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The Investigation of TSE Efficiency: An Emerging Market involved in pandemic, and Economic Sanctions

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ABSTRACT

This study examines the efficiency of Iranian capital market after the imposition of economic sanctions, currency crisis and Covid 19 pandemic. Some events after 2008 have fundamentally changed the Iranian capital market environment and we expect these reforms to change the level of market efficiency. This research investigates the daily returns behavior in Tehran Stock Exchange (TSE) utilizing autocorrelation, augmented Dickey-Fuller, and runs tests over the period 2008-2022. The statistical significance of the data was assessed using both parametric and nonparametric test statistics. The results confirm that the Tehran Stock Exchange index has been affected by the Covid-19 pandemic crisis. It was also further revealed that economic and banking sanctions have had a direct impact on the Iranian economy and the Tehran Stock Exchange market, such that after the approval of each of the sanctions, significant structural failures were observed in the trend of the Tehran Stock Exchange index. And also the results indicate that all tests don't support that TSE daily returns follow random walk. Therefore, we conclude that in the Iranian capital market, abnormal returns can still be obtained by using technical and fundamental analysis. The study's contribution might have been compromised by the absence of socio-demographic, technical, financial and other significant policy factors from the analysis. This paper is the first to examine the efficiency of the capital market at a weak form, during the period of the Covid-19 pandemic and the imposition of international sanctions against the Iranian economy.

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1. Introduction

An efficient stock market is critical to economic development. While a market is efficient, financial resources are allocated economically. Efficient stock markets encourage people to invest in stocks and help corporate executives maximize shareholder wealth. On the other hand, capital market inefficiency is one of the factors contributing to the unfavorable business environment. Unsuitable business environment increases the cost of economic enterprises and discourages investment, causing domestic producers to fall behind their foreign competitors (Miraskari & Rezaei Pitenoei, 2024)."Market efficiency" as stated in Fama (1970)'s main work is referred to as the financial efficiency of financial markets, which emphasizes the role of information in determining prices. The efficient market hypothesis is one of the topics that has been extensively researched in the last few decades. In addition, it continues as an issue that has both pros and cons. Market efficiency is affected by the ability of traders to collect and disseminate information. More investors are attracted by more efficient stock markets, which in turn increases market liquidity. Market efficiency is important for investors, because their wealth depends on changes in stock prices. In general, stock market inefficiencies may affect consumption and investment expenditures and thus the performance of the economy (Edelgan, 2003).It is assumed that prices essentially follow a "random walk", which allows them to take advantage of a rational price distribution behavior. This theoretical support justifies the financial industry for calculating various asset prices using special mathematical and statistical tools (Malkiel, 2003). In this context, empirical evidence such as bubbles and crises, which often appear to fit the model, are considered accidental or examined in a different time perspective (Maloumian, 2022).

The efficient market hypothesis (EMH) shows that price changes in the stock market follow a random walking model. Random walks mean that price changes are independent and that the stock price on each day in the market immediately reflects the information announced on the same day.

Because news is unpredictable by the market, stock prices reflect unpredictable random news (Malkiel, 2003). The efficient market hypothesis (EMH) is a well-defined theoretical body that has been discussed in numerous studies since its first introduction by Eugene Fama in 1970 (Titan, 2015). According to the efficient market hypothesis, current prices reflect existing information about companies' future profitability. When new information is announced to the market, stock prices are quickly adjusted with the information. For this reason, market investors can't use the available information to make abnormal gains (Pearce, 1987). The efficiency of stock markets implies that there is a positive elationship between expected returns on stocks and their systematic risk (Beneda, 2005). Fama (1970) in his main work classifies EMH as weak, semi-strong and strong form. Following his work, many studies examined the randomness of stock price changes to demonstrate capital market performance. In this paper, we concentrate on the weak-form category, which asserts that security prices fully reflect all information contained in the past price history of the market. The Iranian Capital Market expected to be efficient to attract individuals for investing their funds in viable investment opportunities that causes economic development (Saeedi & et al, 2014). This encouraged research in this area to identify the level of efficiency and the problems preventing the development of the market for effective regulations. The aim of this study is to evaluate daily return behavior in Tehran Stock Exchange (TSE) focusing on the weak-form version of EMH. The literature indicates that weak-form version of market efficiency will be accepted if stock market daily returns follow random walk. In other words, whenever, the daily returns are following the random walk theory then, the weak-form version of efficient market is accepted (Namazi and Shoushtarian, 1996). This study employs the most popular tests; Autocorrelation, Runs, and Augmented Dickey-Fuller tests to examine the TSE weak-form efficiency. Maloumian (2022) believes that EMH is a model for which there is truth and in which a valid measurement of this truth is possible. This theoretical model supports uncertainty as a fundamental horizonand and it has established this horizon on definitions of extremely imprecise contours including that information, price and value are not independent concepts.However, a number of studies (for examples: Nasrollahi, 1992; Fadaeenejad, 1994; Namazi and Shoushtarian, 1996; Allahyari, 2009; Saeedi & et al, 2014) have researched the efficiency of Iranian stock market but those study the market for the periods before 2010. Some events, after aforementioned date, have fundamentally changed the environment of the Iranian capital market. Those events that have taken place in recent years that have affected the Iranian economy are economic sanctions, the Covid 19 pandemic and exchange rate fluctuations. The Covid 19 pandemic, which has had significant economic effects around the world, also affected Iran's economy and capital market. First discovery of local COVID 19 cases had a substantial impact on all 12 Asian markets on the event day, as shown by statistically significant negative average abnormal return (AAR) and cumulative average abnormal return (CAAR) (Adnan, 2022). Demand, supply and financial shocks are the primary drivers of the socioeconomic and political repercussions of the global spread of the COVID 19 virus. Because of the governments' lockdown, shutdown and quarantine efforts to prevent the epidemic, demand-side shocks have led to a loss in people's capacity to acquire products and services (Mishra and Mishra, 2021). The stoppage of manufacturing sites, international supply chain interruption and prohibitions on internal and overseas labor movements have all contributed to the decrease in nations' economic productivity and growth (Gereffi, 2020; Caggiano *et al.*, 2020). Tehran Stock Exchange (TSE) from the beginning of the pandemic (January 2020) to August 2020 spent one of its best and most dreamy days, so that the Tehran Stock Exchange index in August reached 2 million units and during the year In 2020, due to the extraordinary growth of the Tehran Stock Exchange, a large number of new stock codes were issued, and due to the attractiveness of this market, novice investors and many people entered this market with small and large capital.

