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MARKET EFFICIENCY DYNAMICS DURING THE COVID-19 PANDEMIC

DYNAMIQUE DE L'EFFICIENCE DU MARCHÉ PENDANT LA PANDÉMIE DE COVID 19

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Abstract

The Adaptive Market Hypothesis (AMH) implies that financial markets experience disruption in market efficiency, especially during an extreme event such as the Covid 19 outbreak. To investigate this implication, we examine the AMH in major developed and emerging financial markets before and during the Covid 19 pandemic. Thus, we use the daily returns over the period from 2012 to 2021 as well as linear and nonlinear tests with rolling window. Empirical findings reveal that the market efficiency is time-varying with successive periods of efficiency and inefficiency. Furthermore, we find that market efficiency is influenced by the Covid 19 event. Indeed, the inefficiency period coincides with the onset of the Covid 19 crisis in all the markets examined except the Brazilian market. However, the degree of market efficiency improved amid the crisis. This change in market efficiency may be driven by the behavior of investors and regulatory policies adopted by authorities to ensure market stability. Therefore, the results are consistent with the AMH which offers a better explanation of the behavior of developed and emerging markets than the Efficiency Market Hypothesis (EMH). Our results have important implications for regulatory policies and investment strategies.

Keywords: Efficiency Market Hypothesis (EMH); Predictability of returns; Linear Dependence; Nonlinear dependence.

Résumé

L'hypothèse des marchés adaptatif (AMH) implique que les marchés financiers connaissent une perturbation au niveau de l'efficience du marché, en particulier lors d'un événement extrême tel que l'épidémie de Covid 19. Pour étudier cette implication, nous examinons l'AMH dans les principaux marchés financiers développés et émergents avant et pendant la pandémie de Covid 19. Ainsi, nous utilisons les rendements journaliers sur la période de 2012 à 2021 ainsi que des tests linéaires et non linéaires sous l'approche de la fenêtre mobile. Les résultats empiriques révèlent que l'efficience du marché varie au cours du temps avec des périodes successives d'efficience et d'inefficace. De surcroît, nous constatons que l'efficience du marché est influencée par l'événement de Covid 19. En effet, la période d'inefficience coïncide avec le début de la crise de Covid 19 dans tous les marchés examinés à l'exception du marché brésilien. Cependant, le degré d'efficience du marché s'est amélioré pendant la crise. Cette variation de l'efficience du marché peut être induite par le comportement des investisseurs et les politiques de régulation adoptées par les autorités pour assurer la stabilité du marché. Par conséquent, les résultats sont cohérents avec l'AMH qui offre une meilleure explication du comportement des marchés développés et émergents que l'hypothèse d'efficience des marchés. Nos résultats ont des implications importantes pour les politiques de régulation et les stratégies d'investissement.

Mots-clés : Hypothèse d'efficience des marchés (EMH) ; Prévisibilité des rendements ; Dépendance linéaire; Dépendance non linéaire.

Introduction

Market efficiency has attracted many researchers to examine whether the financial market is efficient or not. According to Fama (1970), a market is considered efficient if prices reflect all available information in a timely manner. Three forms of market efficiency have been distinguished, namely the weak form efficiency, the semi-strong efficiency and the strong efficiency. The weak form efficiency incorporates all historical information into the prices. The semi-strong efficiency involves all publicly available information. The strong form efficiency is based on public and private information. The weak form is the most examined in the literature, but also the most controversial. This form implies that prices are serially uncorrelated and thus returns follow a random walk. Accordingly, no one can use historical prices to predict

future returns and obtain abnormal profits.

However, the empirical studies examining the weak form of efficiency under the EMH yield controversial results. Thereby, there is still non consensus on whether the EMH is valid or not. In fact, these studies examine the EMH in developed and emerging markets and sometimes report the evidence for the EMH (Ayadi & Pyun, 1994; Cheung & Andrew Coutts, 2001; Fama, 1970; Granger & Morgenstern, 1963; Lock, 2007; Poon, 1996; Stachowiak, 2004), but sometimes no evidence to support it (Al-Ajmi & Kim, 2012; Bley, 2011; Butler & Malaikah, 1992; Claessens et al., 1995; Jarrett, 2010; Lovatt et al., 2007; McPherson et al., 2005; Shi & Zhou, 2017; Smith, 2012; Squalli, 2006). In this setting, the market efficiency is analyzed as all-or-nothing condition, ignoring the relative efficiency of a certain period in relation to others or of a market in relation to others (Campbell et al., 1997).

