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Impact of the 2020 and 2022 Events on the Efficiency of Europe's Capital Markets

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Abstract: *This paper intends to test efficiency, in its weak form, in the capital markets of the Netherlands (AEX), Belgium (BEL 20), France (CAC 40), Ireland (ISEQ 20), and Portugal (PSI 20), for the period from September 18th, 2017, to September 15th, 2022. Given the skewness and kurtosis coefficients, the time series shows signs of deviation from the normality hypothesis. We also observe that during the Tranquil and second Covid-19 wave subperiods, European equity markets are in equilibrium and that the (in) efficiency hypothesis, in its weak form, does not hold, implying that investors will struggle to achieve returns above the market average without incurring additional risk. When we examine the first Covid-19 subperiod, we find that all capital markets show long memories, indicating a propensity to forecast returns, particularly the Portuguese capital market shows the highest value of persistence (0.65), while the stock indexes of Belgium (BEL 20), France (CAC 40), Ireland (ISEQ 20) have exponents of 0.62, and the Netherlands 0.61. In the fourth sub-period that corresponds to the Russian invasion of Ukraine in 2022, we find that the efficiency hypothesis, in its weak form, is rejected for all stock indexes, except for the French capital market (CAC 40). When the sub-periods of the first wave of COVID-19 and the Russian invasion of Ukraine in 2022 are compared, we notice that markets exhibit more pronounced imbalances during the first wave of COVID-19, due in large part to uncertainty regarding the course of the 2020 pandemic. In addition, we emphasize that during subperiods of higher uncertainty in the global economy, prices do not fully reflect available information and that price fluctuations are not i.i.d. In other words, there is a reversion to the mean, and prices become predictable, allowing regional and international investors to achieve above-market average returns. The authors suggest that these findings are significant for regulators and supervisors of European capital markets to promote efforts to guarantee that available market information is rectified more effectively.*

1. INTRODUCTION

Most writers claim that a stock market is efficient when market agents act in the best interests of the market. Prices of securities traded in an efficient financial market reflect all available information and respond completely and rapidly to new information. In addition to the premise that market information is freely available (Fama, 1965, 1970, 1991).

One of the most fundamental assumptions in financial economics is the Efficient Market Hyp-othesis (EMH), which contends that rates of return have no memory (correlation),

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suggesting that agents cannot obtain returns above the market average without incurring additional risk (Ferreira & Dionísio, 2016).

One of the fundamental concepts of financial theory concerns the efficiency of markets, where the prices of financial assets provide the appropriate signals for the purchase of resources. The market efficiency hypothesis starts from the premise that an investor cannot obtain an extraordinary risk-adjusted return. However, several empirical studies have demonstrated that for the same level of risk, an investor may eventually achieve a return above the market average (Dias et al., 2022; Guedes et al., 2022; Teixeira et al., 2022; Zebende et al., 2022).

Given the events of 2020, the Covid-19 pandemic crisis, and the Russian invasion in 2022, it becomes pertinent to study the predictability of the stock indexes of the Netherlands (AEX), Belgium (BEL 20), France (CAC 40), Ireland (ISEQ 20), Portugal (PSI 20), in the period from September 18th, 2017, to September 15th, 2022. The results show that during the first wave of Covid-19, the markets exhibit significant imbalances caused by global economic uncertainty, implying that the prices of these regional markets could be predictable; similar results were also observed during the Russian invasion in 2022 but to a lesser extent. The results reveal that these markets are balanced during the Tranquil and second wave of Covid-19 sub-periods and that the informational hypothesis cannot be questioned.

This work is divided into five sections in terms of structure. Section 2 is a review of the literature on the efficient market theory in international financial markets. The methods and data are described in Section 3. The findings are presented in Section 4. Section 5 concludes.

2. LITERATURE REVIEW

The author Gibson (1889) produced the first concept of market efficiency, which demonstrated that information regarding stock value was not only complete but also free. In a complementary way, the mathematician Bachelier (1900), showed that asset prices fluctuate randomly and unpredictably, that is, they are independent of previous fluctuations, thus formulating the random walk hypothesis, contributing to what would become one of the most famous theories in finance, the market efficiency hypothesis. Later, the authors Cowles (1933), Cowles (1944), Working (1949) endorsed the random walk hypothesis, stating that investors cannot forecast future values based on previous prices.

