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Received: 11 January 2024

Accepted: 14 October 2025

Pakistan's Stock Market Reaction to Large and Small Shocks in Oil Prices: An Assessment with the MT-NARDL Model

Abstract: This article empirically explores the impact of both small and large fluctuations in the crude oil prices on Pakistan's stock market utilizing the multiple t hreshold non-linear autoregressive and distributed lag model from 1997–2021. The empirical results demonstrate that larger shocks to the prices of crude oil have a significant negative impact on Pakistan's stock market. However, small shocks to the prices of crude oil positively stimulate its activity. Pakistan's stock market is heavily and asymmetrically impacted by the United States' stock market: positive shocks, reflected in the Standard & Poor's 500, have a positive impact on Pakistan's stock market, while negative shocks have an adverse effect. All estimated coefficients are statistically significant. Pakistan's stock market is also negatively affected by foreign direct investments (FDI) and exchange rates, but the inflow of remittances has a positive effect. Based on empirical findings, the article recommends that policymakers in both the private and public sectors should estimate the expected fluctuations in the prices of crude oil, FDI, remittance inflows, and exchange rates when investing in the Pakistani stock market.
Keywords: Pakistan stock exchange, S&P 500, Crude oil, Foreign direct investment, Non-linear autoregressive distributed lag
JEL: G_0, G_1, G_2

1. Introduction

A significant amount of capital inflow has been observed in the stock exchanges of developing countries from developed countries due to recent financial liberalization, which has resulted in financial integration (Baharumshah & Thanoon, 2006; M. K. Khan, Teng, Khan, & Khan, 2023). These global markets are connected through commodity prices, such as for oil and gold, as well as interest rates and other variables. Among other commodities, crude oil is one of the primary sources of energy in the economy, which significantly affects economic and political conditions (Alamgir & Amin, 2021; Galieriková & Materna, 2020; Hashmi, Ahmed, Alhayki, & Syed, 2022; Hashmi, Chang, Huang, & Uche, 2022; Sodeyfi & Katircioglu, 2016).

Increases in oil prices can be expected, unexpected, and exogenous. They can be transmitted to real economic activities through demand and supply channels (Alamgir & Amin, 2021; Herrera, Karaki, & Rangaraju, 2019; Olomola, 2006; Olomola & Adejumo, 2006). The supply-side effects include, if oil prices rise, a rise in the costs of production and a fall in productivity, whereas demand-side effects can be seen in a decrease in household consumption (Alamgir & Amin, 2021; Olomola, 2006; Olomola & Adejumo, 2006). These economic changes can be reflected in the performance of the stock markets of oil-importing countries. Falling stock prices can lead to decreases in household wealth, consumption, investor confidence, and overall global investment in those countries (Alamgir & Amin, 2021; M. I. Khan, Teng, Khan, Jadoon, & Khan, 2021; Prabheesh, Padhan, & Garg, 2020).

In recent times, prices of oil have shown considerable volatility such as increasing to $132.3 from the low level of $73 during 2000 to 2008 and declining to $39.95 during the financial crisis. However, in 2011, oil prices jumped to $100 per barrel and fell back to $26.68 in 2016, even turning negative on April 20, 2020 (Hashmi, Ahmed, et al., 2022; Prabheesh et al., 2020). Such volatility affects the stock market directly (Hashmi, Ahmed, et al., 2022; Liu, Umair, & Gao, 2023) through supply- and demand-side channels, (Olomola, 2006; Olomola & Adejumo, 2006; Sodeyfi & Katircioglu, 2016).

Shocks in oil prices can be small, medium, or large. Each type of shock can have significantly different impacts. Small shocks can be gradual and easily absorbed by the market, while medium or large shocks (often caused by geo-political events) can disrupt the stability of an oil-importing, developing country like Pakistan. The study of these shocks, especially in the presence of asymmetric effects of the United States' Standard & Poor's 500 (S&P 500), can greatly enhance the ability of policy makers to mitigate its risk.

The present article addresses a research gap by examining the short- and long-term impact of small, medium, and large shocks in oil prices on the stock market of Pakistan during 1997 and 2021 in the presence of asymmetric shocks of S&P 500. The multiple threshold non-linear autoregressive and distributed lag (MT-NARDL) model has been used to decompose the shocks in S&P 500 into negative and positive along with other explanatory variables such as foreign direct investments (FDI), the inflow of remittances, and exchange rates. As far as the researchers know, this approach has not yet been applied in this context, though other authors have adopted a variety of methodologies (Chang, 2020; Cheikh, Naceur, Kanaan, & Rault, 2021; Pal & Mitra, 2016). The MT-NARDL model provides a new perspective on how oil price shocks can impact emerging economies, specifically Pakistan. The peculiarities of Pakistan being an oil-importing and developing economy necessitate a customized analysis, and our results pave the way for better comprehension of the influence of oil price shocks on the stock market in this background.

2. Literature Review

There are various theories in economics and finance that can inform economic agents about the working of stock markets. The popular theories include the efficient market hypothesis (EMH) presented by Fama (1970), the theory of global spill-over effects, and the symmetric and asymmetric transmission mechanisms of oil prices into stock markets through the study of changes in the decision-making of consumers, producers, businesses, governments, and financial institutions.

The EMH posits that information regarding changes in the oil price is readily available to all market participants and is promptly incorporated into stock prices. Ideally, movements in the stock market in response to changes in oil prices should be immediate and rational. In other words, once information comes to light, it is ideally readily available and easily interpreted by the agent by factoring it into the prices of various companies' stocks. This implies that if the Pakistan stock market is efficient, stock prices should adjust very quickly to changes in global oil prices. These adjustments should rapidly occur as soon as the information is available to the economic agents in the markets. In this fully logical market, the distinction of shocks into small, medium, and large becomes irrelevant as economic agents rapidly and rationally adjust their decisions according to the changing market conditions.

On the other hand, the theory of global spillover effects considers the global connectedness of world markets. It explains that disturbances in one market, especially a large market, can be rapidly transmitted to other emerging markets through this global spillover effect. Theories of global market integration suggest that major global indices have a significant influence on the stock markets of emerging countries, including Pakistan. Oil price shocks that are hit the global economy can simultaneously affect financial markets both globally and in Pakistan. Therefore, the fluctuations of the S&P 500, being indicative of global investors' sentiments, can rapidly spread to the Pakistan Stock Exchange (PSX). The evidence provided in the current study will therefore be significant for Pakistani policy as the impact of positive and negative shocks to the S&P 500 accords with global spillovers theories, which suggests that markets are connected in a globalized financial system.

The transmission mechanism of the changes in oil prices into stock markets also occurs through various channels. For instance, Dvarionienė et al. (2012) pointed out that oil price changes affect stock markets through cost–push and demand–pull channels. In cost–push channels, higher oil prices increase production costs. Businesses can increase the prices of commodities for end users, see reductions in profits, or even operate at a loss, as it is sometimes very difficult for firms to raise prices due to competition. The demand-side effects arise when higher oil prices reduce households' purchasing power. This can be due to rising energy bills or the increased prices of finished goods. In both cases, the real income of a household falls, leading to reduced investment. In the combination of the above factors, economic growth and development can be significantly slowed. These theories imply that large oil price shocks have a negative association with the PSX, which is consistent with the cost–push and demand-side perspectives, since large shocks have a more devastating impact on production and consumption than small ones.