Lo (2004, 2005) proposes an alternative theory to EMH called the Adaptive Market Hypothesis (AMH). The AMH is based on an evolutionary approach and aims to reconcile the EMH with behavioral finance approach. Therefore, individual makes mistakes, but adapts to market conditions, causing waxing and waning of the degree of market efficiency. The market is not fully efficient or inefficient but adaptable by switching between periods of efficiency and inefficiency according to changing market conditions. The AMH is based on the following principles: (i) Individuals act in their own self-interest; (ii) they make mistakes; (iii) they learn and adapt; (iv) competition drives adaptation and innovation; (v) natural selection shapes market ecology; and (vi) evolution determines market dynamics.

The AMH has received increasing attention from researchers who have tested it empirically in various developed (Alvarez-Ramirez et al., 2012; Boya, 2019; Ito et al., 2016; Ito & Sugiyama, 2009; Kim et al., 2011; Lim et al., 2013) and emerging financial markets (Abdmoulah, 2010; Charfeddine & Khediri, 2016; Kılıç, 2020; Phan Tran Trung & Pham Quang, 2019; Shahid et al., 2019; Smith, 2012; Todea et al., 2009; Tuyon & Ahmad, 2016). According to Lo (2004, 2005), market efficiency is influenced by market conditions. The outbreak of the highly contagious COVID-19 pandemic is a surprise event with unprecedented uncertainty that can impact market efficiency.

The purpose of this article is to examine the AMH in major developed and emerging financial markets before and during the Covid 19 pandemic. Our empirical findings show that the degree of market efficiency varies over time with alternating periods of efficiency and inefficiency

depending on certain market conditions. In fact, the market efficiency decreased at the beginning of the Covid 19 outbreak in all the markets examined except the Brazilian market, but it improved thereafter. This change in market efficiency may be driven by investors behavior and authorities' actions in response to market instability. Hence, the results are congruent with the AMH implications.

Therefore, our contribution to the existing literature is fourfold. First, we use more recent daily data (from 2012 to 2021) to investigate the AMH in developed and emerging financial markets, which has not been previously investigated. Second, our sample consist of the most developed markets and the largest emerging markets, which offers a strong support to the AMH. Third, we combine linear and nonlinear tests to get robust results. Fourth, we relate the evolution of the degree of market efficiency to the ongoing Covid 19 outbreak to see how this crisis affected financial market dynamics using the rolling sample approach. To our knowledge, this is the first assessment of financial markets' efficiency during such an extreme event of the Covid-19 pandemic in these markets.

The remainder of the article is organized as follows. Section 2 reviews the existing literature. Section 3 exhibits methods and data. Section 4 presents and discusses the results. Section 5 concludes.

I. LITERATURE REVIEW

In extension to Lo (2004, 2005) papers, numerous studies have examined the AMH in various financial markets using different adapted tests. They found strong evidence for the AMH. The studies were conducted in developed as well as in emerging financial markets. As for developed market, Ito and Sugiyama (2009) apply the time-varying autoregressive coefficients to monthly returns and observe fluctuations in the degree of market efficiency in the S&P 500. Kim et al. (2011) examine the AMH in the DJIA (Dow Jones Industrial Average) index over the period from 1900 to 2009. They find that the return predictability is time-varying in the US capital market depending on market conditions, which is consistent with the implications of the AMH. In fact, they find that insignificant predictability of returns occurs during stock market crashes and that the degree of uncertainty results in predictability of return. Using the same index over the period sample from 1929 to 2012, Alvarez-Ramirez et al. (2012) support the AMH in the US market. The same conclusion is reached by Lim et al. (2013). Using the Wild Bootstrapping of Automatic Variance Ratio test (WBAVR) and the AR test with rolling window, they find

that the US market experiences alternating periods of efficiency and inefficiency. Moreover, based on the TV-AR model of Ito et al. (2014, 2016), Noda (2016) validates the AMH in the Japanese stock markets (TOPIX and TSE2) over the period 1961-2015. The AMH is also valid for the French stock market. Indeed, Boya (2019) utilizes the rolling variance ratio test approach over the period from 1988 to 2018 and finds that the market efficiency fluctuates between periods of efficiency and inefficiency and that inefficiency periods coincide with major macroeconomics events.

