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Effects of Oil Shocks on the Trade Balance of Azerbaijan: Evidence from the TVP-VAR Model

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ABSTRACT

This study examines the effect of oil shocks on Azerbaijan's trade balance using a Time-Varying Parameter Vector Autoregression (TVP-VAR) model, drawing on monthly data from December 1994 to November 2024. The results indicate that the negative effects of oil production shocks on Azerbaijan's trade balance exhibit considerable variation over time and that these adverse impacts become statistically significant in the post-COVID-19 period, indicating a heightened sensitivity of the trade balance to oil production fluctuations in the wake of the pandemic. Although the time-varying responses to oil price shocks are generally positive, they lose statistical significance during periods of sharp decline, suggesting a weakening of the transmission mechanism under extreme market conditions. The impact of exchange rate misalignment on the trade balance fluctuates, showing positive responses following major devaluation or policy changes. This study underscores the necessity of reducing dependence on oil exports and diversifying public revenues to lessen reliance on oil. These results provide important information for controlling external balances in nations that rely heavily on natural resources.

Keywords: Oil Production, Oil Price, Trade Balance, Azerbaijan, TVP-VAR
JEL Classifications: C32, C51, F14, F32, Q43

1. INTRODUCTION

Azerbaijan's economy relies heavily on oil and is vulnerable to external fluctuations in global oil markets. The relationship between oil shocks and trade balance is of particular interest in oil-exporting countries, such as Azerbaijan. Hydrocarbons account for over 90% of Azerbaijan's total exports, underscoring the country's structural dependence on energy-related income sources (World Bank 2022). Consequently, external shocks to oil prices and production levels have vital implications for the trade and macroeconomic stability of the country.

This paper examines the impacts of oil shocks on the trade balance of Azerbaijan in a time-varying context. The analysis of the impact of oil shocks on the trade balance is crucial for Azerbaijan for two reasons. First, the global oil market has witnessed significant structural changes in recent decades, including the 2008 financial crisis, 2014 oil price collapse, and unprecedented disruptions caused by the COVID-19 pandemic in 2020. These events might lead to significant structural breaks, leading to serious parameter instabilities that might not be accurately analyzed with constant parameter specifications. Second, Azerbaijan has experienced major political and economic transitions, such as changes in the exchange rate regime, such as the devaluation of Manat in 2015 and macroeconomic reforms aimed at reducing oil dependency, which have likely altered the transmission mechanisms of external shocks over time.

This research aims to contribute to the existing literature on oil-exporting economies by providing a detailed analysis of the relationship between oil shocks and trade balance in Azerbaijan. Our study is novel in two respects: First, in the course of our overview of literature, we observed that several studies are conducted on Azerbaijan to analyze the effects of oil price shocks on macroeconomic variables, such as inflation exchange rates and economic activity (Humbatova et al., 2019; Mukhtarov et al., 2019; Majidli and Guliyev, 2020). However, only one study, i.e. Yildirim and Arifli (2021) explicitly considered the impact of oil price fluctuations on trade balance using a linear VAR model. This study fills this gap by utilizing a TVP-VAR model because of its ability to capture time-varying relationships among the variables. Second, the impact of global oil production on the trade balance of Azerbaijan is analyzed for the 1st time.

The layout of the paper is organized as follows: An overview of the literature on studies investigating the influence of oil shocks on the trade balances of countries is presented in Section 2. The data used in the analysis are described in Section 3. Section 4 introduces the TVP-VAR model. Empirical findings are discussed in Section 5. Based on the results of this study, policy implications and recommendations are presented in section 6.

2. LITERATURE REVIEW

This section provides a comprehensive overview of the literature on the impact of oil shocks on trade balances, structured across three main groups of countries: oil-exporting economies, oil-importing economies, and comparative cross-country studies.

Numerous studies have examined the macroeconomic consequences of oil price shocks on oil-exporting economies, emphasizing the sensitivity of trade balances to global oil market dynamics. One of the foundational contributions is by Kilian et al. (2009) showed that oil-exporting nations typically experience improvements in trade balances following positive oil price shocks. Chuku et al. (2011) find that Nigeria's current account is affected by oil price shocks. The similar result is obtained by Helmi et al. (2023) for Saudi Arabia; Elfaki and Elsharif (2025) for Saudi Arabia. Utilizing VAR model, data from 2006 to 2018, Yildirim and Arifli (2021) provide evidence that a decline in oil prices lead to a decrease in trade balance in Azerbaijan.

