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The Impact of Oil Prices on Kazakhstan's Business Cycles: An Empirical Approach Considering Asymmetry

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Abstract

This study examines the impact of global oil price fluctuations on Kazakhstan's business cycles using vector autoregression models (VAR, TVAR) and the Markov-switching model (MSM). This approach allows for the consideration of both linear and nonlinear relationships, as well as the asymmetry in the economy's response to oil price changes across different economic cycles. The results indicate that negative oil price shocks exert the most pronounced effect on Kazakhstan's GDP during crisis periods, whereas positive shocks remain statistically insignificant. The threshold value for the quarterly dynamics of real oil prices, identified in the TVAR model, is -14%, beyond which the impact of oil prices on GDP becomes significantly more pronounced. This finding highlights the Kazakh economy's sensitivity to major oil market shocks. The analysis using the MSM model confirmed a high probability of transitioning into a crisis regime in the event of a substantial decline in oil prices. The study's conclusions contribute to the existing literature and provide an empirical foundation for the development of economic policies aimed at enhancing the resilience of Kazakhstan's economy to commodity price volatility.

Keywords: business cycles, GDP, oil prices, asymmetry, VAR, TVAR, Markov-switching, economic growth, Kazakhstan.

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Introduction

The relationship between oil price shocks and macroeconomic fluctuations has attracted significant attention from researchers, particularly in the context of oil-exporting countries. Kazakhstan, with its substantial oil reserves and high fiscal dependence on the oil sector, represents a compelling case for studying this dynamic. The objective of this study is to assess how oil price fluctuations impact business activity in Kazakhstan, providing deeper insights into the effects of commodity price volatility on economic indicators in resource-dependent economies.

Kazakhstan's economy exhibits a high degree of sensitivity to changes in global oil prices. Budget revenues, export earnings, and overall economic stability are closely tied to the performance of the oil sector. Sharp oil price movements, driven by geopolitical events, shifts in global demand, or supply disruptions, can lead to significant economic shocks. These shocks manifest either as short-term price spikes or as sustained price declines, each affecting macroeconomic indicators in different ways.

To evaluate the magnitude and nature of oil price shocks' impact on business activity, three complementary approaches were employed: vector autoregression (VAR), threshold vector autoregression (TVAR), and the Markov-switching model (MSM). The VAR model allowed for the assessment of linear relationships between oil prices and Kazakhstan's GDP, as well as the estimation of impulse responses to price changes. The TVAR model captured threshold effects, enabling the identification of economic transitions between growth and recession regimes and differences in the economy's response at specific oil price change levels. Additionally, the MSM model was applied to analyze regime shifts in the economy, incorporating asymmetric and nonlinear effects of oil price shocks.

A particular focus of this study is the asymmetric impact of oil prices on economic activity, examined through impulse response analysis (VAR, TVAR) and regime transition probabilities (MSM). These results illustrate how Kazakhstan's GDP responds to positive and negative oil price shocks during both stable and crisis periods, enhancing the understanding of macroeconomic dynamics in relation to prevailing economic conditions.

The findings of this study provide an empirical basis for analyzing the relationship between oil prices and business activity in Kazakhstan, highlighting the key mechanisms through which external shocks influence macroeconomic stability. Moreover, the conclusions contribute to the broader academic discourse on the challenges faced by resource-dependent economies.

Literature review

Existing empirical studies explore the relationship between oil prices and key economic indicators, yet their findings remain inconclusive regarding the magnitude and significance of this relationship. Various analytical approaches have been proposed in the literature, ranging from linear models to more sophisticated methods that account for structural breaks and asymmetric effects.

Long-term linkages between oil prices and economic growth have received significant attention, particularly in the context of identifying changes in macroeconomic responses to oil shocks. Gadea (2016) provides an example of vector autoregression (VAR) modeling and impulse response analysis to examine this dynamic using U.S. data from 1861 to 2016. The study finds that the impact of oil shocks on GDP has evolved over time, influenced by structural transformations such as energy source diversification and technological advancements. In the post-industrial era, the direct effect of oil prices on economic growth has weakened due to increased energy efficiency and reduced dependence of production costs on oil prices. However, impulse response analysis suggests that GDP exhibits asymmetric reactions to sharp oil price fluctuations, underscoring the importance of understanding short-term effects.

Expanding on this approach, Salem et al. (2024) employ a threshold vector autoregression (TVAR) model to capture regime-dependent variations in the relationship between oil prices and macroeconomic indicators. Their study, covering 20 oil-importing and exporting countries from 1995 to 2023, reveals significant cross-country differences in threshold levels, emphasizing the necessity of accounting for national economic characteristics when assessing the effects of oil shocks. The findings indicate that oil price effects are most pronounced during periods of extreme volatility, leading to substantial fluctuations in GDP components such as consumption and investment.

