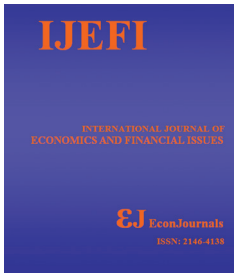

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Asymmetric Effects of Oil Prices and Global Financial Factors on the Saudi Stock Market: A NARDL Approach

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ABSTRACT

This research paper examines the asymmetric effects of key macroeconomic and international stock market indices on the "Saudi stock market (TASI)." This research employs a "non-linear autoregressive distributed lag (NARDL) model" that incorporates monthly information from 2000 to 2024 to inspect the impacts of "oil prices (WTI), interest rates, exchange rates (REER), oil production, inflation, and global equity markets (the S&P 500 and the Shanghai Composite)." The empirical evidence reveals significant long-run asymmetries, particularly from positive oil production shocks, which appear to have a strong and positive impact on "TASI." In the short run, currency depreciation and declines in oil prices also lead to improved market returns. In contrast, factors such as interest rates, inflation rates, and global stock indices show limited influence. Overall, the findings shed light on the central role of oil and exchange rate dynamics in shaping the Saudi financial market. These insights offer meaningful findings for regulators and investors seeking to promote market stability and navigate external shocks in an increasingly interconnected global economy.

Keywords: International Stock Indices, Crude Oil, Saudi Stock Market, Macroeconomic Factors, NARDL
JEL Classifications: C1, D53, G10, G12, G15, Q43

1. INTRODUCTION

Stock markets play a central role in the advancement of a nation's financial system by facilitating the optimal allocation of capital. They serve as a platform that facilitates the exchange of equity securities between investors, thereby directing household and institutional savings into various business investment instruments. This illustrates why stock markets are recognized as a measure of a nation's economic well-being, as an efficient stock market promotes economic growth by improving capital allocation, enhancing investment efficiency, and fostering long-term productivity gains (Levine and Zervos, 1998).

Crude oil is among the most significant commodity assets affecting a nation's growth and prosperity due to its significant influence on both the real economy and on financial markets (Reboredo and Rivera-Castro, 2014). The robust use of oil products in almost all aspects of production and distribution means that even modest oil price movements can impact inflation, production costs, and investment decisions, which in turn can affect economic stability and market performance. According to Al-Hajj et al. (2018), oil price volatility can lead to significant fluctuations in stock market returns. Following the work of Jones and Kaul (1996), the connection between oil prices and the performance of stock market has been widely investigated over the years.

Yet, the nature of the association between stock market performance and oil price volatility remains a subject of debate. For instance, a large body of research have identified a negative connection between oil price shocks and stock market performance, asserting that oil price hikes can weaken stock market returns (Jones and Kaul, 1996; Filis, 2010; Kilian and Park, 2009). In contrast,

other literature suggests a positive association between oil price shocks and stock market performance, demonstrating that rising oil prices can enhance stock market returns (Luo and Qin, 2017; El-Sharif et al., 2005; Narayan and Narayan, 2010). Others found insignificant results (Apergis and Miller, 2009). Further, Bouoiyour and Selmi (2016) assert that the association between oil prices and stock returns is strongly influenced by a country's economic institutions, its oil dependency, and the specific form of oil shock involved. These factors can shape the direction and the strength of the stock market- oil nexus. Pointing out that the impact is not the same across different economies.

For nations that depend on oil, such as Saudi Arabia, where the oil sector makes a significant contribution to GDP, understanding the association between oil prices and stock market performance is crucial. Crude oil prices have a profound impact on Saudi Arabia's economy, as the country relies heavily on oil exports (Hammoudeh and Aleisa, 2004; Onour, 2007). Despite recent initiatives that aim to broaden the economy and reduce reliance on oil, such as Vision 2030, oil price fluctuations continue to exert a substantial influence on the Saudi stock market. The Saudi Arabian stock market (TASI) is comprised of many companies closely tied to the oil sector, such that variability in oil prices can lead to movements in the stock market. Understanding this association is crucial, as it can significantly influence economic stability, performance, investment decisions, and policy outcomes.

In addition to oil, global financial interconnectedness has become increasingly relevant. Stock market co-movements, which refer to the simultaneous movement of stock markets across different countries (and often called contagions), have recently been widely explored in the literature (Abdou et al., 2024). Higher co-movement between markets indicates stronger inter-market connections, meaning that crisis or volatility in one market is more likely to influence others (Graham et al. 2013).

Beyond the U.S., China is also playing an increasingly influential role in Saudi financial markets. Abdou et al. (2024) highlight the growing influence of China on the "TASI," underscoring the importance of Chinese economic ties with Saudi Arabia. They point out how China's stock market has become increasingly influential post-2006. Together, this reinforces the need to include both the "S&P 500 and the Shanghai Composite" in this study, ensuring a more thorough examination of global effects on the Saudi stock market.

Numerous papers have inspected the impact of oil prices on the Saudi stock market or explored how global stock indices influence it (Abdou et al., 2024; Marashdeh and Afandi, 2018). However, a notable gap remains, in that no study has simultaneously investigated the combined effects of key macroeconomic variables, oil price dynamics, and global stock market movements on "TASI." What further sets this study apart is its use of the "Non-linear ARDL (NARDL) model" to account for the complex, asymmetric, and non-linear relationships between those variables affecting the valuation of the "TASI," thereby offering a deeper and more accurate understanding of its key drivers. This gap is especially significant now, as the country navigates major geopolitical shifts and advances its Vision 2030 plans to diversify the economy beyond oil exports.

