Effect of spot and futures prices of crude oil on the stock market return of Kazakhstan

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Abstract

This thesis investigates the relationship between crude oil spot prices, crude oil futures prices, interest rates and stock market return of Kazakhstan, which is an oil exporting country. ARCH family regressions along with VAR and IRF models used to evaluate the impact of oil prices, revealed that both spot prices and futures prices of crude oil have a significant positive effect on the stock market returns, while interest rates predominantly influence the volatility of stock market gains. Paper also examines how the market responds to shocks in oil prices and interest rates. Furthermore, analysis of the asymmetric effect of oil prices showed that negative shocks in oil prices had a higher impact on the market volatility, compared to the positive shocks. The findings in this thesis may prove to provide valuable insights to the behavior of the stock market of Kazakhstan and its relationship with crude oil prices that can be utilized by policymakers, investors and portfolio managers.

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1. Introduction

Kazakhstan is an oil exporting emerging economy that heavily relies on crude oil trading. Consequently, it is only rational to assume the sensitivity of its stock market return to the swings in crude oil prices, as the companies revenues depend on the export of crude oil as primary revenue. Understanding this interlinkage of oil prices, interest rates and stock market returns is of high significance for formulating effective monetary and fiscal policies as well as investment strategies. Thesis' empirical analysis is divided into three parts. Section 3 investigates the effect of oil prices and interest rates on the market returns as well as how they influence the volatility of market gains. Results suggest that in separate ARCH family models, both spot prices and futures prices of crude oil play a statistically significant positive role in the returns of the stock market, however, they both lack impact on the volatility of the market. Interest rates, conversely, revealed to have minimal effect on the returns of the market as itself, but play a huge role as a driver of volatility of the market. When conducting a joint model, we could observe that futures prices of crude oil have much more weight in dictating the returns in the stock market compared to spot prices of crude oil due to their forward looking nature. Stock market returns and oil prices often have periods with high and low volatility that can cluster together. Both autoregressive conditional heteroskedasticity (ARCH) and general autoregressive conditional heteroskedasticity (GARCH) models do an effective job for capturing this phenomenon by accounting for the time varying volatility, since they were specifically designed for similar time series. They also capture the persistence of volatility in market returns. This approach was inspired by a similar research question by Perry Sadorsky in 1999 in a widely cited and popular paper called "Oil price shocks and stock market activity". Sadorsky used a similar approach of investigating the relationship between US market returns (S&P 500 Index) and the spots of crude oil prices using ARCH family regressions and asymmetric analysis. Section 4 examines the similar question on how crude oil prices affect the stock market returns by using vector autoregressive (VAR) model along with impulse response function (IRF), cumulative impulse response function (CIRF) and forecast error variance decomposition (FEVD). Results showed that while real oil prices do not have a significant effect on the market returns, futures price at second lag had a positive statistically significant impact. Interest rates also proved to have statistically significant but weak negative effects. Market returns indicated strong persistence and momentum. IRF, CIRF and FEVD graphs revealed that both spot prices and futures prices of crude oil shocks have positive reactions from the market that are also persistent in the long-term run. While ARCH family regressions focus on the time varying volatility within stock market returns, VAR, IRF, CIF and FEVD methods allow the analysis of the interdependence and interrelationship of all the variables and their responses to shocks. Implementing futures prices into the equation was inspired by a paper written by Huang et al. in 1996 in a highly cited paper “Energy Shocks and Financial Markets”. Paper investigates the relationship between futures prices of crude oil and stock prices S&P 500 Index using the VAR model. Section 5 of the paper focuses on the asymmetric effect of crude oil prices on the market gains, which proved to be worth investigating. Threshold autoregressive conditional heteroskedasticity (TARCH) model revealed that negative shocks in real oil spot prices have a greater and statistically significant effect on the stock market returns compared to the positive ones, which proved to be insignificant. Similar pattern was observed in the futures prices, however, the statistical significance of the TARCH model itself proved to be unreliable, which leaves us with no precise conclusion on how asymmetric the effect of futures prices of crude oil.

2. Data

Natural logarithms of the variables used in this paper are denoted as follows: real stock return (rsr), interest rates (lr), oil prices (lo) and future oil prices(fo). Real stock returns are calculated as the difference between continuously compounded return on the Kazakhstan Stock Exchange Index (KASE) and the inflation rate calculated using the consumer price index. The data for Kase was downloaded from the IRIS Terminal provided by the KASE themselves and the inflation rate was acquired from the statistics of the National Bank of Kazakhstan. Difference between Brent crude oil prices accessed from U.S. The Energy Information Administration and the producer price index for fuel from FRED was used as the real oil price as it is the one used as a benchmark for the Kazakhstan Export Blend Crude Oil (KEBCO). Futures prices variable used a similar approach for Brent crude oil futures prices. Interest rates were measured using the Tenge OverNight Index Average (TONIA). The data are monthly and cover the periods from 2007:10 - 2024:11.