The asymmetric impact of oil price fluctuations on stock markets is another key economic concept at play. Models that decompose changes in oil prices into asymmetric and nonlinear components, such as the NARDL model employed in this study, propose that positive and negative oil price shocks have asymmetric effects on economies and stock markets, which consequently invalidate the empirical results drawn from models that are based on linear association. Positive oil price shocks may indicate an increased demand in the global economy and higher future profits, which could potentially trigger a positive response on the stock market. Conversely, negative oil price shocks, especially large ones, can instill fears of an economic slowdown among economic agents, which can in turn trigger expectations of a reduction in corporate profitability and, consequently, an adverse reaction in the stock market.

The positive effects of small oil price shocks and the negative effects of large price shocks align with asymmetric economic theories. A small shock might occur due to a positive economic environment (e.g., the slow growth of oil prices). In contrast, a large one suggests an economic disruption (e.g., due to a geopolitical crisis or a supply-side issue). In yet another perspective, the response of economic agents to large shocks would also depend on how long the large shocks are expected to last. If it is expected that larger shocks are short-lived, the magnitude of the negative reaction can be lessened. However, if large shocks are permanent or stay relatively constant for a long time, their negative impact will be greater. In such situations, research into alternative energy sources will intensify. If significant progress is made, the negative impact can become smaller over time at a rate that corresponds to the widening adoption of alternatives.

Empirical studies have sought to explain the real-world economic impacts of oil price fluctuations within the frameworks described above. These studies have been diverse regarding the regions evaluated, their sample sizes, the nature of the data used, the choice of econometric technique, and so on.

Shabbir, Kousar, and Batool (2020) investigated the impact of prices of two essential commodities (gold and crude oil) on the PSX. They used a dataset from 1991 to 2016 and estimated an ARDL model. The bound test detected that there was a long-run equilibrium relationship among these variables. They reported that there had been a negative relationship between prices of crude oil and stock exchange activities in Pakistan.

Sheikh, Asad, Ahmed, and Mukhtar (2020) investigated the relationship between macroeconomic variables, including oil prices, and stock exchange of Pakistan using the NARDL model. They used time series data divided this data into three parts: pre-financial crisis (January 2004–January 2008), post-crisis (January 2010–January 2018), and the entire period (January 2004–January 2018). The macroeconomic variables included the prices of crude oil and gold and the exchange rates. They concluded that a symmetrical relationship among the macroeconomic variables and Pakistan's stock exchange had existed before the financial crisis but was replaced by an asymmetrical relationship after the crisis.

M. K. Khan et al. (2023) analyzed the impacts of changes in the prices of crude oil, gold, and the exchange rate on the returns of the Shanghai stock market, China. They collected time series data at a monthly frequency between 2000 and 2018 and estimated a dynamic simulated ARDL (DS-ARDL) model. They reported that changes in the prices of crude oil and gold had a direct impact on the returns to stocks in both the short and long runs, whereas exchange rates had an inverse effect in the same period.

The dynamic relationship between the prices of crude oil, exchange rates, and returns to stock in Pakistan was also investigated by Hashmi, Chang, et al. (2022) during 2000 and 2019. They collected quarterly data and applied a Quantile ARDL (QARDL) model. They reported that the impact of changes in the prices of crude oil and exchange rates varied across bullish, bearish, and normal states.

Prabheesh et al. (2020) studied the relationship between stock returns and oil prices when the global economy was impacted by COVID-19, specifically for Asian countries that were net oil importers, including China, Japan, India, and Korea. They fitted the DCC-GARCH model for the period of 1 January 2020, to 8 June 2020. They reported a positive correlation coefficient with small values of the coefficients. However, from February to March, the correlation coefficients had strengthened. This indicated that COVID-19 had improved the relationship between crude oil price and stock exchanges of these countries.

In a similar study, Hashmi, Ahmed, et al. (2022) examined the impact of crude oil prices on China's stock exchange and various industries from 26 December 2001 to 30 April 2019. They found that the effects of oil prices on the Chinese stock exchange and its main sectors were significant.

M. I. Khan et al. (2021) analyzed the effects of crude oil prices and other macroeconomic factors on the development of Pakistan's stock exchange. They used time series data from 1985 and 2017 and utilized a DS-ARDL model. They found that an increase in the prices of crude oil, FDI, and the inflow of remittances positively affected the PSX and its development. In contrast, the exchange rate had a negative impact on the PSX and its development.

Atil, Nawaz, Lahiani, and Roubaud (2020) investigated the impact of changes in the prices of crude oil on Pakistan's financial development. They used data from 1972 to 2017. They reported that changes in the prices for crude oil had a positive effect on the financial development index, including the stock market as a dimension of the financial development in Pakistan.

Alamgir and Amin (2021) examined the relationship between the prices of crude oil and stock exchanges in Bangladesh, India, Pakistan, and Sri Lanka, utilizing data from 1997 to 2018. They used a NARDL model and established a positive correlation between oil prices and the stock exchange. Moreover, they found that stock exchanges reacted directly to the adverse shocks in the oil prices. However, they confirmed a positive linkage between the prices of crude oil and the stock exchange in both the long and the short run.

The linkage between volatility and returns in stock exchanges has been investigated by Sarwar, Tiwari, and Tingqiu (2020) for the stock markets of Karachi, Bombay, and Shanghai. They used different frequencies of data—namely daily, weekly, and monthly—from 1997 to 2015. They estimated a BEKK-GARCH model for the data, which was divided into pre- and post-financial crisis. They concluded that the spillover effect of oil price volatility varied across the markets and over time. Overall, they confirmed the bidirectional spillover between the volatility of crude oil prices and Karachi's stock exchange of Karachi. However, it was unidirectional in the case of the Shanghai stock exchange. The stock exchange of Bombay showed no precise results. These findings were consistent both before and after the financial crisis.

Chang (2020) assessed the linkage of extremely small and extremely large changes in the prices of crude oil with the stock exchanges of Brazil, Russia, India, Mexico, China, Indonesia, and Turkey. He estimated a MT-ARDL model for the daily data from 23 September 1997 to 6 February 2020. He decomposed shocks in the prices of crude oil into deciles and five partial sum series. He concluded that both in the short and long run, there was an asymmetric relationship between prices of crude oil and the stock markets when shocks in oil prices were decomposed into five partial sums.

Salisu and Isah (2017) reported that, using Panel NARDL, the relationship between stock prices and oil prices was asymmetrical in both oil-exporting and -importing countries. In a similar study, Hashmi, Chang, and Bhutto (2021) studied the asymmetric effect of oil prices on the stock prices of selected oil-exporting (Russia, Mexico, Venezuela, Norway) and oil-importing (i.e. India, China, Japan, South Korea) countries based on daily time series data from 25 September 1997 to March 2020. They used a QARDL model and reported that stock prices reacted asymmetrically to shocks in oil prices in the short and long runs for both oil-exporting and -importing countries.

Ghosh and Kanjilal (2016) explored non-linear co-integration, with endogenous structural breaks, between oil prices and India's stock exchange. They collected daily time series data on the prices of crude oil, the exchange rate, and the Bombay stock exchange indices for the period from 2 January 2003 to 29 July 2011. They did not find any relationship in the long run among the variables for the whole sample. However, when they divided the data set into three shorter phases, they found that a long-run co-integration relationship existed only in Phase II. They also reported that the Toda-Yamamoto version of the Granger causality test showed that crude oil Granger-caused stock exchange in India in Phase II and III. However, no impact was found from stock exchange on the crude oil prices.

Liu et al. (2023) noted that the growth rate of productivity and business activities at stock exchanges were adversely affected at the global level by the prices of gold and oil during the financial market crisis and the COVID-19 pandemic. The prices of commodities showed significant volatility and uncertainty. They investigated the influence of these commodities' prices on the stock exchanges of five countries from 2000 to 2020. They selected Germany, Japan, France, the United States, and China as case studies. They reported that increasing volatility negatively influenced returns to the stocks of different companies.