Ferreira and Dionísio (2014) examined the predictability of 10 capital markets, showing that the stock indexes of Spain, Greece and Portugal present pronounced long memories, which may put into question the hypothesis of portfolio diversification. The authors Dias et al. (2019) analyzed the financial integration and persistence in Latin American capital markets in the period from 1999 to 2016. The authors show that markets are partially integrated in periods of crisis and non-crisis, and that time data do not reveal strong long memories from the subprime crisis, indicating a rebalancing in these regional markets beginning in 2013. Takyi and Bentum-Ennin (2021) examined the functioning of African capital markets from October 2019 to June 2020; the authors concluded that the global pandemic of 2020 had negative effects on efficiency in its weak form. In a complementary manner Aslam et al. (2020) studied 8 European stock markets, used intraday (5-minute) data, over the period from January 1st, 2020 to March 23rd, 2020, and found that the Spanish stock market is the most efficient, while the Austrian market the most (in)efficient. The authors show that the global pandemic of 2020 required a broad response from regulators and supervisors in order to improve the market's informational efficiency during pandemic outbreaks.

Dias, Alexandre, Vasco, et al. (2021) and Dias, Heliodoro, Alexandre, et al. (2021) tested the commodities and stock markets during the 2020 global pandemic and show that the random walk hypothesis is rejected for the gold, platinum, and silver markets, as well as for the Asian stock markets. The authors demonstrate that returns are autocorrelated over time, which means that price fluctuations are not i.i.d., allowing investors to get above-average returns without incurring additional risk. Vasco et al. (2021) analyzed the efficient market hypothesis, in its weak form, in the capital markets of Brazil, China, South Korea, the USA, Spain, and Italy, in the period from December 2nd, 2019, to May 12th, 2020. The authors highlight that the analyzed markets present long memories, suggesting that the analyzed stock indexes present some predictability.

Guedes et al. (2022) investigated if the recent 20 years' financial crises lowered efficiency in its weak form in 19 stock markets belonging to the 20 most developed nations (G-20). The authors demonstrate, for the most part, that markets exhibit signs of (in) efficiency, such as asymmetries and non-Gaussian distributions, as well DFA exponents different from 0.5.

In a complementary manner, the authors Zebende et al. (2022) employed intraday data to measure market efficiency, in its weak form, in G20 capital markets. The authors show that for time scales less than 5 days, stock markets tend to be efficient, while for time scales longer than 10 days, stock markets tend to be inefficient.

The authors Dias et al. (2022) tested the random walk hypothesis in capital markets of Africa (namely, Botswana, Egypt, Kenya, Morocco, Nigeria, and South Africa) US, the UK, and Japan. The authors suggest that returns are autocorrelated over time, that is, the random walk hypothesis is rejected for all the markets under analysis, with no differences between mature and emerging markets.

In summary, this paper aims to contribute to providing information to investors and regulators of European capital markets, where individual and institutional investors seek diversification benefits, as well as to help promote the implementation of policies that contribute to the efficiency of international markets.

3. METHODOLOGY AND DATA

3.1. DATA

The data analyzed are the prices index of the capital markets of the Netherlands (AEX), Belgium (BEL 20), France (CAC 40), Ireland (ISEQ 20), Portugal (PSI 20), in the period from 18th September 2017 to 15th September 2022. To gauge the research question more efficiently we divided the sample into four sub-periods: the first sub-period we call Tranquil, which comprises the period from September 18th, 2017 to December 31st, 2019; the time-lapse of January 1st, 2020 to December 31st, 2020 represents the 1st Covid-19 Wave and for the 2nd Wave of the global pandemic we define the period from January 1st, 2021 to December 31st, 2021; the fourth sub-period we define the period from January 1st, 2022 to September 15th, 2022 and is related to the Russian invasion of Ukraine. The daily price indexes are derived from the Thomson Reuters Eikon platform and are in euros.

Table 1. The name of countries and their indexes used in this paper

Country	Index
Netherlands	AEX
Belgium	BEL 20
France	CAC 40
Ireland	ISEQ 20
Portugal	PSI 20

Source: Own elaboration

3.2. METHODOLOGY

The research will proceed in stages. In the first step, we will graph levels and returns to better understand the volatility of European capital markets between 2017 and 2022. To determine if the time series has a normal distribution, we will use traditional descriptive statistics, such as skewness and kurtosis estimates, as well as the Jarque and Bera (1980) test.

