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### *The Changing Efficiency of the European Stock Markets*

**Keywords:** efficient markets hypothesis; evolving efficiency; stock markets

**JEL:** C12; G14; G15

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#### **Abstract**

The purpose of this article is to examine how the weak-form efficiency of the European stock markets has changed over the years. The study focuses its attention not on answering the question if the markets were efficient but on explaining how efficiency evolved. With a process based on the random walk model proposed by Louis Bachelier in 1900 still commonly applied in this research, market efficiency was examined using three different tests of the normality of the distribution for the returns of 20 selected European stock market indexes. The tests were performed for each year and for additional two-year sub-periods during the 20-year research period (1999–2018). Moreover, the tests were run for one-, two-, three- and four-day returns' intervals. The study allowed for a partial rejection of the research hypothesis, finding that on a long-term basis the efficiency of European stock markets tends to improve. Indeed, the results indicate that overall efficiency tended to improve but only since the end of the 2008 global financial crisis. From the very beginning of the research period until 2008, overall efficiency was shown to decrease.

## Introduction

Even though studies on weak-form market efficiency are conducted in many markets all over the world, their attention is mainly focused on answering the question of whether or not the markets are efficient. One of the reasons that studies on weak-form market efficiency are replicated so often is that the factors that affect market efficiency are constantly changing (Lim & Brooks, 2011). Nevertheless, few researchers have thus far attempted to examine exactly how market efficiency can change over time. Information on changes in market efficiency would be important for investors who would need to know whether their chances of forecasting prices correctly will increase, stay the same or decrease. Policymakers would also need to know if the implemented financial reforms and regulations will positively influence market efficiency, as its efficiency increases investors' confidence in the markets and protects the markets from external shocks (Mensi, Tiwari, & Al-Yahyaee, 2019).

The purpose of this article is to examine how the weak-form efficiency of European stock markets have changed over the years. The study focuses its attention not on answering the question whether the markets were efficient but on explaining how the efficiency has evolved over the years. Based on the random walk model proposed by Louis Bachelier in 1900, market efficiency was examined using three different tests of the normality of the distribution for the returns of 20 selected European stock market indexes. The Bachelier random walk model is still commonly applied by researchers, although it is considered to be a very rigid way of describing the dynamics of the financial asset price fluctuations (Czekaj, 2014). The tests were performed for each year and for additional two-year sub-periods during the 20-year research period (1999–2018). Moreover, the tests were run for one-, two-, three- and four-day returns' intervals. Our proposed research hypothesis states that the efficiency of the European stock markets tend to improve over the long term. In this paper, improving efficiency is understood as meaning an increasing percentage of efficient markets. A gradually implemented formalisation of the information transmission mechanisms by policymakers should have aided common and equal access to information, as well as improved the safety and transparency of trading (Dziawgo, 2011). As a result, the overall efficiency of financial markets should have increased.

This paper presents findings of the study at the level of the average results for all indexes examined as well as at the level of particular indexes. The aim of presenting data at the level of particular indexes is to verify whether the changes in their efficiency were similar to the average changes calculated for all indexes. It also allows us to check whether the average results can be perceived as being representative of the indexes as a whole.

## Literature review

The results of the study by Borges (2010), which were devoted to six selected European stock markets in the period from January 1993 to December 2007, indicated diverse conclusions on changes in market efficiency depending on the market examined and at what point during the research period they were examined. The study gave no grounds for stating unambiguously that efficiency improved over time. The research applied the runs test and the joint variance ratio tests, performed for daily and weekly data. Zalewska-Mitura and Hall (1999), in their research on the London Stock Exchange (LSE) and the Budapest Stock Exchange (BSE), proposed that in the case of the LSE, the tested series manifested no changes in weak-form efficiency over the entire investigative period. In the case of the BSE, the results suggested fluctuating levels of inefficiency. The researchers extended the classical test for autocorrelation of returns by combining a multi-factor model with time-varying coefficients and the generalised autoregressive conditional heteroskedasticity in mean (GARCH-M) errors. In the study on four shares listed at the Bulgarian stock exchange in the period from the first week of 1994 to the first week of 1996, Emerson, Hall and Zalewska-Mitura (1997) found varying levels of efficiency and different time of price discovery. Again, the researchers applied a multi-factor model with time-varying coefficients and GARCH errors.

