RANDOM WALKS AND MARKET EFFICIENCY: GOLD, PLATINUM, SILVER VS ASIA EQUITY MARKETS

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Abstract: *This paper aims to analyze the efficiency, in its weak form, in the markets of commodities, Platinum (London Platinum Free Market $/Troy oz), GOLD (Gold Bullion LBM $/t oz DELAY), SILVER (Silver – Zurich SW. francs/kg) and the stock markets of KOREA, CHINA, JAPAN, PHILIPPINES, INDONESIA, from January 1, 2019 to October 20, 2020. To perform this analysis, different approaches were undertaken to assess whether: (i) the Gold, Platinum, Silver markets have more robust levels of efficiency when compared to Asian stock markets? The results of the variance test indicate that the random walk hypothesis is rejected in the Gold, Platinum and Silver markets, as well as in the Asian stock markets, with no differences between markets. These findings show that profitability is auto-correlated over time, with a reversal of the mean, because the values of variance ratios are lower than the unit, i.e., price fluctuations are not i.i.d. The results have significant implications for investors, as market inefficiency can affect the domestic and international flows of an economy. In conclusion, the hypothesis of market efficiency, in weak form, may be questionable, since the prediction of the movement of a given market can be improved if the out-of-the-current movements of the other markets are considered, thus enabling the occurrence of arbitrage operations. These findings also make room for regulators in these markets to take steps to ensure better information between these markets and international markets.*

Keywords: *Commodities, Asia, Efficiency, Portfolio diversification.*

1. INTRODUCTION

Globalization has accentuated the integration of international financial markets and has shown that the correlation between international financial markets has increased significantly. If a given stock market is strongly linked to another country's stock market, the financial stability of the former depends in part on the financial stability of the second. For this reason, a close or strong link between markets increases the levels of vulnerability to external shocks and, consequently, influences the economic conditions and levels of well-being of their countries, as well as the efficiency of the market itself. The hypothesis of market efficiency 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 synchronism of their assets being low. Testing market synchronizations and

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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 an anomalous profitability when selecting an appropriate trading strategy, i.e., to obtain anomalous profitability without incurring additional risk. The possibility of investors being able to estimate price fluctuations may cause imbalances in financial markets, calling into question the implementation of strategies for efficient portfolio diversification (Alexandre, Dias, and Heliodoro, 2020; Alexandre, Heliodoro, and Dias, 2019; Diass, Rui; Carvalho, Luisa, 2020; Dias, Alexandre, and Heliodoro, 2020, 2020; Dias, da Silva, and Dionysus, 2019; Dias, Heliodoro, and Alexandre, 2019, 2020; Dias, Heliodoro, Alexandre, and Vasco, 2020b, 2020a; Dias, Heliodoro, Alexandre, et al., 2020a; Dias, Heliodoro, Teixeira, and Godinho, 2020; Dias et al., 2020; Dias, Pardal, Teixeira, & Machová, 2020; Heliodoro, Dias, and Alexandre, 2020; Heliodoro, Dias, Alexandre, and Vasco, 2020; Heliodoro, Dias, Alexandre, et al., 2020; Sparrow, P., Dias, R., Šuleř, P., Teixeira, N., and Krulický, 2020; Saints, Hortense; Dias, Rui, 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 goes through massive modernization initiatives (Jr. and Camba, 2020).

This paper aims to analyze the efficiency, in its weak form, in the markets of commodities Platinum (London Platinum Free Market $/Troy oz), GOLD (Gold Bullion LBM $/t oz DELAY), SILVER (Silver – Zurich SW. and the stock markets of KOREA, CHINA, JAPAN, PHILIPPINES, INDONESIA from January 1, 2019 to October 20, 2020. The results show that the random walk hypothesis is rejected in all markets, with no efficiency differences between the Gold, Platinum, Silver and Asian stock markets. These findings show that the global pandemic has affected the memory properties of the markets analyzed suggesting that price fluctuations are not independent, which could lead to international investors obtaining anomic yields without incurring additional risk.

This research adds relevant contributions to the literature. The most relevant contribution is related to the comparison whether the Gold, Platinum and Silver markets have higher levels of efficiency when compared to Asian markets under analysis during the 2020 pandemic. Understanding the different predictability between the various markets analyzed could make it easier for international investors to protect their assets, as well as rebalance their portfolios in an international context. As far as we know the authors Aggarwal (2018), Rehman, Chhapra, Kashif, and Rehan (2018), Malafeyev, Awasthi, S.Kambekar, and Kupinskaya (2019), tested the random walk hypothesis in Asian markets, but the research questions, the markets analyzed, the sampling period and the methodology were essentially different from the one followed in this trial.

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

2. LITERATURE REVIEW

A market is designated as efficient, when all relevant information about the stock price is reflected in the market price. The lack of consensus among economists and financial analysts regarding market efficiency requires the study of the efficient market hypothesis (EMH). An-

other significant reason to study market efficiency is the role of stock markets acting as financial intermediaries between the saver and the borrower in the distribution of scarce resources via the price mechanism (Jain, 2020; Karasiński, 2020).