To determine if the turmoil in the capital markets caused structural breakdowns, we will estimate the Clemente et al. test (1998). To answer the study issue and evaluate efficiency in its weak form in European capital markets, we will use the BDS model to determine if the temporal data is nonlinear or has a strong nonlinear component (Brock & de Lima, 1996). This test is useful for detecting dependence in time series by evaluating the null hypothesis that a series is i.i.d. (independent and identically distributed).

The calculation of the BDS test comprises the following procedures:

1. Given a time series, with N observations, we calculate the first difference of the logarithms of the time series data;

$$\{x_j\} = [x_1, x_2, x_3, \dots, x_N] \tag{1}$$

2. Choosing a value of *m* (dip dimension), one plunges the series into the vectors of dimension *m*, choosing each of the m successive points in the series. This procedure converts the series of scalars into series of vectors;

$$x_1^m = (x_1, x_2, \dots x_m) \tag{2}$$

$$x_2^m = (x_2, x_3, \dots x_{m+1}) \tag{3}$$

$$x_{N-m}^m = (x_{N-m}, x_{N-m+1}, \dots x_N) \tag{4}$$

3. We calculate the correlation integral, in order to measure the spatial correlation of the points, by adding the number of pairs of the points (*i,j*), where $1 \leq i \leq N$ and $1 \leq j \leq N$, in the space of dimension m, which is closed, on the assumption that the points are within the tolerance radius, of Ɛ , each.

$$C_{\varepsilon,m} = \frac{1}{N_m(N_m - 1)} \sum_{i \neq j} l_{i,j;\varepsilon}$$

where $l_{i,j;\varepsilon} = 1$ if $l_{i,j;\varepsilon} \| X_i^m - X_j^m \| \leq \varepsilon = 0$, otherwise: (5)

4. Brock and de Lima (1996) concluded that if a series is i.i.d., then:

$$C_{\varepsilon,m} \approx [C_{\varepsilon,1}]^m \tag{6}$$

And that the quantity $\left[C_{\varepsilon,m} - (C_{\varepsilon,1})^m\right]$ follows a normal distribution, with mean zero and variance V(ε,m), defined as:

$$V_{\varepsilon,m} = 4\left[K^m + 2\sum_{j=1}^{m-1} K^{m-j}C_\varepsilon^{2j} + (m-1)^2 C_\varepsilon^{2m} - m^2 K C_\varepsilon^{2m-2}\right] \tag{7}$$

Where:

$$K = K_\varepsilon = \frac{6}{N_m(N_m-1)(N_m-2)} \sum_{i<j<N} h_{i,j,N;\varepsilon}; \tag{8}$$

And:

$$h_{i,j,N;\varepsilon} = \frac{\left[l_{i,j;\varepsilon} l_{j,N;\varepsilon} + l_{i,N;\varepsilon} l_{N,j;\varepsilon} + l_{j,i;\varepsilon} l_{i,N;\varepsilon}\right]}{3} \tag{9}$$

5. The BDS test statistic is as follows:

$$BDS_{\varepsilon,m} = \frac{\sqrt{N}\left[C_{\varepsilon,m} - (C_{\varepsilon,1})^m\right]}{\sqrt{V_{\varepsilon,m}}} \tag{10}$$

Brock and de Lima (1996) determined that when a sample has more than 500 observations, like in the case of the series analyzed, this statistic follows the asymptotic normal distribution. The BDS test is two-sided, rejecting the null hypothesis if the value taken by the test statistic is higher than the critical value (for example, for 0,05 the corresponding critical value is ±1,96).

The Econophysical Detrended Fluctuation Analysis (DFA) model will be used to validate and robust the results. DFA is a method of analyzing time dependency in nonstationary time series. By assuming that the time series are non-stationary, this method prevents false conclusions when the study focuses on the long-run relationships of the time series. This approach was then used to investigate the behavior of financial series.

