HAS THE GLOBAL PANDEMIC OF 2020 LED TO PERSISTENCE IN THE SHARE PRICES OF LARGE GLOBAL COMPANIES?

Hortense Santos[1]
Rui Dias[2]
Cristina Vasco[3]
Paulo Alexandre[4]
Paula Heliodoro[5]

DOI: https://doi.org/10.31410/EMAN.S.P.2021.1

Abstract: *This paper aims to analyze the predictability of the stocks of Apple, Microsoft Amazon.com, Tesla, Facebook, Samsung, Electronics, Johnson & Johnson, Walmart, in the period from October 1, 2019 to January 11, 2021. To carry out such an analysis, it is intended to answer two research questions, namely: (i) is there predictability in the stock prices of the companies under analysis? (ii) Can investors diversify risk by incorporating these companies' shares into their portfolios? The results of the Exponents Detrended Fluctuation Analysis (DFA) show that Apple (0.51) Microsoft (0.49), Amazon.com (0.53), Samsung Electronics (0.53), Johnson & Johnson (0.53) do not have long memories in their time series, that is, investors cannot obtain abnormal profitability without incurring additional risk. Walmart (0.41) has anti-persistence, while Tesla (0.60), Facebook (0.55) indicate some predictability, meaning investors adjusting their trading strategies to the necessary missteps may have some above-average profitability, which partly rejects the first question of the research. To answer the second research question, we estimated the Detrended cross-correlation coefficient (pDCCA) model, which indicates 17 mean correlation coefficients (≈ 0.333 → ≈ 0.666), 7 strong cross-trend correlation coefficients (0.666 → ≈ 1,000), 4 weak correlation coefficients (≈ 0.000 → ≈ 0.333). These results show that investors should be careful to incorporate the shares of these companies into a single portfolio; the suggestion would be to group only the shares of companies that do not present predictability and have low rhoDCCA. The authors consider that this evidence will be important for institutional investors when carrying out trading strategies based on maximizing profitability, but also mitigating risk when diversifying.*

Keywords: *Covid-19, Predictability of stock prices, Diversification of portfolios.*

1. INTRODUCTION

The market efficiency hypothesis is a very relevant concept for international investors who want to have their portfolios diversified, with the purpose of mitigating the inherent risk of global financial markets. With the global economy increasingly integrated, international investors have sought to diversify their portfolios into more exotic markets in different ways, with the aim of the synchronization of their assets being low. Testing market synchronizations and deducing the existence of assumptions of portfolio diversification when markets are not integrated may lead to distorted indications. We have seen a strong correlation between past and future data series, which makes it possible for the investor to have anomalous profitability when selecting an appropriate trading strategy. The possibility of investors being able to pre-

[1] School of Business and Administration, Polytechnic Institute of Setúbal, Portugal
[2] School of Business and Administration, Polytechnic Institute of Setúbal, Portugal and CEFAGE-UE, IIFA, University of Évora, Portugal
[3] School of Business and Administration, Polytechnic Institute of Setúbal, Portugal
[4] School of Business and Administration, Polytechnic Institute of Setúbal, Portugal
[5] School of Business and Administration, Polytechnic Institute of Setúbal, Portugal

dict future price changes may lead to imbalances in financial markets, making it difficult to implement efficient portfolio diversification strategies (Alexandre, Dias, and Heliodoro, 2020; Alexandre, Heliodoro, and Dias, 2019; Dias, R. and Pereira, 2020; Dias and Carvalho, 2020; Dias, Alexandre, & Heliodoro, 2020; Dias, da Silva, and Dionysus, 2019; Dias, Heliodoro, and Alexandre, 2019, 2020b, 2020a; Dias, Heliodoro, Alexandre, Santos, and Farinha, 2021; Dias, Heliodoro, Alexandre, and Vasco, 2020a, 2020b; Dias, Heliodoro, Alexandre, et al., 2020a, 2020a; Dias, Heliodoro, Teixeira, and Godinho, 2020; Dias, Pardal, Teixeira, and Machová, 2020; Dias, Teixeira, Machova, et al., 2020; Heliodoro, Alexandre, and Dias, 2019; Heliodoro, Dias, and Alexandre, 2020; Heliodoro, Dias, Alexandre, and Vasco, 2020; Sparrow, P., Dias, R., Šuleř, P., Teixeira, N., and Krulický, 2020; Santos and Dias, 2020).

The efficient market hypothesis (EMH) explains the random walk hypothesis, suggesting that stock prices are independent of each other, so it is impossible to achieve abnormal profitability without incurring additional risk. The positive effect of a well-functioning and highly efficient financial market in the global economy is largely due to massive modernization initiatives (Jr. and Camba, 2020).

Speculation in financial markets has been a process that aims to discover asset prices by investors in international financial markets. However, measures taken to mitigate this speculation have significantly reduced informational efficiency in those markets. Given these events, this paper aims to analyze the predictability of the quotations of Apple, Microsoft Amazon.com, Tesla, Facebook (CLASS A), Samsung Electronics, Johnson & Johnson, Walmart, in the period from October 1, 2019 to January 11, 2021. To carry out such an analysis, it is intended to answer two research questions, namely: (i) is there predictability in the stock prices of the companies under analysis? (ii) Can investors diversify risk by incorporating these companies' shares into their portfolios? The results show, for the most part, that the shares of companies do not present predictability, that is, investors are unable to obtain anomic profitability without incurring the additional risk, except for Tesla (0.60), Facebook (0.55) which rejects in part the first question of the research. To answer the second research question, we estimated the *Detrended cross-correlation coefficient* (*pDCCA*) model, which indicates 17 mean correlation coefficients (≈ 0.333 → ≈ 0.666), 7 strong cross-trend correlation coefficients (0.666→ ≈1,000), 4 weak correlation coefficients (≈ 0.000 → ≈ 0.333). These results show that investors should be careful to incorporate the shares of these companies into a single portfolio; the suggestion would be to group only the shares of companies that do not present predictability and have low *rhoDCCA.*

In terms of structure, this test is organized in 5 sections, including the introduction. Section 2 shows the characteristics of companies. Section 3 describes the methodology and data. Section 4 contains the results. Section 5 concludes.

