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Delving into the Exchange-Traded Funds (ETFs) Market: Understanding Market Efficiency

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Abstract

Exchange-traded funds (ETFs) are the most popular products in the financial sector today. There is extensive literature on the multifractal analysis of some stock markets, but not about the multifractal behaviour of the ETF market. This study examines the efficiency of stock index ETFs worldwide from an Efficient Market Hypothesis (EMH) perspective, using the ETFs: Ishares Msci World ETF (URTH), Ishares Russell 1000 ETF (IWB), SPDR S&P 500 ETF TRUST (SPY), Ishares Global Clean En. ETF (ICLN), Ishares USD Green Bond ETF (BGRN), from 1 January 2021 to 24 May 2024. It analyses a pre-conflict and a geopolitical conflict to uncover distinct patterns of behaviour reflecting significant changes in market conditions. Before the conflict, the Ishares MSCI World, Ishares Russell 1000, SPDR S&P 500 and Ishares USD Green Bond ETFs showed signs of anti-persistence in returns, indicating a lack of strong relationship or predictability between short-term price movements. The Ishares Global Clean Energy ETF did not reject the random walk hypothesis, suggesting that returns follow a pattern closer to random, where market prices already efficiently reflect all available information. During the conflict, there was a transition in the ETFs' behaviour patterns, as evidenced by the increases in slope values for Ishares MSCI World, Ishares Russell 1000, SPDR S&P 500, Ishares Global Clean Energy and Ishares USD Green Bond. Thus, the possible transition from anti-persistence to long-term memories in ETF returns during the conflict. For portfolio managers, these findings highlight the need to continually adapt investment strategies to manage risks better and take advantage of opportunities in a dynamic and complex investment environment.

Keywords: *Long Memory, Exchange-Traded Funds, Relative Efficiency.*

Introduction

Recent trends show a growing interest among investors in passive investment funds, especially exchange-traded funds (ETFs). This preference for ETFs can be explained by the fact that, unlike traditional index funds, ETFs can be easily traded on the market and sold short by investors. This mechanism not only facilitates price discovery but also improves the informational efficiency of the market. Several studies on ETFs analyse their efficiency using net asset value (NAV) or the prices of the underlying indices. These have examined ETF premiums and discounts (Engle & Sarkar, 2006) and the drag effects between ETFs and their underlying indices (Chen & Huang, 2010). Other important areas of literature include (a) the contributions of ETFs to the price discovery of the underlying indices compared to other products such as futures (Schlusche, 2009) and passive investment funds (Agapova, 2011); (b) the impact of ETFs on the liquidity of the underlying assets (Richie & Madura, 2007); (c) risk and return characteristics, as well as the portfolio diversification benefits of foreign equity ETFs for emerging market investors (Thanakijsombat & Kongtoranin, 2018); and (d) the liquidity of ETFs and their impact on investor behaviour (Broman & Shum, 2018).

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There is no academic consensus regarding the role of ETFs in the efficiency of underlying assets. While some prominent studies indicate that ETF trading increases the informational efficiency of the underlying securities (Xu et al., 2019; Glosten et al., 2021), evidence is also contrary (Israeli et al., 2017; Lynch et al., 2019). These differences in results may be due to the wide variation in the design of these ETFs. Many "passive" ETFs use stock borrowing and swap-based transactions to simulate the underlying index's returns. This activity of these ETFs can increase the risk for investors (Cheng et al., 2019). In addition, prior market liquidity can also be a factor. In simple terms, (il)liquid stocks may have more liquidity due to ETF trading (Bae & Kim, 2020). In addition, the synchronicity (or lack thereof) of ETF trading and its underlying indices impacts efficiency. In other words, unlike domestic ETFs, international ETFs that trade in different time zones to their underlying indices overreact to the arrival of information on domestic markets(Hilliard, 2014).

The theme that emerges from these studies is the analysis of ETFs' efficiency based on the underlying assets' prices. That said, the efficiency of a financial asset can also be defined in terms of stochastic theory, according to which prices follow a random path. Recent studies in this field have examined ETFs from a univariate perspective to determine their degree of efficiency (Zhu & Bao, 2019). This study is a step in this direction, as the relative efficiency of international equity ETFs from an Efficient Market Hypothesis (EMH) perspective will be examined.