As far as emerging financial markets are concerned, Lekhal and El Oubani (2020a) inspect the AMH in the Moroccan financial market using the WBAVR test and the Automatic Portemanteau test over the sample period from 2006 to 2019. Their results corroborate the AMH in the Moroccan market. Continuing in the same direction, Lekhal and El Oubani (2020b) scrutinize different aspects of the AMH in the Moroccan financial market over the period from 1992 to 2019 through different approaches. On the basis of the daily returns on the MASI index, they measure the evolution of the degree of market efficiency through the linear and nonlinear tests with rolling window. In addition, they examine the time-varying profit opportunities according to the degree of market efficiency and market conditions by tracking the evolving performance of momentum-based trading strategies. The linear and nonlinear tests results reveal that the efficiency degree is time-varying. Moreover, they report via momentum test that profit opportunities appear from time to time and disappear once they are exploited. The emergence of momentum profits is linked both to the degree of market efficiency and to certain market conditions. The findings are consistent with the AMH framework which turns out to be a better explanation of the behavior of emerging markets than the EMH. Smith & Dyakova (2014) investigate the AMH in eight African stock markets using three finite-sample variance ratio tests with rolling window. Their results exhibit alternating periods of return predictability and return unpredictability, which is supportive to the AMH. Obalade and Muzindutsi (2019) examine the AMH through the behavior of the day-of-the week (DOW) under different bull and bear market conditions using the Markov Switching Model. They find that the DOW effect emerges in bearish case and vanishes in bullish case, validating the AMH. The results imply that active investment management can be used fruitfully to gain abnormal returns for investors during bearish conditions. Rejichi and Aloui (2012) use the Hurst Exponent with rolling sample from 1997 to 2007 and find that MENA markets have experienced long-range memory, but the efficiency of some of them has improved. The authors relate the differences in inefficiency

degrees to trading costs, market capitalization and anti-self-dealing index. In the same vein, Sensoy (2013) investigates the evolving market efficiency in fifteen MENA markets for the period that covers from 2007 to 2012. On the basis of the Generalized Hurst Exponent Analysis with rolling window and the daily data, the author reports that these markets have experienced a time-varying degree of long-term dependency that differs across the markets. To inspect the time-varying efficiency in Vietnamese financial market over the period from 2005 to 2019, Phan Tran Trung and Pham Quang (2019) employ the linear and nonlinear tests and the weekly returns. They find that the predictability of returns of two major Vietnamese stock markets (HSX and HNX) evolves in a cyclical manner. On the basis of four calendar effects, Xiong et al. (2019) study the AMH in the Chinese stock market using subsample analysis and rolling window, as well as constructing trading strategies based on these calendar effects. Indeed, they attempt to verify whether the calendar effect and the trading strategies emerge from time to time according to the implications of the AMH. Their findings show that both the calendar effect's performance as well as the excess returns yield by the investment strategies appear in a sporadic manner, which validates the AMH in the Chinese stock market. However, the AMH is not supported by Kılıç (2020) in Borsa Istanbul. In fact, the author tests the predictability of return within the framework of the AMH over the period 2013-219 using the Automatic Portmanteau Box-Pierce test, the Generalized Spectral test and the WBAVR test with the rolling window approach. He reports that the degree of efficiency of the stock market does not change over time depending on market conditions.

II. METHODS AND DATA

2.1. Methods

To examine the evolution of the degree of market efficiency under the AMH, we use linear and nonlinear tests, namely the Automatic Portmanteau test and the Mcleod-Li test. If these tests exhibit autocorrelations in returns, then it is possible to predict the future stock returns based on historical returns. These tests are robust to the conditional heteroscedasticity which is a stylized fact in stock market returns. In addition, we employ the rolling window approach to track the evolution of the degree of market efficiency according to market conditions.

2.1.1. Automatic Portmanteau test

Escanciano and Lobato (2009) propose the Automatic Portmanteau that uses a fully data dependent to determine the optimal value of p. The test is as follows:

$$AQ = Q_p^* = T\sum_{i=1}^{p} \hat{p}_i^2 \quad AQ \sim x^2$$

where, $\hat{p}$ is the optimal lag order determined by the Akaike's Information Criterion or Bayesian Information Criterion. The test statistic follows Chi-squared distribution with one degree of freedom.

2.1.2. McLeod–Li test

The first test presented above is a linear test which can neglect the nonlinear dependences in returns considered as a stylized fact (Lim & Brooks, 2011). To intercept this nonlinearity, we utilize the McLeod–Li test (McLeod & Li, 1983). The statistic of the test is as follows:

$$Q(m) = \frac{n(n+2)}{n-k}\sum_{k=1}^{m} r_\alpha^2(k)$$

where, $r_\alpha^2(k) = \frac{\sum_{t=k-1}^{n} e_t^2 e_{t-k}^2}{\sum_{t=1}^{n} e_t^2}\,(k = 0,1,\dots,n-1)$, r_α^2 represents autocorrelation of e_t^2. If the e_t series is independent and identically distributed, then the $Q(m)$ is asymptotically distributed as χ_m^2. The null hypothesis of the test implies the absence of dependence in returns against the presence of the nonlinear ARCH/GARCH effects in data.

