“Assessing market efficiency in Palestine Securities Exchange (PSE) market at weak form: Analysis from 2010–2022”

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ASSESSING MARKET EFFICIENCY IN PALESTINE SECURITIES EXCHANGE (PSE) MARKET AT WEAK FORM: ANALYSIS FROM 2010–2022

Abstract

The efficient market hypothesis (EMH) asserts that financial markets are efficient, meaning that current market values of stocks incorporate all available information. This study examines the weak-form efficiency of Palestine Stock Exchange stocks using the indices returns from 2010 to 2022. The study used parametric tests (Augmented Dickey-Fuller (ADF) unit root, serial autocorrelation) and nonparametric tests (Phillips-Perron (PP) unit root, run test, variance ratio test). The findings of these tests provide insights into the behavior of the Palestine Stock Exchange market.

The run test outcomes reveal a statistically significant pattern in the data for general, insurance, and service indices, with a p-value below the significance level. Furthermore, the unit root tests indicate statistical significance for all indices with 0.00 p-values and t-statistic below the critical values of –2.86 for level and intercept, and –3.14 for level, trend, and intercept, signifying that the indices returns are stationary. In addition, serial autocorrelation test show that the general and Al-Quds indices show statistically significant links between consecutive observations at all four lags. However, the insurance, investment, and services indices show statistically significant results on three lags. The variance ratio test results challenge the random-walk hypothesis for all indices except industry and insurance. With low probability values, a discernible, long-term, predictable pattern is evident in the Palestine Stock Exchange indices.

The analysis reveals that Palestine Stock Exchange index returns exhibit nonrandom behavior, suggesting predictability and patterns in daily returns, indicating the possibility of exploiting market inefficiencies in investment strategies.

Keywords autocorrelation, efficient market, financial markets, predictability, randomness, stationarity, random walk

JEL Classification G10, G14, G12, C22, O16

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INTRODUCTION

The Palestine Securities Exchange (PSE) is a growing market with a $4.9 billion capitalization in 2022, featuring companies from sectors like banking, telecoms, pharmaceuticals, and real estate. Listed corporations include Palestine Telecom Company, Bank of Palestine, and Palestine Development and Investment Company. Established in 1997, the PSE is Palestine's sole securities exchange, featuring 49 listed companies from various sectors as of December 2022. With its headquarters in Nablus, the PSE offers an electronic trading platform for share transactions, aiming to boost efficiency and transparency and enhance the trading experience for market participants (PEX, 2022).

In 1970, Eugene Fama proposed the Efficient Market Hypothesis (EMH) concept, arguing that stock prices adjust quickly to new information, implying that current market values of stocks follow a

random walk pattern, taking into account all available data. The concept of market efficiency, particularly in its weak form, revolves around the notion that current prices reflect all past market information.

By exploring this dimension (weak level) within the PSE from 2010 to 2022, this study aims to shed light on the effectiveness of past market data in predicting future price movements and to demonstrate whether the PSE exhibits characteristics consistent with weak-form market efficiency. Understanding the efficiency level of the PSE is not only relevant from an academic standpoint but also holds practical implications for investors, analysts, and policymakers navigating this market.

In recent years, market efficiency has gained significant attention in financial research. PSE stands as a unique and emerging market, presenting opportunities to delve into the intricacies of market behavior. This study contributes to the broader understanding of financial markets by assessing the market efficiency of PSE in the context of weak-form efficiency.

1. LITERATURE REVIEW

Based on efficiency, stock markets fall into three categories: weak, semi-strong, and strong (Fama, 1970). The weakest level suggests that current stock values contain all past data, so predicting future prices from past prices is ineffective (Awad & Daraghma, 2009; Masuku & Gopane, 2022). Semi-strong efficiency assumes current stock values include historical and public information (Awad & Daraghma, 2009). Strong efficiency assumes stock values reflect past and present public information. Additionally, it assumes stock values reflect public and private information (Abushammala, 2011; Awad & Daraghma, 2009).

Numerous researchers have studied market efficiency in developed and developing nations (Dias et al., 2020; Emenike Kalu, 2017; Guidi et al., 2011; Hawaldar et al., 2017; Shaker, 2013). Emenike Kalu (2017) provides evidence of random walk hypotheses (RWH) on the Nigerian Stock Exchange (NSE) and its sectors. The ARCH-LM test and other statistical measures suggest that asset returns exhibit volatility clustering and serial correlation, indicating that they are not serially uncorrelated, as the RWH assumes. Hence, NSE stock prices exhibit inefficiencies and fail to include all relevant information comprehensively. Furthermore, analysts consider the Indian stock market inefficient; they believe that stock prices do not fully reflect historical data, implying that investors could leverage market valuation discrepancies to earn above-average profits. (Luniya & Basarkar, 2022).