The primary goal of this research paper is to examine how and to what extent "oil price shocks, interest rates, the real effective exchange rate (REER), oil production, inflation," and assess how movements in major global stock markets, represented by the "U.S. S&P 500 and China's Shanghai Composite," affect returns in the "Saudi stock market (TASI)" both in the short and long term.

To achieve these objectives, this research utilizes the "non-linear autoregressive distributed lag (NARDL) model." The "NARDL" model is ideal for capturing the non-linear and asymmetric effects of "oil prices, exchange rates (REER), interest rates, inflation, and oil production" on the Saudi stock market, and is well-suited to identify both short-term and long-term dynamics, which are essential given the nature of the variables involved.

This research provides novel contributions to the existing body of literature. First, unlike previous studies, this investigation focuses on key factors that directly influence the Saudi stock market. Oil prices (WTI) are crucial, given Saudi Arabia's significant reliance on oil revenues. Additionally, interest rates will affect capital costs, while the Real Effective Exchange Rate (REER) will provide a better understanding of exchange rate dynamics, particularly due to the peg between the Saudi Riyal and the U.S. dollar. Other important variables include oil production and inflation, which will help capture both supply-side and demand-side factors that influence stock market returns.

Second, incorporating international stock market indices, such as the "S&P 500 and the Shanghai Composite" will provide valuable insights into how well-integrated, external markets influence the Saudi stock market, especially in terms of global financial interconnections. These observations can be insightful for investors and portfolio managers looking to improve portfolio diversification, mitigate risk exposure, and make informed cross-border investment decisions in an increasingly interconnected financial landscape.

Third, this study utilizes the NARDL approach, which can capture how positive and negative changes in an explanatory variable may affect the dependent variable differently, both in the short run and the long run. The large sample size for this analysis alleviates the challenge avoids limitations presented in the form of multicollinearity or loss of degrees of freedom. This model specification will provide deeper insight into how global markets and oil influence Saudi stock market returns.

Fourth, this study uses a sample that covers a recent and extended time frame, including periods of heightened global uncertainty and oil market disruptions. Notable events throughout this period include the "global financial crisis of 2008, the GCC conflict, tensions with Iran, the Iraq War, the Arab Spring, the COVID-19 pandemic, and the Russian-Ukraine war," which had a profound impact on oil prices and global stock markets. This enables a more comprehensive understanding of how major global shocks influence the Saudi stock market over time, delivering valued insights for investors and regulators.

2. LITERATURE REVIEW

Numerous theoretical frameworks highlight the complex link between stock market dynamics and oil prices. The connection between the two can be explained through the valuation process in economic theory, in that the stock value is largely determined by the discounted value of the anticipated future cash flows. However, the stock market's response to oil price shocks is complex, as oil price fluctuations can impact both a firm's future cash flows and the discount rates applied to those flows (Reboredo and Rivera-Castro, 2014). These influences vary depending on the relationship between the firm and the oil industry. Therefore, any reaction by the stock market is necessarily multifaceted.

For instance, if the firm is an oil producer, upward movement in oil prices can positively impact the firm's expected cash flows. In contrast, rising oil prices can negatively impact the firm's expected cash flows for oil-dependent firms. The other pathway derives from the impact of oil price fluctuations on key macroeconomic factors, but in an indirect way. For instance, oil price fluctuations can impact macroeconomic factors like interest rates and inflation, thereby directly affect the discount rate used in stock valuations.

Understanding such co-movements is essential for properly motivating portfolio diversification, and for understanding market integration and risk transmission. Such information is important for investors, as it informs asset allocation decisions, particularly in assisting portfolio diversification investment objectives across different countries. For example, markets that exhibit strong positive co-movement with the Saudi market may limit the benefits of international diversification. In contrast, negatively correlated markets can be valuable for risk mitigation and hedging opportunities. Furthermore, policymakers must monitor and understand co-movement to anticipate how global shocks could impact domestic markets (Abdou et al. 2024).

Further, Saudi Arabia and the United States maintain deep and evolving economic, political, and financial linkages. Kenner and Al-ahmad (2021) posit that their economic ties are more complex than perceived. While energy and security issues remain a key pillar, recent years have seen a rise in trade and investment between the two nations. American companies are increasingly involved in Saudi Arabia's growing sports and entertainment sectors, as well as in major development projects across the country. At the same time, Saudi investments in the U.S. have also increased substantially, including the purchase of U.S. debt and financing of U.S. businesses.

A key part of this connection lies in the Saudi Riyal's peg to the U.S. dollar, which anchors Saudi monetary policy and exchange rate stability to U.S. economic conditions. As a result, financial shocks in the U.S., such as crises and policy changes, can be transmitted to the Saudi market, reinforcing the financial interconnectedness between the two economies. However, this close link brings both opportunity and risk. Smoother capital flows are married to increases systemic risk, allowing the potential for crises in one country to easily ripple into others, with disruptions in one market impacting the stability, asset valuations, and investor sentiment in the other market.

2.1. The Role of Oil Prices

The near ubiquitous use of oil-related products in the production and distribution of goods and services in any developed economy implies that an increase in oil prices often raises a firm's production costs. These higher costs are then transferred to consumers through elevated retail prices for goods and services. This results in supply-side pressures on the overall price level, ultimately resulting in higher inflation. Yet, central banks typically to reduce price pressure by dissuading both business investment and consumer spending on durable goods. Higher rates increase borrowing costs, which in turn lead to adjustments in the discount rate used to value stocks, causing stock prices to fall (Degiannakis et al., 2018).

