	Sector	5.053	0.025	5.053	0.080	14.073	0.003
IYH	Sector	0.063	0.802	4.788	0.091	5.847	0.119

IYJ	Sector	0.223	0.637	4.623	0.099	5.005	0.171
IYK	Sector	0.973	0.324	1.701	0.427	1.702	0.636
IYM	Sector	3.232	0.072	4.005	0.135	4.662	0.198
IYR	Sector	5.286	0.022	7.158	0.028	13.525	0.004
IYW	Sector	2.375	0.123	9.321	0.009	10.045	0.018
IYZ	Sector	2.247	0.134	2.255	0.324	3.364	0.339
XLB	Sector	1.887	0.170	2.064	0.356	2.864	0.413
XLF	Sector	5.819	0.016	8.072	0.018	9.592	0.022
XLI	Sector	0.758	0.384	2.847	0.241	3.380	0.337
XLK	Sector	2.490	0.115	7.046	0.030	7.637	0.054
XLP	Sector	0.000	0.991	0.402	0.818	0.410	0.938
XLU	Sector	0.889	0.346	2.268	0.322	2.268	0.322
XLV	Sector	2.509	0.113	3.513	0.173	3.861	0.277
Average		**2.346**	**0.352**	**5.595**	**0.206**	**7.748**	**0.183**

When it comes to the serial correlation of first order, the average respective estimate is equal to 2.946 while the corresponding average P-value is equal to 0.352. The average terms imply that there is no serial correlation in the ETF returns on average. In other words, these results imply that, on average, the ETF market is efficient at the weak form. However, the individual 1st-order serial correlation estimates indicate that efficiency does not apply to all the ETFs of the sample. In particular, there are 14 coefficients which are significant at the 5% level. The statistically significant serial correlations do not allow us to reject the alternative hypothesis of non-efficiency for the specific ETFs.

The 2nd- and 3rd- order serial correlations behave similarly to the ones of the 1st serial correlation. The average LM statistics are equal to 5.595 and 7.748, respectively, but the corresponding average P-values is equal to 0.206 and 0.183. Though, there are 24 and 20 out of 66 single serial correlations of 2nd- and 3rd- order serial correlation respectively that are not statistically insignificant at the 5% level. Therefore, we draw the same conclusions as in the case of the 1st- order serial correlation, that is, the pricing of ETFs is efficient at an average level even though there are a part of the selected ETFs whose pricing is not a white noise.

5.1.3 Augmented Dickey-Fuller Unit Root Test

The results of the last parametric test used to examine the pricing efficiency of U.S. ETFs -the Augmented Dickey Fuller test- are presented in Table 6. The table presents the ADF coefficient for each ETF along with the P-value which indicates the statistical significance of the estimates for the rejection of the H_0 hypothesis for the existence of a unit root in returns. In addition, Table 6 presents three alternative estimations of

ADF test, that is, ADF coefficients when a constant is considered as an exogenous variable in the regression test, when both a constant and a time trend are included in the regression test and when neither a constant nor a time trend are taken into account in the ADF test.