Table 1 shows the results from the Phillips and Perron unit root test for all the variables. Results show that out of three variables in level, only crude oil prices are stationary at 10% significance level. All variables are best described as being stationary in their first difference form.

Table 1
Unit root tests

Variable	
Natural logarithms	
l_Brent	-2.640*
l_Tonia	-2.447
l_Kase	-0.820
l_Futures	-2.597*
First differences	
Δro	-16.001***
Δr	-16.155***
Δrsr	-9.618***
Δfo	-11.070***

Before continuing with the models, checking for cointegration is required. To determine whether the variables have any common stochastic trends, we implement Johansen test for cointegration. The λ_{max} and trace tests showed no evidence for cointegration between the variables at second lag order.

Table 2
Tests for cointegration using the Johansen procedure

Hypothesis	r=0	r>1	r>2
Trace test	28.62*	11.34	0.14
Critical value	29.68	15.41	3.76

3. **Variability in oil prices (ARCH & GARCH model)**

Figure 1 represents the crude oil price over time. We can note the high volatility in the prices of crude oil throughout the whole period. Oil price volatility might play an important part in affecting the stock market return of an oil exporting country like Kazakhstan. Autocorrelation function of the oil prices showed slow decay, thus, the low order General Autoregressive Conditional Heteroskedasticity (GARCH) model should be a good fit.

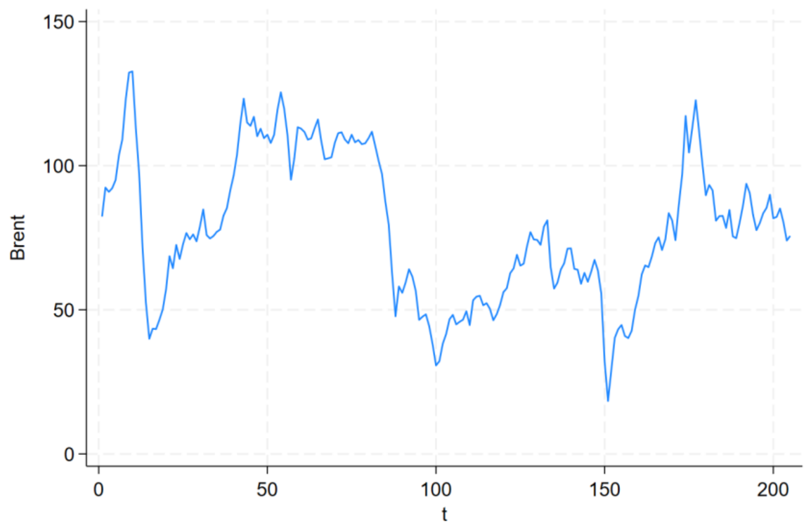

Figure 1. Oil prices over time

Table 3 represents the results acquired from the ARCH 1,1 and GARCH 1,1 models. Panel A shows that the real interest rates have a weak positive and statistically insignificant effect on the real market returns. This implies that interest rates may not play a significant role in the market returns potentially due to lack of efficient transmission mechanism between monetary policies of the National Bank and equity markets of Kazakhstan. Real oil prices, on the other hand, showed positive and statistically significant effects on the stock market gains. According to the model, 1 unit increase in oil prices is associated with 0.122% increase in the market returns. Intuitively, since Kazakhstan is an oil-exporting country, the market is sensitive to oil prices. Increase in oil prices potentially increases the investor confidence in oil related sectors of Kazakhstan, which take up substantial shares of the local stock market. Panel B, variance equation, shows that the real interest rates have a highly significant effect on the volatility of the market gains. This could be explained by the rationale that increases in interest rates indicate monetary policy adjustments or uncertainties in the local economy, which eventually increase the speculations among investors and volatility in the market returns. Panel C proves the significance of both ARCH and GARCH terms, which implies that past shocks significantly affect the current volatility and the persistence of the volatility over long term. Log-likelihood is equal to 278 and Wald Chi2 (2) 5.52***. This states that the model fits the data well and that model is statistically significant overall.

$$\Delta rsr_t = \alpha_0 + \alpha_t \Delta r_t + \alpha_2 \Delta ro_t + \varepsilon_t$$
$$h_t = \omega + \gamma_t \varepsilon_{t-1}^2 + \delta_t h_{t-1}$$

- h_t: conditional variance of ε_t at time t
- ε_t: error term (innovations)
- γ_t: Coefficient for lagged squared errors (ARCH effect)
- δ_t: Coefficient for lagged variances (GARCH effect)

