

MARKET EFFICIENCY IN ITS WEAK FORM: THE PRE-COVID AND COVID INDONESIA ANALYSIS

Rui Dias¹ 

Paula Heliodoro² 

Paulo Alexandre³ 

Hortense Santos⁴ 

Cristina Vasco⁵ 

DOI: <https://doi.org/10.31410/EMAN.2021.1>

Abstract: *This essay aims to analyze the efficiency, in its weak form, in the Exchange Markets IDR/MYR (Indonesia-Malaysia), IDR/PHP (Indonesia-Philippines), IDR/SGD (Indonesia-Singapore), IDR/THB (Indonesia-Thailand), IDR/GBP (Indonesia-UK), IDR/US (Indonesia-USA), IDR/EUR (Indonesia-Euro Zone/Europe). The sample comprises the period from September 3, 2018, to October 20, 2020, and the sample was partitioned into two subperiods: Pre-Covid and Covid. To carry out this analysis, different approaches were undertaken to assess whether: (i) the global pandemic promoted in (efficiency) in the exchange rates of Indonesia vs Malaysia, Philippines, Singapore, Thailand, UK, USA, Eurozone? The results suggest that in the Pre-Covid subperiod we can see that the random walk hypothesis is rejected, IDR/MYR (0.61), IDR/SGD (0.60), IDR/US (0.59), IDR/THB (0.56), IDR/EUR (0.55), IDR/GBP (0.54), except for the IDR/PHP pair (0.45) which evidences anti persistence. Already in the Covid period, we noticed that persistence increased significantly, like followed, IDR/EUR (0.82), IDR/PHP (0.81) IDR/SGD (0.80), IDR/US (0.80), IDR/MYR (0.78), IDR/THB (0.71), IDR/GBP (0.62). These findings show high levels of arbitrage, i.e., investors will be able to obtain abnormal profitability without incurring the additional risk, which could jeopardize the implementation of efficient portfolio diversification strategies due to market imbalance. The authors believe that these findings can help policymakers formulate a comprehensive response to improve the efficiency of the foreign exchange market during a global pandemic event.*

Keywords: *Exchange rates, Efficiency, Arbitration, Portfolio diversification.*

1. INTRODUCTION

The hypothesis of market efficiency is a very relevant concept for international investors who want to have their portfolios diversified, to mitigate the inherent risk of global financial markets. With the global economy increasingly integrated, international investors have aimed to diversify their portfolios into more exotic markets in different ways, with the aim of the synchronism 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 predict future price changes may lead to imbalances in financial markets, making it difficult to implement efficient portfolio diversi-

¹ School of Business and Administration, Polytechnic Institute of Setúbal, Portugal and CEFAGE-UE, IIFA, University of Évora, Portugal

² School of Business and Administration, Polytechnic Institute of Setúbal, Portugal

³ School of Business and Administration, Polytechnic Institute of Setúbal, Portugal

⁴ School of Business and Administration, Polytechnic Institute of Setúbal, Portugal

⁵ IIEP, Portugal

fication strategies (Alexandre, Heliodoro, and Dias, 2019; Dias, da Silva, and Dionysus, 2019; Dias, Heliodoro, and Alexandre, 2019, 2020; Alexandre, Dias, and Heliodoro, 2020; Heliodoro, Dias, and Alexandre, 2020; Dias, Heliodoro, et al. , 2020a, 2020b; Dias, Sparrow, et al., 2020; Sparrow, P., Dias, R., Šuleř, P., Teixeira, N., and Krulický, 2020; Dias and Carvalho, 2020; Dias et al., 2020; Santos and Dias, 2020).

The efficient market hypothesis (HME) 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 is a way of trying to anticipate asset prices by international investors, but market regulation itself when trying to avoid this process partly reduces the informational efficiency of financial markets, i.e., information that comes to the market is not adjusted immediately in quotes, which sometimes causes some imbalance. Given these events, this essay aims to test the efficiency, in its weak form, in the IDR/MYR (Indonesia-Malaysia), IDR/PHP (Indonesia-Philippines), IDR/SGD (Indonesia-Singapore), IDR/THB (Indonesia-Thailand), IDR/GBP (Indonesia-UK), IDR/US (Indonesia-US), IDR/EUR (Indonesia-Euro/Europe) exchange markets. The sample comprises the period from September 3, 2018, to October 20, 2020. The results of the exponents *Detrended Fluctuation Analysis (DFA)* show that the foreign exchange markets reject the random walk hypothesis in the Pre-Covid and Covid subperiods. These results show that investors using strategies adjusted with appropriate lags will be able to achieve abnormal profitability without incurring the additional risk, which could jeopardize the implementation of an efficient portfolio diversification strategy.