In a similar vein, Joo and Park (2021) conducted a study to investigate the relationship between the volatility of crude oil prices and stock exchanges in 10 major oil-importing countries (France, India, Italy, China, Germany, South Korea, Japan, Spain, the Netherlands, and the United States). The study period was from May 2001 to December 2019. They reported that the stock exchanges showed asymmetrical responses to the uncertainty in the prices of crude oil. They also tested the sensitivity of the results to the level of returns to stock of these countries and the prevailing conditions in the crude oil market. Consequently, they revealed that when volatility in the prices of crude oil and stock returns was low, volatility in oil prices had a negative impact on stock returns. Moreover, in cases of higher returns on stocks and lower volatility in crude oil prices, an increasing impact was found on stock returns due to the volatility in crude oil prices.

Xiao, Zhou, Wen, and Wen (2018) explored how returns to stock, at aggregate as well as at sectoral levels, reacted to the uncertainty in the prices of crude oil in China in the presence of reforms introduced on 27 March 2013 to control the oil prices in the domestic market. They measured the uncertainty in the prices of crude oil by the volatility index. They concluded that markets had shown a bearish trend, and that uncertainty in the prices of oil had adversely affected returns to stocks in both the sectoral and the aggregate level. However, they also reported that these findings were dependent on whether shocks in the prices of crude oil were positive or negative. Finally, they found out that China's reforms had reduced the effects of uncertainty in the prices of crude oil (especially from positive shocks) on the return to stocks.

Alqahtani, Klein, and Khalid (2019) assessed how returns to stocks of the council of Gulf Cooperation responded to the uncertainty in the prices of crude oil. They found that the uncertainty in the prices of oil had statistically different effects from zero effects on the returns to stocks in these countries. They also found that these results varied over time and concluded that these effects were negative throughout the entire analysis period. However, they did not find homogeneous effects of uncertainty in the prices of crude oil on the returns to stocks of these countries.

Boateng, Adam, and Junior (2021) conducted a similar study on African countries. However, they performed the analysis based on the imports and exports of crude oil. They particularly focused on the COVID-19 pandemic. They also conducted their study on various distributions of returns to stock. In the selected stock exchanges, they confirmed that volatility in the prices of crude had shown a negative impact on the stock returns. These results were found to be valid when stock exchanges were heading downward. They also found that the effects of shocks on the volatility in the prices of crude oil on returns to stocks were asymmetrical. The differentiation of shocks into positive or negative was found to be of vital importance for the portfolio managers.

The variations in the prices of oil can be divided into negative and positive changes, and their impact can be analyzed in the return to stock. You, Guo, Zhu, and Tang (2017) focused on the same concept in the Chinese economy using data on a monthly frequency. The study period spanned from January 1995 to March 2016. They classified market situations into bullish, bearish, and normal stock exchange settings and confirmed that shocks to crude prices are asymmetrical. They also reported that an increasing trend in the prices of crude negatively influenced returns to stock in the bullish trend well before the financial crisis. In the other market scenarios, its impact was found to be positive and significant. On the other hand, returns to stock were found to be lower in the case of declining prices of crude oil before the financial crises and in conditions in which markets were normal or bullish.

Based on the above literature, it can be concluded that there has been no study that has decomposed the variations in the prices of crude into small, medium, and large magnitudes using methodology similar to Verheyen's (2013) in the presence of negative and positive shocks in the leading global indices of stock exchanges, or using Shin, Yu, and Greenwood-Nimmo's (2014) decomposition methodology. In this context, the present study contributes significantly to the body of literature as it is the first study, at least in the case of Pakistan, using the MT-NARDL model by Verheyen (2013).

3. Data and Methodology

3.1 Data

The present study examines the impacts of small, medium, and large changes in the oil prices and the asymmetric effects of movements in the S&P 500 (USX_t) on the stock exchange of Pakistan (PSX_t.) using foreign direct investment (FDI_t), remittances (REM_t), and exchange rates (ER_t) as the additional explanatory variables. The USX and PSX are the annual percentage changes (computed in US dollars) of equity indices, respectively. The USX_t time series has been decomposed into positive and negative shocks using Shin et al.'s (2014) methodology. FDI_t measures the net inflow of FDI_t as a percentage of Pakistan's gross domestic product (GDP). The exchange rate is the average annual exchange rate of rupees per US dollar. The value of oil is measured using the West Texas Intermediate spot average. It is decomposed into small, medium, and large shocks using Verheyen (2013) methodology. REM_t measures personal remittances received as a percentage of the GDP.

The data for USX_t, PSX_t, FDI_t , REM_t, and ER_t are collected from the World Bank's World Development Indicators (WDI). The data on the oil prices are collected from the US Energy Information Administration (EIA). Most of the studies analyzing the stock market and oil prices have used data of shorter frequencies, while the present study utilizes annual data, making data on FDI and the inflow of remittances not readily available for the shorter frequencies. Moreover, FDI and remittances are expressed in percentage of GDP and time series data for the GDP are not available for most developing countries, including Pakistan. The reason behind the use of FDI and remittances as a percentage of GDP is to avoid the outliers in these series.

The sample size is restricted to 1997–2021 because the relevant PSX data necessary for consistency and accuracy are not available before 1997. In the present study, the annual percentage change in the indices of PSX and USX is used, which are computed in US dollars. Both series are calculated with the same methodology. Unfortunately, the data on PSX before 1997 is not available.

The constraints of using FDI and the exchange rate as control variables, including FDI and the exchange rate, are crucial for capturing the wider economic environment of the stock market. Both these factors, however, have limitations. FDI could also fail to reflect investment dynamics as FDI flows are affected by a plethora of factors such as geopolitical tensions or investor sentiment, which are not directly affected by oil price shocks. There could also be other reasons behind exchange rate changes beyond changes in oil prices, such as actions of central banks, political events, and global economic conditions. Therefore, while these controlling variables are informative, their inclusion does not suggest that oil price shocks are the sole drivers of stock market dynamics in Pakistan.

3.2 Methodology

The NARDL model developed by Shin et al. (2014) is an extension of Pesaran, Shin, and Smith's (2001) ARDL model. As pointed by Shin et al. (2014), the estimation of NARDL requires that time series be integrated of order zero or one or a mix of both. It is therefore crucial to test the order of integration of the time series, which are widely tested by using Phillips and Perron's (1988) and Dickey and Fuller's (1979) unit root tests. Similarly, the MT-NARDL model is the extension of NARDL model to two thresholds by Verheyen (2013).

Because the present study analyzes the impact of small, medium, and large changes in the prices of crude oil as well as asymmetric effects of USX on the PSX, while including FDI, ER, and REM as additional macroeconomic variables, it is therefore vital to decompose USX into positive and negative values and oil into small and large shock following Shin et al. (2014) and Verheyen (2013), respectively. $USX_t^+ = \sum_{n=1}^{t} USX_t^+ = \sum_{n=1}^{t} max(\Delta USX_t, 0)$ ……………….(1)

$$USX_t^- = \sum_{n=1}^{t} USX_t^- = \sum_{n=1}^{t} mim(\Delta USX_t, 0) \text{ ……………….(2)}$$

In Equations (1) and (2), $USX_t^+$and USX_t^- represent positive and negative shocks or variations in the American stock market measured by annual percentage change in the annual market value of the S&P 500 (USX), expressed in US dollars. In other words, USX_t^+ indicates the partial sum of positive shocks in the USX, whereas USX_t^- represents the partial sum of negative shocks in the same series.