For oil-exporting nations like Saudi Arabia, another pathway explains the connection between oil stocks and the market. Income from oil exports can shape government spending patterns, influencing both short- and long-term investment plans. An upsurge in oil prices can lead to an upsurge in government spending, which in turn will drive up corporate cash flows, ultimately driving up share prices. In contrast, a decrease in oil prices reduces government spending, thereby leading to a decline in corporate cash flows, resulting in a decrease in stock prices (Abdou et al., 2024).

The robust nature of the connection between stock market performance and oil price volatility remains a subject of debate. For example, Jones and Kaul (1996) studied the association between oil prices and stock market performance in the United States and found a statistically negative association between stock market performance and oil price shocks. Similarly, Chen (2010) and Filis (2010) study other markets and find a negative link between the stock market performance and oil price shocks.

In contrast, studies such as Bjørnland (2009), Luo and Qin (2017), and Davoudi et al. (2018) assert a positive link between stock market performance and oil price shocks. Arouri and Rault (2012) investigated the connection between oil prices and stock markets in GCC countries in the long-run, using "bootstrap panel co-integration techniques and unrelated regression (SUR) methods." Their findings imply that oil price hikes have a positive influence on stock prices in all GCC nations excluding Saudi Arabia.

Al-Hajj et al. (2018) find that the qualitative results of this relationship rely on the characteristics of the economy under investigation, whether the country is an oil-consuming (importing) or oil producing (exporting) nation. They find that an upward trend in oil prices will lead to wealth reallocation from oil-consuming nations to oil producing nations, which suggests that oil producing nations can utilize this additional wealth to invest in their economies, thereby stimulating growth and, in turn, enhancing market performance.

Further, Bjørnland (2009) examines the influence of oil price fluctuations on stock market performance in oil-exporting Norway, employing a structural VAR model. Their model identified the macroeconomic transmission mechanism of oil prices to suggest that a 10% increase in oil prices results in a 2.5% rise in stock returns, albeit at a diminishing rate. The study highlights that rising

oil prices contribute to increased national wealth and domestic demand in Norway.

Likewise, Davoudi et al. (2018) investigated whether oil price shocks can influence the volatility of Tehran's stock market returns. The study incorporates data covering the period between January 1993 and March 2014. Firstly, the study employed the "Generalized Auto-Regressive Conditional Heteroscedasticity (GARCH) model" to forecast stock market volatility. The study then used the "ARDL approach" to analyze the consequence of oil price instability. The empirical results show a positive link between stock market performance and oil price shocks, indicating that oil price disruptions contribute to the growth of the stock price index in Iran.

Luo and Qin (2017) examined the influence of both oil price volatility shocks and oil price shocks on stock market performance in China. Their analytical results suggest a statistically significant positive association between stock market performance and oil price shocks. In contrast, oil price volatility shocks, as measured by the "CBOE crude oil volatility index (OVX) shocks," negatively impact the stock price index in China.

2.2. Competing Model Specifications that Reveal Asymmetry in Qualitative Responses

Numerous studies have presumed a symmetric association exists between oil price swings and stock returns. These model specifications were chosen under the assumption that the quantitative impact between price hikes and price drops are equally balanced. Other studies have used model specifications to explore whether the influence of positive and negative oil price shocks on equity returns is asymmetric, either between positive and negative shocks, or between short-term and long-term impacts.

For example, Al-Hajj et al. (2018) investigate whether stock market returns in Malaysia are asymmetrically influenced by oil price fluctuations, changes in exchange rates, industrial production, oil production, interest rates, and inflation using the "non-linear autoregressive distributed lag (NARDL) approach." The analysis encompasses information spanning the period from May 2000 to November 2016, encompassing overall stock market and nine individual economic sectors. The study observations assert that oil price shocks tend to have a negative effect on stock market returns in Malaysia, confirming the presence of long-run asymmetric relationships between "oil price shocks, industrial production, interest rates, exchange rates, inflation, and stock market returns" across both the aggregate market and most economic sectors.

Likewise, Raza et al. (2016) investigated the asymmetric impact of oil price volatility and gold price volatility on emerging stock markets, namely "China, India, Brazil, Russia, South Africa, Mexico, Thailand, Chile, and Indonesia." The study incorporates monthly data from 2008 to June 2015, using a "non-linear ARDL bounds testing approach." The empirical results reveal that oil prices exhibit a negative effect on all markets under investigation, however, emerging markets are more responsive to negative shocks and economic instability.

Other empirical studies uncover that oil price turbulences have asymmetric influences over time. Several studies show a strong link between oil price movements and stock markets in "Gulf Cooperation Council (GCC) countries" (such as Arouri and Rault, 2012; Awartani and Maghyereh, 2014; Alqahtani et al., 2019; Mokni and Youssef, 2019; Cheikh et al., 2021). For instance, Alqahtani et al. (2019) inspected the influence of global oil market uncertainty on GCC stock market returns using an "ARMA-DCC-EGARCH and time-varying Student-*t* copula models." Their findings reveal that oil price instability exerts a significant and time-varying impact on GCC stock returns. While the findings reveal a negative impact of oil price instability, this impact differs on a cross-country level, with Bahrain and Oman showing relatively lesser sensitivity. Such empirical findings reveal the potential for portfolio diversification within the GCC countries and offer insights for policymakers and investors.

A recent study by Cevik (2021) studied the asymmetric association between oil price fluctuations and GCC stock markets to reveal that GCC stock markets exhibit varying degrees of sensitivity to changes in oil prices. Pointing out that four out of six markets exhibit a heightened reaction to significant oil fluctuation than to minor shocks, they posit that stock returns in these countries are more sensitive to oil shocks. The study emphasizes the need for economic reforms and stabilization policies to help reduce sensitivities and improve market resilience.