Table 6. Augmented Dickey-Fuller (ADF) Test

Symbol	Category	Intercept		Intercept and Trend		None	
		T-statistic	P-value	T-statistic	P-value	T-statistic	P-value
IJJ	Broad	-23.990	0.000	-23.985	0.000	-23.942	0.000
DIA	Broad	-23.678	0.000	-23.680	0.000	-23.676	0.000
IJH	Broad	-24.044	0.000	-24.044	0.000	-24.001	0.000
IJK	Broad	-24.076	0.000	-24.086	0.000	-24.039	0.000
IJR	Broad	-23.924	0.000	-23.920	0.000	-23.877	0.000
IJS	Broad	-23.793	0.000	-23.788	0.000	-23.749	0.000
IJT	Broad	-24.049	0.000	-24.047	0.000	-24.001	0.000
IOO	Broad	-23.349	0.000	-23.355	0.000	-23.353	0.000
IVE	Broad	-24.023	0.000	-24.024	0.000	-24.025	0.000
IVV	Broad	-23.993	0.000	-24.003	0.000	-23.994	0.000
IVW	Broad	-23.910	0.000	-23.933	0.000	-23.911	0.000
IWB	Broad	-24.002	0.000	-24.012	0.000	-24.001	0.000
IWD	Broad	-24.206	0.000	-24.202	0.000	-24.201	0.000
IWF	Broad	-23.672	0.000	-23.708	0.000	-23.675	0.000
IWM	Broad	-24.065	0.000	-24.064	0.000	-24.032	0.000
IWN	Broad	-24.252	0.000	-24.247	0.000	-24.206	0.000
IWO	Broad	-23.665	0.000	-23.675	0.000	-23.646	0.000
IWV	Broad	-24.012	0.000	-24.021	0.000	-24.010	0.000
IWW	Broad	-24.221	0.000	-24.218	0.000	-24.215	0.000
IWZ	Broad	-23.675	0.000	-23.709	0.000	-23.678	0.000
IYY	Broad	-23.987	0.000	-23.998	0.000	-23.985	0.000
MDY	Broad	-24.580	0.000	-24.580	0.000	-24.536	0.000
OEF	Broad	-24.058	0.000	-24.071	0.000	-24.063	0.000
QQQQ	Broad	-22.984	0.000	-23.024	0.000	-22.983	0.000
SPY	Broad	-24.099	0.000	-24.109	0.000	-24.100	0.000
EWA	International	-22.812	0.000	-22.808	0.000	-22.748	0.000
EWC	International	-23.315	0.000	-23.322	0.000	-23.258	0.000
EWD	International	-24.157	0.000	-24.176	0.000	-24.131	0.000
EWG	International	-23.174	0.000	-23.174	0.000	-23.166	0.000
EWH	International	-22.769	0.000	-22.793	0.000	-22.747	0.000
EWI	International	-22.765	0.000	-22.762	0.000	-22.770	0.000
EWJ	International	-22.786	0.000	-22.786	0.000	-22.786	0.000

EWK	International	-23.033	0.000	-23.032	0.000	-23.034	0.000
EWL	International	-24.187	0.000	-24.206	0.000	-24.165	0.000
EWM	International	-21.231	0.000	-21.235	0.000	-21.135	0.000
EWN	International	-23.404	0.000	-23.413	0.000	-23.406	0.000
EWO	International	-22.067	0.000	-22.082	0.000	-22.005	0.000
EWP	International	-23.326	0.000	-23.323	0.000	-23.308	0.000
EWQ	International	-23.935	0.000	-23.933	0.000	-23.934	0.000
EWS	International	-21.269	0.000	-21.291	0.000	-21.232	0.000
EWT	International	-22.475	0.000	-22.477	0.000	-22.464	0.000
EWU	International	-24.441	0.000	-24.441	0.000	-24.442	0.000
EWW	International	-23.302	0.000	-23.299	0.000	-23.190	0.000
EWY	International	-23.815	0.000	-23.812	0.000	-23.720	0.000
EWZ	International	-23.098	0.000	-23.112	0.000	-23.012	0.000
EZU	International	-23.324	0.000	-23.322	0.000	-23.325	0.000
IEV	International	-23.961	0.000	-23.961	0.000	-23.959	0.000
IDU	Sector	-22.561	0.000	-22.563	0.000	-22.563	0.000
IYC	Sector	-23.722	0.000	-23.729	0.000	-23.715	0.000
IYE	Sector	-24.066	0.000	-24.066	0.000	-24.004	0.000
IYF	Sector	-25.880	0.000	-25.875	0.000	-25.884	0.000
IYG	Sector	-25.888	0.000	-25.883	0.000	-25.892	0.000
IYH	Sector	-24.968	0.000	-24.971	0.000	-24.969	0.000
IYJ	Sector	-23.172	0.000	-23.180	0.000	-23.165	0.000
IYK	Sector	-23.418	0.000	-23.415	0.000	-23.380	0.000
IYM	Sector	-24.091	0.000	-24.096	0.000	-24.045	0.000
IYR	Sector	-26.048	0.000	-26.043	0.000	-26.010	0.000
IYW	Sector	-22.990	0.000	-23.018	0.000	-22.991	0.000
IYZ	Sector	-23.277	0.000	-23.320	0.000	-23.280	0.000
XLB	Sector	-23.480	0.000	-23.477	0.000	-23.445	0.000
XLF	Sector	-25.690	0.000	-25.685	0.000	-25.695	0.000
XLI	Sector	-22.583	0.000	-22.592	0.000	-22.578	0.000
XLK	Sector	-22.791	0.000	-22.823	0.000	-22.795	0.000
XLP	Sector	-24.414	0.000	-24.444	0.000	-24.411	0.000
XLU	Sector	-22.775	0.000	-22.776	0.000	-22.777	0.000
XLV	Sector	-23.797	0.000	-23.792	0.000	-23.794	0.000
Average		**-23.675**	**0.000**	**-23.682**	**0.000**	**-23.655**	**0.000**

