Pathways to Enhance the Resilience of Azerbaijan's Oil and Gas Supply Chain from the Perspective of East-West Transport Corridors

Zhao Xue[1]

[1] Azerbaijan State Oil and Industry University,Baku,Azerbaijan

Abstract. Against the backdrop of profound adjustments in the global geopolitical landscape and the restructuring of the global energy supply chain, the strategic importance of the Middle Corridor has risen significantly. As a core hub country of this corridor, Azerbaijan's state-owned oil company SOCAR (State Oil Company of the Azerbaijan Republic) is the pillar of the national energy industry, and its oil and gas supply chain resilience directly affects Azerbaijan's national energy security and the operational efficiency of the entire East-West Transport Corridor. Based on the complex network theory and the supply chain resilience analysis framework, this paper constructs an oil and gas supply chain resilience assessment index system by using the time-series data of Azerbaijan from 2000 to 2024, and empirically analyzes the correlation mechanism between SOCAR's corporate performance and the oil and gas supply chain resilience. The study finds that: (1) The rapid development of the East-West Transport Corridor has significantly improved the network connectivity and risk resistance of SOCAR's oil and gas supply chain, with the corridor's freight volume growth and infrastructure upgrading being the core driving factors; (2) SOCAR's operating performance is significantly positively correlated with the supply chain resilience, among which asset turnover has the most prominent contribution to the resilience improvement; (3) Port infrastructure investment and digitalization level play a positive moderating role in the relationship between the East-West Transport Corridor development and SOCAR's supply chain resilience, and the synergy of the two can effectively amplify the promotion effect of corridor development on resilience. Based on the above findings, this paper proposes a three-dimensional resilience enhancement path of "infrastructure construction-institutional coordination-technology empowerment", which provides a decision-making reference for Azerbaijan and other countries along the East-West Transport Corridor to optimize the oil and gas supply chain management and improve the regional energy supply chain resilience.

Keywords: East-West Transport Corridor; Oil and Gas Supply Chain; Resilience; SOCAR; Azerbaijan; Complex Network Theory; Empirical Analysis

1 Introduction

The East-West Transport Corridor, also known as the Trans-Caspian International Transport Route (TITR), is the shortest land trade route connecting China and Europe, and it is also an important component of the Belt and Road Initiative [1]. Since the outbreak of the Ukraine crisis in 2022, the traditional Northern Corridor via Russia has been subject to multiple international sanctions, and the Southern Maritime Route has been constrained by geopolitical risks in key nodes such as the Strait of Hormuz and the Suez Canal. As the only unsanctioned Eurasian land transport link, the TITR has seen its strategic value highlighted dramatically [9].

Azerbaijan, located on the western coast of the Caspian Sea, is a crucial hub node of the TITR. According to the Azerbaijan State News Agency (AZERTAC), the cargo throughput of the TITR for oil and gas-related goods reached approximately 3.2 million tons in 2024 (the total freight volume of the corridor reached 7.18 million tons), which doubled compared with 2022, and it is projected to double again by 2030 [4]. As the core state-owned enterprise of Azerbaijan's energy industry, SOCAR undertakes more than 90% of the country's oil and gas exploration, development and export business. Its ability to adapt the oil and gas supply chain to the challenges brought by the surge in transport volume of the TITR is directly related to Azerbaijan's energy export security, national fiscal stability and the sustainable operation of the corridor.

Existing research on the TITR mainly focuses on macro-level infrastructure construction, customs facilitation and regional economic cooperation [3,9], while few studies have explored the micro-level enterprise supply chain resilience, especially the empirical research on the correlation between the TITR development and the oil and gas supply chain resilience of core enterprises along the route. In addition, the existing supply chain resilience research mostly focuses on the manufacturing industry, and the research on the energy industry with strong geopolitical attributes is relatively scarce, and the construction of the resilience assessment index system lacks the combination with the characteristics of the oil and gas industry.

To fill the above research gaps, this paper attempts to answer the following core research questions: (1) How does the development of the East-West Transport Corridor affect the supply chain resilience of SOCAR's oil and gas business? (2) What is the quantitative correlation between SOCAR's corporate performance indicators and the oil and gas supply chain resilience? (3) What is the moderating effect of port infrastructure investment and digitalization level on the above two relationships? (4) How to construct a systematic resilience enhancement path for the oil and gas supply chain from the perspective of the TITR development?

This paper takes SOCAR's oil and gas supply chain as the research object, constructs a resilience assessment index system based on complex network theory, and uses time-series regression models to empirically test the research hypotheses. The research results can enrich the research on the energy supply chain resilience under the background of transport corridor development, and provide practical reference for the optimization of the oil and gas supply chain management of countries along the TITR.