Finally, the source of oil price disturbances appears to have asymmetric impacts. For example, Kilian and Park (2009) note that the reaction of stock returns to oil price fluctuation depends on the nature of the shock, whether it is caused by demand or supply shocks. The effect of these shocks relies on a country's oil dependence. Thus, the stock market's response to oil price shocks is complex and is context dependent. Moreover, Wang et al. (2013) state that the stock market response to oil price changes varies across countries, and the qualitative response depends on a nation's oil trade status (importer or exporter) and the cause of the oil shock (supply or demand). The study found that the impact of uncertainty in global demand affects stock markets more strongly and for a longer period in oil-exporting nations than in oil-importing nations. Their results imply that stock markets in oil-exporting nations tend to move more closely together as a result for positive deviations in aggregate demand, stressing the need for regulators to consider how oil and stock markets interact when planning strategies to stabilize financial systems.

Marashdeh and Afandi (2018) investigate the impact of oil price fluctuations on the stock market performance in the largest oil-exporting (producing) countries, namely Saudi Arabia, Russia, and the United States. The study employs "vector error correction models" to analyze data covering the period 2000-2015. The research findings reveal that the influence of oil price fluctuations on stock prices relies on whether the shock originates from the demand side or the supply side of the economy, as well as whether the country is a net oil exporter or importer. The study confirms that oil price changes stemming from supply shocks have a positive effect on Russian stocks, a negative effect on U.S. markets, and mixed effects in Saudi Arabia. In contrast, demand-driven oil

shocks have a positive influence on stock returns in all three countries.

Overall, the association between oil prices and stock market performance has been extensively researched. The majority of available research agree that the impact varies across countries, depending on whether the nation is an oil exporter or importer and the nature of the oil shock (supply versus demand shock).

2.3. Contagion and Heterogeneity Across Countries

Awartani and Maghyereh (2014) investigated the oil price shock contagion relationship among GCC countries by exploring the volatility of spillovers and returns between the oil market and the GCC stock markets. As expected for oil-exporting nations, their findings reveal bi-directional and asymmetric spillover effects, with oil returns having a considerable impact on all GCC stock markets.

Mokni and Youssef (2019) employ a "copula model" to explore the level of dependence between crude oil prices and stock markets in the GGC countries using daily data from 2010 to 2017. Their empirical results indicate a robust and positive link between oil prices and the GCC stock market, though with different degrees of persistence across countries. Their findings reveal that Saudi Arabia exhibits the strongest reaction persistence. The study also indicates that the reliance level between oil prices and GCC stock markets increased after the 2014 oil price crash. Moreover, despite asymmetry in oil prices, their impact on persistence is limited.

Kisswani et al. (2017) inspect the association between sector-level stock prices on the "Kuwait Stock Exchange (KSE) and oil prices (Brent and West Texas Intermediate, WTI) using a non-linear autoregressive distributed lag (NARDL) model." The study incorporates information covering ten sectors in Kuwait, namely "Banks, Financial Services, Basic Materials, Oil and Gas, Industries, Real Estate, Consumer Goods, Consumer Services, Telecommunication, and Technology," using daily data. Their empirical findings suggest that some market sectors are more sensitive to oil price fluctuations than others, with some sectors exhibiting significant long-run asymmetric effects in response to oil price fluctuations. In particular, sectors such as "banks, consumer goods, consumer services, industry, and real-estate" show a negative long-run asymmetry effect between oil price and stock market performance.

2.4. The Saudi Experience

Numerous research papers have explored the association between oil prices and the performance of the Saudi stock market, highlighting the country's status as the world's biggest oil exporter. Studies such as those by Marashdeh and Afandi (2018), Jouini (2013), Alam (2020), Abdou et al. (2024), Cevik et al. (2021), Finta et al. (2019), Bouri and Demirer (2016), and Azar and Basmajian (2013) included or focused on Saudi Arabia in their analyses.

For instance, Jouini (2013) use a "vector autoregressive (VAR) and generalized autoregressive conditional heteroskedasticity (GARCH) model" to analyze weekly data throughout the period between January, 2007, to September, 2011. The empirical results reveal return and volatility contagion between oil price and stock sectors, with unidirectional effects from oil shocks to sector returns and two-way volatility links from market sectors to oil prices.

Alam (2020) investigated the connection between "stock market returns (TASI), crude oil prices, money supply, inflation, and interest rates" in Saudi Arabia using the "Johansen test of co-integration, the vector error correction model, and the Wald test." The study utilizes time series data from 2009 to 2016 to reveal a long-term equilibrium relationship between (TASI) and key macroeconomic factors. Money supply is positively linked to stock market performance, while inflation, short-term interest rates, and crude oil prices have negative effects. The findings underscore the substantial impact of macroeconomic variables on stock market dynamics in Saudi Arabia.

In addition to oil, global financial interconnectedness has become increasingly relevant, with stock market co-movement having been broadly investigated in the literature. A recent study by Abdou et al. (2024) examines the influence of oil prices and six major international stock markets on the Saudi stock market using five separate "Machine Learning (ML) techniques and the Generalized Method of Moments (GMM)." Their empirical results reveal that before the stock market collapse "known as the "Black February" in 2006, oil shocks exerted minimal impacts while post-collapse oil became a dominant factor. Moreover, as for the international stock market's influence, the UK and Japan were the most impactful prior to the 2006 crash. In contrast, after the 2006 collapse, China's influence grew, surpassing that of the UK market. These findings highlight Saudi Arabia's reliance on oil and the growing importance of its economic ties with China.