The paper is organised as follows: Section 2 reviews related studies on efficiency, in its weak form, in ETFs. Section 3 describes the data and methodology used to address the research questions. Section 4 presents the data analysis and provides interpretations of the results. Finally, Section 5 offers conclusions based on the results presented in the paper.

Literature Review

Analysing equity exchange-traded funds (ETFs) from the efficiency perspective is relevant in the current financial landscape. ETFs play a crucial role in price formation and the efficient allocation of resources in the market due to their ability to be traded like shares and their growing popularity among investors. By enabling intraday trading, short-selling and diversified exposure to various indices and sectors, ETFs introduce a dynamic that can significantly influence financial markets' liquidity and informational efficiency. Understanding how these instruments affect price discovery, the liquidity of the underlying assets and investor behaviour is essential to assessing their contribution to overall market efficiency.

The authors Zhu and Bao (2019), Almudhaf and Alhashel (2020), and Glosten et al. (2021) examined efficiency in its weak form in the ETF market as well as in its underlying assets. Zhu and Bao (2019) provide clear evidence that the US ETF market was multifractal in nature. It can be seen that the QQQ exhibits the strongest level of efficiency. Secondly, the efficiency of the US ETF market decreased after the global financial crisis. In addition, efficiency levels that vary over time are determined using a sliding window approach. At the same time, the authors Almudhaf and Alhashel (2020) investigated the pricing efficiency of Saudi Sharia-compliant (i.e. Islamic) exchange-traded funds (ETFs). The results reveal a significant positive relationship between the trading volume of Saudi ETFs and volatility, a significant positive correlation between ETF returns and contemporaneous deviations, and a significant negative relationship between returns and lagged deviations. These findings can be interpreted as evidence against the market efficiency of Saudi ETFs.

In a complementary way, the authors Glosten et al. (2021) investigated the effect of exchange-traded fund (ETF) activity on the short-term informational efficiency of their underlying securities. The authors found that ETF activity increases short-term informational efficiency in stocks with weaker information environments. The increase in informational efficiency results from the timely incorporation of systematic earnings information. In contrast, we found no such effect for stocks with stronger information environments. ETF activity increases return comovement, and this increase is partially attributable to the timely incorporation of systematic earnings information.

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More recently, Henriques et al. (2024) examined the efficiency of alternative energy equity exchange-traded funds (ETFs) and conventional energy equity ETFs from 2018 to 2020. The findings indicate that alternative energy ETFs have the potential for long-term outperformance compared to conventional energy ETFs in terms of efficiency. However, during financial crises, the performance differences between the two types of ETFs decrease, with no significant outperformance observed in either category. Meanwhile, Kristjanpoller et al. (2024) investigated the multifractal and asymmetric cross-correlation characteristics between blockchain ETFs and the cryptocurrency and Nasdaq markets. Multifractality exists in the cross-correlations between blockchain ETFs and the cryptocurrency and Nasdaq markets. There is greater persistence in the cross-correlation behaviours between blockchain ETFs and cryptocurrencies in the uptrend, while the persistence between blockchain ETFs and Nasdaq is more pronounced in the downtrend. On the one hand, this suggests that significant fluctuations in the cryptocurrency markets lead to large fluctuations in the blockchain ETF markets. On the other hand, large fluctuations in the Nasdaq index lead to small fluctuations in the blockchain ETF markets.

Studies in this area not only elucidate the inner workings of ETFs but also offer valuable insights for regulators, asset managers and investors, promoting a better understanding of their economic and strategic implications.

Methods

Data

The data used in this article are the index prices of the Ishares Msci World ETF (URTH), Ishares Russell 1000 ETF (IWB), SPDR S&P 500 ETF TRUST (SPY), Ishares Global Clean En. ETF (ICLN), Ishares USD Green Bond ETF (BGRN), from 1 January 2021 to 24 May 2024. To this end, we divided the sample into two sub-periods: pre-conflict, which covers the years from 1 January 2021 to 23 February 2022, and a second sub-period, which we refer to as conflict, from 24 February 2022 to 24 May 2024. The data was retrieved from the Thomson Reuters Eikon platform and is in local currency to mitigate exchange rate distortions.