2.2. Data

Our sample consists of three major developed markets (US, Europe, Japan) and three main emerging markets (China, Brazil, Turkey). We employ the indices returns over the period from January 2012 to August 2021, obtained from the website investing.com. Based on the daily closing prices, we compute the log first difference of the time series to obtain the returns:

$$x_t = ln(p_t/p_{t-1})$$

where, p_t is the daily closing price of the index at time t, and p_{t-1} is the daily closing price of the index at time t-1.

III. Results

Descriptive statistics of the returns in the DJIA index (US), the Euro Stoxx 50 index (Euronext), the Nekkei 225 index (Japan), the BIST 100 index (Turkey), the Shanghai Composite index (China), and the Bovespa index (Brazil) are shown in Table 1.

Table 1. Descriptive statistics and Jarque-Bera test

Index	Skewness	Kurtosis	JB	*N*
DJIA	-1.096	27.884	0.000	2,424
Euro Stoxx 50	-0.830	13.676	0.000	2,470
Nekkei 225	-0.273	4.578	0.000	2,385
Shanghai Composite	-0.994	10.054	0.000	2,343
Bovespa	-0.894	16.040	0.000	2,382
BIST 100	-0.775	5.317	0.000	2,418

Notes: JB is the *p*-value of the of Jarque-Bera test (1980); *n* is the number of observations; R version 3.6.1 was used to calculate the statistics.

From Table 1, the kurtosis coefficient in all the markets exceeds that of the normal distribution, which by construction equals 3. In addition, unlike the normal distribution in which the skewness coefficient is zero, the data from our sample are negatively skewed. The normal distribution of the data is also rejected by the test of Jarque-Bera at the 1 percent significance level ($p < .01$). Thus, the distribution is leptokurtic, which is a property common to various financial markets.

To track the linear and nonlinear autocorrelations in returns and therefore the degree of time-varying financial market efficiency, we perform the Automatic Portmanteau linear test (AQ)) and the McLeod-Li nonlinear test with rolling window approach. Unlike most previous studies which examine the autocorrelation in returns based on a predetermined sample period and report the lack of such autocorrelation as stylized fact, we measure the time-varying autocorrelation because returns display structural breaks.

Figures 1, 2, 3, 4, 5 and 6 show the empirical results of the Automatic Portmanteau test for the US, Japanese, Euronext, Chinese, Brazilian, and Turkish markets, respectively. The test exhibits the time-varying linear dependence in the returns. When the test statistics are above the 5 percent level significance, the returns are autocorrelated; however, they are independent when they are below this level.

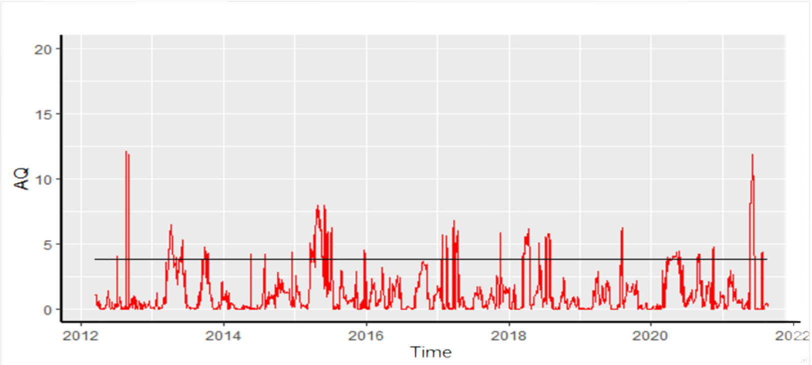

Figure 1. Automatic portmanteau test results for the US market. *Notes*: The red line indicates the automatic portmanteau test statistic, and the black line represents the *F*-statistic at the 5% significance level. R version 3.6.1 was used to calculate the statistics.

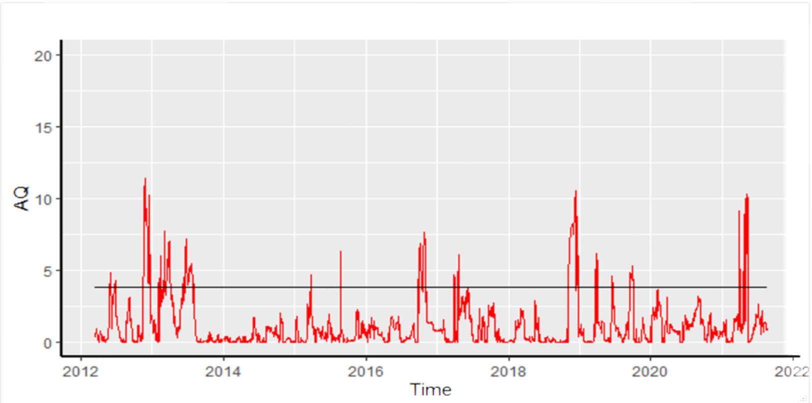

Figure 2. Automatic portmanteau test results for the Japanese market. *Notes*: The red line indicates the automatic portmanteau test statistic, and the black line represents the *F*-statistic at the 5% significance level. R version 3.6.1 was used to calculate the statistics.