This research adds relevant contributions to the literature. The most relevant contribution is related to the study of the reversal of the average in Indonesia's foreign exchange markets through its international peers during this global pandemic period of 2020. Understanding the different predictability between the exchange rates analyzed means that international investors can protect their assets, as well as rebalance their portfolios in an international context. As far as we know, the authors Njindan Iyke (2019), Chaudhry et al. (2019), Aslam et al. (2020), tested the random walk hypothesis in the foreign exchange markets, but the research questions, the markets analyzed, the sampling period and the methodology were essentially different from that followed in this paper.

In terms of structure, this paper is organized into 5 sections. Section 2 presents a Literature Review regarding articles on the random walk hypothesis in international foreign exchange markets. Section 3 describes the methodology and data. Section 4 contains the results. Section 5 concludes.

2. LITERATURE REVIEW

Different studies have addressed the issue of market efficiency, analyzing the hypothesis of predictability of profitability, through the analysis of patterns of reversal of stock prices average, inspired by the seminal works of Poterba and Summers (1988), Fama and French (1988), which documented the reversal of the average in the profitability of stock markets, on-time horizons of more than one year.

Azad (2009), Chiang, Lee, Su, and Tzou (2010), Belaire-Franch and Opong (2010) examined the predictability of international exchange rates. Azad (2009) empirically tested the hypothesis of efficiency, in its weak form, in 12 Asia-pacific exchange markets, which proves that exchange rates with a daily scale do not reject the Martingale hypothesis, but when the time scales are weekly there is the rejection of the random walk hypothesis. Chiang, Lee, Su, and Tzou (2010) show that the foreign exchange markets of Japan, South Korea and the Philippines are efficient, in its weak form, while the Taiwan foreign exchange market shows signs of (in)efficiency, i.e. the existence of some arbitrage signals that may be exploited by investors. Belaire-Franch and Opong (2010) tested the random walk hypothesis in the three major international currencies Japanese yen, the US dollar and the pound sterling, showing mixed results.

Al-Khazali, Pyun, and Kim (2012), Sheik and Banu (2015), Çıtak, Akel, and Çetin (2016), analyzed the hypothesis of whether foreign exchange markets have high levels of arbitrage. Al-Khazali, Pyun, and Kim (2012) tested the random walk hypothesis between the Australian dollar and seven Asian currencies against three reference currencies between 1993 and 2008, showing hybrid results regarding the adjustment of information in exchange rates at different times of financial crises. Sheik and Banu (2015) examined the Efficient Market Hypothesis (HME) in the Indian foreign exchange market, using the exchange rates of China, Indonesia, and the U.S. in relation to the Indian rupee. The results indicate that the three exchange rates analyzed follow the random walk hypothesis, that is, international investors should have difficulty obtaining abnormal profitability without incurring additional risk. Çıtak, Akel, and Çetin (2016) examine the hypothesis of an efficient market, in its weak form, in turkey's foreign exchange markets, and show that the random walk hypothesis is rejected for the nominal exchange rate TRY/USD from January 2000 to December 2013.

Nan and Kaizoji (2019), Njindan Iyke (2019), Chaudhry et al. (2019) tested the random walk hypothesis in international foreign exchange markets. Nan and Kaizoji (2019) suggested a bitcoin-based USD/EUR exchange rate and investigated the random walk hypothesis in the spot and future markets. Structural change tests, unit root and Johansen indicate that the bitcoin exchange rate follows the random walk hypothesis and is integrated with the FX series. The results suggest that the integration coefficients suggest the nature of long-term "impartiality" and "fair play" in the short-term exchange rate of bitcoin, evidencing market efficiency in its weak and semi-strong form. Njindan Iyke (2019) tested the efficient market hypothesis (HME) in the Indonesian foreign exchange market, and evidences that when structural breakdowns and heteroscedasticity are accommodated, efficient market hypothesis (EMH) is rejected in 50% cases, and that 71% of rates rebalance in a month. Chaudhry et al. (2019) examined the efficiency, in its weak form, of the Pakistan foreign exchange market, represented by Japanese yen (JPY/PKR), Swiss franc (CHF/PKR), British pound (GBP/PKR), US dollar (USD/PKR). The authors show that Pakistan's foreign exchange market is efficient, in its weak form.