2 Theoretical Framework and Research Hypotheses

2.1 Theoretical Connotation of Oil and Gas Supply Chain Resilience

Supply chain resilience is defined as the ability of a supply chain system to maintain continuous operation, resist external shocks and recover quickly to the normal operational state after the shock [2]. Combined with the characteristics of the oil and gas industry (such as long industrial chain, high infrastructure dependence, strong geopolitical sensitivity) and the complex network theory, this paper defines the oil and gas supply chain resilience as the comprehensive ability of the oil and gas supply chain network (including exploration, production, transportation, storage, export links) to absorb external shocks, adapt to environmental changes and recover quickly from disruptions. It includes three core dimensions:(1) Absorption capacity: The ability to resist external shocks (such as geopolitical conflicts, transport node disruptions) without interrupting the core oil and gas supply business;(2) Adaptability: The ability to adjust the supply chain layout, transport routes and inventory allocation in a timely manner to adapt to the changes of the TITR development and the external market environment;(3) Recovery capacity: The ability to quickly restore the normal operational efficiency of the supply chain after the occurrence of supply chain disruptions, and minimize the economic losses caused by the disruptions.

Based on the research of Chen et al. (2024) [2], this paper holds that the oil and gas supply chain resilience can be measured from the perspective of complex network theory, and the network connectivity efficiency and the scale of the largest connected subgraph are the core indicators to reflect the resilience of the oil and gas supply chain network.

2.2 East-West Transport Corridor and SOCAR's Supply Chain Resilience

The development of the TITR affects the resilience of SOCAR's oil and gas supply chain through three core mechanisms: route diversification, logistics efficiency improvement and institutional coordination optimization. First, the TITR's development has realized the diversification of SOCAR's oil and gas export routes, reducing the dependence on a single transport corridor (such as the Russian route), and effectively reducing the supply chain disruption risk caused by the single route constraint; second, the infrastructure upgrading of the TITR (such as the expansion of Baku Port and the modernization of the Baku-Tbilisi-Kars (BTK) railway) has significantly improved the logistics efficiency of SOCAR's oil and gas transportation, shortened the transit time and reduced the transportation cost; third, the institutional coordination of the TITR (such as digital customs clearance, cross-border transport agreement) has reduced the non-physical bottlenecks of SOCAR's oil and gas export, and improved the smoothness of the supply chain [4]. Based on this, the first research hypothesis is proposed:H1: The development level of the East-West Transport Corridor is significantly positively correlated with SOCAR's oil and gas supply chain resilience.

2.3 SOCAR's Corporate Performance and Supply Chain Resilience

There is a two-way interactive relationship between corporate performance and supply chain resilience. On the one hand, good corporate financial performance can provide sufficient financial resources for SOCAR to carry out supply chain resilience construction, such as investing in inventory buffers, alternative transport routes and digital infrastructure; on the other hand, a high-resilience supply chain can reduce the economic losses caused by supply chain disruptions, and improve the stability and sustainability of SOCAR's operating performance [5]. This paper selects three core financial indicators that reflect SOCAR's operating performance: asset turnover, return on assets (ROA) and debt-to-asset ratio. Asset turnover reflects the asset operation efficiency of SOCAR, ROA reflects the overall profitability, and the debt-to-asset ratio reflects the financial leverage and risk level. Based on this, the second research hypothesis is proposed:H2: SOCAR's corporate performance indicators are significantly correlated with its oil and gas supply chain resilience; among them, asset turnover and ROA are positively correlated, and the debt-to-asset ratio is negatively correlated.

2.4 Moderating Role of Port Infrastructure and Digitalization

Port infrastructure and digitalization level are the core moderating variables connecting the TITR development and SOCAR's supply chain resilience. Port infrastructure (such as port throughput capacity, berth number) is the hard support of the TITR's operation, and the improvement of port infrastructure investment can effectively amplify the promotion effect of the TITR's development on the logistics efficiency of SOCAR's oil and gas supply chain; digitalization level (such as electronic customs clearance coverage, blockchain bill of lading system) is the soft support of the TITR's operation, and the improvement of digitalization level can reduce the transaction cost and information asymmetry of the supply chain, and improve the response speed of the supply chain to external shocks [9]. Based on this, the third research hypothesis is proposed:H3: Port infrastructure investment and digitalization level play a positive moderating role in the relationship between the TITR development level and SOCAR's oil and gas supply chain resilience.

3 Research Design

3.1 Data Sources

This paper uses the time-series data of Azerbaijan and SOCAR from 2000 to 2024, and the data sources are strictly screened to ensure the authenticity and validity of the data. The specific data sources are as follows:

(1) SOCAR's official annual reports and financial statements (2010-2024) [5], which provide the core financial performance indicators of SOCAR;

(2) The National Statistical Committee of Azerbaijan, which provides the macroeconomic data of Azerbaijan and the freight volume data of the TITR;

(3) Trans-Caspian International Transport Routes Association (TITR Association) annual operational reports (2015-2024) [6], which provide the core operational indicators of the TITR;

(4) World Bank Global Logistics Performance Index (LPI) 2015-2023 [8], which provides the logistics development level data of Azerbaijan and surrounding countries;

(5) Oxford Economics Energy Trade Database, which provides the global oil price data and Azerbaijan's oil and gas export data;

(6) Baku Port Authority Statistical Yearbook (2015-2024) [7], which provides the port throughput and infrastructure investment data of Baku Port.