Table 3
ARCH (1) and GARCH (1) model estimates (Selected based on SBIC)

Variable	Coefficient	St.Error
Panel A. Mean Equation		
Δr	.003	.003
Δro	.122**	.059
_cons	.007*	.004
Panel B. Variance Equation		
Δr	.216***	.061
Δro	-6.655	4.529
_cons	-7.3168***	.3063
Panel C. Arch and Garch terms		
ARCH (L1)	.418***	.147
GARCH(L1)	.392***	.091

Table 4
Shapiro-Wilk Test for Residual Normality

Variable	W	v	z	p-value
u	.91021	13.571	6.005	0

Conducting the same analysis on the futures of crude oil shows similar results as in spot prices. Table 5 represents the difference between crude oil prices and futures prices. Future prices proved to have higher significance levels at 1% confidence level with lower standard error. Interest rates on contrast showed to be significant when estimated along with futures prices in the mean equation. Similar to spot prices, futures prices also did not have a significant effect on market gains volatility in the variance equation of the model. Both ARCH and GARCH terms showed significance at 1% significance level proving the good fitness of the model. Log-likelihood is equal to 285 and Wald Chi2 (2) 15.8***. This states that the model fits the data well and that model is statistically significant overall.

Table 5
ARCH (1) and GARCH (2) model estimates (Selected based on SBIC)

Variable	Coefficient	St.Error
Panel A. Mean Equation		
Δr	.005**	.002
Δfo	.138***	.041
_cons	.007	.004
Panel B. Variance Equation		
Δr	.217***	.056
Δfo	-2.811	3.278
_cons	-6.922***	.256
Panel C. Arch and Garch terms		
ARCH (L1)	.515***	.152
GARCH(L2)	.256***	.106

Table 6
Shapiro-Wilk Test for Residual Normality

Variable	W	v	z	p-value
uf	.9229	11.653	5.654	0

When adding both spot prices of crude oil and futures prices and conducting similar analysis, we get slightly different results. To satisfy the assumptions of ARCH family regressions, a collinearity test was conducted to ensure absence of multicollinearity issues in the model. The VIF indicator for all variables showed a mean VIF value of 1.16, which is far less than the 5 value, giving confidence in conducting the joint model. Table 7 showed us the relationship between the effect of spot prices and future prices on the market gains. In the mean equation of the model, real oil spot prices stopped being statistically significant, while futures prices showed being statistically significant in both joint and separate models. In the variance equation, both spots and futures prices remained to be statistically insignificant. It can be observed that futures prices of crude oil play a significant role in determining market returns of Kazakhstan, but do not impact volatility as much. This proves the value of futures prices as a forward-looking indicator, and suggests that their value is already priced in the expectation of market returns but not in market uncertainty. Real oil spot prices become overshadowed by the futures prices due to futures prices' forward-looking nature, which is why it became insignificant in the joint model. Log-likelihood is equal to 286 and Wald Chi2 (2) 17.46***. This states that the model fits the data well and that model is statistically significant overall.

Table 7
ARCH (1) and GARCH (2) model estimates (Selected based on SBIC)

Variable	Coefficient	St.Error
Panel A. Mean Equation		
Δr	.005**	.002
Δfo	.133***	.045
Δro	.044	.051
_cons	.007	.004
Panel B. Variance Equation		
Δr	.232***	.057
Δfo	-.528	3.204
Δro	-6.111	4.628
_cons	-6.999***	.282
Panel C. Arch and Garch terms		
ARCH (L1)	.531***	.148
GARCH(L2)	.243***	.096

Presence of significant ARCH and GARCH terms prove the time-varying volatility in market returns where different shocks have prolonged effects on the uncertainty of the market, which is common for other emerging markets like Kazakhstan. The Shapiro-Wilk test rejects the normality of residuals hypothesis, which can be explained by common issues in financial data in time series, since returns can often follow non-normal distributions due to fat tails.

4. Empirical Model (VAR model)

The results from the Vector Autoregressive model in table 8 show that for the stock market returns, the past performance of the market influences future returns, which is indicated by statistically significant positive coefficient. This is a common feature of financial markets which is often driven by momentum and sentiment of investors. Interest rates also showed significant negative effects on the returns of the market. This implies that the increase in interest rates dampens future returns of the market. This coincides with the theoretical interpretation that states that tighter monetary policies increase the cost of carry for companies, which reduces profitability and valuations of their equity. Real oil prices ended up having a positive but insignificant effect on market performance. Lack of significance might suggest that the relationship between the market returns and real oil prices is more complex, severely delayed or mediated by exchange rates. For interest rates, only the lagged interest rates showed significant effect, which shows the persistence of interest rates dynamics. This is a common central bank practice where monetary policy adjustments are quite gradual. Real oil prices showed their exogenous nature by not being significantly affected by any of the variables used in the equation.