Regarding market efficiency, many developing countries exhibit lower efficiency levels than developed countries (GAZEL, 2020). Several factors contribute to this disparity, such as thin trading, low liquidity, and a lack of financially literate investors (Awad & Daraghma, 2009). Additionally, investors in developing countries often have to contend with unreliable information and high volatility at multiple political, economic, and social levels (Alkhatib & Harasheh, 2014). Several studies confirm the inefficiency of emerging markets (Nguyen & Parsons, 2021; Sadat & Hasan, 2019; Turguttopbas, 2021). Emerging markets lack full integration with world capital markets, and investors could earn arbitrage profits from market inefficiency in these countries. This situation suggests that investors may lack the necessary information to make informed decisions (Nguyen & Parsons, 2021).

The market efficiency at the weak level of Brazil, China, Russia, Turkey, and South Africa stock markets was subject to testing. Turguttopbas (2021) uses nonlinear statistical methods to test market efficiency at a weak level for these markets and found that the stock market indices in these countries are stationary and inefficient at weak levels. Furthermore, Dias et al. (2020) examined 16 global financial markets (Belgium, Brazil, China, France, Germany, Japan, Malaysia, Mexico, Philippines, Portugal, Greece, Hong Kong, Ireland, Spain, Thailand, and USA) between January 2002 and July 2019 to evaluate market efficiency at a weak level. The findings suggest evidence of mean reversion and a rejection of the weak form of the informa-

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tion efficiency hypothesis in both developed and emerging markets and in European and non-European markets. Miloş et al. (2020) examined the multifractal characteristics of seven stock markets in Central and Eastern European (CEE) countries (Bulgaria, Croatia, Czech Republic, Hungary, Romania, Poland, and Slovenia). The results reveal that the CEE stock indices demonstrate significant long-range correlations, implying that stock market returns deviate from the randomness expected by the RMH (Miloş et al., 2020).

The results indicate a market inefficiency in the weak form of the EMH in the CEE stock markets. This result aligns with the results of Guidi et al. (2011). The study suggests that the CEE equity markets are not fully efficient, as evidenced by the mixed results of the weak-form efficiency tests. The authors find that some markets exhibit significant deviations from the random walk hypothesis, indicating the presence of mispricing that informed investors can exploit. The study also finds evidence of day-of-the-week effects in some markets, particularly in Polish, Slovakian, and Slovenian stock markets, implying that investors may be able to earn abnormal profits by timing their trades based on the day of the week (Guidi et al., 2011).

In their research on Vietnamese stock market efficiency, Le and Luong (2020) conducted various tests to determine the market efficiency in the Vietnamese stock market. The study results indicate that the Vietnamese stock market generally does not follow a random walk, which means that investors and financial managers can forecast future prices based on past prices or other information. In addition, this study observes that the Vietnamese stock market has recently experienced increased efficiency. As indicated by the study, the improvement in market efficiency in the Vietnamese stock market over time is significant for the EMH in emerging countries.

Several studies have tested the weak form of market efficiency of the Dhaka Stock Exchange (DSE) in Bangladesh. Sadat and Hasan (2019) conducted a study to evaluate the DSE market efficiency in Bangladesh at a weak level from 2006 to 2015 using various tests. Sadat and Hasan (2019) suggested that the DSE is inefficient in the weak form of the EMH. The researchers observed that the DSE did not follow a random walk pattern, suggesting deviations from the market efficiency. Furthermore, Ahmed and Hossain (2019) suggested that the DSE is an inefficient market at a weak level of the EMH, indicating the possibility of abnormal returns using historical information to predict future prices. The findings concerning the DSE align with those of Ahmed (2021). The findings indicate that changes in the stock price index do not support the hypothesis of stock return randomness when subjected to various tests (Ahmed, 2021). These combined tests suggest that the DSE is an inefficient market at a weak level.

Bahrain Securities Market (BSM) is another market investigated and found to be informationally inefficient at a weak level (Al-Jafari, 2011). This study focuses on the period from 2011 to 2015 and analyzes market efficiency at a weak level for individual equities listed on the BSM. The study employed various tests, and the results suggest that the market did not fully conform to the RWH at a weak level. These findings indicate that most companies' stock price movements are nonrandom, and share prices show low-to-moderate correlations with varying positive and negative values. Furthermore, Hawaldar et al. (2020) suggested that the BSM is an inefficient market at a weak EMH level and that there are opportunities to make profits by exploiting mispricing. These findings are consistent with the conclusions drawn by Salameh (2011), who found that the BSM, along with other Arab markets, is inefficient at a weak EMH level. At a 10% significance level, nine Arab stock markets – including Amman, Kuwait, Abu Dhabi, Morocco, Tunisia, Oman, Saudi Arabia, Egypt, and Bahrain – rejected the null hypothesis of random time series, as shown by (Salameh, 2011).

Regarding the Muscat Securities Market (MSM), several studies (Jawad, 2011; Kharusi, 2014; Kumar et al., 2017) tested the weak form of the market and concluded that the MSM index is inefficient at the weak level of the EMH. Using daily and monthly observations from 2005 to 2009, Jawad (2011) suggests that MSM are weak-form inefficient, with a significant nonrandomness in daily data but some signs of market efficiency in data on the monthly level. Furthermore, Kharusi (2014) suggests that MSM were weak-form inefficient during all three

test periods (preceding, during, and following the crisis). Kumar et al. (2017) analyzed the MSM30 index and concluded that MSM is an inefficient market at a weak level.