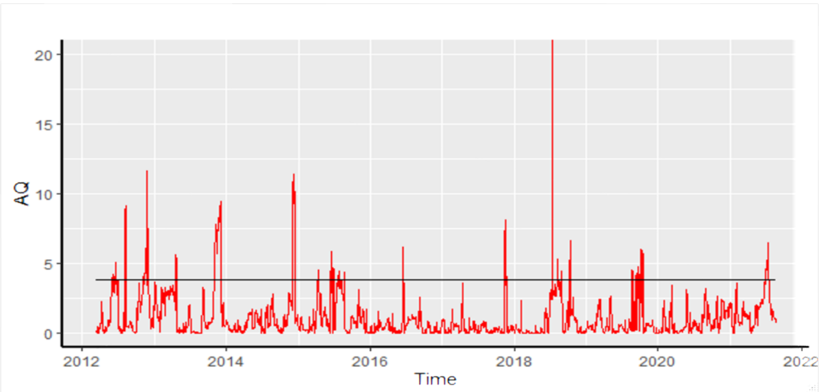

Figure 3. Automatic portmanteau test results for the Euronext market. *Notes*: The red line indicates the automatic portmanteau test statistic, and the black line represents the *F*-statistic at the 5% significance level. R version 3.6.1 was used to calculate the statistics.

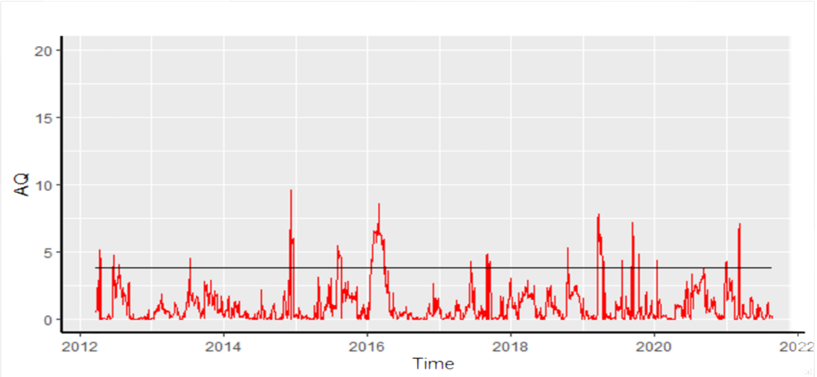

Figure 4. Automatic portmanteau test results for the Chinese market. *Notes*: The red line indicates the automatic portmanteau test statistic, and the black line represents the *F*-statistic at the 5% significance level. R version 3.6.1 was used to calculate the statistics.

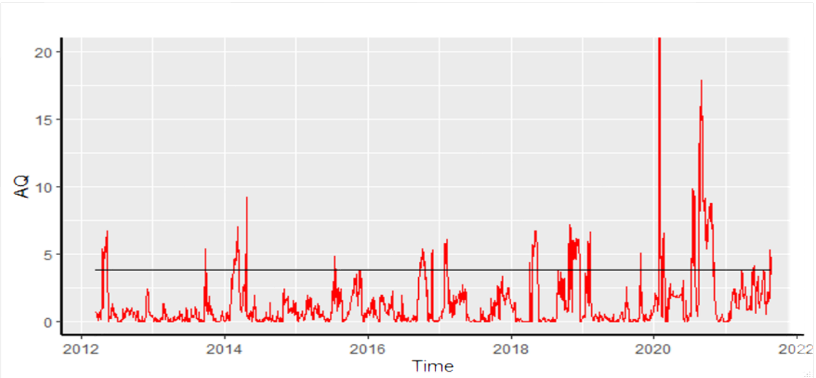

Figure 5. Automatic portmanteau test results for the Brazilian market. *Notes*: The red line indicates the automatic portmanteau test statistic, and the black line represents the *F*-statistic at the 5% significance level. R version 3.6.1 was used to calculate the statistics.