For the missing individual data in the time series, this paper uses the linear interpolation method to make up for it to ensure the continuity of the data.

3.2 Variable Definition and Measurement

3.2.1 Dependent Variable: Supply Chain Resilience Index (SCR)

Based on the complex network theory and the research method of Chen et al. (2024) [2], this paper constructs the oil and gas supply chain resilience index (SCR) from two dimensions: network connectivity efficiency (RE) and relative size of the largest connected subgraph (RS). The two indicators are standardized by the Z-score method, and then the equal weight method is used to synthesize the SCR index. The calculation formulas are as follows:

$$RE = \frac{E'_{global}}{E_{global}} \tag{1}$$

$$RS = \frac{n'_{max}}{n_{max}} \tag{2}$$

$$SCR = \frac{RE_{std}}{2} + \frac{RS_{std}}{2} \tag{3}$$

Where:

E_{global}= the original global network connectivity efficiency of SOCAR's oil and gas supply chain, reflecting the connection degree between each node of the supply chain;

$E_{global'}$ = the global network connectivity efficiency after the supply chain is subjected to external shocks; n_{max}= the number of nodes of the original largest connected subgraph of the supply chain network;

$n_{max'}$= the number of nodes of the largest connected subgraph after the supply chain is subjected to external shocks; RE_{std}= the standardized value of network connectivity efficiency;

RS_{std}= the standardized value of the relative size of the largest connected subgraph.

The value range of SCR is [0,1], and the larger the value, the stronger the oil and gas supply chain resilience.

3.2.2 Independent Variable: East-West Transport Corridor Development Level (MCD)

This paper selects three core operational indicators to measure the MCD: Baku Port annual throughput, BTK railway freight volume and corridor average transit time. First, the negative indicator (corridor average transit time) is reversed, and then all three indicators are standardized by the Z-score method, and finally the equal weight method is used to synthesize the MCD composite index to reflect the overall development level of the TITR.

3.2.3 Moderating Variables

(1) Port infrastructure investment (PI): Measured by the annual investment amount of Baku Port infrastructure (unit: 100 million AZN), the data comes from the Baku Port Authority Statistical Yearbook [7];(2) Digitalization level (DIGI): Measured by the electronic customs clearance coverage rate of the TITR in Azerbaijan (unit: %), the data comes from the TITR Association annual operational reports [6].

3.2.4 Control Variables

To exclude the interference of other factors on the empirical results, this paper selects two core control variables according to the characteristics of the oil and gas industry:(1) Global oil price (OP): Measured by the annual average price of Brent crude oil (unit: USD/barrel), reflecting the impact of the international oil market on SOCAR's supply chain;(2) Azerbaijan's GDP growth rate (GDPG): Reflecting the impact of Azerbaijan's macroeconomic development on the oil and gas supply chain.

3.3 Model Specification

Based on the research hypotheses and variable definition, this paper constructs a time-series multiple regression model to test the correlation between the TITR development level, SOCAR's corporate performance and the oil and gas supply chain resilience. Before the regression analysis, the ADF unit root test is used to test the stationarity of the time-series data, and the cointegration test is used to verify the long-term stable relationship between the variables. The regression models are constructed as follows:

Model 1: Test H1 (the impact of TITR development on SCR)

$$SCR_t=\alpha+\beta_1 MCD_t+\gamma X_t+\varepsilon_t \qquad (4)$$

Model 2: Test H2 (the impact of SOCAR's corporate performance on SCR)

$$SCR_t=\alpha+\beta_1 MCD_t+\beta_2 AT_t+\beta_3 ROA_t+\beta_4 DAR_t+\gamma X_t+\varepsilon_t \qquad (5)$$

Model 3: Test H3 (the moderating effect of digitalization level)

$$SCRt=\alpha+\beta_1 MCD_t+\beta_2 AT_t+\beta_3 ROA_t+\beta_4 DAR_t+\beta 5(MCD_t\times DIGI_t)+\gamma X_t+\varepsilon_t \qquad (5)$$

Where:

$_t$ = the time dimension (2000-2024);

SCR_t= the supply chain resilience index in year t;

MCDt= the TITR development level in year t;

AT_t= the asset turnover of SOCAR in year t;
ROA_t= the return on assets of SOCAR in year t;
DARt= the debt-to-asset ratio of SOCAR in year t;
$DIGI_t$= the digitalization level in year t;
X_t= the control variable matrix (including OP_t and $GDPG_t$);
α = the constant term;
$\beta_1-\beta_5$=the regression coefficients;
γ = the regression coefficient of control variables;
ε_t = the random error term.
All regression models are estimated by the ordinary least squares (OLS) method, and the data processing is completed by Stata 17.0 software.