In a 2020 research paper, Khoj and Akeel conducted an in-depth examination of the weak-form efficiency of the Saudi Stock Exchange, also known as Tadawul, from January 2012 to January 2019. Their research involved several tests, such as VRT and JB, and examined Tadawul's market efficiency. The results revealed that Tadawul is weak-form efficient because the VRT, JB, and run tests accept the random walk null hypothesis. This finding suggests that investors cannot use historical information to predict future Tadawul stock prices. They concluded that their study provided evidence supporting Tadawul's weak form efficiency (Khoj & Akeel, 2020). This result is consistent with Asiri and Alzeera (2013), who confirm weak-form market efficiency in the Saudi stock market for the Tadawul All Share Index (TASI) and 11 individual sectors. However, based on their analysis, they could not determine whether other indices followed random walks. Furthermore, Salameh (2011) showed that the stock market in Saudi Arabia is unique among Arab markets in its random behavior.

In contrast, other Arab stock markets, including Amman, Kuwait, Dubai, Abu Dhabi, Egypt, Morocco, Tunisia, Qatar, Oman, Bahrain, and Palestine, do not exhibit random behavior, signifying that their prices can be somewhat predicted (Salameh, 2011). Conversely, Lamouchi (2020) examined the Saudi Arabian stock market performance, specifically the Tadawul All Share Index (TASI), from 1998 to 2020. This study examines the dependency structure of stock market index returns and volatility to determine its effects on the stock market. The findings reveal that Saudi Arabia's stock market has a long memory. The Saudi Stock Market's long memory process provides data that refutes the EMH. The ARFIMA model provides additional evidence against EMH by confirming the existence of long-term dependence on the historical volatility of the Saudi stock market (Lamouchi, 2020).

Different researchers have undertaken many empirical investigations employing various methodologies (Moustafa, 2004; Salameh, 2011; Squalli, 2006) to scrutinize the efficiency of the United Arab Emirates (UAE) market. Squalli (2006) presented evidence of nonrandomness in UAE market stock returns, suggesting that financial markets are characterized by long-term memory, implying that the UAE financial market is an inefficient market at a weak level. Squalli (2006) used the variance ratio and run tests to examine the stock markets in both the Dubai Financial Market (DFM) and the Abu Dhabi Securities Market (ADSM) for 2000–2005. The research findings indicate that, except for the DFM banking sector, not all sectors in both markets follow RWH principles, indicating inefficiency.

Moreover, the conducted run test indicated that, except for the insurance industry, all sectors within the ADSM were deemed inefficient. Based on the principles of the EMH, Squalli (2006) classified only the insurance sector in the ADSM as efficient at a weak level. Conversely, Salameh (2011) reached a different conclusion, stating that the DFM and ADSM do not adhere to RWH. However, the results of Squalli (2006) are inconsistent with those of Moustafa (2004).

In a study from October 2001 to September 2003, Moustafa evaluated the UAE market's efficiency at a weak level. The study examined the returns of 43 stocks listed on the UAE stock market. The test results of this analysis reveal that the pricing dynamics of these stocks indicate adherence to the weak form of the EMH (Moustafa, 2004).

Using 3,441 observations of the Amman stock market (ASE) weighted index between January 2000 and December 2013, a study on the ASE employed various tests like serial correlation, run test, and unit root tests to evaluate market efficiency. The outcomes of these tests consistently pointed to weak-form inefficiency in the ASE (Ananzeh, 2014). These findings agree with Salameh's (2011) assertion that stock prices in the ASE do not conform to the Random Walk Hypothesis (RWH).

The market efficiency of MSCI ETF indices in developed and emerging nations was examined at a weak level from 2009 to 2013 using traditional unit root and Fourier unit root tests (GAZEL, 2020). The study investigated the weak form market efficiency in the MSCI ETF indices of devel-

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oped and developing countries using conventional and Fourier unit root tests. According to the study results, the MSCI ETFs of Australia, Canada, England, South Korea, South Africa, and Indonesia do not contain unit roots and are stable at the level. However, the ETFs for Australia, Canada, Mexico, Argentina, and Indonesia do not contain unit roots and tend to return to the average. Therefore, the study concluded that according to traditional and Fourier unit root test results, Australia, Canada, and Indonesia are inefficient in the weak form. (GAZEL, 2020).

Few studies have evaluated the PSE efficiency, particularly in the context of its weak form efficiency. Different and independent studies agreed that the PSE constitutes a market with weak-form inefficiency (Abushammala, 2011; Alkhatib & Harasheh, 2014; Awad & Daraghma, 2009; Salameh, 2011). These studies used various PSE indices' past returns as the primary data. The techniques employed included serial correlation, Augmented Dickey-Fuller (ADF) test (parametric test) and run test (nonparametric test). These tests show that PSE exhibits autocorrelation and stationary behavior, supporting the weak-form inefficiency hypothesis.