To fully grasp the impact of oil shocks on macroeconomic dynamics, it is crucial to consider the asymmetric responses of the economy across different business cycle phases. Raymond and Rich (1997) applied a generalized Markov-switching model (MSM) to examine the effects of oil shocks on U.S. postwar business cycle fluctuations. Their results show that oil price changes significantly affect GDP growth during low-growth phases but do not notably influence the probability of transitions between different economic growth regimes. Hamilton (1996) proposed using the net oil price increase indicator, which compares current prices to their highest level over the previous year, to capture asymmetric effects of oil shocks. Hooker (1996), however, found that the significance of this asymmetry diminishes when extending the sample period, suggesting that structural shifts in the economy must be considered when evaluating the impact of oil prices on macroeconomic indicators.

While most studies, such as those mentioned above, focus on developed economies, it is essential to recognize that developing economies like Kazakhstan are far more vulnerable to oil shocks. Togonidze and Kočenda (2022) highlight that small economic size, high dependence on raw material extraction, and lack of export diversification make resource-exporting countries particularly sensitive to energy price fluctuations. Their study employs Markov-switching models (MSM) to account for nonlinear interactions between variables. Their findings reveal that the probability of entering a recessionary regime significantly increased in 2010 and during 2014–2016 for oil-exporting nations. Moreover, the impact of oil prices on GDP was statistically significant during economic downturns, reinforcing the role of oil prices as a key indicator of crisis periods. In contrast, GDP sensitivity to oil shocks weakened during stable periods, illustrating the varying macroeconomic responses depending on economic conditions.

When analyzing Kazakhstan's business cycles using the Markov-switching model (MSM), it is crucial to account for the role of fiscal and monetary policy, as government measures play a fundamental role in shaping macroeconomic stability. Given the country's high reliance on oil exports, these policies become particularly important in mitigating external shocks and sustaining domestic demand. Krugman and Obstfeld (2009) and Rodrik (2008) emphasize that a competitive exchange rate supports export growth and economic development. However, Dornbusch (1987) and Burstein et al. (2005) argue that currency depreciation can lead to inflation and a decline in real incomes, especially in economies with a high import share. Tanzi and Schuknecht (1997) and Herrera and Pang (2005) stress the importance of the structure and efficiency of public expenditures, particularly during economic crises. Lastly, Bernanke and Gertler (1995) demonstrate that in downturns, lowering the key interest rate can significantly support domestic demand and investment.

Data

Quarterly GDP and monthly inflation data for Kazakhstan were obtained from the Bureau of National Statistics of the Agency for Strategic Planning and Reforms of the Republic of Kazakhstan. Monthly data on government budget expenditures were sourced from the Ministry of Finance. The nominal exchange rate of the U.S. dollar to the Kazakhstani tenge and daily repo rates were retrieved from the Kazakhstan Stock Exchange. Monthly Brent oil prices were taken from the U.S. Energy Information Administration. Monthly inflation data for the United States, used to deflate oil prices and calculate the real exchange rate, were obtained from the Federal Reserve Economic Data (FRED) database.

Seasonal adjustment is a crucial step in time series analysis, particularly for economic indicators. The X12-ARIMA method was selected due to its reliability in handling economic time series. This method is well-documented in the literature and is widely used by statistical agencies worldwide. Seasonally adjusted monthly indicators were converted into quarterly data.

For the vector autoregression (VAR) models, the variables were transformed into log differences of Kazakhstan's GDP and deflated oil prices. For the Markov-switching model (MSM), the same variables were supplemented with log differences of the real exchange rate of the U.S. dollar to the tenge, government expenditures, and repo rates, as well as a dummy variable indicating the monetary policy regime. The dataset covers the period from Q2 2009 to Q2 2024, including 61 observations.

Methodology

To assess the impact of oil prices on macroeconomic activity, a combined approach was used, incorporating vector autoregression (VAR), threshold vector autoregression (TVAR) with impulse response functions, and Markov-switching models (MSM). This approach captures both linear and nonlinear relationships between oil prices and real GDP, as well as the asymmetric effects of oil price shocks under different economic conditions.

The endogenous variable vector is defined as $y_t = [GDP_t, Brent_t]$, whereas the VAR model can be written as follows:

$$y_t = c + \sum_{i=1}^{p} A_i y_{t-i} + \varepsilon_t,$$

in which c – vector of constants, A_i – coefficient matrices for each lag i, ε_t – the vector of stochastic errors. The optimal number of lags is determined using the Akaike Information Criterion (AIC), Schwarz Criterion (SC), and Hannan-Quinn Criterion (HQC).