In a study focused on Russia and China, Balli et al. (2021) utilize a TVP-VAR model covering quarterly data from 1993:Q1 to 2018:Q3 and found that the impact of oil shocks affects positively the trade balance of Russia but negatively affects China. Nasir et al. (2018) investigated the shocks of oil price on the BRICS economies using TVP-VAR covering the period from 1987:Q2 to 2017:Q2. The results show that responses to the oil price shocks differ across the members of BRICS countries. Furthermore, utilizing SVAR model, Nasir et al. (2019) found that GCC countries are affected by oil price shock during the period of 1980-2016. Mohaddes and Pesaran (2016) utilized a global VAR framework (GVAR) from 1979:Q2 to 2013:Q1 for 27 countries to explore the nexus between oil supply shocks and macroeconomic outcomes. The findings show that the magnitude and duration of trade balance responses differ to the extent of dependence on oil revenues. For oil-importing countries, Le and Chang (2013) analyzed the effects of oil price fluctuations on trade imbalances for Singapore, Malaysia and Japan economies using monthly data from 1999:M1 to 2011:M11. The findings reveal that higher oil prices deteriorate the trade balance of Japan. Similar results are obtained by Arouri et al. (2014) for India; Nasir et al. (2018) for India; Kaushik and Shastri (2024) for India for the period of 1985-2019; Alom et al. (2013) for Korea and Taiwan; Yalta and Yalta (2017) for Turkey; Ozlale and Pekkurnaz (2010) for Turkey; Ahad and Anwer (2020) for Pakistan; Abu Eleyan et al. (2022) for Thailand; Pan et al. (2022) for China. For South Korea, Baek (2022) asserts that the effects of oil price shocks on trade balance varies with the reasons for oil prices fluctuations. Comparative studies across countries reveal heterogeneity in the impact of oil shocks. Yildirim and Guloglu (2024) examines the impact of oil price shocks on BRIC countries considering financial conditions, utilizing SVAR model found that negative oil price shocks deteriorate the trade balance of oil-exporter countries, specifically Russia This finding in line with the results of Lebrand et al. (2024) for 45 countries employing SVAR methodology; Nashi and Ouakil (2025) for 47 countries considering the period between 1995 and 2023; Arif et al. (2023) for China, Pakistan, and India between 2006:Q1 and 2020:Q4 employing PMG-ARDL; Yessymkhanova et al. (2025) for Argentina, Indonesia, India, Mexico and Turkey for the period of 1980-2023; Forson et al. (2022) for sub-Sahara African countries.

3. DATA

To investigate the effect of oil price shocks on Azerbaijan's trade balance, this study uses a four-variable VAR model following Gnimassoun et al. (2017), Ozlale and Pekkurnaz (2010) and Kilian (2009). For this purpose, a monthly dataset covering the period from December 1994 and November 2024 is collected based on the availability of the trade balance data of Azerbaijan. All data are retrieved from Refinitv Eikon database (Eikon Datastream, 2025). The vector of endogenous variables employed in the estimates can be specified as follows:

$$y_t' = \left[goilpro_t \; poil_t \; miser_t \; xm_t \right] \qquad (1)$$

where $goilpro_t$ is global oil production in thousands of barrels per day and$poil_t$ denotes global price of oil proxied by spot price of Brent crude in US dollar per barrel. $miser_t$ is the misalignment of the nominal exchange rate, i.e. Azerbaijan Manat per US dollar, calculated following Balli et al. (2021), Ozlale and Pekkurnaz (2010), and Gnimassoun (2017) as the deviation in the exchange rate from its long-run trend, derived by applying the Hodrick and Prescott (1997) filter. Finally, xm_t signifies trade balance of Azerbaijan, computed as exports of goods and services divided by imports of goods and services in US dollars. Before the analysis, natural log transformation is applied to $goilpro_t$ and $poil_t$. The remaining variables are used in their levels as $miser_t$ has negative values and xm_t is already defined in terms of ratio of two variables.