$$\begin{bmatrix} \Delta rsr_t \\ \Delta ro_t \\ \Delta r_t \end{bmatrix} = \begin{bmatrix} \beta_{11} & \beta_{12} & \beta_{13} \\ \beta_{21} & \beta_{22} & \beta_{23} \\ \beta_{31} & \beta_{32} & \beta_{33} \end{bmatrix} \begin{bmatrix} \Delta rsr_{t-1} \\ \Delta ro_{t-1} \\ \Delta r_{t-1} \end{bmatrix} + \begin{bmatrix} \varepsilon_{rsr,t} \\ \varepsilon_{ro,t} \\ \varepsilon_{r,t} \end{bmatrix}$$

- β_{ij}: Coefficients representing the effect of lagged variable j on dependent variable i
- $\varepsilon_{i,t}$: Error term for equation i at time t

Table 8
VAR Model Results

Variable	Coefficient		St.Error
Panel A. Real Stock Return			
Δrsr	0.359***		0.065
Δr	-0.007***		0.003
Δro	0.083		0.075
Panel B. Interest Rate			
Δrsr	-2.276		1.766
Δr	-0.138**		0.069
Δro	0.094		2.032
Panel C. Real Oil Prices			
rsr	0.024		0.062
Δr	-0.000		0.002
Δro	-0.082		0.072
Panel D. Explanatory Power	RMSE	R-sq	p-value
Δrsr	.069	0.19	0.000
Δr	1.88	0.03	0.127
Δfo	.066	0.00	0.722

Since VAR models assume absence of cointegration between variables, we cannot use both spot prices and futures prices, thus, have to conduct separate models for both of them and compare the results. The optimal lag for the VAR model was chosen to be 1-2 by HQIC and SBIC. Based on the results from Table 9, we can derive several insights. In Panel A, we can see strong persistence of the market gains, where the lagged value of real market returns has a positive and highly significant effect on the current returns of the market. The lagged interest rates negatively affect the market gains consistent with the rationale of discouragement of investment initiatives due to higher borrowing costs. We can also observe the delayed transmission mechanism of second lag of futures prices of crude oil affecting positively market gains of Kazakhstan. According to Panel C, the lag of Kazakhstan's market gains influences positively the prices of crude oil futures. This potentially could be explained by the feedback from market performance to the futures market of oil or due to the fact that Kazakhstan contributes a decent portion of crude oil to the global market of oil. Eigenvalue stability condition test resulted in all eigenvalues being within the unit circle (stable). The Lagrange multiplier test also showed no autocorrelation at lags 1 and 2.

$$\begin{bmatrix} \Delta rsr_t \\ \Delta fo_t \\ \Delta r_t \end{bmatrix} = \begin{bmatrix} \beta_{11,1} & \beta_{12,1} & \beta_{13,1} \\ \beta_{21,1} & \beta_{22,1} & \beta_{23,1} \\ \beta_{31,1} & \beta_{32,1} & \beta_{33,1} \end{bmatrix} \begin{bmatrix} \Delta rsr_{t-1} \\ \Delta fo_{t-1} \\ \Delta r_{t-1} \end{bmatrix} + \begin{bmatrix} \beta_{11,2} & \beta_{12,2} & \beta_{13,2} \\ \beta_{21,2} & \beta_{22,2} & \beta_{23,2} \\ \beta_{31,2} & \beta_{32,2} & \beta_{33,2} \end{bmatrix} \begin{bmatrix} \Delta rsr_{t-2} \\ \Delta fo_{t-2} \\ \Delta r_{t-2} \end{bmatrix} + \begin{bmatrix} \varepsilon_{rsr,t} \\ \varepsilon_{fo,t} \\ \varepsilon_{r,t} \end{bmatrix}$$

Table 9
VAR Model Results

Variable	Coefficient		St.Error
Panel A. Real Stock Return			
Δrsr L1.	.411***		.073
Δrsr L2.	-.082		.074
Δr L1.	-.006**		.003
Δr L2.	.003		.003
Δfo L1.	-.019		.055
Δfo L2.	.101*		.055
Panel B. Interest Rate			
Δrsr L1.	-.909		1.946
Δrsr L2.	-.481		1.968
Δr L1.	-.125*		.069
Δr L2.	.060		.069
Δfo L1.	-1.65		1.47
Δfo L2.	.530		1.46
Panel C. Real Oil Prices			
Δrsr L1.	.295***		.096
Δrsr L2.	.048		.097
Δr L1.	-.003		.003
Δr L2.	.004		.003
Δfo L1.	.158**		.073
Δfo L2.	-.068		.072
Panel D. Explanatory Power	RMSE	R-sq	p-value
Δrsr	.069	0.19	0.00
Δr	1.86	0.04	0.293
Δfo	.093	0.12	0.00