To evaluate the impact of oil price increases and decreases on GDP, the vector y_t is modified as follows:

$$y_t = [GDP_t, Brent_t(+), Brent_t(-)]$$

$$Brent_t(+) = \begin{cases} Brent_t, if\ Brent_t > 0 \\ 0 \qquad\quad , if\ Brent_t \leq 0 \end{cases}$$

$$Brent_t(-) = \begin{cases} Brent_t, if\ Brent_t < 0 \\ 0 \qquad\quad , if\ Brent_t \geq 0 \end{cases}$$

Splitting the data into two separate time series simplifies the model structure while maintaining statistical stability, which is particularly useful given the limited number of observations.

To account for nonlinearity and asymmetry, the TVAR model extends the VAR framework by introducing a threshold mechanism. TVAR allows the dataset to be divided into two or more regimes, determined by a threshold variable, and evaluates the interactions between variables in each regime. The general form of the TVAR model is:

$$y_t = \begin{cases} c_1 + \sum_{i=1}^{p} A_{1,i} y_{t-i} + \varepsilon_t, & q_{t-d} \leq \gamma \\ c_2 + \sum_{i=1}^{p} A_{2,i} y_{t-i} + \varepsilon_t, & q_{t-d} > \gamma \end{cases}$$

in which c_1 and c_2 – vectors of constants for each regime, $A_{1,i}$ and $A_{2,i}$ – coefficient matrices for each regime and lag i, ε_t – the vector of stochastic errors, q_{t-d} – threshold variable with lag d, γ – threshold value. The optimal threshold variable is determined based on the minimization of the sum of squared errors.

The Markov-switching model (MSM) is a regime-dependent time series model that allows transitions between different states or regimes with certain probabilities. Within each regime, the model follows a weighted least squares (WLS) equation:

$$GDP = \beta_0 + \beta_1 Brent + \beta_2 FXR + \beta_3 Govs + \beta_4 Repo + \beta_5 Dummy + \epsilon,$$

Here β_i – regime-specific coefficients, and ϵ – the stochastic error term. Each regime model uses the entire data series by weighting observations according to the transition probabilities between regimes.

In a regime-switching model, transition probabilities between regimes are calculated using the maximum likelihood estimation (MLE), which selects the values of P_{ij} that maximize the probability of observing the data. MLE is used to find the parameters that make the model best fit the time series of data, taking into account transition probabilities and structural breaks.

$$P = \begin{pmatrix} P_{11} & P_{12} \\ P_{21} & P_{22} \end{pmatrix}$$

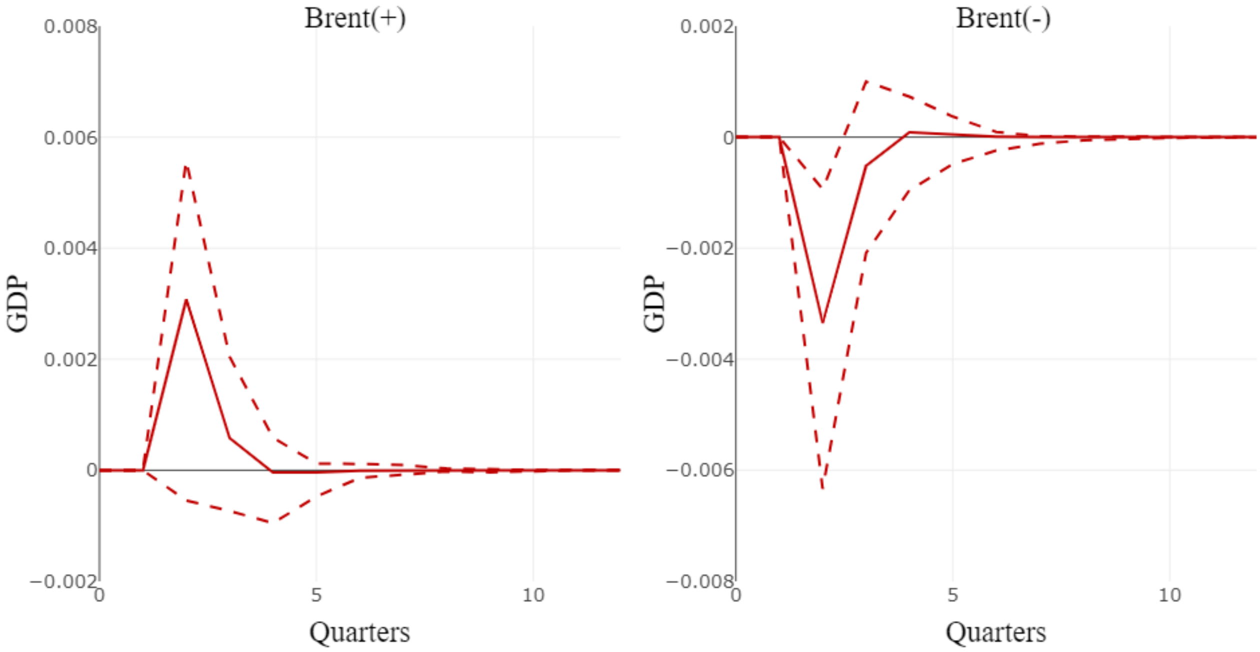
The average probabilities of transitions between regimes are described by a transition matrix P, where the element P_{ij} indicates the probability of transition from regime i to regime j, based on a specific model and time period. These probabilities are then used as weights in the weighted least squares (WLS) method, which allows for the contribution of each observation to be taken into account based on its probability of belonging to one or another regime. In this way, the model becomes sensitive to fluctuations in economic conditions, allowing for more flexible and accurate modeling of each regime.