Table 1 presents the descriptive statistics for the variables. The variables employed in the analysis are also plotted in in Figure 1.

Next, unit root tests are utilized to avoid spurious relationships as well as to determine the order of integration of the variables as a first step before proceeding with the estimation. The unit root test results, presented in Table 2, reveals critical insights into the stationarity properties of the variables under investigation. Augmented Dickey and Fuller (1981) (ADF) and Phillips and Perron (1988) (PP) show that global oil production (goilpro) and the trade balance (xm) exhibit stationarity at the 5% and 1% significance levels, respectively. However, the oil price series (poil) demonstrates non-stationarity at levels, but achieves stationarity after first differencing, consistent with its classification as I(1). The exchange rate misalignment (miser) series displays strong stationarity at levels across both test specifications.

The ADF structural breakpoint unit root test unveils significant regime shifts across all variables, with breaking dates clustered around major economic events: oil price volatility episodes (2014-2015), fundamental changes in global energy markets due to the outbreak of COVID-19. These structural breaks verify the presence of parameter instability that conventional linear models would fail to capture. It is worth mentioning that the significant breakpoint detected in 2020 for global oil production is associated with the extraordinary oil demand shock during the COVID-19 pandemic and subsequent OPEC+ production adjustments.

The coexistence of level stationarity in some variables and difference stationarity in others, coupled with multiple structural breaks, necessitates a modeling approach that accommodates both integrated processes and time-varying dynamics. This empirical evidence strongly justifies the adoption of the TVP-VAR framework, as it inherently accounts for the evolving data-generating process through its nonparametric estimation of coefficient matrices. The methodological choice aligns with recent applications in energy economics literature that emphasize the importance of capturing structural instabilities in oil-market relationships (Balli et al., 2021; Primiceri, 2005).

4. TVP-VAR METHODOLOGY

The paper utilizes the TVP-VAR methodology developed by Primiceri (2005) to examine the impacts of oil shocks on Azerbaijan's trade balance. Unlike the linear VAR model, the TVP-VAR model is specifically designed to capture the evolving dynamics among variables in response to changing economic conditions. Consequently, the model can be represented as follows (Casas and Fernandez-Casal, 2019: 17):

$$Y_t = A_{0,t} + A_{1,t}Y_{t-1} + \ldots + A_{p,t}Y_{t-p} + U_t,\ t = 1,2\ldots,T, \tag{2}$$

In this context, Y_t denotes the vector of endogenous variables as previously defined, while $A_{i,t}$ (where i = 0, 1..., p) signifies matrices of coefficients that change over time, and U_t is the innovation vector characterized by a covariance matrix Σ_t that also varies with time. Unlike the TVP-VAR model, which relies on Bayesian methods, the coefficients in $A_{i,t}$ are expressed as a smooth function of time ($\tau = t/T$) (Robinson, 1989). The process of estimating these coefficients employs nonparametric kernel regression, with parameters being locally estimated at each time point. This involves performing weighted regressions, where the weights are assigned using a kernel Epanechnikov function and a bandwidth parameter. The bandwidth parameter, which is crucial for adjusting the smoothness of the time-varying parameters, is selected through cross-validation to achieve a balance between bias and variance (Li and Racine, 2007).

The application of nonparametric polynomial kernel regression in estimation presents notable advantages. Firstly, this estimator facilitates entirely data-driven estimates, unlike Bayesian methodologies such as those proposed by Primiceri (2005) and Cogley and Sargent (2005), which require the specification of prior distributions for the coefficients. Additionally, in contrast to the Bayesian approach, which typically assumes that time-varying parameters are a random walk process, this technique does not impose any priori assumption regarding the coefficients' law of motion, thereby allowing it to adapt flexibly to complex or unknown data-generating processes (Fan, 2018; Robinson, 1989). Finally, as a form of local linear estimator that focuses on a small subset of data at each point in time, it is capable of capturing abrupt changes in the relationships among variables, thereby providing a more efficient analysis of structural changes, including economic crises or policy interventions (Chen et al., 2017).