Impulse response function is illustrated on image 2, where impulses interest rates and real oil prices and the response is of real stock market returns. On the left hand side, interest rates showed minimal effect on the real stock market returns and it fades quickly. This suggests that interest rates do not have a statistically significant impact on the market gains. The right panel of the graph shows that shocks in real oil prices result in immediate and significant positive response in the market gains. The reaction peaks in the first 1-2 months and diminishes at around 5 months. This suggests that the oil prices shock is short term and does not have a lasting effect on the market. This goes with the idea of Kazakhstan being an oil exporting country, where revenue is dependent on the oil prices, where investors positively react to anticipation of increased profitability of the local oil sector.

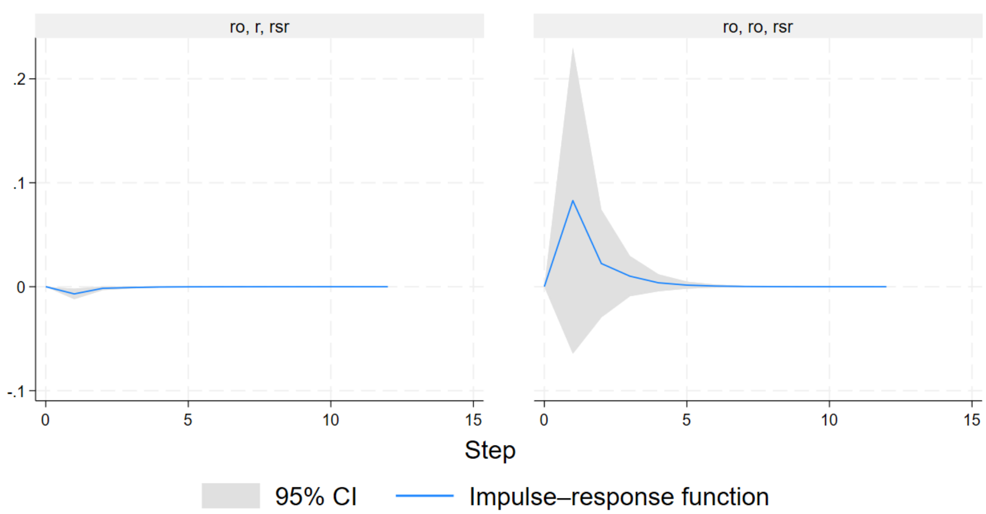

Image 2. Impulse response function

Image 3 represents the cumulative response function for the same shocks and responses as image 2. Similarly to impulse response function, interest rates showed no significant effect on the market returns in cumulative impulse response function. Shocks to oil prices, in contrast, showed sharp increase in the first 2-3 steps and stabilized positively at step 5. This shows that oil prices have lasting and positive cumulative effect on the market gains, showing persistence of the market sensitivity to oil prices swings.

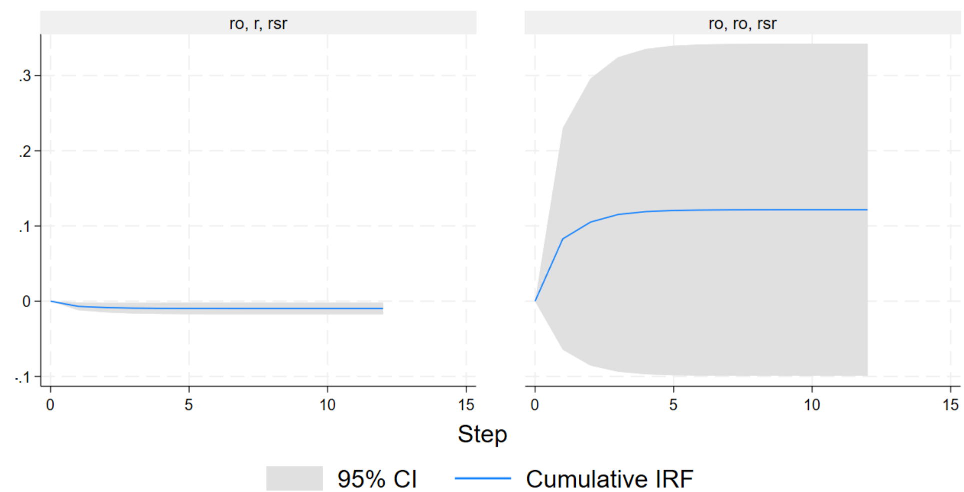

Image 3. Cumulative impulse response function

Forecasted variance decomposition graph is illustrated in image 4. Results indicate that the interest rates contribute to a larger positive portion of the forecast error variance compared to the oil prices, however, wider confidence intervals bands lead to higher uncertainty in the estimates. This goes along with the results obtained in ARCH-GARCH models, where interest rates influenced the volatility of the market gains rather than the expected market gains.

