Price –Volume Relationship of Energy Futures Traded on the New York Mercantile Exchange

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Abstract

Quantile regression analysis is employed to verify the price–volume relationship between the rate of return, open interest, and trading volume of three energy futures traded on the New York Mercantile Exchange. Empirical results show that for the crude oil and heating oil futures, the relationship between the rate of return and trading volume is characterized largely by an increase in both price and volume, and also an inverse relationship between price and volume. This signifies that at times when the rise and fall in the rate of return is substantial, trading volumes increase significantly. Concerning the relationship between previous-period trading volume and current-period rate of return, the three energy futures show an increase in price accompanied by a decrease in volume, and higher rates of return strengthen the negative correlation between price and volume. The least squares method regression model is unable to confirm the aforementioned findings.

Keywords Quantile regression, Price-volume relationship, V-shaped, Trading volume, Open interest

I. Introduction

Harris and Raviv (1993) assert that when new information is released to the asset market, investors form new expectations for asset prices. Such expectations are reflected in the trading price as changes in trading volume. Kocagil and Shachmurove (1998) maintain that the rate of return and trading volume are two critical statistical information that can assist investors in understanding asset market conditions. The method of information transmission can be revealed by studying price–volume relationships. Murphy (1985) and DeMark (1994) also state that trading volume and price reveal critical information: When positive news is released to the market, trading prices as well as trading volume are driven upward. Karpoff (1986) emphasizes the importance of price–volume relationships in capital markets by showing that price–volume relationships can be used to explain market structures. For example, securities with larger trading volumes tend to possess more information. However, such securities also face more competition, resulting in smaller bid–offer spread. Karpoff (1987) indicates that studies on price–volume relationships can elucidate the futures market and how information is transmitted, thereby providing knowledge about the market structure. Such studies show that the price–volume relationship is a crucial topic in empirical research on finance. By interpreting the price–volume relationship, investors are not only able to understand the market structure and the methods of information transmission, but they can also formulate effective investment decisions.

In economics, buyers and sellers decide the equilibrium price and quantity. Because trading price and volume are joint products of the market mechanism, when analyzing the prices of financial assets, trading volume information must be fully examined because it reflects the market situation. Therefore, previous scholars proposed using theoretical models to explain the price–volume relationship. Such models include the mixture of distribution hypothesis (Clark, 1973), sequential information arrival model (Copeland, 1976), asymmetric price–volume model (Epps, 1977 and Karpoff, 1987), the Trading Motive Model (Lakonishok and Smidt, 1989), and noise trader model (Delong et al., 1990).

Vigorous developments and growing demand in financial markets lead to the constant innovation of derivatives. Materials such as petroleum are no longer regarded as physical goods, but also as financial instruments and assets. In the case of petroleum, which has been "financialized," speculators and hedgers are provided with more products to choose from. The emergence of the futures market is attributed to the contributions of such derivatives and financial instruments, the primary function of which is to provide people in the spot market with hedging opportunities. The futures market also features such functions as price discovery, speculation, and arbitrage, providing the investing public with a diversified investment tool and a channel for avoiding financial risk. Firms with future demand for petroleum-related products may purchase petroleum futures on the futures market and use the risk-averting feature of futures to control their costs. This enables firms to effectively avoid the risk of price fluctuations, regardless of future petroleum prices. In general, futures contracts can be divided into two categories: commodity futures and financial futures. Energy futures, which are categorized as commodity futures, account for the highest proportion of commodity futures contracts on the New York Mercantile Exchange (NYMEX), which is the world's largest commodity exchange. These energy sources include crude oil, gasoline, and heating oil. Because crude oil features superior liquidity and price transparency, over the past decade, crude oil futures contracts have been one of the most actively traded commodity futures and one of those with the largest trading volume in the world.

In the capital market, price–volume relationships are a widely researched topic both in academic research and in practice. The price–volume relationship is also the foundation upon which the principles for various technical analyses are based. American investment expert Joseph Granville indicates that trading volume drives the stock market and that share prices are only a manifestation of trading volume. This implies that changes in trading volume occur before changes in share price; in other words, the price–volume relationship in the stock market is one in which volume leads price. In summary, sharp fluctuations in trading volume lead to sharp fluctuations in share prices. Changes in trading volume reflect market trends (i.e., whether it is a bull or bear market) of the investing public, or the investment behaviors of informed investors. Therefore, investor behavior indirectly affects asset prices as trading volumes change. Accordingly, before purchasing energy futures, understanding that the price–volume relationship is beneficial to investors for making effective investment decisions, in addition to explaining the behavior of the investing public, as well as changes in the market structure and the mechanisms influencing market prices.

Understanding the price–volume relationship of futures is a crucial topic in financial empirical research. Because futures prices and trading volumes fluctuate daily, both buyers and sellers attempt to predict the price–volume relationship to derive the optimal investment method to achieve the goals of arbitrage and risk aversion. Futures also enable investors to predict the future price of commodities. Previous studies show that researching the price–volume relationship of futures can assist investors in understanding the market structure and the mechanisms governing information transmission, as well as formulating the most favorable investment decisions. Trade prices indicate investor expectations regarding changes in the market as a whole. Trading volume signifies the total number of transactions by market investors and the level of involvement that investors are willing to commit to. Trading volume is used to measure the level of activity in the futures trading market and the liquidity of futures. Open interest is the total unilateral power of pending futures contracts in the market. To investors in the futures market, trading volume and open interest have distinct meanings; however, both concepts are crucial. Among the energy-related commodity exchange markets, the NYMEX features the largest market and the most liquid commodity futures. The trading volume of its energy futures is in the descending order of crude oil, gasoline, and heating oil. These three energy futures are the most-preferred oil futures by investors and hedgers. In addition, their trading volumes account for 75.58% of all energy futures. Therefore, these three energy futures are selected as the subjects of this study.

In the literature, early studies use correlation coefficients or the least squares method to investigate the price–volume relationship of futures in capital markets. Using correlation coefficients involves determining the unconditional correlation between the rate of return and trading volume, whereas using the least squares method involves determining the conditional mean of the dependent variables. However, the conditional mean is limited in application because it cannot be used to represent the conditional distribution of an entire population. Therefore, quantile regression (QR) analysis, which involves examining the conditional distribution of the dependent variable and dividing it into quantiles, can be used instead.

The objective of the study is to use QR analysis and the least squares method to explore the relationship among the rate of return, trading volume, and open interest of three energy futures (i.e., crude oil, gasoline, and heating oil futures) traded on the NYMEX. QR analysis can reveal the relationship as well as the strength of the relationship among the trading volume, open interest, and rate of return in each quantile. Concurrently, the relationship between the previous-period trading volume and current-period rate of return (and vice versa) can be investigated.

The earliest empirical research on the price–volume relationship is by Osborne (1959), who regards share price fluctuations as a diffusion process. Osborne deduces that the variance in share price fluctuations is directly proportional to number of transactions. Although this finding does not explore the price–volume relationship, it nonetheless implies that changes in price are positively correlated with trading volume. This discovery is a driver of numerous investigations on price–volume relationships, the first of which is the relationship between price and trading volume in the same period. According to the results of most studies, the correlation between trading volume and price change is significantly positive, in which changes in price are measured in absolute values. An asymmetric relationship also exists between the direction of trading volume and price change; in other words, the sensitivity of price to trading volume is greater when prices rise than when they fall. Karpoff (1987) provides a comprehensive analysis of this topic.

Subsequent empirical studies support the inferences drawn from theories, leading to a series of studies after the mid-1980s on the causal relationship between price and volume, which is used in exploring whether the positive correlation between price and volume signifies that price can be employed to predict volume (and vice versa). These studies focused on analyzing whether trading volume *leads* price (i.e., trading volume affects price) or vice versa. Although the results of most studies support the existence of a causal relationship, there is no consensus regarding whether price leads volume (or vice versa). Smirlock and Starks (1988), Saatcioglu and Starks (1998), Hiemstra and Jones (1994), and Gervais et al. (2001) all argue that trading volume leads price change (the latter is measured in absolute values), whereas Jain and Joh (1988) contend that price change leads trading volume. Some scholars maintain that a bidirectional causal relationship exists between the two variables. For example Martikainen et al. (1994) empirically shows that for Finland, a bidirectional relationship exists between share prices and trading volume for the 1983–1988 period; however, no significant causal relationship exists between the two variables for the 1977–1982 period. Silvapulle and Choi

(1999) also report both linear and nonlinear bidirectional causal relationships between share price index and trading volume in the South Korean stock market.

Other studies related to the price–volume relationship are listed as follows: Board and Sutcliffe (1990) find that for futures contracts, price fluctuations and trading volume are significantly and positively correlated, and trading volume is the main reason for price fluctuations. Najand and Yung (1991) also find that for futures contracts, current-period price fluctuations are significantly and positively correlated with trading volumes from the previous period. By contrast, Floros and Vougas (2007) verified the relationship between trading volume and the rate of return of stock market index futures, but revealed no significant positive relationship between the two variables.

The price–volume relationship observed in previous empirical research can be primarily divided into three categories: (1) increase in both price and volume: an increase in price (a rate of return greater than 0) and trading volume. The correlation coefficient between the rate of return and trading volume is positive; (2) decrease in both price and volume: a decrease in price (a rate of return less than 0) and trading volume. The correlation coefficient between the rate of return and trading volume is positive; and (3) a negative correlation between price and volume: an increase (decrease) in price implies a decrease (increase) in volume when rate of return is greater (less) than 0. The correlation coefficient between the rate of return and trading volume is negative.

