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RESEARCH PAPER

Oil Price Pass-Through and Stock Market Dynamics in an Oil-Exporting Economy: Results from a Quantile Regression for Iran

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Abstract
Linkages between oil prices and macroeconomic variables are widely studied in economics while there is some debate regarding oil price pass-through (OPP-T) and its impact on the stock market in oil- rich countries. OPP-T refers to the extent to which a change in oil prices affects the prices of other goods and services in the economy. the relationship between the two markets can be both positive and negative, and the magnitude of their correlation is dependent on various economic factors. In This study, the direct and indirect OPP-T effects of oil price on the stock market are empirically analyzed for Iran as a major oil-exporting economy, during March 2001 to February 2019. The quantile regression (QR) model is used because this model is extremely effective to recognize the distribution pattern form of the dependent variable at different levels of the independent variable. The results show that there is a positive and significant relationship between OPP-T and stock market returns. Moreover, the results indicate OPP-T directly on the stock market, as well as indirectly through the exchange rate channel. in higher quantities, i.e., when the stock market is booming, the change of crude oil price returns on the stock market, passes only through an indirect path (through the exchange rate channel) while, the decline in the crude oil price (or crude oil revenues), strengthens the stock market index by increasing the exchange rate. Additionally, the paper highlights the importance of understanding the oil market dynamics and policy implications for stock market participants, policymakers, and investors. Stock market traders in oil-exporting countries are advised to take into account the risk that arises from the fluctuations in crude oil and foreign exchange markets to the stock market.
Keywords: Exchange Rate, Oil-Exporting Economy, Oil Price Pass-Through, Stock Market.
JEL Classification: B23, C01, N75.

1. Introduction
The oil market is strongly associated with other financial markets so that fluctuations in this market affect other financial markets (Qamruzzaman, 2023;

Bashir, 2022; Basher et al., 2018; Dutta et al., 2017; Kang et al., 2015; Liu et al., 2013; Sadorsky, 1999). Before the 1980s, due to the organizational structure of the international oil market, crude oil prices did not fluctuate significantly, thus did not involve oil agents at significant risk. From the late 1980s, after the establishment of the NYMEX stock exchange in New York and with graduate deepening of this market in the subsequent decade, the discovery of dominant oil price indexes (such as Brent and WTI) was affected by the demand and supply conditions in future markets and spot prices (Buyuksahin et al., 2013; Silverio and Szklo, 2012). With the development and financialization of the oil market and the presence of other non-fundamental effective factors, global oil prices were volatile with a wide range (Fattouh and Mahadeva, 2012). During various periods, global oil prices experience excessive volatility. For example, after a peak of 148$ per barrel in July 2008, the oil price has declined to about 40$ per barrel in late December. Another example is the decline of global oil prices from 107$ in August 2014 to about 40$ in September 2015. These price volatilities and fluctuations yield frequent market risks and lead to heavy potential losses for activists in the international oil market and other financial markets.

Investigating the impact of oil price variations on financial markets is highly important because the factors influencing this market affect other financial markets greatly. In recent decades, global oil price volatilities have been about two times the volatility of other products. The concept of excess volatility of global oil price is that trade periods, as well as other financial markets, are constantly affected by global oil price volatilities (Filis et al., 2011). Recently, investigation of the impact of oil price shocks on stock market returns has attracted the attention of many researchers (Rahman, S. 2022; Boldanov et al., 2016; Degiannakis et al., 2013; Kilian, 2009; Ready, 2018; Soyemi et al., 2019; Zankawah and Stewart, 2019), but a small body of literature focus on emerging markets or net oil-exporters.

Although developing oil-exporting countries mostly have narrow stock markets, there is frequent evidence of the relationship between stocks and the oil market in these countries because the stock value depends on the present value of its future cash flows (Elwood, 2001; Khamis et al., 2018). Moreover, oil price volatility in oil-exporting countries can be considered as one of the most important macro factors influencing the stock market. Theoretically, the stock value equals the sum of the discounted value of the expected future cash flows (Ali et al., 2022; Arouri and Rault, 2010; Khamis et al., 2018; Narayan and Narayan, 2010). These cash flows can certainly be affected by macroeconomic variables such as oil shocks. An increase in oil price is expected that positively affects the currency inflow of the country, budget expenditure supply, and aggregate demand (Shahrestani and Rafei, 2020). Note that since oil-exporting countries supply a major part of their required goods from advanced and emerging countries, therefore, a rise in oil price may lead to an increase in the cost of importing consuming and capital goods for oil-exporting countries.

On the other hand, the effect of crude oil price on stock price and the exchange rate is important for both groups of importing and exporting countries, because it is a strategic factor for supplying -energy and supplying raw materials for the products of industrial enterprises. Since the crude oil in the importing country is considered as a factor of production, increasing the price of imported crude oil increases the cost of production and, the price of consumer goods increases. This increase in the price of consumer goods reduces the value of the importing country's currency against other currencies, which in turn leads to changes in firms' costs and changes in their stock prices. In contrast, rising crude oil prices in exporting countries have led to optimistic expectations about a boom and boost in economic activity and the level of profitability, and their stock prices will rise with increasing demand for corporate stocks.

Moreover, the crude oil price pass-through can be considered as an important economic risk, which in some cases can have negative effects on investing in the stock market. Fluctuations in crude oil prices affect the economy of a country whose budget is based on crude oil. Given the coverage of the bulk of the annual budgets of countries with crude oil revenues and their reliance on crude oil, the slightest change in the price of crude oil affects the budget and, the changes in the price of crude oil through the budget channel affect macroeconomic variables and, consequently, the returns of enterprises and, ultimately, the returns of the capital market.

Therefore, according to the mentioned discussions, the change in the price of crude oil has a great impact on other economic variables. It also plays a key role in economic growth and development, social welfare, improving the quality of life and security of a society. Although the stability of supply and demand of various energy carriers is one of the most important issues in energy security, crude oil as a common usable fuel, unfortunately, has not had price stability.