Aslan *et al.* (2020), Anggitawati and Ekaputra (2020), tested the hypothesis of market efficiency, in its weak form, in the international foreign exchange markets. Aslan *et al.* (2020) analyzed the efficiency of foreign exchange markets during the initial period of the 2020 global pandemic that disrupted global financial markets. The authors used high frequency data (5-minute interval) for the six major currencies traded on the foreign exchange markets during the period from October 1, 2019 to March 31, 2020. Overall, the results confirm the presence of multifractality in the foreign exchange markets; the greatest effect is observed for the Australian dollar, which shows the highest (lowest) efficiency before (during) the 2020 pandemic, assessed in terms of

low (high) multifractality. The Canadian dollar and the Swiss franc exhibited the highest efficiency during the Covid-19 outbreak. Anggitawati and Ekaputra (2020) show two-way shocks between NFI stock market yields and the IDR/USD exchange market. Additionally, the authors show that the holdings of international investors have more impact on the foreign exchange market than on the stock market.

In summary, this paper aims to contribute to the provision of information to investors and regulators in the international exchange markets, where individual and institutional investors seek to efficiently diversify their portfolios, in a period of uncertainty and lack of confidence arising from the global pandemic (Covid-19).

3. METHODOLOGY

3.1. Data

The data used for the preparation of the work were the prices index (daily) of the exchange markets IDR/MYR (Indonesia-Malaysia), IDR/PHP (Indonesia-Philippines), IDR/SGD (Indonesia-Singapore), IDR/THB (Indonesia-Thailand), IDR/GBP (Indonesia-UK), IDR/US (Indonesia-USA), IDR/EUR (Indonesia-Zone Euro/Europe). The sample comprises the period from September 3, 2018 to October 20, 2020, and the sample was partitioned into two subperiods: Pre-Covid (September 3, 2018 to August 30, 2019); Covid (September 2, 2019 to October 20, 2020, data extracted from the *Thomson Reuters* platform.

3.2. Methodology

The development of the research took place through several stages. The characterization of the sample used was performed through descriptive statistics, the adherence test of Jarque and Bera (1980). To evaluate the time series parking, we used unit root tests in Hadri panel (2000), Levin, Lin, and Chu (2002), which postulate null hypotheses contrary. In order to answer the research question, we will use the *Detrended 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. *Detrended Fluctuation Analysis* presents the following interpretation: $0 < \alpha < 0,5$ anti persistent series; $\alpha = 0,5$ series features random walk; $0,5 < \alpha < 1$ persistent series. The function of this technique is to examine the relationship between values x_k and $x_{(k+t)}$ in different moments (Ferreira, Dionysus, Guedes, and Zebende, 2018).

Consider a dataset x_k , with $k = 1, \dots, t$ 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 $z_{(t)}$ of each fraction, 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 $x(t)$ and $Z(t)$ is estimated, the DFA function being given by

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

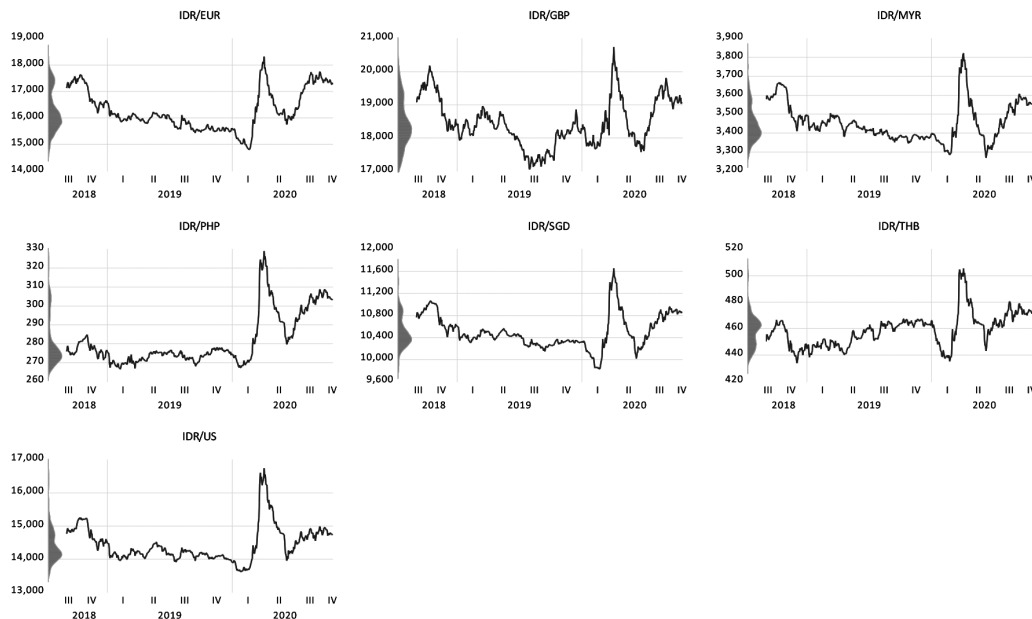
Estimating the average $F(s)$ for all centralized boxes in s generates the value of fluctuations, $\langle F(s) \rangle$, depending on s . This estimation will be repeated for all distinct values of s , expecting a process of a power-law, i.e.