The PSE market inefficiency affects both investors and policymakers. This finding implies that investors can achieve abnormal returns. Prudent investors can capitalize on these opportunities by utilizing historical stock price patterns and other market information to earn abnormal returns. However, investors may encounter challenges in accurately valuing securities and making informed decisions. Policymakers may need to consider measures to improve market efficiency, such as enhancing liquidity, promoting diversification, and strengthening regulatory frameworks. These measures can help reduce market participants' opportunities to exploit the mispricing. Additionally, this can facilitate informed investment decisions for investors.

Research on the efficiency of the PSE at a weak level remains relatively scarce despite its importance in understanding the dynamics of this emerging financial market. Few studies have ventured into assessing the efficiency of the PSE from the perspective of information diffusion and stock price adjustments. This gap in research presents an intriguing opportunity to delve deeper into the efficiency dynamics of the PSE. This study aims to appraise the weak-form efficiency of the PSE market nine years after Alkhatib and Harasheh (2014) conducted their tests. This study utilizes parametric and nonparametric tests to determine the PSE efficiency level. The tests included serial correlation, unit root, run, and variance ratio tests. Through the combined tests, this study aims to provide evidence regarding PSE market efficiency at the weak level, contributing to the existing literature by providing additional evidence on the efficiency of the PSE market. The null hypothesis is that the PSE stock market is efficient at the weak-form level and that the RWH shows that PSE stock prices are independent.

The present study aims to evaluate PSE efficiency at a weak level by analyzing 49 stocks listed on the exchange.

The null and alternative hypotheses are:

H_0: *PSE's stock returns follow a random pattern throughout the study period, suggesting a weak level of an efficient market.*

H_1: *PSE's stock returns follow a nonrandom pattern over the study period, indicating a weak level inefficient market.*

2. RESEARCH METHODOLOGY

A thorough understanding of the methodology is crucial to assess the validity and generalizability of the outcomes. This study obtained data from the official PSE websites and retrieved electronic records of the PSE to obtain data for all PSE indices. The dataset consists of 3,155 observations of daily stock index time-series data from the PSE, covering January 2010 to December 2022. All data will be made available upon reasonable request. The daily returns of the PSE indices were computed using the following equation:

$$R(t) = \frac{P_{(t)} - P_{(t-1)}}{P_{(t-1)}} \cdot 100, \quad (1)$$

where $R(t)$ is the return of an index at time t, $P_{(t)}$ is the price at time t, and $P_{(t-1)}$ is the price at time $(t-1)$. The research followed these steps:

1. Data Collection: The study gathered daily stock index data from the official PSE website from 2010 to 2022.

2. Data Transformation: The study calculated daily returns using the formula described above.

3. Preliminary Analysis: The study conducted a Jarque-Bera (JB) normality test to examine the distribution of returns.

4. Parametric Tests: The study performed ADF and serial correlation tests.

5. Non-Parametric Tests: The study conducted a run test, PP unit root test, and variance ratio test.

6. Interpretation and Conclusion: Analyzed the test results to assess the weak-form efficiency of the PSE.

The statistical analyses were conducted using EViews version 13. By providing this level of detail, the study aims to illustrate the methodology comprehensively, enabling other researchers to replicate the work or apply similar methodologies to other contexts.

3. RESULTS AND DISCUSSION

The mean, which serves as the average value of the observations, suggests that all the PSE indices exhibit positive returns on average throughout the study. The general index exhibits the highest mean return of 0.011%, followed closely by the Al-Quds index at 0.01%. The insurance index displays the highest average return at 0.036% on the sector-level indices, whereas the service index displays the lowest mean return at 0.004%. However, when considering the median, which represents the middle value in the dataset, most indices had returns close to zero, suggesting that approximately half of the observations yield positive returns, whereas the other half yield negative returns. The general and Al-Quds indices exhibited negative median returns of –0.007% and –0.01%, respectively.

The maximum and minimum values, as measures of dispersion, provide insight into the range of returns within each index. Over the study period, the highest returns for the general and Al-Quds indices were 9.57% and 10.13%, respectively. Among the sector-level indices, the insurance and industry indices display the highest maximum returns, at 77.07% and 40.77%, respectively, indicating significant gains. Conversely, the insurance and industry indices also exhibited the lowest minimum returns at –48.81% and –31.90%, respectively, highlighting the possibility of substantial losses. Furthermore, the study calculated the standard deviations of the data. Based on the results presented in Table 1, the insurance index shows the highest standard deviation of 1.76%, indicating higher volatility, whereas the banking index shows the lowest standard deviation of 0.74%.