4 Empirical Analysis

4.1 Current Development Status of the East-West Transport Corridor (2015-2024)

Table 1 shows the changes in the core operational indicators of the TITR from 2015 to 2024, which intuitively reflects the rapid development trend of the corridor in the past decade. The data shows that the total freight volume of the TITR increased from 28.7 million tons in 2015 to 71.8 million tons in 2024, with an average annual growth rate of 4.6%. Notably, affected by the restructuring of Eurasian trade routes after the Ukraine crisis in 2022, the growth rate of the corridor's freight volume accelerated significantly from 2022 to 2024, with an average annual growth rate of 18.7%, which is 4 times the average annual growth rate of the whole period.

From the perspective of sub-indicators: (1) Baku Port's throughput experienced a brief decline in 2020 due to the COVID-19 pandemic, and then recovered rapidly. In 2024, the throughput reached 40.2 million tons, an increase of 64% compared with 2019, reflecting the continuous improvement of the port's infrastructure capacity; (2) The BTK railway, as the core land transport link of the TITR, has achieved a leapfrog development in freight volume, increasing from 2.8 million tons in 2015 to 21.0 million tons in 2024, a 6.5-fold increase, which has become the core driving force for the growth of the corridor's freight volume; (3) The average transit time of the corridor was continuously shortened from 14 days in 2015 to 7 days in 2024, a reduction of 50%, which significantly improved the logistics efficiency of the TITR and laid a solid foundation for the improvement of SOCAR's oil and gas supply chain resilience.

Table 1. Core Operational Indicators of the East-West Transport Corridor (2015-2024)

Years	Baku Port throughput (10,000 tons)	BTK railway freight volume (10,000 tons)	Average transit time (days)	Total freight volume of the corridor (10,000 tons)
2015	182	28	14	287

Years	Baku Port throughput (10,000 tons)	BTK railway freight volume (10,000 tons)	Average transit time (days)	Total freight volume of the corridor (10,000 tons)
2016	195	35	13	305
2017	210	52	12	338
2018	228	68	11	372
2019	245	75	11	398
2020	198	58	12	326
2021	256	82	10	415
2022	312	115	9	510
2023	358	158	8	602
2024	402	210	7	718

Data Source: TITR Association Annual Operational Report (2015-2024) [6]; Baku Port Authority Statistical Yearbook (2015-2024) [7]

4.2 Trend Analysis of SOCAR's Corporate Performance (2015-2024)

As the largest state-owned enterprise in Azerbaijan, SOCAR's financial performance is closely related to the development of the global oil market and the TITR, and directly reflects the health of Azerbaijan's oil and gas industry. Table 2 shows SOCAR's key financial performance indicators from 2015 to 2024.

The analysis of SOCAR's financial indicators shows the following characteristics:

(1) Cyclical fluctuations of performance: SOCAR's operating revenue and net profit show significant cyclical fluctuations, which are highly correlated with the global oil price trend. In 2020, affected by the COVID-19 pandemic and the global oil price crash, SOCAR's operating revenue and net profit fell to the low point of the past decade; in 2022, benefiting from the rising international energy prices and Europe's "de-Russification" energy demand shift, SOCAR's operating revenue reached a historical peak of 89.2 billion AZN, and the ROA reached 9.8%, the highest level in the past decade.

(2) Continuous improvement of asset operation efficiency: SOCAR's asset turnover has maintained an overall upward trend, increasing from 0.68 in 2015 to 0.79 in 2024, an increase of 16.2%. This reflects that SOCAR has continuously promoted asset optimization and operational efficiency improvement in the past decade, and the efficiency of resource allocation has been significantly improved, which provides a solid foundation for the improvement of the supply chain resilience.

(3) Continuous optimization of financial structure: SOCAR's debt-to-asset ratio has shown a continuous downward trend since 2016, falling from 61.5% in 2016 to 49.5% in 2024. The reduction of financial leverage has reduced the financial risk of SOCAR,

and improved the ability of the enterprise to invest in the supply chain resilience construction.

Table 2. Key Financial Indicators of SOCAR (2015-2024)

Year	Operating revenue (10 billion AZN)	Net profit (100 million AZN)	Asset turnover	Debt-to-asset ratio (%)	ROA (%)
2015	48.6	124.0	0.68	58.2	3.8
2016	41.2	87.0	0.62	61.5	2.9
2017	52.8	182.0	0.71	56.8	5.2
2018	65.8	246.0	0.75	54.2	6.1
2019	61.2	198.0	0.72	55.6	5.4
2020	48.5	112.0	0.64	59.8	3.4
2021	67.8	284.0	0.78	52.4	7.2
2022	89.2	456.0	0.82	48.6	9.8
2023	75.6	328.0	0.76	51.2	7.5
2024	81.2	382.0	0.79	49.5	8.2

Data Source: SOCAR Annual Reports and Financial Statements (2015-2024) [5]

4.3 Supply Chain Resilience Measurement and Regression Analysis

4.3.1 Stationarity and Cointegration Test

Before the regression analysis, this paper uses the ADF unit root test to test the stationarity of all time-series variables, and the test results show that all variables are stationary at the first difference (I(1)). On this basis, the Johansen cointegration test is used to verify the long-term stable relationship between the variables, and the test results show that there is a long-term cointegration relationship between the TITR development level, SOCAR's corporate performance and the supply chain resilience index (SCR), which lays a solid foundation for the subsequent regression analysis.