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

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

4. RESULTS

Figure 1 shows the fluctuations in levels of the exchange markets, IDR/MYR (Indonesia-Malaysia), IDR/PHP (Indonesia-Philippines), IDR/SGD (Indonesia-Singapore), IDR/THB (Indonesia-Thailand), IDR/GBP (Indonesia-UK), IDR/US (Indonesia-US), IDR/EUR (Indonesia-Euro Zone/Europe). The sample comprises the time horizon of the period from September 3, 2018 to October 20, 2020, and it is a period of great complexity, due to understanding the global pandemic (Covid-19). The exchange rates analyzed clearly show the instability experienced in these markets in December 2019, January, February, and March 2020.

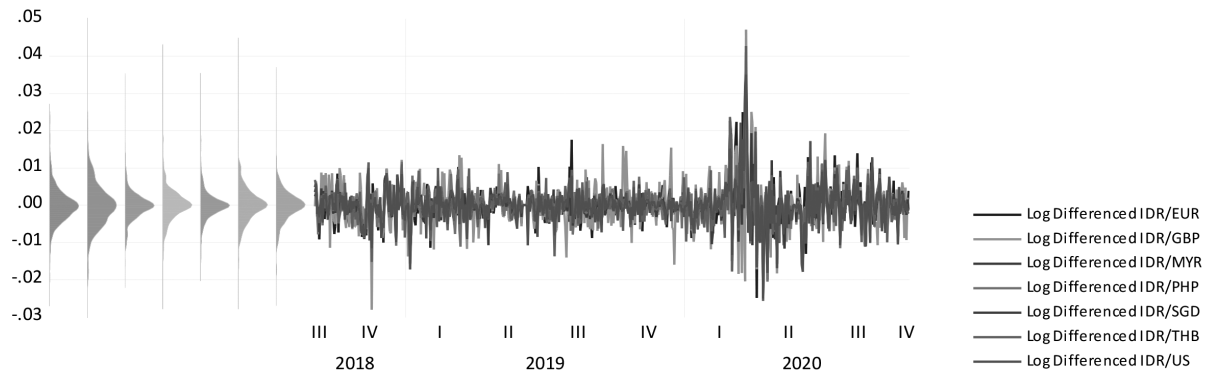


Note: Thomson Reuters: September 3, 2018, 557-point data.

Figure 1. Evolution, in levels, of the 7 exchange rates, in the period from September 3, 2018 to October 20, 2020.

Source: Own elaboration.

Figure 2 shows the evolutions of the exchange markets under analysis, and we can see that the time series present a relatively high dispersion around the average, as well as a relatively synchronized behavior between the data series. Through graphical analysis, very strong volatility is observed in the first quarter of 2020.



Note: Thomson Reuters: September 3, 2018, 556-point data.

Figure 2. Evolution, return, of the 7 exchange rates, in the period from September 3, 2018 to October 20, 2020.

Source: Own elaboration.

Figure 3 shows the average yields of the 7 exchange rates, and we can see that exchange pairs IDR/MYR ($-1.35E-05$), IDR/US ($-4.63E-06$), IDR/GBP ($-2.68E-06$) have negative average yields. The exchange rates IDR/PHP (0.000169), IDR/SGD ($1.39E-05$), IDR/THB ($8.21E-05$), IDR/EUR ($2.10E-05$) show positive yields.