The estimations in Table 6 demonstrate that the time series of ETF daily returns do not suffer from any non-stationarity bias. In particular, all the single ADF coefficients, either when the first or the second or the third alternative ADF estimation is considered, are highly significant, namely they are more negative than the MacKinnon critical values (these values are not clearly reported in the table), which are used for the rejection of the hypothesis of a unit root. The average ADF coefficient when the first alternative measurement is examined is equal to -23.68. The corresponding average P-value is equal to 0.00. The corresponding critical value is equal to -2.86. All the single ADF coefficients are very low whereas the P-value for all of them is equal to 0.00. Therefore, the H_0 hypothesis for the existence of a unit root is rejected and, thus, the ETF market is considered efficient. The average ADF estimate when the second alternative approach is taken into account is equal to -23.68, the critical value is equal to -3.41 while the respective P-value is equal to 0.00 indicating the lack of a unit root. This is also the case for all the individual ETFs of the sample. Consequently, the H0 hypothesis is rejected once again. Finally, the average ADF coefficient resulted from the third alternative approach is equal to -23.66 being much more negative than the relevant critical value, which is equal to -1.94.

Overall, the applied Augmented Dickey Fuller test demonstrates that the returns of ETFs are independent to their lagged values and that all the available information is incorporated in the prices of ETFs. Therefore, the U.S. ETF market must be considered efficient in the weak-form and thus no investor is expected to be able to gain above market returns by using any information that the market already knows.

5.2 Non-Parametric Tests

5.2.1 Phillips-Peron Unit Root Test

The results of the non-parametric Phillips-Peron test are presented in Table 7. This test examines whether there is a unit root in the time series of ETF returns, which will indicate that the underlying ETF market is not efficient, and, therefore, investors may have significant chances of outperforming the average market returns. Table 7 presents the coefficients and the P-values on the significance of the estimated PP coefficients which will make us reject to null hypothesis for the existence of a unit root, which would violate the efficient capital market hypothesis. Furthermore, the PP coefficients are presented for the three alternative cases when a constant is considered in the regression test, when both a constant and a time trend are included in the model, and when neither a constant nor a time trend is incorporated in the determinative variables of the model.