Regarding studies of other markets, the results of the study by Arshad, Rizvi, Ghani and Duasa (2016) on 11 markets belonging to the Organization of the Islamic Conference indicated that overall efficiency varied across the countries over the short and long term, although the overall trend showed improvement over the years. The study covered the period of 1998–2012. In research pertaining to eight selected African stock markets, Smith and Dyakova (2014) applied three finite-sample variance ratio tests to examine the time series over the period beginning in February 1998 and ending in December 2011. The study assumed that there were successive periods of predictability and non-predictability, i.e. non-efficiency and efficiency. Results of the study by Abdmoulah (2010) on 11 Arab stock markets in a 10-year period ending in March 2009 using the GARCH-M(1,1) approach, indicated that no significant improvement of the market informational efficiency could be seen.

Jefferis and Smith's (2004) study of the informational efficiency of the Johannesburg Stock Exchange applied the variance ratio tests and tests of evolving efficiency using a GARCH approach with time-varying parameters. The results of the research did not indicate any trend towards efficiency over the sample period. Jefferis and Smith (2005) then extended the research sample in their next study to include seven selected African stock markets. Implementing the same research methods, the researchers found that the changes of the informational efficiency were diverse and country dependent. Results of a study of the Indian stock market by Samanta (2004) indicated a fluctuating informational efficiency from sub-period to sub-period. Using spectral shape tests, the study was carried out on the BSE-100 index over a period

of nine years from 1993 to 2001. The entire research period was partitioned into 18 sub-periods, with separate tests run in each sub-period.

### Research methodology

Taking into account Bachelier's random walk model, the level of the weak-form efficiency was estimated with the use of three different tests of the normality of the distribution, namely the Lilliefors test, the Shapiro–Wilk test and the D'Agostino–Pearson test. Bachelier's random walk model, considered by many researchers to be synonymous with weak-form efficiency, proposes that the returns are subject to a random walk model when they are normally distributed (Czekaj, 2014). The tests were performed for the logarithmic returns of selected main European stock market indexes, as shown in Table 1.

**Table 1.** Selected European stock market indexes included in the study

| No. | Index code | Stock exchange            | Country        |
|-----|------------|---------------------------|----------------|
| 1   | AEX        | Euronext Amsterdam        | Netherlands    |
| 2   | ATH        | ATHEX Composite Index     | Greece         |
| 3   | ATX        | Vienna Stock Exchange     | Austria        |
| 4   | BEL 20     | Euronext Brussels         | Belgium        |
| 5   | BUX        | Budapest Stock Exchange   | Hungary        |
| 6   | CAC 40     | Euronext Paris            | France         |
| 7   | DAX        | Frankfurt Stock Exchange  | Germany        |
| 8   | FTSE 250   | London Stock Exchange     | United Kingdom |
| 9   | FTSE MIB   | Borsa Italiana            | Italy          |
| 10  | IBEX 35    | Madrid Stock Exchange     | Spain          |
| 11  | MOEX       | Moscow Exchange           | Russia         |
| 12  | OMXC20     | Nasdaq Copenhagen         | Denmark        |
| 13  | OMXHPI     | Nasdaq Helsinki           | Finland        |
| 14  | OMXIPI     | Nasdaq Iceland            | Iceland        |
| 15  | OMXS30     | Nasdaq Stockholm          | Sweden         |
| 16  | PSI 20     | Euronext Lisbon           | Portugal       |
| 17  | PX         | Prague Stock Exchange     | Czech Republic |
| 18  | SAX        | Bratislava Stock Exchange | Slovakia       |
| 19  | SMI        | SIX Swiss Exchange        | Switzerland    |
| 20  | WIG        | Warsaw Stock Exchange     | Poland         |

Source: Author's own study.