3. DATA AND METHODOLOGY

3.1. Data Sample

Due to the nature of this research problem, this study utilizes monthly data from January of 2000 to December of 2024 to evaluate the interplay between the "Tadawul All Share Index (TASI)" and key explanatory variables. The primary variables include Inflation Rate (%) and Interest Rate (%), which reflect the influence of domestic economic conditions and monetary policy. The Real Effective Exchange Rate (REER) is included to adjust for inflation and provide a more accurate measure of currency competitiveness, given the Saudi riyal's peg to the U.S. dollar.

Crude Oil Prices "West Texas Intermediate (WTI)" is selected over Brent Crude due to WTI's deeper integration in financial markets, stronger historical consistency, and broader use in economic modeling (Kilian and Park, 2009). While Brent Crude is globally referenced, WTI more accurately represents U.S. market dynamics, which are crucial for Saudi Arabia's economy, given its reliance on oil exports (Zhang et al., 2020). S&P 500 Returns and Chinese Index Returns are also included to capture the influence of external markets, particularly given Saudi Arabia's significant trade relations with both the U.S. and China. These variables were selected based on empirical relevance and theoretical justification, ensuring a thorough analysis of the factors influencing Saudi stock market returns.

This comprehensive dataset enables a thorough understanding of what drives stock market performance in Saudi Arabia during this period. Using monthly data provides a closer look at the connection between oil prices and stock market movements, as it captures changes more quickly and accurately. This approach has also been adopted by Bjørnland (2009), Al-Hajj et al. (2018), and Raza et al. (2016), who used monthly data to better reflect the short-term dynamics between oil and financial markets.

The stock market data is collected from Tadawul (the Saudi Stock Exchange) and Investing.com. West Texas Intermediate (WTI) benchmark, obtained from Investing.com, is used for oil prices. Meanwhile, macroeconomic indicators, including interest rates, inflation, and the real effective exchange rate, are collected from the Saudi Central Bank (SAMA), the IMF's official database, and the World Bank databases. This set of reliable data sources enables a comprehensive investigation into the market dynamics and economic influences on Saudi Arabia's stock market during the study period.

The study also examines how "interest rates, exchange rates (REER), oil production, inflation, and major international stock market indices (S&P 500 and Shanghai Composite) asymmetrically affect the Saudi stock market (TASI)," using a Non-linear ARDL model. The main model of this research is as follow:

$$Y = F\ (WTI_t^+, WTI_t^-, IR_t^+, IR_t^-, SHCOMP_t^+, SHCOMP_t^-, S\&P500_t^+, S\&P500_t^-, CPI_t^+, CPI_t^-,\ REER_t^+, REER_t^-, OP_t^+, OP_t^-)$$

Where Y the Saudi stock market index (TASI), the dependent variable. WTI_t^+, WTI_t^- account for the upward and downward movements in "West Texas Intermediate (WTI) crude oil prices," representing oil price shocks. IR_t^+, IR_t^-, denotes the upward and downward movements in the interest rate, $SHCOMP_t^+, SHCOMP_t^-$ denote the upward and downward movements in the Shanghai Composite Index, used to capture the influence of the Chinese stock market. $S\&P500_t^+, S\&P500_t^-$ Refer to the upward and downward movements in the S&P 500 index, which represents the influence of the U.S. stock market. CPI_t^+, CPI_t^- reflect positive and negative changes in the inflation rate, measured by the Consumer Price Index. $REER_t^+, REER_t^-$, indicate positive and negative changes in the Real Effective Exchange Rate (REER), capturing currency appreciation and depreciation. OP_t^+, OP_t^- denotes upward and downward movements in crude oil production, reflecting supply-side dynamics in the oil market.

The descriptive statistics shown in Table 1 provide an overview of the behavior and variability of important economic and financial indicators during the period from 2000 to 2024. The TASI index has an average of 8.860 and a relatively low standard deviation of 0.480, indicating moderate stability and low volatility in the Saudi stock market. Conversely, crude oil prices exhibit the greatest level of volatility, with the WTI exhibiting a standard deviation of 6.290. Such fluctuations reflect global oil supply and demand disruptions, including the COVID-19 pandemic.

With respect to macroeconomic variables, the inflation rates vary widely across the sample, ranging from −5.8% to 5.6%, reflecting both inflationary and deflationary periods. The real effective exchange rate also exhibits significant variability, with a standard deviation of 1.260, underscoring the importance of monetary competitiveness and exchange rate policy. Interest rates exhibit reasonable volatility, with a standard deviation of 1.67, as monetary policy changes over time. Both the Chinese Index return and S&P 500 return are included. Each exhibits means that are very close to zero, and each have very low standard deviations (0.09 and 0.07, respectively), indicating normal market behavior with some rare extreme values.

Crude oil production, which happens to record the minimum level of variability, with a standard deviation of only 0.09, reflects a relatively stable output level over the sample period. Overall, the data suggest that global and domestic economic forces occasionally shape financial and macroeconomic conditions. Variables associated with energy market activities, particularly crude oil prices, emerge as significant factors in determining these conditions, especially during periods of global disruption such as the COVID-19 pandemic (Zhang et al., 2020; Wasiuzzaman, 2022).

3.2. Data Suitability Testing

Table 2 reports the results of the "Augmented Dickey-Fuller (ADF) unit root test," which reveals that the variables exhibit mixed levels of stationary, some variables are stationary at I(0) while others at first difference I(1). The interest rate, Chinese Index Return, and S&P 500 Return are stationary at the level, supported by $P < 0.05$, thus confirming that they are I(0). The Δ Inflation Rate and Δ Real Effective Exchange Rate become stationary after first differencing, implying they are integrated of order one, I(1). Furthermore, the TASI index, Crude Oil Production, and Crude Oil Prices in West Texas are all statistically significant at 10 percent, indicating that the order of integration is one. These results satisfy the conditions of applying the "non-linear autoregressive distributed lag (NARDL) model" that enables the application of I(0) and I(1) variables together, provided that neither of them is I(2) (Shin et al., 2014).