Another important issue that has cast its shadow over Iran's economy in recent years is economic policy. From the perspective of political economy in the Islamic Republic of Iran, important changes have taken place in different areas, different from the nature and content of the Islamic Revolution. These changes have taken place over fourteen periods, from modernization to fundamentalism and traditionalism, in the field of culture and ideology from industrial capitalism and petty bourgeois orientation, and in the political field from liberal democracy and political pluralism to a kind of mass democracy, theocracy, and populism (movasaghi, 2006). After the revolution, due to the lack of compromise and peaceful coexistence with the superpowers of the East and the West, Iran has always faced numerous unilateral or multilateral economic and noneconomic sanctions of the Western countries (Miraali & et al, 2022). Sanctions are one of the factors that hinder the attraction of foreign direct investment introduces economic sanctions as manipulation of economic relations in order to achieve political goals (Peksen & Drury, 2009). In other words, sanctions are economic sanctions that are imposed by one country (or a group of countries) against another country to meet the political goals of the sanctioning countries. In recent decades, economic sanctions have been referred to as a superior policy or an alternative to military means (war) at a lower cost. That is why countries use economic sanctions to get their political goals, such as regime change (shokri & et al, 2022).

Another important issue that has cast its shadow over Iran's economy in recent years is economic sanctions. While UN sanctions have been in place since 2006, mainly targeting Iran's nuclear program, the new sanctions imposed on Iran in 2012 were aimed at bringing the Iranian economy closer to complete financial and trade self-destruction. These sanctions are the most comprehensive international sanctions regime ever imposed on a country. As an unprecedented step, the European Union froze the assets of the Central Bank of Iran and barred the Iranian financial sector from accessing SWIFT’s messaging service, In March 2012. In other words, it cut off Iran's access to a secure international payment system. This was in addition to the oil embargo imposed in 2012 (Kelishomi & Nistico, 2022).

The results of research from other markets show that economic sanctions, the Covid 19 pandemic, and market reforms have a variety of effects on the capital market efficiency (for example: Majnoni and Massa, 2001; Singh, 2010; Saeedi & et al, 2014; Hatmanu & Cautisanu, 2021; Kelishomi & Nistico, 2022; Adnan, 2022). The objective of this study is to examine the Iranian capital market efficiency after the changes in the market, because we expect them to affect stock market efficiency. We use the daily returns for the period of 2008-2022 to test the research hypothesis: The TSE daily return follows random walk. The research data are extracted from TSE website (www.TSE.ir). The results don't show that TSE daily returns follow random walk.

The rest of the paper is organized as follows. The next section examines the capital market efficiency literature, the specific features of the Iranian economy, as well as a review of some empirical evidence. Section 3 outlines the research methodology while Section 4 presents the empirical results. Section 5 provides the summary and conclusions.