To derive time-varying impulse responses, the TVP-VAR model outlined in Equation (2) can be converted into a Wold representation as demonstrated by Casas and Fernandez-Casal (2019: 18):

$$Y_t = \sum_{j=0}^{\infty} \Phi_{j,t} U_{t-j} \tag{3}$$

Such that $|Y_t - Y_t| \to 0$. Matrix $\theta_{0,t} = I_N$ and matrix $\Phi_{h,t} = \sum_{j=0}^{h} \Phi_{h-j} A_{j,t}$ for horizons h=1,2,…h. as for the constant model $\theta_{h,t}$ represent the time-varying coefficient matrices of the impulse response functions. It can be interpreted as the expected response of $Y_{i,t+s}$ to and exogenous shock of $Y_{j,t}$ ceteris paribus lags of Y_t when the innovations are orthogonal.

The orthogonal time-varying responses can be derived from the Cholesky decomposition of the time-varying variance-covariance matrix Σ_t. This decomposition leads to a lower triangular matrix P_t

Table 1: Summary statistics

Statistics	goilpro	poil	miser	xm
Mean	11.208	58.457	0.000	16.984
Median	11.209	57.740	0.000	14.808
Maximum	11.346	138.400	0.233	72.542
Minimum	11.027	9.910	−0.210	3.027
Std. Dev.	0.083	32.290	0.044	10.972
Skewness	−0.285	0.311	0.076	1.840
Kurtosis	2.040	2.007	12.438	7.039
Jarque-Bera	18.727	20.607	1336.526	447.730
Probability	0.000	0.000	0.000	0.000
Sum	4034.935	21044.380	0.000	6114.186
Sum Sq. Dev.	2.490	374298.501	0.685	43220.452
Observations	360	360	360	360

Figure 1: Data

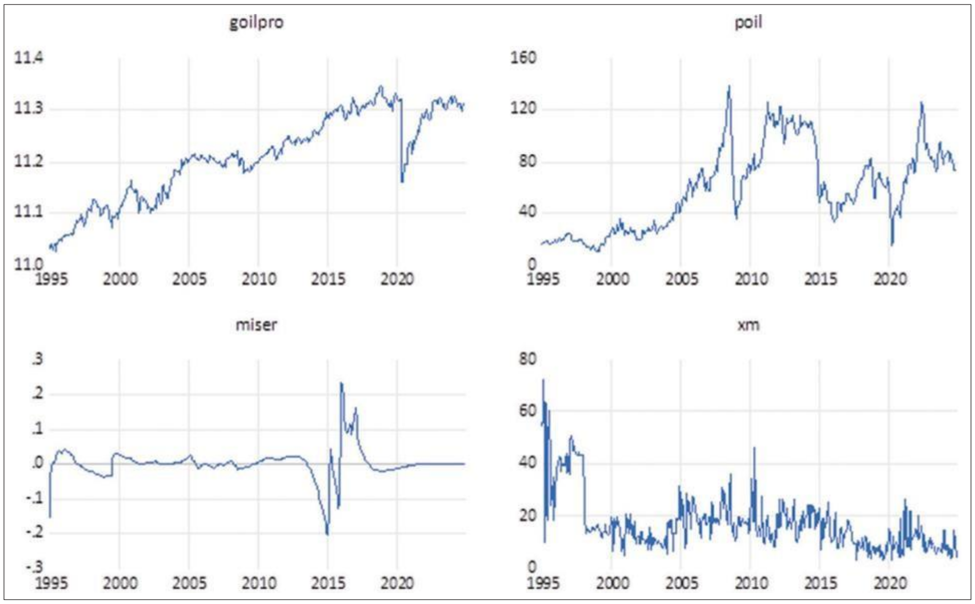


Table 2: Unit root test results

Test type	Transformation	goilpro	poil	miser	xm
Phillips and Perron	Level	−3.6041**	−2.5228	−5.9946***	−13.1123***
	First difference	-	−18.2197	-	-
ADF	Level	−3.6019**	−2.6326	−5.7322***	−5.5533***
	First difference	-	−17.8811	-	-
			yüzde10		
ADF with breakpoint test	Level	−6.908542***	−4.967459*	−7.031412***	−11.17164***
	Breaking Date	2020M04	2014M08	2015M11	1995M07
	First difference	-	−19.00372	-	-
	Breaking Date		2020M05		