Table 3 presents the results for the "Variance Inflation Factor (VIF)," a metric used to evaluate whether the model exhibits multicollinearity. VIF values above 10 indicate extreme multicollinearity that decreases the accuracy of the coefficient estimates. The values of the VIF for all variables used in the current study range from 1.020 to 1.780, as shown in Table 3. This suggests a low degree of multicollinearity between all variables, with a mean of 1.270. Therefore, the estimated coefficients are appropriate, and the model is stable.

3.3. The Non-linear Autoregressive Distributed Lag (NARDL) model Specification

The "Non-linear Autoregressive Distributed Lag (NARDL) model" offers several advantages: First, it accounts for both the short-term and long-term dynamics between the variables. Second, the model can handle variables that are integrated of different

Table 1: Descriptive statistics of data

Variable	n	Mean	Median	Standard Deviation	Min.	Max.
Interest rate	298	3.010	2.000	1.670	1.000	7.000
Chinese index return	298	0.000	0.000	0.090	−1.000	0.270
S&P 500 return	298	0.000	0.010	0.070	−1.000	0.130
Inflation rate	298	0.010	0.000	0.630	−5.800	5.600
Real effective exchange rate	298	−0.010	−0.020	1.260	−3.140	5.500
Crude oil prices west texas	298	0.140	0.630	6.290	−32.600	16.340
TASI	298	8.860	8.950	0.480	7.680	9.730
Crude oil production	298	9.140	9.150	0.090	8.880	9.390

Table 2: ADF unit root test

Variables	Statistics	P-value
Augmented dickey-fuller test		
Interest rate	−3.834	0.003*
TASI	−2.575	0.098**
Chinese index return	−11.923	0.000*
Crude oil production	−2.694	0.075**
S&P 500 return	8.106	0.000*
Δ Inflation rate	−6.729	0.000*
Δ Real effective exchange rate	−13.235	0.000*
Crude oil prices west texas	−2.807	0.057**

*P<0.05, **P<0.10

Table 3: Results of VIF

Variable	VIF	1/VIF
S&P 500 return	1.780	0.562
Chinese index return	1.760	0.567
Δ real effective exchange rate	1.110	0.900
Δ crude oil prices west texas	1.090	0.921
Crude oil production	1.080	0.929
Interest rate	1.070	0.936
Δ Inflation rate	1.020	0.984
Mean VIF	1.270	

orders, handling a mix of I(0) and I(1). Most importantly, the "NARDL" can capture asymmetric effects, helping to determine whether positive or negative shocks in oil prices, interest rates, or stock indices can have a more significant impact on "Saudi stock market returns (TASI)." The current investigation employs the "Non-linear Autoregressive Distributed Lag (NARDL) model," suggested by Shin et al. (2014). This specification accounts for the possibility of asymmetries existing in the relationship between the "Tadawul All Share Index (TASI)" values and the macroeconomic variables, allowing one to isolate explanatory variables into their positive and negative variations. This characteristic helps identify any asymmetry effect in both the short-term and long-term. The general specification of the NARDL model for TASI can be expressed as follows:

$$TASI_t = \propto + \beta_1 TASI_{t-1} + \beta_2 X^+_{t-1} + \beta_3 X^-_{t-1} + \sum \theta_1 \Delta TASI_{t-i} + \sum \theta_2 \Delta X^+_{t-i} + \sum \theta_3 \Delta X^-_{t-i} + \varepsilon_t$$

Where,

- X□ and X□ represent the positive and negative partial sums of the explanatory variables
- β terms represent long-run coefficients
- θ terms represent short-run dynamics
- ε_t is the error term.

This modeling framework is highly useful in financial time series analysis because the coefficient estimates of the shock effects are not restricted to be equal or opposite in magnitude. For example, increased oil prices may benefit the "TASI" values over time, as they lead to higher profits for oil-exporting countries like Saudi Arabia. Conversely, falling oil prices need not have a negative impact due to market expectations, stabilizing factors, and other supporting variables. The "NARDL" framework captures these potential asymmetries by estimating separate paths for positive and negative changes in explanatory variables. This enables the model to surpass the limitations of traditional linear methodologies to offer a more accurate representation of market behavior. This is important for both policymakers and investors because it shows that investment decisions in equity markets may respond disproportionately to positive and negative shocks or respond in a sentiment-sensitive way to macroeconomic indicators.

4. EMPIRICAL RESULTS

4.1. Results of the Non-linear Autoregressive Distributed Lag (NARDL) Model

The results of the "NARDL model," presented in Table 4, reveal both short-run dynamics and long-run relationships through decomposed positive and negative partial sums. The findings indicate that, in the long run, $TASI_{t-1}$ (Tadawul All Share Index) exhibits mean-reverting behavior. The coefficient estimate for lag TASI is −0.135 with a $P < 0.01$, suggesting that deviations from the equilibrium level tend to self-correct over time. This is a common feature in stock index modeling, as the market typically returns to its long-term trend after experiencing shocks or disturbances (Enders, 2015).