Therefore, understanding the mechanism of the formation of crude oil prices can reduce the risk of crude oil price fluctuations and their negative effects on the Iranian economy, such as financial and capital markets, including the stock market. Many empirical studies in developed markets also show that stock prices fluctuate with changes in many factors. Naturally, many factors are influential in shaping the information and views of market participants and ultimately the stock prices of companies. Some of these factors are internal and some are due to the situation of variables outside the scope of the domestic economy. Accordingly, the factors affecting the stock price can be classified into internal and external factors: external factors such as economic factors (sectoral economics, macroeconomics, microeconomics), political-military factors as well as cultural-behavioral factors, and internal factors such as earnings per share, the financial structure of the company, changes in accounting procedures, etc. fall into this category.

Therefore, it is expected that the stock price index has a strong relationship with macroeconomic variables, variables such as expected value, appropriate discount rate and cash payment at the end of the period, etc. that addressing all the variables in the economy is not within the scope of this study, but crude oil price changes are specifically considered. Since the share of crude oil in the stock market is constantly changing and is experiencing several fluctuations, it is important to study the reasons for the change in crude oil prices and the effect of crude oil price pass-through on other sectors, including the stock market.

Considering the importance of crude oil market and capital market interactions, in this study, the effect of crude oil price pass-through on stock price index in Iran is investigated using quantile regression (QR) model. One of the advantages of QR model is the ability to assess the relationships between the independent and dependent variables not only in the center of the distribution but also in the upper and lower tails of the conditional distribution of the response variable. Also, conducting the role of the exchange rate for an indirect oil price path pass-through analysis is another research contribution. Moreover, most studies in this regard have been conducted on oil importing countries. It seems that applying this model to Iran as a major oil-exporting country can provide policy recommendations for effective stock market management in oil-exporting countries.

2. Theoretical Background

As shown in Figure 1, global crude oil price volatility can lead to changes in stock prices in oil-exporting countries from various channels. These channels can be categorized into five groups. In the liquidity creation channel, revenue obtained from selling oil is transferred to the central bank's foreign currency account and leads to an increase in the central bank's foreign net assets and the monetary base. In the case of a decrease in oil revenues (caused by oil price declines), an increase in budget deficit compels the government to borrow from the central bank, leading to an increase in the monetary base.

The second channel is the impact of oil prices on stock prices through the exchange rate channel (Kumar et al., 2023; Beckmann et al., 2020; Morley and Pentecost, 2000). Some studies have concluded that there is a greater correlation between crude oil prices and exchange rates in oil-exporting countries than in oil-importing countries (Reboredo, 2012; Yang et al., 2017). The exchange rate as one of the economic indicators has always been directly affected by crude oil fluctuations and in Iran, most exchange rate fluctuations are related to crude oil shocks. This shows the vulnerability of the Iranian economy to crude oil price changes, much of which is due to the passive role of foreign exchange policies. The main reason for these fluctuations is the various exchange rate policies adopted in Iran. The fall in crude oil prices in the past has caused the value of the domestic currency to rise in the short run due to misguided exchange rate policies.

The third channel is the impact of oil prices on stock prices through the expectations effect (Byrne et al., 2019). Theoretically, variations in oil prices can affect the formation of expectations in the capital market and, consequently, the stock price index of the active companies on the stock exchange market through various channels. The result of these impacts is associated with the extent to which the companies are dependent on global oil market volatilities (Wu, 2023; Basher et al., 2012). With an increase in oil prices and revenues in oil-exporting countries, optimistic expectations are formed about the boom and raising the level of economic activities. Therefore, the increased profitability of companies active in the stock exchange and, consequently, a rise in the stock index is expected (Lu et al., 2001).

Revenue effect is the fourth channel through which global oil prices affect stock prices. Indeed, higher oil prices mean the wealth transfer from the oil-importing countries to the oil-exporting ones. The effect of these changes in prices depends on the performance of the government in dealing with the revenue increase. If the revenue increase is in line with the purchase of domestic goods and services, it can lead to an increase in public wealth (Sayadi and Khosroshahi, 2020). With an increase in the demand for labor and capital, many trading and investment opportunities have been created, affecting the future cash flows of the firms and the increase in profitability.

The fifth channel is the impact of oil prices on stock prices in oil-exporting countries through the recursive effect. Oil price increase leads to an increment in total costs of goods produced by industrial countries, causing a rise in the monetary value of imports for oil-based countries and negative impact on future cash flows of their firms and, consequently, a decrease in stock prices (Arouri and Rault, 2010). The net effect of oil price volatility on stock price in oil-exporting countries depends on the resultant of positive and negative impacts related to the channels mentioned.

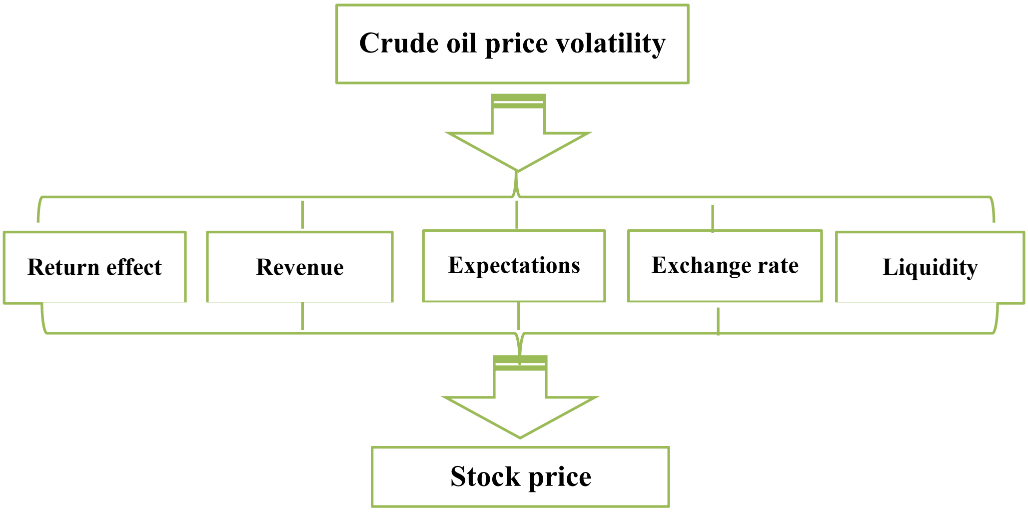

Figure 1. Crude Oil Price Volatility Impact Channels on Stock Price Volatility
Source: Research finding.