Results and discussion

This section analyzes the impact of oil price shocks on Kazakhstan's GDP using three complementary approaches: VAR, TVAR, and MSM. These methods provide a comprehensive understanding of the economy's response to positive and negative oil price changes under different economic conditions.

The VAR model demonstrated an asymmetric response of Kazakhstan's GDP to oil price shocks. Negative shocks exert the most significant impact, with the maximum effect observed two quarters after the shock and a cumulative GDP decline of 0.37 percentage points (p.p.) one year later. In contrast, positive shocks are statistically insignificant, indicating that the economy remains relatively stable during growth periods. Impulse response functions (Figure 1) illustrate that Kazakhstan's GDP reacts only to negative oil price fluctuations, regardless of the economic regime.

Figure 1. Impulse Response of GDP to a One Standard Deviation Oil Price Shock

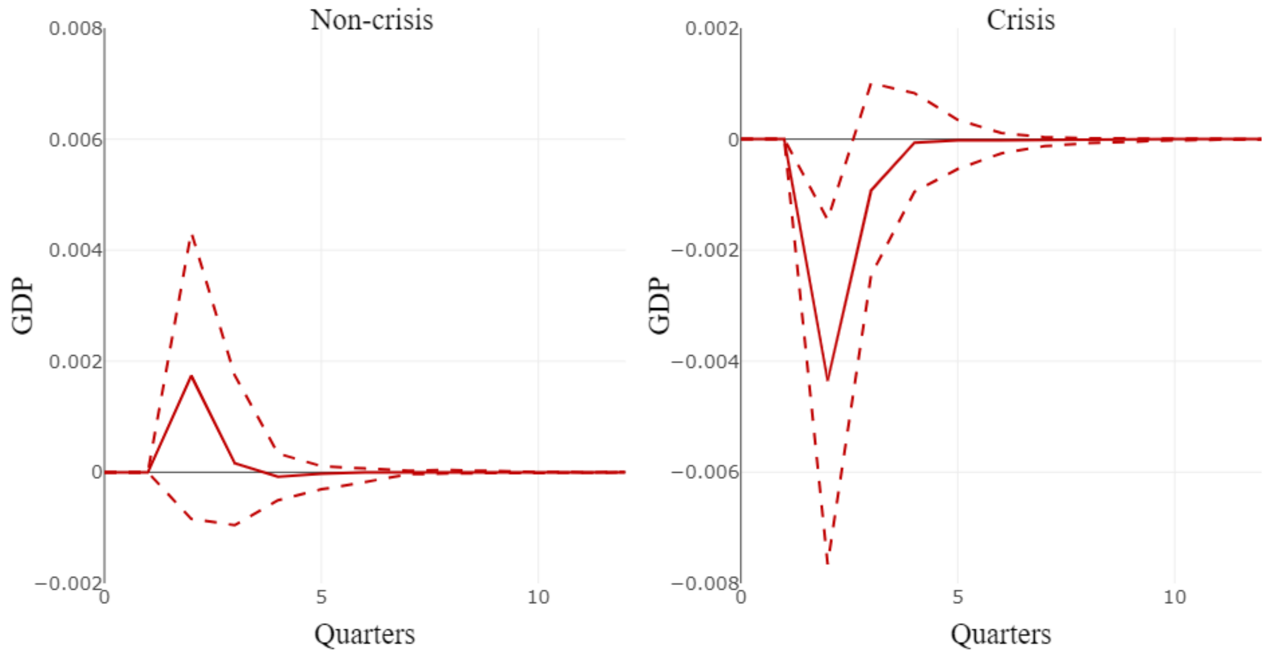


Source: Author's calculations

The TVAR model identified a threshold level of oil price changes that triggers Kazakhstan's economy to shift from stability to crisis. This threshold was estimated at -14%. Thus, a real oil price decline of 14% compared to the previous quarter marks the transition into a crisis regime. This threshold distinguishes stable periods from crises, demonstrating that oil prices have a minor impact on GDP in stable times but a significantly stronger effect during crises.