DFA has the following interpretation: $0 < \alpha < 0{,}5$: anti persistent series; $\alpha = 0{,}5$ series exhibits random walk; $0{,}5 < \alpha < 1$ persistent series. For a better understanding of this model see the articles developed by Dias et al. (2019), Dias et al. (2022), Zebende et al. (2022), Guedes et al. (2022).

4. RESULTS

Figure 1 shows the evolution, in levels, of the 5 capital markets, namely the AEX (Netherlands), BEL 20 (Belgium), CAC 40 (France), ISEQ 20 (Ireland), PSI 20 (Portugal) stock indexes, for the period from September 18th, 2017, to September 15th, 2022. Based on the observation of the graphs we realize that there is extreme volatility in the first quarter of 2020, evidencing possible breaks in structure. These findings are validated by the authors Dias, Heliodoro, Alexandre, et al. (2021), and Teixeira et al. (2022), who demonstrate the existence of structural fractures in international financial markets in their works.

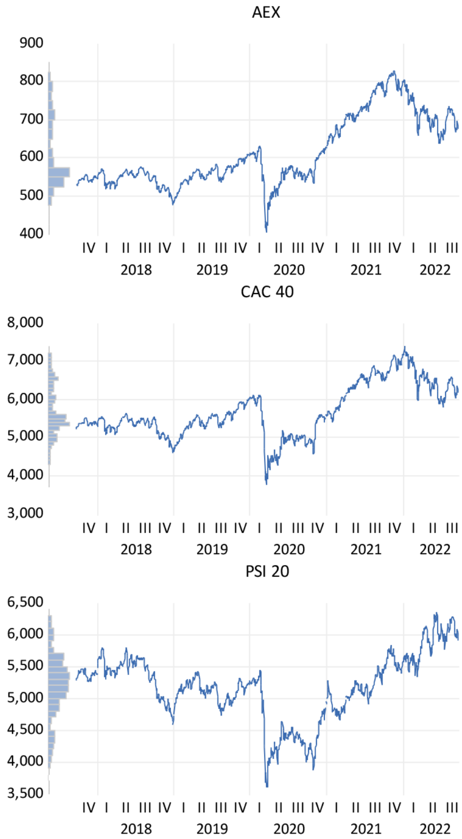


Figure 1. Evolution, in levels, of the 5 European capital markets for the period from 18th September 2017 to 15th September 2022

Source: Own elaboration

In figure 2 we can observe that the data series present a high dispersion around the mean, as well as the existence of sharp structure breaks, due to the sudden drop of stock prices in the analyzed markets. This evidence was also found by the authors, Silva et al. (2020), Vasco et al. (2021), Pardal, Dias, et al. (2021), and Dias et al. (2022).

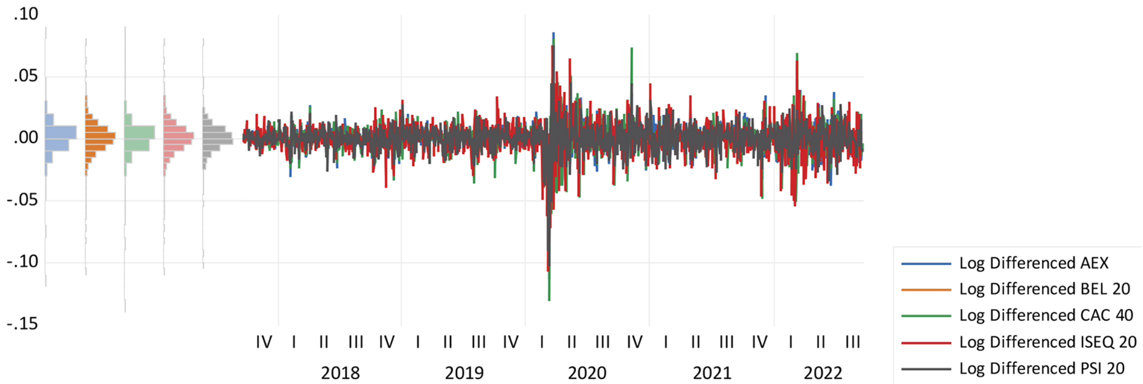


Figure 2. Evolution, in returns, of the 5 European capital markets for the period from September 18th, 2017, to September 15th, 2022