The stock price index is the most important factor influencing investors' decisions in the stock market. Therefore, accurate forecasting of stock price index movements is very important for investors. the crude oil price pass-through, which is equivalent to the effect of the percentage change in crude oil price change on the percentage change in domestic price, is examined in this study (Shioji and Uchino, 2011). Therefore, it is important to study the effect of crude oil price pass-through on the stock price index.

3. Literature Review

Table 1 presents a summary of some main features of the relevant studies, which have conducted to investigation the relationship of the oil market and stock market.

Table 1. Main Features of the Relevant Studies

Author(s)	Object(s)	Method(s)	Case Study	Result(s)
(Angelidis et al., 2015)	stock market regimes and crude oil price shock	Regime switching model	USA	• The crude oil price shock has great power in predicting the stock market situation.
(Balcilar et al., 2015)	crude oil price regime model change and stock market	Regime switching model	USA	• The highly fluctuating regime existed before the Great Depression and after the 1973 crude oil price shock under the influence of the OPEC
(Ghosh and Kanjilal, 2016)	Correlation between international crude oil price and Indian stock market	threshold cointegration	India	• No significant relationship found between the crude oil price and the Indian stock market in the long-term equilibrium.
(Zhu et al., 2016)	Heterogeneous correlation between crude oil price changes and China industry stock market	Quantile regression	China	• The market response to crude oil is significantly heterogeneous in the conditional distribution of industry stock returns.
(Diaz et al., 2016)	Crude oil price fluctuations and stock returns	Vector autoregressive (VAR) model	G7 economies	• Negative response from G7 stock markets to rising crude oil price fluctuations. • Global crude oil price fluctuations are generally greater for stock markets than crude oil price fluctuations.
(Nusair and Al-Khasawneh, 2018)	Oil price shocks and stock market returns	quantile regression analysis	GCC countries	• Positive shocks to aggregate demand and specific demand for crude oil are associated with negative effects on changes in stock returns.
(Delgado et al., 2018)	The relationship between oil prices, the stock market, and the exchange rate	Vector Autoregressive Model (VAR)	Mexico	• the exchange rate has a negative and statistically significant effect on the stock market index • The consumer price index has a positive effect on the exchange rate and a negative effect on the stock market index. • Oil prices are statistically significant against the exchange rate, concluding that an increase in oil prices creates an appreciation of the exchange rate.
(Kelikume and Muritala, 2019)	The Effect of Crude Oil Price Changes on Market Shares	dynamic panel analysis	Africa	• Economic growth has a positive effect on stock returns in Africa • Relationship between the stock market and the crude oil price in this region is significant.

(Kocaarslan and Soytas, 2019)	Asymmetric pass-through between oil prices and the stock prices of clean energy firms	nonlinear auto-regressive distributed lag (NARDL)	clean energy stocks	• Significant asymmetric effects among the variables of oil prices, interest rates, and the stock prices of clean energy and technology firms. • The increased investments in clean energy stocks appear to be due to speculative attacks along with an increase in oil prices in the short-run., • In the long-run, the increased oil price has a negative impact on clean energy stock prices and this impact is asymmetric
(de Jesus et al., 2020)	The non-linear relationship between oil prices and stock prices.	Dynamic Ordinary Least Squares model	oil-importing and oil-exporting countries	• A positive long-term relationship was found between oil and stock prices. • the wealth effect prevailed for oil-exporting countries • Oil-importing countries with emerging economies have experienced a positive sign in the long-term relationship • The United States has seen asymmetric adjustments in the long-term relationship between oil and stock prices.
(Xiao and Wang, 2020)	Dynamic complexity and causality of crude oil and major stock markets	the Kernel method Granger Causality	major stock markets	• Nonlinear bidirectional causal relationships are found between oil and stock. • The WTI and the Brent crude oil prices are not playing identical roles in their interactions with multiple stock markets.
(Chang et al., 2020)	The asymmetric effects of oil price on sectoral Islamic stocks	Quantile-on-Quantile (QQ) approach	Islamic stock indices	• Lower (upper) quantiles of oil prices negatively affect the upper (lower) quantiles of the DJ Islamic index. • Upper or lower quantiles of both markets indicate a positive relationship.
(Amiri et al., 2021)	Oil price shock and macroeconomic outcome	DSGE	Iran	• Upward oil price shocks will weaken real exchange rates. • Upward oil price shocks will lead to a loss in economic competitiveness. • Upward oil shocks will increase the liquidity.

(Olayungbo and Ojeyinka, 2021)	asymmetric response of petroleum product prices to international crude oil prices	hidden cointegration approach	Nigeria	• Petroleum prices in Nigeria respond asymmetrically to changes in crude oil prices. • positive changes (increase) in crude oil prices produce a larger and stronger effect on petroleum prices than the effect of negative changes • Evidence to support the hypothesis of "rocket and feather" in the pass-through effect of crude oil prices on petroleum prices in Nigeria.
(Shioji, 2021)	Pass-through of oil supply shocks to domestic gasoline prices	SVAR-IV	Japan	• Pass-through is so fast: about 70% of the entire adjustment process is completed within just 18 days.
(Balcilar and Usman, 2021)	exchange rate and oil price pass-through	Diebold-Yilmaz spillover index and rolling-windows	BRICS countries	• there is strong evidence of directional spillovers across the countries • The total spillovers are low, with Russia (China) having the highest (lowest). This suggests a low pass-through across the countries • the net spillovers of oil price and exchange rate are positive in Brazil, Russia, and South Africa, while in India, they are both negative. • The spillovers exhibit significant bursts with no clear-cut evidence of trends across these countries. These findings are useful in formulating an optimal monetary policy.
(Jiménez-Rodríguez and Morales-Zumaquero, 2021)	commodity price pass-through along the pricing chain for the global commodity price index and the indices of its main categories	country-by-country VAR and Pool model	advanced and emerging countries	• Partial pass-through from commodity prices to producer prices. • The pass-through seems to be led for producer prices. • Higher prices in the four categories (agricultural raw materials only in the short-run) induce significant higher producer prices in almost all cases. • Energy prices explain the highest variability of producer and consumer prices.