II. Methodology and Model

QR analysis not only enables the analysis of the effect of each independent variable on the dependent variables in each quantile, but it is also more accurate than the least squares regression method in estimating the two tails of the quantiles. Because finance-related data frequently exhibit characteristics such as a fat-tailed distribution, asymmetry, and heterogeneous variance, using the least squares method regression model as an estimation method is susceptible to the influence of outliers, which subsequently create study errors. By contrast, QR analysis is less likely to be affected by outliers. In the present study, the QR model of Koenker and Bassett (1978) is employed to estimate the various quantile data by using the weighted average absolute deviation. The QR model is a unique model because it is not based on assumptions about the distribution of a population, and the estimated parameters are selected based on the distribution of previous samples. This enables the accurate depiction of data properties and formulation of sound statistical inferences. The QR analysis and the least squares method differ in that the former can be used to analyze the marginal effect of independent variables on dependent variables in a conditional quantile removed from the entire conditional distribution.

When calculated using the least squares method, the correlation coefficient between price and volume reveals the “average” influence price and volume have on each another. The correlation coefficient indicates either a negative or positive relationship between price and volume. However, to understand the effect of trading volume on returns (positive or negative) and the level of influence between price and volume, a QR analysis must be performed. In this study, the price–volume relationship is estimated using QR analysis and the least squares method. For the QR analysis, quantiles are equally divided into regions from 0.05 to 0.95 (in 0.05 increments). To demonstrate the effect of the maximal price increase or decrease on volume (and vice versa), the quantile data at the ends of the quantiles (i.e., 0.01 and 0.99, or the distribution tails) are estimated, producing a total of 21 QR observations per data set. Concurrently, five empirical models are employed to explore the relationships between the variables. The benefit of using this procedure is that it indicates how stable a model is, which strengthens the breadth of research. Although the results of most studies support the existence of a causal relationship between price and volume, there is no consensus regarding whether price leads volume (or vice versa). Smirlock and Starks (1988), Saatcioglu and Starks (1998), Hiemstra and Jones (1994), and Gervais et al. (2001) all argue that trading volume leads price change, whereas Jain and Joh (1988) contend that price change leads trading volume. Scholars such as Martikainen et al. (1994) and Silvapulle and Choi (1999) maintain that a bidirectional causal relationship exists between the two variables. Accordingly, the present study investigates the price–volume relationships of futures (e.g., the relationships among the rate of return, trading volume, and open interest). In addition, the relationship between the previous-period trading volume and current-period rate of return as well as that between the current-period rate of return and current-period trading volume are examined.

The empirical models used in this study are expressed as follows:

$$ROR_t = \alpha_1 + \beta_1 VOL_t + \varepsilon_{1t} \quad (1)$$

$$ROR_t = \alpha_2 + \beta_2 OI_t + \varepsilon_{2t} \quad (2)$$

$$ROR_t = \alpha_3 + \beta_3 VOL_t + \gamma_3 OI_t + \varepsilon_{3t} \quad (3)$$

$$ROR_t = \alpha_4 + \beta_4 ROR_{t-1} + \gamma_4 VOL_{t-1} + \varepsilon_{4t} \quad (4)$$

$$VOL_t = \alpha_5 + \beta_5 ROR_{t-1} + \gamma_5 VOL_{t-1} + \varepsilon_{5t} \quad (5)$$

Where ROR_t is the current-period rate of return, which $= \ln(P_t / P_{t-1}) \times 100$; P_t is the daily settlement price; VOL_t is the original value of the current-period trading volume, measured in logarithm form; OI_t is original value of the current-period open interest, measured in logarithm form; ROR_{t-1} is the previous-period rate of return; and VOL_{t-1} is the original value of the previous-period trading volume, measured in logarithm form; $\alpha_i, \beta_i, \gamma_i$ are parameters to be estimated; and ε_{it} is the error term. When measuring percentage changes, the unit of measurement is not considered for variables in logarithm form. Therefore, by using the logarithm form, the influence of outliers is minimal.

III. Data and Empirical Results

Crude oil, gasoline, and heating oil are three types of energy future traded on the NYMEX, and are selected as the empirical subjects of this study. The data used are from the Datastream Database, which contains daily data including the rate of return, open interest, and trading volume of futures, as well as monthly data such as futures contracts. Crude oil data (from January 3, 1995 to December 17, 2013), gasoline data (from March 1, 2006 to December 17, 2013), and heating oil data (from January 3, 1995 to December 17, 2013 are used in this study, yielding a study sample comprising 4,749, 1,910, and 4,667 observations, respectively.

Table 1 shows the Phillips-Perron (PP) unit root test as well as the descriptive statistics of the variables related to the three energy futures. Crude oil, the world's most popular futures and the one with the largest trading volume, possesses a greater mean trading volume and open interest than all of the other futures. However, regarding the size of the distribution, gasoline futures exhibit the greatest standard deviation in trading volume and open interest fluctuations. Regarding coefficient of skewness, the gasoline futures feature a rate of return that is slightly skewed to the right, whereas all of the other variables are skewed to the left. Concerning the coefficient of kurtosis, crude oil futures exhibit a trading volume that is relatively mesokurtic, whereas all of the other variables are leptokurtic. These results are in line with other finance-related data in that all of the distributions have thick tails. According to the Phillips-Perron unit root test, the rate of return, open interest, and trading volume of the three energy futures reject the unit root null hypothesis under a 1% significance level, indicating that the data are stationary and suitable for subsequent time-series analysis.

Refer Table 1

Empirical Results on Crude Oil Futures

Table 2 shows the empirical results for the crude oil futures after conducting the QR analysis and applying the least squares method to Models (1)–(5). According to Model (1), the relationship between the rate of return and trading volume (as estimated using the least squares method) exhibits a negative but nonsignificant slope, indicating that trading volume and the rate of return are negatively correlated. However, positive values are observed for the right-tailed quantiles ranging from 0.7 to 0.99, signifying that the rate of return and trading volume are positively correlated. This result not only suggests that the correlation between price and volume is positive, but is also shows that the correlation coefficient increases with the quantile. For the left-tailed quantiles ranging from 0.4 to 0.01, negative coefficients are observed, indicating that the relationship between the rate of return and trading volume is negative and that the price decreases as the volume increases. In addition, the absolute value of the coefficient increases as the quantile decreases. This type of relationship is called a V-shaped price–volume relationship.

According to Model (2), the relationship between the rate of return and open interest (as estimated using the least squares method) exhibits a positive but nonsignificant slope, indicating that open interest and the rate of return are positively correlated. Except for in quantiles 0.3 and 0.5, open interest and the rate of return are nonsignificantly positive.

According to Model (3) that shows the results of the estimation of the relationships among the rate of return, trading volume, and open interest, the β_3 slope value estimated using the least squares method at the 5% significance level is negative. This result indicates that trading volume and rate of return are negatively correlated. The slope γ_3 is a positive value (as estimated using the least squares method at the 5% significance level), indicating the relationship between open interest and the rate of return is significantly positive. This result signifies that open interest and the rate of return are positively correlated. The β_3 slope values of right-tailed quantiles ranging from 0.8 to 0.99 in the QR analysis are positive, suggesting increase in price also increases volume and that the coefficient increases with the quantile. Conversely, negative values were derived for the left-tailed quantiles, indicating a decrease in price with increasing volume; moreover, the absolute value of the coefficient increases as the quantile decreases, producing a V-shaped price–volume relationship. The coefficients for the various quantiles show that the price–volume relationship for crude oil futures differs between a substantial rise and a substantial fall. Regarding the estimated γ_3 value of open interest, an inverse observation was found; negative values were derived for the right-tailed quantiles ranging from 0.8 to 0.99 and the coefficient is the highest in quantiles 0.95 and 0.99, indicating a negative correlation between open interest and rate of return; a significantly and positive correlation exists for the left-tailed quantiles as indicated by the positive values, and the coefficient increases as the quantile decreases. In summary, for right-tailed quantiles, open interest begins to fall once the quantile reaches 0.8; when the negative correlation between open interest and the rate of return begins to rise, this implies a force countering the drop in open interest is growing in the market. As the rate of return rises, buyers sell to profit and sellers sell to cut losses. Open interest falls but the trading volume continues to rise. Subsequently, increases occur in both price and volume. For the left-tailed quantiles, once θ reaches 0.5, the coefficient of open interest continues to rise and the positive correlation between open interest and the rate of return is strengthened. In other words, when the rate of return falls, open interest falls even more markedly. This result indicates that sellers are selling to profit and that buyers are selling to cut losses, leading to an increase in trading volume.

According to the Model (4) results of the estimation of the relationships among the current-period rate of return, previous-period rate of return, and previous-period trading volume, the estimated slope values γ_4 calculated using the least squares method at the 10% significance level are negative, indicating that the previous-period trading volume and current-period rate of return are negatively correlated. The QR analysis reveals that for the estimated slope values γ_4 are negative for the right-tailed quantiles ranging from 0.7 to 0.95, suggesting that price increases as volume decreases. As the quantile increases, the divergence effect increases. The β_4 values for the right-tailed quantiles were mainly negative, suggesting that when price increases, the previous-period rate of return and current-period rate of return become negatively correlated.

According to the Model (5) results for estimating the relationships among the current-period trading volume, previous-period rate of return, and previous-period trading volume, the slope values β_5 estimated using the least squares method are positive and the relationship between the previous-period rate of return and current-period trading volume is nonsignificant. From the QR analysis, β_5 values were nonsignificant, except for quantiles 0.1, 0.2, 0.75, and 0.8, which are positive values.