Nisar and Hanif (2012), Mehla and Goyal (2013), El Khamlichi, Sarkar, Arouri, and Teulon (2014), Hamid, Suleman, Ali Shah, and Imdad Akash (2017) analyzed Ásia's stock markets by testing the random walk hypothesis, i.e. if these markets have any predictability. Nisar and Hanif (2012) examined major stock exchanges in South Asia, including India, Pakistan, Bangladesh and Sri Lanka. The authors show that the random walk hypothesis is rejected and there is autocorrelation in profitability, that is, investors will be able to obtain abnormal yields based on historical prices. Mehla and Goyal (2013) show that India's stock market does not have random walk properties suggesting some predictability in price fluctuations. Hamid, Suleman, Ali Shah, and Imdad Akash (2017) analyzed the financial markets of Pakistan, India, Sri Lanka, China, Korea, Hong Kong, Indonesia, Malaysia, Philippines, Singapore, Thailand, Taiwan, Japan and Australia, evidencing that these markets are predictable and that prices are not i.i.d., or arbitrage levels are steep.

Aggarwal (2018), Rehman, Chhapra, Kashif, and Rehan (2018), Malafeyev, Awasthi, S.Kambekar, and Kupinskaya (2019), Pernagallo and Torrisi (2019) examined the efficiency of the market, in its weak form, in the international financial markets. Aggarwal (2018) analyzed the Korean stock price index from July 1997 to September 2016, showing that the series do not follow a random walk model. Rehman, Chhapra, Kashif, and Rehan (2018) analyzed the KSE 100, S&P BSE 500 and CSE All Share indices. The results show that these stock exchanges do not have random walk characteristics, i.e. investors may make additional gains based on historical price fluctuations. Malafeyev, Awasthi, S.Kambekar, and Kupinskaya (2019) studied the stock markets of China and India, analyzing the impact of the global financial crisis of 2008 and the recent Chinese crisis of 2015 Data from the last 20 years of the Bombay Stock Exchange (BSE200), and the Shanghai Stock Exchange Composite Index, that were selected and divided into four subperiods: before the period of the financial crisis (period I), during the financial crisis of 2008 (period II), after the *subprime crisis,* before the Chinese crisis (period III) and the beginning of the Chinese crisis to date (period IV). Evidence confirms that the Indian and Chinese stock markets show no market efficiency in its weak form. Pernagallo and Torrisi (2019) analyzed if the behavior of the diary profitability of the stock indices of 12 emerging economies corroborates the hypothesis of "fat tails" and if these series show long memory. The authors show that Hurst's exponents range from 0.51 to 0.62 showing significant long memories and similarities between the stock markets of emerging economies and developed countries.

In summary, this work aims to contribute to the provision of information to investors and regulators in the Gold, Platinum and Silver markets, as well as the Asian stock 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

Data are the commodity price indexes – Platinum (London Platinum Free Market $/Troy oz), GOLD (Gold Bullion LBM $/t oz DELAY), SILVER (Silver – Zurich SW. Francs/kg), that are quoted in US dollars and Swiss francs, respectively. Price indexes of the stock markets of KO-

REA, CHINA, JAPAN, PHILIPPINES, INDONESIA are quoted in local currency. The sample period covers the period from January 1, 2019 to October 20, 2020 (471-point data). The time scales are daily and were obtained from the *DataStream* database.

3.2. Methodology

Research will develop throughout several stages. Market graphs were made, at levels, and in profitability, to estimate the evolution of the markets under study. The characterization of the sample will be performed using descriptive statistics in order to verify whether the data follow a normal distribution. In order to assess whether the time series follow a white noise (mean = 0; constant variance), the unit root tests will be used in Hadri panel (2000), Levin, Lin, and Chu (2002) that postulate null hypotheses contracted. To answer the question of investigation we will use the method of the variance reason proposed by Lo and Mackinlay (1988) in order to evaluate the autocorrelation between the series of profitability. This is classified as a parametric test. The efficient market hypothesis in its weak form establishes that it is not possible to predict future prices based on historical prices. The author Rosenthal (1983) advocates whether a market is efficient in its weak form, then there should be no linear dependence between the profitability allocated both in the statistical sense (absence of autocorrelation) and in the economic sense (no positive profitability after considering transaction costs). The Lo and Mackinlay model (1988) defines how the P_t price of an asset in t and X_t as the natural logarithm of P_t, the random walk hypothesis is given by:

$$X_t = \mu + X_{t-1} + \epsilon_t \quad [1]$$

Where μ it is an arbitrary motion parameter and is the random error ϵ_t term; an important feature of the random walk process is that the variance of increments increases linearly according to the observation interval.

4. RESULTS

Figure 1 shows the swings in levels of the Platinum (London Platinum Free Market $/Troy oz), GOLD (Gold Bullion LBM $/t oz DELAY), SILVER (Silver – Zurich SW commodity markets, francs/kg), and the stock markets of KOREA, CHINA, JAPAN, PHILIPPINES, INDONESIA. The sample period comprises the period from January 1, 2019 to October 20, 2020, and it is a period of great complexity, due to the understanding of global pandemic (Covid-19). The markets analyzed clearly reveal the instability experienced in these markets in the first quarter of 2020.

