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The effect of oil price on stock market performance and petrochemical stock value using NARDL

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ABSTRACT

The aim of the study is to examine the impact of oil prices on the stock market performance and the stock value of petrochemical companies on the Tehran Stock Exchange (TSE). For this, it utilizes the Non-linear autoregressive distributed lag during 2011 to 2021 using time series data with monthly frequency. The results showed that in the short run, the oil price has an asymmetric impact on the stock value of petrochemical industries and also on the performance of the stock market, while in the long run, this effect is symmetrical. So, the influence of bouncing up the oil price is greater than the impact of its moving down. Then, the asymmetric effect happens through the increase in oil prices. Therefore, ups and downs in oil prices lead to fluctuations in the stock market returns, especially in petrochemical companies. Based on the results, capital market participants should watch the informational content of oil price fluctuations to make buying and selling decisions and invest in companies' shares according to these fluctuations.

I. Introduction

In stock markets, small savings can be optimally placed on the path of movement towards more considerable investments. Participation in this market for investors deciding on the best investment options is a breathtaking issue. Consequently, based on the decision theory in uncertain conditions, the decision-makers try to pick out the best available options (Bird et al., 2014). In the current era, crude oil is known to be a crucial important factor in producing all kinds of products. In any economy, fluctuations in crude oil prices can have both positive and negative shocks on economic developments. The oil price is one of the most exogenous variables that affect many economic variables, including the stock exchange index (Samadi et al., 2007).

One of the logical reasons for using oil price as the most essential element in stock market analysis is the valuation of stock prices by the present value of future cash flows that are affected by macroeconomic events (Bhar and Nikolova, 2009). In oil exporting countries, the influence of the oil price related variations may be varied, so oil revenues affect the main variables of these economies. Therefore, oil price fluctuations affect these companies' productions, operations, and sales, which ultimately varies stock returns and stock market value (Paytakhti Oskooe and Shafei, 2016). To study how the oil price affects the stock market, researchers have examined the impacts of oil price variations on the stock exchange value, (see Ciner, 2013; Bouri, 2015; Mohanty et al. 2010; Phan et al., 2015; Cunado and de Gracia, 2014; Nusair, 2016; Dizaji, 2014). The last studies showed that the inflation in oil price has multiple influences on exporting and importing countries; as a consequence, this research has examined the impact of crude oil prices on Iran's stock market and petrochemical stocks using the NARDL approach. In the following, the literature review and background, research methods and patterns, findings, and finally the conclusion have been discussed.

2. Literature Review and Theorical Background

Considering the relationship between oil prices and stock market indices can get care from investors to build up an investment portfolio and risk caring in the stock market. Also, it can help policymakers in regulating and effectively monitoring the stock market. Although the stock

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market in oil-exporting countries, including Iran, has less depth, the changes in oil prices affect the returns of the stock market and the stock value in different ways.

First of all, the liquidity is created by exporting oil. In this way, with the increase in the oil price, abundant foreign currencies will flow to the Foreign Exchange Reserve Account. Oil price shocks coupled with the rise in oil revenues result in a broadening of the monetary base, and inevitably leads to liquidity growth and higher inflation rates. Besides, such an oil price shock leads to a depreciation within the real exchange rate and a decline in economic competitiveness in all scenarios. Hence, monetary rules-regardless of the exchange rate regime would lead to a lack of competitiveness with shifting degrees of intensity (Amiri et al., 2021). A positive affiliation between oil prices and financial liquidity in the medium run. Monetary liquidity led oil prices in the short run during the worldwide monetary retreat (Khan et al., 2021). Therefore, when there isn't sufficient request for these currencies, the Central Bank must oversee the currency exchanges and constrained to purchase it and alter it to Rial for governmental transactions, as the result of these policies, bouncing the net foreign assets of the Central Bank and expanding the monetary amount of the country. On the contrary, at the time of oil price reduction, since the government could not dimmish its expenses, it is forced to borrow from the Central Bank; subsequently, the government's net obligations to the Central Bank has expanded, which moreover increased the monetary amount of the country. In this manner, the government's financial policy may increment the money supply. A boost in the sum of money in the economy can affect the stock price index both as a political variable at the large scale and as a portion of a portfolio (Ebrahimi and Shokri, 2012).