This study decomposes the Oil_t variable into $small\_c_t$, $medium\_c_t$ and $large\_c_t$, which are given in Equations (3)–(5). Below, $small\_c_t$ and $large\_c_t$ represent small and large shocks in oil prices over the study period, respectively, whereas '$medium\_c_t$' represents shocks that are neither notably small nor notably large. If shocks are not classified as small or large, they can be classified as medium. These shocks are also vital as a return to and influence on the stock exchange.

$$small\_c_t = \sum_{j=1}^{t} \{\Delta Oil_j < Q(25|\Delta Oil)\}\Delta Oil_j \text{ ………………………….. (3)}$$

$$medium\_c_t = \sum_{j=1}^{t} \{Q(25|\Delta Oil) < \Delta Oil_j < Q(75|\Delta Oil)\}\Delta Oil_j \text{ ……… (4)}$$

$$large\_c_t = \sum_{j=1}^{t} \{\Delta Oil_j > Q(75|\Delta Oil)\}\Delta Oil_j \text{ ……………………………… (5)}$$

The small, medium, and large shocks in prices of crude oil are computed at the cut-off rates of 25%, 26–74%, and 75–100%. Equations (1)– (5) are then utilized to form a NARDL model, as given in Equation (6):

$$\Delta PSX_t = \alpha_0 + \sum_{i=1}^{p} b_i \Delta PSX_{t-i} + \sum_{i=1}^{p} c_i \Delta FDI_{t-i} + \sum_{i=1}^{p} d_i \Delta REM_{t-i} + \sum_{i=1}^{p} e_i \Delta ER_{t-i} + \sum_{i=1}^{p} (g_i^+ \Delta USX_{t-i}^+ + g_i^- \Delta USX_{t-i}^-) + \sum_{i=1}^{p} (h_{1i} \Delta small\_c_t + h_{2i} \Delta median\_c_t + h_{3i} \Delta large\_c_t) + \theta_1 PSX_{t-1} + \theta_2 FDI_{t-1} + \theta_3 REM_{t-1} + \theta_4 ER_{t-1} + \theta_5 USX_{t-1}^+ + \theta_6 USX_{t-1}^- + \theta_7 small\_c_{t-1} + \theta_8 median\_c_{t-1} + \theta_9 large\_c_{t-1} + \varepsilon_t \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (6)$$

In Equation (6), the coefficients of b_i, c_i, d_i, and e_i represent the influence of these variables in the short term. Alternatively, if the coefficients of these variables are found to be statistically different from zero, it is concluded that these variables have economically meaningful effects on the dependent variable. Similarly, the coefficients of g_i^+ and g_i^- are also of particular interest in the present study. These coefficients represent how increasing and decreasing trends in the global stock market impact Pakistan's stock exchange. In economic theory, it is expected that if leading global stocks are under pressure due to any factor, it would transmit to PSX. Therefore, g_i^+ and g_i^- are positive and negative, respectively. Furthermore, it is also expected that null hypotheses $H_0: g_i^+ = 0$ and $H_0: g_i^- = 0$ will be rejected at the conventional level of statistical significance.

The model also represents the different magnitudes of shocks to the prices of crude oil and their impact on Pakistan's stock exchange. These are represented by h_{1i}, h_{2i}, and h_{3i} in the short period. It is believed that economic agents can investigate the magnitude of the shocks and thereby tailor their behavior regarding investment in stocks. It is also expected that economic agents will be more sensitive to shocks of larger magnitude, especially if these are expected to prevail for a longer period. It is in this sense that coefficients of h_{1i}, h_{2i}, and h_{3i} of key interest. These coefficients will be tested as $H_0: h_{1i} = 0$, $H_0: h_{2i} = 0$, and $H_0: h_{3i} = 0$ against the alternative that they are not equal to zero (i.e., statistically significant). The dynamics of the model for the longer period are given in Equation (6) and are represented by the parameter θ_i. This includes a total of seven coefficients, including the one-year lag coefficient of PSX.

The Wald test is employed to test the hypothesis of asymmetric effects of USX. The generalized null hypothesis is $H_0: g_i^+ = g_i^-$ against the alternative hypothesis $H_a: g_i^+ \neq g_i^-$. If the alternative hypothesis is accepted, it means that positive and negative variations in the prices of crude oil differently affect Pakistan's stock exchange and that Pakistani investors must keep a close eye on the conditions and trends of global stocks.

In Equation (6), the selection of lags can significantly affect the estimation, consistency of coefficients, and their reliability. A lag's structure can be selected manually by testing different lag options and comparing their results or by determining the criteria for optimal lag length. In the present study, the latter option is used because testing the length of optimal lag manually would be highly time-consuming. In the present model, therefore, the optimal lag length is automatically detected and selected during simulations, and empirical results corresponding to the optimal lag lengths are reported. It is not separately tested using lag length criteria as conventionally done with ARDL models. The lag structure of the variable USX_t is set to be automatically selected using Akaike Information Criterion (AIC).

The long-run asymmetric effect of USX on PXS is confirmed by using the Wald test ($H_0: \theta_5 = \theta_6$) against the alternative hypothesis. Similarly, the Wald test can be used to differentiate the impact of small and large shocks on the prices of crude oil (Oil_t) on PSX_t. The null hypothesis of the differential effects of large and small shocks in the prices of crude oil in the short run is given by $H_0: h_{1i} = h_{2i} = h_{3i}$ against the alternative hypothesis that at least one is not equal. The test statistics used for the Wald test are square and F-statistics. Finally, it is crucial to differentiate the asymmetric effects in the short run from those of the long run using the null hypothesis $H_0: \theta_7 = \theta_8 = \theta_9$ against the alternative that $H_a: \theta_7 \neq \theta_8 \neq \theta_9$ (i.e., at least one is different from the other two). This is also carried out using the Wald test.

4. Results and Discussion

Table 1 provides descriptive statistics for the data, and a graph of the time series variables is available in Supplementary Figure 1. The average exchange rate of Rupees to US dollars is 85.4749, with a maximum value of 162.906 and a minimum of 41.1115. The average of net inflow of FDI as a percentage of GDP (estimated in US dollars) is 1.10666. The maximum and minimum are 3.66832 and 0.37553, respectively. The average value of oil (i.e., the West Texas Intermediate spot average) is 55.9204 US dollars per barrel, and its maximum and minimum values are 99.67 and 14.42, respectively.

Table 1 Descriptive Statistics

Variables	ER_t	FDI_t	Oil_t	PSX_t	REM_t	USX_t
Mean	85.4749	1.1066	55.920	12.456	4.9215	9.2938

Median	81.7129	0.7722	56.65	16.693	5.1839	12.782
Maximum	162.906	3.6683	99.67	112.03	8.9909	31.0082
Minimum	41.1115	0.3755	14.42	-61.922	1.3106	-38.485
Std. Dev.	35.2104	0.9019	26.872	38.120	2.1173	17.5672
Observations	25	25	25	24	25	25

Source: Authors' calculation using E view 12.

One of the assumptions of ARDL, NARDL, and MT-NARDL is that the set of time series should be integrated of order zero *I(0)* or *I(1)* or both (Chang, 2020). Following this assumption, the estimated results of unit roots are given in Table 2 using augmented Dickey-Fuller (ADF) and Phillips-Perron (PP).