Figure 2 shows the evolutions of the markets under analysis, and we can see that these indices present very similar patterns of behavior during the sampling period and that they were strongly affected by the pandemic. The values of the indexes suffered strong variations over the months studied. However, despite the strong variations, the yields present characteristics of seasonality in the average, giving the first indication that the series can be stationary. On the other hand, the graphical analysis also allows to verify the existence of a more pronounced bear market period in the first quarter of 2020, and to a lesser extent the third quarter. These indications arise due to the climate of pessimism and uncertainty experienced in international markets due to the evolution of the Covid-19 pandemic.

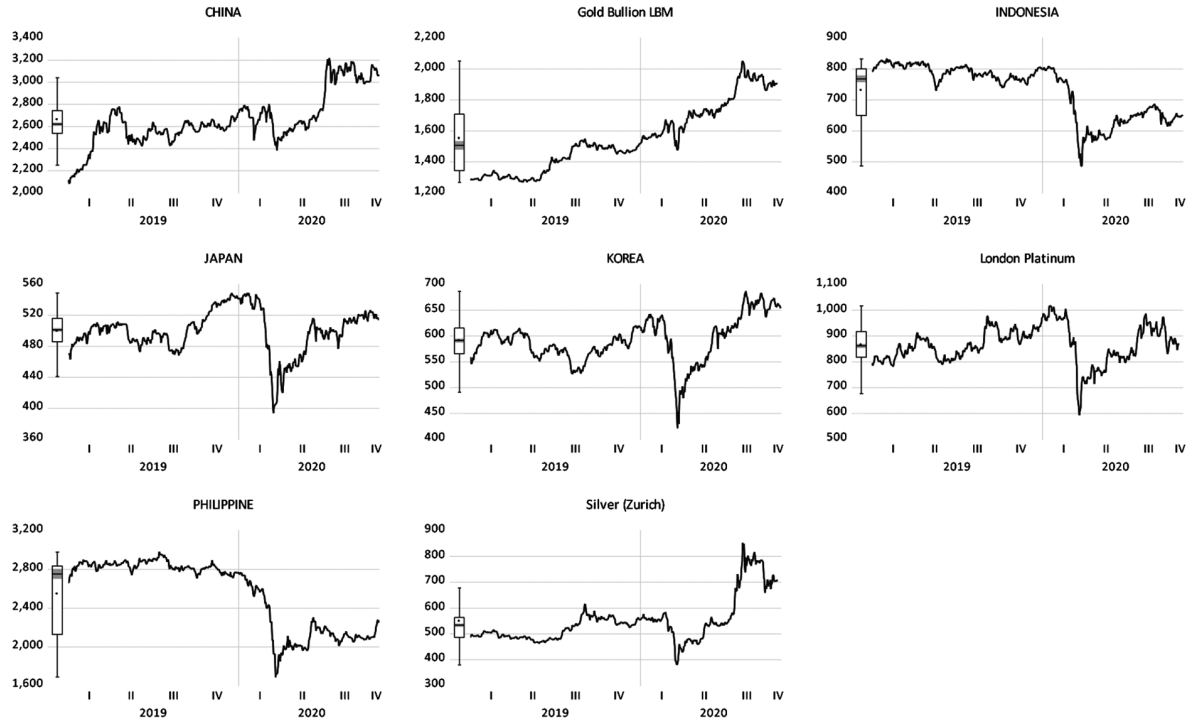

Figure 1. Evolution, in levels, of the 8 markets,
in the period from January 1, 2019 to October 20, 2020.

Source: Own elaboration.

Note: Thomson Reuters: January 1, 2019, 471-point data.

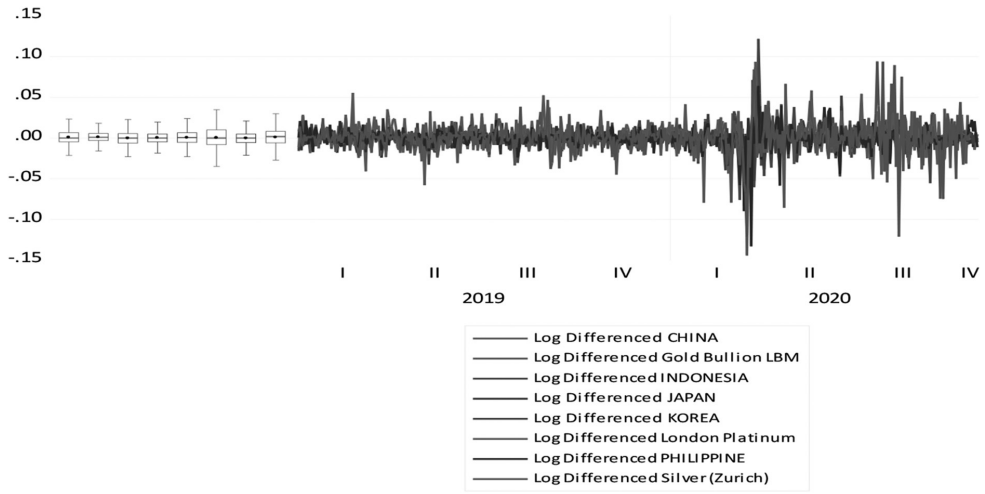

Figure 2. Evolution and return of the 8 markets,
in the period from January 1, 2019 to October 20, 2020.