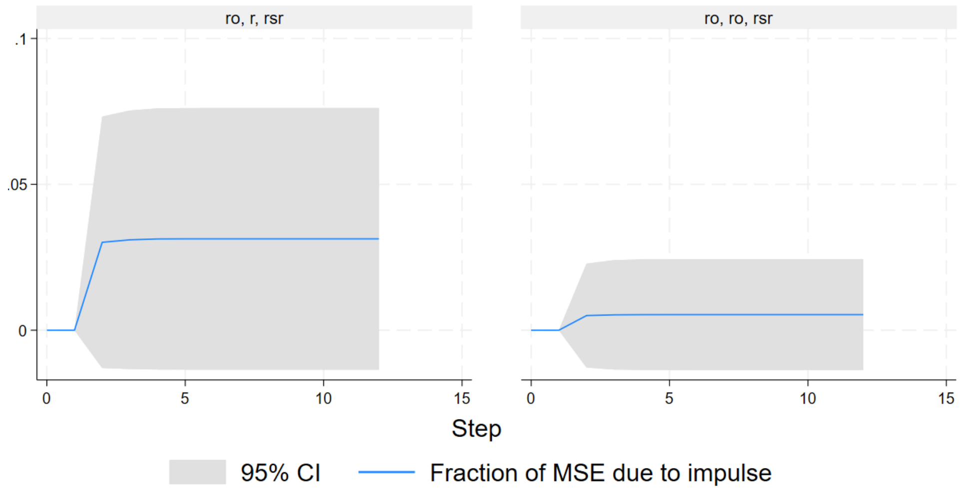

Image 4. Forecasted variance decomposition

Image 5 illustrates the impulse response function of the market returns on shocks in cured oil futures prices and interest rates. Shock to futures prices result in sharp positive response in market gains peaking at 1-2 steps. This is similar to the reaction of market returns on spot prices of oil, but delayed by one step. The reaction of market returns tells us that market reacts quickly and positively to shocks in futures prices, which can be explained by optimistic perception of future gains of investors in the oil sectors of Kazakhstan. Interest rates remained insignificant as in previous graphs.

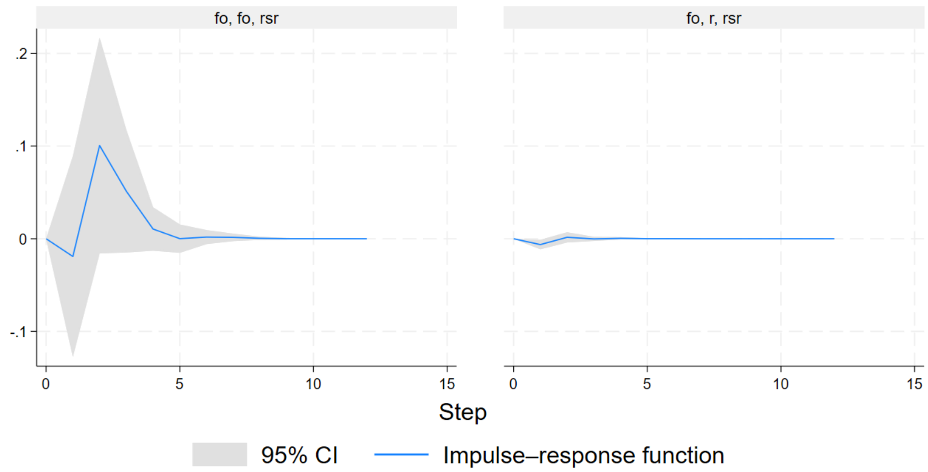

Image 5. Impulse response function

Image 6 contains the cumulative impulse response function including the futures prices of crude oil. Similar to spot prices, we can observe the positive quick reaction of market returns that stabilizes at around step 4. This implies that shocks in futures prices of crude oil have a cumulative lasting effect on market returns. However, the confidence interval's width rises skepticism in the reliability of the conclusion. Interest rates showed similar results as in previous cumulative response function.