The tests were run for each year and for addition two-year sub-periods over the 20-year research period (1999–2018). Moreover, the tests were conducted for one-, two-, three- and four-day returns' intervals. The reason for running tests for additional sub-periods and returns' intervals is the need to check whether the results will allow the drawing of the same conclusions. As is standard for normality tests, two hypotheses are proposed. The null hypothesis states that the empirical distribution is compatible with

the normal one, while the alternative hypothesis states that the empirical distribution is not compatible with the normal one. The null hypothesis is rejected in favour of the alternative hypothesis when the  $p$ -value is less than  $\alpha = 0.05$ , where the  $p$ -value constitutes a probability that the distribution is normal and the  $\alpha$  refers to  $s$  significance level (Borowski, 2017). Even though the tests that were applied aimed to verify the same thing – namely, whether the distribution is normal – the  $p$ -values returned may be different due to the different methodologies used by each test (Czekaj, 2014).

According to the proposed research hypothesis, which states that the efficiency of the European stock markets tends to improve over the long term, it is expected to observe increasing levels of efficiency when more returns are normally distributed. In addition, in the case of shorter sub-periods and longer intervals, higher levels of efficiency are expected to be observed. The reason for this is that it is harder to reject the null hypothesis in the normality test when the sample size is smaller.

### Empirical results

Tables 2 and 3 present the percentage of cases in which the returns were normally distributed (where there were no grounds to reject the null hypothesis in the normality test) presented for each test, each period and each returns' interval. Table 2 presents data for one-year sub-periods, while Table 3 presents data for two-year sub-periods. The tables mentioned above constituted a basis for the preparation of Figures 1 and 2 and show the average percentage of cases in which the returns were normally distributed during each sub-period. Each curve relates to a particular interval of returns. The average results for each year have been calculated by factoring in the scores for all 20 indexes examined in all three normality tests. Figure 1 presents the average results of tests conducted for each year separately, while Figure 2 presents the average results of tests run for the two-year sub-periods. Even though the data presented in Figure 1 seems to be more diverse than the data in Figure 2, both figures allow for similar conclusions to be drawn.

**Table 2.** The average percentage of cases in which the returns were normally distributed presented for each test, for each year and for each returns' interval

| Test<br>Period/<br>interval | Lilliefors |    |    |    | Shapiro–Wilk |    |    |    | D'Agostino–Pearson |    |    |    | All tests |    |    |    |
|-----------------------------|------------|----|----|----|--------------|----|----|----|--------------------|----|----|----|-----------|----|----|----|
|                             | 1          | 2  | 3  | 4  | 1            | 2  | 3  | 4  | 1                  | 2  | 3  | 4  | 1         | 2  | 3  | 4  |
| 1999                        | 70         | 85 | 95 | 95 | 30           | 65 | 85 | 85 | 30                 | 60 | 80 | 70 | 43        | 70 | 87 | 83 |
| 2000                        | 60         | 55 | 90 | 85 | 40           | 50 | 90 | 85 | 35                 | 60 | 80 | 85 | 45        | 55 | 87 | 85 |
| 2001                        | 50         | 60 | 75 | 80 | 15           | 40 | 40 | 50 | 25                 | 40 | 30 | 40 | 30        | 47 | 48 | 57 |
| 2002                        | 35         | 70 | 80 | 90 | 25           | 50 | 65 | 85 | 35                 | 60 | 75 | 75 | 32        | 60 | 73 | 83 |
| 2003                        | 25         | 70 | 60 | 70 | 10           | 45 | 50 | 60 | 25                 | 45 | 50 | 55 | 20        | 53 | 53 | 62 |
| 2004                        | 25         | 75 | 60 | 85 | 5            | 60 | 50 | 75 | 5                  | 50 | 50 | 75 | 12        | 62 | 53 | 78 |
| 2005                        | 50         | 55 | 30 | 55 | 20           | 40 | 20 | 40 | 5                  | 40 | 25 | 35 | 25        | 45 | 25 | 43 |