Based on this threshold condition, 13.3% of the observations in the sample period correspond to crisis periods, while 86.7% are stable periods. The cumulative effect of negative oil price shocks in crisis periods results in a 0.54 p.p. GDP decline over a year, confirming the economy's high sensitivity to sharp oil price drops during instability (Figure 2). Thus, the TVAR model complements the VAR findings by identifying the threshold at which oil price changes drive the economy from one regime to another.

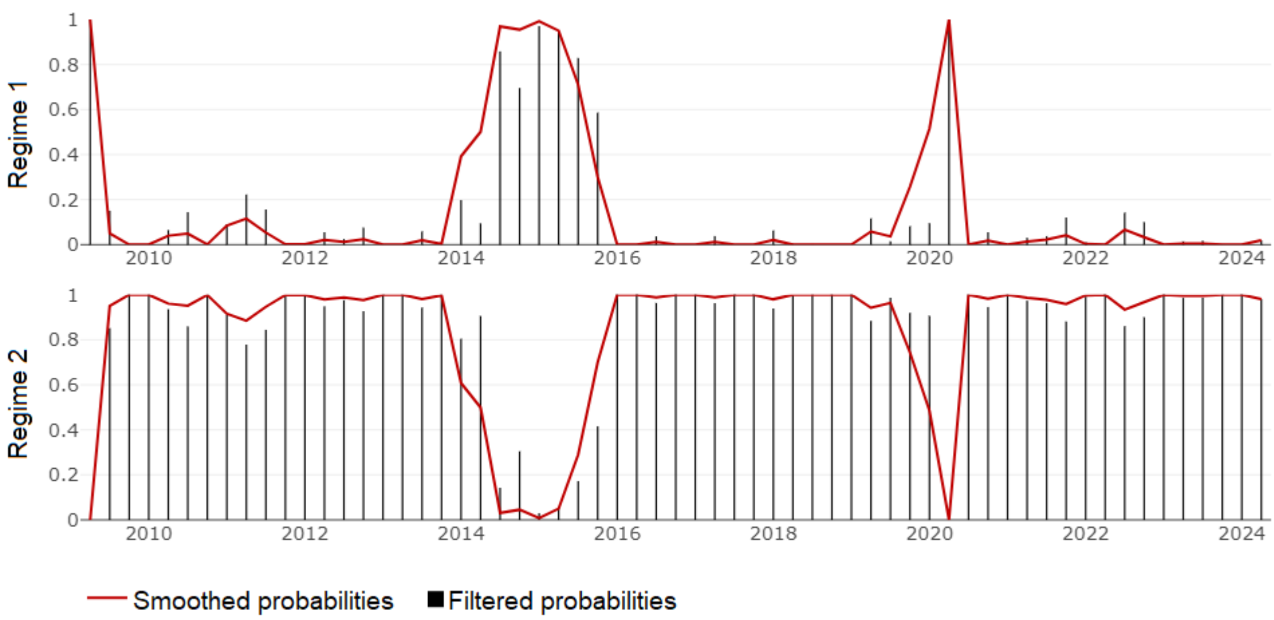
Figure 2. Impulse Response of GDP to a One Standard Deviation Oil Price Shock in Expansion and Contraction Cycles



Source: Author's calculations

The Markov-switching model (MSM) deepens the analysis by estimating the probabilities of transitions between growth and recession phases (Figure 3). The MSM results align with the TVAR findings, highlighting the role of negative oil price shocks in triggering crisis periods.

Figure 3. Transition Probabilities Between Regimes Over Time*



** The filtered probability is calculated based on past and current values of the variable, while the smoothed probability uses the entire available time series.*
Regime 1 – Recession/Crisis, Regime 2 – Stability

Based on the GDP state, for each time interval a probability estimate of the transition to another state is calculated. The transition probability matrix is defined as follows:

Table 1. Transition Probability Matrix

	Regime 1 (crisis)	Regime 2 (stability)
Regime 1 (crisis)	0,7178	0,0703
Regime 2 (stability)	0,2822	0,9297

According to the obtained results, the probability of remaining in a crisis once it starts is nearly 72% for the next quarter. However, the model also detects a 28% probability of exiting the crisis in the following quarter. Similarly, the probabilities of continuing economic growth and transitioning into a crisis stand at 93% and 7%, respectively, indicating the stability of growth periods and the low likelihood of sudden transitions into recessions (Table 1).