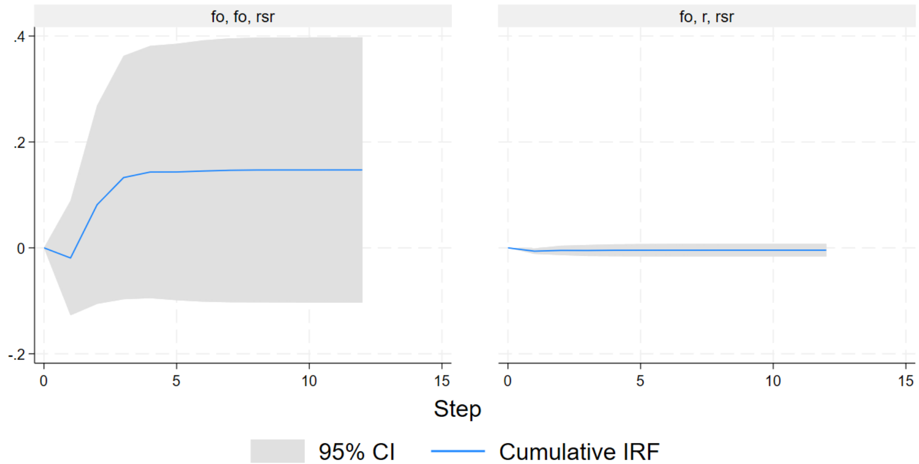

Image 6. Cumulative impulse response function

Forecasted variance decomposition is illustrated in the image 7. Graph shows that while both interest rates and futures prices account for some portion of the variance in market gains, the confidence intervals are wide enough to be skeptical of making conclusions about the results.

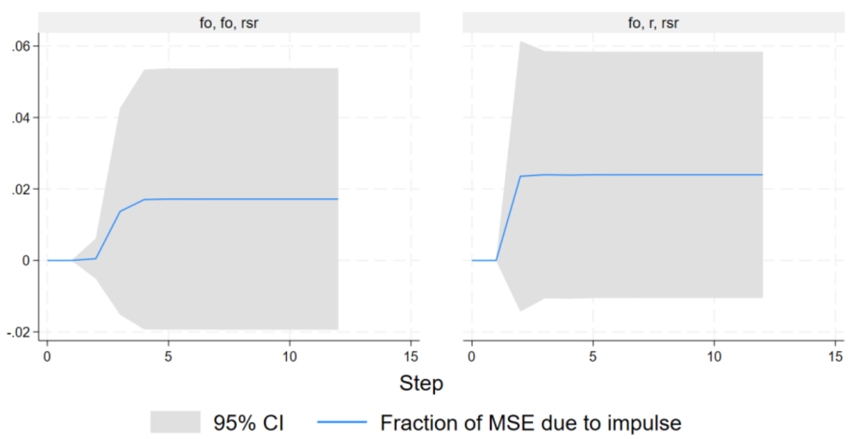

Image 7. Forecasted variance decomposition

5. Asymmetric effect

Relationship between crude oil prices and market returns is not always linear and can be complex, which raises reasons to investigate how increase and decrease in oil prices may have different effects on the market gains and their volatility. Understanding the asymmetric effect of oil price changes potentially allows for deeper understanding of market behavior and how to react to swings in prices. Policymakers, investors and portfolio managers can benefit from incorporating asymmetricity into their decision making to increase accuracy in the fiscal or monetary policies, accounting for possible risks etc. Threshold autoregressive conditional heteroskedasticity model as used to evaluate the asymmetric effect of oil prices on market returns. Numbers of lags were chosen based on Schwarz information criterion. Returns of real oil spot prices were divided into positive and negative values, where positive variables take the value of itself when above zero and is equal to zero, when the value is negative. Similar logic was applied to negative variable but vice-versa.

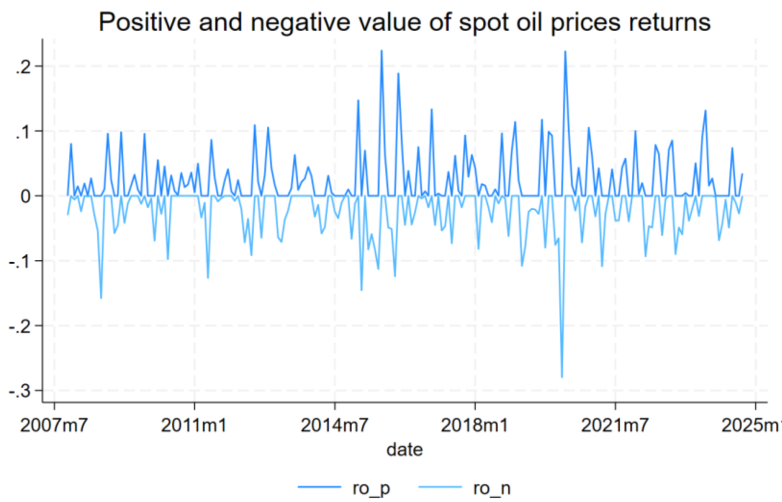

Image 7. Line graph of divided spot prices

Similar to the first model, real oil prices showed a positive and significant effect on the market gains of Kazakhstan, while interest rates do not impact them directly. Variance equations proved that investigating asymmetric effects might be insightful. Negative oil price shocks decrease the volatility of the market returns, while positive shocks do not have significant impact. The possible explanation for such a controversial outcome could be the built-in resilience and offsetting increase in exports. Oil dependent countries can develop resilience to various oil related shocks through previous experience, and companies familiar with such citations can account for possible outcomes. Additionally, while negative prices reduce the revenues of local companies, lower costs can also mean they can export more oil for a cheaper price, which can offset the negative impact and stabilize the market in the short term. Interest rates, similar to before, showed that they significantly affect the volatility of the market returns. The TARCH term is also proved to be significant at 10% significance level, which confirms that negative shocks create more volatility than positive shocks do.