(*)Significant at the 10%; (**)Significant at the 5%; (***) Significant at the 1%. Breaking dates of the series

such that $\Sigma_t = P_t P_t^{T}$. Finally using the orthogonalized innovations, the time-varying impulse response functions at horizon h are computed as follows:

$$\Psi_{h,t} = \theta_{h,t} P_t \tag{4}$$

The time-varying responses measure how endogenous variables react to a one-unit disturbance in the orthogonalized innovations, thereby enabling the identification of interactions among the variables within a time-varying context.[1]

5. EMPIRICAL FINDINGS

The TVP-VAR model has been utilized to analyze the time-varying responses of the Azerbaijani trade balance to oil shocks in this section. Nevertheless, linear responses to oil shocks are examined prior to the TVP-VAR analysis. The trade balance has deteriorated as a result of positive global oil production shocks, as evidenced by the results in Figure 2. This is consistent with the hypothesis that a rise in the global oil supply results in a decrease in oil prices, which in turn reduces revenues from oil exports, as a net oil exporter. In contrast, it has been noted that Azerbaijan's trade balance improves in response to positive oil price shocks. Finally, it is concluded that the trade balance is significantly and positively affected by exchange rate shocks in linear specification.

The linear VAR's stability is examined through VAR breakpoint analysis following the linear impulse response analysis. The results depicted in Figure 3 suggest the existence of statistically significant breakpoints that coincide with significant global events, including the 2014-2015 oil price collapse and the 2020 COVID-19 shock. This supports the use of a time-varying approach. This confirmation of structural breaks underscores the limitations of conventional linear models and underscores the importance of employing adaptive frameworks such as the TVP-VAR for precise analysis in dynamic economic environments. It also indicates that significant external events and potential domestic policy shifts have fundamentally altered the transmission mechanisms that influence Azerbaijan's trade performance.

Following the confirmation of significant parameter instabilities, time-varying responses are calculated using the estimation generated from the TVP-VAR model. The findings are illustrated in Figures 4-6. Panel (a) of the figures presents surface plots illustrating the cumulative responses, while panel (b) displays the cumulative

1 tvReg package of R developed by Casas and Fernandez-Casal (2019) is used in the TVP-VAR estimation.