Table 7. Phillips-Peron (PP) Test

Symbol	Category	Intercept		Intercept and Trend		None	
		T-statistic	P-value	T-statistic	P-value	T-statistic	P-value
IJJ	Broad	-53.292	0.000	-53.282	0.000	-53.268	0.000
DIA	Broad	-54.762	0.000	-54.755	0.000	-54.768	0.000
IJH	Broad	-52.186	0.000	-52.179	0.000	-52.166	0.000
IJK	Broad	-51.022	0.000	-51.023	0.000	-51.008	0.000
IJR	Broad	-53.189	0.000	-53.179	0.000	-53.164	0.000
IJS	Broad	-54.395	0.000	-54.384	0.000	-54.371	0.000
IJT	Broad	-51.818	0.000	-51.809	0.000	-51.794	0.000
IOO	Broad	-47.425	0.000	-47.422	0.000	-47.434	0.000
IVE	Broad	-54.083	0.000	-54.076	0.000	-54.092	0.000
IVV	Broad	-55.137	0.000	-55.135	0.000	-55.145	0.000
IVW	Broad	-56.060	0.000	-56.066	0.000	-56.069	0.000
IWB	Broad	-54.773	0.000	-54.772	0.000	-54.781	0.000
IWD	Broad	-55.002	0.000	-54.992	0.000	-55.007	0.000
IWF	Broad	-54.065	0.000	-54.077	0.000	-54.074	0.000
IWM	Broad	-54.246	0.000	-54.237	0.000	-54.231	0.000
IWN	Broad	-56.164	0.000	-56.153	0.000	-56.140	0.000
IWO	Broad	-51.996	0.000	-51.996	0.000	-51.990	0.000
IWV	Broad	-54.707	0.000	-54.705	0.000	-54.714	0.000
IWW	Broad	-55.112	0.000	-55.102	0.000	-55.116	0.000
IWZ	Broad	-53.896	0.000	-53.907	0.000	-53.904	0.000
IYY	Broad	-54.558	0.000	-54.556	0.000	-54.564	0.000
MDY	Broad	-52.733	0.000	-52.726	0.000	-52.714	0.000
OEF	Broad	-55.493	0.000	-55.492	0.000	-55.504	0.000
QQQQ	Broad	-52.239	0.000	-52.251	0.000	-52.244	0.000
SPY	Broad	-54.132	0.000	-54.130	0.000	-54.140	0.000
EWA	International	-50.593	0.000	-50.583	0.000	-50.553	0.000
EWC	International	-48.002	0.000	-47.999	0.000	-47.969	0.000
EWD	International	-48.819	0.000	-48.821	0.000	-48.808	0.000
EWG	International	-50.416	0.000	-50.413	0.000	-50.417	0.000
EWH	International	-50.332	0.000	-50.341	0.000	-50.320	0.000
EWI	International	-49.390	0.000	-49.381	0.000	-49.400	0.000
EWJ	International	-53.671	0.000	-53.664	0.000	-53.679	0.000
EWK	International	-45.563	0.000	-45.556	0.000	-45.570	0.000
EWL	International	-49.691	0.000	-49.697	0.000	-49.684	0.000
EWM	International	-44.475	0.000	-44.471	0.000	-44.406	0.000
EWN	International	-49.787	0.000	-49.787	0.000	-49.796	0.000
EWO	International	-47.240	0.000	-47.246	0.000	-47.201	0.000

EWP	International	-49.518	0.000	-49.511	0.000	-49.510	0.000
EWQ	International	-50.965	0.000	-50.957	0.000	-50.972	0.000
EWS	International	-49.312	0.000	-49.321	0.000	-49.286	0.000
EWT	International	-48.546	0.000	-48.540	0.000	-48.542	0.000
EWU	International	-51.781	0.000	-51.774	0.000	-51.789	0.000
EWW	International	-45.659	0.000	-45.650	0.000	-45.587	0.000
EWY	International	-48.826	0.000	-48.820	0.000	-48.761	0.000
EWZ	International	-48.034	0.000	-48.035	0.000	-47.983	0.000
EZU	International	-49.724	0.000	-49.715	0.000	-49.731	0.000
IEV	International	-50.442	0.000	-50.436	0.000	-50.448	0.000
IDU	Sector	-52.979	0.000	-52.980	0.000	-52.989	0.000
IYC	Sector	-51.526	0.000	-51.521	0.000	-51.527	0.000
IYE	Sector	-54.523	0.000	-54.517	0.000	-54.496	0.000
IYF	Sector	-56.516	0.000	-56.505	0.000	-56.527	0.000
IYG	Sector	-55.090	0.000	-55.079	0.000	-55.101	0.000
IYH	Sector	-51.390	0.000	-51.391	0.000	-51.400	0.000
IYJ	Sector	-52.324	0.000	-52.322	0.000	-52.326	0.000
IYK	Sector	-53.440	0.000	-53.431	0.000	-53.425	0.000
IYM	Sector	-53.081	0.000	-53.076	0.000	-53.057	0.000
IYR	Sector	-61.436	0.000	-61.424	0.000	-61.423	0.000
IYW	Sector	-51.599	0.000	-51.604	0.000	-51.606	0.000
IYZ	Sector	-51.837	0.000	-51.850	0.000	-51.847	0.000
XLB	Sector	-51.834	0.000	-51.824	0.000	-51.817	0.000
XLF	Sector	-55.628	0.000	-55.617	0.000	-55.639	0.000
XLI	Sector	-51.901	0.000	-51.899	0.000	-51.904	0.000
XLK	Sector	-52.613	0.000	-52.619	0.000	-52.622	0.000
XLP	Sector	-54.819	0.000	-54.843	0.000	-54.827	0.000
XLU	Sector	-54.295	0.000	-54.290	0.000	-54.304	0.000
XLV	Sector	-50.693	0.000	-50.684	0.000	-50.695	0.000
Average		**-52.133**	**0.000**	**-52.130**	**0.000**	**-52.126**	**0.000**