Table 10
ARCH (3) and TARCH (1) model estimates (Chosen based on SBIC)

Variable	Coefficient	St.Error
Panel A. Mean Equation		
Δr	.001	.004
Δro	.114**	.053
_cons	.004*	.004
Panel B. Variance Equation		
ro_positive	-3.156	2.596
ro_negative	-11.448***	2.527
r	.179***	.064
_cons	-6.339***	.179
Panel C. Arch and Tarch terms		
ARCH (L3)	.411***	.085
TARCH(L1)	.148*	.084

When conducting the same analysis using futures prices of crude oil, similar results were obtained. Futures prices of crude oil showed statistically significant and positive impact on the returns of the stock market. Interest rates showed to be a statistically significant driver of volatility in market gains. Similar to spot prices of crude oil, negative shocks to futures prices showed to be a higher influence on the stability of market returns than positive ones. Similar to the previous model, this could indicate that forward looking value like futures of crude oil signals clear expectations of lower oil prices in the future reducing the uncertainty. Futures market can also allow portfolio managers to hedge against the future potential losses and this anticipation potentially could reduce the impact of negative oil shocks on market returns. However, unlike the previous model, the TARCH term showed no statistical significance in panel C of table 11. This gives ground for scepticism regarding the asymmetry in futures prices' effect on the market returns of Kazakhstan.

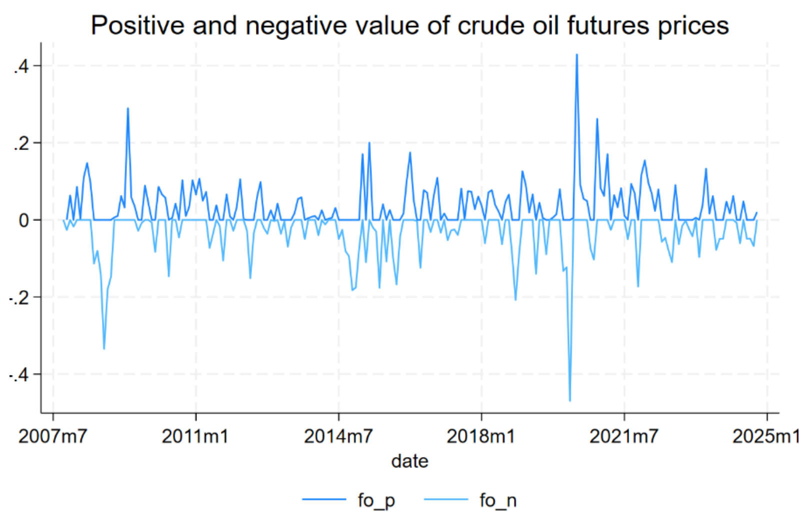

Image 7. Line graph of divided futures prices

Table 11
ARCH (3) and TARCH (1) model estimates (Chosen based on SBIC)

Variable	Coefficient	St.Error
Panel A. Mean Equation		
Δr	.001	.004
Δfo	.272***	.058
_cons	.001	.004
Panel B. Variance Equation		
fo_positive	4.86	1.61
fo_negative	-9.581***	2.330
r	.167**	.066
_cons	-6.264***	.160
Panel C. Arch and Tarch terms		
ARCH (L3)	.411***	.098
TARCH(L1)	.101	.069

6. Conclusion

This thesis highlights the importance of crude oil prices in the stock market performance of Kazakhstan using various empirical models. Positive shocks in crude oil spot prices and futures prices increase investor confidence, which leads to increased stock market gains in Kazakhstan. While prices of crude oil do not affect the volatility of market returns as a whole, negative shocks in real oil spot prices were shown to statistically decrease the volatility of stock market returns. Futures prices of crude oil, however, did not show asymmetricity in their effect like spot prices did. Interest rates, while not affecting the expected returns in the stock market, proved to have a high significance in driving the volatility of the stock market, which gives us the presumption of the important role of monetary policy in the stability of the financial market of Kazakhstan. These results underlie the insight for both policymakers and investors to be aware of the asymmetric effect of negative shocks for effective risk management and policy creation.

7. Reference List

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