| Test  | Lilliefors |    |    |    | Shapiro–Wilk |    |    |    | D'Agostino–Pearson |    |    |    | All tests |    |    |    |
|-------|------------|----|----|----|--------------|----|----|----|--------------------|----|----|----|-----------|----|----|----|
| 2006  | 5          | 30 | 50 | 45 | 5            | 30 | 30 | 25 | 5                  | 25 | 40 | 10 | 5         | 28 | 40 | 27 |
| 2007  | 30         | 55 | 60 | 55 | 0            | 40 | 45 | 45 | 5                  | 30 | 35 | 60 | 12        | 42 | 47 | 53 |
| 2008  | 0          | 20 | 25 | 70 | 0            | 10 | 25 | 35 | 0                  | 15 | 20 | 30 | 0         | 15 | 23 | 45 |
| 2009  | 70         | 80 | 70 | 85 | 65           | 65 | 60 | 75 | 60                 | 60 | 65 | 75 | 65        | 68 | 65 | 78 |
| 2010  | 10         | 40 | 80 | 60 | 0            | 25 | 65 | 55 | 0                  | 30 | 60 | 50 | 3         | 32 | 68 | 55 |
| 2011  | 5          | 30 | 50 | 75 | 0            | 10 | 35 | 45 | 5                  | 25 | 50 | 45 | 3         | 22 | 45 | 55 |
| 2012  | 60         | 85 | 75 | 95 | 35           | 85 | 80 | 85 | 40                 | 80 | 75 | 85 | 45        | 83 | 77 | 88 |
| 2013  | 50         | 85 | 80 | 85 | 15           | 50 | 50 | 55 | 20                 | 50 | 55 | 50 | 28        | 62 | 62 | 63 |
| 2014  | 40         | 90 | 85 | 85 | 25           | 75 | 85 | 70 | 20                 | 75 | 80 | 70 | 28        | 80 | 83 | 75 |
| 2015  | 40         | 65 | 80 | 85 | 20           | 60 | 65 | 65 | 15                 | 45 | 70 | 65 | 25        | 57 | 72 | 72 |
| 2016  | 5          | 30 | 65 | 75 | 5            | 15 | 45 | 75 | 0                  | 25 | 30 | 60 | 3         | 23 | 47 | 70 |
| 2017  | 55         | 70 | 80 | 95 | 30           | 40 | 65 | 95 | 20                 | 40 | 60 | 85 | 35        | 50 | 68 | 92 |
| 2018  | 60         | 65 | 75 | 80 | 45           | 50 | 60 | 60 | 40                 | 50 | 55 | 80 | 48        | 55 | 63 | 73 |
| Total | 37         | 61 | 68 | 78 | 20           | 45 | 56 | 63 | 20                 | 45 | 54 | 60 | 25        | 50 | 59 | 67 |

Source: Author's own study.

**Table 3.** The average percentage of cases in which the returns were normally distributed presented for each test, each two-year sub-period and each returns' interval

| Test                | Lilliefors |    |    |    | Shapiro–Wilk |    |    |    | D'Agostino–Pearson |    |    |    | All tests |    |    |    |
|---------------------|------------|----|----|----|--------------|----|----|----|--------------------|----|----|----|-----------|----|----|----|
| Period/<br>interval | 1          | 2  | 3  | 4  | 1            | 2  | 3  | 4  | 1                  | 2  | 3  | 4  | 1         | 2  | 3  | 4  |
| 1999–2000           | 45         | 55 | 75 | 80 | 15           | 35 | 65 | 75 | 10                 | 40 | 60 | 70 | 23        | 43 | 67 | 75 |
| 2001–2002           | 15         | 35 | 60 | 65 | 5            | 35 | 30 | 45 | 5                  | 35 | 20 | 35 | 8         | 35 | 37 | 48 |
| 2003–2004           | 10         | 35 | 35 | 50 | 5            | 20 | 20 | 35 | 5                  | 10 | 20 | 45 | 7         | 22 | 25 | 43 |
| 2005–2006           | 5          | 20 | 15 | 15 | 0            | 15 | 15 | 5  | 0                  | 15 | 5  | 0  | 2         | 17 | 12 | 7  |
| 2007–2008           | 0          | 5  | 10 | 20 | 0            | 0  | 0  | 5  | 0                  | 0  | 0  | 5  | 0         | 2  | 3  | 10 |
| 2009–2010           | 0          | 20 | 60 | 70 | 0            | 15 | 35 | 70 | 0                  | 15 | 35 | 55 | 0         | 17 | 43 | 65 |
| 2011–2012           | 5          | 5  | 30 | 75 | 0            | 10 | 10 | 40 | 0                  | 10 | 15 | 30 | 2         | 8  | 18 | 48 |
| 2013–2014           | 25         | 55 | 50 | 80 | 0            | 25 | 25 | 45 | 0                  | 15 | 25 | 35 | 8         | 32 | 33 | 53 |
| 2015–2016           | 5          | 25 | 55 | 55 | 0            | 10 | 40 | 40 | 0                  | 0  | 25 | 35 | 2         | 12 | 40 | 43 |
| 2017–2018           | 20         | 35 | 50 | 70 | 5            | 20 | 45 | 45 | 5                  | 20 | 50 | 60 | 10        | 25 | 48 | 58 |
| Total               | 13         | 29 | 44 | 58 | 3            | 19 | 29 | 41 | 3                  | 16 | 26 | 37 | 6         | 21 | 33 | 45 |

Source: Author's own study.