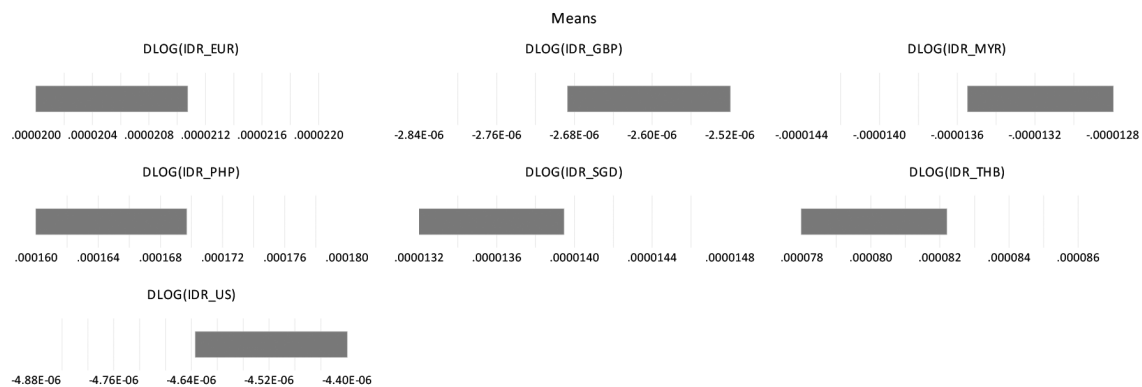


Figure 3. Evolution of the average yields of the 7 exchange rates, in the period from September 3, 2018 to October 20, 2020.

Source: Own elaboration.

Figure 4 shows the Skewness of the 7 exchange rates, and we can verify that exchange pairs IDR/PHP (1.180533), IDR/MYR (1.034002), IDR/SGD (1.001855), IDR/THB (0.953976), IDR/US (0.803038), IDR/GBP (0.709587), IDR/EUR (0.591387) have different Skewness than a normal distribution (Skewness = 0).

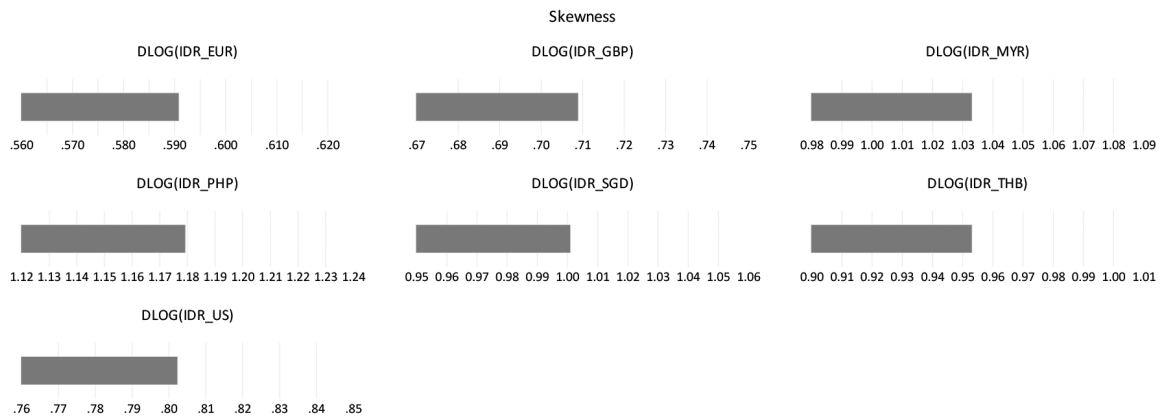


Figure 4. Evolution of the Skewness of the 7 exchange rates, in the period from September 3, 2018 to October 20, 2020.

Source: Own elaboration.

Figure 5 shows the Kurtosis of the IDR/MYR (Indonesia-Malaysia), IDR/PHP (Indonesia-Philippines), IDR/SGD (Indonesia-Singapore), IDR/THB (Indonesia-Thailand), IDR/GBP (Indonesia-UK), IDR/US (Indonesia-US), IDR/EUR (Indonesia-Euro/Europe) exchange markets. Based on the results, time series do not follow normal distributions, IDR/PHP (15.97799), IDR/THB (13.85505), IDR/SGD (12.76840), IDR/MYR (11.76382), IDR/US (11.58651), IDR/GBP (9.141990), IDR/EUR (7.393601). These results confirm the assumptions that time series do not follow a normal distribution, because asymmetry and Kurtosis are different from reference values (Skewness = 0; Kurtosis = 3).