(Badamvaanchig et al., 2021)	Pass-through of commodity price to stock price	NARDL	Mongolia	• The results show clear evidence of asymmetric long-run relationships between stock and the commodity prices • a positive relationship between copper price and stock price in the case of a positive shock on copper price, but no clear relationship in the case of a negative shock on copper price.
(Atif et al., 2022)	Oil price changes and stock returns	Panel VAR	oil exporting and oil importing countries	• in the period marked by the rapid outbreak of the covid-19 pandemic, causality from oil to stocks increased • both oil exporting and oil importing countries were affected in a similar way, oil price changes had a larger impact on oil exporting countries.
(Xing et al., 2023)	The impact of the Russia–Ukraine conflict on the energy subsector stocks	A network-based approach	China	• the key energy stocks in terms of volatility correlations would certainly change during the Russia–Ukraine conflict. • during the conflict, several renewable energy stocks tend to influence other stocks in the system.

Source: Mentioned Research.

In general, most studies have examined the effect of crude oil shocks on various macroeconomic variables, and some studies have been conducted on the effect of crude oil price pass-through on the stock market. On the other hand, the use of the quantile method to investigate this effect has not been done in previous studies. Therefore, in this study, we examine the effect of crude oil price pass-through on the stock market through the quantile method. Also, in addition to the direct relationship, our study examines the oil price path- through on the stock market with regard to the key role of the exchange rate (indirect oil price path-through).

3. Methodology

To better understand the concept of quantile regression, it is first necessary to explain the concept of quantile and how to obtain it. Each stochastic variable has a cumulative distribution function that can be represented as follows:

$$F(y) = P(Y \leq y) \tag{1}$$

For example, if the stochastic variable Y has a standard normal distribution, its cumulative distribution function will be in the following form. If y=0 then, the value of the cumulative distribution function at this point will be 0.5. This means that the probability of occurrence of values less than zero for y is equal to 50% (Davino et al., 2013).

Now for each $0 < \tau < 1$, the τ-th quantile of the distribution can be calculated as follows:

$$Q(\tau) = F^{-1}(\tau) \tag{2}$$

Figure (3) shows the inverse of the standard normal cumulative distribution function. If we want to calculate the value of the standard normal distribution of the quantile 0.5 (quantile 0.5 of the distribution is the median of the distribution and the mean for the normal distribution is equal to the median), will be zero.

If we want to define the quantile of a distribution accurately, we can use the following mathematical definition:

$$Q(\tau) = inf\{y: F(y) \geq \tau\} \tag{3}$$

Equation (4) is a simple optimization problem that can be written in a simpler form as follows:

$$Q(\tau) = arg\ min\left\{\sum_{i:Y_i \geq \vartheta} \tau|Y_i - \vartheta| + \sum_{i"Y_i < \vartheta} (1-\tau)|Y_i - \vartheta|\right\} \tag{4}$$

where, I is the observation index of the variable Y that takes values of 1 to n. In fact, based on the above equation, quantile of a stochastic variable such as Y is obtained through minimization of the weighted average of the observations larger than quantile and observations smaller than quantile. Of course, the above weighted average gives asymmetric weights to values smaller and larger than quantile. If an observation is larger than quantile, it receives weight of τ, and if it is smaller, it gains the weight of $1 - \tau$. For example, if we want to calculate the 10% quantile of the distribution, the weight of the values smaller than the quantile will be 0.9 and the weight of the larger quantile will be 0.1 (Koenker, 2005).

The idea of the calculation of quantile based on Equation (4) can also be generalized to regression analysis. As mentioned earlier, in an ordinary least squares estimator, the goal is to find a line that exceeds the conditional mean distribution of the dependent variable (EYX). In the OLS method, we determine the model coefficients so that the regression line passes the conditional mean distribution of the dependent variable. Now if we extend this idea and want the regression line to pass through the τ-th quantile of the conditional distribution of the dependent variable instead of passing the conditional mean distribution of the dependent variable, then the estimator would be the quantile regression estimator. The idea of quantile regression has been shown in Figure (2). In this figure, the regression line coefficients have been estimated to pass the distribution quantile of 0.9. In this figure, the line passing through the center of the conditional distributions is the same regression line estimated by the OLS method. The other line that crosses the distribution sequences is the regression line of 90% quantile (Koenker, 2005).

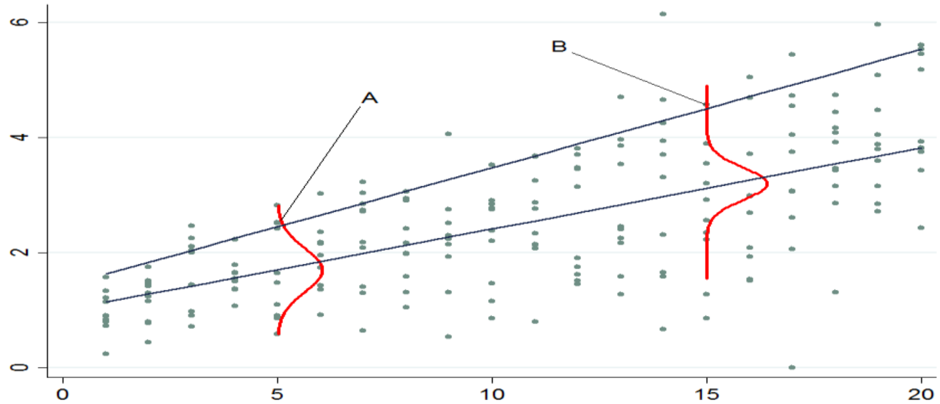

Figure 2. Comparison of the Quantile Estimator with the Ordinary Least Squares Estimator

Source: (Koenker, 2005).