Furthermore, analyzing skewness provides insights into the asymmetry of the return distribution. The negative skewness observed in all indices, except industry and insurance, suggests a tendency toward negative returns. The skewness of

Table 1. Descriptive statistics

Statistics	General	Al-Quds	Banking	Industry	Insurance	Investment	Service
				PSE Indices			
Mean	0.011%	0.010%	0.016%	0.032%	0.036%	0.019%	0.004%
Median	–0.007%	–0.010%	0.000%	0.000%	0.000%	0.000%	0.000%
Maximum	9.57%	10.13%	18.94%	40.77%	77.07%	18.56%	12.71%
Minimum	–12.98%	–9.70%	–21.37%	–31.90%	–48.81%	–19.68%	–16.82%
Std. Dev.	0.51%	0.57%	0.74%	1.06%	1.76%	0.99%	0.83%
Skewness	–3.196	–0.255	–2.083	9.508	19.818	–0.006	–3.666
Kurtosis	178.18	71.41	356.82	955.67	1342.69	93.26	111.53
Jarque–Bera	4,039,382	615,218	16,459,040	119,356,402	236,144,943	1,070,905	1,555,574
Probability	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Observations	3155	3155	3155	3155	3155	3155	3155

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the general and Al–Quds indices was –3.196 and –0.255, respectively. The service index exhibited the most negative skewness at –3.667. By contrast, the insurance index displays a significantly positive skewness of 19.818, indicating a right–skewed distribution with the potential for highly positive returns. Kurtosis measures the tailedness of the distribution and reflects the extreme observations. The insurance index demonstrates the highest kurtosis value of 1,342.69, indicating a distribution with heavy tails and a high frequency of extreme returns.

Similarly, the other indices showed high kurtosis values, suggesting fat-tailed distributions, except for the investment index, which had the lowest kurtosis at 93.26. This lower kurtosis value for the insurance index suggests fewer extreme observations than other indices. Finally, the study applied the JB test to evaluate the normality of the distribution of daily returns for PSE. The results indicate that all indices produced notably high JB test statistics, suggesting substantial deviations from normality.

The Wald-Wolfowitz run test, which is known simply as the run test, is the first test used to evaluate the efficiency of the PSE market at the weak level. The run test is applied to determine how random a given dataset is. This nonparametric test tests the hypothesis that a data sequence follows a random distribution.

According to the data presented in Table 2, the outcomes of this study unveil distinctive patterns within the indices examined. The general, insurance, and services indices showcase marked deviations from the realm of randomness. Their respective z-scores of –2.162, –3.934, and 3.298 reinforce this notion. Correspondingly, the associated p-values 0.031, 0.000, and 0.001 underscore the significance of these deviations, all registering below the threshold of 0.05, suggesting that these indices veer away from randomness, revealing a statistically significant departure.

Contrastingly, the remaining four indices (Al-Quds, banking, industry, and investment) do not exhibit such compelling deviations from randomness. Their z-scores –0.761, 1.384, 0.013, and 1.133 align with this observation. Simultaneously, the p-values 0.447, 0.166, 0.99, and 0.257 reinforce the lack of significance compared to the 0.05 threshold, implying that these indices do not diverge significantly from randomness.

Considering the null hypothesis in light of the run test results, a clear conclusion emerges. The general, insurance, and service indices exhibit substantial deviations from the realm of randomness, shedding light on the fact that stock returns within these indices do not adhere to the Random Walk Hypothesis (RWH). Conversely, the Al Quds, banking, industry, and investment indices maintain a closer alignment with randomness, indicating that stock returns in these categories follow the tenets of the RWH.

Furthermore, the research carried out a unit root test that included both the ADF and PP tests to evaluate the efficiency of the PSE market at the weak level. The test detects whether unit roots are present in the indices' daily returns, which can help in understanding the stationarity and non-randomness behavior of the PSE returns.

Table 2. Indices run test results

Indicators	General	Al-Quds	Banking	Industry	Insurance	Investment	Service
			PSE Indices				
Test Value	0.011%	0.010%	0.016%	0.032%	0.036%	0.019%	0.004%
Cases < Test Value	1,645	1,636	1,721	1,812	2,082	1,721	1,694
Cases ≥ Test Value	1,510	1,519	1,434	1,343	1,073	1,434	1,461
Total Cases	3,155	3,155	3,155	3,155	3,155	3,155	3,155
Number of Runs	1,515	1,555	1,604	1,544	1,318	1,597	1,662
Z	–2.162	–0.761	1.384	0.013	–3.934	1.133	3.298
Asymp. Sig. (2-tailed)	0.031	0.447	0.166	0.990	0.000	0.257	0.001

Note: The null hypothesis for the run test assumes that the sequence of observations is random. The significance level (α) for rejecting the null hypothesis is 0.05.

Table 3. ADF and PP test results

	ADF Test		PP Test	
	Level and Intercept	Level, Trend, and Intercept	Level and Intercept	Level, Trend, and Intercept
		P-value		
General Index	0.00	0.00	0.00	0.00
Al-Quds Index	0.00	0.00	0.00	0.00
Banking Index	0.00	0.00	0.00	0.00
Industry Index	0.00	0.00	0.00	0.00
Insurance Index	0.00	0.00	0.00	0.00
Investment Index	0.00	0.00	0.00	0.00
Service Index	0.00	0.00	0.00	0.00
		t-statistic		
General Index	–36.25	–36.26	–52.88	–52.87
Al-Quds Index	–35.82	–35.82	–52.24	–52.23
Banking Index	–57.04	–57.04	–57.13	–57.13
Industry Index	–56.05	–56.06	–56.06	–56.06
Insurance Index	–36.69	–36.7	–57.07	–57.07
Investment Index	–55.62	–55.62	–55.81	–55.8
Service Index	–37.24	–51.61	–54.63	–54.64

Note: The null hypothesis for the Augmented Dickey-Fuller (ADF) test posits that a unit root is present in the time series data. The null hypothesis for the Phillips-Perron (PP) test is similar, asserting that the data contains a unit root. Critical t-statistic values for rejecting the null hypotheses are: For Level and Intercept: −2.86, For Level, Trend, and Intercept: −3.14. The significance level (α) for rejecting the null hypothesis is 0.05.