From the analyzed period, the average duration of expansion phases was 14.22 quarters, while recessions lasted an average of 3.54 quarters. The key finding is that the average oil price change during crisis periods was -13.95%, which is very close to the TVAR model's estimated threshold of -14%.

Bringing the results together, it can be concluded that negative oil price shocks have the most pronounced effect on Kazakhstan's GDP. These effects intensify as the economy shifts between different regimes, as confirmed by the TVAR and MSM analyses. Although positive shocks have some influence according to MSM coefficient estimates (Appendix), they remain less significant in overall macroeconomic dynamics. The use of three approaches – VAR, TVAR, and MSM – provides a holistic view of Kazakhstan's economic response to external shocks, particularly global oil price fluctuations, capturing both linear and nonlinear mechanisms.

Conclusion

The study confirms the significant influence of oil prices on Kazakhstan's macroeconomic dynamics. The use of VAR, TVAR, and MSM models allowed for the identification of linear and nonlinear dependencies, as well as the asymmetry in economic reactions to positive and negative oil shocks under different economic conditions.

Negative oil price shocks have the most substantial impact on Kazakhstan's GDP, particularly during crisis periods. According to impulse response analysis, the maximum effect occurs two quarters after the shock, with a cumulative GDP decline of 0.37 p.p. over one year. In contrast, positive shocks are not statistically significant, highlighting the asymmetric economic response. These findings align with previous theoretical studies (Hamilton, 1996; Raymond & Rich, 1997), confirming the central role of oil shocks as drivers of economic fluctuations in resource-dependent economies.

The TVAR model clarified the nature of macroeconomic dynamics by identifying a -14% oil price decline threshold as the trigger for Kazakhstan’s transition into a crisis phase. When oil prices fall by 14% compared to the previous quarter, the economy shifts into recession. During crisis periods, a one standard deviation oil shock leads to a 0.54 p.p. GDP contraction over a year, whereas in stable periods, oil prices have minimal influence on GDP. This emphasizes the importance of considering threshold effects in business cycle analysis and confirms that Kazakhstan’s economy is more vulnerable to external shocks during instability.

The MSM model complemented the analysis by estimating the average duration of economic phases: expansion periods lasted 14.22 quarters, crisis periods lasted 3.54 quarters. The MSM results confirm that negative oil shocks play a key role in initiating crisis phases, whereas exiting recessions requires a more complex combination of internal and external factors. These findings are consistent with Togonidze & Kočenda (2022), highlighting the exogenous nature of downturns driven by commodity price fluctuations. Furthermore, the average oil price decline in crisis periods (-13.95%) closely matches the TVAR model’s estimated threshold (-14%).

This study contributes to the academic discussion on the resilience of resource-dependent economies, emphasizing the need for comprehensive approaches to analyzing macroeconomic stability in the face of external shocks.

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Appendix

The estimated Markov process, based on maximum likelihood estimation (MLE), is independent of regime model coefficients and their quality. Before interpreting the coefficients, the weighted least squares (WLS) model was tested for heteroskedasticity, autocorrelation, and residual normality. In Regime 1, the residuals vs. fitted values plot indicates heteroskedasticity (Figure 2A), while the autocorrelation function (ACF) suggests autocorrelation in the first, fifth, and sixth lags (Figure 3A). In Regime 2, no significant autocorrelation or heteroskedasticity was detected. However, the residual plot shows several outliers, corresponding to extreme GDP movements during periods of high uncertainty. Both regimes exhibit substantial deviations from normality, with excess kurtosis and residual clustering at the distribution tails (Figure 4A).

The regime-switching model effectively captures major and significant recession episodes. However, the residual analysis reveals heterogeneity and instability in error variance, indicating that crisis episodes vary considerably. To ensure reliable coefficient interpretation, a robust linear model was used, accounting for the non-normal residual distribution. Additionally, Newey-West standard errors, which are consistent in the presence of heteroskedasticity and autocorrelation, were applied (Table 1A).

Table 1A. Markov-Switching Model Coefficients

	Regime 1 (crisis)		Regime 2 (stability)	
Intercept	0.0174 (0.03777)	*	0.0101 (< 2.2e-16)	***
Brent	0.0836 (< 2.2e-16)	***	0.0106 (0.10900)	
FXR	-0.099 (0.08111)	.	-0.038 (0.00447)	**
Govs	-0.355 (3.236e-11)	***	0.0056 (0.07184)	.
Repo	-0.006 (0.00031)	***	-0.002 (0.32705)	
Dummy	0.0071 (0.17214)		0.0045 (0.00149)	**

Note: p-value in parentheses,
‘*’ p<0.001, ‘**’ p<0.01, ‘*’ p<0.05, ‘.’ p<0.1;**
FXR – inverse quotation (price per $1)

Intercept

The positive and statistically significant intercept suggests a baseline economic growth trend when isolating the effects of model variables. While consumption, investment, and net exports were not explicitly included in the model, their contribution to GDP growth is likely reflected in the positive constant term.