Source: Own elaboration

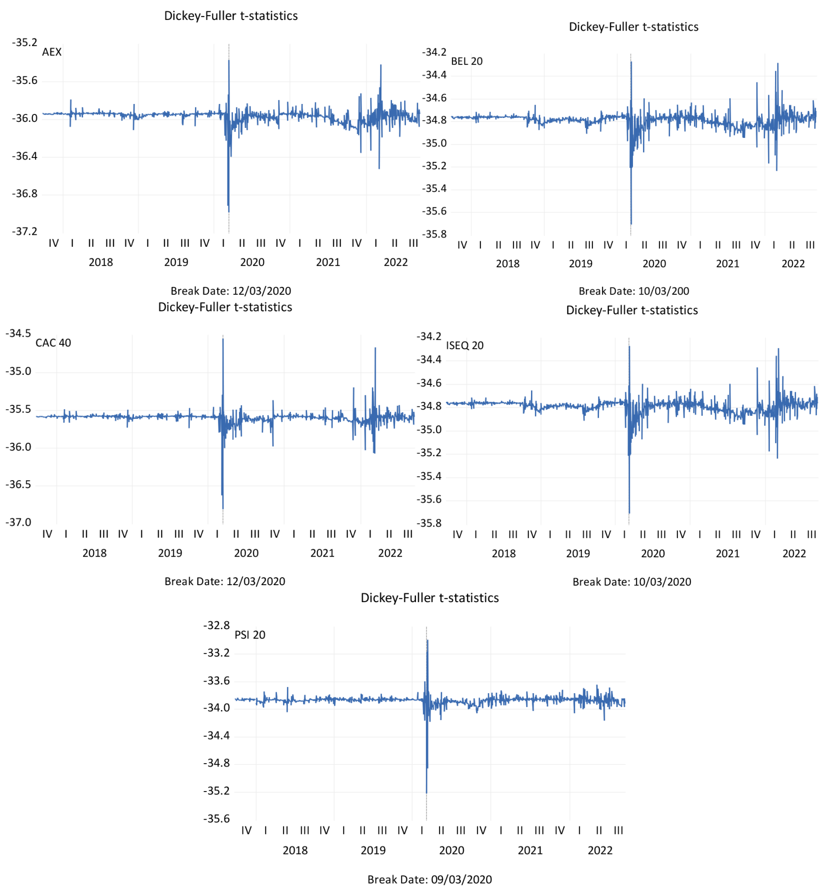
Table 2 shows the main descriptive statistics of the AEX (Netherlands), BEL 20 (Belgium), CAC 40 (France), ISEQ 20 (Ireland), PSI 20 (Portugal) stock indexes, for the period from September 18th, 2017, to September 15th, 2022. The markets under consideration had positive average returns, with the stock indexes of Belgium and Ireland (0.013579) having the highest standard deviation when compared to the other markets under consideration. The French stock market (CAC 40) has the most significant skewness (-1.075170) and Kurtosis (17.49855), as seen in the remaining time series. To confirm this evidence, we use Jarque and Bera's (1980) test, which demonstrates that data do not follow a normal distribution since H0 is rejected at a 1% significance level.

Table 2. Descriptive statistics, return, of the 5 European capital markets over the period from September 18th, 2017, to September 15th, 2022

	AEX	BEL 20	CAC 40	ISEQ 20	PSI 20
Mean	0.000189	6.83E-05	0.000127	6.86E-05	8.76E-05
Std.Dev.	0.011682	0.013579	0.012773	0.013579	0.010942
Skewness	-0.957693	-0.666450	-1.075170	-0.666485	-0.993261
Kurtosis	14.99638	10.38800	17.49855	10.38769	15.13170
Jarque-Bera	7871.026	3005.824	11457.70	3005.587	8059.975
Probability	0.000000	0.000000	0.000000	0.000000	0.000000
Sum	0.242368	0.087369	0.163003	0.087746	0.112159
SumSq.Dev.	0.174530	0.235826	0.208652	0.235830	0.153137
Observations	1280	1280	1280	1280	1280

Note: ***. **. *. represent significance at 1%. 5% and 10%, respectively

Source: Own elaboration



Note: Lag Length (Automatic Length based on SIC) Break Selection: Minimize Dickey-Fuller t-statistic. The lateral values in parentheses refer to lags. ***. **. *. represent significance at 1%. 5% and 10%. respectively