2. COMPANY CHARACTERIZATION

Apple is an American company with a market capitalization of 2,340T that produces and sells computers, personal electronics, peripherals and computer software. It presented its first product in 1976 at the hands of its founders Steve Jobs and Steve Wozniak. In the last 20 years, it popularized devices such as iPod, iPhone and iPad, thus creating new market segments where it became the leader and target of its competitors, making design and status its main commercial flag. As it can be seen in figure 1, Apple has shown a constant revenue and net income; however, the profit margin fell in the years 2019 and 2020, from approximately 22.5% to 21%. The value of assets

and liabilities has also been stable; in the year 2020 the percentage of debt grew significantly (37.75%). With an increasing operating cash flow of 80,674M in 2020, we found that the cash flow of financial activities was approximately (-87,000M), representing a significant reduction of 4.5% compared to 2019. Cash flow investing fell from approximately 46,000M in 2019 to a negative cash flow investing of 4,000M in 2020 (Apple, 2021; Bloomberg, 2021; Reuters, 2021).

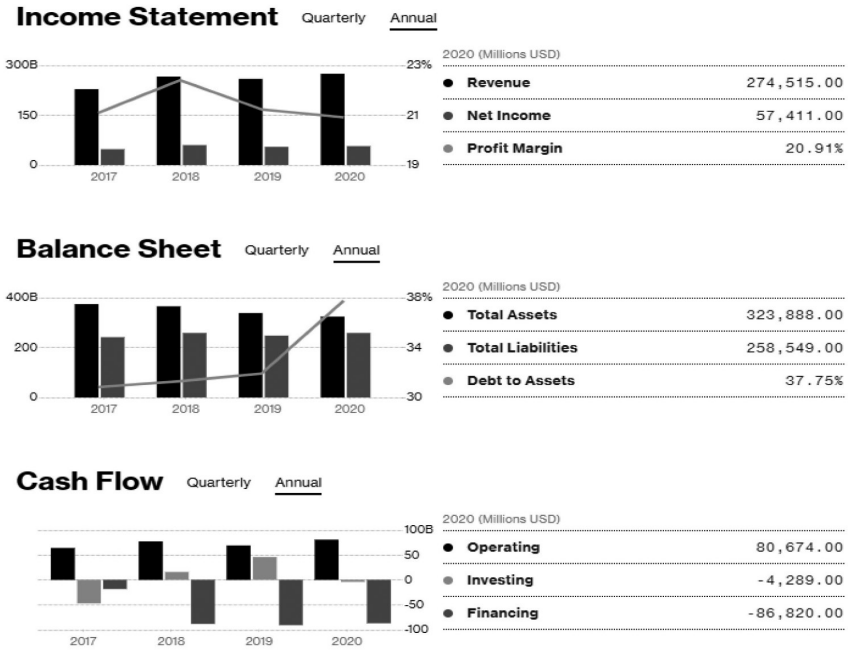

Figure 1. Financial data of the Apple company
Source: https://www.bloomberg.com/quote/AAPL:US

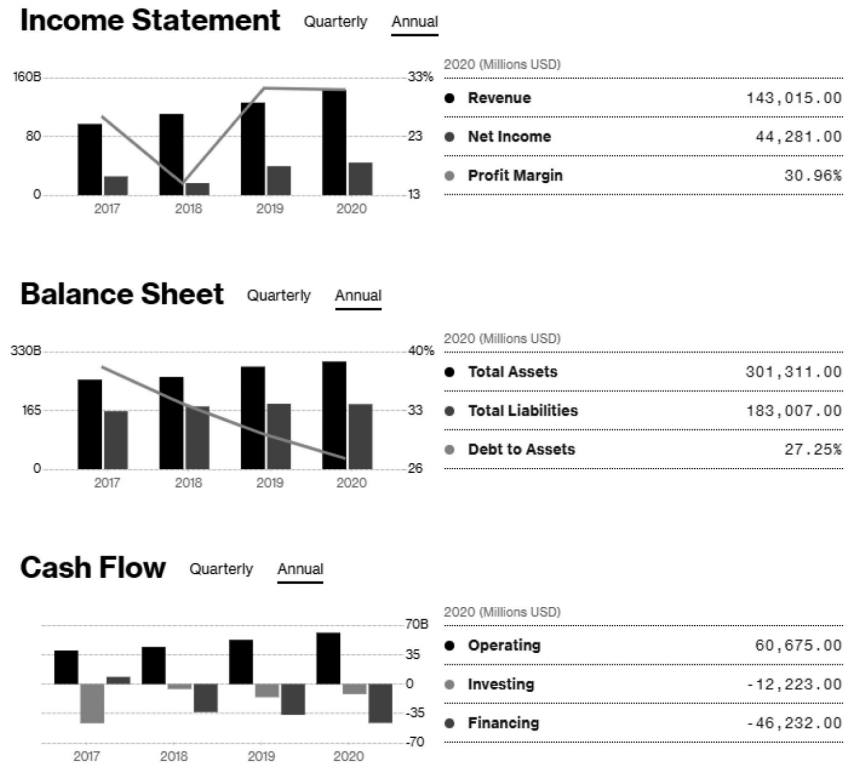

Figure 2. Microsoft company financial data
Source: https://www.bloomberg.com/quote/MSFT:US

Microsoft has a market capitalization of 1,708T and is the world's leading producer of personal computer software and applications. Founded in 1975 by Bill Gates and Paul Allen, its genesis was the creation of an operating system at the request of the giant, IBM, then MS-DOS was born. It was in the late 1980s that it had exponential growth, dominating the world market entirely. In the 2000s Microsoft diversified its offering, specifically in video games (Xbox ecosystem) and smartphone markets. Currently, they maintain the domain on personal computers with the Windows operating system and the Office productivity suite. However, it focuses a lot on cloud services and business solutions, where its main competitor is Google. According to Figure 2, Microsoft has shown a revenue with the constant growth of approximately 15% per year; the net result in 2018 shows losses of 35% when compared to the year 2017, recovered in consecutive years, rising from 2018 to 2019 (136%). With a view to total assets, this figure has grown steadily from 3.5% to 10%, total liabilities increased between 2017 and 2019, and remained stable in 2020, with a debt percentage of 27.25%. With an increasing operating cash flow of 60,675M in 2020, we found that the cash flow of financial activities was negative (- 46.232M) also in 2020. Cash flow investing increased compared to 2019 and was negative in 2020 at -12.223 million dollars (Microsoft,2021; Bloomberg, 2021; Reuters, 2021).