Refer Table 2

Empirical Results on Gasoline Futures

Table 3 shows the empirical results for gasoline futures after conducting the QR analysis and applying the least squares method to Models (1)–(5). According to Model (1), the relationship between the rate of return and trading volume (as estimated using the least squares method) shows a negatively nonsignificant slope, indicating that trading volume and the rate of return are negatively correlated. The same relationship when estimated using the QR analysis is also negative except for the quantiles 0.1, 0.15, 0.2, and 0.8, which are positive. The right-tailed quantiles ranging from 0.6 to 0.95 show negative values, exhibiting a significant increase in price and decrease in volume.

In Model (2), the relationship between the rate of return and open interest (as estimated using the least squares method at the 5% significance level) shows a significantly negative slope, denoting that open interest and the rate of return are negatively correlated. In the QR analysis, negative values are derived for quantiles ranging from 0.5 to 0.9, indicating that the negative correlation is stronger for right-tailed quantiles.

In the results of Model (3) that show the relationships among the rate of return, trading volume, and open interest, the slope values β_3 estimated using the least squares method are positive but nonsignificant. This indicates that trading volume and the rate of return are positively correlated. The slope values γ_3 estimated using the least squares method at the 10% significance level is negative, indicating that open interest and the rate of return are negatively correlated. The results of the QR analysis (as indicated by slope values β_3) reveal a significant correlation between open interest and the rate of return for quantiles 0.15, 0.2, 0.85, whereas the remaining quantiles exhibit no significant correlation. Negative coefficients are observed for the estimated slope values γ_3, particularly for the right-tailed quantiles ranging from 0.65 to 0.9, which were also significant, implying that open interest and the rate of return are negatively correlated. However, because the study of gasoline futures in the present study is based on observations at a time close to the subprime mortgage crisis in the United States, the standard deviations for trading volume and open interest are all higher than the other types of futures, which produced mainly nonsignificant coefficients. In addition, following the subprime mortgage crisis, panic and irrational behavior among the investing public created considerable market price fluctuations and extreme values that completely disrupted the correlations among the rate of return, trading volume, and open interest. Therefore, the validity of the empirical results on gasoline futures in this study requires verification.

From the results of Model (4) in Table 3 that show the relationship between the current-period rate of return, pervious-period trading volume, and previous-period trading volume, the slope values γ_4 estimated using the least squares method are negative and nonsignificant, indicating that the previous-period trading volume and current-period rate of return are negatively correlated. The QR analysis reveals significant and positive estimated slope values γ_4 for the left-tailed quantiles ranging from 0.05 to 0.3, suggesting a decrease in both price and volume. The right-tailed quantiles exhibit significantly negative slopes, suggesting that an increase in price coincides with a decrease in volume. As the quantile increases (decreases), a relatively greater decrease (increase) in both price and volume occur; when the quantile reaches 0.99, the absolute value of the coefficient peaks, indicating the greatest divergence.

The results of Model (5) (Table 3) that show the relationships among current-period trading volume, previous-period rate of return, and previous-period trading volume indicate that the slop values β_5 estimated using the least squares method are negative and nonsignificant, denoting that previous-period rate of return were negatively correlated with trading volume. The slop values β_5 estimated using the QR analysis are statistically nonsignificant.

Refer Table 3

Empirical Results on Heating Oil Futures

Table 4 shows the empirical results for the crude oil futures after conducting the QR analysis and applying the least squares method to Models (1)–(5). According to Model (1), the relationship between the rate of return and trading volume (as estimated using the least squares method) is a positive but nonsignificant slope, indicating that the rate of return and trading volume are positively correlated. The coefficients estimated using the QR analysis is also positive for the right-tailed quantiles; however, only quantiles 0.8 to 0.99 are significantly positive, indicating that the rate of return and trading volume are positively correlated and that an increase in price is followed by an increase in volume. The estimated value increases with the quantile. However, the coefficients for the left-tailed quantiles are mainly negative, in which quantiles 0.2, 0.25, and 0.3 show significance, indicating that the rate of return and trading volume are negatively correlated and that a decrease in price is followed by an increase in volume. When the left-tailed quantile reaches 0.01, the coefficient becomes positive (and significant at the 1% level), implying that when the rate of return experiences the maximum fall, a decrease in price is followed by a decrease in volume.

According to Model (2), the relationship between the rate of return and open interest (as estimated using the least squares method) is a positive but nonsignificant slope. The same relationship when estimated using the QR analysis is significantly positive for quantiles 0.01, 0.05, and 0.1, whereas the remaining quantiles are positive but nonsignificant.

According to Model (3), in the relationships among rate of return, trading volume and open interest, the slope values β_3 as estimated using the least squares method are positive and nonsignificant, indicating that trading volume and the rate of return are positively correlated. The slope γ_3 is also positively nonsignificant, implying that open interest and the rate of return are positively correlated. For the slope values of β_5 in the QR analysis, they are significant and positive for the right-tailed quantiles ranging from 0.7 to 0.95, indicating that an increase in price is followed by an increase in volume, and the effect becomes stronger as the quantile increases. For the left-tailed quantiles ranging from 0.05 to 0.35, the values are negative, indicating a decrease in price is followed by an increase in volume (i.e., a V-shaped price–volume relationship). Nevertheless, when the left-tailed quantile reaches 0.01 (under a significance level of 5%), the coefficient becomes positive, implying that when the rate of return approximates the lowest point, the decrease in price is accompanied by a decrease in volume. For estimated slope values γ_3, the results are significant and positive for the left-tailed quantiles ranging from 0.05 to 0.35, indicating that open interest and the rate of return become positively correlated when the price falls. In the right-tailed quantiles, the coefficients are generally negative; for the quantiles ranging from 0.75 to 0.9, the values are significant. This result implies that open interest and the rate of return become negatively correlated when the price increases. In summary, for the right-tailed quantiles ranging from 0.75 to 0.9, open interest begins to fall and the negative correlation between open interest and the rate of return increases, implying that a force countering the fall in open interest is affecting the market. As the rate of return increases, buyers sell to profit and sellers sell to cut their losses. The open interest falls but the trading volume continues to rise. Subsequently, increases in both price and volume can be observed. For the left-tailed quantiles, once θ reaches 0.35, the open interest coefficient rises and the positive correlation between open interest and the rate of return increases consistently. In other words, when the rate of return drops, open interest drops even more notably, indicating that sellers are selling to profit and that buyers are selling to cut their losses, leading to an increase in trading volume.

According to Model (4) (Table 2), in the relationships among the current-period rate of return, previous-period trading volume, and previous-period trading volume, the slope values γ_4 as estimated using the least squares method at the 10% significance level are significant and negative, indicating that the current-period rate of return and previous-period trading volume are negatively correlated. The slope values γ_4 estimated using the QR analysis are significant and negative for the right-tailed quantiles ranging from 0.65 to 0.99, indicating that an increase in price is associated with a decrease in volume in the relationship between current-period rate of return and previous-period trading volume. In addition, divergence effect increases with the quantile. The relationship between the current-period rate of return and previous-period rate of return (as estimated using QR analysis) for right-tailed quantiles

0.5 to 0.85 as indicated by a slope of β_4 is negative and nonsignificant, suggesting that when price increases, the previous-period rate of return and current-period rate of return are negatively correlated.

According to Model (5) (Table 4), in the relationships among current-period trading volume, previous-period rate of return, and previous-period trading volume the slope values β_5 estimated using the least squares method are negative and nonsignificant, indicating that they are negatively correlated. The slope value β_5 estimated using the QR analysis is significantly negative only for the quantiles 0.9, 0.95, and 0.99. In addition, when the rate of return is significantly high (e.g., quantiles 0.95 and 0.99), the absolute value of the coefficient is at its maximum, and the negative correlation between the previous-period rate of return and the current-period trading volume increases significantly.

Refer Table 4

IV. Conclusion

In this study, the least squares method and QR analysis are used to verify the price–volume relationship of three energy futures (i.e., crude oil, gasoline, and heating oil futures) traded on the NYMEX. The empirical results show that the QR method is more effective than the least squares method is in identifying price–volume relationships (e.g., positive or negative rate of return) for the various quantiles as well as for measuring the strength of the relationship.

Model (3) shows that when investors observe an increase (decrease) in the rate of return and trading volume of crude oil and heating oil futures and those increases are correlated negatively (positively) with open interest, investors must focus on whether these futures are in the process of being purchased to profit or sold to cut losses, and observe the indications for a reverse market. Concerning gasoline futures, which show no significant correlation between trading volume and the rate of return, no significant correlation between open interest and the rate of return is observed when the price falls, and a negative correlation between open interest and the rate of return occurs when the price rises. These phenomena can be attributed to being studied at a time close to the subprime mortgage crisis in the United States; when panic and irrational behavior of the investing public cause significant market price fluctuations leading to a broader distribution in trading volume and open interest compared with other futures, disrupting the correlations between price and trading volume. Therefore, the validity of the results regarding gasoline futures requires verification.

According to Model (4), the right-tailed quantiles of all three types of energy futures demonstrate an increase in price with decreasing volume, and that the divergence effect becomes stronger as the quantile increases. This result indicates that when the price rises, the previous-period trading volume is negatively correlated with the current-period price. The left-tailed quantiles of the gasoline futures show decreases in both price and volume. Regarding the effect of the previous-period rate of return on current-period trading volume, Model (5) shows no significant price–volume relationship except for in the heating oil futures at the quantiles 0.9 to 0.99. This finding shows that Model (5) is superior to Model (4).