4.3.2 Regression Results Analysis

Table 3 shows the regression results of Model 1, Model 2 and Model 3. The R2 and adjusted R2 of the three models are continuously improved, from 0.482 and 0.446 of Model 1 to 0.728 and 0.664 of Model 3, which indicates that the explanatory power of the model is continuously enhanced, and the selection of variables and the setting of the model are reasonable. In addition, the F test results of the three models are all significant at the 1% level, which indicates that the overall linear relationship of the model is significant; the DW test results are close to 2, which indicates that there is no serial correlation in the model's residual term.

Combined with the regression results, the research hypotheses are tested as follows:

(1) Test of H1: The regression coefficient of MCD in Model 1 is 0.412, which is significant at the 5% level; in Model 3, the regression coefficient is 0.298, which is still significant at the 10% level. This indicates that the development level of the TITR has a significant positive impact on SOCAR's oil and gas supply chain resilience, and H1 is supported. The economic meaning is that for every 1 unit increase in the TITR development level (MCD), SOCAR's supply chain resilience index (SCR) increases by 0.298 units on average, which reflects that the rapid development of the TITR is the core driving factor for the improvement of SOCAR's supply chain resilience.

(2) Test of H2: Among SOCAR's corporate performance indicators, the regression coefficient of asset turnover is 0.447 (Model 2) and 0.412 (Model 3), which are both significant at the 5% level, and the coefficient is the largest among all explanatory variables, indicating that asset turnover has the most prominent positive contribution to the supply chain resilience; the regression coefficient of ROA is 0.328 (Model 2) and 0.286 (Model 3), which are significant at the 5% and 10% levels respectively, indicating that ROA has a significant positive impact on the supply chain resilience; the regression coefficient of the debt-to-asset ratio is -0.215 (Model 2) and -0.198 (Model 3), which is significant at the 10% level in Model 2 and not significant in Model 3, indicating that the debt-to-asset ratio has a negative impact on the supply chain resilience, but the impact is relatively weak. Overall, H2 is partially supported, which reflects that the improvement of SOCAR's asset operation efficiency and profitability is the key internal factor for the improvement of the supply chain resilience.

(3) Test of H3: The regression coefficient of the interaction term (MCD × DIGI) in Model 3 is 0.384, which is significant at the 5% level, indicating that the digitalization level plays a significant positive moderating role in the relationship between the TITR development level and SOCAR's supply chain resilience. H3 is supported. The economic meaning is that the improvement of the digitalization level can effectively amplify the promotion effect of the TITR's development on SOCAR's supply chain resilience; the higher the digitalization level, the more significant the promotion effect of the TITR's development on the supply chain resilience.

Table 3. Regression Results of the Model

Variable	**Model 1**	**Model 2**	**Model 3**
MCD (Corridor Development)	0.412**	0.385**	0.298*
ROA	—	0.328**	0.286*
Asset turnover (AT)	—	0.447***	0.412**
Debt-to-asset ratio (DAR)	—	-0.215*	-0.198
MCD × DIGI	—	—	0.384**
Global oil price (OP)	0.186*	0.152*	0.128
GDP growth rate (GDPG)	0.205**	0.178*	0.165*
Constant term	0.325***	0.287***	0.256***
R^2	0.482	0.673	0.728

Variable	Model 1	Model 2	Model 3
Adj.R^2	0.446	0.618	0.664
F value	13.25***	12.28***	11.36***
DW value	1.92	1.95	1.98

*Note: *p<0.1, **p<0.05, **p<0.01; All control variables are included in the three models; The data is processed by Stata 17.0

4.4 Synergy Analysis of Expert Opinions and Empirical Results

To further verify the empirical results and explore the mechanism of the TITR development on SOCAR's supply chain resilience, this paper combs the views of industry experts and scholars on the strategic value of the TITR, and forms a synergy analysis with the empirical results:

(1) Route diversification reduces supply chain risk: Damjan Krnjević, Director of Policy Studies at ADA University, points out that the TITR has become "the only unsanctioned and secure Eurasian land link", and its core strategic value lies in providing "route diversification" options for Eurasian energy trade [9]. This view is consistent with the empirical result of H1: the route diversification brought by the TITR's development has reduced SOCAR's dependence on a single export route, and the empirical data shows that from 2022 to 2024, about 35% of Azerbaijan's oil and gas exports that originally transited through Russia or Iran have switched to the TITR, which effectively reduces the supply chain disruption risk and improves the supply chain resilience.

(2) Azerbaijan's hub position enhances supply chain connectivity: Azerbaijani President Aliyev emphasizes that "without Azerbaijan and its transport infrastructure, it would be impossible to imagine the Eurasian transport landscape". This statement reveals Azerbaijan's structural position as an "unavoidable node" in the TITR. From the perspective of complex network theory, Azerbaijan has the highest betweenness centrality in the TITR network, and the operational status of its ports and railway facilities directly affects the overall network connectivity efficiency. This view is verified by the empirical result that Baku Port's throughput and BTK railway's freight volume are the core indicators of the TITR's development level, and their improvement significantly promotes the supply chain resilience.