Now, based on the idea of Equation (4), the problem of quantile regression optimization can be written as follows:

$$\hat{\beta}(\tau) = \arg min \left\{ \sum_{i:Y_i \geq \acute{X}_i\hat{\beta}(\tau)} \tau \left| Y_i - \acute{X}_i\hat{\beta}(\tau) \right| + \sum_{i:Y_i < \acute{X}_i\hat{\beta}(\tau)} (1-\tau) \left| Y_i - \acute{X}_i\hat{\beta}(\tau) \right| \right\} \tag{5}$$

If we calculate the regression coefficients at the quantile of 0.5 in Equation(5), the regression line will exceed the conditional distribution median of the dependent variable and, the quantile regression is equivalent to median regression or the least absolute deviation (LAD). Also, if, instead of the absolute value in Equation (6), we used the second power of the errors and assumed the quantile to be 0.5, Equation (6) would become the OLS estimator. Figure (6) shows the weighting differences of the errors in the three ordinary least squares regressions, least absolute deviations, and quantile regression. In this figure, q = 0.5 is equivalent to the regression of absolute deviations, squared error, ordinary least squares and, q = 0.1, 0.9 is the quantile estimator at two quantiles of 10% and 90%.

To estimate the quantile models, unlike the OLS method, which has an algebraic solution, optimization methods are used. In fact, Equation (5) is a linear programming problem that needs to be solved by one of the methods related to solving optimization problems. For example, the common simplex approach (SIMPLEX) proposed by Barrodale and Roberts (1973) and later modified by Koenker and d'Orey (1987) can be used to obtain quantile regression coefficients and solve the optimization problem. Of course, in addition to this method, any other method that exists to solve linear programming problems can be used for this purpose.

A common approach in studies related to quantile regression is to estimate the main regression of the study in different quanta. Then, using ANOVA test, they test whether the desired regression coefficients are statistically different at different quantiles. If the null hypothesis of the ANOVA test is rejected, this will mean that the regression coefficients have statistically significant differences at different quantiles; therefore, it is necessary to use quantile regression to examine the relationship between variables. Then, the regression coefficients at each quantile are calculated and analyzed according to the research subject. However, if the number of quantiles is large, graphs are usually used instead of reporting the results of the coefficients in the tables. In these graphs, in addition to the value of the coefficient of each variable at the desired quantile, the 95% confidence interval is also given so that it is easy to comment on the significance of the coefficient at each quantile.

4. Results

4.1 Research Model

The regression pattern used in this study is as follows; it should be noted that the variables included in the following model are taken from two studies of Zhu et al. (2016) and Delgado et al. (2018).

$$RSMR_t = c^q + \beta_1^q ROILR_t + \beta_2^q REXR_t + \beta_3^q ROILRM_t * REXRM_t + \varepsilon_t^q \quad (6)$$

where, $RSMR_t$ represents the real stock market return, which has been calculated as the growth percentage of the total real price index. The total real stock market price index is obtained by dividing the total price index of the Tehran Stock Exchange by the consumer price index (base year of 2016). $ROILR_t$ in this equation also shows the percentage increase in the dollar price of crude oil, which has been adjusted by the US consumer price index. In fact, this has been done to make the crude oil dollar price real. The dollar value depreciates every year due to inflation, therefore, in order to be able to compare the price of crude oil in different years, it is necessary to adjust it with the US consumer price index. $REXR_t$ also shows the real exchange rate growth percentage.. Since revenues from oil exports have a large impact on the economies of oil-exporting countries, and in particular the stock market, the exchange rate is a key variable in modeling the economies of these countries. The exchange rate is included in the model as an interactive variable. The real exchange rate in this study has been calculated as follows:

$$REX_t = EX_t \frac{CPI_t^{US}}{CPI_t^{IR}} \quad (7)$$

where, EX_t represents the nominal exchange rate (Rials per dollar) in the informal market, CPI_t^{IR} is the Iranian consumer price index and CPI_t^{US} denotes the US consumer price index.

In this study, to investigate the role of exchange rate in the crude oil price pass-through over the stock market, (as in other studies) a new variable has been defined obtained by multiplying the variables of real exchange rate growth and real crude oil price growth. Of course, before multiplying these variables, the following changes have been applied to these variables and then the product of their multiplication has been calculated. In fact, the change applied to the variables was that their mean has been subtracted from each of the variables. This change in the variable is done to deal with the alignment problem. When, in addition to the $ROILR_t$ and $REXR_t$ variables, the $ROILR_t * REXR_t$ variable is also included in the model. Since the probability of strong linearity between the variables is very high, one approach to solve this problem is to average the variables and then multiply the averaged variables.

$$ROILRM_t = ROILR_t - \mu_{ROILR} \quad (8)$$

$$REXRM_t = REXR_t - \mu_{REXR} \quad (9)$$

Accordingly, if the exchange rate causes a change in the direction and size of the crude oil price pass-through over the stock market, the $ROILRM_t * REXRM_t$ variable will be significant and its coefficient will show the adjustment of this relationship.

Table 2 indicates the list of variables include of variables name, description, frequency measurement, and source. RSMR_t, ROILR_t, and REXR_t denote the real stock market return, real Brent crude oil spot price return, and real exchange rate return, respectively. The US PPI is used to adjust nominal prices to obtain real oil prices.