Methodology

Initially, the main descriptive statistic measures will be used to characterise the sample, as well as the Jarque and Bera (1980) adherence test, whose null hypothesis is the normality of the data. Dickey and Fuller (1981) with Fisher Chi-square transformation and Choi (2001), panel unit root tests will be used to validate the assumption of data stationarity, i.e. whether the series follows a white noise process (mean 0; constant variance), which postulate the same hypotheses ($H_0 = unit\ root$) eand, to validate the results, we will use the Hadri (2000), test, with the opposite null hypothesis ($H_0 = stationarity$). The intersection of the tests will enable us to assess the stationarity of the time series more robustly. The ADF (Augmented Dickey-Fuller) test is widely used when analysing financial time series and consists of different versions, namely the Fisher Chi-square ADF test and the Choi Z-stat ADF test. The ADF Fisher Chi-square test is a version that uses the test statistic based on the difference between the estimated and hypothetical value of a coefficient in the regression model. The Choi Z-stat ADF version uses an alternative approach and the statistic is calculated based on the maximum likelihood estimate of the autoregressive model. Both versions are used to test for the presence or absence of a unit root in the time series.

The Detrended Fluctuation Analysis (DFA) models will be used to answer the research questions. DFA is an analysis method that examines time dependence in non-stationary data series. By assuming that the time series are non-stationary, this technique avoids spurious results when analysing the long-term relationships of the data series. The DFA has the following interpretation: $0 < \alpha < 0{,}5$: anti-persistent; $\alpha = 0{,}5$ random walk series; $0{,}5 < \alpha < 1$ persistent series. The purpose of this technique is to examine the

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relationship between the values x_k and x_{k+t} at different times (Guedes et al., 2018). Table 1 shows the interpretation of the exponents α_{DFA}

Table 1. Detrended Fluctuation Analysis α_{DFA}

Exponent	Type of signal
$\alpha_{DFA} < 0.5$	long-range anti-persistent
$\alpha_{DFA} \simeq 0.5$	uncorrelated, white noise
$\alpha_{DFA} > 0.5$	long-range persistent

Results and Discussion

Figure 1 shows the trajectory of the returns of five different ETFs: Ishares Msci World ETF (URTH), Ishares Russell 1000 ETF (IWB), SPDR S&P 500 ETF TRUST (SPY), Ishares Global Clean Energy ETF (ICLN) and Ishares USD Green Bond ETF (BGRN), over the period from 1 January 2021 to 24 May 2024. The ETFs represent a diversity of markets, from global and US equities to specific sectors such as clean energy and green bonds in dollars.

By visually analysing the data, significant variations can be seen in the returns of the ETFs, which suggests a relatively wide dispersion around the average. This behaviour indicates not only that returns fluctuated considerably but also that there were periods of high volatility, reflecting the instability and uncertainty of the financial market during the period analysed.

Furthermore, the analysis reveals that the ETFs exhibit a synchronised behaviour. This means that despite the differences in the markets and sectors each ETF represents, their return trajectories tend to move similarly over time. This phenomenon can be attributed to macroeconomic factors that widely affect financial markets, such as monetary policies, geopolitical events and changes in investor expectations.

Remarkably, volatility proved especially pronounced in the first months of 2021 and 2022. This period coincides with significant global events, such as Russia's invasion of Ukraine. The invasion, which began in February 2022, brought great uncertainty to global markets, resulting in sudden increases in commodity prices, disruptions in supply chains and fluctuations in the economic policies of various countries.