The efficiency of the markets tended to drop on a long-term basis from the very beginning of the research period until 2006–2008 depending on the returns' interval. Then, starting from the same years, efficiency tended to increase in the long term but not as significantly. Particularly in the case of shorter intervals. Fluctuations in efficiency appear to be more significant in the case of longer returns' intervals.



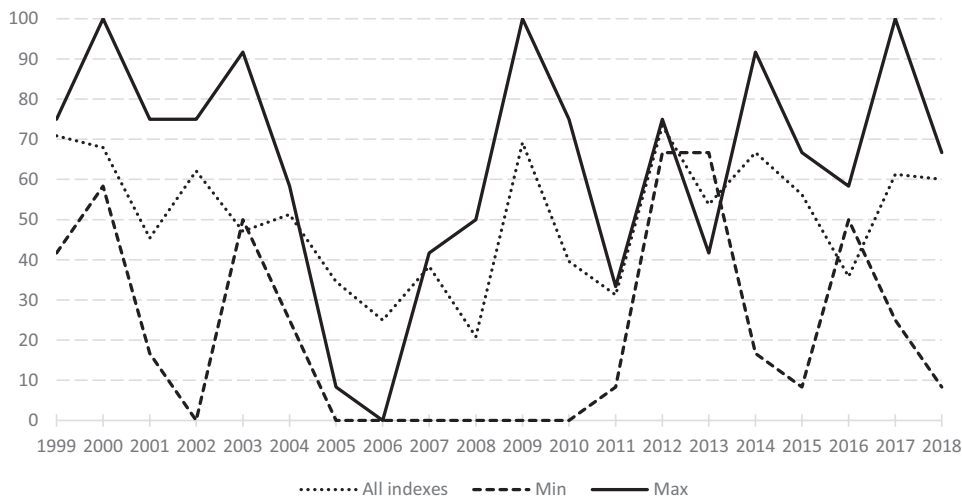
**Figure 1.** The average percentage of cases in which the returns were normally distributed, taking into account all tests performed and all indexes, presented for each year and for each returns' interval

Source: Author's own study.



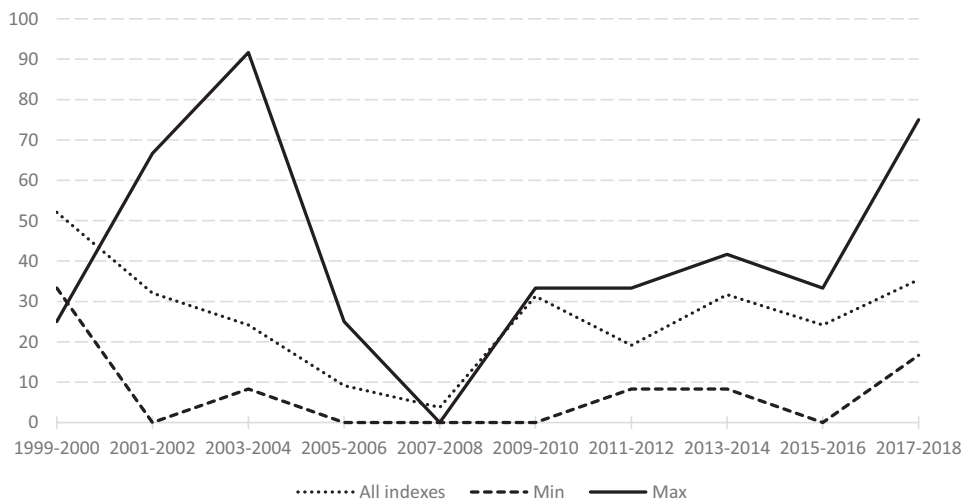
**Figure 2.** The average percentage of cases in which the returns were normally distributed, taking into account all tests performed and all indexes presented for each two-year sub-period and each returns' interval

Source: Author's own study.