Source: Own elaboration.

Note: Thomson Reuters: January 1, 2019, 470-point data.

Figure 3 shows the average yields of the Platinum (London Platinum Free Market $/Troy oz), GOLD (Gold Bullion LBM $/t oz DELAY), SILVER (Silver – Zurich SW commodity markets, francs/kg), and the stock markets of KOREA, CHINA, JAPAN, PHILIPPINES, INDONESIA. Markets in CHINA (0.000831), GOLD (0.000844), JAPAN (0.000206), KOREA (0.000356), PLATINUM (0.000189), SILVER (0.000797) have positive average yields, while PHILIPPINE markets (-0.000442), INDONESIA (-0.000432) have negative averages.

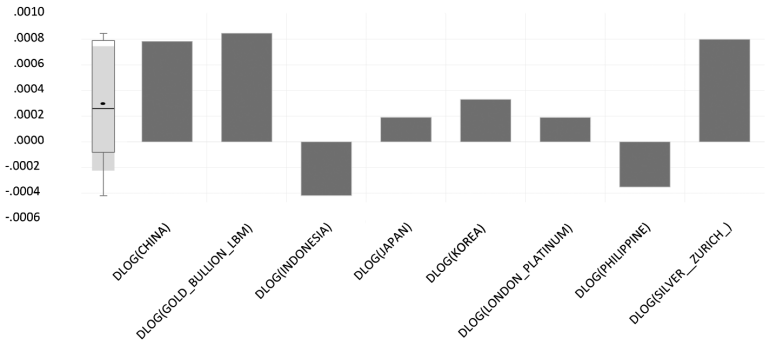

Figure 3. Evolution of average yields on the 8 markets January 1, 2019 to October 20, 2020.
Source: Own elaboration.

Figure 4 shows the standard deviations for the 8 markets under review. Commodity markets, namely SILVER (0.020311), PLATINUM (0.018795) have the sharpest standard deviations, while GOLD (0.009371) presents the lowest risk. The INDONESIA stock markets (0.014654) have the sharpest standard deviation, while the stock indices of KOREA (0.013826), PHILIPPINES (0.013766), CHINA (0.012678), JAPAN (0.010971) show less marked standard deviations.

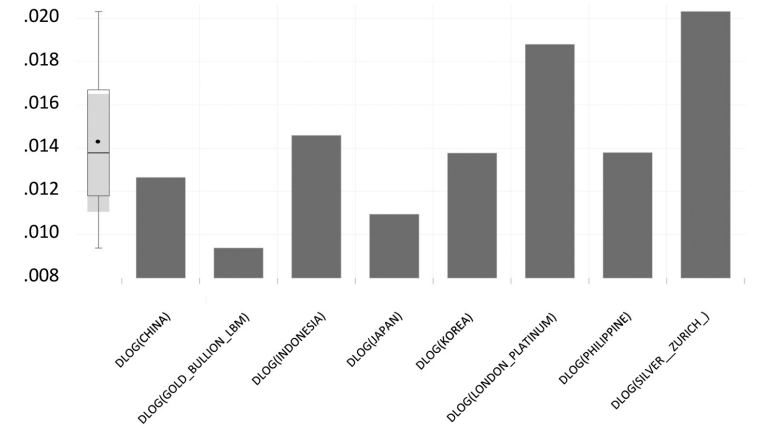

Figure 4. Evolution of Standard Deviations
for the 8 markets under review from January 1, 2019 to October 20, 2020
Source: Own elaboration.

Figure 5 shows the Skewness for the 8 markets under review. Commodity markets, namely PLATINUM (-1.026253), SILVER (-0.445377), have negative asymmetries, while GOLD (-0.305960) has smaller (negative) asymmetry. Philippine stock markets (-2.684595), JAPAN (-0.079217) CHINA (-0.690930), KOREA (-0.039344) have negative asymmetries, while INDONESIA (0.422974) has positive asymmetry. These values are different from the reference values for normal distributions (Skewness = 0).

Figure 6 shows the Kurtosis of the Platinum (London Platinum Free Market $/Troy oz), GOLD (Gold Bullion LBM $/t oz DELAY), SILVER (Silver – Zurich SW commodity markets, francs/kg), and the stock markets of KOREA, CHINA, JAPAN, PHILIPPINES, INDONESIA. The PHILIPPINE market (27.59491) has the strongest value, while INDONESIA (16.87296), PLATINUM (13.10225), SILVER (12.36280), KOREA (11.15687), CHINA (9.130501), JAPAN (8.980370), GOLD (8.137330) have smaller Kurtosis values. However, these values are different from the reference values (Skewness = 0; Kurtosis = 3), so we can evidence that time series do not follow normal distributions.