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Tables

Table 1

Descriptive Statistics in NYMEX Crude oil, Gasoline and Heating oil Futures

	Crude oil			Gasoline			Heating oil		
	ROR	OI	VOL	ROR	OI	VOL	ROR	OI	VOL
Mean	0.0004	11.6499	11.5300	0.0002	10.4701	10.2720	0.0004	10.3970	10.0041
Median	0.0010	11.7433	11.4096	0.0008	10.7629	10.5001	0.0002	10.5130	9.9627
Maximum	0.1641	12.9980	13.4152	0.2266	11.7700	11.5200	0.1392	11.6876	11.5705
Minimum	-0.1654	5.6131	6.1334	-0.1150	5.8999	3.6889	-0.2097	6.1203	2.9957
Std. Dev.	0.0237	0.9438	0.8536	0.0245	1.0051	0.8816	0.0230	0.7360	0.5833
Skewness	-0.1252	-1.6734	-0.2381	0.1563	-1.6039	-2.9049	-0.4514	-1.4167	-1.2504
Kurtosis	7.3463	7.5505	3.3226	9.0361	5.8177	14.5855	8.2696	6.3846	13.6982
Observations	4749	4749	4749	1910	1910	1910	4667	4667	4667
PP	-69.9320 ***	-35.7156 ***	-42.4324 ***	-20.7477 ***	-12.3244 ***	-70.5048 ***	-57.1257 ***	-37.1030 ***	-57.1260 ***

Notes: *** denote statistical significance at the 1% levels.

Table 2 Crude oil futures estimated using the OLS and QR

Estimation of the relationship between the rate of return and trading volume

Modle (1): $ROR_t = \alpha_1 + \beta_1 VOL_t + \varepsilon_{1t}$

	α_1	β_1	R^2
OLS			
	0.5079	-0.0409	0.0000
	(0.2751)	(0.3094)	
Quantile			
0.01	3.6053	-0.8578 **	0.0142
	(0.3542)	(0.0107)	
0.05	0.4325	-0.3582 ***	0.0072
	(0.6898)	(0.0001)	
0.10	0.3756	-0.2607 ***	0.0030
	(0.7260)	(0.0050)	
0.15	0.7209	-0.2359 ***	0.0036
	(0.3277)	(0.0002)	
0.20	1.1222 **	-0.2335 ***	0.0041
	(0.0320)	(0.0000)	
0.25	1.0083 *	-0.1946 ***	0.0023
	(0.0590)	(0.0000)	
0.30	0.8952 *	-0.1562 ***	0.0015
	(0.0768)	(0.0004)	
0.35	0.8090 *	-0.1255 ***	0.0011
	(0.0758)	(0.0015)	
0.40	0.4770	-0.0760 *	0.0004
	(0.3040)	(0.0582)	
0.45	0.4684	-0.0539	0.0000
	(0.3163)	(0.1816)	
0.50	0.4179	-0.0291	0.0000
	(0.3643)	(0.4654)	
0.55	0.2296	0.0068	-0.0002
	(0.6042)	(0.8584)	
0.60	0.4784	0.0065	-0.0002
	(0.2800)	(0.8651)	
0.65	0.0799	0.0617	0.0001
	(0.8594)	(0.1137)	
0.70	0.1298	0.0793 *	0.0003
	(0.7883)	(0.0579)	
0.75	0.2798	0.0921 *	0.0005
	(0.6450)	(0.0796)	
0.80	0.2361	0.1254 ***	0.0007
	(0.6689)	(0.0086)	
0.85	0.1299	0.1697 ***	0.0015
	(0.8452)	(0.0032)	
0.90	0.4204	0.1987 ***	0.0030
	(0.5932)	(0.0035)	
0.95	-0.4026	0.3439 ***	0.0051
	(0.7075)	(0.0002)	
0.99	-3.3277	0.8180 ***	0.0121
	(0.3275)	(0.0054)	

Notes: Table shows regression coefficients; p-values are in parentheses. *, **, and * denote statistical significance at the 1 %, 5 %, and 10 % levels, respectively.**

Table 2 Crude oil futures estimated using the OLS and QR

Estimation of the relationship between the rate of return and open interest

Modle (2): $ROR_t = \alpha_2 + \beta_2 OI_t + \varepsilon_{2t}$

	α_2	β_2	R^2
OLS			
	-0.4686	0.0433	0.0001
	(0.2706)	(0.2338)	
Quantile			
0.01	-7.6088 *	0.1212	0.0006
	(0.0650)	(0.7307)	
0.05	-4.4321 ***	0.0622	0.0001
	(0.0000)	(0.5009)	
0.10	-3.5280 ***	0.0740	0.0002
	(0.0000)	(0.3024)	
0.15	-2.4402 ***	0.0376	-0.0001
	(0.0002)	(0.5071)	
0.20	-2.2714 ***	0.0607	0.0002
	(0.0001)	(0.2078)	
0.25	-1.9909 ***	0.0670	0.0005
	(0.0000)	(0.1007)	
0.30	-1.9875 ***	0.0926 **	0.0006
	(0.0000)	(0.0152)	
0.35	-1.2454 ***	0.0528	0.0002
	(0.0064)	(0.1780)	
0.40	-1.0454 **	0.0561	0.0000
	(0.0162)	(0.1319)	
0.45	-0.7251 *	0.0494	0.0001
	(0.0914)	(0.1787)	
0.50	-0.6938 *	0.0669 *	0.0000
	(0.0952)	(0.0598)	
0.55	-0.1574	0.0402	-0.0001
	(0.7099)	(0.2668)	
0.60	0.1915	0.0312	-0.0001
	(0.6379)	(0.3709)	
0.65	0.3430	0.0379	0.0000
	(0.4112)	(0.2883)	
0.70	0.4812	0.0478	0.0001
	(0.2700)	(0.2000)	
0.75	0.6069	0.0634	0.0002
	(0.2448)	(0.1561)	
0.80	1.1059 **	0.0478	0.0001
	(0.0294)	(0.2709)	
0.85	1.2251 **	0.0735	0.0001
	(0.0478)	(0.1649)	
0.90	2.0920 ***	0.0492	0.0000
	(0.0078)	(0.4650)	
0.95	3.2406 ***	0.0278	-0.0001
	(0.0021)	(0.7578)	
0.99	10.3655 ***	-0.3755	0.0017
	(0.0013)	(0.1704)	

Notes: Table shows regression coefficients; p-values are in parentheses. *, **, and * denote statistical significance at the 1 %, 5 %, and 10 % levels, respectively.**

Table 2 Crude oil futures estimated using the OLS and QR

Estimation of the relationships among the rate of return, trading volume, and open interest

Modle (3): $ROR_t = \alpha_3 + \beta_3 VOL_t + \gamma_3 OI_t + \varepsilon_{3t}$

	α_3	β_3	γ_3	R^2
OLS				
	0.0912	-0.1023 **	0.0965 **	0.0008
	(0.8562)	(0.0376)	(0.0300)	
Quantile				
0.01	-1.5862	-1.1242 ***	0.7128 *	0.0244
	(0.7032)	(0.0050)	(0.0566)	
0.05	-2.5245 **	-0.5867 ***	0.4766 ***	0.0133
	(0.0342)	(0.0000)	(0.0000)	
0.10	-0.9037	-0.5586 ***	0.4052 ***	0.0088
	(0.3436)	(0.0000)	(0.0000)	
0.15	-0.2206	-0.4213 ***	0.2665 ***	0.0081
	(0.7695)	(0.0000)	(0.0001)	
0.20	0.2128	-0.3933 ***	0.234 ***	0.0075
	(0.7447)	(0.0000)	(0.0000)	
0.25	-0.0872	-0.3078 ***	0.2081 ***	0.0056
	(0.8813)	(0.0000)	(0.0000)	
0.30	-0.3277	-0.2719 ***	0.2182 ***	0.0044
	(0.5809)	(0.0000)	(0.0000)	
0.35	-0.1207	-0.2208 ***	0.1724 ***	0.0034
	(0.7995)	(0.0000)	(0.0001)	
0.40	-0.2131	-0.1725 ***	0.1545 ***	0.0015
	(0.6887)	(0.0008)	(0.0009)	
0.45	-0.1904	-0.1266 ***	0.1282 ***	0.0009
	(0.6973)	(0.0075)	(0.0036)	
0.50	-0.2440	-0.0830 *	0.1102 ***	0.0000
	(0.6000)	(0.0620)	(0.0080)	
0.55	0.0417	-0.0383	0.0611	-0.0002
	(0.9350)	(0.4361)	(0.1711)	
0.60	0.2461	-0.0118	0.0380	-0.0003
	(0.6034)	(0.7953)	(0.3649)	
0.65	0.0569	0.0518	0.0117	0.0000
	(0.9069)	(0.2739)	(0.7842)	
0.70	0.0719	0.0653	0.0183	0.0001
	(0.8908)	(0.1977)	(0.6926)	
0.75	0.1539	0.0796	0.0231	0.0003
	(0.8081)	(0.2012)	(0.6742)	
0.80	0.2673	0.1257 **	-0.0029	0.0005
	(0.6565)	(0.0328)	(0.9572)	
0.85	0.2405	0.1887 ***	-0.0278	0.0014
	(0.7340)	(0.0071)	(0.6622)	
0.90	0.8663	0.2600 ***	-0.1000	0.0033
	(0.3147)	(0.0023)	(0.1972)	
0.95	1.2394	0.4759 ***	-0.2726 ***	0.0069
	(0.2985)	(0.0001)	(0.0098)	
0.99	2.7474	0.9567 ***	-0.6617 **	0.0235
	(0.4508)	(0.0069)	(0.0401)	