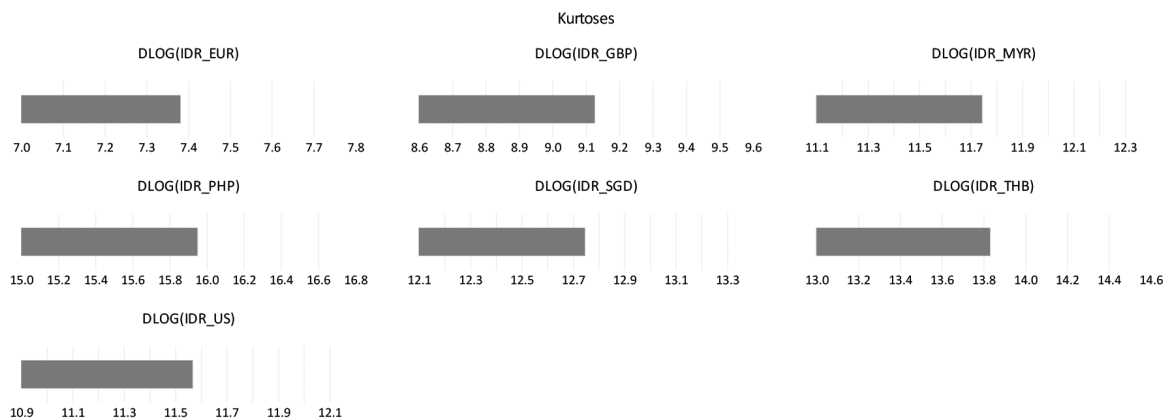


Figure 5. Kurtosis evolution of the 7 exchange rates, in the period from September 3, 2018 to October 20, 2020.

Source: Own elaboration.

Since we are in the presence of time successions, we should study the stationary nature of the series relating to the 7 exchange markets under analysis. To this end, we used the tests of unitary roots in Hadri panel (2000), Levin, Lin, and Chu (2002), which postulate null hypotheses contrary to the intersections of unitary root tests in panel show the temporality of the time series, in the first differences, that is, we are facing a white noise (average = 0; constant variance) (see tables 1 and 2).

Table 1. Hadri stationary test (2000) applied at 7 exchange rates from September 3, 2018 to October 20, 2020.

Method	Statistic	Prob.**		
Hadri Z-stat	-1.39899	0.9191		
Heteroscedastic Consistent Z-stat	-1.57277	0.9421		
Intermediate results on D(UNTITLED)				
Series	Lm	Hac	Bandwidth	Note
D(IDR/EUR)	0.0883	4697.410	5.0	259
D(IDR/GBP)	0.0882	9434.111	3.0	259
D(IDR/MYR)	0.0534	152.9859	2.0	259
D(IDR/PHP)	0.0540	0.869032	7.0	259
D(IDR/SGD)	0.0607	1109.453	3.0	259
D(IDR/THB)	0.1051	3.461144	4.0	259
D(IDR/US)	0.0965	3377.255	1.0	259

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

Source: Own elaboration.

Table 2. Levin, Lin, and Chu stationary test (2002), applied at 7 exchange rates, from September 3, 2018 to October 20, 2020.

Method	Statistic	Prob.**					
Levin, Lin & Chu t*	-48.0510	0.0000					
Intermediate results on D(UNTITLED)							
Series	2nd stage Coefficient	Variance Of Reg	HAC of Dep.	Lag	Max Lag	Band-Width	Note
D(IDR/EUR)	-0.98905	4612.6	256.02	0	15	46.0	258
D(IDR/GBP)	-1.02417	9382.0	326.72	0	15	62.0	258
D(IDR/MYR)	-0.92568	131.23	8.3704	0	15	31.0	258
D(IDR/PHP)	-0.88679	0.9569	0.0281	0	15	94.0	258
D(IDR/SGD)	-0.93855	980.30	49.692	0	15	46.0	258
D(IDR/THB)	-0.91514	3.2232	0.1254	0	15	75.0	258
D(IDR/US)	-0.89918	3026.7	130.75	0	15	55.0	258
Pooled	Coefficient	T-Stat	SE Reg	mu*	sig*	Note	
	-0.93950	-40.096	1.001	-0.509	0.740	1806	

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

Source: Own elaboration.