The findings in Table 3 reveal that, for all indices, the p-values obtained from the ADF and PP tests are below the significance level of 0.05, indicating statistical significance. As a result, index returns are deemed stationary and display nonrandom behavior. Furthermore, the t-statistic values for all the tests fell below the critical value, providing additional support for rejecting the null hypothesis.

Examining the general and Al-Quds indices, the ADF and PP tests produced remarkably significant p-values (p-value = 0.00), along with strongly negative t-statistics. The findings presented in this study offer compelling support for rejecting the null hypothesis. The results propose that the returns of the general and Al-Quds indices exhibit stationarity. Likewise, the sector-level indices display similar trends. All the observed p-values are 0.00, indicating a statistically significant result. The t-statistic values range from –35.82 to –57.13 and are considerably lower than the t-statistic critical values of –2.86 and –3.41. The critical values of –2.86 and –3.41 correspond to the approximate value needed to achieve statistical significance at the 5% level (with a two-tailed test). The findings consistently provide evidence for rejecting the null hypothesis, suggesting that the returns of these indices demonstrate stationarity; thus, stock prices behave nonrandomly, opposing the RWH.

Furthermore, this study tested the autocorrelation in daily index returns using a serial correlation test executed with one, two, three, and four lags. Autocorrelation shows the correlation between a variable and its lag value. Table 4 presents the findings of the serial correlation tests for all indices at different lags.

The results of the serial autocorrelation test, as outlined in Table 4, unveil distinctive patterns across the examined indices. The Al-Quds and general indices display a compelling correlation between the errors in these indices, substantiated by remarkably low p-values of 0.00 across all four lag instances. This pronounced association implies a substantial and statistically significant link between consecutive observations within these indices.

Moreover, an intriguing pattern emerges from the insurance, investment, and service indices, wherein p-values attaining significance at the 0.05 level reveal noteworthy correlations across three specific lags (lag two, three, and four). Consequently, we can reject the null hypothesis for these lags,

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Table 4. Serial auto-correlation test

Number of Lags	General	Al-Quds	Banking	Industry	Insurance	Investment	Service
PSE Indices							
***p*-value**							
1	0.000	0.000	0.385	0.898	0.427	0.618	0.110
2	0.000	0.000	0.199	0.907	0.000	0.020	0.005
3	0.000	0.000	0.319	0.849	0.000	0.021	0.007
4	0.000	0.000	0.330	0.904	0.000	0.009	0.013
Q-stat							
1	17.664	23.564	0.754	0.017	0.631	0.248	2.547
2	27.580	36.420	3.233	0.195	23.374	7.874	10.426
3	29.403	36.646	3.516	0.801	24.723	9.701	11.997
4	30.985	38.469	4.609	1.038	24.867	13.583	12.660
AC							
1	0.075	0.086	−0.015	0.002	−0.014	0.009	0.028
2	0.056	0.064	0.028	0.008	0.085	0.049	0.050
3	0.024	0.008	0.009	0.014	0.021	−0.024	−0.022
4	0.022	0.024	0.019	0.009	0.007	0.035	−0.014

Note: The null hypothesis for the Serial Auto-correlation test assumes that the errors in the time series model are not serially correlated. The significance level (α) for rejecting the null hypothesis is 0.05.

signaling the presence of autocorrelation within the data during these distinct lag periods for these indices.

Conversely, the banking and industry indices diverge in their autocorrelation profiles. Their lack of significant correlation between the errors in these indices holds across all four examined lags. Evidenced by p-values surpassing the 0.05 threshold, the correlation levels within these indices do not achieve statistical significance, bolstering the perception of an absence of systematic correlation between successive observations.

In addition, the Q-Stat values provide additional insights into autocorrelation. Higher Q-stat values indicate higher autocorrelation between daily returns. In this regard, the Al-Quds and general indices at four lags and the insurance, investment, and service indices at three lags (lag two, three, and four) exhibit relatively higher Q-Stat values, confirming the autocorrelation in their daily returns. Conversely, the banking industry at four lags and the insurance, investment, and service indices at one lag have lower Q-Stat values, suggesting a weaker autocorrelation than the other two.

Finally, the study conducted a variance test ratio. According to Shaker (2013), the VRT developed in 1988 is considered more accurate and effective than traditional models. This test investigated the hypothesis that PSE daily returns follow a random-walk process. The null hypothesis proposes that the data series adheres to a random walk, indicating the absence of predictable patterns or long-term dependencies. The study performed VRT with multiple lags and presents the results in Table 5.