Figure 3. Unit root tests, with structural breaks, of Clemente et al. (1998), concerning the 5 European capital markets for the period from September 18th, 2017, to September 15th, 2022

Source: Own elaboration

In Figure 3 we can observe the unit root tests with structural breaks of Clemente et al. (1998), conducted to the capital markets of the Netherlands (AEX) Belgium (BEL 20), France (CAC 40), Ireland (ISEQ 20), Portugal (PSI 20), in the period from September 18th, 2017 to September 15th, 2022. Based on the results we can evidence that the most significant break, during the sample period, occurs in March 2020, with no significant differences between markets. These findings are validated by the authors Pardal, Dias, et al. (2020), Bagão et al. (2020), Dias, Teixeira, Machova, et al. (2020), and Teixeira et al. (2022), who show that the uncertainty surrounding the 2020 pandemic outbreak (Covid-19) caused significant losses in international financial markets.

Table 3. BDS test applied to time series residuals, concerning the 5 European capital markets, for the period from September 18th, 2017, to September 15th, 2022

BDS Test for PSI 20					
Dimension	**BDS Statistic**	**Std. Error**	**z-Statistic**	**Prob.**	
2	0.018174	0.002338	7.774201	0.0000	
3	0.038447	0.003707	10.37036	0.0000	
4	0.051997	0.004405	11.80284	0.0000	
5	0.058456	0.004582	12.75786	0.0000	
6	0.060739	0.004409	13.77499	0.0000	
Raw epsilon		0.013870			
Pairs within epsilon		1151852.	V-Statistic	0.703035	
Triples within epsilon		1.12E+09	V-Statistic	0.536060	
Dimension	**C(m,n)**	**c(m,n)**	**C(1,n-(m-1))**	**c(1,n-(m-1))**	**c(1,n-(m-1))^k**
2	418725.0	0.512339	574523.0	0.702969	0.494165
3	314858.0	0.385854	573638.0	0.702985	0.347407
4	241391.0	0.296285	572779.0	0.703033	0.244288
5	187687.0	0.230730	572235.0	0.703467	0.172273
6	147581.0	0.181711	571168.0	0.703257	0.120972
BDS Test for AEX					
Dimension	**BDS Statistic**	**Std. Error**	**z-Statistic**	**Prob.**	
2	0.023786	0.002612	9.107616	0.0000	
3	0.050947	0.004143	12.29835	0.0000	
4	0.069855	0.004924	14.18570	0.0000	
5	0.082876	0.005124	16.17455	0.0000	
6	0.088175	0.004933	17.87396	0.0000	
Raw epsilon		0.014350			
Pairs within epsilon		1150938.	V-Statistic	0.702477	
Triples within epsilon		1.13E+09	V-Statistic	0.540174	
Dimension	**C(m,n)**	**c(m,n)**	**C(1,n-(m-1))**	**c(1,n-(m-1))**	**c(1,n-(m-1))^k**
2	422516.0	0.516978	573957.0	0.702276	0.493192
3	324014.0	0.397075	572933.0	0.702121	0.346128
4	255689.0	0.313834	572598.0	0.702811	0.243979
5	207277.0	0.254812	572011.0	0.703191	0.171936
6	170226.0	0.209593	571518.0	0.703688	0.121418
BDS Test for BEL 20					
Dimension	**BDS Statistic**	**Std. Error**	**z-Statistic**	**Prob.**	
2	0.017039	0.002522	6.756537	0.0000	
3	0.038910	0.004000	9.726749	0.0000	
4	0.052988	0.004755	11.14347	0.0000	
5	0.062637	0.004947	12.66050	0.0000	
6	0.065294	0.004763	13.70883	0.0000	
Raw epsilon		0.016811			
Pairs within epsilon		1151338.	V-Statistic	0.702721	
Triples within epsilon		1.13E+09	V-Statistic	0.538912	