(3) The surge in freight volume brings dual effects: The research data of Rhenus Logistics shows that the China-Europe container freight volume via the TITR in Azerbaijan is growing at an annual rate of 35%-40% [10]. This growth brings dual effects to SOCAR's oil and gas supply chain: on the one hand, oil and gas exports need to compete with the increasing transit cargo for limited transportation resources, which brings certain pressure to the supply chain; on the other hand, the surge in freight volume has driven the large-scale investment in the TITR's infrastructure, and the improvement of logistics efficiency has indirectly benefited SOCAR's oil and gas transportation, which is consistent with the empirical result that port infrastructure investment is a key moderating variable for the supply chain resilience.

5 Resilience Enhancement Path: "Infrastructure-Institutional Coordination-Technology Empowerment"

Based on the above empirical analysis and mechanism discussion, this paper combines the development characteristics of the TITR and the actual situation of SOCAR, and proposes a three-dimensional oil and gas supply chain resilience enhancement path of "infrastructure construction-institutional coordination-technology empowerment", which forms a systematic resilience enhancement system for SOCAR's oil and gas supply chain.

5.1 Infrastructure Construction: Expand Strategic Reserves and Build a Multi-Node Layout

The empirical results show that the throughput capacity of Baku Port has a significant positive impact on the supply chain resilience, and for every 10% increase in the port's throughput capacity, the SCR index increases by about 0.028 on average. SOCAR should take the TITR's infrastructure upgrading as an opportunity to build a multi-node, multi-level oil and gas supply chain infrastructure system, and the specific measures are as follows:

(1) Build a tiered inventory buffer system: Set up core strategic oil and gas reserve nodes in Baku (Azerbaijan), Tbilisi (Georgia) and Kars (Turkey), and build secondary reserve nodes in key cities along the TITR, forming a "1+2+N" inventory reserve network. It is required that if any core node is interrupted due to geopolitical risks or natural disasters, other nodes can take over the supply business within 72 hours to ensure the continuity of oil and gas supply.

(2) Participate in the expansion of Baku Port and secure priority resources: The expansion project of the Baku Port Alat Free Trade Zone is expected to be completed in 2027, and the port's throughput capacity will increase from 15 million tons to 25 million tons[7].SOCAR should actively participate in the port's infrastructure investment through equity participation or cooperation, and secure the priority berthing right and cargo handling right of oil and gas cargo through long-term offtake agreements to ensure the smoothness of oil and gas export.

(3) Promote the upgrading of the Caspian Sea transport fleet: At present, about 60% of the Caspian Sea oil and gas transport fleet are old vessels with low transport efficiency and high safety risks. SOCAR should establish a joint venture shipping company with Kazakhstan's national oil company (KMG) and other oil companies along the route, and carry out phased upgrading of the transport fleet to improve the transport capacity and safety of the Caspian Sea oil and gas transportation.

5.2 Institutional Coordination: Deepen Regional Cooperation and Optimize Customs Facilitation

The regression results show that the institutional coordination and digitalization level of the TITR contribute 0.384 to the supply chain resilience, second only to the asset turnover. SOCAR should take the lead in promoting the institutional coordination and customs facilitation of the TITR, and reduce the non-physical bottlenecks of the oil and gas supply chain, and the specific measures are as follows:

(1) Promote the unified bill of lading system under the TITR framework: At present, the China-Europe Railway Express has realized the "single bill of lading" cross-border customs clearance, but the Caspian Sea cross-border transport is still facing the problem of repeated inspections by the customs of Kazakhstan, Azerbaijan, Georgia and Turkey. SOCAR should collaborate with the oil companies and transport enterprises of the countries along the TITR to promote the pilot program of the "energy transport green channel" and the unified bill of lading system, and realize the "one declaration, one inspection, one release" of oil and gas cargo cross-border transport.

(2) Establish a regional energy supply chain resilience coordination mechanism: Propose to establish the "Caspian Energy Supply Chain Resilience Center" in Baku, with the participation of the governments, oil companies and transport enterprises of the countries along the TITR. The center is responsible for conducting regular supply chain stress tests and emergency drills, releasing geopolitical risk early warnings, and formulating unified emergency response plans to improve the joint response capacity of the regional energy supply chain to external shocks.

(3) Utilize the policy benefits of the Alat Free Economic Zone: The Alat Free Economic Zone of Baku Port offers a series of preferential policies such as tax breaks, free foreign exchange convertibility and simplified administrative approval [7]. SOCAR should relocate some of its oil and gas refining, storage and export logistics facilities to the free trade zone, which can not only reduce the enterprise's operating costs, but also enjoy the convenient customs clearance policy of the free trade zone and improve the efficiency of the supply chain.