Second, entering foreign currency into the country, that is, the drift of oil prices happens through foreign currency. Since oil is exchanged for dollars in the international markets, eventually, with the increase in the oil price, a lot of foreign currency enters the country; in this case, two scenarios arise: the first scenario is an increase in the oil price, an increase in income and it follows foreign exchange reserves, which result in strengthening the value of the national currency against foreign currency. This situation leads to an increase in the income of companies that export goods and in the value of their shares. In the second scenario, an increase in the oil price will reduce the profitability of importing companies and ultimately reduce the value of their shares (Morley and Pentecost, 2000).

Third, the bounce of oil prices impacts society's desires. The going up the oil prices bring up oil incomes for oil-supplying countries, at that point it leads to the formation of optimistic expectations related to the development and prosperity of economic exercises in the country, which causes expectations to extend the profitability of listed companies will ultimately lead to the increment and positive growth of the future long run cash stream and, consequently, increase the stock index (Fang et al., 2009).

Fourth, another impact path of oil prices is on income channel. Selling oil at a higher price blows wealth from oil-importing countries to oil-exporting countries. The influence of this increase depends on the government's utilization of it. In case these incomes adjust with the purchase of domestic services and merchandise, it will raise the public wealth. Contrarily, with the increment in demand for labor and capital, many investment opportunities will pop up. As a result, it leads to a positive drift in the future cash flow of companies. Inflation in oil price, however, as a production input leads to an increase in the cost and a decrease in the income of the companies, which hurts the cash flows of the companies, which will reduce the market value of these companies (Hassanzadeh and Kianvand, 2014).

Fifth, the oil prices have a reversible impact. The oil price inflation moves quickly up the cost of products made by developed countries, and since most of the countries supplying oil do not have the necessary ability and technology to process oil, they import oil products and their derivatives, which has a negative effect on the future cash flows for the companies located in these countries, and consequently, it leads to a decrease in the stock market value (Arouri and Rault, 2009).

Hosseini and Dadras Moghadam (2022) showed that companies' stock returns are strongly influenced by oil price shocks. Mohammadi et al. (2021) have found a negative and significant relation between oil prices and returns of asset for companies in the chemical and refining industry on TSE. Taleblo et al. (2017) have found that the oil price shocks contain a negative impact on the stock returns, and it will take four future periods to alter its effect. Sardar and Sharma (2022) explored the non-linear relation between oil prices and stock returns by modeling the asymmetric effect around the zero lower bound using government-dependent local forecasts; they showed that when the economy works in the zero lower bound, oil price shocks raise stock returns. However, when interest rates are high, stock returns and oil prices have a negative relation. Alzyadat et al. (2021) presented evidence of a reverse asymmetric effect in the Saudi Arabian stock market during the period before the COVID-19 pandemic. Cheikh et al. (2021) found that the stock markets of the Persian Gulf Cooperation Council do not have the same sensitivities to oil price variations and documented that oil price variations have asymmetric impacts on stock returns in some countries of the Persian Gulf Cooperation Council. Liu et al. (2020) explores the response of China's petrochemical markets to oil price hops. They showed that the current oil price bounced have reversely drifts on the proceeds of petrochemical products and petrochemical stocks. But the effect of the postponed transformations on these earnings is inverse. So, the previous could be a reflection of panic caused by information of extreme peril, and the last is a reflection of rationality by hoarders. According to the above arguments, the following hypotheses can be proposed:

- The rise and fall of oil prices have asymmetric drift on the stock market index.
- The rise and fall of oil prices have asymmetric drift on the petrochemical industries stock index.

3. Research Method and Model

This study is a post-event research. Secondary data collection method was used to collect the necessary data and information. These monthly data have been gathered for the period 2011-2021 the websites of TSE and Rahavard-Navin database. Since the oil price is an exogenous variable compared to the stock market index, the autoregressive distributed lag (ARDL) can be used. Still, the reaction of the stock market to oil price fluctuations may be different and non-linear. So, a non-linear autoregressive distributive lag (NARDL) is better to employ (Kumar et al. 2023). In this method, the effect of ups and downs of oil price is separated into two categories, because of different responses of the stock price index.