Table 2 Results of Stationarity Tests

	Unit Root Test PP									
	With Constant				With constant & trend			Without constant & trend		
	Variables	t-Statistic	Prob.		t-Statistic	Prob.		t-Statistic	Prob.	
At level	ER_t	1.566	0.999	no	-0.918	0.937	n0	4.146	0.999	no
	FDI_t	-1.890	0.330	no	-1.918	0.613	n0	-1.289	0.176	no
	Oil_t	-1.777	0.382	no	-1.818	0.664	n0	-0.074	0.647	no
	PSX_t	-4.685	0.001	***	-4.809	0.004	***	-4.515	0.000	***
	REM_t	-0.226	0.922	no	-2.957	0.163	n0	1.3416	0.950	no
	USX_t	-4.498	0.001	***	-5.628	0.000	***	-3.789	0.000	***
At First difference		With Constant			With constant & trend			Without constant & trend		
		t-Statistic	Prob.		t-Statistic	Prob.		t-Statistic	Prob.	
	ΔER_t	-2.538	0.120	no	-2.433	0.354	no	-2.110	0.036	**
	ΔFDI_t	-3.170	0.035	**	-3.162	0.116	no	-3.246	0.002	***
	ΔOil_t	-5.070	0.000	***	-5.226	0.001	***	-5.093	0.000	***
	ΔPSX_t	-11.49	0.000	***	-16.21	0.000	***	-12.25	0.000	***
	ΔREM_t	-4.178	0.003	***	-3.879	0.030	**	-3.384	0.001	***
	ΔUSX_t	-12.40	0.000	***	-18.76	0.000	***	-12.86	0.000	***
Unit Root Test ADF										
At Level		With constant			With constant & trend			Without constant & trend		
		t-Statistic	Prob.		t-Statistic	Prob.		t-Statistic	Prob.	
	ER_t	2.377	0.999	no	-0.380	0.981	no	2.837	0.997	no
	FDI_t	-2.471	0.134	no	-2.565	0.297	no	-1.415	0.142	no
	Oil_t	-1.858	0.344	no	-1.833	0.656	no	-0.259	0.582	no
	PSX_t	-4.685	0.001	***	-3.695	0.046	**	-4.514	0.000	***
	REM_t	-0.662	0.836	no	-4.303	0.012	**	1.444	0.958	no
	USX_t	-4.505	0.001	***	-5.136	0.002	***	0.339	0.773	no
At First difference		With constant			With constant & trend			Without constant & trend		
		t-Statistic	Prob.		t-Statistic	Prob.		t-Statistic	Prob.	
	ΔER_t	-1.920	0.316	no	-3.247	0.103	no	-0.514	0.481	no
	ΔFDI_t	-3.170	0.035	**	-3.125	0.124	no	-3.246	0.002	***
	ΔOil_t	-5.044	0.000	***	-5.073	0.002	***	-5.082	0.000	***
	ΔPSX_t	-7.230	0.000	***	-7.222	0.000	***	-7.462	0.000	***
	ΔREM_t	-4.607	0.001	***	-3.996	0.024	**	-3.461	0.001	***
	ΔUSX_t	-5.440	0.000	***	-5.154	0.003	***	-3.590	0.001	***

Note: * Significance at the 10% level; ** Significance at the 5% level; *** Significance at the 1% level; "No" = not significant. All use MacKinnon's (1996) one-sided *p*-values.

The null hypothesis of the ADF and PP stationarity tests is that the time series has a unit root process. Both tests can be conducted at level as well as at the first difference of a series, including three specifications: with constant, with constant and trend, and without constant and trend. If the null hypothesis is not rejected at level or first difference, it means that the time series is integrated of order zero or one, or at *I(0)* or *I(1),* respectively. The results in Table 2 show that the PSX and USX series are *I(0)* in both tests, under the ADF test, without trend and intercept conditions. Other variables show stationary processes if variables are differenced once, except ER, which shows mixed results when the first difference is taken. In the ADF test, the presence of unit root processes is confirmed even at the first difference, whereas it is stationary without constant and trend as per the PP test. Overall, all the time series are a mix of integrated of zero and one, that is, I *(0)* and *I (1),* which meets the first condition for the application of both the NARDL and MT-NARDL models.

Table 3 Results of MT-NARDL Model

Panel A: Short Run Coefficients				
Variable	Coefficient	Std. Error	t-Statistic	Prob
ΔPSX_{t-1}	0.773454	0.077497	9.980466	0.0001
$\Delta Large\_c_t$	-1.59982	0.336912	-4.748463	0.0032
ΔFDI_t	-1.80442	6.331435	-0.284993	0.7852
ΔER_t	-2.29089	0.527726	-4.34106	0.0049
ΔREM_t	18.71217	4.659799	4.015659	0.0007
Panel B: Long Run Coefficients				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
PSX_{t-1}	-3.04655	0.173089	-17.60105	0.0000
$Small\_c_t$	1.38573	0.272889	5.0779	0.0023
$Median\_c_t$	0.148413	0.815613	0.181965	0.8616
$Large\_c_{t-1}$	-3.68685	0.414963	-8.884763	0.0001
FDI_{t-1}	-15.5871	5.989525	-2.602399	0.0405
ER_{t-1}	-1.70862	0.234358	-7.290658	0.0003
REM_{t-1}	42.68502	5.043277	8.463748	0.0001
USX_t^+	1.117007	0.248807	4.489456	0.0042
USX_t^-	-0.81081	0.294426	-2.753858	0.0331

Source: Authors' calculation using E view 12.

The estimated results of the model are given in Table 3, which contains coefficients of both the short and long runs, along with the tests of various assumptions of the econometric model. Panel A gives the coefficients of the short run, which are selected per the AIC. In the short run, only large shocks in oil prices ($Large\_c_t$) have a significant impact on the PSX. The sign of the coefficient is negative and significant at a higher level of statistical significance. It indicates that large shocks in the oil prices, represented by rates of 75% or above, have a significantly negative impact on the PSX, as investors cannot ignore this information when deciding whether to buy, sell, invest, or divest at PSX. This means that it is a short-run phenomenon as economic agents will seek ways to mitigate the harmful impacts of large shocks in the oil prices, which are there to stay in the long run. It shows that it is crucial to decompose the shocks in the prices of crude oil into small and large components and thereby test their impact on the PSX.

However, in the long run, smaller shocks in oil prices ($Small\_c_t$) have a positive impact on the PSX. This is statistically significant at the 1% level of significance. On the other hand, larger shocks in oil prices ($Large\_c_t$) have a statistically significant negative effect on the PSX. This demonstrates that small and large shocks in the prices of crude oil have differential impacts on the PSX. As reported by Cheikh et al. (2021), the stock exchanges of Kuwait, Qatar, Oman, and Saudi Arabia showed higher sensitivity to the large changes in oil prices than small changes using a non-linear vector smooth transition regression (VSTR) framework. The present results are similar to those of Cheikh et al. (2021), though the econometric methodologies differ.

Umer (2016) estimated the effect of 11 macroeconomic variables on the performance of Pakistan's stock exchange using Johanson's co-integration technique. He reported that oil prices have a positive impact on stock market performances in the long run. However, he did not consider the possible nonlinearity of the oil variable. However, Ullah (2019) estimated the impact of shocks in the supply and demand of oil on the return to stocks of Pakistan using the NARDL model. He confirmed that shocks in supply of and oil demand, in the long run, show asymmetric impacts. In China, as reported by Hu, Liu, Pan, Chen, and Xia (2018), there was no evidence of effects of asymmetric nature of oil supply shocks on the stock exchange of China. The present study's results are similar to Ullah (2019), though the methodologies are different, as Ullah (2019) decomposed the changes into supply and demand types, whereas, the present research decomposes it according to magnitude. Hashmi, Chang, et al. (2022) revealed that the effects of changes in prices of crude oil on the stock market vary across the bullish, bearish, and normal market states using a QARDL model. However, the results of the studies by Umer (2016), Ullah (2019) and Hashmi, Chang, et al. (2022) cannot be considered appropriate when economic agents show different reactions to small and large shocks in the oil prices.