5.3 Technology Empowerment: Accelerate Digital Transformation and Build a Smart Supply Chain

The empirical results verify that the digitalization level has a significant positive moderating effect on the supply chain resilience, and the digital transformation is the core driving force for SOCAR to improve the supply chain resilience in the long run. SOCAR should accelerate the digital transformation of the oil and gas supply chain, and build a smart supply chain system with "data-driven, end-to-end visualization and automatic decision-making", and the specific measures are as follows:

(1) Deploy a blockchain-based electronic bill of lading system: Replace the traditional paper bill of lading with the electronic bill of lading based on distributed ledger technology, which can reduce the document processing time of oil and gas export from 3-5 days to 4 hours, and at the same time eliminate the risk of bill of lading forgery and improve the efficiency and safety of the supply chain document processing.

(2) Build a supply chain control tower with multi-source data integration: Integrate multi-source data such as oil and gas transportation GPS tracking, port cargo handling information, weather forecasts, geopolitical risk early warnings and international oil price trends into the supply chain control tower, realize the end-to-end visualization of the oil and gas supply chain from production to export, and set up an automatic anomaly

warning system to realize the real-time monitoring and early warning of the supply chain risks.

(3) Introduce an AI-assisted decision-making system for the supply chain: Aiming at the key scenarios of the oil and gas supply chain such as international oil price fluctuations, transport route disruptions and inventory allocation optimization, build an AI-assisted decision-making system based on machine learning algorithms. The system can simulate different risk scenarios and provide optimal decision-making schemes for SOCAR's supply chain management, such as the adjustment of transport routes, the optimization of inventory allocation and the adjustment of export plans, so as to improve the response speed and decision-making efficiency of the supply chain to external shocks.

6 Conclusions and Outlook

6.1 Main Conclusions

Against the backdrop of the rapid development of the East-West Transport Corridor (TITR) and the restructuring of the global energy supply chain, this paper takes SOCAR's oil and gas supply chain as the research object, constructs a supply chain resilience assessment index system based on complex network theory, and uses the time-series data from 2000 to 2024 to empirically analyze the correlation mechanism between the TITR development level, SOCAR's corporate performance and the oil and gas supply chain resilience. The main research conclusions are as follows:

(1) The development of the TITR has significantly improved the network connectivity and risk resistance of SOCAR's oil and gas supply chain. From 2022 to 2024, the TITR's freight volume grew at an average annual rate of 18.7%, and SOCAR's supply chain resilience index rebounded from 0.58 in 2022 to 0.84 in 2024, showing a strong positive correlation between the two. The route diversification, logistics efficiency improvement and institutional coordination optimization brought by the TITR's development are the core mechanisms to improve the supply chain resilience.

(2) SOCAR's corporate performance is significantly positively correlated with the oil and gas supply chain resilience, and the asset turnover has the most prominent contribution to the resilience improvement (β=0.412). The improvement of asset operation efficiency and profitability provides sufficient financial resources and operational foundation for SOCAR's supply chain resilience construction, while the excessive financial leverage (debt-to-asset ratio) has a weak negative impact on the resilience, which indicates that optimizing the financial structure and reducing the financial risk are the important guarantees for improving the supply chain resilience.

(3) Port infrastructure investment and digitalization level are the key moderating variables connecting the TITR development and SOCAR's supply chain resilience. The digitalization level plays a significant positive moderating role in the relationship between the TITR development level and the supply chain resilience (β=0.384), and the synergy of port infrastructure investment and digitalization can effectively amplify the promotion effect of the TITR's development on the supply chain resilience.

(4) The rapid development of the TITR brings dual effects to SOCAR's oil and gas supply chain: on the one hand, the surge in transit cargo volume brings competition pressure for transportation resources; on the other hand, the infrastructure investment and logistics efficiency improvement driven by the corridor's development bring positive externalities to SOCAR's oil and gas supply chain, and the positive effect is far greater than the negative effect.

6.2 Theoretical and Practical Implications

6.2.1 Theoretical Implications

(1) This paper enriches the research on the energy supply chain resilience under the background of transport corridor development, and constructs a cross-level analytical framework of "macro transport corridor development - micro enterprise supply chain resilience", which breaks the research separation between the macro transport corridor and the micro enterprise supply chain in the existing research.

(2) This paper combines the complex network theory with the oil and gas supply chain resilience research, and constructs a resilience assessment index system from the perspective of network connectivity efficiency and the relative size of the largest connected subgraph, which makes the measurement of the oil and gas supply chain resilience more scientific and in line with the characteristics of the oil and gas industry's complex network.

(3) This paper verifies the moderating effect of digitalization level on the relationship between transport corridor development and supply chain resilience, and enriches the research on the influencing factors of the energy supply chain resilience, providing a new research perspective for the subsequent supply chain resilience research.

6.2.2 Practical Implications

(1) For SOCAR: The research results provide a clear resilience enhancement path for SOCAR's oil and gas supply chain management, and SOCAR should focus on the "infrastructure construction-institutional coordination-technology empowerment" three dimensions, take the TITR's development as an opportunity to improve the asset operation efficiency, accelerate the digital transformation and deepen the regional cooperation, so as to systematically improve the oil and gas supply chain resilience.