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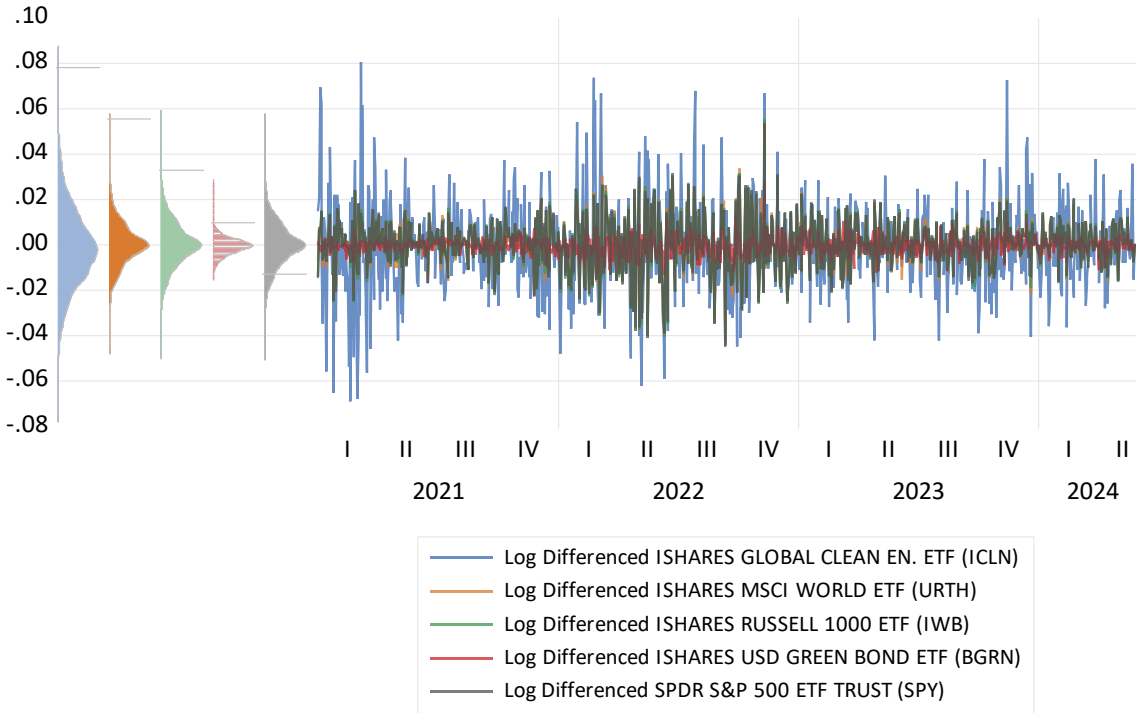

Figure 1. Historical evolution, in returns, of the trajectory of five ETFs from 1 January 2021 to 24 May 2024.

Table 2 shows the main statistics for the five ETFs: Ishares Msci World ETF (URTH), Ishares Russell 1000 ETF (IWB), SPDR S&P 500 ETF TRUST (SPY), Ishares Global Clean Energy ETF (ICLN) and Ishares USD Green Bond ETF (BGRN), over the period from 1 January 2021 to 24 May 2024. The ETFs show positive performance signals, namely URTH (0.00028), IWB (0.00034), and SPY (0.00038), while the ICLN (-0.0007), BGRN (-0.00021) ETFs show negative mean returns.

Regarding the most volatile ETFs, ICLN (0.01917) had the highest dispersion in relation to the mean, while the BGRN ETF (0.00377) had a lower dispersion in relation to the mean, showing that it is a less volatile market. It was also observed that the URTH (-0.1545), IWB (-0.2053) and SPY (-0.21370) ETFs had negative asymmetry values different from zero, while the ICLN (0.3370) and BGRN (0.2694) ETFs had positive asymmetries. The Kurtosis values show values above 3, suggesting distributions that do not obey the Gauss curve, which can be validated by the Jarque-Bera test that rejects the null hypothesis with a significance probability of $p<0.0001$.

Table 2. Descriptive Statistics For Etfs From 1 January 2021 To 24 May 2024.

	ICLN	URTH	IWB	BGRN	SPY
Mean	-0.0007	0.00028	0.00034	-0.00021	0.00038
Std. Dev.	0.01917	0.01013	0.010718	0.00377	0.01054
Skewness	0.3370	-0.1545	-0.2053	0.2694	-0.21370
Kurtosis	4.8721	5.0233	4.8391	6.5075	4.91528
Jarque-Bera	146.167***	154.65***	131.11***	464.88***	142.16***
Probability	0.0000	0.0000	0.0000	0.0000	0.0000
Observations	886	886	886	886	886

The stationarity hypothesis in the time series of the ETFs: Ishares Msci World ETF (URTH), Ishares Russell 1000 ETF (IWB), SPDR S&P 500 ETF TRUST (SPY), Ishares Global Clean Energy ETF (ICLN) and Ishares USD Green Bond ETF (BGRN), over the period from 1 January 2021 to 24 May 2024, was verified using the panel unit root tests of Levin, Lin, and Chu (2002), Im et al. (2003) which postulate the same null hypotheses (unit roots). The Dickey and Fuller (1981) and Phillips and Perron (1988) tests with

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Fisher's chi-square transformation and Choi's (2001) unit root tests will be used to make the results more robust. A log transformation followed by first-order differentiation was applied to the time series to ensure stationarity, aiming to achieve white noise characteristics (zero mean; constant variance). The stationarity hypothesis was validated by rejecting the null hypothesis at a significance level of 1%, as shown in Table 3.