Conversely, the positive changes in crude oil production have a significant and positive effect on TASI (coefficient = 0.411, P = 0.006), confirming the critical role of oil production in influencing the Saudi stock market. This suggests that expansions in oil output likely signal fiscal strength and investment momentum, thereby stimulating stock prices. This may reflect market expectations that higher oil production will lead to increased government revenues, which in turn may translate into greater economic activity. In oil-dependent countries like Saudi Arabia, this kind of signal often boosts investor confidence, especially when it aligns with broader national goals like those outlined in Vision

Table 4: Results of NARDL model

Variable	Coefficient	Standard	t	P>t
TASI $_{(t-1)}$	−0.135	0.030	−4.480	0.000*
Inflation rate $_{(t-1)}^{+}$	−0.006	0.018	−0.360	0.719
Inflation rate $_{(t-1)}^{-}$	0.002	0.017	0.120	0.906
Real effective exchange rate $_{(t-1)}^{+}$	0.004	0.009	0.400	0.689
Real effective exchange rate $_{(t-1)}^{-}$	0.000	0.009	0.050	0.958
Crude oil price west texas $_{(t-1)}^{+}$	0.001	0.002	0.500	0.614
Crude oil price west texas $_{(t-1)}^{-}$	0.002	0.002	1.130	0.259
Crude oil production $_{(t-1)}^{+}$	0.411	0.147	2.790	0.006*
Crude oil production $_{(t-1)}^{-}$	0.137	0.117	1.170	0.245
Chinese index return $_{(t-1)}^{+}$	0.244	0.162	1.500	0.134
Chinese index return $_{(t-1)}^{-}$	0.242	0.154	1.570	0.118
S&P 500 return $_{(t-1)}^{+}$	0.083	0.299	0.280	0.781
S&P 500 return $_{(t-1)}^{-}$	0.013	0.310	0.040	0.966
Δ TASI $_{(t-1)}$	−0.004	0.061	−0.070	0.946
Δ inflation rate^{+}	−0.011	0.016	−0.650	0.517
Δ inflation rate $_{(t-1)}^{+}$	0.008	0.013	0.590	0.553
Δ inflation rate^{-}	−0.006	0.014	−0.430	0.665
Δ inflation rate $_{(t-1)}^{-}$	−0.017	0.015	−1.110	0.267
Δ real effective exchange rate^{+}	0.009	0.009	1.020	0.307
Δ real effective exchange rate $_{(t-1)}^{+}$	−0.008	0.009	−0.810	0.416
Δ real effective exchange rate^{-}	0.020	0.009	2.140	0.033*
Δ real effective exchange rate $_{(t-1)}^{-}$	0.010	0.009	1.230	0.220
Δ crude oil price west texas^{+}	0.000	0.002	0.120	0.907
δ Crude oil price west texas $_{(t-1)}^{+}$	−0.003	0.002	−1.570	0.117
δ Crude oil price west texas^{-}	0.003	0.002	1.720	0.088**
δ Crude oil price west texas $_{(t-1)}^{-}$	0.001	0.002	0.640	0.526
Δ Crude oil production^{+}	0.282	0.322	0.870	0.383
Δ Crude oil production $_{(t-1)}^{+}$	−0.317	0.365	−0.870	0.387
Δ Crude oil production^{-}	0.008	0.299	0.030	0.978
Δ Crude oil production $_{(t-1)}^{-}$	−0.168	0.280	−0.600	0.549
Δ Chinese index return^{+}	0.173	0.149	1.160	0.246
Δ Chinese index return $_{(t-1)}^{+}$	−0.055	0.142	−0.390	0.697
Δ Chinese index return^{-}	0.029	0.130	0.230	0.822
Δ Chinese index return $_{(t-1)}^{-}$	0.130	0.142	0.920	0.359
Δ S&P 500 return^{+}	−0.055	0.219	−0.250	0.802
Δ S&P 500 return $_{(t-1)}^{+}$	−0.149	0.226	−0.660	0.509
Δ S&P 500 return^{-}	−0.024	0.152	−0.160	0.877
Δ S&P 500 return $_{(t-1)}^{-}$	−0.129	0.269	−0.480	0.632
Constant	1.035	0.228	4.540	0.000*
F (38, 257)	1.380			
Prob > F	0.079			
R-squared	0.169			
Portmanteau test	51.320			
P-value	0.108			
Breusch/Pagan Heteroskedasticity Test	1.090			
P-value	0.296			

*P<0.05, **P<0.10

2030. This finding is consistent with prior research highlighting oil supply dynamics as a key driver of equity market performance in oil-exporting economies (Kilian and Park, 2009).

In the short run, Δ Real Effective Exchange Rate^{-} (negative changes in the Real Effective Exchange Rate) exerts a positive and significant effect on TASI (coefficient = 0.020, P = 0.033). This result implies that depreciation of the Saudi Riyal can enhance stock market performance, potentially by boosting export competitiveness or oil revenues in local currency. Bjørnland (2009) found that exchange rate depreciation tends to make a country's goods and services more competitively priced in the global market, thereby boosting exports, attracting higher foreign capital investment, thereby boosting the country's overall economic performance. Thus, in the short run, currency depreciation is associated with a significant positive effect on the Saudi stock market valuation (TASI). Additionally, a negative Δ Crude Oil Price West Texas also shows a significant positive effect on TASI (coefficient = 0.003, P = 0.088). While counterintuitive, this result possibly reflects an anticipatory market reaction stemming from policy-driven investor optimism in response to oil price downturns (Zhang et al., 2020).