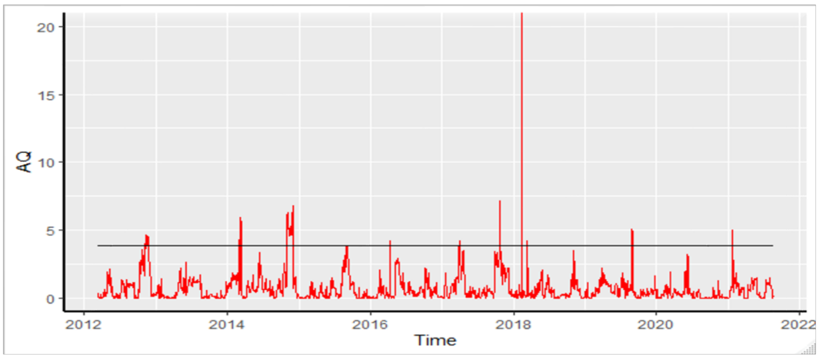

Figure 6. Automatic portmanteau test results for the Turkish market. *Notes*: The red line indicates the automatic portmanteau test statistic, and the black line represents the *F*-statistic at the 5% significance level. R version 3.6.1 was used to calculate the statistics.

From these Figures, we can observe that all the markets show that the autocorrelation in returns evolves over time with successive periods of dependence and independence. Nonetheless, the periods of efficiency are longer than the periods of inefficiency. This implies that the financial markets are efficient most of the time, but they can become inefficient during certain market

conditions such as extreme events.

Nevertheless, the linear test may fail to detect nonlinear dependences in returns. To detect these nonlinear dependences, we conducted the McLeod-Li test (Figures 7, 8, 9, 10, 11 and 12). The test results also show alternating periods of dependence and independence in returns. The *p*-value below the 5 percent significance line denotes the autocorrelations in returns, but when the *p*-value is above that line, there is no autocorrelation. This finding is consistent with previous studies (Almudhaf et al., 2020; Ghazani & Ebrahimi, 2019; Shahid et al., 2019) which find nonlinear autocorrelations in returns. Transaction costs, market psychology and investor heterogeneity are the major factors that cause this nonlinearity.

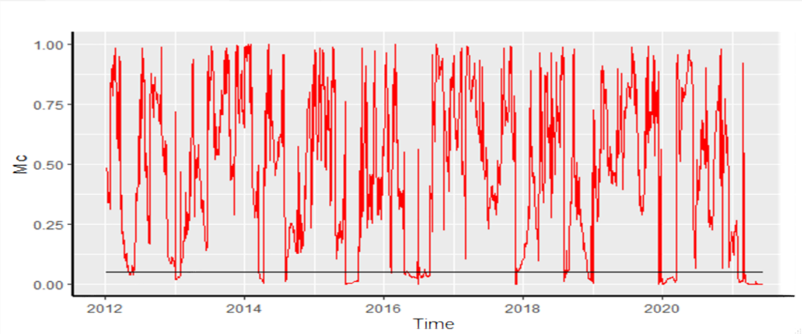

Figure 7. The *p*-values of the McLeod-Li test for the US market. *Notes*: The red line indicates the *p*-values of the McLeod-Li test, and the black line represents the 5% significance level. R version 3.6.1 was used to calculate the statistics.

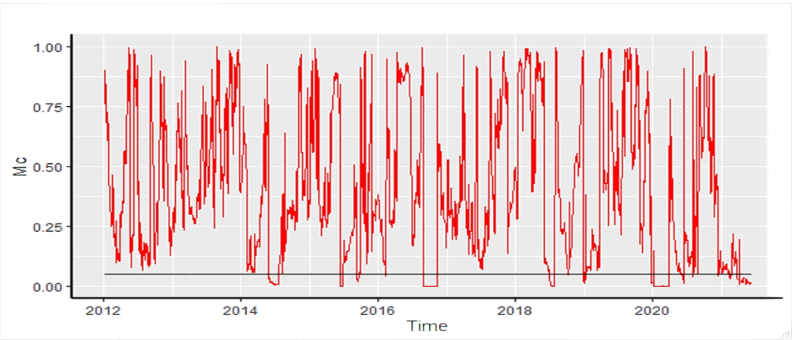

Figure 8. The *p*-values of the McLeod-Li test for the Japanese market. *Notes*: The red line indicates the *p*-values of the McLeod-Li test, and the black line represents the 5% significance level. R version 3.6.1 was used to calculate the statistics.