Table 3. Panel Unit Root Test Applied To Etfs Over The Period From 1 January 2021 To 24 May 2024.

Group unit root test: Summary				
Method	Statistic	Prob.**	Cross-sections	Obs
Null: Unit root (assumes common unit root process)		0.0000		
Levin, Lin & Chu t*	-81.6312	0.0000	5	4419
Im, Pesaran and Shin W-stat	-68.4374	0.0000	5	4419
ADF - Fisher Chi-square	856.7906	0.0000	5	4419
PP - Fisher Chi-square	807.4961	0.0000	5	4420

** Probabilities for Fisher tests are computed using an asymptotic Chi-square distribution. All other tests assume asymptotic normality.

Figure 2 shows the Q-Q Plots applied to the ETFs: Ishares Msci World ETF (URTH), Ishares Russell 1000 ETF (IWB), SPDR S&P 500 ETF TRUST (SPY), Ishares Global Clean Energy ETF (ICLN) and Ishares USD Green Bond ETF (BGRN), over the period from 1 January 2021 to 24 May 2024. The graphical analysis shows that all the index distributions are asymmetrical, as evidenced by the deviations of the points from the 45-degree line. These deviations indicate that the time series of the indices do not follow a normal distribution, exhibiting irregular asymmetry and kurtosis. This behaviour has important implications for econometric modelling, suggesting that methods that assume normality may not be appropriate.

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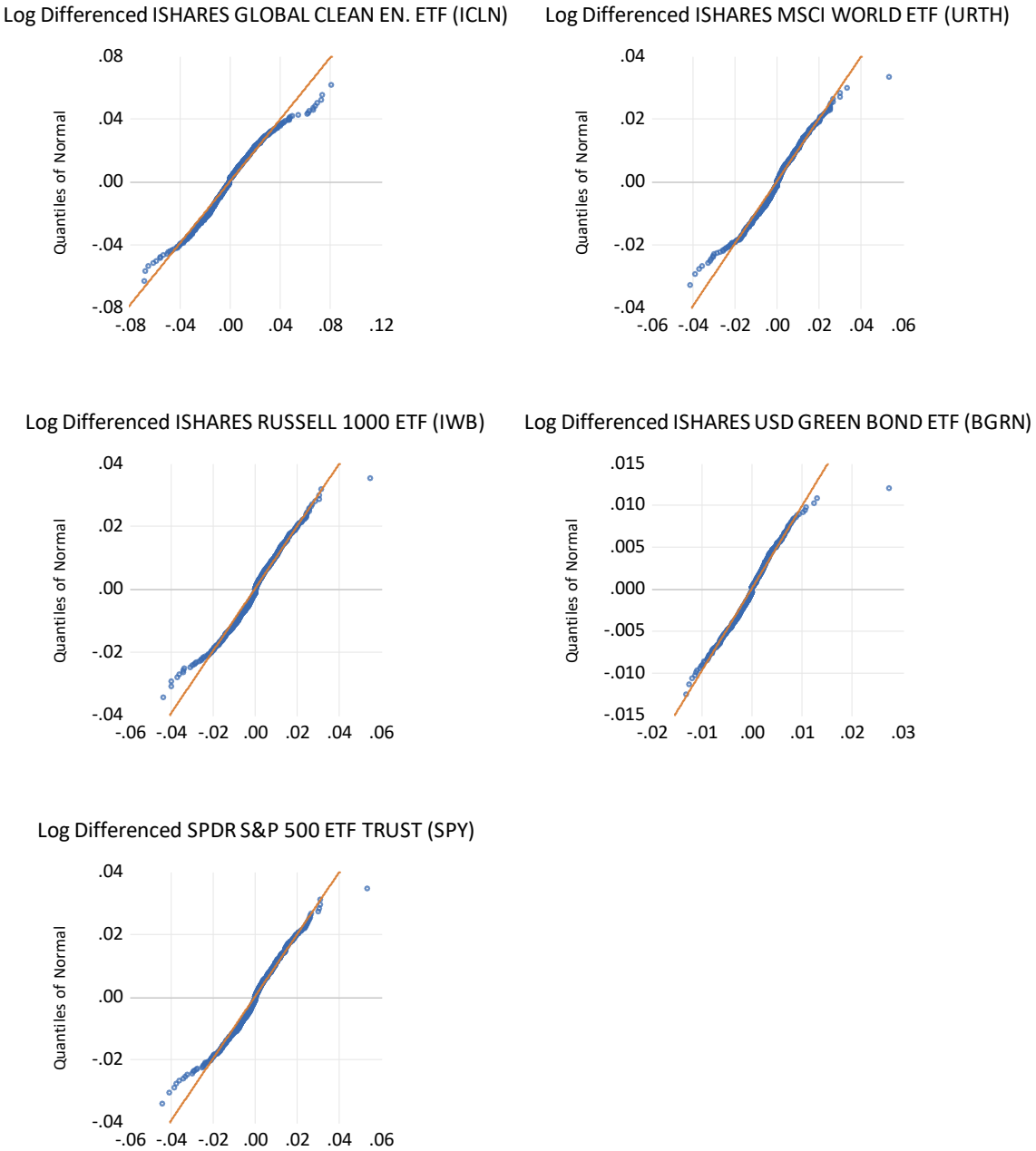