Figure 2: Linear VAR responses of xm

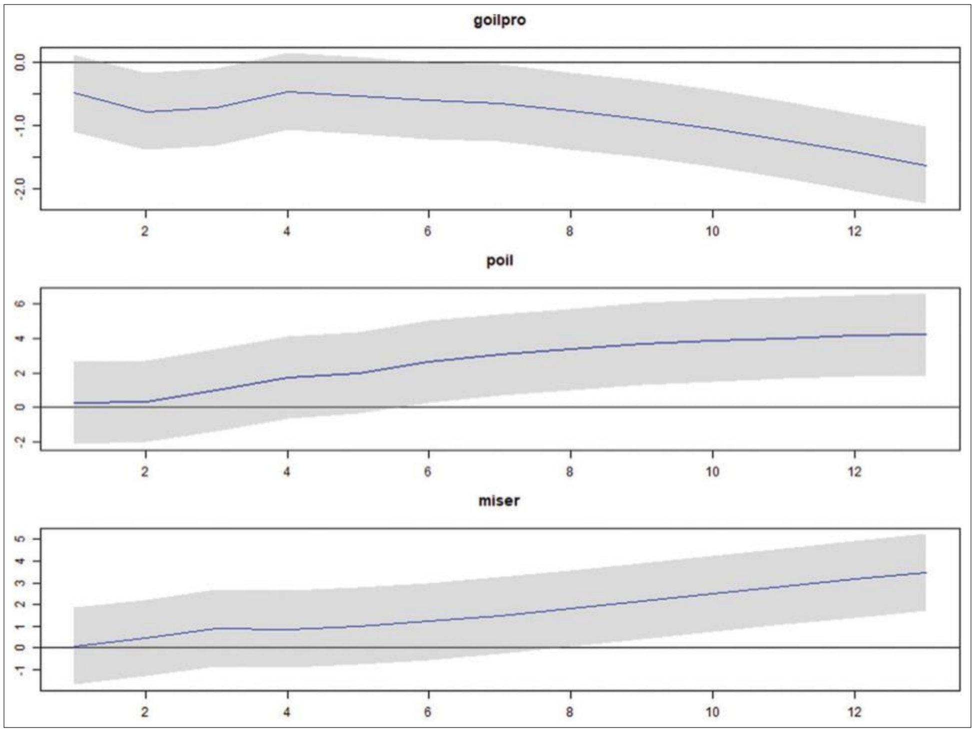
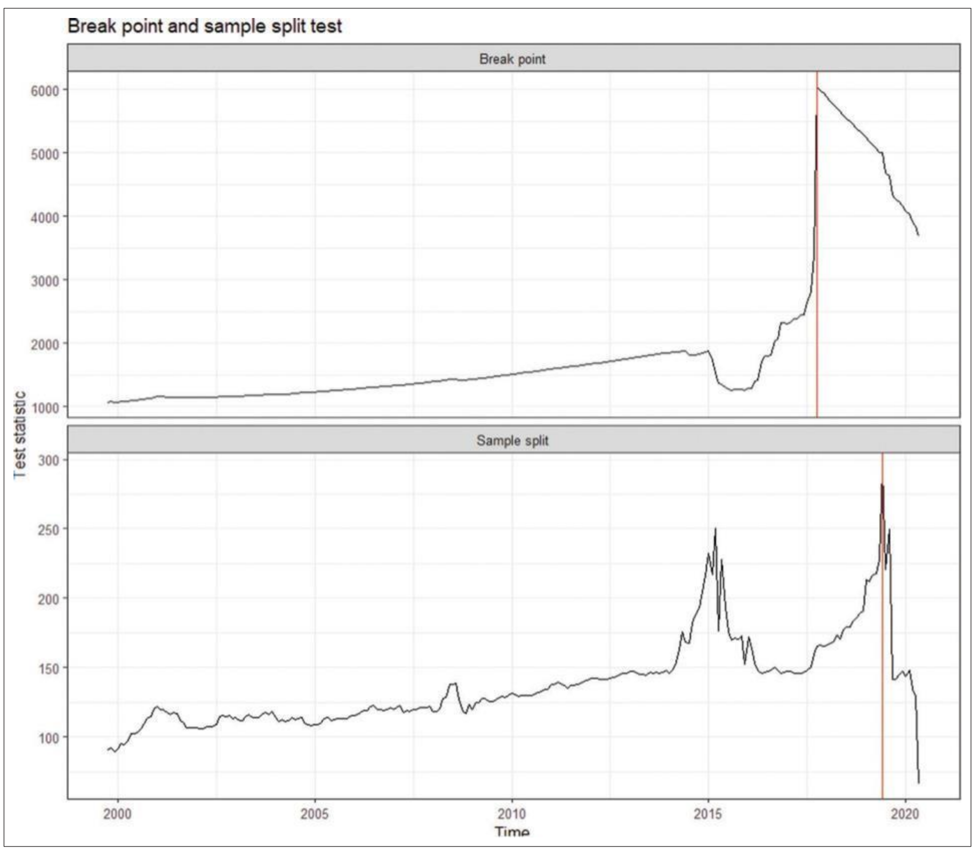


Figure 3: VAR breakpoint analysis



responses at the h=12th month horizon, accompanied by 90% confidence bands to assess the significance of the responses overtime.

Figure 4 illustrates the dynamic responses of the trade balance with respect to oil supply shocks over time. The analysis reveals that an increase in oil supply correlates with a decline in the trade balance throughout most of the period examined. However, the confidence bands indicate that the negative impact of oil production shocks attains statistical significance mainly during the period following the onset of the COVID-19 pandemic. This suggests that the

Figure 4: TVP-VAR responses of xm to shocks in goilpro. (a) Surface plot of the responses. (b) Cumulative responses at h = 12