Dimension	**C(m,n)**	**c(m,n)**	**C(1,n-(m-1))**	**c(1,n-(m-1))**	**c(1,n-(m-1))^k**
2	416974.0	0.510197	573937.0	0.702252	0.493157
3	314063.0	0.384880	572846.0	0.702015	0.345970
4	240780.0	0.295535	571756.0	0.701777	0.242547
5	189218.0	0.232612	570700.0	0.701580	0.169975
6	150322.0	0.185086	570235.0	0.702109	0.119791
BDS Test for CAC 40					
Dimension	**BDS Statistic**	**Std. Error**	**z-Statistic**	**Prob.**	
2	0.025278	0.002716	9.307648	0.0000	
3	0.051174	0.004313	11.86499	0.0000	
4	0.070954	0.005133	13.82197	0.0000	
5	0.082595	0.005348	15.44321	0.0000	
6	0.086794	0.005156	16.83338	0.0000	
Raw epsilon		0.014859			
Pairs within epsilon		1151922.	V-Statistic	0.703077	
Triples within epsilon		1.14E+09	V-Statistic	0.542880	
Dimension	C(m,n)	c(m,n)	C(1,n-(m-1))	c(1,n-(m-1))	c(1,n-(m-1))^k
2	424511.0	0.519419	574509.0	0.702952	0.494141
3	324960.0	0.398234	573447.0	0.702751	0.347060
4	256915.0	0.315339	572836.0	0.703103	0.244385
5	207574.0	0.255177	572440.0	0.703719	0.172582
6	169301.0	0.208454	571708.0	0.703922	0.121660
BDS Test for ISEQ 20					
Dimension	**BDS Statistic**	**Std. Error**	**z-Statistic**	**Prob.**	
2	0.017047	0.002522	6.760052	0.0000	
3	0.038926	0.004000	9.731058	0.0000	
4	0.053009	0.004755	11.14849	0.0000	
5	0.062645	0.004947	12.66269	0.0000	
6	0.065304	0.004763	13.71146	0.0000	
Raw epsilon		0.016812			
Pairs within epsilon		1151334.	V-Statistic	0.702719	
Triples within epsilon		1.13E+09	V-Statistic	0.538907	
Dimension	**C(m,n)**	**c(m,n)**	**C(1,n-(m-1))**	**c(1,n-(m-1))**	**c(1,n-(m-1))^k**
2	416978.0	0.510202	573935.0	0.702249	0.493154
3	314073.0	0.384892	572844.0	0.702012	0.345966
4	240795.0	0.295553	571754.0	0.701775	0.242544
5	189238.0	0.232636	570711.0	0.701593	0.169991
6	150341.0	0.185109	570246.0	0.702122	0.119805

Note: The method considered in the BDS test was the pair fraction, for a value of 0.7. The first column refers to the embedding dimension. The values presented in the table refer to z-Statistic.
***, ** represent significance at 1% and 5%, respectively

Source: Own elaboration

Table 3 shows the results of the BDS test, performed on the capital markets of the Netherlands (AEX), Belgium (BEL 20), France (CAC 40), Ireland (ISEQ 20) and Portugal (PSI 20), for the period from September 18th, 2017 to September 15th, 2022. Based on the findings, we show that the data is not independent and identically distributed (i.i.d.), indicating that the returns of the European capital markets under consideration are non-linear or have a strong non-linear component.

The rejection of the null hypothesis, may be explained, among other factors, by the existence of autocorrelation or heteroscedasticity in the stock market indexes under analysis. These findings may be verified in the works of the authors Santos et al. (2020), Santos et al. (2021), that show the existence of persistence in financial market returns.

The findings of the DFA exponents are shown in tables 4 and 5, and during the calm sub-period, the random walk hypothesis is not rejected in any of the European stock indexes. When we look at the first Covid-19 subperiod, we see that all financial markets have long memories, or a propensity to forecast returns. The Portuguese stock market has the highest value of persistence (0.65), while the stock indexes of Belgium (BEL 20), France (CAC 40), Ireland (ISEQ 20), and the Netherlands have exponents of 0.62 and 0.61, respectively.

In the second Covid-19 wave subperiod, we find that markets tend towards equilibrium, a finding validated by the non-rejection of the random walk hypothesis. In the fourth sub-period where we analyze the time-lapse of the Russian invasion of Ukraine in 2022, we find that the hypothesis of efficiency, in its weak form, is rejected in all stock indexes, except for the French capital market (CAC 40).