The NARDL, an amplified form of the ARDL, was created by Granger and Yoon (2002). This method is utilized to identify non-linear and asymmetric relations between variables within the long and short run. In this way, the fluctuations of the variables are divided into two groups of ups and downs fluctuations. The $NARDL_{pq}$ model is defined as follows:

$$Y_t=\sum_{i=1}^{p}\omega_j Y_{t-i}+\sum_{i=0}^{q}(y_i^+ X_{t-i}^+ + y_i^- X_{t-i}^-)+\varepsilon_t \quad (1)$$

Positive and negative fluctuations are defined as follows:

$$X_t^+=\sum_{j=1}^{t}\Delta X_j^+=\mathrm{Max}(\Delta X_{j.0}) \quad (2)$$

$$X_t^-=\sum_{j=1}^{t}\Delta X_j^-=\mathrm{Min}(\Delta X_{j.0}) \quad (3)$$

The cumulative NARDL model with short-term and long-term asymmetry is equal to:

$$\Delta Y_t=\mu+pY_{t-1}+yX_{t-1}\sum_{i=1}^{p-1}\omega_i\,\Delta Y_{t-i}+\sum_{i=0}^{q-1}(\vartheta_i^+\Delta X_{t-i}^+ + \vartheta_i^-\Delta X_{t-i}^-)+\varepsilon_t \quad (4)$$

$$\Delta Y_t=\mu+pY_{t-1}+y^+X_{t-1}^+ + y^-X_{t-1}^- + \sum_{i=1}^{p-1}\omega_i\,\Delta Y_{t-i}+\sum_{i=0}^{q-1}\vartheta_i\,\Delta X_{t-i}+\varepsilon_t \quad (5)$$

When an asymmetry is detected in the NARDL model, either in the short or long run, this asymmetry reacts to a positive or negative shock. This direct reaction is derived from positive and negative dynamic coefficients and is related to a change in X^+ and X^-. The use of this model has the following advantages: (1) This model can be used regardless of whether the variables of the model are I(1) and I(0) or a combination of both. (2) This method does not include the short-term dynamics in the error correction part. (3) This method can be used with few observations. (4) It is possible to use this method even when the explanatory variables are endogenous (Monjazab and Nosrati, 2018).

The first model to test the first hypothesis:

$$\Delta LTSE_t=\beta_0+\beta_1\textstyle\sum_{t=1}^{t}\Delta LTSE_{t-1}+\delta_1 LTSE_{t-1}+\delta_2^+ LOILP_{t-1}+\delta_3^- LOILP_{t-1}+D1+D2+\delta_4 ECT_{t-1}+\varepsilon_t \quad \text{Model (1)}$$

The second model to test the second hypothesis:

$$\Delta LPETRO_t=\beta_0+\beta_1\textstyle\sum_{t=1}^{t}\Delta LPETRO_{t-1}+\delta_1 LPETRO_{t-1}+\delta_2^+ LOILP_{t-1}+\delta_3^- LOILP_{t-1}+D1+D2+\delta_4 ECT_{t-1}+\varepsilon_t \quad \text{Model (2)}$$

The dependent variables:

LTSE: A logarithm of the stock exchange index, the stock price index in the TEPIX of TSE, is based on the Laspeyres formula.

LPETRO: A logarithm of Petrochemical Industries Index in the TSE.

The independent variable:

LOILP: A Logarithm of the price of each barrel of OPEC crude oil is used as an explanatory variable.

Dummy variable:

The time series may undergo sudden switching that leads to structural failure, and ignoring it will cause false results. In the time frame of this study, factors such as Iran's nuclear negotiations, oil and non-oil sanctions, turning to clean energy such as wind and solar power, the political risk of the OPEC member countries, and finally, the COVID-19 pandemic, affected the oil price. They made a strong impact. Therefore, the following dummy variables have been used.

D1: the first dummy variable (from December 2017 to July 2018, it takes 1 and for the rest it takes zero).

D2: the second dummy variable (from February 2016 to March 2019, it takes 1 and for the rest it takes zero).

4. Findings

4.1. Checking the reliability of the variables

If the variables of a model do not have a single root, the results will be completely misleading. This problematic situation leads to false regression (Koop, 2013). In examining the significance of research variables, the results of the generalized Dickey-Fuller test and Phillips-Perron test showed that all variables are significant with one lag difference.

Table 1: Stationarity test: Dickey-Fuller & Phillips- Phillips-Perron

Variables	ADF				PP			
	Zero order difference		First order difference		Zero order difference		First order difference	
	t	**Sig.**	**t**	**Sig.**	**t**	**Sig.**	**t**	**Sig.**
LOILP	-2.561	0.103	-8.770	0.000	-2.224	0.198	-11.919	0.000
LTSE	0.789	0.993	-6.927	0.000	1.055	0.997	-6.943	0.000
LPETRO	0.563	0.988	-8.065	0.000	0.633	0.990	-8.655	0.000

According to Table 1, the results of the unit root tests, the NARDL approach is suitable for the estimation.