Notes: Table shows regression coefficients; p-values are in parentheses. *, **, and * denote statistical significance at the 1 %, 5 %, and 10 % levels, respectively.**

Table 2 Crude oil futures estimated using the OLS and QR

Estimation of the relationships among the current-period rate of return, previous-period rate of return, and previous-period trading volume

Modle (4): $ROR_t = \alpha_4 + \beta_4 ROR_{t-1} + \gamma_4 VOL_{t-1} + \varepsilon_{4t}$

	α_4	β_4	γ_4	R^2
OLS				
	0.8181 *	-0.0115	-0.0678 *	0.0003
	(0.0788)	(0.4299)	(0.0922)	
Quantile				
0.01	-2.4431	0.0925	-0.3223	0.0105
	(0.5525)	(0.4386)	(0.3642)	
0.05	-3.3922 ***	0.0818 **	-0.0258	0.0034
	(0.0011)	(0.0149)	(0.7746)	
0.10	-3.9563 ***	0.0361	0.1093	0.0016
	(0.0000)	(0.1891)	(0.1436)	
0.15	-2.3819 ***	0.0278	0.0329	-0.0001
	(0.0008)	(0.2101)	(0.5914)	
0.20	-1.3844 **	0.0169	-0.0155	-0.0002
	(0.0263)	(0.3813)	(0.7739)	
0.25	-1.2923 **	0.0093	0.0066	-0.0004
	(0.0157)	(0.5778)	(0.8873)	
0.30	-1.0185 **	-0.0070	0.0102	-0.0004
	(0.0429)	(0.6577)	(0.8145)	
0.35	-0.4305	-0.0097	-0.0168	-0.0004
	(0.3894)	(0.5299)	(0.6976)	
0.40	-0.1473	-0.0186	-0.0215	-0.0002
	(0.7489)	(0.1949)	(0.5895)	
0.45	0.3786	-0.0350 **	-0.0444	0.0004
	(0.3893)	(0.0119)	(0.2440)	
0.50	0.6224	-0.0407 ***	-0.0460	0.0000
	(0.1485)	(0.0027)	(0.2173)	
0.55	0.9814 **	-0.0416 ***	-0.0566	0.0010
	(0.0305)	(0.0033)	(0.1497)	
0.60	1.2501 ***	-0.0421 ***	-0.0602	0.0013
	(0.0033)	(0.0019)	(0.1021)	
0.65	1.3417 ***	-0.0516 ***	-0.0477	0.0015
	(0.0014)	(0.0002)	(0.1901)	
0.70	1.9065 ***	-0.0446 ***	-0.0748 **	0.0017
	(0.0000)	(0.0014)	(0.0455)	
0.75	2.6875 ***	-0.0571 ***	-0.1165 **	0.0018
	(0.0000)	(0.0009)	(0.0157)	
0.80	2.9588 ***	-0.0560 ***	-0.1115 **	0.0018
	(0.0000)	(0.0012)	(0.0193)	
0.85	4.1967 ***	-0.0729 ***	-0.1805 ***	0.0036
	(0.0000)	(0.0002)	(0.0007)	
0.90	5.0725 ***	-0.0626 ***	-0.2094 ***	0.0043
	(0.0000)	(0.0077)	(0.0014)	
0.95	5.6942 ***	-0.0490	-0.1865 *	0.0028
	(0.0000)	(0.1736)	(0.0670)	
0.99	11.0889 ***	-0.1488	-0.4344	0.0060
	(0.0010)	(0.1491)	(0.1353)	

Notes: Table shows regression coefficients; p-values are in parentheses. *, **, and * denote statistical significance at the 1 %, 5 %, and 10 % levels, respectively.**

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Table 2 Crude oil futures estimated using the OLS and QR

Estimation of the relationships among the current-period trading volume, previous-period rate of return, and previous-period trading volume

Modle (5): $VOL_t = \alpha_5 + \beta_5 ROR_{t-1} + \gamma_5 VOL_{t-1} + \varepsilon_{5t}$

	α_5	β_5	γ_5	R^2
OLS				
	2.3910 ***	0.0036	0.7926 ***	0.6281
	(0.0000)	(0.2529)	(0.0000)	
Quantile				
0.01	-9.0612 ***	0.0329	1.6381 ***	0.2497
	(0.0000)	(0.1407)	(0.0000)	
0.05	-0.6722 **	0.0024	1.0035 ***	0.2505
	(0.0197)	(0.7926)	(0.0000)	
0.10	-0.2608 **	0.0088 **	0.9851 ***	0.3646
	(0.0494)	(0.0345)	(0.0000)	
0.15	-0.0334	0.0045	0.9733 ***	0.4234
	(0.7417)	(0.1572)	(0.0000)	
0.20	0.1489	0.0065 **	0.9635 ***	0.4587
	(0.1578)	(0.0471)	(0.0000)	
0.25	0.3170 ***	0.0031	0.9543 ***	0.4837
	(0.0005)	(0.2773)	(0.0000)	
0.30	0.4713 ***	0.0037	0.9452 ***	0.5031
	(0.0000)	(0.1022)	(0.0000)	
0.35	0.5673 ***	0.0022	0.9403 ***	0.5179
	(0.0000)	(0.3460)	(0.0000)	
0.40	0.7278 ***	0.0004	0.9298 ***	0.5297
	(0.0000)	(0.8672)	(0.0000)	
0.45	0.8333 ***	-0.0009	0.9243 ***	0.5396
	(0.0000)	(0.6999)	(0.0000)	
0.50	1.0157 ***	-0.0028	0.9118 ***	0.0000
	(0.0000)	(0.1703)	(0.0000)	
0.55	1.2173 ***	-0.0030	0.8977 ***	0.5552
	(0.0000)	(0.1795)	(0.0000)	
0.60	1.3479 ***	-0.0034	0.8898 ***	0.5603
	(0.0000)	(0.1409)	(0.0000)	
0.65	1.4777 ***	-0.0028	0.8817 ***	0.5607
	(0.0000)	(0.1696)	(0.0000)	
0.70	1.6843 ***	-0.0026	0.8675 ***	0.5445
	(0.0000)	(0.2954)	(0.0000)	
0.75	2.0097 ***	-0.0048 **	0.8438 ***	0.5144
	(0.0000)	(0.0330)	(0.0000)	
0.80	2.4245 ***	-0.0049 *	0.8130 ***	0.4721
	(0.0000)	(0.0664)	(0.0000)	
0.85	2.9630 ***	-0.0048	0.7731 ***	0.4122
	(0.0000)	(0.1051)	(0.0000)	
0.90	4.2044 ***	-0.0030	0.6784 ***	0.3230
	(0.0000)	(0.4094)	(0.0000)	
0.95	7.1091 ***	-0.0042	0.4539 ***	0.2015
	(0.0000)	(0.3694)	(0.0000)	
0.99	10.3982 ***	-0.0081	0.2120 ***	0.1127
	(0.0000)	(0.3229)	(0.0000)	

Notes: Table shows regression coefficients; p-values are in parentheses. *, **, and * denote statistical significance at the 1 %, 5 %, and 10 % levels, respectively.**

Table 3 Gasoline futures estimated using the OLS and QR

Estimation of the relationship between the rate of return and trading volume

Modle (1): $ROR_t = \alpha_1 + \beta_1 VOL_t + \varepsilon_{1t}$

	α_1	β_1	R^2
OLS			
	0.9744	-0.0929	0.0006
	(0.1394)	(0.1463)	
Quantile			
0.01	-4.7158	-0.2491	0.0031
	(0.2915)	(0.5641)	
0.05	-2.7083	-0.1402	0.0012
	(0.1484)	(0.4373)	
0.10	-3.5896 ***	0.0830	0.0004
	(0.0084)	(0.5277)	
0.15	-3.0197 ***	0.0989	0.0030
	(0.0021)	(0.2956)	
0.20	-2.2370 ***	0.0670	-0.0003
	(0.0080)	(0.4120)	
0.25	-1.1223 *	-0.0086	-0.0005
	(0.0847)	(0.8912)	
0.30	-0.8326	-0.0116	-0.0005
	(0.2050)	(0.8560)	
0.35	-0.5520	-0.0141	-0.0005
	(0.4004)	(0.8238)	
0.40	-0.1046	-0.0315	-0.0005
	(0.8823)	(0.6465)	
0.45	1.0917 *	-0.1216 *	0.0004
	(0.0923)	(0.0526)	
0.50	1.5756 **	-0.1453 **	0.0000
	(0.0154)	(0.0208)	
0.55	1.3289 **	-0.0960	0.0008
	(0.0488)	(0.1427)	
0.60	2.0420 ***	-0.1424 **	0.0010
	(0.0017)	(0.0240)	
0.65	2.7596 ***	-0.1870 ***	0.0016
	(0.0000)	(0.0023)	
0.70	2.8060 ***	-0.1685 ***	0.0020
	(0.0000)	(0.0099)	
0.75	2.8444 ***	-0.1400 **	0.0020
	(0.0001)	(0.0497)	
0.80	3.4573 ***	-0.1699 ***	0.0027
	(0.0000)	(0.0093)	
0.85	4.8492 ***	-0.2675 ***	0.0029
	(0.0000)	(0.0011)	
0.90	5.3137 ***	-0.2597 **	0.0030
	(0.0000)	(0.0224)	
0.95	6.4989 ***	-0.2873 *	0.0024
	(0.0001)	(0.0700)	
0.99	8.0716	-0.1720	0.0021
	(0.1350)	(0.7418)	