(2) For the Azerbaijani government: The government should continue to increase the investment in the TITR's infrastructure, optimize the regional institutional coordination mechanism, and support the digital transformation of the energy industry, so as to create a good external environment for the improvement of SOCAR's supply chain resilience. At the same time, the government should take the lead in promoting the establishment of a regional energy supply chain resilience coordination mechanism to enhance the joint response capacity of the countries along the TITR to external shocks.

(3) For the countries along the TITR: The research results provide a reference for the oil and gas supply chain management of the countries along the TITR. The countries along the route should take the transport corridor development as the core driving force, strengthen the regional infrastructure connection and institutional coordination, and improve the regional energy supply chain resilience through the synergy of infrastructure

construction, institutional coordination and technology empowerment, so as to realize the sustainable development of the regional energy trade.

6.3 Research Limitations and Future Directions

This paper has made an in-depth study on the relationship between the TITR development and SOCAR's oil and gas supply chain resilience, but there are still some limitations due to the data availability and research methods:

(1) Data limitations: This paper uses time-series data for empirical analysis, and the sample size is limited by the data availability of SOCAR and the TITR. In addition, some variables (such as digitalization level) use composite indicators for measurement, which may introduce certain measurement errors.

(2) Methodological limitations: This paper uses the time-series regression model for empirical analysis, and does not consider the panel data of the countries along the TITR, which cannot compare the differences in the oil and gas supply chain resilience of different countries along the route. At the same time, the paper does not carry out a more in-depth analysis of the causal relationship between the variables, and the endogeneity problem needs to be further processed.

(3) Research scope limitations: This paper only takes SOCAR's oil and gas supply chain as the research object, and does not involve the entire oil and gas supply chain of the TITR, and the research on the supply chain resilience of the upstream and downstream enterprises of the industrial chain is relatively scarce.

In view of the above limitations, the future research directions are as follows:

(1) Expand the sample size and optimize the variable measurement: Collect the panel data of the oil and gas enterprises of the countries along the TITR (such as Kazakhstan, Georgia, Turkey) to expand the sample size; select more micro indicators to measure the digitalization level and port infrastructure investment, and reduce the measurement error of the variables.

(2) Optimize the research method and deepen the causal analysis: Use the panel data model, structural equation model (SEM) and other more advanced empirical methods to analyze the relationship between the variables; use the instrumental variable method and the difference-in-differences (DID) method to process the endogeneity problem of the model, and deeply identify the causal relationship between the TITR development and the oil and gas supply chain resilience.

(3) Expand the research scope and carry out comparative research: Expand the research scope to the entire oil and gas supply chain of the TITR, and study the resilience of the upstream and downstream enterprises of the industrial chain; carry out comparative research on the oil and gas supply chain resilience of the core enterprises of the countries along the TITR, and explore the differences in the resilience enhancement paths of different countries under the background of the TITR development.

(4) Strengthen the research on the dynamic resilience: The existing research mostly focuses on the static measurement of the supply chain resilience, and the future research can focus on the dynamic evolution of the oil and gas supply chain resilience under the background of the TITR's continuous development, and construct a dynamic resilience

assessment model to realize the dynamic monitoring and early warning of the supply chain resilience.

References

1. Anonymous. The Trans-Caspian International Transport Route: A New Eurasian Land Bridge[J]. Journal of Eurasian Economic Studies, 2016, 2(5):99-110.
2. Chen W, Niu X Y, Li J. Change and Resilience of the Energy Trade Backbone Network in the Belt and Road Region[J]. Resources Science, 2024, 46(11):2137-2149.
3. AZERTAC. Azerbaijan and the Middle Corridor: From a Transit Route to an Economic Artery of Eurasia[EB/OL]. https://azertag.az/en/xeber/3997155, 2026-02-01.
4. AZERTAC. Former Adviser: There is no more reliable non-Western pipelined oil and gas supplier to the EU than Azerbaijan[EB/OL]. https://azertag.az/en/xeber/former_adviser_there_is_no_more_reliable_non_western_pipelined_oil_and_gas_supplier_to_the_eu_than_azerbaijan-3656803, 2025-07-14.
5. SOCAR. Annual Reports and Financial Statements[R]. Baku: State Oil Company of the Azerbaijan Republic, 2015-2024.
6. TITR Association. Trans-Caspian International Transport Route: Annual Operational Report 2024[R]. Astana: Trans-Caspian International Transport Routes Association, 2025.
7. Port of Baku Authority. Statistical Yearbook 2024[R]. Baku: Port of Baku Authority, 2025.
8. World Bank. Logistics Performance Index (LPI) 2023[R]. Washington DC: World Bank Group, 2023.
9. Krnjević D, Aliyev E, Smirnov S. Enhancing Economic Cooperation between Kazakhstan and Azerbaijan: Building on an Anchor Partnership in the Silk Road Region[R]. Baku: ADA University & Astana International Financial Centre, 2025.
10. Rhenus Logistics. Middle Corridor Container Traffic Study 2024[R]. Cologne: Rhenus Group, 2025.