2. Literature review

The efficient-market hypothesis (EMH) is one of the most important economic and financial hypotheses that have been tested over the past century (woo & et al, 2020). The main function of the capital market is the optimal allocation of financial resources. A market is efficient when financial resources are allocated economically and optimally. Efficient stock markets encourage people to invest in stocks and help corporate executives maximize shareholder wealth (Saeedi & et al, 2014). There might be two kinds of traders: "Informed" and " Uninformed". Informed traders have access to valuable information about the intrinsic value of each share. They sell (buy) over-priced (under-priced) stocks, make a profit, and quickly return the price to its fundamental value. Uninformed traders don't invest their resources in gathering information, but they know that current prices reflect the information from informed traders. Fama (1970) defines three types of efficiency, namely weak-form efficiency, semi-strong-form efficiency and strong-form efficiency. In a weak-form efficient market, no investor is able to earn excess returns based on historical price or return information. According to Fama (1991), weak-form version of market efficiency implies the predictability of future returns using past returns. If prices follow random trends, stock price changes are independent, otherwise they are dependent. Semi-strong-form version of efficiency infers that no investor is able to earn excess returns based on any publicly available information. Strong-form efficiency implies that no investor is able to earn excess returns using any type of information, whether publicly available or not (Adelegan, 2003). Despite the fact that a series of studies with negative effects have been used on both the auxiliary and primary hypotheses, it has so far been somewhat "effective" in attracting claimants' opinions against EMH. But so far none of the reciprocal hypotheses has been able to explain the current state of stock markets like the efficient market hypothesis (Lakatos, 1970; Maloumian, 2022).

Following Fama (1970) many capital markets researchers investigated the random walk behavior of stock price changes. The aim of those researches was the demonstration of capital markets efficiency (Saeedi & et al, 2014). Then, other researchers studied market inefficiencies by identifying systematic and persistent changes in stock market returns (Jarrett, 2008). There has been a great deal of research on weak form tests in the United States, and early trials have strongly supported this hypothesis. Many early literatures use serial correlation (autocorrelation) to examine the linear dependence of changes or delayed price returns. Also, some researchers use Runs tests to determine the duration of up and down changes (Singh, 2010). Alam et al. (1999) test the random walk hypothesis for five Asian stock markets. Their results show that all the stock return indices except the Sri Lankan index follow a random walk. In their study, Magnusson and Wydick

(2000), examine the weak-form efficiency of eight African countries and their findings shows that African stock markets are more supportive than other emerging stock markets, and Despite all the existing anomalies, the efficiency was confirmed at a weak-form. Emenike & Joseph (2018) evaluates the Ugandan Securities Exchange (USE) for evidence of a weak-form efficient market hypothesis in the context of random walk model, using both linear and non-linear models. Estimates from the linear models show evidence of weak-form efficiency. Conversely, estimates from non-linear models show evidence against weak-form efficiency of the USE. The study concludes that USE returns may only be predicted using non-linear models and fundamental analysis. In other words, linear models and technical analyses may be clueless for predicting future returns. Squalli (2006) tests the weak-form efficiency of two exchanges in the United Arab Emirates, the Dubai Financial Market (DFM) and the Abu Dhabi Securities Market (ADSM). The results of variance ratio tests show that all sectors in the UAE financial markets except banking sector of the DFM are inefficient. The stock returns in the two financial markets are negatively serially correlated, which indicates the inefficiency of the markets. Jarrett and Kyper (2006) examined the existence of time series features of the daily stock prices of 62 companies listed on the NYSE and NASDAQ. The results of the research indicate that the stock price does not follow a random walk.

The empirical findings demonstrate that the initial local detection announcement of the COVID 19 pandemic has a mixed influence on the major Asian stock market indices. While, major indices in China, Hong Kong, Japan, India, Singapore and South Korea showed an insignificant reaction, the market indices of Vietnam, Indonesia, Malaysia, Bangladesh, Sri Lanka and Pakistan showed a significant negative reaction to the detection announcement. Furthermore, there is little evidence that Asian stock market indices vary significantly from the FTSE All-World Index. The findings suggest that a significant spike in market return volatility occurred during the fast spread of the coronavirus, which was predominantly prompted by weakened investor attitudes as a result of announcement effects (Papakyriakou et al., 2019; Mishra and Mishra, 2021). Content analysis was used by Baker *et al.* (2020) to assess the effects of daily confirmed COVID 19 cases and fatalities on the variability of Dow Jones index returns. According to the study, other viral infections like Spanish flu and Ebola have a much less impact on stock market swings than COVID 19. Infectious outbreaks in the past have had a minor impact on the stock market in the USA. In comparison to past pandemics, the analysis finds that public limits on economic activities and voluntary social distancing are the most likely drivers of the US financial markets' unprecedented dramatic response to the COVID 19 epidemic. Yilmazkuday (2022) adds to the findings of Baker *et al.* (2020) by demonstrating that a 1% increase in median daily COVID 19 infections in the USA appears to contribute approximately 0:01% of the average fall in the S&P 500 indices on the first day and after one month, the reduction was around 0:03%.