Brent Oil Prices

Higher Brent oil prices positively impact economic growth in both recessionary and stable periods, but to varying degrees, supporting the asymmetry hypothesis. Given that oil exports dominate Kazakhstan's trade structure, oil price fluctuations are critical for sustaining GDP growth, especially when other sectors face challenges. Crisis periods in Kazakhstan have historically coincided with oil price declines, reflecting the exogenous nature of economic downturns. During stable periods, the economy becomes less dependent on oil prices, as indicated by the reduced magnitude and borderline significance ($p > 0.1$) of the coefficient. Thus, oil price volatility has a weaker effect on growth when oil prices are high and the economy is stable compared to recessionary periods.

Real Exchange Rate

The analysis shows that economic growth in both crisis and stable periods is accompanied by a stronger real exchange rate. A stronger tenge reduces export competitiveness but enhances domestic consumption and capital investment by lowering the cost of imported consumer, intermediate, and capital goods, thus stimulating internal demand.

Government Expenditures

The impact of government spending on business activity depends on economic conditions. During recessions, fiscal stimulus is necessary for economic stabilization, involving short-term social spending, subsidies, and industrial support. However, such measures do not yield immediate positive GDP growth effects. During stable periods, government spending boosts economic growth through long-term infrastructure investments.

Monetary Policy Rate

Monetary easing during recessions promotes economic recovery. Lowering interest rates improves access to credit, driving both consumer spending and business investment. Households tend to increase purchases of durable goods (e.g., cars and housing), whereas businesses benefit from lower financing costs for operations and expansion. These factors foster economic recovery and support domestic demand. However, the lack of statistical significance during stable periods suggests that interest rate changes have a weaker influence on investment decisions in growth phases, likely due to higher consumer confidence and strong demand. The transmission mechanism of monetary policy may be weak, affected by fiscal dominance and interest rate subsidies. Fiscal dominance occurs when fiscal policy has a stronger impact than monetary policy, reducing the effectiveness of interest rate changes. Subsidized interest rates mitigate the impact of monetary policy actions, reducing their influence on borrowing costs and economic behavior. The insignificance of repo rates during stable periods suggests that other dominant growth drivers are at play during non-recessionary phases.

Monetary Policy Regime

The dummy variable captures the transition to inflation targeting and reflects structural shifts in some variables. The positive and statistically significant coefficient highlights the growth-enhancing effect of a fixed exchange rate regime, particularly in non-crisis periods. A fixed exchange rate system reduces currency volatility, providing stability for businesses and consumers and fostering higher investment and trade activity, leading to a more stable macroeconomic environment. However, this system has certain limitations, including limited monetary policy flexibility, depletion of foreign exchange reserves, exposure to trade imbalances, and capital flow volatility. Despite its positive impact on economic growth, the results do not imply that other monetary regimes are ineffective. Instead, they emphasize the stability benefits of exchange rate management during non-crisis periods.