Table 2. List of Variables

Variables	Description	Frequency	Measurement	Source
$RSMR_t$	Real Stock Market Return	monthly	%	Tehran Stock Exchange
$ROILR_t$	Real Brent Crude Oil Spot Price Return	monthly	%	https://tradingeconomics.com/
$REXR_t$	Real Exchange Rate Return	monthly	%	Central Bank of Iran

Source: Research finding

Statistical descriptions of the variables are summarized in Table 3 to provide more information about the data for this study. Table 3 shows the descriptive statistics (include mean, median, max, min, standard deviation, skewness, kurtosis, and Jarque-Bera criteria) of variables. The mean values are positive for all variables and standard deviations show the unconditional volatility. The skewness for $RSMR_t$ and $REXR_t$ is positive, while the skewness for $ROILR_t$ is negative. A negative skewness indicates a greater number of larger values, whereas a positive skewness indicates a greater number of smaller values. Since the skewness of the variables is either less or more than zero, series distributions are all non-normal. Based on the results of Jarque-Bera criterion, the null hypothesis (the normality of distribution) for all variables be rejected. Moreover, kurtosis of all variables are positive and more than 2. It can be noted that, A positive value for the kurtosis indicates a distribution more peaked than normal. In contrast, a negative kurtosis indicates a shape flatter than normal. Analogous to the skewness, the general guideline is that if the kurtosis is greater than +2, the distribution is too peaked. Likewise, a kurtosis of less than −2 indicates a distribution that is too flat.

Table 3. Descriptive Statistics

Variables	Mean	Median	Max	Min	St. Dev	Skewness	Kurtosis	Jarque-Bera (Prob)
$RSMR_t$	0.70	-0.22	26.10	-13.37	5.76	0.83	4.50	45.22 (0.000)
$ROILR_t$	0.60	1.52	20.09	-26.42	8.08	-0.67	3.82	22.26 (0.000)
$REXR_t$	0.22	-0.64	29.55	-21.49	4.81	1.95	14.33	1293.41 (0.000)

Source: Research finding.

4.2 Results

Before estimating the main research model using quantile regression, in order to compare, the model has been first estimated using the ordinary least squares method and the results have been reported in Table (4).

Table 4. Results from the OLS Method

Variable	Coefficient	T Test	P value
C	*0.70	1.83	0.069
ROILR	**0.11	2.22	0.027
REXR	0.11	1.34	0.183
ROILR*REXR	***-0.03	-2.74	0.007

Source: Research finding.

Note: *, **, *** denotes significance levels at the 10%, 5%, and 1%, respectively.

The results of the normality test of the above regression error terms (Table3) show that the estimated model error terms are not normal (Table5). As mentioned earlier, the ordinary least squares method is not a suitable method for estimating model parameters in such cases. On the other hand, the presence of outliers in the real stock market return variable also causes the estimator results to be biased at least ordinary squares. Accordingly, quantile regression is used, which is robust for both of the above problems.

Table 5. Result of Testing Normality

J-B Statistic	Probability
55/55	0/000

Source: Research finding.

In order to be able to provide a convincing reason for using quantile regression, we first need to test whether the regression coefficients at different quanta are significantly different. For this purpose, the ANOVA test is used, which tests the equality of the means of several groups (in the present application, the means of the groups are the same as the coefficients of the model) simultaneously. As shown in Table (6), regression coefficients have significant differences at different quantiles. Null hypothesis of this test represents the equality of coefficients at quantiles and the opposite hypothesis is the inequality of coefficients. According to the obtained results, the null hypothesis of the test has been rejected at the level of one percent. It should be noted that this test was performed for quantiles of 0.05 to 0.95 (with an increase of 0.05 in each step).

Table 6. Results from ANOVA Test

F Statistic	D.F of the Numerator	D.F of the Denominator	Probability
1.986	54	4050	0/000

Source: Research finding.

Figure (3) shows the coefficients of the model variables at different quantiles of the real stock market return variable. There are several major differences between the results of quantile estimation using the ordinary least squares method. First, the real exchange rate growth rate variable in the OLS method was insignificant however, this variable is not insignificant at all quantiles, and at the end quantities of distribution, where the stock market records high returns, this variable has a significant effect on the stock market. Of course, it should be noted that this effect is related to the pure impact of this variable on the stock market. Because a part of the effect of the exchange rate variable, which is due to crude oil price changes has been included in the model as another variable and, so the coefficient estimated for the exchange rate variable is different from the effect that the real exchange rate applies to the stock market as a result of crude oil price changes. The second difference between the results of quantile regression and the results of the OLS method is that the real yield variable of crude oil price does not have a significant effect on the stock market at all quantities of real stock market returns (although it means a direct effect). A decrease (or increase) in the price of crude oil is more effective at the lower quantities of the stock market, i.e. where the stock market is in a recession. In other words, if the market is declining and the crude oil price falls, the crude oil price pass-through over the stock market will deepen the stock market recession. Of course, in order to be able to make a final statement about the price of crude oil, we must also consider its indirect effect.

According to Figure (3), the indirect crude oil price reduction pass-through works in the opposite direction. In other words, lowering the price of crude oil, by increasing the real exchange rate, neutralizes a part of its negative effect. In other words, if we assume that crude oil price growth will decline, it will directly reduce real stock market returns. But on the other hand, lower crude oil prices will increase the nominal exchange rate and the real exchange rate will increase. The occurrence of two currency shocks as a result of sanctions confirms such a relationship between crude oil revenues and the foreign exchange market. Decreasing the price of crude oil will reduce crude oil revenues and reducing crude oil revenues will reduce the supply of currency. Since crude oil revenues are an important part of the foreign exchange supply in the Iran, the decrease in foreign exchange supply will be accompanied by an increase in the nominal exchange rate. Since the nominal exchange rate pass-through on the consumer price index is not complete (the exchange rate pass-through in Iran is between 20 and 30% according to calculations), the nominal exchange rate in the real exchange rate formula will increase, but the denominator of the deduction, which is the domestic consumer price index, will not increase accordingly. As a result, the real exchange rate will increase. An increase in the real exchange rate will also increase the competitiveness and profitability of Stock Export Companies as a result, a part of the reduction in stock market returns will be neutralized in this way.