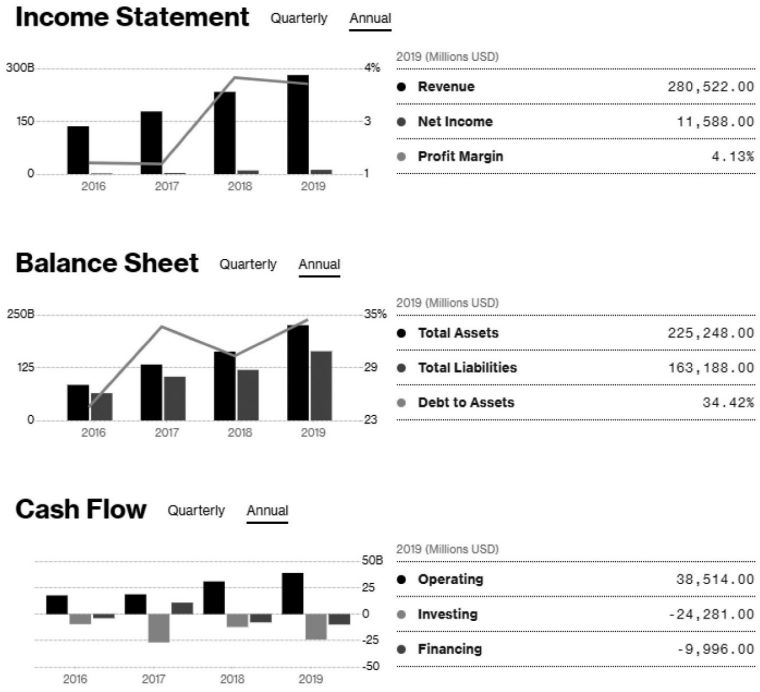

Figure 3. Amazon financial data

Source: https://www.bloomberg.com/quote/AMZN:US

Amazon is an American company with a market capitalization of 1,652T and is now the leading online retailer available worldwide. Founded in 1994 by Jeff Bezos, it was year 1995 when it stood out as an online bookstore; after 2 months of its launch, the company ensured service to all 50 U.S. states and 45 countries (Amazon, 2021).

Since the year 2000, Amazon has diversified its product, expanded from selling books to basically everything from electronics to consumer goods. In the last decade, the accent was on the mobile market with the launch of smartphones, tablets, e-readers of own brand, streaming multimedia content, with Amazon Prime and the Echo ecosystem that promises the virtualization and automation of housing. According to Figure 3, Amazon has achieved an increasing revenue in the

years under the analysis of approximately 30% per year; the net result shows equal behavior, and in the year 2018 it raised 232% compared to the previous year; the profit margin also had an exponential growth from 2017 to 2018. As for total assets and liabilities, there has been recorded a growth in both headings in the same order of magnitude, and the share of the debt was 34.42% in 2019. It had an increasing operating cash flow of 38,514M in 2019; we found that the cash flow of financial activities was approximately -9,996M, remaining at the same value as in 2018; the cash flow from investing reduced to -24. 281M (Amazon, 2021; Bloomberg, 2021; Reuters, 2021).

Walmart is a U.S. company with a stock market capitalization of 414,009B, founded in 1962 by Sam Walton in Texas, soon realized that only massive growth would bring profitability. So, it opted for the strategic opening of establishments in rural areas, and 1967 already owned 24 stores. In the 1990s, it expanded its activity to China, Canada and the United Kingdom. Currently, they remain one of the world's leading retail players, with sustained expansion in countries that are not yet present and with an increasingly solidified online position (Walmart, 2021).

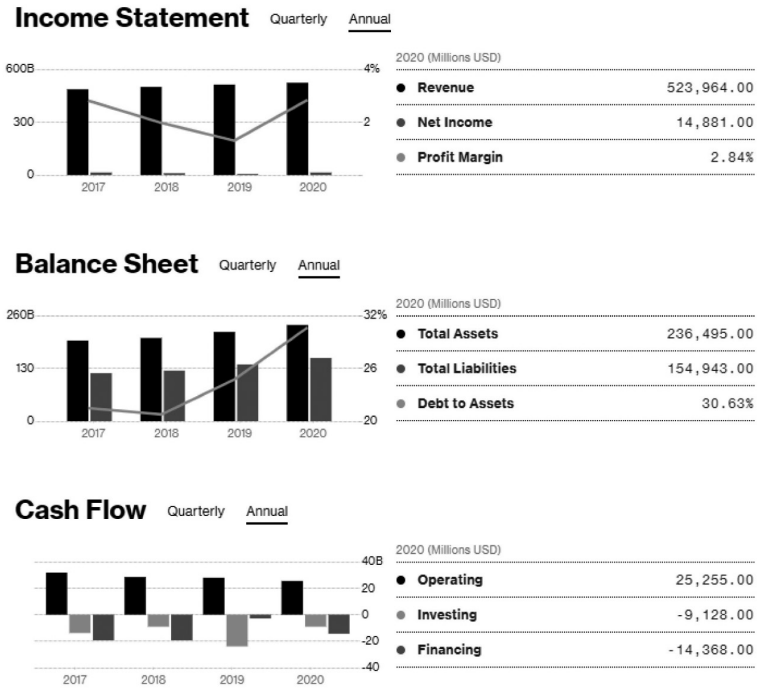

Figure 4. Financial data of Walmart

Source: https://www.bloomberg.com/quote/WMT:US

Figure 4 shows some financial data from Walmart, which has shown stable revenue over the years, with an increase of approximately 2% per year. The net result has similar ratios (2%), having decreased in the years 2018 and 2019, and in 2020 it recovered (15,000M); the profit margin fell in the years 2018 and 2019, following the movement of net income (2.84%) in the year 2020. Total assets and liabilities show growth in both headings, with the growth of total assets between 7-10% and total liabilities of 10%; the percentage of debt was 30.63% in 2020. With an operational cash flow to decline, the value was 25,255M in 2020, so it turns out that the financial cash flow was -14.368M. Cash flow from investing was -9,128M in 2020 (Walmart, 2021; Bloomberg, 2021; Reuters, 2021).