Table 3 shows the results of the *Detrended Fluctuation Analysis (DFA)* exposure for the IDR/MYR (Indonesia-Malaysia), IDR/PHP (Indonesia-Philippines), IDR/SGD (Indonesia-Singapore), IDR/THB (Indonesia-Thailand), IDR/GBP (Indonesia-UK), IDR/US (Indonesia-US), IDR/EUR (Indonesia-Euro/Europe) exchange markets. In the Pre-Covid period we can see that the random walk hypothesis is rejected, namely at the IDR/MYR (0.61), IDR/SGD (0.60), IDR/US (0.59), IDR/THB (0.56), IDR/EUR (0.55), IDR/GBP (0.54), except for the IDR/PHP pair (0.45) which evidences anti persistence. Already in the Covid period, we have noticed that persistence increased significantly, as presented, IDR/EUR (0.82), IDR/PHP (0.81) IDR/SGD (0.80), IDR/US (0.80), IDR/MYR (0.78), IDR/THB (0.71), IDR/GBP (0.62). These findings show high levels of arbitrage, i.e., investors will be able to obtain anomie profitability without

incurring the additional risk, which could jeopardize the implementation of efficient portfolio diversification strategies due to market imbalance. These results are corroborated, in part, by the authors Palma and Sartoris (2016), Olufemi et al. (2017) who tested the market efficiency hypothesis (HME) in several foreign exchange markets, showing that markets show some predictability due to the sharp level of arbitrage.

Table 3. DFA exponent for return.
The values of the linear adjustments for α_{DFA} always had $R^2 > 0.99$

Index	EXPONent DFA (Before-Covid)	EXPONENT DFA (Covid)
IDR.MYR	0.61 \cong 0.0038	0.78 \cong 0.0072
IDR.PHP	0.45 \cong 0.0274	0.81 \cong 0.0065
IDR.SGD	0.60 \cong 0.0029	0.80 \cong 0.0148
IDR.THB	0.56 \cong 0.0031	0.71 \cong 0.0079
IDR.GBP	0.54 \cong 0.0012	0.62 \cong 0.0114
IDR.US	0.59 \cong 0.0031	0.80 \cong 0.0044
IDR.EUR	0.55 \cong 0.0026	0.82 \cong 0.0242

Note: The hypotheses are: $H_0\alpha = 0.5$ and: $H_1\alpha \neq 0.5$.

Source: Own elaboration.

5. CONCLUSION

The general conclusion to be withheld and sustained in the results obtained, through the tests carried out with econometric and mathematical models suggest that these exchange markets have high levels of integration, which may question the diversification of portfolios efficiently. In corroboration, through the *DFA* model, we found that the exchange markets analyzed, present signs, mostly, of (in) market efficiency, in its weak form. This situation has implications for investors, since some profitability can be expected, creating opportunities for arbitration and abnormal income, contrary to the assumptions of *random walk* and informational efficiency. To conclude, the global pandemic of 2020 affected the memory properties of these foreign exchange markets; the authors suggest that the implementation of strategies for diversifying efficient portfolios in these markets may be questionable. These findings also make room for regulators in these markets to take steps to ensure better information between these markets and international markets.

REFERENCES

- Al-Khazali, O.M., Pyun, C. S., & Kim, D. (2012). Are exchange rate movements predictable in Asia-Pacific markets? Evidence of random walk and martingale difference processes. *International Review of Economics and Finance*. <https://doi.org/10.1016/j.iref.2011.07.002>
- 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>
- Anggitawati, D., & Ekaputra, I. A. (2020). Foreign Portfolio Investment Flows and Exchange Rate: Evidence in Indonesia. *Emerging Markets Finance and Trade*. <https://doi.org/10.1080/1540496X.2018.1496419>