Figure 2. Q-Q Plots, In Returns, Applied To Etfs From 1 January 2021 To 24 May 2024

To remove the doubts that emerged when analysing the return graphs, the Clemente et al. (1998) unit root model that postulates breaks in structure was estimated for the Exchange Traded Funds (ETFs), namely Ishares Msci World ETF (URTH), Ishares Russell 1000 ETF (IWB), SPDR S&P 500 ETF TRUST (SPY), Ishares Global Clean En. ETF (ICLN), Ishares USD Green Bond ETF (BGRN), from 1 January 2021 to 24 May 2024.

The Ishares Global Clean Energy ETF (ICLN) shows a breakdown in structure on 7 January 2021, which we associate with the market correction after a period of euphoria in 2020. The clean energy sector experienced significant growth driven by expectations of stricter environmental policies following the election of Joe Biden. However, this euphoria led to excessively high valuations, which began to correct in January 2021. The transition to greener policies has faced practical challenges, leading investors to adjust their expectations and resulting in a structure breakdown in the ICLN ETF.

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The collapse of the Ishares USD Green Bond ETF (BGRN) on 3 March 2022 can be explained by the sensitivity of the bond market to expectations of rising interest rates due to high inflation. In March 2022, the prospect of imminent interest rate rises by the Federal Reserve affected bond prices, including green bonds. In addition, the energy crisis aggravated by the war in Ukraine may have impacted investments in green bonds, reflecting changes in energy policies and the associated uncertainties.

The structure breaks in the Ishares MSCI World (URTH), Ishares Russell 1000 (IWB) and SPDR S&P 500 Trust (SPY) ETFs on 13 June 2022 can be attributed to a combination of economic and geopolitical factors. During the first half of 2022, global inflation reached high levels, leading the US Federal Reserve to raise interest rates to tackle inflation. This restrictive monetary policy generated uncertainty about economic growth. In addition, the war in Ukraine, which began in February 2022, added geopolitical uncertainty, negatively affecting global market sentiment and contributing to the volatility of ETFs.

In summary, the breaks in structure identified in ETFs highlight how macroeconomic factors, monetary policies, geopolitical uncertainties and market adjustments after periods of euphoria can significantly impact the behaviour patterns of ETFs, causing abrupt and significant changes in their returns and market volatility.