South Korea's Samsung Electronics, with a market capitalization of 518,177T, founded in 1969 by Lee Byung-Chull, began its activity as a producer of electronic and semiconductor compo-

nents. In the 1980s it achieved globalization by establishing its position as one of the world's 5 largest electronics producers. Between 1990 and 2000 it adjusted its offer, entering convincingly in markets such as personal computers, peripherals and smartphones. In the last 20 years, it consolidated this position, being one of the main players in personal and industrial technology. Figure 5 shows that Samsung Electronics has a stable revenue over the years; however, the net result shows a sharp drop in the years 2018 and 2019, with a recovery in 2020; the profit margin tracks the performance of net income, showing in 2020 a value of 11.02%. Total assets and liabilities show proportional growth in both headings, the share of debt was 5.22% in 2020. With an operational cash flow to decline, but in line with that recorded in 2017, the value was KRW 45,382.92B in 2019; it turns out that the financial cash flow increased in 2019, being -8,829.25B KRW. Cash flow from investing was also growing at -39,948.17B KRW (Samsung, 2021; Bloomberg, 2021; Reuters, 2021)

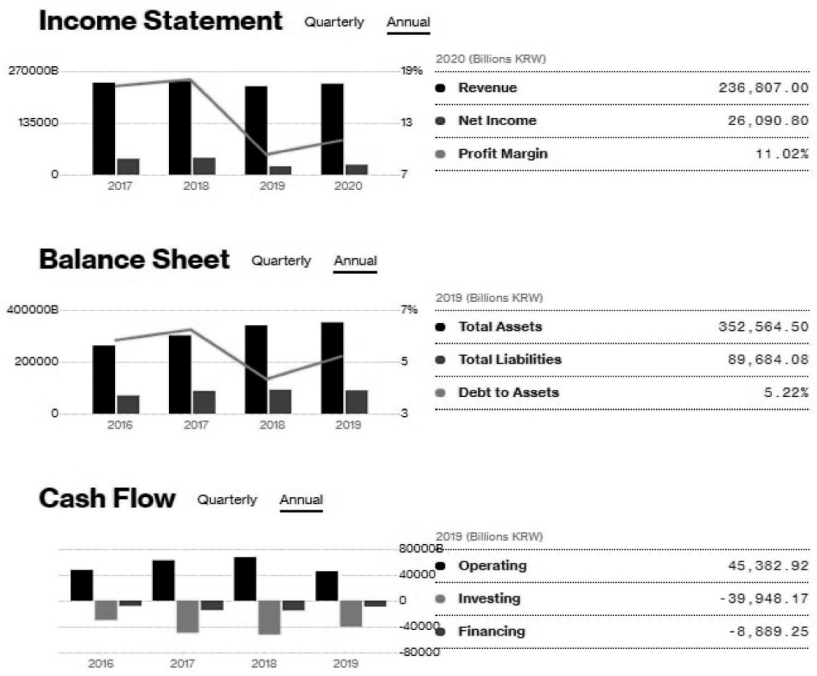

Figure 5. Financial data of Samsung Electronics
Source: https://www.bloomberg.com/quote/005930:KS

Johnson & Johnson was founded in 1886 by three brothers: Robert Wood Johnson, James Wood Johnson and Edward Mead Johnson, and currently has a stock market capitalization of 430,552B. At the foundation, it produced and marketed medical supplies, home products and medical guides. The sale of first aid kits had the first commercial success. Since then, research has played a key role in the development of the company's business model, with the acquisition of scientifically relevant laboratories being the focus of its strategy. Figure 6 shows some financial data from Johnson & Johnson, which has seen slight growth in its revenue in recent years, e.g. revenue of 82,584M in 2020; however, net results in 2018 grew by more than 1000%, the profit margin tracks the performance of net income, with a value of 17.82% in 2020. Total assets and total liabilities increased in 2018 and have remained stable since then, the share of debt was 18.18% in 2020. With an increasing operating cash flow (23,416M) in 2020, it turns out that financial cash flow increased slightly (-18,024M), with cash flow from investing in 2020 of 6,194M. (Bloomberg, 2021; Reuters, 2021).

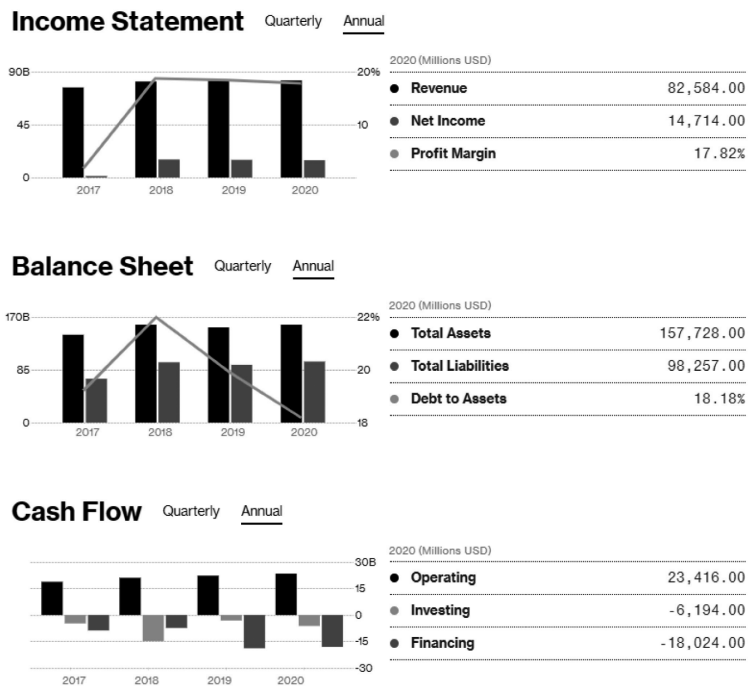

Figure 6. Financial data of Johnson & Johnson
Source: https://www.bloomberg.com/quote/JNJ:US

3. METHODOLOGY

3.1. Data

The data used for the preparation of this paper were the stocks of Apple, Microsoft Amazon. com, Tesla, Facebook (CLASS A), Samsung Electronics, Johnson & Johnson, Walmart, in the period from October 1, 2019 to January 11, 2021, and the data were extracted from the *Thomson Reuters* platform. The prices index has daily scales and is found in local currency to mitigate distortions arising from exchange rates.

3.2. Methodology

The development of the research took place through several stages. In the first phase, we chart the evolutions of exchange rates in levels. The characterization of the sample was performed through descriptive statistics, the adherence test of Jarque and Bera (1980). To validate extreme market volatility we carry out stability tests on waste, as well as tests for structural breakdowns, through the model of Clemente, Montañés, and Reyes (1998). To answer the first research question, we will use the D*etrended Fluctuation Analysis (DFA)* methodology. DFA is an analysis method that examines temporal dependence on non-stationary data series. This technique by assuming that time series are non-stationary avoids spurious results when the analysis focuses on the relationships of the data series in the long term. This methodology was developed by Peng et al. (1994) , having the same origin in the study of the behavior of *DNA*. Later this method was used to examine the behavior of financial series. DFA has the following interpretation: $0<\alpha<0,5$ anti-persistent series; series features $\alpha=0,5$ *random walk;* $0<\alpha<1$ persistent series. The function of this technique is to examine the relationship between values x_k and x_{k+t} and in different moments (Dias, da Silva, and Dionysus, 2019; Santos and Dias, 2020; Dias, Heliodoro, and Alexandre, 2020a; Dias, Heliodoro, Alexandre, Santos, and Farinha, 2021).