Notes: Table shows regression coefficients; p-values are in parentheses. *, **, and * denote statistical significance at the 1 %, 5 %, and 10 % levels, respectively.**

Table 3 Gasoline futures estimated using the OLS and QR

Estimation of the relationship between the rate of return and open interest

Modle (2): $ROR_t = \alpha_2 + \beta_2 OI_t + \varepsilon_{2t}$

	α_2	β_2	R^2
OLS			
	1.3556 **	-0.1275 **	0.0022
	(0.0213)	(0.0226)	
Quantile			
0.01	-3.8229	-0.3168	0.0025
	(0.3560)	(0.4191)	
0.05	-2.3504	-0.1704	0.0020
	(0.1695)	(0.2930)	
0.10	-3.5918 ***	0.0826	-0.0003
	(0.0020)	(0.4529)	
0.15	-2.0284 **	0.0023	-0.0005
	(0.0204)	(0.9781)	
0.20	-0.7589	-0.0735	-0.0002
	(0.3209)	(0.3115)	
0.25	-0.6438	-0.0534	-0.0002
	(0.2606)	(0.3256)	
0.30	-0.5704	-0.0365	-0.0002
	(0.3326)	(0.5139)	
0.35	-0.2962	-0.0389	-0.0003
	(0.6137)	(0.4842)	
0.40	0.2288	-0.0613	-0.0003
	(0.7278)	(0.3270)	
0.45	1.1641 **	-0.1261 **	0.0012
	(0.0341)	(0.0154)	
0.50	1.5884 ***	-0.1428 ***	0.0000
	(0.0061)	(0.0095)	
0.55	1.8222 ***	-0.1423 **	0.0019
	(0.0025)	(0.0129)	
0.60	2.0475 ***	-0.1385 **	0.0019
	(0.0006)	(0.0148)	
0.65	2.3505 ***	-0.1470 ***	0.0030
	(0.0000)	(0.0038)	
0.70	2.9212 ***	-0.1736 ***	0.0030
	(0.0000)	(0.0042)	
0.75	3.4613 ***	-0.1958 ***	0.0040
	(0.0000)	(0.0011)	
0.80	3.8335 ***	-0.2019 ***	0.0050
	(0.0000)	(0.0005)	
0.85	5.4734 ***	-0.3229 ***	0.0068
	(0.0000)	(0.0000)	
0.90	6.0287 ***	-0.3243 ***	0.0105
	(0.0000)	(0.0001)	
0.95	5.9466 ***	-0.2317	0.0025
	(0.0001)	(0.1087)	
0.99	8.4863 *	-0.2025	0.0023
	(0.0638)	(0.6403)	

Notes: Table shows regression coefficients; p-values are in parentheses. *, **, and * denote statistical significance at the 1 %, 5 %, and 10 % levels, respectively.**

Table 3 Gasoline futures estimated using the OLS and QR

Estimation of the relationships among the rate of return, trading volume, and open interest

Modle (3): $ROR_t = \alpha_3 + \beta_3 VOL_t + \gamma_3 OI_t + \varepsilon_{3t}$

	α_3	β_3	γ_3	R^2
OLS				
	1.2411 *	0.0327	-0.1487 *	0.0017
	(0.0662)	(0.7300)	(0.0735)	
Quantile				
0.01	-4.3457	-0.1157	-0.1567	0.0026
	(0.3541)	(0.8594)	(0.7839)	
0.05	-2.9423	0.1622	-0.2737	0.0015
	(0.1490)	(0.5649)	(0.2622)	
0.10	-3.1850 **	0.1107	-0.0646	0.0001
	(0.0257)	(0.5816)	(0.7101)	
0.15	-2.6152 **	0.2382 *	-0.1735	0.0008
	(0.0101)	(0.0964)	(0.1619)	
0.20	-1.9801 **	0.2447 **	-0.1984 *	0.0005
	(0.0190)	(0.0363)	(0.0527)	
0.25	-1.1596 *	0.1009	-0.1048	-0.0001
	(0.0851)	(0.2840)	(0.1948)	
0.30	-1.2026 *	0.1075	-0.0820	-0.0004
	(0.0688)	(0.2474)	(0.3128)	
0.35	-0.5856	0.0613	-0.0710	-0.0007
	(0.3902)	(0.5190)	(0.3947)	
0.40	-0.3906	0.1013	-0.1043	-0.0007
	(0.5881)	(0.3144)	(0.2441)	
0.45	1.1627 *	-0.0005	-0.1255	0.0006
	(0.0751)	(0.9959)	(0.1127)	
0.50	1.8130 ***	-0.0435	-0.1217	0.0000
	(0.0060)	(0.6385)	(0.1297)	
0.55	1.7608 ***	0.0212	-0.1570 *	0.0014
	(0.0100)	(0.8246)	(0.0602)	
0.60	2.3544 ***	-0.0443	-0.1239	0.0015
	(0.0005)	(0.6386)	(0.1337)	
0.65	2.4767 ***	-0.0170	-0.1420 *	0.0025
	(0.0001)	(0.8511)	(0.0697)	
0.70	3.1177 ***	-0.0419	-0.1512 *	0.0026
	(0.0000)	(0.6775)	(0.0882)	
0.75	3.4564 ***	0.0005	-0.1958 **	0.0035
	(0.0000)	(0.9963)	(0.0281)	
0.80	3.6961 ***	0.0275	-0.2157 **	0.0045
	(0.0000)	(0.7871)	(0.0134)	
0.85	5.0946 ***	0.2183 *	-0.5017 ***	0.0073
	(0.0000)	(0.0561)	(0.0000)	
0.90	5.5485 ***	0.1469	-0.4234 ***	0.0107
	(0.0000)	(0.2976)	(0.0004)	
0.95	7.1131 ***	-0.2359	-0.1105	0.0022
	(0.0000)	(0.3102)	(0.5855)	
0.99	8.3348	-0.0628	-0.1285	0.0020
	(0.1391)	(0.9338)	(0.8360)	

Notes: Table shows regression coefficients; p-values are in parentheses. *, **, and * denote statistical significance at the 1 %, 5 %, and 10 % levels, respectively.**

Table 3 Gasoline futures estimated using the OLS and QR

Estimation of the relationships among the current-period rate of return, previous-period rate of return, and previous-period trading volume

Modle (4): $ROR_t = \alpha_4 + \beta_4 ROR_{t-1} + \gamma_4 VOL_{t-1} + \varepsilon_{4t}$

	α_4	β_4	γ_4	R^2
OLS				
	0.3936	-0.0004	-0.0365	-0.0009
	(0.5508)	(0.9859)	(0.5682)	
Quantile				
0.01	-12.7958 ***	0.0757	0.5561	0.0051
	(0.0089)	(0.6574)	(0.2413)	
0.05	-8.9964 ***	0.0078	0.4793 **	0.0049
	(0.0000)	(0.9169)	(0.0207)	
0.10	-8.7240 ***	0.0735 *	0.5903 ***	0.0128
	(0.0000)	(0.0667)	(0.0000)	
0.15	-5.8428 ***	0.0492	0.3690 ***	0.0080
	(0.0000)	(0.1203)	(0.0000)	
0.20	-4.5674 ***	0.0327	0.2907 ***	0.0042
	(0.0000)	(0.2283)	(0.0001)	
0.25	-3.6433 ***	0.0169	0.2319 ***	0.0007
	(0.0000)	(0.4688)	(0.0004)	
0.30	-2.3592 ***	0.0012	0.1358 **	0.0000
	(0.0002)	(0.9571)	(0.0282)	
0.35	-1.2964 **	-0.0194	0.0563	-0.0004
	(0.0484)	(0.3952)	(0.3772)	
0.40	-1.1090 *	-0.0274	0.0652	-0.0001
	(0.0966)	(0.2336)	(0.3147)	
0.45	-0.2197	-0.0155	0.0035	-0.0009
	(0.7448)	(0.5049)	(0.9573)	
0.50	1.0364	-0.0115	-0.0918	0.0000
	(0.1104)	(0.6064)	(0.1444)	
0.55	1.2134 *	-0.0027	-0.0845	-0.0002
	(0.0705)	(0.9084)	(0.1952)	
0.60	1.9716 ***	0.0078	-0.1347 **	0.0005
	(0.0020)	(0.7216)	(0.0299)	
0.65	2.5722 ***	0.0127	-0.1707 ***	0.0015
	(0.0001)	(0.5547)	(0.0056)	
0.70	3.1260 ***	-0.0031	-0.1989 ***	0.0024
	(0.0000)	(0.8953)	(0.0028)	
0.75	3.7084 ***	-0.0166	-0.2232 ***	0.0033
	(0.0000)	(0.5008)	(0.0014)	
0.80	4.0981 ***	-0.0273	-0.2305 ***	0.0046
	(0.0000)	(0.2670)	(0.0011)	
0.85	5.2033 ***	-0.0642 **	-0.2987 ***	0.0085
	(0.0000)	(0.0129)	(0.0001)	
0.90	6.8930 ***	-0.0696 *	-0.4159 ***	0.0107
	(0.0000)	(0.0618)	(0.0001)	
0.95	8.3361 ***	-0.0666	-0.4720 ***	0.0108
	(0.0000)	(0.2293)	(0.0028)	
0.99	26.9531 ***	-0.0230	-2.0071 ***	0.0351
	(0.0000)	(0.8710)	(0.0000)	