4.2. Diagnostic tests: according to Table (2), the results of the diagnostic tests show that the tests of non-homogeneity of variance (Breusch-Pagan), serial autocorrelation (Brush-Godfrey), and dependent form of the model (Ramsey's RESET test) indicate the absence of serial autocorrelation and homogeneity of variance. Also, the explained model has a correct and appropriate specification.

Table 2: Diagnostic tests of the research hypotheses

Hypotheses	diagnostic tests	test results	
		f	Sig.
(1)	Variance heterogeneity	1.2291	0.246
	Serial autocorrelation	1.2554	0.289
	F-statistic	0.0274	0.868
(2)	Variance heterogeneity	0.9056	0.555
	Serial autocorrelation	0.0228	0.977
	F-statistic	0.2254	0.635

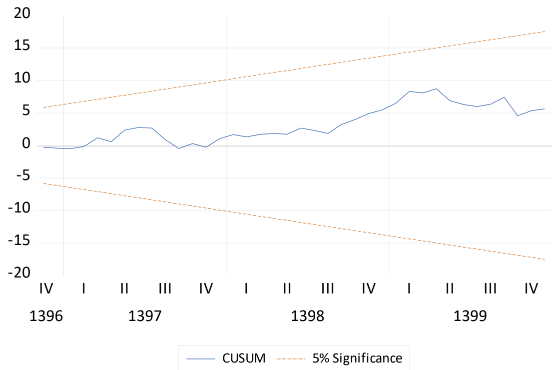
4.3. The results of the hypotheses

The non-linear ARDL approach requires determining the optimal lag. In this research, the optimal lag has been estimated using on the Hannan-Quinn criterion (for data between 100 and 200). According to the lowest value of this criterion, the optimal lag is 4, and selected models with and without dummy variables for the first hypothesis (3, 4, 3, 0, 0) and the second hypothesis (3, 4, 3, 0, 0), respectively.

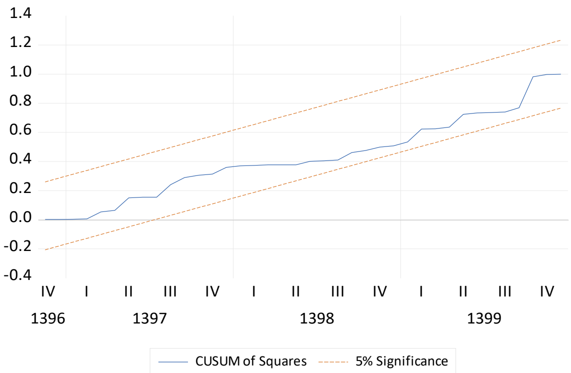
4.4. The results of the first hypothesis test

According to Table (3), in the short term, the stock market index has a lag-positive and significant effect on the stock price index in the current period. The positive oil price shock has a positive and significant impact on the stock market index in lags 1 and 4, and in lag 3, it has a significantly negative effect. Also, the negative oil price shock has a positive and significant impact on the stock market index in lag 3. In the long term, the coefficients of positive and negative fluctuations of oil prices are substantial, but according to the results of the bound test and the statistical value of F (2.484), it is less than the listed bounds at a significant level of 5%; so, there is not a long-term accumulation between the oil price and the stock market index. Based on this, the error correction model test (ECM) is not performed.

To check the stability, the sum of regression residuals test and its square have been used. The results of the tests in graphs (1) and (2) show that considering that the movement path of the residuals did not go out of the bilinear range, therefore the parameters of the hypothesis are stable.