Consider a dataset x_k, with $k = 1,..., t$ equidistant observations. DFA's first step is the construction of a new series:

$$x(t) = \sum_{k=1}^{t} x_k \quad (1)$$

The second step is to obtain the trend of each fraction $z(t)$, through the least squares method, obtaining the subtracted series from the trend (detrended), i.e.

$$x_s(t) = x(t) - z(t) \quad (2)$$

The original application assumes that the trend present in each of the boxes is a linear trend, i.e. $Z(t) = at + b$ subsequent applications indicate that it is likely to contain other polynomial tendencies (Kantelhardt, Koscielny-Bunde, Rego, Havlin, and Bunde, 2001). For each box, the value of the trend equation is obtained by the least squares method and later the root of the mean square deviation between the series is estimated $x(t)Z(t)$ and, the DFA function being given by:

$$F(s) = \sqrt{\frac{1}{2N} \sum_{t=1}^{2N} [x_s(t)]^2} \quad (3)$$

Estimating the average $F(s)$for all centralized boxes in s generates the value of fluctuations $\langle F(s) \rangle$, depending on s. This estimation will be repeated for all distinct values of s, expecting a process of a power-law, i.e.

$$\langle F(s) \rangle \sim s\alpha^{\alpha} \quad (4)$$

To answer the second research question, we will use the Detrended cross-correlation coefficient model, *pDCCA*. The cross-correlation coefficient depends on the length of the box (time scale). One of the advantages of this cross-correlation coefficient is centered on the possibility of measuring the correlations between two non-stationary time series at different time scales. The sdcca cross-correlation coefficient varies $-1 \leq \rho DCCA \leq 1$ within the logical range; 1 means perfect cross correlation, –1 means perfect cross-correlation and 0 means that there is no correlation (Podobnik and Stanley, 2008). Table 1 shows the interpretation of the exponent *pDCCA*.

Table 1. Detrended cross-correlation coefficient, *pDCCA*

Weak	Medium	Strong
≈ 0,000 → ≈ 0.333	≈ 0.333 → ≈ 0.666	≈ 0.666 → ≈ 1,000

Source: Own elaboration.

4. RESULTS

Figure **7** shows the fluctuations, in levels, in the stocks of Apple, Microsoft, Amazon.com, Tesla, Facebook (CLASS A), Samsung Electronics, Johnson & Johnson, Walmart. The sample comprises the time horizon from October 1, 2019 to January 11, 2021, and it is a period of great complexity, due to understanding the global pandemic (Covid-19). The actions of these companies clearly reveal the instability experienced in these markets in the first quarter of 2020.

Tables 2 and 3 show the main descriptive statistics of Apple, Microsoft, Amazon, Tesla, Facebook, Samsung Electronics, Johnson & Johnson, Walmart, as well as the Jarque-Bera adherence test. The analysis of descriptive statistics allows us to measure profitability, present positive daily averages,

while Tesla (0.051005) shows the most pronounced standard deviation. The asymmetries are mostly negative except for Walmart (1.007663), Amazon (0.034238), Samsung (0.388962), while Walmart (14.34802) has the sharpest shorts. We can then evidence that the coefficients of asymmetry and kurtosis are statistically different from those of a normal distribution, and such indications were validated through the Jarque-Bera adherence test that rejects the null hypothesis with a significance of 1%.

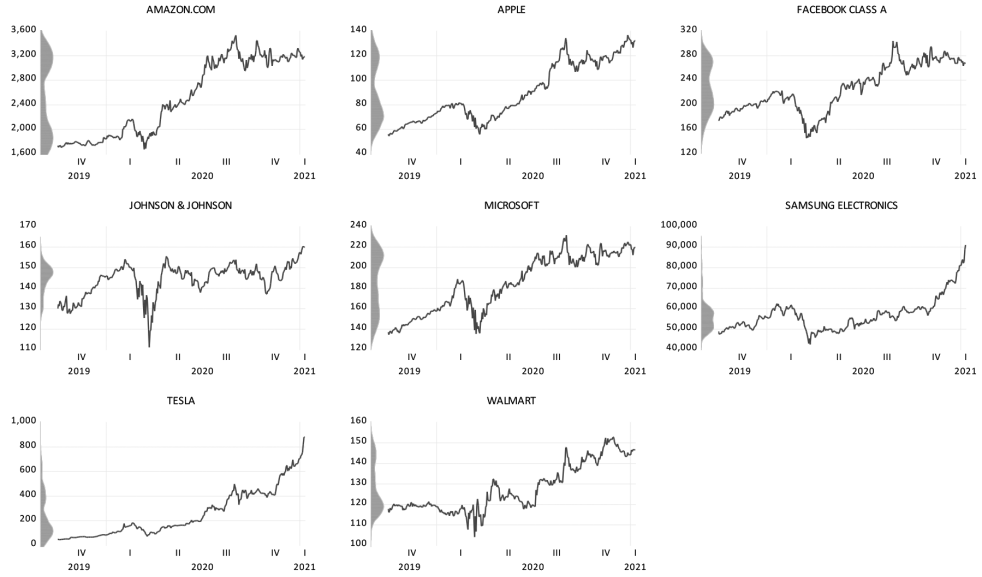

Figure 7. Evolution, in levels, of the quotations of the 8 companies, in the period from October 1, 2019 to January 11, 2021.

Source: Own elaboration.

Note: Thomson Reuters: October 1, 2019 to January 11, 2021, 335-point data.

Table 2. Descriptive statistics on profitability of the quotations of the 8 companies from October 1, 2019 to January 11, 2021.

	Amazon	Apple	Facebook	JOHNSON & JOHNSON
Mean	0.001810	0.002553	0.001254	0.000621
Std. Dev.	0.021566	0.026207	0.025917	0.017472
Skewness	0.034238	-0.352427	-0.490237	-0.010623
Kurtosis	5.094894	8.201442	8.406280	9.147459
Jarque-Bera	61.32274***	384.5774***	421.3908***	527.5092***
Observations	335	335	335	335

Source: Own elaboration.

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

Table 3. Descriptive statistics on profitability of the 8 company's quotes from October 1, 2019 to January 11, 2021.