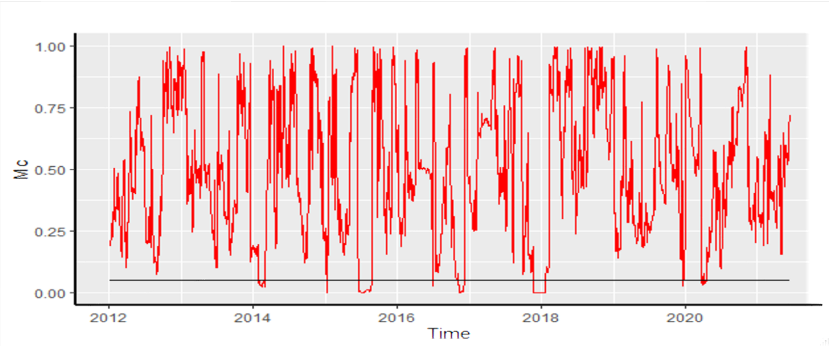

Figure 9. The *p*-values of the McLeod-Li test for the Euronext market. *Notes*: The red line indicates the *p*-values of the McLeod-Li test, and the black line represents the 5% significance level. R version 3.6.1 was used to calculate the statistics.

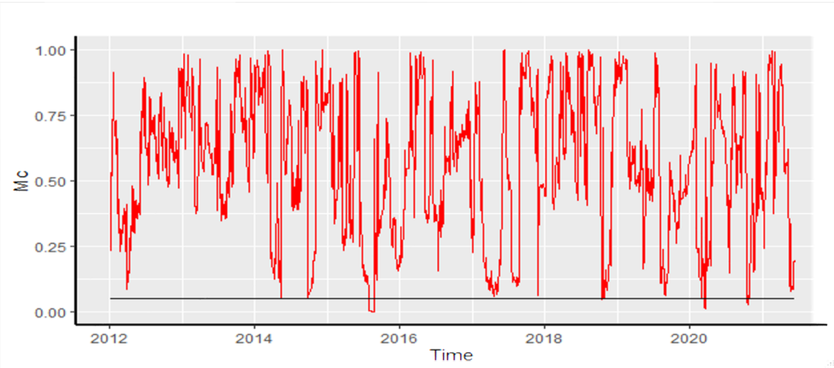

Figure 10. The *p*-values of the McLeod-Li test for the Chinese market. *Notes*: The red line indicates the *p*-values of the McLeod-Li test, and the black line represents the 5% significance level. R version 3.6.1 was used to calculate the statistics.

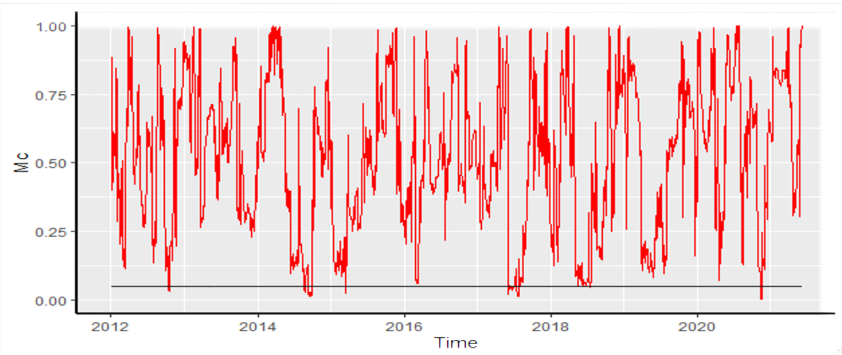

Figure 12. The *p*-values of the McLeod-Li test for the Brazilian market. *Notes*: The red line indicates the *p*-values of the McLeod-Li test, and the black line represents the 5% significance level. R version 3.6.1 was used to calculate the statistics.

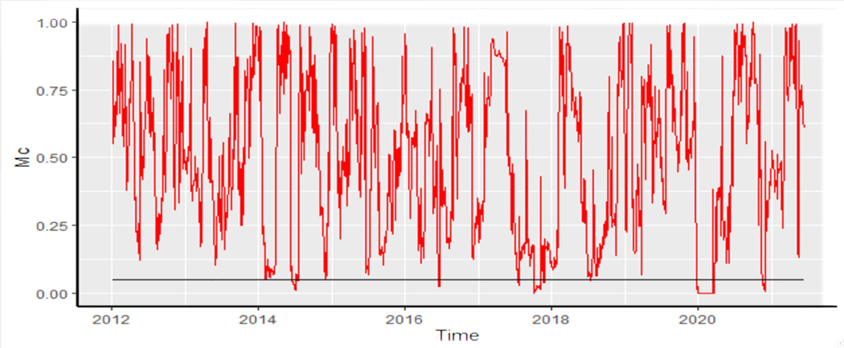

Figure 11. The *p*-values of the McLeod-Li test for the Turkish market. *Notes*: The red line indicates the *p*-values of the McLeod-Li test, and the black line represents the 5% significance level. R version 3.6.1 was used to calculate the statistics.