Further investigation into the statistical properties of the indices reveals compelling insights. The calculated p-values, obtained from rigorous testing involving various lag combinations, exhibit a significant p-value (p-value = 0.00) for all indices except for the industry and insurance indices. This crucial statistical metric indicates a robust rejection of the null hypothesis associated with the random walk process at the significance level 0.05. This outcome furnishes substantial empirical support to the proposition that the daily return dynamics of a specific subset of indices – encompassing the general, Al-Quds, banking, investment, and service indices – diverge significantly from the characteristics expected of a random walk. This outcome, underscored by the statistical significance of the obtained p-values, implies that discernible, nonrandom patterns underpin the temporal behavior of these indices' returns. Consequently, these indices exhibit an intriguing long-term, predictable pattern, offering potential avenues for predictive modeling and a deeper understanding of the underlying factors that influence their trajectory over time.

Table 5. Variance ratio test results

Index	Number of Lags	Var. Ratio	z–Statistic	Probability
General Index	2	0.510	–3.734	0.000
	4	0.264	–3.727	0.000
	8	0.133	–3.734	0.000
	16	0.067	–3.699	0.000
Al-Quds Index	2	0.513	–5.770	0.000
	4	0.267	–5.719	0.000
	8	0.135	–5.648	0.000
	16	0.068	–5.437	0.000
Banking Index	2	0.479	–3.109	0.002
	4	0.242	–3.006	0.003
	8	0.122	–2.970	0.003
	16	0.062	–2.936	0.003
Industry Index	2	0.498	–1.821	0.069
	4	0.249	–1.815	0.070
	8	0.126	–1.809	0.070
	16	0.063	–1.809	0.071
Insurance Index	2	0.451	–1.666	0.096
	4	0.245	–1.513	0.130
	8	0.122	–1.493	0.135
	16	0.062	–1.478	0.139
Investment Index	2	0.480	–5.808	0.000
	4	0.244	–5.546	0.000
	8	0.125	–5.360	0.000
	16	0.064	–5.124	0.000
Service Index	2	0.489	–5.067	0.000
	4	0.261	–4.805	0.000
	8	0.130	–4.731	0.000
	16	0.064	–4.604	0.000

Note: The null hypothesis for the Variance Ratio Test posits that the time series follows a random walk, implying that the market is weak-form efficient. The *p*-value significance level for rejecting the null hypothesis is 0.05.

The study delves into a comprehensive evaluation of the efficiency of the PSE market. The research focuses on the weak form of market efficiency and spans the period from 2010 to 2022. The findings of this investigation shed light on the degree of randomness, stationarity, and correlation present in various segments of the PSE market.

At the core of the PSE lies the pivotal general index, a revered benchmark that comprehensively evaluates the exchange's overall performance. The study conducted a set of tests, encompassing the run test, unit root test, serial autocorrelation test, and variance ratio test, to assess the efficiency of the general index. The combined findings from these tests consistently affirm a noteworthy observation: the efficiency of the general index in terms of its return behavior is deemed inefficient at a weak level. This conclusion arises from the index's returns exhibiting a nonrandom pattern and a propensity for stationarity and correlation. In addition, the Al-Quds index stands out prominently among PSE indices. The Al-Quds index meticulously tracks the performance of the market's largest and most actively fifteen-traded corporations. The outcomes of this analysis reveal noteworthy parallels between the index's behavior and the general index through three distinct tests: the unit root test, auto-correlation assessment, and VRT. In all three tests, it becomes apparent that a nonrandom pattern and exhibit correlation and stationarity characterize the index's returns data. However, a point of divergence emerges in the analysis of the run test results, showing a statistically insignificant p-value at the 0.05 significance level, suggesting that, contrary to the other tests, the return pattern possesses a certain degree of randomness. Accordingly, the Al-Quds index can be classified as inefficient since three tests support the notion of the index's inefficiency. Moreover, further exploration of this inconsistency could offer valuable insights into the underlying dynamics of the Al-Quds index's behavior and its relationship to market trends.

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Expanding upon the indices within the PSE, we encounter a set of sector-specific indices. These indices delve into the nuanced performances of distinct economic sectors, providing a focused lens through which to assess economic vitality. The PSE has thoughtfully categorized these sector-based indices into five distinct groups, each tailored to encapsulate the dynamics of a specific segment of the country's economy.

Upon scrutinizing the efficiency of these sector-based indices, we encounter a diverse spectrum of results. For instance, when subjecting the service index to a battery of four tests, none substantiated this particular index's efficiency. These tests imply that the returns associated with the service index exhibit a nonrandom pattern characterized by both stationarity and correlation. Accordingly, the service index is inefficient at a weak level.

Turning our attention to the other two indices, namely insurance and investment, a similar theme of inefficiency prevails. In this case, three of the four tests conducted on each of these indices failed to validate their efficiency. Consequently, the outcomes indicate that these sector-based indices display nonrandom return patterns and varying degrees of stationarity and correlation. Thus, these indices can be classified as inefficient.