Overall, the empirical findings presented in Table 4 show that positive oil production shocks have a substantial long-term influence on the Saudi stock market, while inflation and other

Table 5: Asymmetry statistics of NARDL model

Variable	Long-run effect [+]			Long-run effect [-]		
	Coefficient	F-stat	P>F	Coefficient	F-stat	P>F
Interest rate	−0.048	0.1293	0.719	−0.015	0.01389	0.906
Real effective exchange rate	0.027	0.170	0.681	−0.003	0.003	0.958
Crude oil prices west texas	0.007	0.254	0.615	−0.015	1.285	0.258
Crude oil production	3.054	11.120	0.001*	−1.015	1.509	0.220
Chinese index return	1.814	2.246	0.135	−1.795	2.528	0.113
S&P 500 return	0.618	0.077	0.782	−0.099	0.002	0.966
		Long-run asymmetry			Short-run asymmetry	
		F-stat	P>F		F-stat	P>F
Inflation rate		2.316	0.129		0.7055	0.402
Real effective exchange rate		0.802	0.371		2.575	0.110
Crude oil prices west texas		4.742	0.030*		3.071	0.081**
Crude oil production		4.176	0.042*		0.050	0.824
Chinese index return		0.003	0.959		0.027	0.870
S&P 500 return		1.136	0.287		0.014	0.906

*P<0.05, **P<0.10

macroeconomic factors, such as interest rates, exhibit limited or no discernible impacts. These results are aligned with previous studies that highlight the role of oil shocks and exchange rate variables in shaping stock market behaviour. For example, Davoudi et al. (2018) examined the Iranian stock market using a GARCH model and found that changes in oil prices and exchange rates had a positive and significant impact on stock market returns, while inflation, measured by the consumer price index, had no significant effect. Although their study focused on Iran, the parallels with Saudi Arabia, another oil-exporting economy, support the broader conclusion that oil market conditions and exchange rate movements are more influential drivers of market performance than other macroeconomic indicators like inflation.

Although past research highlights strong financial ties between Saudi Arabia and global markets (Abdou et al., 2024), the insignificant impact of the "S&P 500 and Shanghai Composite" variables on TASI suggests that factors such as oil price shocks and key macroeconomic conditions play a more significant role. This could be because the Saudi market is heavily influenced by the energy sector and government-related companies, which tend to be less reactive to short-term shifts in international stock markets.

The value of R-squared statistic indicates that 16.9% of the total variation in TASI is explained by the model. The diagnostic checks confirm the model's reliability: the Portmanteau test (P = 0.108) indicates no serial correlation in residuals, and the Breusch-Pagan Test for Heteroskedasticity imply that the residuals in the model are homoscedastic and standard errors are reliable, with a P = 0.296. This confirms the adequacy and proper specification of the "NARDL model." Overall, the model is statistically significant at a 10% confidence interval with a P-value = 0.079.

4.2. Asymmetric Effects Analysis

The asymmetry tests further validate the non-linear approach of the specification. Table 5 reveals significant long-run asymmetry in crude oil production (F = 4.176, P = 0.042), indicating that positive and negative shocks in oil production affect TASI differently. Similarly, West Texas crude oil prices exhibit both long-run (F = 4.742, P = 0.030) and short-run (F = 3.071, P = 0.081) asymmetries, supporting the hypothesis that markets respond asymmetrically to increases and decreases in oil prices. This is in line with Shin et al. (2014), who argue that separating the effects of positive and negative shocks through partial sum decomposition provides deeper insights into asymmetric financial market adjustments. Moreover, such asymmetric responses are particularly crucial in oil-dependent economies where investor sentiment is highly sensitive to the direction, not just the magnitude, of oil market fluctuations (Enders and Siklos, 2001).

These findings confirm that the "NARDL" framework is more suitable than linear models in capturing the actual behavior of stock market responses to external shocks, especially markets such as "TASI." The Saudi stock market is particularly reactive to oil sector variables, reflecting the nation's structural dependence on energy exports. Positive oil production signals appear to strengthen the market over time, whereas short-run corrections are driven by currency and oil price dynamics. The presence of positive oil production signals seems to amplify the market in the long run, but currency and oil price interactions are involved in short-run corrections. Therefore, policymakers and traders should consider the directional sensitivity of these macroeconomic indicators to predict the stock market and develop responsive policies (Shin et al., 2014).

5. CONCLUSION

The empirical evidence based on the "NARDL model" indicates a substantial, asymmetrical impact of macroeconomic factors on the "Tadawul All Share Index (TASI)." The model verifies that positive shocks in crude oil production have a robust, statistically significant long-run effect on "TASI," indicating a structural reliance of the Saudi stock market on oil production. The changes in the real effective exchange rate and crude oil prices also affect "TASI" in the short run, as do movements in the real effective exchange rate and crude oil prices. The evidence points out to that currency depreciation and oil market fluctuations motivate these measurable investor reactions. Further, the existence of mean-reverting dynamics in the "TASI" valuation over time confirms the presence of a long-term equilibrium. Ultimately, the diagnostic

tests validate the robustness and reliability of the model.

Importantly, the asymmetry tests confirm the dominance of the "NARDL model" over linear models, showing that the market is demonstrated to be asymmetrically sensitive to the positive and negative variations in the oil related variables. These empirical findings support the importance of applying non-linear and asymmetric models in the process of examining the markets that are dominated by commodity exports such as oil. These findings indicate that policymakers and investors should take directional sensitivity in oil prices and production into consideration in shaping economic policy or formulating portfolio choice.

Future studies can examine industry-specific responses within "TASI" to detect heterogeneity across their respective contributions to the market valuation over time. Additionally, a further sectoral focus can be used to evaluate how these confirmed market asymmetries might be affected by new, anticipated global shocks, including geopolitical conflicts in the Middle East or Asia, or the constantly evolving energy technology transformations that are being supported by the Western economies.

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