In the future, US sanctions against Iran are divided into three general categories: sanctions imposed before 2006, sanctions from 2006 to 2015, and new sanctions imposed since 2018 with the return of previous sanctions. Sanctions were not fully implemented until 2006 due to the non-alignment of third countries with the US government's foreign policy. In 2015, with the approval of JCPOA[1], other Security Council resolutions regarding Iran's nuclear activities were canceled. However, in 2018, after the United States withdrew from the JCPOA, newer unilateral sanctions were imposed by the US government along with the previous unilateral sanctions against Iran (Piri & Sohrabi 2020). Among these sanctions, the sanctions imposed in 2006 and after are among the most severe sanctions that have been imposed against Iran so far. In general, in the theory of sanctions, from 2005 onwards, economic sanctions has led to internal inefficiency and then weak economic growth and development. Also, one of the most important factors on which the effects of the wave of sanctions have slowed down the speed of

1. Joint Comprehensive Plan of Action

economic growth and development in the country is the issue of foreign direct investment, and unfortunately the adverse effects of sanctions have prevented Iran from achieving this important factor of economic growth. Despite the positive effects of foreign direct investment, the facts show that Iran's economy has performed poorly in terms of attracting foreign direct investment compared to the world and the region in the second half of the century due to the economic sanctions imposed by the West, especially the United States (miraali & et al, 2022).

Among all the sanctions that were aimed at hitting Iran's economy, the bank sanctions affected the country's economy more than other sanctions. One of the influences of these sanctions on the Iranian economic system is the decrease in the currency value, as it is estimated that since 2011, the exchange rate of the rial in the market has fallen by 80% and has reached a figure of about 35 thousand rials against one dollar. This sanction strongly affected the prosperity of investment because a main pillar of foreign investment is the existence of advanced and international banks that can provide all financial facilities to investors at any moment and in any part of Iran to other countries, connect points in the world and make profit and capital transfers possible. Economic embargo through bank embargo increases country risk and imposed costs. In addition, applying successive sanctions in different fields deprives the country's economy of security and peace and provides the basis for the outflow of capital from the country. By sanctioning banks through increasing the cost of transactions, interrupting the SWIFT system and disrupting foreign exchange operations, it affects foreign direct investment. In their research, Miraali & et al (2022) concluded that the sanctions leads to almost 12 billion $ reduction in the FDI compared to the nosanctions situation. Following the escalation of sanctions under the Trump administration and the withdrawal of the US from the JCPOA, the adverse effects of declining FDI peaked at 20 billion $ in 2020.The placebo tests also show that the there are statistical significance in findings

The unit root test is another type of statistical test utilized for examining the weak-form efficiency. In the test, if the data are non-stationary the random walk hypothesis is supported and otherwise that is evidence of mean reversion (Saeedi & et al, 2014). The results of previous studies on the random walk hypothesis using various approaches of unit root test are mixed. Cooray and Wickremasinghe (2005) investigate the weak-form stock market efficiency in the stock markets of India, Sri Lanka, Pakistan and Bangladesh. They find that for all of the countries the classical unit root tests support weak-form efficiency. Narayan and Smyth (2005) used the ADF unit root test to stock market indices from 22 OECD countries. Overall, the results of their study supports strongly random walk hypothesis and they could only reject the random walk hypothesis for New Zealand. Later, Narayan and Smyth (2006) extends their previous study by applying multiple trend break unit root tests to investigate the random walk hypothesis for 15 European stock markets and provide strong support for the random walk hypothesis. Narayan and Smyth (2004) as well applied the conventional ADF unit root test with one and two structural breaks to the stock price index of South Korea. The results indicate that stock prices in South Korea are consistent with the efficient market hypothesis. Jarrett and Kyper (2005a) examine the efficient market hypothesis utilizing index numbers of daily stock market prices in US. They find that the ADF test shows a unit root for many time series of closing prices. Emenike & Joseph (2018) evaluates the nature of random walk weak-from efficiency of the Ugandan Securities Exchange for the period ranging from 01 September 2011 to 31 December 2016, using the autocorrelation test, Ljung-Box Q test, unit roots tests, and ARCHLM test. The preliminary analyses show that the USE return is zero, indicating that positive and negative returns cancel each other. It also shows negative skewness and leptokurtosis in the return series. Results of the linear models estimated using ACF and Ljung-Box Q statistics suggest evidence of random walk (3) weak form efficiency for USE. Chaudhuri and Wu (2003) studied 17 emerging markets and their results show that the ADF unit root test rejects the random walk hypothesis for 10 out of 17 emerging markets. Lu and Ito (2010) use unit root test to examine the efficiency of Chinese stock markets. They provide some evidence that do not reject the random walk hypothesis.