Moreover, our findings show that the level of market development does not have a significant impact on market efficiency, as both developed and emerging financial markets exhibit the same efficiency pattern. This implies that the degree of market efficiency is driven by the changing market conditions impacting the behavior of investors. Hence, the findings support the implications of the AHM and therefore both fundamental and technical analysis trading strategies might work from time to time with varying probabilities of success.

Now, to see the impact of market conditions on the degree of efficiency, we scrutinize the impact of the Covid 19 outbreak on market efficiency. It is obvious that large and sudden shocks, such as the global economic crisis, result in structural breaks in financial markets, which can then have potential asymmetric effects on market efficiency (Rapach & Strauss, 2008; Managi & Okimoto, 2013). Since the beginning of the COVID-19 pandemic, financial markets are experiencing massive disruption with a very aggressive reassessment and adjustment process across the world amid this pandemic (Aslam et al., 2020). For example, the Dow Jones Industrial Average fell 12.9% and the S&P 500 index lost almost 12% in a single day, on March 16, 2020, ,in its worst day since 1987; also, the Japanese financial market plunged more than 20% from its highest position in December 2019. The results of this study reveal that, overall, the market efficiency is time-varying before and during the Covid 19 pandemic. Specifically, we can observe that returns witnesses certain periods of nonlinear dependence and long periods of nonlinear independence and that the periods of dependence coincide with certain major events such as the Covid19 crisis. In fact, in the onset of the crisis, the market efficiency decreases in all the markets, although the degree of efficiency of the Brazilian market is more resilient than the others. The changes in the degree of market efficiency of the financial markets examined might be caused by investors' sentiment prevailing in the market during the crisis

regarding the underlying fundamentals of the economy such as the fear, uncertainty, loss aversion, pessimism, herding. Such behavior can cause significant autocorrelation, and therefore a decrease in market efficiency. These findings are in line with the results of Lim et al. (2008) who find that the 1997 financial crisis adversely affected the market efficiency in most Asian stock markets. The efficiency's trajectory becomes more chaotic during periods of major uncertainty, such as the pandemic. During this period, investors can construct investment strategies to exploit market inefficiencies.

However, the degree of market efficiency has improved amid the crisis. One can attribute this enhancement in the degree of market efficiency to the fact that crises cause the market correction, the evaporation of excess liquidity, reduction in overconfidence and optimism and the rational behavior among investors. In addition, the intervention of policymakers through certain actions can ensure the stability in the underlying macroeconomic fundamentals. Indeed, central banks and authorities responded immediately to market instability by launching their policy instruments into the market. For instance, on March 15, 2020, the Federal Reserve announced a zero percent interest rate policy and at least a $ 700 billion quantitative easing program. Eight days later, the Federal Reserve announced an unlimited quantitative easing policy.

Thereby, the AMH is validated in these markets and can better explain their behavior than the EMH.

Conclusion

This paper examined the extent to which the AMH framework can explain the behavior of major developed and emerging financial markets, especially under an extreme event like the Covid 19 outbreak. To this end, we employed the daily returns over the period from 2012 to 2021 as well as the linear and nonlinear tests with moving window. Our empirical results show that the market efficiency degree is time-varying. Furthermore, we reported that the onset of the period of Covid 19 outbreak coincides with a decrease in the degree of market efficiency in all the markets investigated except for the Brazilian financial market. However, amid the pandemic, the market efficiency has improved. This change in market efficiency may be driven by investors behavior on the one hand, and the intervention of the policymaker to address the market inefficiency on the other hand. Thus, our conclusions are in line with the AMH and its

implications according to which the degree of market efficiency is waxing and waning and depends on certain market conditions. As a result, the AMH framework provides a better explanation of the behavior of financial markets than the EMH.

The results of our research make it possible to extend the literature review on the AMH and therefore to unveil the ambiguity related to the behavior of market efficiency, especially during extreme events. The findings provided strong evidence in favor of this hypothesis as a framework that can clearly explain the market efficiency in developed and emerging markets. These results allow regulators to better understand the factors that influence efficiency in order to take necessary policies to improve market efficiency. As for investors, these results allow them to understand how market efficiency evolves and the underlying factors that influence price dynamics in order to feed them into their decision-making.

Further research can capitalize on this study to thoroughly investigate the psychological biases prevalent during the Covid 19 outbreak and the effectiveness of regulatory policies in response to market instability resulting from the investors behavior.

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