- Aslan, F., Aziz, S., Nguyen, D. K., Mughal, K. S., & Khan, M. (2020). On the efficiency of foreign exchange markets in times of the COVID-19 pandemic. *Technological Forecasting and Social Change*. <https://doi.org/10.1016/j.techfore.2020.120261>
- Azad, A. S.M. (2009). Random walk and efficiency tests in the Asia-Pacific foreign exchange markets: Evidence from the post-Asian currency crisis data. *Research in International Business and Finance*. <https://doi.org/10.1016/j.ribaf.2008.11.001>
- Belaire-Franch, J., & Opong, K. K. (2010). Testing for random walk in euro exchange rates using the subsampling approach. *Applied Economics Letters*. <https://doi.org/10.1080/00036840902817581>
- Chaudhry, A. F., Hanif, M.M., Hassan, S., & Chani, M. I. (2019). Efficiency of the Black Foreign Exchange Market. *International Journal of Economics and Finance*. <https://doi.org/10.5539/ijef.v11n2p165>
- Chiang, S.M., Lee, Y. H., Su, H.M., & Tzou, Y. P. (2010). Efficiency tests of foreign exchange markets for four Asian Countries. *Research in International Business and Finance*. [HTTPS://DOI.ORG/10.1016/J.RIBAF.2010.01.001](https://doi.org/10.1016/J.RIBAF.2010.01.001)
- Çıtak, L., Akel, V., & Çetin, M. (2016). Testing random walk hypothesis in Turkish foreign exchange market. In *International Business: Concepts, Methodologies, Tools, and Applications*. <https://doi.org/10.4018/978-1-4666-9814-7.ch046>
- 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. *Mednarodno Inovativno Poslovanje = Journal of Innovative Business and Management*. <https://doi.org/10.32015/jibm.2020.12.2.13-19>
- 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., 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. (2020). 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>
- Fama, E. F., & French, K. R. (1988). Dividend yields and expected stock returns. *Journal of Financial Economics*. [https://doi.org/10.1016/0304-405X\(88\)90020-7](https://doi.org/10.1016/0304-405X(88)90020-7)
- Ferreira, P., Dionísio, A., Guedes, E. F., & Zebende, G. F. (2018). A sliding windows approach to analyse the evolution of bank shares in the European Union. *Physica A: Statistical Mechanics and Its Applications*, 490, 1355–1367. <https://doi.org/10.1016/j.physa.2017.08.095>

- Hadri, K. (2000). Testing for stationarity in heterogeneous panel data. *The Econometrics Journal*. <https://doi.org/10.1111/1368-423x.00043>
- 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](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](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](https://doi.org/10.1016/S0304-4076(01)00098-7)
- Nan, Z., & Kaizoji, T. (2019). Market efficiency of the bitcoin exchange rate: Weak and semi-strong form tests with the spot, futures and forward foreign exchange rates. *International Review of Financial Analysis*. <https://doi.org/10.1016/j.irfa.2019.06.003>.
- Njindan Iyke, B. (2019). A Test of the Efficiency of the Foreign Exchange Market in Indonesia. *Buletin Ekonomi Moneter Dan Perbankan*. <https://doi.org/10.21098/bemp.v0i0.976>
- Olufemi, A. P., Adewale, A. O., & Oseko, M. S. (2017). Efficiency of Foreign Exchange Markets in Sub-Saharan Africa in the Presence of Structural Break: A Linear and Non-Linear Testing Approach. *Journal of Economics and Behavioral Studies*. <https://doi.org/10.22610/jeb.v9i4.1827>.
- Palma, A. A., & Sartoris, A. (2016). Weak-Form Market Efficiency of the Brazilian Exchange Rate: Evidence from an Artificial Neural Network Model. *Latin American Business Review*. <https://doi.org/10.1080/10978526.2016.1171720>
- 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. *Equilibrium. Quarterly Journal of Economics and Economic Policy*, 15(4), 627–650. doi: 10.24136/eq. 2020,027
- Poterba, J.M., & Summers, L. H. (1988). Mean reversion in stock prices. Evidence and Implications. *Journal of Financial Economics*. [https://doi.org/10.1016/0304-405X\(88\)90021-9](https://doi.org/10.1016/0304-405X(88)90021-9)
- Santos, H. & Dias, R. (2020). *The Interactions of Stock Prices and Exchange Rates in the ASEAN-5 Countries: The DCCA approach*. Research in Theory and Practice in Contemporary Business Issues opportunity. ISBN: 9789617061093
- Sheik, M.M., & Banu, M. A., Study on Weak-Form Efficiency of Foreign Exchange Markets of Developing Economies: Some India Evidence. *International Journal of Management*.