The reason for the difference between the results of quantile regression and the ordinary least squares method for indirect crude oil price changes pass-through is that the coefficient of this variable in quantile regression is higher with the increase in real stock market return (higher quantiles of real stock market return variable). In other words, when we are at high quantiles of the stock market or during the boom of this market, the pass-through of the crude oil price reduction over the stock market is not only negative, rather, it is done indirectly, positively, to the stock market. This result is very important and is consistent with empirical evidence. Crude oil revenues fell sharply in the last two sanctions, but the stock market experienced a growing trend. One of the main reasons was the increase in the exchange rate as a result of the decrease in crude oil revenues which made export companies profitable and neutralized the effect of lower crude oil prices.

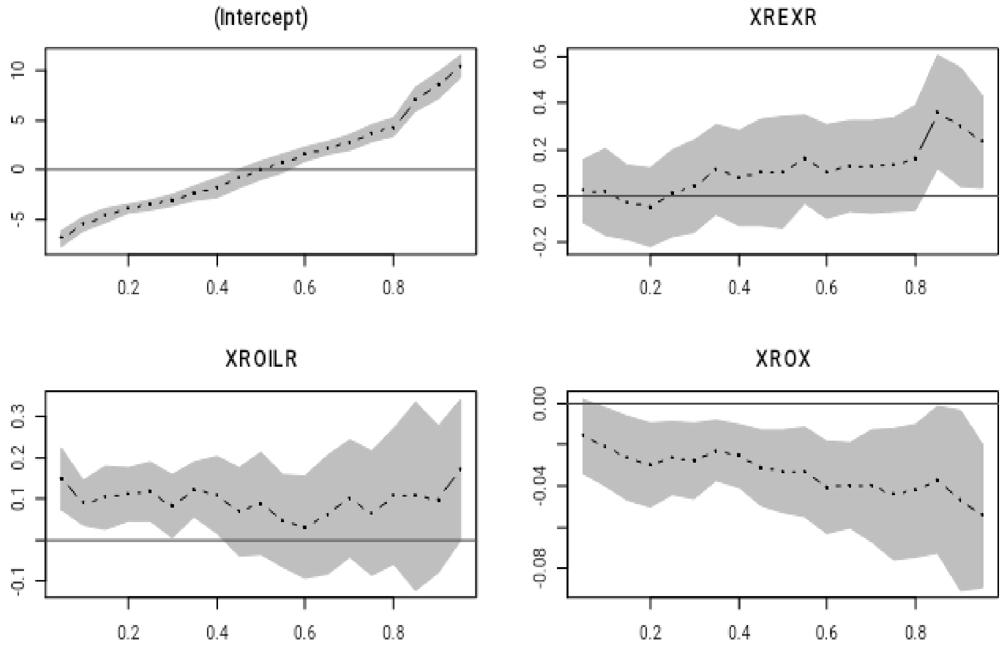

Figure 3. The Coefficients of Variables in Different Quantiles of $RSMR_t$
Source: Research finding

This research aims to test the hypothesis that there is a positive and significant relationship between oil prices and the stock market in different quantiles. Table (7) shows the values of the coefficients at different quantiles as well as their significance. In fact, these results are the same as those presented in Figure (3); but here we have tried to provide more details. As observed, the value of the real crude oil price return coefficient at the first four quantiles (ten percent quantile) is statistically significant. In other words, the crude oil price pass-through to the stock market up to the fourth quantile (quantile of 40%) occurs both directly and indirectly (due to the significance of the indirect channel at all quantiles). But from the fourth to the ninth quantile (90% quantile), the effect of changes in the real crude oil price return on the stock market, or in other words, the crude oil price pass-through on the stock market, is indirect. In fact, when the stock market is booming, a drop in crude oil prices not only does not reduce the stock market's real return, but it has a positive effect on the stock market through the exchange rate channel; the value of this positive effect is maximized at the ninth quantile or where the stock market is in full bloom. The coefficient of the real price variable of crude oil in this quantile is statistically insignificant or in other words, it is equal to zero. Also, the value of the ROILR * REXR variable coefficient at this quantile is significant and higher than the previous quantiles (in terms of absolute value). In addition, the real exchange rate is significant at this quantile, and in addition to the mediating effect through the ROILR*REXR variable, it also has a direct positive effect on stock market returns.

If the data distribution is normal, the median will match the mean and, it is expected that the results of quantile regression at the quantile of 50% (or the median) is equal to the results of ordinary least squares regression. When the distribution of data is not normal, the expectation of the equality of results will not matter. Comparison of the results obtained in Table (5) for the 50% quantile with the results of the OLS estimator reported in Table (2) shows that the results are different. Of course, there is no significant difference between the results. The only difference is the slight reduction of the real exchange rate coefficients and the real crude oil return, as well as the insignificance of the real crude oil return coefficient in the quantitative regression (at the quantile of 50%). ANOVA test was used to evaluate the equality (symmetry) of OLS regression coefficients with quantile regression at 50%. The results of this test have been reported in Table (8). As can be seen in this table, the null hypothesis of the test is rejected and it can be concluded that the coefficients of these two regressions are different.

Table 7. The Coefficients of Variables in Different Quantiles of $RSMR_t$

Variable	q.10	q.20	q.30	q.40	q.50	q.60	q.70	q.80	q.90
C	***-5.45	***-3.85	***-3.03	***-1.74	***0.03	***1.58	***2.79	***4.32	***8.58
REXR	0.01	-0.05	0.04	0.08	0.10	0.10	0.13	0.16	*0.30
ROILR	***0.09	***0.11	**0.08	*0.11	0.09	0.03	0.10	0.11	0.10
ROILR*REXR	*-0.02	**-0.03	***-0.03	**-0.03	***-0.03	***-0.04	***-0.04	**-0.04	**-0.05

Source: Research finding.

Note: *, **, *** denotes significance levels at the 10%, 5%, and 1% , respectively.