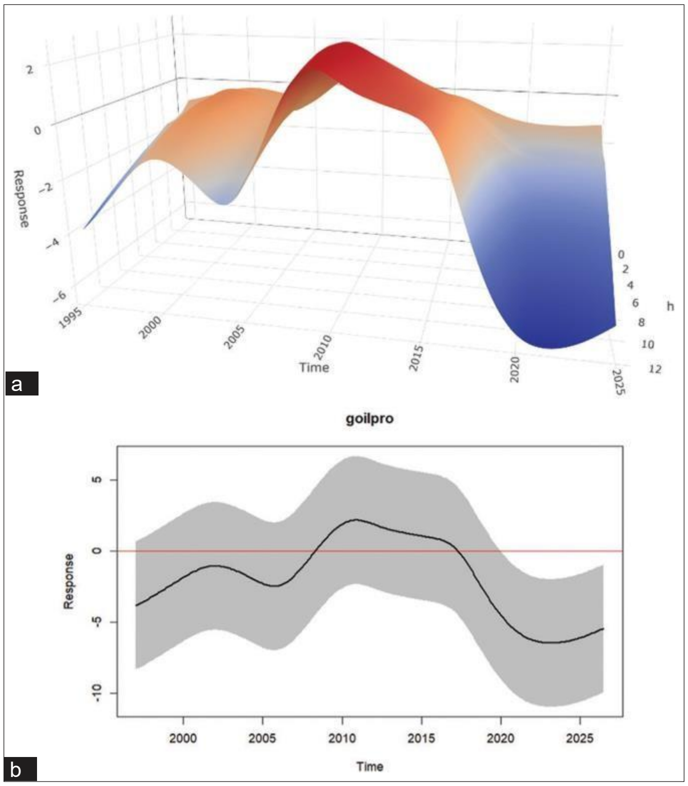
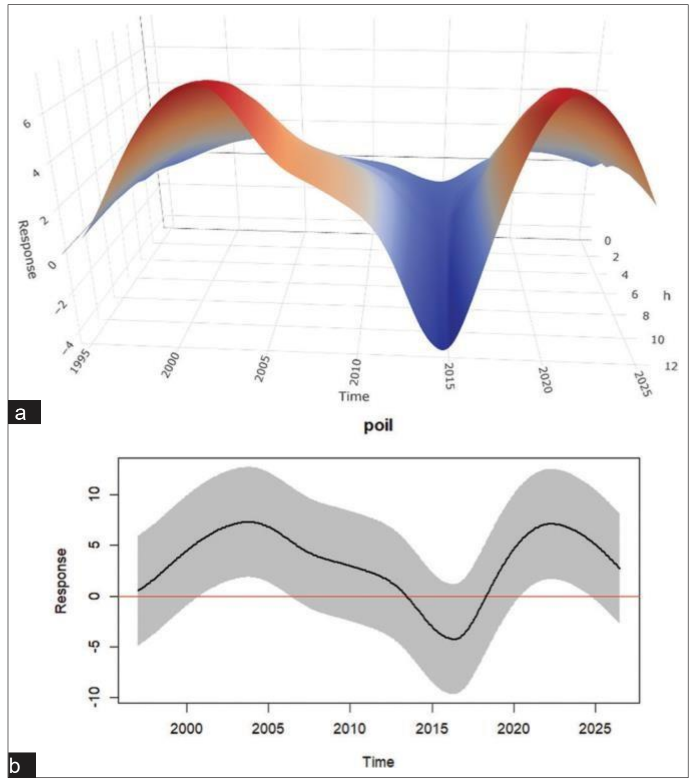


Figure 5: TVP-VAR responses of xm to shocks in poil. (a) Surface plot of the responses. (b) Cumulative responses at h = 12