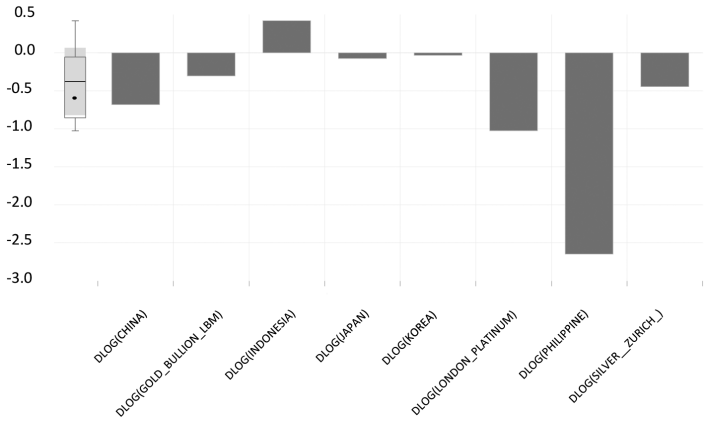

Figure 5. Evolution of the Skewness, concerning the 8 markets under review, January 1, 2019 to October 20, 2020.
Source: Own elaboration.

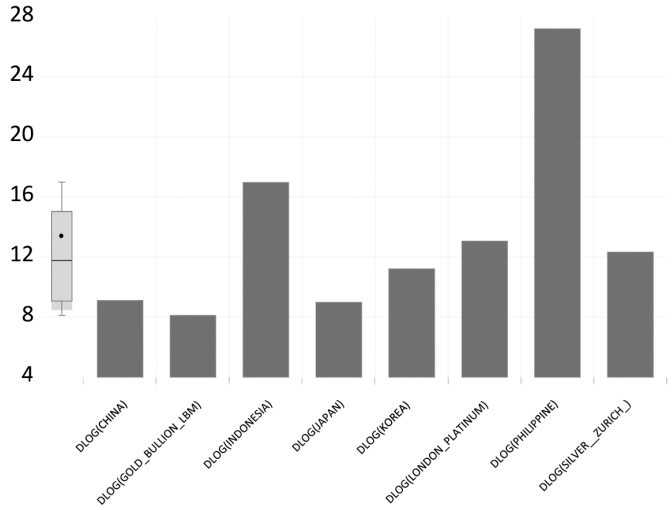

Figure 6. Evolution of Kurtosis for the 8 markets under review January 1, 2019 to October 20, 2020
Source: Own elaboration.

Table 1 shows the results of the Jarque-Bera adherence test and we can see that the null hypothesis that time series follow a normal distribution are rejected with a significance level of 1%. These results corroborate the analyses previously performed on asymmetries and Kurtosis, which confirmed that time successions do not follow normal distributions.

Table 1. Jarque-Bera test for the 8 markets under review from January 1, 2019 to October 20, 2020.

	China	Gold	INDONE-SIA	Japan	KOREA	Platinum	PHILIP-PINES	Silver
Jarque-Bera	775.0418***	525.2947***	3791.051***	702.3773***	1305.861***	2085.515***	12437.11***	1735.940***
Observations	471	471	471	471	471	471	471	471

Source: Own elaboration.

Figure 7 shows the stability tests performed on stock market residues, measuring the existence of disturbances in variance. Additionally, when examining the graphs and the probability limits of 95% we verified the existence of violation of probability limits, therefore, the time series show an unstable behavior.