Panel A of Table 3 also displays the effect of FDI_t on PSX_t. It can be verified that its effect on PSX_t is negative regardless of the length of time. In other words, FDI_t adversely affects PSX_t. However, only the coefficient of FDI_{t-1} is statistically significant in the long run at a significance level of 5%. This may be because the inflow of FDI_t, to developing markets is highly dependent on the overall economic, political, and social conditions of these countries. Developing countries are frequently faced with political unrest and hence economic uncertainty, which makes investors hyper-sensitive to changes.

The effect of FDI_t on the stock exchange was not the same in previous studies. For instance, Tsagkanos, Siriopoulos, and Vartholomatou (2019) reported the direct (but weak) impact of FDI on the development of the Greek stock exchange. Meanwhile, Khatri Chettri, Bhattarai, and Gautam (2023) reported the different impacts of FDI on the stock market in Nepal. It was negative in the short term, but positive in the long term. M. K. Khan et al. (2023) also reported a positive effect of the FDI on the performance of the stock exchange of Pakistan using simulated ARDL.

The negative effect of FDI on Pakistan's stock market, as found in the present study, may at first glance appear inconsistent with traditional investment theory, which typically suggests that foreign inflows of capital have a positive impact on stock returns. However, this outcome might be due to various reasons specific to Pakistan's economy and the inconsistency of FDI inflow over time.

The short-term ease of absorbing small oil price shocks is likely due to investor myopia and information absorption lags. In emerging markets like Pakistan's, investors might be more concerned with the long-term economic trends than slight changes in oil prices. This is the phenomenon of investor myopia, in which market agents neglect to respond to smaller (but more frequent) oil price fluctuations. Furthermore, the rate at which information about oil prices is absorbed by less liquid, more volatile markets (such as Pakistan's) could be slower, meaning the effects of smaller changes in oil price may take longer to impact stock prices. Thus, investors' responses to small shocks will not necessarily be equal in both speed and magnitude in the short run.

The impact of REM_t on PSX_t is positive irrespective of the period. The coefficient of REM_t is highly statistically significant. This means that inflow of personal remittances positively affects PSX_t. The coefficients corresponding to ΔREM_t and REM_{t-1} are 18.71217 and 42.68502, respectively and their magnitudes demonstrate that the long-run impact is greater than the short run. This means that PSX_t is heavily and positively influenced by the REM_tin the long term.

These results are similar to previous studies such as those by Qamruzzaman, Karim, and Jahan (2021), Sajid, Hashmi, Abdullah, and Hasan (2021), and M. K. Khan et al. (2023), who found that the inflow of remittances plays vital role in the development of stock exchange. Faheem, Mohamed, Farooq, and Ali (2019), confirmed that an increased inflow of remittance boosted Pakistan's stock market activity both in the short and long term. Interestingly, they reported positive coefficients for both negative and positive shocks to the inflow of remittances and their impact on the Pakistani stock market during 1997–2008. However, only the coefficient of negative shocks to remittance was found to be statistically significant. Their results are surprising in the sense that positive shocks to inflow of remittances are expected to be a welcome note for the PSX, as it can increase the country's overall liquidity. On the other hand, negative shocks are usually expected to have a negative impact on their coefficients. Nevertheless, they reported a positive impact on both.

The present study also reports the effects of ER_t on PSX_t. The effects of ΔER_t are negative in both the short and long runs and both coefficients are highly statistically significant. This means that the continuous depreciation of Pakistan's rupee against the US dollar plays a negative role in the performance of Pakistan's stock exchange. The magnitude of coefficients of ΔER_t and $ER_{t-1}$are -2.29089 and -1.70862, respectively. This demonstrates that the adverse impact of ER_t on PSX_t is more severe in the short term. This may be because companies seek ways to avoid long-run costs associated with variations in sudden depreciations in the ER_t. However, in the short run, companies tend to bear the huge costs of sudden depreciations if ways to avoid them are not available.

There are several potential transmission channels of ER_t into PSX_t. For instance, when local currency depreciates, the price of imported energy products increases and hence increases the cost of production (Olomola, 2006; Olomola & Adejumo, 2006). If the increased cost of production cannot be recovered through rising prices for the finished goods for the end consumers due to severe competition or government price regulations, the companies' profitability would fall. In practice, most of the increased cost of production is recovered through upward adjustments in the prices of finished goods, particularly in developing countries, where markets are not perfectly competitive either in most parts of a country or across most of the industries within it. Another channel is the import of essential raw materials. As most industries rely on imported raw materials, the continuous depreciation of local currency means a constant upward trend in production costs. The negative effect of ER_t on PSX_t can be understood in this context.

Many studies have reported similar results. For example, Chang, Meo, Syed, and Abro (2019) reported the indirect impact of ER_t on PSX_t from 1997 to 2018. They collected and analyzed time series data at a quarterly frequency. Meanwhile, Ahmad, Rehman, and Raoof (2010) estimated the positive effect of ER_t on PSX_t from 1998 to 2009. Other studies examined the impact of exchange rate volatility on stock markets. For example, Hajilee and Al Nasser (2014) and Bagh, Azad, Razzaq, Liaqat, and Khan (2017) reported the positive impact of exchange rate volatility on Pakistan's stock market.

In Panel B of Table 3, the coefficients of PSX_{t-1} are negative and highly significant. This means that a drop in $PSX_{t-1}$is followed by a rise in PSX_t in the current period. In other words, there is always some degree of correction in a healthy stock market. An upward trend is followed by a downward correction, and vice versa. Stock exchanges are also interlinked, especially stock markets of developing and emerging countries, which take feedback from the behavior of global stock markets, as mentioned by Hammoudeh and Choi (2006). The US S&P 500 is one of the leading international stock market indices, and its contents can have a significant influence on other stock markets. In the present study, shocks in the S&P 500 are decomposed into positive and negative shocks, and their effects on PSX_t are estimated. Table 3 confirms that positive shocks to USX (USX_t^+) can positively affect PSX_t and negative shocks to USX (USX_t^-) can negatively affect PSX_t in the long run. Both coefficients are statistically significant. These results align with those of Hammoudeh and Choi (2006). This means that PSX_t rises as USX_t rises and vice versa. The magnitude of the coefficients of USX_t^+ and USX_t^- are 1.117007 and -0.81081, respectively, demonstrating that PSX_t reacts to USX_t^+ more heavily and positively. However, USX_t^- negatively affects PSX_t but at a lesser magnitude than the positive shocks.

Finally, Table 3 contains the coefficients of the small, medium, and large shocks in crude oil prices. In the short run, only $\Delta Large\_c_t$ is reported. The result is statistically significant and negative, differing from zero at a 5% level of significance. Its magnitude is -1.59982. However, in the long run (see Table 3, Panel B) the coefficient of $Small\_c_t$ and $Medium\_c_t$ is positive and the coefficient of $Large\_c_{t-1}$ is negative. These are statistically significant except for the coefficient of $Medium\_c_t$. The magnitudes of the coefficients are 1.38573 and -3.68685 for $Small\_c_t$ and $Large\_c_{t-1}$, respectively. This indicates that reactions of PSX_t to $Small\_c_t$ and $Large_c_{t-1}$are significantly different. They are more abruptly negative for $Large\_c_{t-1}$ and less abruptly positive for $Small\_c_t$. This means that one can expect a panic-type situation at the stock exchange if news of a larger increase in crude prices is reported and vice versa. These results are the expected signs of the coefficients based on economic theory per Chang (2020) and Prabheesh et al. (2020).