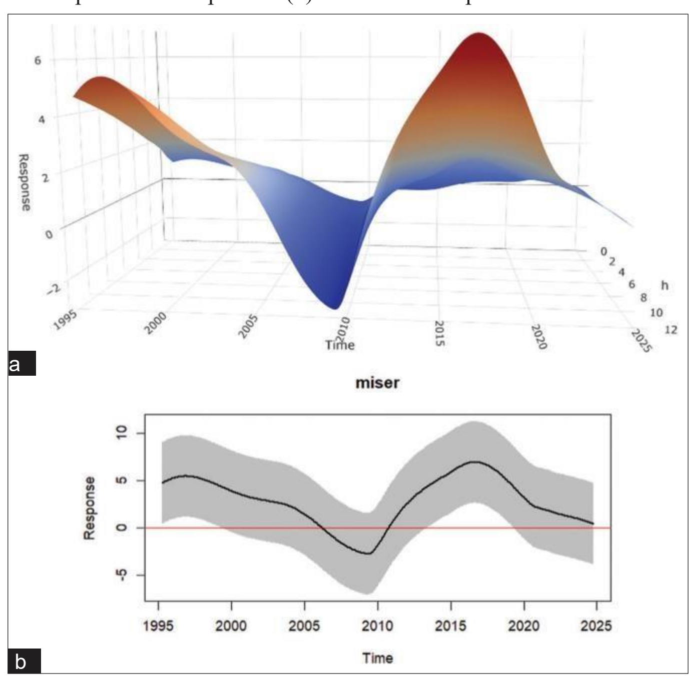


rise in global oil supply has had an apparent adverse effect on Azerbaijan's trade balance, particularly following that period. The increased sensitivity observed, especially following COVID-19, indicates a greater susceptibility of the Azerbaijani economy to supply-side choices made by significant global producers and variations in global energy demand trends.

The trade balance of Azerbaijan is depicted in Figure 5, which shows the time-varying effects of oil price shocks. Azerbaijan's trade balance has generally improved in response to positive oil price shocks, apart from the "Great Plunge" period, around 2014-2016, during which oil prices experienced a substantial decline and the response turned out insignificant or marginally negative. Azerbaijan's export revenues are more robustly responsive to price increases during periods of sustained market upswings, as evidenced by the significant positive responses that are particularly evident in the periods following major price recoveries and stabilization phases, such as the late 2000s and the post-2016 recovery period. The persistent, yet unstable, dependence of the economy on hydrocarbon revenues is underscored by the fluctuating magnitude and significance of oil price shocks, which remain a critical determinant of trade balance performance, as revealed by the TVP-VAR.

Figure 6 illustrates the effect of exchange rate misalignment on the trade balance. Over-depreciation tends to positively influence the trade balance, though the magnitude and significance of this influence fluctuate significantly over time. An in-depth analysis of Figure 6b reveals that statistically significant positive responses are concentrated in particular sub-periods, likely aligning with phases

Figure 6: TVP-VAR responses of xm to shocks in miser. (a) Surface plot of the responses. (b) Cumulative responses at h = 12



that follow major devaluations or changes in exchange rate policy (e.g., adjustments after 2015). The fluctuations and changing significance in addressing exchange rate misalignment highlight the intricate and possibly time-sensitive efficacy of exchange rate policy as a mechanism for managing external balances within the Azerbaijani framework.

6. CONCLUSIONS

This paper examined the time-varying effects of oil shocks on the Azerbaijan trade balance in a time-varying context. To this aim, the TVP-VAR model is employed to analyze the impact of global oil production, oil prices, and exchange rate misalignment on trade balance from December 1994 to November 2024. Furthermore, the nonparametric kernel regression technique used in this paper enables data-driven estimation of time-varying coefficients without imposing prior assumptions on parameter variation, in contrast with methodologies based on Bayesian estimation.

The linear and time-varying responses estimated in this paper uncover important information about the transmission of oil shocks into Azerbaijan's trade balance. In the linear responses, global oil production shocks exhibited a substantial negative impact on the trade balance. The findings of the study demonstrated a consistent positive impact of exchange rate shocks and a positive effect of oil price shocks. The TVP-VAR results implied that the negative effects of oil production shocks varied remarkably, with statistical significance mainly witnessed in the post-COVID-19 period. Time-varying responses to oil price shocks are mostly positive but became statistically insignificant during the oil price collapse, emphasizing the drawbacks of linear methodologies. These results agree with the findings of Abu Eleyan et al. (2022) about ASEAN countries, Balli et al. (2021) regarding Russia, Nasir et al. (2019) and Alassaf (2024) about GCC members, showing that economies that rely on resources are affected by changes in the external energy market.

The analyses conducted in this paper have several policy implications. The time-varying analysis indicates that the reaction of trade balances to the oil shocks varies in terms of magnitude and significance across the periods. This evidence corroborates the necessity of decreasing dependence on oil exports by promoting non-oil sectors to alleviate the impacts of oil reliance. Diversifying public revenues and implementing appropriate fiscal adjustments and structural reforms can be another crucial strategy to be adopted by the policymakers. The impact of oil shocks on Azerbaijan's fiscal balance could be considered as a topic for further research.

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