Graph 1. Cumulative sum test of regression residuals



Graph 2. Cumulative sum of squares test of regression residuals

Table 3: Results of the first hypothesis test

variable		coefficient	t statistic
C		0.812	2.681**
LTSE(-1)		1.233	13.420**
LTSE(-2)		-0.145	-1.030
LTSE(-3)		-0.168	-1.937
LOILP_POS		-0.036	-0.248
LOILP_POS(-1)		0.328	2.016*
LOILP_POS(-2)		.0295	1.872
LOILP_POS(-3)		-0.664	-4.698**
LOILP_POS(-4)		0.284	2.699**
LOILP_NEG		-0.007	-0.084
LOILP_NEG(-1)		-0.228	-1.630
LOILP_NEG(-2)		0.053	0.330
LOILP_NEG(-3)		0.300	2.415*
D1		-0.041	-1.322
D2		-0.042	-1.341
F statistic		Adj. R^2	DW
1894.1*		0.995	1.984
LOILP_POS		2.546	4.398**
LOILP_NEG		1.458	2.890**
D1		0.514	1.317
D2		0.527	1.801
		F-bound test	
F statistic	I(1)	I (0)	Sig.
	3.22	2.303	10%
2.484	3.698	2.688	5%
	4.787	3.602	1%

** Significance at the 1% level, * Significance at the 5% level.

According to Table (4) and also according to the significance of the F statistic in the short term, the oil price has an asymmetric effect on stock returns. On the other hand, considering the non-significance of the F statistic in the long term, the H_0 of this hypothesis (symmetric effect) is confirmed. The results of the Wald test also confirm the results of Table (3) and show that the oil price affects the stock market index only in the short term.

Table 4: Wald test results for the first hypothesis

Short term F-statistics	Long-term F-statistics
8.1743**	0.0113

** Significance at the 1% level, * Significance at the 5% level.

4.5. The results of the second hypothesis test

According to Table (5), in the short term, the petrochemical industry index has a positive and significant effect on the petrochemical industry stock price index in the current period. The positive oil price shock has a positive and significant effect on the petrochemical index in lags 1 and 4, and in lag 3, it has a negative and significant impact. So, with a 1% increase in the oil price, the stock index of petrochemical industries decreases by 0.74% (lag 3). Also, the negative shock of oil prices has a positive and significant effect on the index of petrochemical industries in lag 3. In the long term, the coefficients of positive and negative fluctuations of oil prices are significant, but according to the results of the F-bound test and the value of the F statistic of 2.175, it is 5% less than the listed bound at a significant level; therefore, there is a difference between the oil price and the petrochemical industry index. There is no long-term co-accumulation. Based on this, the test of the error correction model (ECM) is not performed.

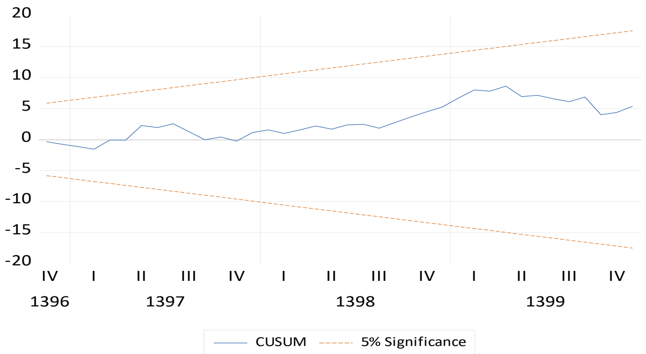
Table 5: The results of the second hypothesis test (effect of oil price on petrochemical index)

variable	coefficient	t statistic
C	0.520	2.555**
LPETRO(-1)	1.151	12.383**
LPETRO(-2)	-0.046	-0.333
LPETRO(-3)	-0.175	-2.010*
LOILP_POS	-.127	-0.751
LOILP_POS(-1)	0.405	2.148*
LOILP_POS(-2)	0.375	2.043*
LOILP_POS(-3)	-.742	-4.504**
LOILP_POS(-4)	0.293	2.399*
LOILP_NEG	0.033	0.340
LOILP_NEG(-1)	-0.236	-1.445
LOILP_NEG(-2)	-0.016	-0.090
LOILP_NEG(-3)	0.342	2.3838*
D1	-0.024	-0.670
D2	-0.042	-1.195
F statistic	Adj. R^2	DW
1419.9*	0.994	1.98
LOILP_POS	2.890	36.55**
LOILP_NEG	1.745	2.460*
D1	-0.343	-0.677
D2	-.604	-1.659