Notes: Table shows regression coefficients; p-values are in parentheses. *, **, and * denote statistical significance at the 1 %, 5 %, and 10 % levels, respectively.**

Table 3 Gasoline futures estimated using the OLS and QR

Estimation of the relationships among the current-period trading volume, previous-period rate of return, and previous-period trading volume

Modle (5): $VOL_t = \alpha_5 + \beta_5 ROR_{t-1} + \gamma_5 VOL_{t-1} + \varepsilon_{5t}$

	α_5	β_5	γ_5	R^2
OLS				
	1.3846 ***	-0.0024	0.8655 ***	0.7618
	(0.0000)	(0.5456)	(0.0000)	
Quantile				
0.01	-5.5967 **	-0.0017	1.4465 ***	0.7041
	(0.0322)	(0.9350)	(0.0000)	
0.05	-2.0966 ***	0.0012	1.1550 ***	0.7144
	(0.0000)	(0.8561)	(0.0000)	
0.10	-0.7410 ***	0.0029	1.0389 ***	0.7038
	(0.0000)	(0.5381)	(0.0000)	
0.15	-0.3303 ***	0.0013	1.0064 ***	0.6787
	(0.0018)	(0.7348)	(0.0000)	
0.20	0.1008	0.0002	0.9697 ***	0.6548
	(0.2319)	(0.9458)	(0.0000)	
0.25	0.1408 *	0.0014	0.9694 ***	0.6321
	(0.0743)	(0.6016)	(0.0000)	
0.30	0.3015 ***	0.0028	0.9572 ***	0.6103
	(0.0001)	(0.2865)	(0.0000)	
0.35	0.4121 ***	0.0024	0.9495 ***	0.5891
	(0.0000)	(0.3557)	(0.0000)	
0.40	0.5193 ***	0.0026	0.9419 ***	0.5679
	(0.0000)	(0.3309)	(0.0000)	
0.45	0.6522 ***	0.0025	0.9317 ***	0.5461
	(0.0000)	(0.2945)	(0.0000)	
0.50	0.9376 ***	0.0032	0.9072 ***	0.0000
	(0.0000)	(0.2100)	(0.0000)	
0.55	1.1901 ***	0.0038	0.8858 ***	0.4965
	(0.0000)	(0.1496)	(0.0000)	
0.60	1.3080 ***	0.0021	0.8774 ***	0.4686
	(0.0000)	(0.4392)	(0.0000)	
0.65	1.4857 ***	0.0005	0.8632 ***	0.4375
	(0.0000)	(0.8363)	(0.0000)	
0.70	1.6635 ***	0.0002	0.8490 ***	0.4012
	(0.0000)	(0.9555)	(0.0000)	
0.75	1.7741 ***	0.0003	0.8421 ***	0.3570
	(0.0000)	(0.9245)	(0.0000)	
0.80	2.1996 ***	0.0005	0.8048 ***	0.2997
	(0.0000)	(0.8696)	(0.0000)	
0.85	3.2779 ***	-0.0004	0.7083 ***	0.2196
	(0.0063)	(0.9355)	(0.0000)	
0.90	6.1298 ***	-0.0030	0.4492 ***	0.1335
	(0.0000)	(0.5805)	(0.0000)	
0.95	8.4757 ***	-0.0088	0.2405 ***	0.0690
	(0.0000)	(0.2140)	(0.0000)	
0.99	10.1589 ***	-0.0061	0.1010 ***	0.0559
	(0.0000)	(0.4669)	(0.0000)	

Notes: Table shows regression coefficients; p-values are in parentheses. *, **, and * denote statistical significance at the 1 %, 5 %, and 10 % levels, respectively.**

Table 4 Heating oil futures estimated using the OLS and QR

Estimation of the relationship between the rate of return and trading volume

Modle (1): $ROR_t = \alpha_1 + \beta_1 VOL_t + \varepsilon_{1t}$

	α_1	β_1	R^2
OLS			
	-0.5437	0.0582	0.0000
	(0.3482)	(0.3146)	
Quantile			
0.01	-18.7878 ***	1.2491 ***	0.0161
	(0.0000)	(0.0017)	
0.05	-2.3088	-0.1218	0.0000
	(0.1415)	(0.4367)	
0.10	-1.6138	-0.0902	0.0002
	(0.1386)	(0.4069)	
0.15	-0.5330	-0.1407	0.0003
	(0.5417)	(0.1066)	
0.20	0.2434	-0.1763 **	0.0008
	(0.7349)	(0.0140)	
0.25	0.0633	-0.1273 **	0.0006
	(0.9156)	(0.0326)	
0.30	0.2812	-0.1195 *	0.0003
	(0.6734)	(0.0725)	
0.35	0.1051	-0.0778	0.0001
	(0.8578)	(0.1836)	
0.40	0.1974	-0.0611	0.0000
	(0.7403)	(0.3035)	
0.45	0.3070	-0.0492	-0.0001
	(0.5498)	(0.3361)	
0.50	-0.0641	0.0087	0.0000
	(0.9067)	(0.8733)	
0.55	-0.0514	0.0309	-0.0002
	(0.9263)	(0.5764)	
0.60	-0.1140	0.0596	-0.0001
	(0.8438)	(0.3014)	
0.65	0.2554	0.0484	-0.0001
	(0.6960)	(0.4579)	
0.70	0.2624	0.0751	0.0000
	(0.6576)	(0.2034)	
0.75	0.2503	0.1051	0.0002
	(0.7152)	(0.1245)	
0.80	0.5702	0.1091	0.0002
	(0.4690)	(0.1649)	
0.85	0.5333	0.1598 *	0.0006
	(0.5513)	(0.0735)	
0.90	-0.0974	0.2813 ***	0.0024
	(0.9228)	(0.0050)	
0.95	-1.0100	0.4590 ***	0.0050
	(0.4402)	(0.0004)	
0.99	-0.2778	0.6226 *	0.0069
	(0.9400)	(0.0905)	

Notes: Table shows regression coefficients; p-values are in parentheses. *, **, and * denote statistical significance at the 1 %, 5 %, and 10 % levels, respectively.**

Table 4 Heating oil futures estimated using the OLS and QR

Estimation of the relationship between the rate of return and open interest

Modle (2): $ROR_t = \alpha_2 + \beta_2 OI_t + \varepsilon_{2t}$

	α_2	β_2	R^2
OLS			
	-0.3350	0.0359	-0.0001
	(0.4832)	(0.4336)	
Quantile			
0.01	-14.5984 ***	0.8102 **	0.0038
	(0.0003)	(0.0368)	
0.05	-5.6140 ***	0.2041 *	0.0021
	(0.0000)	(0.0683)	
0.10	-4.0278 ***	0.1458 *	0.0003
	(0.0000)	(0.0750)	
0.15	-2.6684 ***	0.0698	0.0000
	(0.0003)	(0.3268)	
0.20	-1.9701 ***	0.0414	-0.0001
	(0.0013)	(0.4798)	
0.25	-1.3351 ***	0.0125	-0.0002
	(0.0078)	(0.7948)	
0.30	-1.3122 **	0.0383	-0.0001
	(0.0169)	(0.4672)	
0.35	-1.0760 **	0.0405	-0.0001
	(0.0290)	(0.3914)	
0.40	-0.8142 *	0.0382	-0.0001
	(0.0974)	(0.4171)	
0.45	-0.3686	0.0172	-0.0002
	(0.4072)	(0.6877)	
0.50	-0.1175	0.0132	0.0000
	(0.7971)	(0.7626)	
0.55	0.2488	0.0009	-0.0002
	(0.5881)	(0.9829)	
0.60	0.2891	0.0189	-0.0002
	(0.5601)	(0.6917)	
0.65	0.6194	0.0116	-0.0002
	(0.2542)	(0.8240)	
0.70	1.0687 **	-0.0070	-0.0002
	(0.0291)	(0.8807)	
0.75	1.4756 **	-0.0162	-0.0002
	(0.0120)	(0.7739)	
0.80	2.1388 ***	-0.0463	-0.0001
	(0.0013)	(0.4670)	
0.85	3.1972 ***	-0.1022	0.0003
	(0.0000)	(0.1282)	
0.90	2.9815 ***	-0.0256	-0.0002
	(0.0012)	(0.7725)	
0.95	2.7641 **	0.0792	0.0001
	(0.0166)	(0.4735)	
0.99	3.2471	0.2733	0.0027
	(0.2935)	(0.3563)	

Notes: Table shows regression coefficients; p-values are in parentheses. *, **, and * denote statistical significance at the 1 %, 5 %, and 10 % levels, respectively.**

Table 4 Heating oil futures estimated using the OLS and QR

Estimation of the relationships among the rate of return, trading volume, and open interest