Figure 1A. Juxtaposition of Variables

Figure 2A. Model Residuals vs. Fitted Values

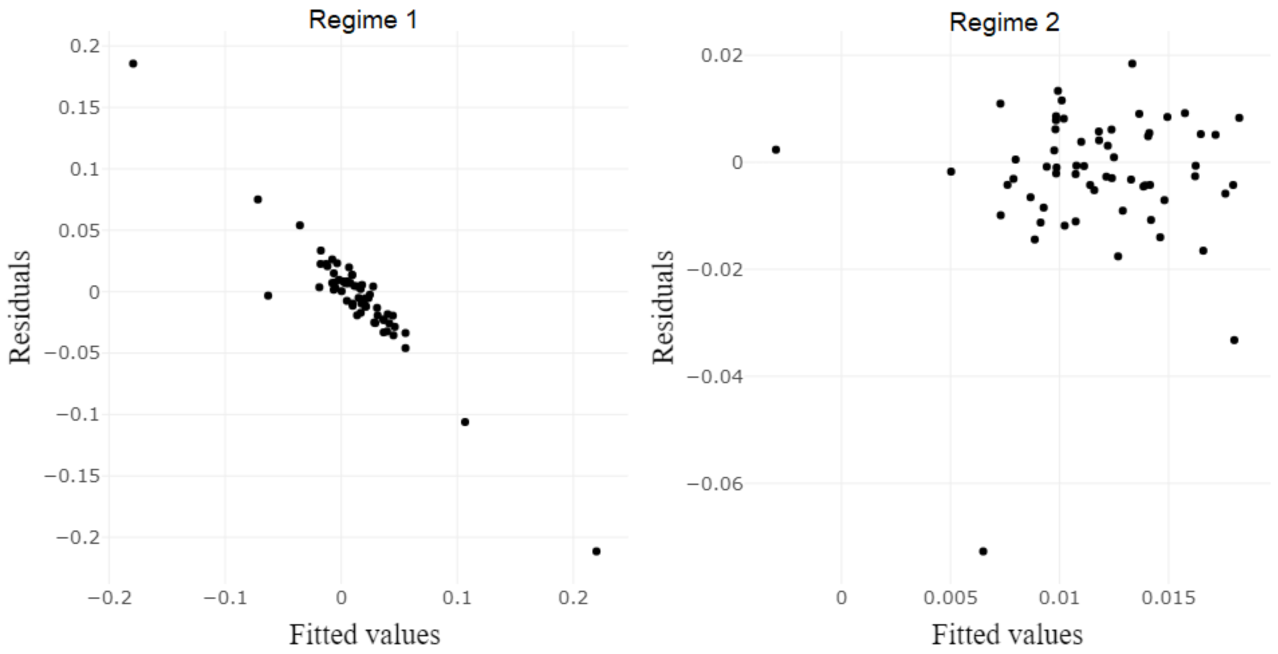

Figure 3A. Autocorrelation functions

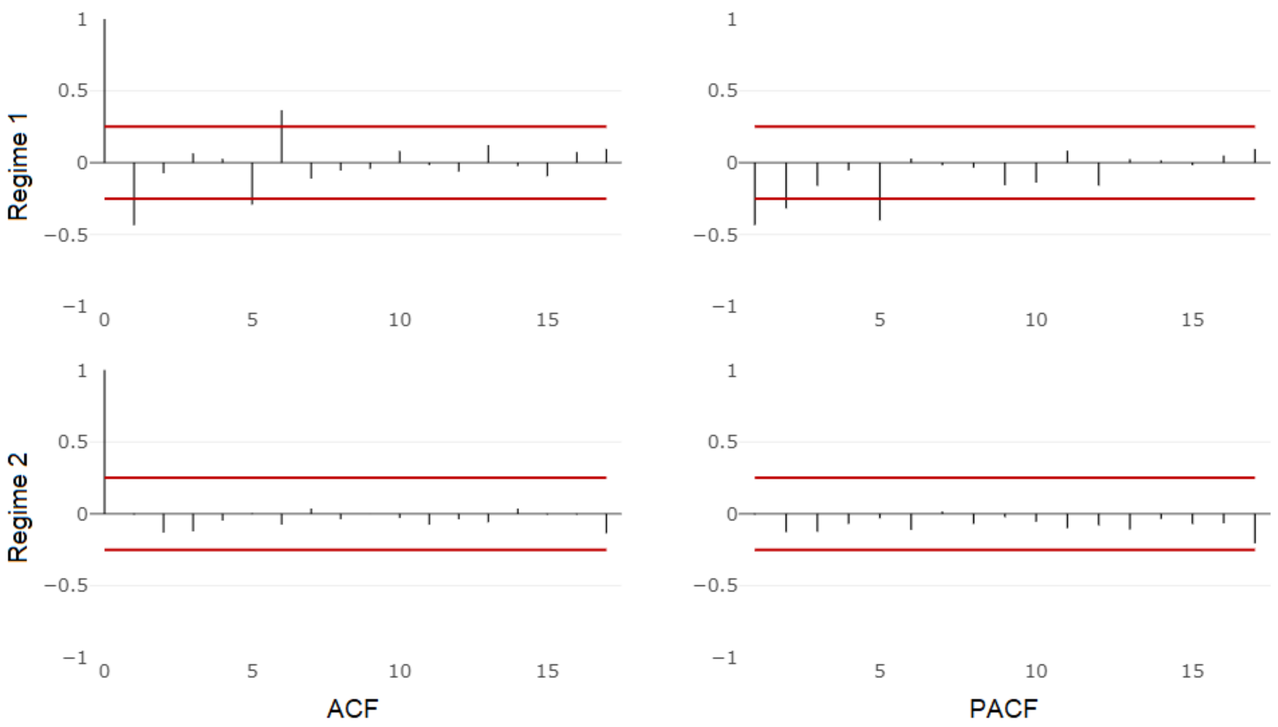

Figure 4A. Q-Q Plot