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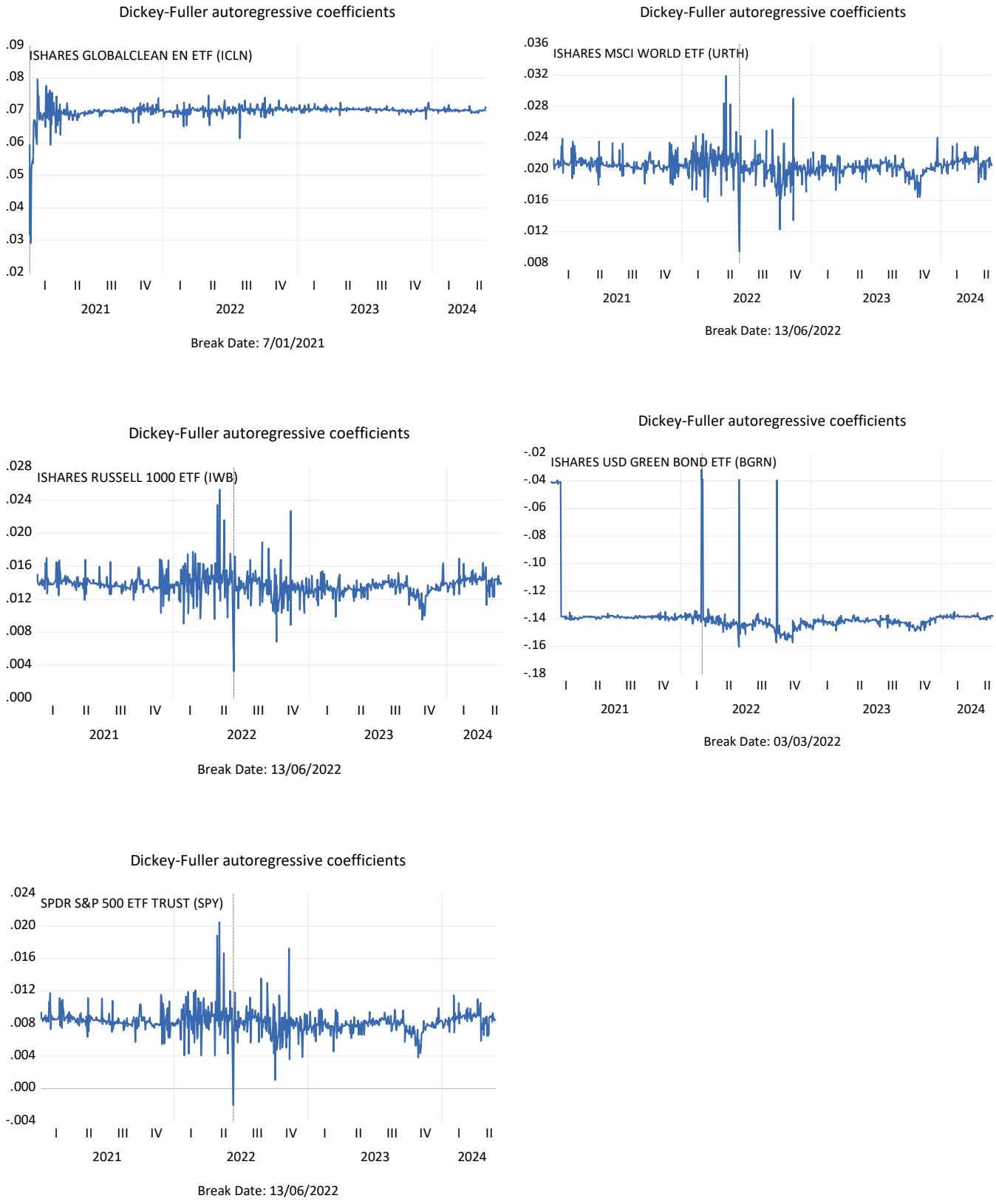

Figure 3. Graphs of the unit root test with structure breaks by Clemente et al. (1998), applied to ETFs from 1 January 2021 to 24 May 2024.

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Table 4 shows the DFA exponents for the Ishares Msci World ETF (URTH), Ishares Russell 1000 ETF (IWB), SPDR S&P 500 ETF TRUST (SPY), Ishares Global Clean En. ETF (ICLN), Ishares USD Green Bond ETF (BGRN), from 1 January 2021 to 24 May 2024. The sample was divided into two sub-periods to ensure greater robustness: pre-conflict, which covers the years from 1 January 2021 to 23 February 2022, and a second sub-period, which we refer to as conflict, from 24 February 2022 to 24 May 2024.

Technical analysis of Exchange Traded Funds (ETFs) during the pre-conflict period reveals different patterns of behaviour that can be interpreted using metrics such as the slope, which indicates the presence of anti-persistence (short-term memory) in the returns of these ETFs.

The ETFs Ishares MSCI World (URTH), Ishares Russell 1000 (IWB), SPDR S&P 500 (SPY) and Ishares USD Green Bond (BGRN) have slopes of 0.45, 0.46, 0.44 and 0.47, respectively. These values suggest that these ETFs exhibit anti-persistence in their returns. In simple terms, anti-persistence means that price movements over a short period do not have a strong relationship or predictability with price movements over subsequent periods. This can be attributed to a rapid change in market conditions, significant external influences (such as changes in monetary policies or geopolitical events) or sharp market reactions to new information.

On the other hand, the Ishares Global Clean Energy ETF (ICLN) does not reject the random walk hypothesis, indicating that returns follow a pattern closer to random or an efficient market. In the financial context, a random walk implies that market prices already efficiently reflect all available information, making it difficult to predict future movements based on historical patterns.