**Figure 3.** The average percentage of cases in which the returns were normally distributed for all indexes, and for the indexes with the lowest and the highest rate of the returns normally distributed throughout the whole research period, taking into account all tests performed and all the returns' intervals presented for each year

Source: Author's own study.



**Figure 4.** The average percentage of cases in which the returns were normally distributed for all indexes and for the indexes with the lowest and the highest rate of the returns normally distributed throughout the whole research period, taking into account all tests performed and all the returns' intervals presented for two-year sub-periods

Source: Author's own study.



Figures 3 and 4 present the average percentage of cases in which the returns were normally distributed for all indexes and for the indexes which reached the lowest and the highest results throughout the whole research period. The average values have been calculated by factoring in all the tests performed and all the returns' intervals. Figure 3 presents the results for each year, while Figure 4 presents the results for the two-year sub-periods. In both Figures 3 and 4, the minimum average results were recorded by the SMI index from the SIX Swiss Exchange. In the case of Figure 3, the maximum average results were recorded the OMXS30 index from the Nasdaq Stockholm. However, in the case of Figure 4, the maximum average results were recorded by the BUX index from the BSE.

The shaping of the efficiency over the years, in the case of the data pertaining to selected indexes and presented in Figures 3 and 4 seems to show similar changes in efficiency as those observed in Figures 1 and 2. Even though some curves presented in Figures 3 and 4 do not have upward and downward trends that are as visible as the curves in Figures 1 and 2, they all show a significant decrease in efficiency, particularly in the period of 2006–2008.

This observation confirms the conclusions of the studies by Anagnostidis, Varsakelis and Emmanouilides (2016), Sensoy and Tabak (2015) and Horta, Lagoa, and Martins (2014), who all proposed that the 2008 global financial crisis had a negative impact on the efficiency of the European stock markets. Nevertheless, there is an argument to be made against this hypothesis. In particular, as Figures 1 and 2 show, the efficiency levels recovered rapidly in 2009, i.e., in the year immediately following the crisis, reaching one of the highest levels throughout the whole research period. A downward trend of the efficiency lasting from the beginning of the research period to 2006–2008 could have been caused by the dotcom bubble and its consequences, as well as by the inflation of the next bubble, which started to burst in 2006. The ongoing upward trend in efficiency since 2006–2008 may be a consequence of the results of some of the policies that were aimed at restoring investor confidence in the markets and protecting the markets from further external shocks.

## Conclusions

The results of this study allow for a partial rejection of the research hypothesis, which stated that the efficiency of the European stock markets tended to improve over the long term. The study indicates that efficiency did improve overall, but only since 2008. Before this time, from the very beginning of the research period, efficiency was showing a long-term decrease. Even if some curves in the figures presented did not indicate any clearly visible upward or downward trend, a common feature for all of them was a significant drop in efficiency, particularly between 2006 and 2008. This finding is in line with the findings of earlier studies on the effect of the 2008 global financial crisis on the efficiency of the European stock markets.

As opposed to many other studies on the efficiency of the financial markets, this study focused its attention on the changes in efficiency over the years, rather than attempting to determine whether the markets were efficient or not. The study shows that the regulations implemented by policymakers after the 2008 global financial crisis positively affected the efficiency of the European stock markets. It is also worth noting that the reaction of the policymakers in response to the 2008 global financial crisis may have been even stronger than the reaction after the dotcom bubble, since efficiency continued to decrease after the dotcom bubble burst. The results of this study also indicate that forecasting possibilities are decreasing, what seems to be bad information for the investors applying technical analysis tools in their decision-making process.

In the literature pertaining to the issue of the efficiency of the financial markets, it is easy to find many other approaches to measuring efficiency and defining the research windows. However, there are very few studies that examine changes in market efficiencies. The reason for this is that these studies are often very time-consuming. An additional problem is that whether or not a market is efficient over a given period of time is irrelevant to investors and the policymakers. Hence, it is recommended to focus attention in the issue-related studies on the changes in efficiency, and to apply other research methods such as rolling-window approaches or comparisons of the empirical distributions with theoretical ones that match the financial time series better than the normal distribution.

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