	Microsoft	Samsung	Tesla	Walmart
Mean	0.001407	0.001857	0.008625	0.000652
Std. Dev.	0.024492	0.019340	0.051005	0.017357
Skewness	-0.466187	0.388962	-0.475444	1.007663
Kurtosis	12.10776	5.682001	6.903570	14.34802
Jarque-Bera	1169.997***	108.8512***	225.3161***	1854.213***
Observations	335	335	335	335

Source: Own elaboration.

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

Since we are in the presence of time successions, we should study the stationary nature of the series relating to the quotations of the 8 companies under analysis. For this, we used the test of unitary roots of Levin, Lin, and Chu (2002), which presents unitary roots in the null hypothesis. The results show the temporality of the time series, in profitability, that is, we are facing a white noise (mean = 0; constant variance) (see table 4).

Table 4. Levin, Lin, and Chu's Park Test (2002), applied to the quotations of the 8 companies, from October 1, 2019 to January 11, 2021.

Method				Statistic		Prob.**	
Levin, Lin & Chu t*				-71.6357		0.0000	
Series	2nd stage Coefficient	Variance Of Reg	HAC of Dep.	Lag	Max Lag	Band-Width	Note
D(AMAZON)	-1.10663	3102.4	95.062	0	16	71.0	333
D(APPLE)	-1.18789	5.1791	0.9103	0	16	12.0	333
D(FACEBOOK)	-1.13544	30.986	1.6117	0	16	36.0	333
D(JOHNSON & JOHNSON)	-1.04761	5.2781	0.5504	1	16	19.0	332
D(MICROSOFT)	-1.34105	15.770	4.4255	0	16	6.0	333
D(SAMSUNG)	-0.95807	1.E+06	48801.	0	16	63.0	333
D(TESLA)	-0.97370	217.64	26.361	0	16	16.0	333
D(WALMART)	-1.22285	4.1802	0.0792	0	16	124.0	333
	Coefficient	T-Stat	Reg SE	mu*	sig*		Note
Pooled	-1.14007	-61.017	1.007	-0.504	0.723		2996

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

Source: Own elaboration.

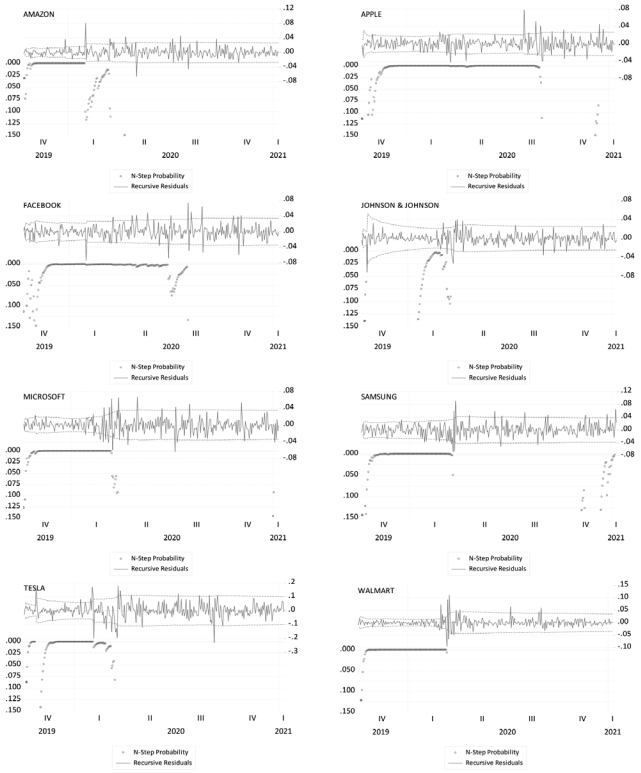

Figure 8. Stability tests carried out on waste applied to the quotations of the 8 companies from October 1, 2019 to January 11, 2021.

Source: Own elaboration.

Figure 8 shows the stability tests performed on the waste of the time series concerning companies Apple, Microsoft, Amazon, Tesla, Facebook, Samsung Electronics, Johnson & Johnson, Walmart, in the period from October 1, 2019 to January 11, 2021, to validate the presence of structural breakdowns. The determination of the structure break is relevant because it has a potentially similar effect to that of the unit roots. Through graphical analysis we can assess the existence of disturbances in variance. Additionally, when examining the graphs and the probability limits of 95%, we verified the existence of a violation of probability limits, therefore, the time series show unstable behavior.

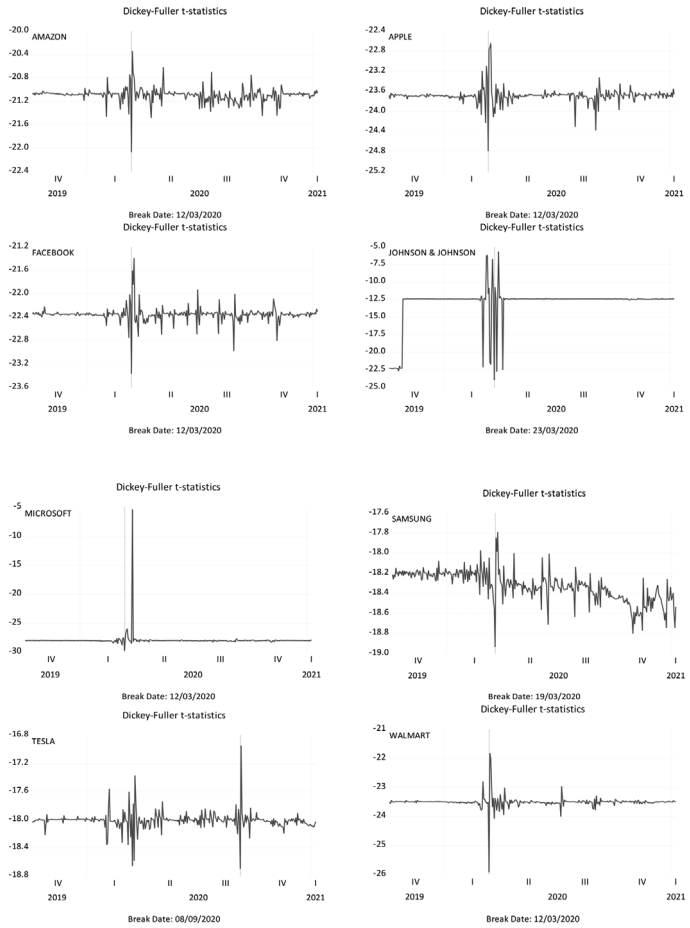

Figure 9. Park Test with structural breaks by Clemente et al. (1998) , return, applied to the quotations of the 8 companies, in the period from October 1, 2019 to January 11, 2021.
Source: Own elaboration.