The essence of the results in Table 7 is similar to the relevant interpretation of the estimations of Augmented Dickey Fuller test. Particularly, all the PP estimates, either the individual ones or the average ones, are significantly more negative than the Mac Kinnon critical values for the rejection of the null hypothesis of a unit root (these values are not reported in Table 7). Indicatively, the average PP coefficient resulted from the first methodological approach reminded above is equal to -52.13 when the corresponding critical value at the 5% level is equal to -2.86. Going further, the average PP estimation related to the second method of the Phillips-Peron test application is also equal to -52.13 whereas the respective critical value at the 5% level of significance is equal to -3.41. Finally, the average PP coefficient calculated via the third alternative approach is equal to -52.13 when the applicable critical value is equal to -1.94. The corresponding average P-values are all equal to zero (this is also the case for all the single P-values).

Before concluding the last section of the analysis of the empirical findings, we should point out that on the question of the truncation lags required by the PP test for the Newey-West correction, which is an extension of the well-known White correction for heteroskedasticity method that simultaneously corrects for heteroskedasticity and serial correlation in ordinary least squares regression analysis, we use the suggested by Newey-West number of lags, which in our case is equal to 7. However, we should note that we also performed the PP test on a sample basis using either more or less than 7 lags. In any case, the usage of other than the suggested number of lags did not derive any different results than the ones analyzed above.

Based on the results derived from the applied Phillips-Peron test, we reject the H0 hypothesis for the existence of a unit root in ETF returns and, consequently, we infer that the U.S. ETF market is informationally efficient at the weak form level. Therefore, the already publicly available information does not seem to provide investors with material opportunities of gaining significant abnormal returns.

6. Conclusion

This paper expands the existing literature on the efficient capital markets framework by investigating the weak form-efficiency of ETF returns. More specifically, we use historical daily return data for a sample of 66 U.S.-listed ETFs invested either in local broad market and sector indexes or in international capital market indexes. The data used covers the ten-year period 2001-2010 while the sample includes some of the most significant, in terms of trading history, trading activity and size, ETFs currently available to equity investors.

In this study, we use a number of parametric and non-parametric tests provided by the finance literature and statistical economics to assess whether all the already publicly known information is reflected in the prices of ETFs or, alternatively, whether an ETF investor is likely to obtain above market returns on the basis of the released information.

Firstly, we apply various types of autocorrelation and serial correlation estimating, such as a correlogram derived from testing the residuals of a third-order autoregressive model or the Breusch-Godfrey LM test. While the estimated autocorrelations provide evidence on the rejection of the efficient market hypothesis, the serial correlation tests show that the majority of U.S. ETFs examined in this study are efficiently priced.

Having assessed the correlation among the fluctuations of ETF daily net asset values, we turn our attention to the examination of stationarity in return time series of ETFs. We examine stationarity by using two alternative methods. The first one, a parametric one, is the well-known Augmented Dickey Fuller test, the results of which demonstrate that there is no issue of a unit root in ETF daily return data. The non-existence of a unit root implies that the returns of ETFs on one day are independent to their lagged returns and, thus, the weak-form of capital market efficiency hypothesis is not rejected in the case of U.S. ETFs. The second stationarity test used is the Phillips-Peron test, a non-parametric one. The estimated PP coefficients verify the non-existence of a unit root, which, consequently, means that the market is efficient.

Overall, our results are similar to the previous findings of the literature which demonstrate that the developed capital markets are basically efficient, at least at the weak level. However, we should conclude this paper by noting that there may be other forms of efficiency applicable in the case of ETFs. One obvious kind of efficiency concerns the tracking efficiency of ETFs, namely, their ability to perfectly replicate the performance of their underlying benchmark indexes. Another form of efficiency may concern the tracking ability of ETFs in comparison with the respective ability of their immediate index funds counterparts. A final type of efficiency, which is probably more relating to the concept of the current study, concerns the efficient arbitrage execution on behalf of large institutional investors. Efficient arbitrage means that any gaps between the trading and net asset values of ETFs are just temporally and they are rapidly eliminated. On the contrary, non-efficient arbitrage execution implies that there are opportunities for informed investors of gaining sufficient above average returns in violence to the efficient capital market hypothesis.

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