Lo and MacKinley (1988) employing variance-ratio statistical tests, reject the random walk hypothesis for daily and weekly returns, but for monthly returns they couldn’t find evidence against the random walk hypothesis. They contrary to Fama and French (1987) that found negative serial correlation for longer horizon returns, find significant positive serial correlation for weekly and monthly holding-period returns. Runs tests were also conducted in the literature, which determine the duration of upward and downward changes. Karemera et al. (1999) investigate the random walk properties of equity returns in 15 emerging capital markets. The results of runs test indicate that most of the examined markets are weak-form efficient. Butler and Malaikah (1992) examine the Saudi and Kuwaiti markets using serial correlation and runs tests. They find that the markets are not efficient in the weak-form. Urrutia (1995) tests the random walk hypothesis for Latin American Emerging Equity Markets and finds that runs tests show they are efficient in weak-form. Fuss (2005) examines the random walk hypothesis for seven Asian emerging markets. He provides evidence that show stock indices become efficient after market liberalization. Squalli (2006) using runs test, investigates the weak-form efficiency of two exchanges in the United Arab Emirates, the Dubai Financial Market (DFM) and the Abu Dhabi Securities Market (ADSM). The study provides evidence of weak-form efficiency only in the insurance sector of the ADSM. Kompa and Matuszewska-Janica (2009) examine the weak-form efficiency in Warsaw Stock Exchange (WSE) using runs test and provide evidence that shows the WSE is efficient in weak-form.

The published literature on weak-form efficiency in Iran is relatively limited. Nasrollahi (1992) examines the weak-form of efficiency in Tehran Stock Exchange (TSE) for the period 1989-1991. She using runs test provides evidence that indicates the TSE is not efficient in weak-form.

Fadaeenejad (1994) using autocorrelation and runs tests, investigates the market for the period 1989-1993. He finds that the TSE is not efficient in weak-form. Namazi and Shoushtarian (1996) study the TSE using the daily and weekly prices for the period 1988-1994. The study does not provide evidence of weak-form efficiency. Allahyari (2009) using autocorrelation and runs tests, examines the weak-form efficiency of TSE for the period 1999-2005. His results don't support weak-form efficiency. Saeedi & et al (2014) similarly evaluated the weak-form of efficiency in Tehran Stock Exchange (TSE) and the results shows that TSE daily returns do not follow a random walk. The previous studies all show that the TSE is not efficient in week-form. This study focuses on the weak-form of the efficient market theory and tries to examine the market efficiency after reforms and fundamental events (Like the Covid 19 pandemic and the sanctions imposed on Iran) in the market after 2008. A noteworthy point in this article is that the destructive effects of financial and economic sanctions that have been imposed on the Iranian market in recent years, and which have also affected the Tehran Stock Exchange market, are to be measured for the first time in this article, and the level of efficiency of the Tehran Stock Exchange market is measured by taking into account the above effects.

3. Research Methodology

We have implemented autocorrelation, augmented Dickey-Fuller, and runs tests to examine the market efficiency over the period 2008-2022, the period when events such as the Covid 19 pandemic and the sanctions imposed on Iran were very influential.

3.1 Serial Correlation

Serial correlation is one of the statistical tools used for measuring the dependence of a variable on the past values of itself. In the other words, this test measures the relationship between the stock return at current period and its value in the previous period, which is defined as follows:

$$\rho_k = \frac{\sum_{t=1-k}^{n}(r_t - \bar{r})(r_{t-k} - \bar{r})}{\sum_{t=1}^{n}(r_t - \bar{r})^2} \tag{1}$$

Where ρ_k is the serial correlation coefficient of daily returns of lag *k*; *N* is the number of observations; r_t is the stock return over period *t*; r_{t-k} is the stock return over period *t-k*; $\bar{r}$ is the mean of stock returns; and *k* is the lag of the period (Saeedi & et al, 2014). This test is frequently performed for the purpose of testing the joint hypothesis that all the ρ_k up to certain lags are simultaneously equal to zero, instead of testing the statistical significance of any individual autocorrelation coefficient (Gujarati, 2004). Statistically, the hypothesis of weak-form efficiency should be rejected if stock returns (price changes) are serially correlated (ρ_k is significantly different from zero). Positive or negative results indicate that there might be potential profitable trading strategies. A zero correlation is consistent with the random walk hypothesis. This research performs this by using the Q statistic developed by Box and Pierce (1970), which is as follows:

$$Q_{BP} = n\sum_{k=1}^{m}\hat{\rho}_k^2 \tag{2}$$

Where *n* is sample size and *m* is lag length. In large samples, it has a chi-square distribution with *m* d.f. (Al-Jafari, 2011). As well, this study for testing the joint hypothesis that all correlations are simultaneously equal to zero, uses the Ljung-Box Statistic Q-statistic(1978) as a variant of Box-Pierce Q statistic (Q), which is as follows:

$$Q_{LB} = (n(n+2)\sum_{j=1}^{h}\frac{\rho^2(j)}{n-j} \tag{3}$$

Where *n* is the sample size, $\rho(j)$ is the autocorrelation at lag *j*, and *h* is the number of lags being tested. Under the null hypothesis of zero autocorrelation at the first *k* autocorrelations ($\rho_1 = \rho_2 = \rho_3 = \cdots = \rho_k$) the Q-statistic is distributed as a chi-squared with degrees of freedom equal to the number of autocorrelation (*k*). If Q-statistic is significantly different from 0, this indicates that the series is serially correlated. Such a result would allow rejecting the null hypothesis that returns are independent (Guidi et al., 2010).