The BEL 20 and ISEQ 20 stock indexes are the most persistent, with exponents of 0.62 and 0.61, respectively, while the PSI 20 has an alpha of 0.57 and the Netherlands (AEX) has an alpha of 0.54. When we compare the sub-periods, we find that markets display more extreme imbalances during the first wave of Covid-19, owing to concern about the 2020 pandemic breakout.

Complementarily we also highlight that, during the sub-periods of the first wave Covid-19, and the Russian invasion in 2022, prices do not fully reflect available information and that fluctuations in prices are not i.i.d. This carries implications for investors, as some returns may be expected, creating arbitrage and abnormal profit opportunities. These results are validated by the authors Dias, Heliodoro, Teixeira, et al. (2020), Dias and Santos, (2020), Dias, Pardal, et al. (2021), and Santos et al. (2021) that suggest the presence of long memories in international financial markets.

Table 4. DFA exponent for index and return. The values of the linear adjustments for α DFA always had R2 > 0.99

Stock market	DFA exponent (Calm)	DFA exponent (1 Vacancy Covid-19)
AEX	0.52 ≅ 0.0067	0.61 ≅ 0.0574***
BEL 20	0.55 ≅ 0.0272	0.62 ≅ 0.0472***
CAC 40	0.52 ≅ 0.0064	0.62 ≅ 0.0406***
ISEQ 20	0.54 ≅ 0.0289	0.62 ≅ 0.0427***
PSI 20	0.53 ≅ 0.0126	0.65 ≅ 0.0327***

Note: The hypotheses are H0: α = 0.5 and H1: α ≠ 0.5.
***. **. *. represent significance at 1%. 5% and 10%. respectively

Source: Own elaboration

Table 5. DFA exponent for index and return. The values of the linear adjustments for α DFA always had R2 > 0.99

Stock market	DFA exponent (2 Vacancy Covid-19)	DFA exponent (invasion 2022)
AEX	0.44 ≅ 0.0183	0.54 ≅ 0.0314**
BEL 20	0.49 ≅ 0.0280	0.62 ≅ 0.0234***
CAC 40	0.49 ≅ 0.0224	0.52 ≅ 0.0362*
ISEQ 20	0.49 ≅ 0.0289	0.61 ≅ 0.0234***
PSI 20	0.45 ≅ 0.0386	0.57 ≅ 0.0193***

Note: The hypotheses are H0: α = 0.5 and H1: α ≠ 0.5.
***. **. *. represent significance at 1%. 5% and 10%. respectively

Source: Own elaboration

5. CONCLUSION

This paper tested efficiency, in its weak form, in the capital markets of the Netherlands (AEX), Belgium (BEL 20), France (CAC 40), Ireland (ISEQ 20), Portugal (PSI 20), in the period from September 18th, 2017 to September 15th, 2022.

The general conclusion to be retained and sustained in the results obtained, through the tests carried out with econometric and mathematical models demonstrated that the worldwide pandemic of 2020 (1st wave) and the Russian invasion in 2022 had a substantial impact on the memory properties of the European markets analyzed.

We also find that the European equity markets, under analysis, are in equilibrium during the Tranquil and second wave Covid-19 subperiods and that the (in) efficiency hypothesis, in its weak form, does not hold, implying that investors are unlikely to obtain returns above the market average without incurring additional risk. When we analyze the sub-period corresponding to the first wave of Covid-19, we find that all capital markets show long memories, which means that, there is a propensity to forecast returns, with the Portuguese capital market having the greatest persistence value (0.65).

For the period corresponding to the Russian invasion of 2022, we find that the hypothesis of efficiency, in its weak form, is rejected in all stock indexes, except for the French stock market (CAC 40). When we compare the sub-periods of the first wave of Covid-19 and the Russian invasion in 2022, we notice that markets exhibit more pronounced imbalances during the first wave of Covid-19, due in part to uncertainty about the developments of the 2020 pandemic outbreak.

Complementarily we also highlight that, during subperiods of greater uncertainty in the global economy, prices do not fully reflect available information and that price changes are not i.i.d. Put in other words there is a reversion to the mean, and prices become predictable, allowing regional and international investors to achieve above-market average returns.

The authors conclude that these findings are significant for regulators and supervisors of European capital markets to promote measures to ensure that available market information is corrected more efficiently.

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