The empirical results show that the impact of medium shocks is also positive but statistically insignificant. The differences between small, medium, and large shocks make the short-run implications of medium shocks far less pronounced. This finding is in line with the evidence in the existing literature that smaller price changes are more likely to go unnoticed in the short term as the investors interpret them as temporary noise. Yet, as demonstrated by the results, even small price changes may accumulate and affect the stock market dynamics in the long run. Hence, though their short-term impact may be relatively small, the long-term consequences of medium shocks should not be underestimated.

Robustness tests the fact that the sample period includes the 1970s, a time when there was considerable instability in oil prices, raising the possibility that the results are not robust. The preliminary results show that the omission of medium shocks does not materially affect the size or sign of the coefficients of small and large oil price shocks. This indicates that medium shocks have a negligible effect on stock market reactions, though they were not dominant in the overall effects that the model captures. Medium shocks are therefore benchmark shocks and may serve as an interesting avenue for future research on the impact of oil price changes on stock market indices.

The empirical findings of this study uncover an interesting phenomenon in the stock market responses to oil price shocks in Pakistan. The results indicate that small oil price shocks have a positive effect on the PSX, and large oil price shocks have a negative impact. This distinction is essential when considering oil price changes and what they might mean for investment and policy. Our results align with the study of (Alamgir & Amin, 2021). The positive impact of small oil price shocks on the PSX may be rationalized by the lagged process of updating information on the market and the expansionary response of the output to moderate oil price increases. In emerging markets like Pakistan's, marginal increases in oil prices could be an indication that global economic activity is improving, which could boost business and investment confidence. Additionally, small shocks do not significantly interfere with supply chains or production costs, making it easier for firms to adapt. Therefore, small shocks can provoke a positive stock market reaction if these stocks are seen as controllable by the investors and policymakers. Moreover, for oil importers, slight rises in oil prices may be interpreted as indicators of global growth and could be conducive to exports and greater economic equilibrium.

In contrast, the large oil price shocks commonly brought about by geopolitical tensions, natural disasters, or sudden changes in oil supply are, on average, much more damaging to the economy. Such shocks frequently result in increased production costs and inflationary influences that can significantly damage corporate profits and impede consumer spending. This, when combined with the economies of oil-importing nations like Pakistan (which are also highly vulnerable to interest rates and oil price shocks) can negatively impact the trade balance, accelerate inflation, and cause economic instability, all of which are detrimental to stock market returns. Investors may view surging oil prices as signs the economy is about to collapse, raising the prospect of an adverse market reaction.

The study also confirms that the PSX is asymmetric to the good and bad news of the S&P 500 as positive news raises the PSX and vice versa. This development highlights the interconnectedness of global financial markets and the way fluctuations in leading international stock indices, such as the S&P 500, resonate with emerging markets like Pakistan's. During periods of strong performance in global markets, investor confidence increases and money flows into emerging markets. Conversely, negative shocks in the S&P 500 are a harbinger of global economic malaise that can damage investor confidence, sparking capital flight from emerging markets.

Table 4 provides the results of the diagnostic tests. The coefficient of Error Correction Term (VCM) is -3.04 and is highly statistically significant. This demonstrates that the system quickly reverts to its equilibrium path if there is any shock to the system.

Table 4 Diagnostic Tests

	Coefficient	Std. error	t-statistic	Prob
VCM	-3.04655	0.092143	-33.06336	0.0000
CUSUM	stable			
CUSUM of squares	stable			
Adjusted R-squared	0.991668			
F-Bounds test	Value	Significant	I (0)	I (1)
F-statistic	52.05646	10%	1.66	2.79
K	8	5%	1.91	3.11
		2.5%	2.15	3.4
		1%	2.45	3.79
t-statistic	-17.6011	10%	-1.62	-4.09
		5%	-1.95	-4.43
		2.5%	-2.24	-4.72
		1%	-2.58	-5.07

Source: Authors' calculation using E view 12.

Another test in MTNARDL is the stability test, as reported by CUSUM and CUSUM Square, presented in Table 4 and illustrated in Figure 1. These tests show that the model is stable overall.

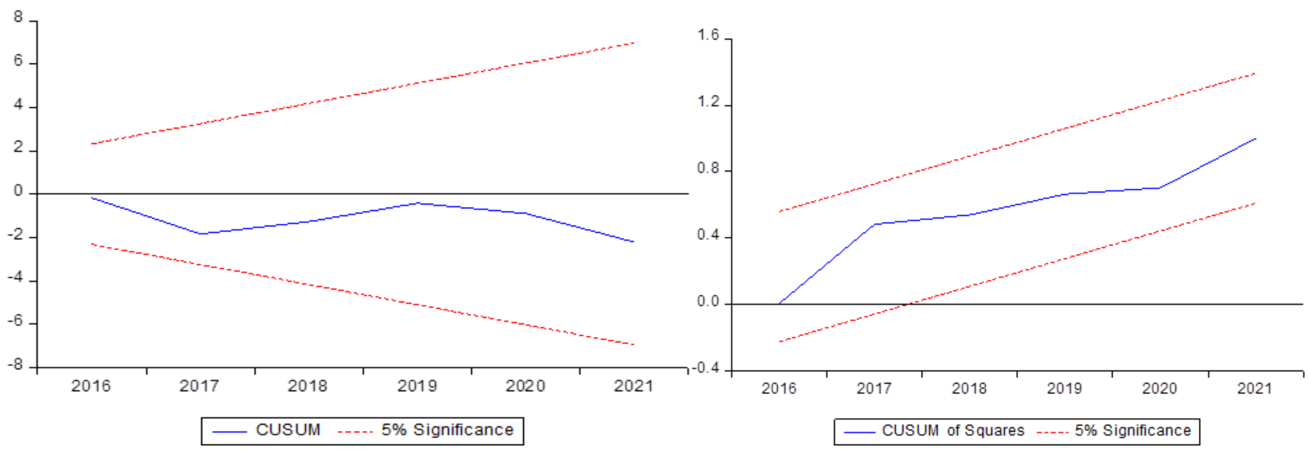

Figure 1 Graph of CUSUM & CUSUM of squares.

The Bound test suggests that a long-run equilibrium relationship exists between the variables. Its test statistics values of both F and t distributions are 52.05 and 17.60, respectively, which are greater than the critical values of upper bounds.

Table 5 Breusch-Pagan-Godfrey Tests of Heteroskedasticity and Serial Correlation

Test of Heteroskedasticity			
F-statistic	0.873088	Prob.F(14,5)	0.6175
Obs*R-squared	14.19389	Prob.Chi-square (14)	0.4354
Breusch-Godfrey Serial Correlation LM test			
F-statistic	6.695257	ii Prob. F (4,2)	0.1342
Obs*R-squared	18.6102	Prob. Chi-Square (4)	0.0009

Source: Authors' calculation using E view 12.

The tests of heteroscedasticity and serial correlation are also given in Table 5, which can easily verify that there is no evidence of heteroscedastic error terms in the model. However, the test of serial correlation shows mixed results. According to the F-statistic, the residuals of the model are not serially correlated. However, the obs*R Square test indicates that the error terms are serially correlated.