Table 8. Results of Equality Test for OLS Coefficients in the 50% Quantiles

F Statistic	D.F of the Numerator	D.F of the Denominator	Probability
2.854	3	429	0.049

Source: Research finding.

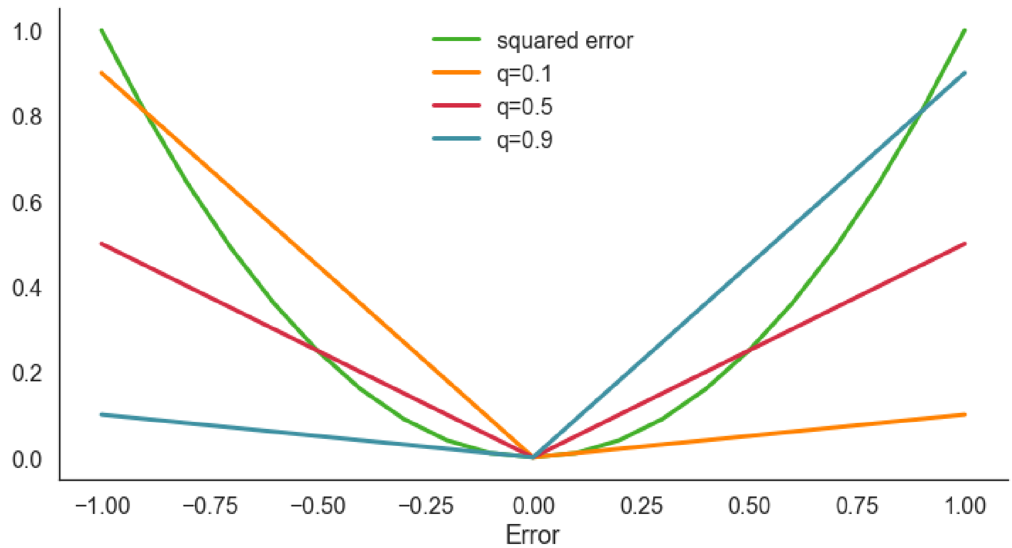

Figure 4. Weighted Errors in OLS, Absolute Least Deviations, and Quantile Regressions

Source: Research finding.

5. Conclusion and Discussion

Examination of the research data, using descriptive statistics, showed that the real stock market return data does not follow the normal distribution and has broader sequences than the normal distribution, and most likely, this variable follows the standard distribution t, which is suitable for financial markets. It was also shown in this section that the real stock market return variable has some outliers, which of course can be another reason for the abnormal data of this variable. The existence of outliers as well as, the abnormality of the distribution of real stock market returns provided evidence based on the inefficiency of the ordinary squares estimator. Estimating the model using the OLS method also confirmed the evidence provided and the error terms of this model were abnormal. The abnormality of the error terms of this model is the primary motivation for using the quantile regression method, but to ensure that this method is suitable for the relationships we intend to examine, we must use the ANOVA test.

The results of this test showed that the quantile regression method is a more appropriate method to examine the main research model. The estimation of the main research model using the quantile regression method indicated that the crude oil price pass-through on the stock market, in addition to the direct path, is also indirect and through the exchange rate channel. So that at the higher quantities, that is, when the stock market is booming, the changes in the crude oil price return on the stock market, pass only indirectly and through the exchange rate channel and, a drop in the price of crude oil (or oil revenues), as in the two periods of sanctions improve the stock market by increasing the exchange rate. Our findings in the line with Abdallah (2013) for stock market of South Africa, and Ajibola et al. (2021) for stock market of Nigeria, and with Wuryandani (2011) for stock market of Indonesia, in which focus on exchange rate channel when investigating of a positive oil price pass-through on stock market. On the other hand, this finding is not consistent with Kilian and Park (2009) found that oil price increases have a negative impact on the US stock market as a net oil-importing country. They argue that higher oil prices increase production costs for firms, which leads to lower profits and subsequently lower stock prices. Similarly, Hooker (1999) analyzed the impact of oil price shocks on the stock market and found that the effect is asymmetrical, with negative shocks having a larger impact than positive shocks.

Their relationship has been studied thoroughly, and many theories have been proposed to explain the correlation between them. The oil price and stock market correlation is not straightforward, and it is influenced by various factors. A positive correlation between oil prices and the stock market means that as oil prices rise, the stock market goes up, and as oil prices fall, the stock market goes down. One of the main reasons for the correlation between oil prices and the stock market is that energy companies are a significant part of the stock market. When the price of oil goes up, energy companies' profits increase, and their stock prices rise. Conversely, when the price of oil goes down, energy companies' profits decrease, and their stock prices fall. Another reason for the correlation is that the price of oil affects the cost of production for many companies. As the price of oil rises, the cost of production increases, which leads to lower profits for non-energy companies. This, in turn, leads to a decrease in their stock prices. However, some studies have shown that there are periods where the correlation between oil prices and the stock market is weak or even negative. This may be due to factors such as changes in consumer behavior, technological advancements, and geopolitical events.

The relationship between oil prices and the stock market has significant policy implications for both policymakers and investors. The paper concludes that the oil price has a significant impact on the stock market, and the pass-through effect varies depending on the economic circumstances of the period and exchange rate variable. Indeed, the oil price and stock market has an interaction specifically from the exchange rate variations in Iran. So, according to the results of this study, one of the recommendations to policymakers in this field can be to reduce dependence on oil revenues or in other words, increase income diversity for oil-exporting countries. In this way, besides trying to increase the market depth, Capital market traders are advised to take into account the risk spillovers of foreign exchange and oil markets to the stock market. Moreover, investors are better off allocating their portfolio in the stock market more carefully, especially when the volatilities in the two markets (exchange and crude oil) are high. Moreover, when the economic sanctions against Iran's economy are lifted, as massive capital inflows might also transform into sudden capital reversal, so this study suggests authority to maintain exchange rate stability.

For further studies, it is suggested to use copula models to evaluate different aspects of the dynamic relationship between two markets, using different variables and for a longer period of time (limitations of the present research).

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