3.2 Augmented Dickey–Fuller

We use the augmented Dickey-Fuller (ADF) because it is still the most common procedure for testing the unit root. This unit root test provides evidence on whether the prices in stock market follow a random walk. Hence, it can be used as a test for the weak-form market efficiency. If the stock market is inefficient in the weak form, then it is implied that market prices do not follow a random walk. Random walk requires that the time series must contain a unit root. Therefore, we test daily returns for the presence of a unit root in them (Al-Jafari, 2011). The original version of the Dickey-Fuller test assumes that there is no correlation between error terms. If this assumption is incorrect then the limiting distributions and critical values obtained by Dickey and Fuller cannot be assumed to hold. When serial correlation is present the ADF version of the test proposes to include in the regression several lags of the difference of the series to account for the serial correlation. Dickey and Fuller (1981) illustrate that the limiting distributions and critical values that they obtain under the assumption that e_t is a random sequence, are also valid when, e_t is autoregressive if the ADF regression is run. Therefore, we assume the data are generated according to $y_t = \rho y_{t-1} + e_t , t = 1,2, \ldots$ with ρ=1 and that e_t is a stationary autoregression of order p:

$$e_t = \theta_1 e_{t-1} + \theta_2 e_{t-2} + \cdots + \theta_p e_{t-p} + \varepsilon_t \quad (4)$$

Where ε_t , is an Independent Identically Distribution (IID) process and considers the reparameterized version of $y_t = \alpha + \beta t + \rho y_{t-1} + e_t$ as follows:

$$\Delta y_t = \alpha + \beta t + \phi y_{t-1} + e_t \quad (5)$$

Where H_0: $\phi = 0$ is to be tested against H_1: $\phi < 0$. Given the equation for e_t in (4) we can write as follows:

$$\Delta y_t = \alpha + \beta t + \phi y_{t-1} + \theta_1 e_{t-1} + \theta_2 e_{t-2} + \cdots + \theta_p e_{t-p} + \varepsilon_t \quad (6)$$

Since $y_t = \rho y_{t-1} + e_t$, $t = 1,2, \ldots$ with ρ=1 gives $e_t = y_t - y_{t-1}$ the equation (6) can be written as follows:

$$\Delta y_t = \alpha + \beta t + \phi y_{t-1} + \theta_1(y_{t-1} - y_{t-2}) + \theta_2(y_{t-2} - y_{t-3}) + \cdots + \theta_p(y_{t-p} - y_{t-p-1}) + \varepsilon_t$$

$$= \alpha + \beta t + \phi y_{t-1} + \sum_{i=1}^{p} \theta_i \Delta y_{t-1} + \varepsilon_t \quad (7)$$

We are unlikely to know the correct value of p for using in the ADF regression and then will be needed to determine that on the basis of the available data. In practice, it is usual to include terms with lag to the extent that ε_t has no correlation and to use Lagrange multiplier tests for serial correlation to check whether the chosen p is adequate. In our test, the null hypothesis is $\phi = 0$; that indicates there is a unit root, in other words, the time series is non-stationary. The alternative hypothesis is $\phi < 0$. Rejecting H_1 implies that we do not reject that the time series has the properties of a random walk (Noferesti, 2000; Harris, 1992a; Al-Jafari and Altaee, 2011).

3.2 Runs Test

The runs test, as a non-parametric test, is used to detect the frequency of the changes in the direction of a time series. Runs test is a strong test for randomness in examining serial dependence in asset price movements. Runs are defined here as the number of sequences of consecutive positive and non-positive (negative or zero) returns. The number of runs is computed as a sequence of the price changes of the same sign (++, - -, 00). When the expected number of runs is significantly different from the observed number of runs, the test rejects the null hypothesis that returns are random (Gu and Finnerty, 2002). To perform this test, we compare the number of actual runs (R) and expected runs (m), which is as follows:

$$m = \frac{N(N+1) - \sum_{i=1}^{3} n_i^2}{N}$$

Where N is the number of observations (daily returns), i is the sign of +, - , or 0, and n_i is the number of observations in each run. For large sample sizes (N>30), expected runs are approximately normally distributed with a standard deviation = σ_m as follows:

$$\sigma_m = \left[\frac{\sum_{i=1}^{3} n_i^2 \left[\sum_{i=1}^{3} n_i^2 + N(N+1)\right] - 2N\sum_{i=1}^{3} n_i^3 - N^3}{N^2(N-1)}\right]^{1/2}$$

Then, we use the standard normal Z-statistic to test whether the actual number of runs is consistent with the random walk hypothesis. The standard normal Z-statistic is calculated as follows:

$$Z = \frac{R - m \pm 0.5}{\sigma_m} \sim N(0,1)$$

Where R is the actual number of runs and 0.5 is continuity adjustment. When the actual number of runs exceed (fall below) the expected runs, the result will be a positive (negative) Z value. Positive (negative) Z value indicates negative (positive) serial correlation in the return series (Abraham et al., 2002). Since, Z statistic is normally distributed $N(0,1)$, critical value for Z statistic at significant level of 0.05 is ± 1.96.