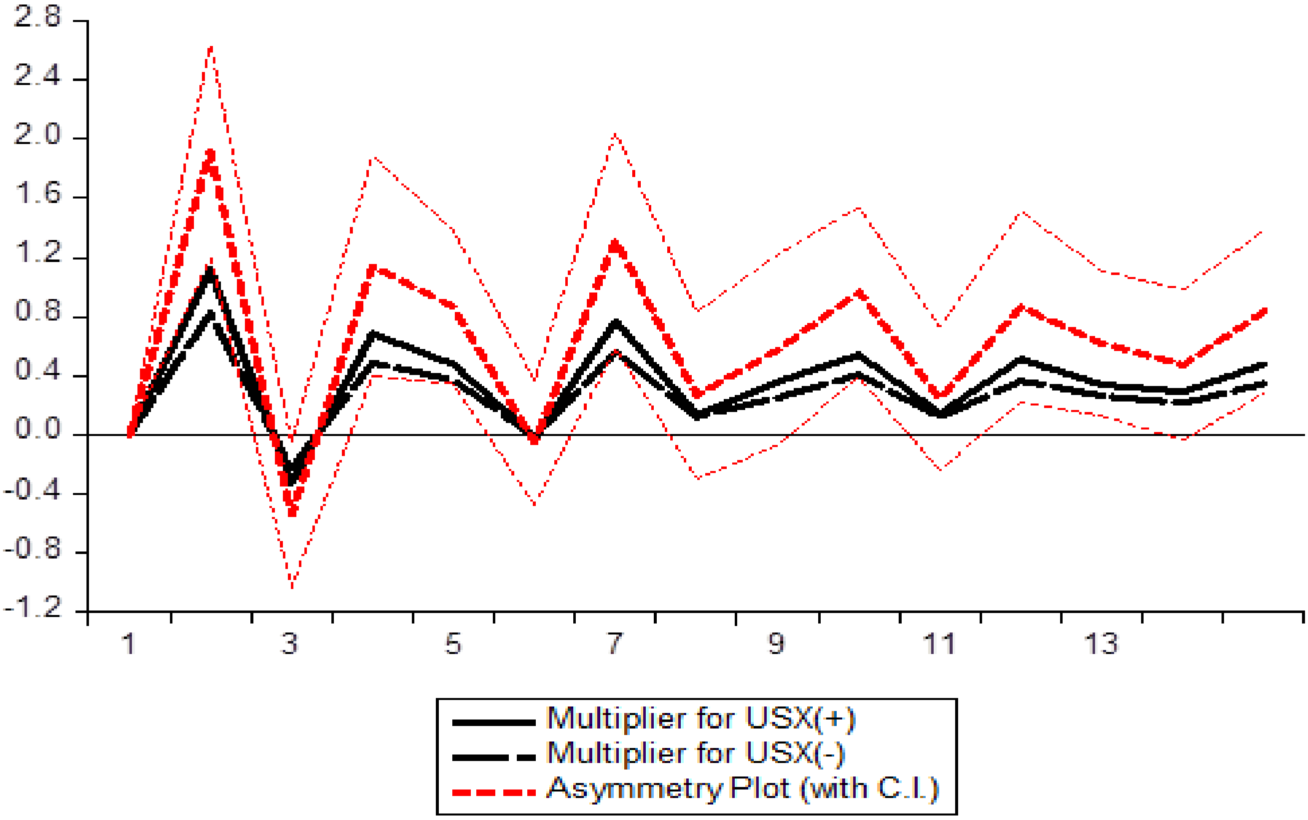

Figure 2 Graph of NARDL Multiplier.

Figure 2 illustrates the dynamic multiplier effect of USX_t on PSX_t. The x-axis represents the number of years required for the system to return to its long-run equilibrium, whereas the y-axis highlights the extent of negative and positive shocks on USX_t.

Table 6 Wald Test Results

LR asymmetric of USX:	F-value: 19.03845, p-value: 0.0048	Asymmetric
$Small\_c_t = Median\_c_t$	F-value: 1.539673, p-value: 0.2610	Symmetric
$Small\_c_t = Large\_c_t$	F-value: 74.38282, p-value: 0.0001	Asymmetric
$Median\_c_t = Large\_c_t$	F-value: 15.64016, p-value: 0.0075	Asymmetric
$Small\_c_t + Median\_c_t + Large\_c_{t-1} = \Delta Large\_c_t$	F-Value: 0.686458, p-value: 0.4391.	Symmetric

Source: Authors' calculation using E view 12.

The Wald test is used to test the short- and long-run asymmetry among the variables. The results of the Wald test are reported in Table 6. The value of F-statistic is 19.03 for the long run asymmetry of USX_t with a p-value of 0.0048. It shows that the effect of USX_t on $PSX_t$is asymmetrical.

The results of tests of asymmetry for oil shocks are also given. The empirical results show that the impact of the 25% and 50% shocks to the oil prices on PSX_t are symmetrical, indicating that the coefficients of these two shocks to the oil prices are not different. However, the effects of small and large shocks to oil prices on the PSX_t are asymmetric, as found by Cheikh et al. (2021). It follows from the empirical results that these small and large changes in the prices of crude oil convey different effects on PSX_t. Similarly, the 50% and 75% shocks to oil prices affect the PSX_t differently; the Wald test shows that this is asymmetrical. Finally, testing the difference in coefficients across the time revealed no significant differences among these coefficients.

5. Conclusions and Recommendations

This paper examines the impact of various factors surrounding oil prices on Pakistan's stock market. These factors include fluctuations in the oil prices, inflows of workers' remittances, FDI inflows, and the exchange rate of the Pakistani rupee against the US dollar. The empirical analyses are conducted to assess the impact of small, medium, and large shocks in oil prices on Pakistan's stock market in the presence of positive and negative shocks to the global stock market. The study utilizes time series data from 1997 to 2021 and estimates using the MT-NARDL model. The findings can be summarized as follows.

The empirical results indicate that large shocks to oil prices have a significant negative effect on the stock market of Pakistan. Other studies have concluded that changes in oil prices are significantly more pronounced in the long term. This implies that the volatility of oil prices is vital in determining the stability of the stock market, which suggests that regulators should communicate better with market participants. This will help investors make better decisions during sharp swings in oil prices while avoiding panics. Based on this empirical evidence, better communication from regulators should be used to shield investors and markets from panic slumps.

The results of the study also show that risk management is essential via hedge instruments such as oil-based derivatives. These hedging instruments can be used to manage risk more effectively. It can be used to stimulate long-term investment and stability in the market. Along with the hedging instruments, there is a need for strategic oil reserves and investment in renewable energy. The strategic reserve can be used to absorb massive supply shocks and minimize their effect on the stock market, whereas investment in renewable energy can reduce dependence on imports of oil. These factors can reduce Pakistan's exposure to minimize damages because of massive shocks in the oil prices.

Moreover, the study reveals that fluctuations in exchange rate and FDI have a negative effect on Pakistan's stock market. The impact of exchange rate fluctuations is more inimical in the short run compared to that of FDI. This suggests that the government should focus more closely on macroeconomic management so that exchange rate fluctuations are minimized. Key practices should include increasing exports, reducing imports, and attracting foreign investments in the real sectors of the economy. Export expansion can be done via adopting pro-export policies, discovering more international markets for exportable goods, and expanding and diversifying the export base. On the import side, a long-term roadmap should be adopted for substituting imports with domestic goods. Furthermore, the government should adopt investment-friendly policies to attract investment into the technology, manufacturing, and infrastructure sectors. This will expand the country's efforts for import substitutions and enhance exports.

Finally, the study also establishes that the inflow of remittances stimulates stock market activity in Pakistan. This suggests that there is a need for policies to attract more worker remittances. Pakistan's stock market is also affected asymmetrically by changes in global markets. Regulators should therefore seek to provide timely information about the international factors that influence global markets and, hence, the local market.

The empirical results strongly advocate for the management of oil price volatility through strategic oil reserves and investment instruments, attracting foreign investment into the real sector of the economy (especially non-oil sectors), and promoting the inflow of remittances, alongside better communication from regulators to market participants about the working conditions of global markets. By implementing these strategies, policymakers can help create a more resilient, robust stock market in Pakistan.

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Supplementary figure 1: Plot of variables over time