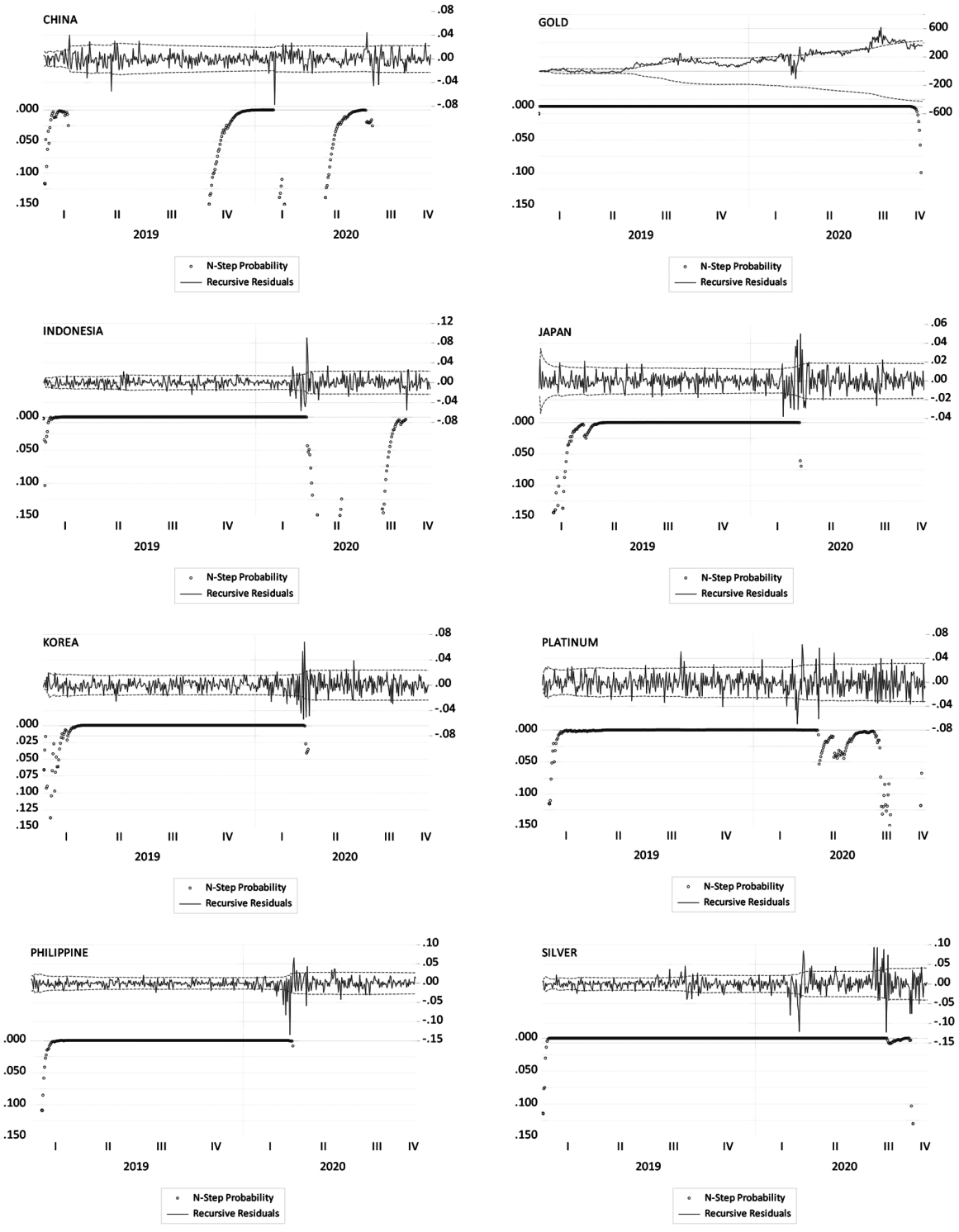

Figure 7. Stability tests carried out on waste for the 8 markets under analysis January 1, 2019 to October 20, 2020.

Source: Own elaboration.

Since we are in the presence of time successions, we should study the stationary nature of the series concerning the 8 markets under analysis. For this, we use the tests of unitary roots in panel of Hadri (2000), Levin, Lin, and Chu (2002), which postulate null hypotheses contrary to the intersections of unitary root tests in panel and 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 2 and 3).

Table 2. Hadri parking test (2000) for the 8 markets under review January 1, 2019 to October 20, 2020.

Method			Statistic	Prob.**
Hadri Z-stat			-1.42427	0.9228
Heteroscedastic Consistent Z-stat			-1.71740	0.9570
Intermediate results on D(UNTITLED)				
Series	Lm	Variance Hac	Bandwidth	Note
D(CHINA)	0.0643	1174.127	1.0	475
D(GOLD)	0.0688	197.7653	15.0	470
D(INDONESIA)	0.0657	108.1340	8.0	475
D(JAPAN)	0.0717	28.17722	1.0	475
D(KOREA)	0.0606	71.83385	7.0	475
D(PHILIPPINES)	0.1399	1174.302	8.0	475
D(PLATINUM)	0.0419	310.1432	6.0	470
D(SILVER)	0.0962	161.7774	13.0	470

Source: Own elaboration.

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

Table 3. Levin, Lin, and Chu parking test (2002) for the 8 markets under review from January 1, 2019 to October 20, 2020.

Method				Statistic		Prob.**	
Levin, Lin & Chu t*				-59.6755		0.0000	
Series	2nd stage Coefficient	Variance Of Reg	HAC of Dep.	Lag	Max Lag	Band-Width	Note
D(CHINA)	-0.98331	1154.9	68.025	0	17	35.0	474
D(GOLD)	-0.94440	237.16	6.5022	0	17	69.0	469
D(INDONESIA)	-0.93152	85.989	0.7427	0	17	229.0	474
D(JAPAN)	-0.95345	26.922	0.9894	0	17	56.0	474
D(KOREA)	-0.84577	54.542	1.9817	1	17	63.0	473
D(PHILIPPINES)	-0.81165	874.75	10.254	2	17	200.0	472
D(PLATINUM)	-0.75950	234.09	6.7638	1	17	75.0	468
D(SILVER)	-0.90342	158.35	5.7795	1	17	59.0	468
	Coefficient	T-Stat	Reg SE	mu*	sig*		Note
Pooled	-0.91299	-48.210	1.002	-0.500	0.707		3772

Source: Own elaboration.

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

Table 4 presents the results of the variance ratio methodology proposed by Lo and Mackinlay (1988) in order to evaluate the autocorrelation between the profitability series. In all cases, statistics were calculated for 2- 16-day lags, with intervals of 1 day. The results of the variance test indicate that the random walk hypothesis is rejected in the Gold, Platinum and Silver markets, as well as in the Asian stock markets, with no differences between markets. These findings show that profitability is auto-correlated over time, with a reversal of the mean, because the values of variance ratios are lower than the unit, i.e., price fluctuations are not i.i.d. These results suggest that the hypothesis of efficiency and market, in weak form, may be questionable, since the prediction of the movement of a given market can be improved if the out-of-lag movements of the other markets are considered, thus enabling the occurrence of arbitrage operations. In the face of these events, investors adjusting their trading strategies to the necessary missteps will be able to achieve anomic profitability without incurring additional risk.