Figure 9 shows the results of unitary root tests, with structural breaks, by Clemente et al. (1998); we can see that the breaks occur, mostly, in March 2020. The structure breaks of Apple's quotes (12.03.2020), Microsoft, Amazon (12.03.2020), Tesla (08.09.2020), Facebook (12.03.2020), Samsung Electronics (19.03.2020), Johnson & Johnson (23.03.2020), Walmart (12.03.2020). The breaks are in line with the evolution of the global pandemic of 2020, and the oil price war in 2020.

Table 5 shows the results of *the Exponents Detrended Fluctuation Analysis* (*DFA),* which shows that Apple (0.51), Microsoft (0.49), Amazon.com (0.53), Samsung Electronics (0.53), Johnson & Johnson (0.53) do not present long memories in their time series, i.e. investors cannot obtain abnormal profitability without incurring additional risk. Walmart (0.41) presents anti-persistence, while Tesla (0.60), Facebook (0.55) indicate some predictability, which suggests that prices do

not fully reflect the information available and that price changes are not i.i.d., i.e., investors adjusting their trading strategies to the necessary lags may have some above-average profitability, which partly validates the first question of the research.

Table 5. DFA exponent for return.
The values of the linear adjustments were always >0.99$\alpha DFAR^2$

Index	Exponent DFA (Covid-19)
Apple	0.51 ≈ 0.0214
Microsoft	0.49 ≈ 0.0079
Amazon.com	0.53 ≈ 0.0019
Samsung Electronics	0.5 ≈ 0.0073
Johnson & Johnson	0.53 ≈ 0.0081
Walmart	0.41 ≈ 0.0190
Tesla	0.60 ≈ 0.0015
Facebook	0.55 ≈ 0.0029

Source: Own elaboration.

Note: The hypotheses are: H_0α = 0.5 and: H_1α ≠ 0.5.

To answer the second research question, we estimated the *Detrended cross-correlation coefficient (pDCCA)* model, which indicates 17 mean correlation coefficients (≈ 0.333 → ≈ 0.666), 7 strong trendless cross-correlation coefficients (0.666→ ≈1,000), 4 weak correlation coefficients (≈ 0,000 → ≈ 0.333). In table 6, these results show that investors should be cautious about incorporating the shares of these companies into a single portfolio, which partly validates the second research question.

Table 6. Table summary of the coefficients, rhoDCCA referring to the quotations of the 8 companies under analysis, in the period from October 1, 2019 to January 11, 2021.

Index	rhoDCCA	Time scale (days)	Trend
APPLE / MICROSOFT	**0.80**	**n > 11 days**	**Strong**
APPLE / AMAZON	0.60	n > 14 days	Medium
APPLE / TESLA	0.42	n > 18 days	Medium
APPLE / FACEBOOK	**0.68**	**n > 9 days**	**Strong**
APPLE / SAMSUNG	0.36	n > 48 days	Medium
APPLE / JOHNSON & JOHNSON	0.47	n > 23 days	Medium
APPLE / WALMART	0.48	n > 6 days	Medium
MICROSOFT/ AMAZON	**0.72**	**n > 8 days**	**Strong**
MICROSOFT / TESLA	**0.67**	**n > 43 days**	**Strong**
MICROSOFT / FACEBOOK	**0.75**	**n > 5 days**	**Strong**
MICROSOFT / SAMSUNG	0.34	n > 45 days	Medium
MICROSOFT / JOHNSON & JOHNSON	**0.68**	**n > 58 days**	**Strong**
MICROSOFT/WALMART	0.57	n > 5 days	Medium
AMAZON / TESLA	**0.67**	**n > 56 days**	**Strong**
AMAZON / FACEBOOK	0.60	n > 11 days	Medium
AMAZON / SAMSUNG	0.10	n > 11 days	Weak
AMAZON / JOHNSON & JOHNSON	0.39	n > 35 days	Medium
AMAZON/WALMART	0.39	n > 6 days	Medium
TESLA / FACEBOOK	0.37	n > 11 days	Medium
TESLA / SAMSUNG	0.34	n > 35 days	Medium

TESLA / JOHNSON & JOHNSON	0.44	n > 38 days	Medium
TESLA / WALMART	0.11	n > 6 days	Weak
FACEBOOK / SAMSUNG	0.34	n > 52 days	Medium
FACEBOOK / JOHNSON & JOHNSON	0.36	n > 36 days	Medium
FACEBOOK/WALMART	0.17	n > 13 days	Weak
SAMSUNG /JOHNSON & JOHNSON	0.36	n > 29 days	Medium
SAMSUNG / WALMART	0.10	n > 36 days	Weak
JOHNSON & JOHNSON / WALMART	0.49	n > 9 days	Medium

Source: Own elaboration.

5. CONCLUSION

The overall conclusion to be withheld and sustained in the results obtained, through tests carried out with econophysics models show that the global pandemic of 2020 partially affected the prices index of Apple, Microsoft, Amazon.com, Tesla, Facebook, Samsung, Johnson & Johnson, Walmart, in the period from October 1, 2019 to January 11, 2021. The results of t*he exponents Detrended Fluctuation Analysis* (*DFA*) show that the actions of the companies under analysis show no predictability and present balance, except for Tesla (0.60), Facebook (0.55) which rejects, in part the first question of the research. To answer the second research question, we estimated the Detrended *cross-correlation coefficient* pDCCA model, which indicates 17 mean correlation coefficients (≈ 0.333 → ≈ 0.666), 7 strong cross-trend correlation coefficients (0.666 → ≈ 1,000), 4 weak correlation coefficients (≈ 0.000 → ≈ 0.333). These results show that investors should be careful to incorporate the shares of these companies into a single portfolio; the suggestion would be to group only the shares of companies that do not present predictability and have low *rhoDCCA.* The authors consider that this evidence will be important for institutional investors when they develop trading strategies based on maximizing profitability, but also mitigating risk when diversifying.