4. Empirical Results

The daily stock returns of Iranian equity market represented by TEPIX are obtained from the web site of the Tehran Stock Exchange (www.irbourse.com). The dataset consist of 1153 daily observations for the period from 2008 to 2022. This study utilizes autocorrelation, augmented Dickey-Fuller, and runs tests to examine the market efficiency using daily returns over the research period. Fig 1 shows the trend of daily returns for the market.

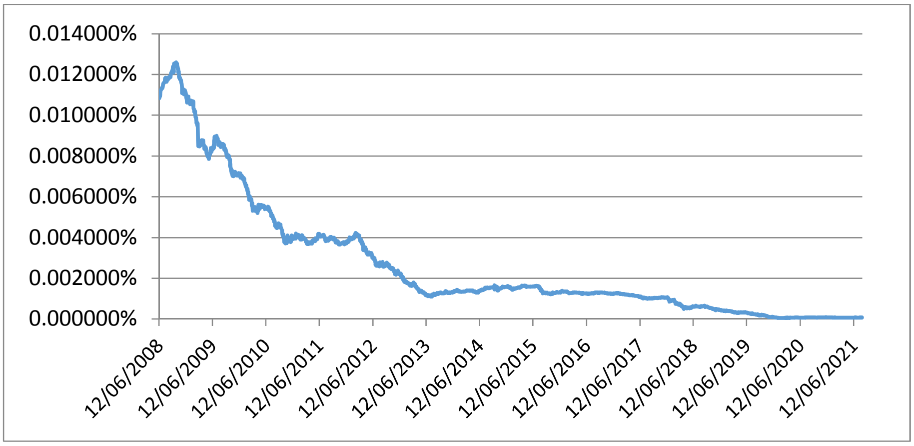
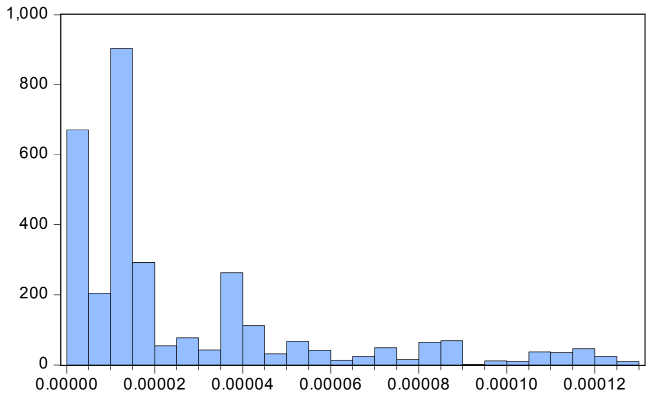


Fig 1: The trend of daily stock returns for Tehran Stock Exchange (during 3167 days)

Fig. 1 shows that the fluctuation trend of the Tehran Stock Exchange return has gradually decreased over 14 years. Source: Research findings

Table 1. Descriptive Statistics for Stock Price Index of Tehran Stock Market



Series: R	
Sample 1 3167	
Observations 3167	
Mean	2.63e-05
Median	1.35e-05
Maximum	0.000126
Minimum	4.70e-07
Std. Dev.	2.99e-05
Skewness	1.665762
Kurtosis	5.015652
Jarque-Bera	2000.740
Probability	0.000000

Table 1 presents descriptive statistics of daily returns of TSE. The results show that daily returns are positively skewed which implies that the returns are flatter to the right and have asymmetric distribution. The results of descriptive statistics based on positive skewness, high kurtosis and Jarque-Bera reject the hypothesis of normally distributed daily returns. Source: Research findings

4.1 Results of Autocorrelation Test

We use autocorrelation test with 25 lags to examine the weak form of market efficiency. Table 2 shows the autocorrelation coefficients, Ljung-Box, and Box-Pierce statistics. The autocorrelation coefficients reported in the table 2 are significant that indicate daily returns of the TSE are serially correlated. The other statistics, Ljung-Box, and Box-Pierce support that the returns are serially correlated. Therefore, the results don't support the weak form efficiency.

4.2 Results of Augmented Dickey-Fuller

The Augmented Dickey-Fuller test is another method to examine the weak form efficiency of TSE. In the ADF test the null hypothesis is that the series has a unit root. We determine the significant level of this test to be 5% and the related critical value is 2.862. The results of the test (presented in appendix) indicate that on the basis of Schwarz Bayesian and Hannan-Quinn Criteria, the white noise of error term (ε_t) occurs in the second lag. In other words, the error term has the highest value at the second lag. The absolute value of Dickey-Fuller statistic at the second lag is 13.828 and greater than the critical value (2.862) at 95% significant level. The results are identical for the Dickey-Fuller regressions including and excluding a linear trend. Therefore, we reject that the daily stock returns for the TSE have the properties of a random walk.