Table 4. Tests of the Variance Ratios of Lo and Mackinlay, return, for the 8 markets under analysis, in the period from January 1, 2019 to October 20, 2020.

Null Hypothesis: CHINA is a random walk

Joint Tests	Value	Df	Probability
Max |z| (at period 2)	9.891207	470	0.0000
Wald (Chi-Square)	129.3755	15	0.0000
Individual Tests			
Period	Var. Ratio	Std. Error	z-Statistic	Probability
2	0.543753	0.046127	-9.891207	0.0000
3	0.371040	0.068761	-9.146993	0.0000
4	0.325561	0.086295	-7.815513	0.0000
5	0.258539	0.101058	-7.336967	0.0000
6	0.248294	0.114028	-6.592297	0.0000
7	0.202096	0.125720	-6.346684	0.0000
8	0.190771	0.136444	-5.930841	0.0000
9	0.168921	0.146404	-5.676603	0.0000
10	0.153518	0.155741	-5.435183	0.0000
11	0.147128	0.164558	-5.182809	0.0000
12	0.142113	0.172932	-4.960836	0.0000
13	0.134540	0.180923	-4.783574	0.0000
14	0.124183	0.188580	-4.644282	0.0000
15	0.123604	0.195940	-4.472782	0.0000
16	0.117778	0.203035	-4.345163	0.0000

Source: Own elaboration.

Null Hypothesis: INDONESIA is a random walk

Joint Tests	Value	Df	Probability
Max |z| (at period 3)	9.247328	475	0.0000
Wald (Chi-Square)	108.3891	15	0.0000
Individual Tests			
Period	Var. Ratio	Std. Error	z-Statistic	Probability
2	0.581053	0.045883	-9.130744	0.0000
3	0.367496	0.068399	-9.247328	0.0000
4	0.318554	0.085840	-7.938610	0.0000
5	0.264649	0.100525	-7.315114	0.0000
6	0.230427	0.113426	-6.784788	0.0000
7	0.221823	0.125056	-6.222611	0.0000
8	0.210580	0.135724	-5.816359	0.0000
9	0.200735	0.145632	-5.488263	0.0000
10	0.197452	0.154919	-5.180424	0.0000
11	0.194629	0.163690	-4.920112	0.0000
12	0.183545	0.172019	-4.746301	0.0000
13	0.176481	0.179969	-4.575905	0.0000
14	0.179603	0.187585	-4.373477	0.0000
15	0.169953	0.194906	-4.258706	0.0000
16	0.168940	0.201964	-4.114893	0.0000

Source: Own elaboration.

Null Hypothesis: PHILIPPINES is a random walk

Joint Tests Max |z| (at period 2)		Value 9.969695	Df 475	Probability 0.0000
Wald (Chi-Square) Individual Tests		134.1463	15	0.0000
Period	Var. Ratio	Std. Error	z-Statistic	Probability
2	0.542559	0.045883	-9.969695	0.0000
3	0.352370	0.068399	-9.468469	0.0000
4	0.286863	0.085840	-8.307794	0.0000
5	0.256082	0.100525	-7.400328	0.0000
6	0.192431	0.113426	-7.119775	0.0000
7	0.175003	0.125056	-6.597002	0.0000
8	0.147364	0.135724	-6.282125	0.0000
9	0.135041	0.145632	-5.939360	0.0000
10	0.119308	0.154919	-5.684840	0.0000
11	0.124550	0.163690	-5.348237	0.0000
12	0.110563	0.172019	-5.170565	0.0000
13	0.111237	0.179969	-4.938434	0.0000
14	0.102427	0.187585	-4.784899	0.0000
15	0.098169	0.194906	-4.627005	0.0000
16	0.093598	0.201964	-4.487936	0.0000

Source: Own elaboration.

Null Hypothesis: JAPAN is a random walk

Joint Tests Max |z| (at period 2)		Value 10.95323	Df 475	Probability 0.0000
Wald (Chi-Square) Individual Tests		164.0095	15	0.0000
Period	Var. Ratio	Std. Error	z-Statistic	Probability
2	0.497431	0.045883	-10.95323	0.0000
3	0.398386	0.068399	-8.795712	0.0000
4	0.293969	0.085840	-8.225016	0.0000
5	0.246203	0.100525	-7.498602	0.0000
6	0.201813	0.113426	-7.037065	0.0000
7	0.193042	0.125056	-6.452757	0.0000
8	0.173259	0.135724	-6.091334	0.0000
9	0.157409	0.145632	-5.785772	0.0000
10	0.152183	0.154919	-5.472636	0.0000
11	0.139889	0.163690	-5.254529	0.0000
12	0.143912	0.172019	-4.976699	0.0000
13	0.129846	0.179969	-4.835037	0.0000
14	0.114014	0.187585	-4.723128	0.0000
15	0.121050	0.194906	-4.509611	0.0000
16	0.114978	0.201964	-4.382078	0.0000

Source: Own elaboration.