REFERENCES

Alexandre, P., Dias, R., & Heliodoro, P. (2020). European Financial Market Integration: A Closer Look at Government Bonds in Eurozone Countries. *Balkans Journal of Emerging Trends in Social Sciences*. https://doi.org/10.31410/balkans.jetss.2020.3.1.78-86

Alexandre, P., Heliodoro, P., & Dias, R. (2019). The Contagion Effect In Europe: A DCC GARH Approach. In *5th LIMEN Conference Proceedings (part of LIMEN conference collection).* https://doi.org/10.31410/limen.2019.73

Clemente, J., Montañés, A., & Reyes, M. (1998a). Testing for a unit root in variables with a double change in the mean. *Economics Letters*. https://doi.org/10.1016/s0165-1765(98)00052-4

Clemente, J., Montañés, A., & Reyes, M. (1998b). Testing for a unit root in variables with a double change in the mean. *Economics Letters*, *59*(2), 175–182. https://doi.org/10.1016/S0165-1765(98)00052-4

Dias, R. & Pereira, J. (2020). The Impact of the COVID-19 Pandemic on Stock Markets: Evidence From a VAR Model, *1*(2), 57–70. https://doi.org/10.4018/IJEGCC.2020070105

Dias, R., & Carvalho, L. (2020). Hedges and Safe Havens: An Examination OF Stocks, Gold and Silver in Latin America‘s Stock Market, 1114–1132.

Dias, R., Alexandre, P., & Heliodoro, P. (2020). Contagion in the LAC Financial Markets: The Impact of Stock Crises of 2008 and 2010. *Littera Scripta*. https://doi.org/10.36708/littera_scripta2020/1/3

Dias, R., da Silva, J. V., & Dionysus, A. (2019). Financial markets of the LAC region: Does the crisis influence the financial integration? *International Review of Financial Analysis*, *63*(January), 160–173. https://doi.org/10.1016/j.irfa.2019.02.008

Dias, R., Heliodoro, P., & Alexandre, P. (2019). Risk Transmission Among Stock Markets in LAC Region: Financial Crises Impact. In *5th LIMEN Selected Papers (part of LIMEN conference collection)*. https://doi.org/10.31410/limen.s.p.2019.91

Dias, R., Heliodoro, P., & Alexandre, P. (2020). Efficiency of Asean-5 Markets: An Detrended Fluctuation Analysis Učinkovitost trgov Asean-5: analyzes nihanj z odstranitvijo trenda, 13–19. https://doi.org/10.32015/JIBM.2020.12.2.2.13-19

Dias, R., Heliodoro, P., Alexandre, P., Santos, H., & Farinha, A. (2021). Long memory in stock returns: Evidence from the Eastern European markets, *01029*, 1–10.

Dias, R., Heliodoro, P., Alexandre, P., & Vasco, C. (2020a). Financial Market Integration of ASEAN-5 with China: An Econophysics Approach. In *4th EMAN Conference Proceedings (part of EMAN conference collection)*. https://doi.org/10.31410/eman.2020.17

Dias, R., Heliodoro, P., Alexandre, P., & Vasco, C. (2020b). The Shocks Between Oil Market to the BRIC Stock Markets: A Generalized VAR Approach. In *4th EMAN Conference Proceedings (part of EMAN conference collection)*. https://doi.org/10.31410/eman.2020.25

Dias, R., Heliodoro, P., Teixeira, N., & Godinho, T. (2020). Testing the Weak Form of Efficient Market Hypothesis: Empirical Evidence from Equity Markets. *International Journal of Accounting, Finance and Risk Management*. https://doi.org/10.11648/j.ijafrm.20200501.14

Dias, R., Pardal, P., Teixeira, N., & Machová, V. (2020). Financial Market Integration of ASEAN-5 with China. *Littera Scripta*. https://doi.org/10.36708/littera_scripta2020/1/4

Dias, R., Teixeira, N., Machova, V., Sparrow, P., Horak, J., ... Vochozka, M. (2020e). Random walks and market efficiency tests: evidence on US, Chinese and European capital markets within the context of the global Covid-19 pandemic, *11*(4). https://doi.org/10.24136/oc.2020.024

Heliodoro, P., Alexandre, Paulo & Dias, R. (2019). Financial markets of the lac region: convergence after the financial crisis?, 45–52.

Heliodoro, P., Alexandre, P., Dias, R. (2019). The contagion effect in Europe: a DCC GARCH Approach, 45–52.

Heliodoro, P., Dias, R., & Alexandre, P. (2020). Financial Contagion Between the US and Emerging Markets: COVID-19 Pandemic Case. In *4th EMAN Selected Papers (part of EMAN conference collection)*. https://doi.org/10.31410/eman.s.p.2020.1

Heliodoro, P., Dias, R., Alexandre, P., & Vasco, C. (2020). Integration in BRIC Stock Markets: An Empirical Analysis. In *4th EMAN Selected Papers (part of EMAN conference collection)*. https://doi.org/10.31410/eman.s.p.2020.33

Jarque, C.M., & Bera, A. K. (1980). Efficient tests for normality, homoscedasticity and serial independence of regression residuals. *Economics Letters*, *6*(3), 255–259. https://doi.org/10.1016/0165-1765(80)90024-5

Jr., A.C.C., & Camba, A. L. (2020). The Existence of Random Walk in the Philippine Stock Market: Evidence from Unit Root and Variance-Ratio Tests. *The Journal of Asian Finance, Economics and Business*. https://doi.org/10.13106/jafeb.2020.vol7.no10.523

Kantelhardt, J. W., Koscielny-Bunde, E., Rego, H. H., Havlin, S., & Bunde, A. (2001). Detecting long-range correlations with detrended fluctuation analysis. *Physica A: Statistical Mechanics and Its Applications*, *295*(3–4), 441–454. https://doi.org/10.1016/S0378-4371(01)00144-3

Levin, A., Lin, C. F., & Chu, C. S. J. (2002). Unit root tests in panel data: Asymptotic and finite-sample properties. *Journal of Econometrics*. https://doi.org/10.1016/S0304-4076(01)00098-7

Sparrow, P., Dias, R., Šuleř, P., Teixeira, N., & Krulický, T. (2020). Integration in Central European capital markets in the context of the global COVID-19 pandemic, *15*(4). https://doi.org/10.24136/eq.2020.027

Peng, C. K., Buldyrev, S. V., Havlin, S., Simons, M., Stanley, H. E., & Goldberger, A. L. (1994). Mosaic organization of DNA nucleotides. *Physical Review E*, *49*(2), 1685–1689. https://doi.org/10.1103/PhysRevE.49.1685

Podobnik, B., & Stanley, H. E. (2008). Detrended cross-correlation analysis: A new method for analyzing two nonstationary time series. *Physical Review Letters*, *100*(8). https://doi.org/10.1103/PhysRevLett.100.084102

Santos, H. & Dias, R. (2020). *The Interactions of Stock Prices and Exchange Rates in the ASEAN-5 Countries: The DCCA approach*.