Table 1: Augmented Dicky-Fuller Test Statistic

		T-Statistic	Prob
Augmented Dicky-Fuller Test Statistic		-4.613821	0.0001
Test Critical Values:	1% Level	-3.432232	
	5% Level	-2.862257	
	10% Level	-2.567196	

Source: Research findings

Table 2. Autocorrelation Function, Ljung-Box, and Box-Pierce Statistics for Daily Stock Returns

Order	ACF	Box-Pierce Statistic	Ljung-Box Statistic
1	0.41115	(0.000) 194.7392	(0.000) 195.2468
2	0.25308	(0.000) 268.5268	(0.000) 269.2910
3	0.20270	(0.000) 315.8583	(0.000) 316.8285
4	0.17053	(0.000) 349.3606	(0.000) 350.5059
5	0.13563	(0.000) 371.7007	(0.000) 372.9823
6	0.13563	(0.000) 392.8920	(0.000) 394.3216
7	0.095704	(0.000) 403.4436	(0.000) 404.9561
8	0.12053	(0.000) 420.1782	(0.000) 421.8169
9	0.15222	(0.000) 446.8711	(0.000) 448.7868
10	0.17378	(0.000) 481.6608	(0.000) 483.9421
11	0.14254	(0.000) 505.0657	(0.000) 507.6136
12	0.15380	(0.000) 532.3158	(0.000) 535.1983
13	0.12755	(0.000) 551.0586	(0.000) 554.1880
14	0.10547	(0.000) 563.8746	(0.000) 567.1842
15	0.12166	(0.000) 580.9256	(0.000) 584.4910
16	0.11953	(0.000) 597.3840	(0.000) 601.2093
17	0.11563	(0.000) 612.7873	(0.000) 616.8704
18	0.13031	(0.000) 632.3484	(0.000) 636.7765
19	0.13162	(0.000) 652.3063	(0.000) 657.1043
20	0.11474	(0.001) 667.4714	(0.000) 672.5642
21	0.076587	(0.000) 674.2285	(0.000) 679.4587
22	0.091000	(0.000) 683.7683	(0.000) 689.2011
23	0.075727	(0.000) 690.3745	(0.000) 695.9536
24	0.069452	(0.000) 695.9513	(0.000) 701.6385
25	0.067129	(0.000) 701.1226	(0.000) 706.9541

Source: Research findings

4.3 Results of Runs Test

This section reports the results of runs test as a nonparametric test, as follows:

Table 3. Results of the Nonparametric Runs Test

Test value	Observations> test value	Observations ≥ test value	Total Observation	# of runs	z-stat	p-value
.00001350	1581	1586	3167	28	-55.325	0.000

Since, the daily stock returns for TSE don't conform to the normal distribution. Table 3 shows the results of the runs test for daily returns. The results show that Z statistic is -55.325 and greater than ±1.96, the critical value. The negative value for Z statistic indicates positive serial correlation. Therefore, runs test shows that TSE is inefficient in weak form. Source: Research findings

5. Conclusions

This study examines the Iranian capital market efficiency after the changes in the market regulations, Covid 19 pandemic and international sanctions, because we expect them to affect stock market efficiency. We use the daily returns for the research period to test the research hypothesis. For the purpose of the hypothesis testing, we implement autocorrelation, augmented Dickey-Fuller, and runs tests. The results of all tests don't support that TSE daily returns follow random walk, and have the mean reversion properties. Therefore, we conclude that it is possible to use the technical skills to attain the abnormal gains, because, the effects of price shocks are convergence in the stationary processes and it can be expected that implementing technical skills causes abnormal returns. Tests implemented at the aggregate level of the TEPIX do not support the hypothesis of weak form efficiency following fundamental changes and reforms in the market. Since the stock market is under the effects of various factors it is difficult to determine exactly the causes of improvement in market efficiency. Given the fundamental changes and reforms that took place in the mechanisms of Tehran Stock Exchange during the research period, it was expected that the market efficiency would be shifted to the weak form of efficiency. However, our findings do not support that the level of efficiency has been increased despite of the reforms in the stock market. The results of the present study regarding the impact of the Covid-19 variable are consistent with the results of Baker et al (2020) and confirm that the Tehran Stock Exchange index has been affected by the Covid-19 pandemic crisis. It was also further revealed that economic and banking sanctions have had a direct impact on the Iranian economy and the Tehran Stock Exchange market, such that after the approval of each of the sanctions, significant structural failures were observed in the trend of the Tehran Stock Exchange index.

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All authors had contribution in preparing this paper.

Conflicts of interest

The authors declare no conflict of interest

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