Null Hypothesis: KOREA is a random walk

Joint Tests	Value	Df	Probability
Max |z| (at period 2)	11.46637	475	0.0000
Wald (Chi-Square)	197.8483	15	0.0000
Individual Tests			
Period	Var. Ratio	Std. Error	z-Statistic	Probability
2	0.473887	0.045883	-11.46637	0.0000
3	0.376193	0.068399	-9.120178	0.0000
4	0.309891	0.085840	-8.039521	0.0000
5	0.257482	0.100525	-7.386407	0.0000
6	0.231423	0.113426	-6.776012	0.0000
7	0.221925	0.125056	-6.221791	0.0000
8	0.219534	0.135724	-5.750380	0.0000
9	0.184520	0.145632	-5.599609	0.0000
10	0.200278	0.154919	-5.162183	0.0000
11	0.182925	0.163690	-4.991616	0.0000
12	0.186375	0.172019	-4.729848	0.0000
13	0.175934	0.179969	-4.578944	0.0000
14	0.169966	0.187585	-4.424850	0.0000
15	0.166790	0.194906	-4.274934	0.0000
16	0.172180	0.201964	-4.098847	0.0000

Source: Own elaboration.

Null Hypothesis: GOLD is a random walk

Joint Tests	Value	Df	Probability
Max |z| (at period 2)	10.74843	470	0.0000
Wald (Chi-Square)	129.2428	15	0.0000
Individual Tests			
Period	Var. Ratio	Std. Error	z-Statistic	Probability
2	0.504212	0.046127	-10.74843	0.0000
3	0.393245	0.068761	-8.824065	0.0000
4	0.336479	0.086295	-7.688999	0.0000
5	0.278858	0.101058	-7.135909	0.0000
6	0.231306	0.114028	-6.741278	0.0000
7	0.216106	0.125720	-6.235249	0.0000
8	0.197247	0.136444	-5.883376	0.0000
9	0.178571	0.146404	-5.610693	0.0000
10	0.174708	0.155741	-5.299124	0.0000
11	0.164645	0.164558	-5.076359	0.0000
12	0.154382	0.172932	-4.889888	0.0000
13	0.144675	0.180923	-4.727556	0.0000
14	0.129343	0.188580	-4.616920	0.0000
15	0.124668	0.195940	-4.467349	0.0000
16	0.125460	0.203035	-4.307326	0.0000

Source: Own elaboration.

Null Hypothesis: LONDON PLATINUM is a random walk

Joint Tests	Value	Df	Probability
Max |z| (at period 2)	10.14569	470	0.0000
Wald (Chi-Square)	107.9239	15	0.0000
Individual Tests			
Period	Var. Ratio	Std. Error	z-Statistic	Probability
2	0.532014	0.046127	-10.14569	0.0000
3	0.391688	0.068761	-8.846704	0.0000
4	0.318037	0.086295	-7.902700	0.0000
5	0.270666	0.101058	-7.216969	0.0000
6	0.229260	0.114028	-6.759226	0.0000
7	0.206900	0.125720	-6.308476	0.0000
8	0.191467	0.136444	-5.925737	0.0000
9	0.169198	0.146404	-5.674710	0.0000
10	0.157813	0.155741	-5.407604	0.0000
11	0.153138	0.164558	-5.146288	0.0000
12	0.151540	0.172932	-4.906326	0.0000
13	0.141592	0.180923	-4.744598	0.0000
14	0.132280	0.188580	-4.601345	0.0000
15	0.128408	0.195940	-4.448263	0.0000
16	0.122997	0.203035	-4.319456	0.0000

Source: Own elaboration.

Null Hypothesis: SILVER is a random walk

Joint Tests	Value	Df	Probability
Max |z| (at period 2)	10.78277	470	0.0000
Wald (Chi-Square)	145.8002	15	0.0000
Individual Tests			
Period	Var. Ratio	Std. Error	z-Statistic	Probability
2	0.502628	0.046127	-10.78277	0.0000
3	0.410889	0.068761	-8.567464	0.0000
4	0.308393	0.086295	-8.014456	0.0000
5	0.266180	0.101058	-7.261360	0.0000
6	0.224454	0.114028	-6.801373	0.0000
7	0.215455	0.125720	-6.240421	0.0000
8	0.191659	0.136444	-5.924335	0.0000
9	0.169664	0.146404	-5.671532	0.0000
10	0.169570	0.155741	-5.332115	0.0000
11	0.165985	0.164558	-5.068216	0.0000
12	0.163239	0.172932	-4.838673	0.0000
13	0.160215	0.180923	-4.641665	0.0000
14	0.151248	0.188580	-4.500762	0.0000
15	0.153894	0.195940	-4.318192	0.0000
16	0.145504	0.203035	-4.208604	0.0000

Source: Own elaboration.

5. CONCLUSION

The general conclusion to be withheld and supported by the results obtained, through the Lo and Mackinlay variance ratio methodology, shows that the random walk hypothesis is rejected in the Gold, Platinum and Silver markets, as well as in Asian stock markets, with no differences between markets. These findings show that profitability is auto-correlated over time, with a reversal of the mean, because the values of variance ratios are lower than the unit, i.e., price fluctuations are not i.i.d. These results suggest that the hypothesis of efficiency and market, in weak form, may be questionable, since the prediction of the movement of a given market can be improved if the out-of-lag movements of the other markets are considered, thus enabling the occurrence of arbitrage operations. In order 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.

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