Furthermore, the banking index, which gauges the performance of financial sector companies listed on the PSE, yielded mixed results. The run and auto-correlation tests suggest that the index's returns follow a random and uncorrelated pattern. However, the unit root and variance ratio tests (VRT) indicate that the banking index's behavior deviates from randomness, hinting at underlying nonrandom dynamics. Accordingly, the study could not draw a definitive conclusion about the index's efficiency. This intriguing blend of outcomes invites further exploration into the factors contributing to this dual nature of efficiency within the banking sector.

Finally, the analysis of the industry index, focusing on PSE-listed companies in the industrial sector, reveals encouraging efficiency trends. Three of the four conducted tests confirm the index's heightened efficiency compared to alternative indices. These findings collectively suggest that the index's returns follow a random pattern. Consequently, despite the stationary nature of the data as indicated by the unit root analysis, the industry index can be categorized as efficient.

In summary, this extensive investigation into the efficiency of the PSE market, specifically focusing on the weak form of market efficiency from 2010 to 2022, has yielded valuable insights into the levels of randomness, stationarity, and correlation across different aspects of the PSE. The research encompassed an analysis of several indices, primarily emphasizing the general index, a crucial benchmark. The findings unveiled a weak level of inefficiency in the general index, characterized by discernible nonrandom return patterns, a tendency towards stationarity, and correlations.

Although the Al-Quds index exhibited similarities to the general index in various aspects, a noteworthy contrast in the run test was observed. Moreover, the sector-specific indices, tailored to capture the intricacies of distinct economic segments, demonstrated a mixed spectrum of efficiency outcomes. The investment, insurance, and service indices exhibited inefficiencies denoted by nonrandom returns and varying degrees of stationarity and correlation. In contrast, the banking index showcased a distinct amalgamation of efficiency and inefficiency. Conversely, the industry index displayed encouraging indicators of efficiency in comparison to the other indices.

The findings of this study are consistent with the other studies that evaluated the PSE's efficiency, specifically focusing on its weak-form efficiency. Notably, Awad and Daraghma (2009), Abushammala (2011), Salameh (2011), and Alkhatib and Harasheh (2014) conducted independent investigations into this matter and collectively arrived at a unanimous conclusion. Their separate studies align harmoniously with the current research, all converging to assert that the PSE operates within an environment characterized by weak-form inefficiency. This collective body of work underscores the persistent nature of the market's inefficiency and reinforces the significance of addressing these shortcomings to foster a more effective and transparent financial environment.

Further research on PSE market efficiency could explore many untested areas. A longitudinal analysis could track market efficiency over a more extended period, revealing the effect of regulations, tech, and geopolitics on efficiency. Examining investor behavior, sentiment, and trading patterns could reveal how human decisions affect market efficiency. Comparing different sectors of the PSE, considering liquidity and market capitalization, could show how efficiency varies. Investigating the integration of blockchain and AI in the PSE could indicate their potential impact on market efficiency. Scholars can advance their knowledge of PSE market efficiency by researching these topics.

CONCLUSION

The analysis of PSE data provides several critical findings regarding weak-form efficiency and the behavior of daily index returns. The run test, which assesses the randomness of the data distribution, reveals that the distribution of data for the general, insurance, and service indices is nonrandom. These indices exhibit p-values below the significance level of 0.05, indicating a departure from randomness. However, the p-values were greater than 0.05 for the other indices, suggesting that the data distribution of the indices other than the general, insurance, and service indices was random.

The outcomes derived from the unit root test, encompassing both the ADF and PP tests, reveal a consistent pattern of stationary behavior across all indices within the PSE. The notable presence of p-values below the critical threshold and t-statistic values that fall beneath the critical level collectively endorse rejecting the null hypothesis. This compelling evidence aligns with the notion that the returns of the various indices do not adhere to the principles outlined by the RWH. The examination of serial autocorrelation delves into the assessment of autocorrelation patterns within the daily index returns. The findings unveil a discernible pattern: across four different lags, two indices – Al-Quds and general indices – showcase robust autocorrelation tendencies, while three other indices – Insurance, investment, and service – display pronounced autocorrelation at three distinct lags. In contrast, the remaining two indices – banking and industry – reveal comparatively higher p-values, signifying a less pronounced autocorrelation tendency.

Finally, the VRT, which examines the presence of a random walk process, strongly rejects the null hypothesis for all the indices at a p-value of 0.05 except for industry and insurance. Consequently, these indices exhibit an intriguing long-term, predictable pattern, offering potential avenues for predictive modeling and a deeper understanding of the underlying factors that influence their trajectory over time.

The analysis reveals that PSE index returns do not follow a random walk process and exhibit nonrandom behavior. The findings suggest predictability and potential patterns in daily returns, indicating the possibility of exploiting market inefficiencies in investment strategies. Therefore, market participants can use past securities prices to forecast future prices, implying that investors and market participants can exploit this predictability to make informed decisions and develop trading strategies based on the observed index return patterns.

AUTHOR CONTRIBUTIONS

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Investigation: Elias Mukarker.
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