During the geopolitical conflict between Russia and Ukraine, there was a significant change in the ETFs' behaviour patterns, evidenced by changes in slope values. The ETFs Ishares MSCI World, Ishares Russell 1000, SPDR S&P 500, Ishares Global Clean Energy and Ishares USD Green Bond showed slopes of 0.53, 0.52, 0.52, 0.54 and 0.54, respectively. These new values suggest transitioning from anti-persistence to long-term memories in ETF returns during the conflict. This phenomenon can be interpreted as greater stability or persistence in short-term price movements, indicating that investors have come to consider prolonged economic conditions and geopolitical impacts on the global financial market more consistently.

These changes in ETF behaviour patterns have significant implications for portfolio managers, who may need to adjust their investment strategies to better adapt to new market conditions. The transition to long-term memories suggests greater consideration of macroeconomic and geopolitical factors in forming return expectations and risk management, highlighting the importance of continuous and adaptive analysis in the investment environment.

Table 3. Dfa Exponent for Return. The Values of The Linear Adjustments For αDFA Always Had $R^2 > 0.99$

ETF	αDFA (Pré-Conflito)	Results	αDFA (Conflito em 2022)	Results
URTH	0.45** ≅ 0.0033	Anti-persistent	0.53 ** ≅ 0.0073	Persistent
IWB	0.46** ≅ 0.0036	Anti-persistent	0.52 ** ≅ 0.0068	Persistent
SPY	0.44** ≅ 0.0037	Anti-persistent	0.52 ** ≅ 0.0074	Persistent
ICLN	**0.50 ≅ 0.0143**	**White noise**	0.54 ** ≅ 0.0083	Persistent
BGRN	0.47** ≅ 0.0016	Anti-persistent	0.54 ** ≅ 0.0016	Persistent

Note: The hypotheses are H_0: α = 0.5 and H_1: α ≠ 0.5. ** IC a 95%.

Conclusion

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This study's main purpose was to test efficiency, in its weak form, in globally recognised stock index ETFs from the perspective of the Efficient Market Hypothesis (EMH), focusing on the Ishares Msci World (URTH), Ishares Russell 1000 (IWB), SPDR S&P 500 (SPY), Ishares Global Clean Energy (ICLN) and Ishares USD Green Bond (BGRN) ETFs. The period analysed runs from 1 January 2021 to 24 May 2024, divided into two distinct sub-periods: pre-conflict, from 1 January 2021 to 23 February 2022; and conflict, from 24 February 2022 to 24 May 2024. This study seeks to understand how these ETFs behave in different market conditions, including significant geopolitical events, and to assess whether the observed returns are consistent with the market efficiency expected by economic theory.

During the analysis period from 1 January 2021 to 24 May 2024, Exchange Traded Funds (ETFs) showed distinct behaviour patterns, particularly during the pre-conflict and geopolitical conflict sub-periods between Russia and Ukraine. Before the conflict, the Ishares MSCI World, Ishares Russell 1000, SPDR S&P 500 and Ishares USD Green Bond ETFs showed signs of anti-persistence in returns, reflected by the slopes of 0.45, 0.46, 0.44 and 0.47, respectively. This indicates a lack of predictability in short-term price movements, influenced by rapid changes in market conditions and external events such as monetary and geopolitical policies. In contrast, the Ishares Global Clean Energy ETF did not reject the random walk hypothesis, suggesting that its returns follow a pattern closer to random or market efficiency, where prices are adjusted quickly to the available information.

During the period of geopolitical conflict, a change in ETF behaviour patterns was observed, highlighted by the increase in slope values for Ishares MSCI World, Ishares Russell 1000, SPDR S&P 500, Ishares Global Clean Energy and Ishares USD Green Bond, which became 0.53, 0.52, 0.52, 0.54 and 0.54, respectively. This transition suggests greater persistence in long-term price movements during the conflict, possibly due to more consistent consideration of prolonged economic conditions and geopolitical impacts by investors.

These findings highlight the importance of continuous and adaptive analysis for portfolio managers to adjust investment strategies to new market conditions. The transition to long-term memory patterns during the conflict implies an increased need to consider macroeconomic and geopolitical factors in risk management and the formation of return expectations. This is key to maximising investment opportunities and mitigating risks in a dynamic and complex global financial environment.

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