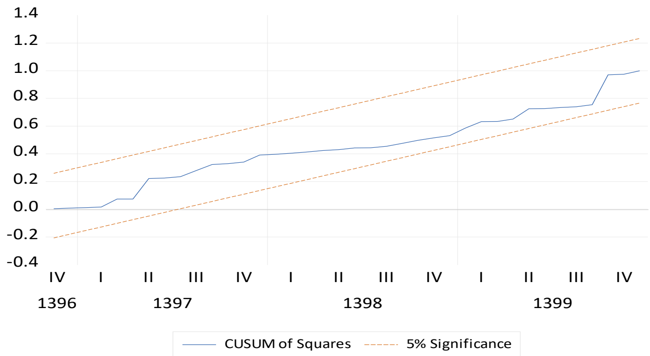
F-bound test			
F statistic	I(1)	I (0)	Sig
2.175	3.22	2.303	10%
	3.698	2.688	5%
	4.787	3.602	1%

** Significance at the 1% level, * Significance at the 5% level.

The results of parameter stability tests in graphs (3) and (4) show the stability of the hypothesis parameters.



Graph 3. Cumulative sum of squares test of regression residuals



Graph 4. Cumulative sum of squares test of regression residuals

To check the symmetry in the short and long term, the Wald test is used, the null hypothesis of which is the existence of symmetry effect in the short and long term, if the significance probability of this test is less than 5%, the null hypothesis is rejected, which means that there is an asymmetric effect (Monjazab and Nosrati, 2018).

Table 6: Wald test results for the second hypothesis

Short term F-statistics	Long-term F-statistics
8.1329*	0.3725

* Significance at the 1% level, ** Significance at the 5% level.

Based on the results of Table (6) and considering the significance of the F statistic in the short term, the null hypothesis of the Wald test, i.e., the existence of a symmetric effect, is rejected. In other words, the oil price has an asymmetric impact on the stock index of petrochemical industries in the short term. On the other hand, considering the non-significance of the F statistic in the long term, the null hypothesis of this hypothesis is confirmed, so, in the long run, the oil price has a symmetric impact on the stock index of petrochemical industries.

5. Conclusions and suggestions

In the economic development of countries, the oil price and the stock market are constantly related to each other. Hence, considering the acceptance of the individuals, economic operators, and investors to activate in the TSE, and on the other hand, since the large and index-making companies, in the TSE are basically petrochemical companies whose volume, in addition to their transactions affecting the movement of the stock market index, the investigation of the impact of oil prices on the stock market performance and the value of petrochemical stocks seems to be a significant issue. In this article, by using time series data with monthly frequency in the period from 2011 to 2021, using the NARDL approach, the effect of oil price on the performance of the stock market and petrochemical industry index was explored. The results show that in the short term, the oil price has an asymmetric effect on the stock market index and the petrochemical index (this results are like Kumar et al. 2023, and Okere et al., 2021), while in the long term, this effect is symmetrical. Since oil price fluctuations have influenced the behavior of investors, so oil price variations have informational content. Therefore, it is recommended that to make the right decision, investors be aware of how the oil price affects the stock market and petrochemical index, because this helps to identify the right time for how to invest and create profit in the stock market. In other words, investors can determine the right time to enter or exit the market by carefully studying the impact of oil prices in the breaks, thus, they will achieve a good return. They can choose a suitable strategy for themselves. On the other hand, managers of petrochemical companies, knowing the different effects of oil prices, can adopt appropriate strategies in the short and long term to maintain the company's competitive position in the market and increase the stock value. Since the oil price variable is considered a powerful exogenous variable, financial managers and investors should examine the actual performance of the company in their evaluations and pay attention to oil price fluctuations as a variable with informational content. In the meantime, the government can reduce its excessive reliance on oil revenues by using tax revenues. Also, it seems necessary to design strategies that can guarantee stability in the capital market along with the serious pursuit of policies supporting economic growth regardless of oil price shocks under sustainability (see Alvarado et al., 2022a, 2022b, Deng et al., 2022; Ongan et al., 2022; Altunöz, 2023; Dogru et al., 2023; Han et al., 2023a, 2023b; Islam et al., 2023; Sümerli et al., 2023; Cui et al., 2024; Işık et al., 2024a, 2024b, 2023, 2021, 2020; Pasigai & Jusriadi, 2024; Rana et al., 2024).

Some limitations in the implementation of this study, such as exchange rate, inflation, interest rate, along with oil price, have an effect on the stock value, therefore, it is suggested to include these factors in the models for future researches.

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Data availability: The datasets generated and analyzed during the current study are available at the Tehran Stock Exchange, and Rah Avard Novin Information Bank.

Conflicts of Interest: The authors declare no conflict of interest.

Compliance with ethical standards

Ethics approval and consent to participate: Not applicable.

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