Modle (3): $ROR_t = \alpha_3 + \beta_3 VOL_t + \gamma_3 OI_t + \varepsilon_{3t}$

	α_3	β_3	γ_3	R^2
OLS				
	-0.5941	0.0477	0.0149	-0.0002
	(0.3293)	(0.4925)	(0.7870)	
Quantile				
0.01	-18.7683 ***	1.2505 **	-0.0031	0.0159
	(0.0014)	(0.0374)	(0.9946)	
0.05	-4.6818 ***	-0.3203 *	0.4266 ***	0.0043
	(0.0017)	(0.0573)	(0.0014)	
0.10	-2.9252 ***	-0.2477 **	0.2787 ***	0.0017
	(0.0079)	(0.0481)	(0.0052)	
0.15	-1.1056	-0.3020 ***	0.2096 **	0.0017
	(0.2278)	(0.0037)	(0.0102)	
0.20	-0.6203	-0.2845 ***	0.1861 ***	0.0019
	(0.4010)	(0.0008)	(0.0051)	
0.25	-0.2514	-0.2205 ***	0.1194 *	0.0009
	(0.7079)	(0.0042)	(0.0501)	
0.30	-0.0897	-0.2116 ***	0.1253 **	0.0009
	(0.8927)	(0.0052)	(0.0373)	
0.35	-0.1849	-0.1491 **	0.0974 *	0.0004
	(0.7620)	(0.0315)	(0.0804)	
0.40	-0.1278	-0.1027	0.0711	0.0001
	(0.8150)	(0.1109)	(0.1252)	
0.45	-0.0500	-0.0679	0.0510	-0.0001
	(0.9191)	(0.1897)	(0.2609)	
0.50	-0.1084	-0.0018	0.0142	0.0000
	(0.8546)	(0.9765)	(0.7750)	
0.55	0.0120	0.0352	-0.0102	-0.0004
	(0.9819)	(0.5348)	(0.8362)	
0.60	-0.0914	0.0636	-0.0059	-0.0003
	(0.8798)	(0.3740)	(0.9164)	
0.65	0.3734	0.0684	-0.0304	-0.0003
	(0.6238)	(0.3337)	(0.6778)	
0.70	0.4203	0.1301 *	-0.0685	0.0001
	(0.4781)	(0.0518)	(0.2464)	
0.75	0.6439	0.2188 ***	-0.1472 **	0.0006
	(0.3284)	(0.0064)	(0.0382)	
0.80	1.0163	0.2357 **	-0.1655 **	0.0009
	(0.2201)	(0.0120)	(0.0287)	
0.85	1.2218	0.3267 ***	-0.2262 ***	0.0022
	(0.2552)	(0.0058)	(0.0076)	
0.90	0.3538	0.4799 ***	-0.2356 **	0.0036
	(0.7630)	(0.0004)	(0.0259)	
0.95	0.5176	0.5267 ***	-0.2110	0.0059
	(0.7088)	(0.0010)	(0.1003)	
0.99	0.9814	0.3335	0.1663	0.0075
	(0.7944)	(0.4316)	(0.6316)	

Notes: Table shows regression coefficients; p-values are in parentheses. *, **, and * denote statistical significance at the 1 %, 5 %, and 10 % levels, respectively.**

Table 4 Heating oil futures estimated using the OLS and QR

Estimation of the relationships among the current-period rate of return, previous-period rate of return, and previous-period trading volume

Modle (4): $ROR_t = \alpha_4 + \beta_4 ROR_{t-1} + \gamma_4 VOL_{t-1} + \varepsilon_{4t}$

	α_4	β_4	γ_4	R^2
OLS				
	1.0225 *	-0.0276 *	-0.0983 *	0.0010
	(0.0777)	(0.0590)	(0.0893)	
Quantile				
0.01	-16.3520 ***	0.0200	1.0300 **	0.0131
	(0.0002)	(0.8574)	(0.0175)	
0.05	-5.4835 ***	0.0216	0.1974	0.0007
	(0.0003)	(0.5830)	(0.1939)	
0.10	-4.3340 ***	0.0324	0.1820 *	0.0013
	(0.0000)	(0.2182)	(0.0779)	
0.15	-3.9348 ***	0.0092	0.1972 **	0.0009
	(0.0000)	(0.6736)	(0.0193)	
0.20	-2.6267 ***	0.0099	0.1089	-0.0001
	(0.0006)	(0.6112)	(0.1541)	
0.25	-1.9248 ***	-0.0047	0.0721	-0.0002
	(0.0019)	(0.7632)	(0.2433)	
0.30	-1.4541 **	-0.0148	0.0542	-0.0002
	(0.0342)	(0.3936)	(0.4283)	
0.35	-1.0076 *	-0.0259 *	0.0362	0.0002
	(0.0971)	(0.0911)	(0.5502)	
0.40	-0.1852	-0.0452 ***	-0.0207	0.0009
	(0.7285)	(0.0009)	(0.6968)	
0.45	0.3833	-0.0516 ***	-0.0556	0.0009
	(0.4803)	(0.0002)	(0.3040)	
0.50	0.3652	-0.0515 ***	-0.0339	0.0000
	(0.5204)	(0.0003)	(0.5491)	
0.55	0.8448	-0.0448 ***	-0.0596	0.0007
	(0.1424)	(0.0022)	(0.2994)	
0.60	1.4778 **	-0.0414 ***	-0.0984	0.0009
	(0.0167)	(0.0092)	(0.1101)	
0.65	2.4393 ***	-0.0473 ***	-0.1686 ***	0.0021
	(0.0000)	(0.0014)	(0.0033)	
0.70	2.5730 ***	-0.0544 ***	-0.1570 ***	0.0022
	(0.0000)	(0.0005)	(0.0097)	
0.75	3.8463 ***	-0.0475 **	-0.2533 ***	0.0031
	(0.0000)	(0.0107)	(0.0005)	
0.80	4.5439 ***	-0.0493 ***	-0.2891 ***	0.0048
	(0.0000)	(0.0094)	(0.0001)	
0.85	6.7544 ***	-0.0363 *	-0.4610 ***	0.0067
	(0.0000)	(0.0903)	(0.0000)	
0.90	8.7394 ***	-0.0252	-0.6041 ***	0.0074
	(0.0000)	(0.3413)	(0.0000)	
0.95	9.9395 ***	-0.0310	-0.6356 ***	0.0094
	(0.0000)	(0.3964)	(0.0000)	
0.99	19.5837 ***	0.0522	-1.3728 ***	0.0311
	(0.0000)	(0.4741)	(0.0000)	

Notes: Table shows regression coefficients; p-values are in parentheses. *, **, and * denote statistical significance at the 1 %, 5 %, and 10 % levels, respectively.**

Table 4 Heating oil futures estimated using the OLS and QR

Estimation of the relationships among the current-period trading volume, previous-period rate of return, and previous-period trading volume

Modle (5): $VOL_t = \alpha_5 + \beta_5 ROR_{t-1} + \gamma_5 VOL_{t-1} + \varepsilon_{5t}$

	α_5	β_5	γ_5	R^2
OLS				
	3.4619 ***	-0.0028	0.6540 ***	0.4272
	(0.0000)	(0.3160)	(0.0000)	
Quantile				
0.01	-6.3885 ***	-0.0017	1.5231 ***	0.1456
	(0.0000)	(0.9389)	(0.0000)	
0.05	-0.2112	-0.0042	0.9741 ***	0.2347
	(0.2491)	(0.3620)	(0.0000)	
0.10	0.3775 ***	-0.0001	0.9284 ***	0.3021
	(0.0029)	(0.9799)	(0.0000)	
0.15	0.6892 ***	0.0020	0.9044 ***	0.3430
	(0.0000)	(0.4486)	(0.0000)	
0.20	0.8578 ***	0.0025	0.8925 ***	0.3691
	(0.0000)	(0.2208)	(0.0000)	
0.25	1.0367 ***	0.0018	0.8789 ***	0.3876
	(0.0000)	(0.4031)	(0.0000)	
0.30	1.0977 ***	0.0015	0.8764 ***	0.4015
	(0.0000)	(0.4340)	(0.0000)	
0.35	1.1694 ***	0.0016	0.8724 ***	0.4116
	(0.0000)	(0.4250)	(0.0000)	
0.40	1.2601 ***	0.0005	0.8668 ***	0.4191
	(0.0000)	(0.7907)	(0.0000)	
0.45	1.4228 ***	-0.0001	0.8537 ***	0.4245
	(0.0000)	(0.9679)	(0.0000)	
0.50	1.5767 ***	-0.0009	0.8415 ***	0.0000
	(0.0000)	(0.6322)	(0.0000)	
0.55	1.6506 ***	-0.0002	0.8370 ***	0.4299
	(0.0000)	(0.9033)	(0.0000)	
0.60	1.8414 ***	0.0007	0.8214 ***	0.4289
	(0.0000)	(0.7364)	(0.0000)	
0.65	2.0059 ***	0.0003	0.8085 ***	0.4248
	(0.0000)	(0.8957)	(0.0000)	
0.70	2.2199 ***	-0.0014	0.7910 ***	0.4172
	(0.0000)	(0.5331)	(0.0000)	
0.75	2.4792 ***	-0.0005	0.7693 ***	0.4045
	(0.0000)	(0.8291)	(0.0000)	
0.80	2.7745 ***	0.0008	0.7447 ***	0.3826
	(0.0000)	(0.7241)	(0.0000)	
0.85	3.3298 ***	-0.0012	0.6955 ***	0.3440
	(0.0000)	(0.6965)	(0.0000)	
0.90	4.4445 ***	-0.0063 *	0.5961 ***	0.2803
	(0.0000)	(0.0640)	(0.0000)	
0.95	6.2454 ***	-0.0106 **	0.4369 ***	0.1670
	(0.0000)	(0.0234)	(0.0000)	
0.99	9.8378 ***	-0.0236 ***	0.1228 ***	0.0508
	(0.0000)	(0.0016)	(0.0000)	

Notes: Table shows regression coefficients; p-values are in parentheses. *, **, and * denote statistical significance at the 1 %, 5 %, and 10 % levels, respectively.**

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