Factors Affecting Economic Resilience for Transition from an Oil-Based Economy

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Abstract

Given Iran's dependence on an oil-based economy—which has been a major factor in the emergence of structural problems and challenges within the national economy—evaluating the economic vulnerabilities resulting from sanctions on Iranian oil exports from various perspectives is crucial for achieving a resilient economy. The main objective of the present study is to compare the resilience of a knowledge-based economy with that of an oil-dependent economy and to assess the resilience of the entrepreneurial sector within Iran's economy. Numerous indicators have been proposed for measuring resilience; among them, two variables—employment rate and economic growth rate (specifically, the growth rate of value added in knowledge-based [high-tech and medium-tech] sectors and in the oil sector)—will be utilized. To select the variables, key studies in the field of resilience have been reviewed, based on which the independent variables of this study include economic shocks such as sanctions, oil sector shocks, foreign trade shocks, patents and innovations, innovation index, exports and imports of knowledge-based products, and imports of capital goods, which represent the most important explanatory variables. For collecting information in the theoretical foundations section, the library method, note-taking, and consultation of Latin sources, books, and articles relevant to the topic will be employed. Data will be obtained from the websites of the Central Bank of Iran, the World Bank, and the World Economic Forum. After extracting the research data, the variables will be calculated and processed using Excel spreadsheet software. Subsequently, to perform statistical analysis and derive reliable results for evaluating the shocks, the Structural Vector Autoregression (SVAR) model will be applied, and the model estimation will be conducted using EViews software.

Keywords: *Economic resilience, non-oil exports, trade diversification, economic shocks*

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1. Introduction

Economic resilience has become one of the most critical policy priorities for nations facing prolonged exposure to external shocks, market volatility, and geopolitical uncertainty. In oil-dependent economies, such as Iran, the ability to adapt, absorb, and recover from such disturbances defines not only the robustness of their macroeconomic systems but also their capacity for sustainable transformation [1]. Economic resilience, as a dynamic process, reflects an economy's structural capacity to anticipate risks, diversify production, and innovate in the face of shocks such as sanctions, fluctuations in oil prices, and energy transitions [2]. For Iran, which has experienced cycles of sanctions and oil revenue dependency, developing resilience mechanisms beyond petroleum exports is not merely an economic necessity but a strategic imperative to ensure long-term stability and national security [3].

The conceptual framework of economic resilience has evolved significantly over the past two decades. Early models emphasized the recovery potential of systems after shocks, while more recent theories consider resilience as an adaptive and transformative process that integrates innovation, institutional quality, and knowledge-based economic structures [4, 5]. Resilience is thus not only the ability to “bounce back” but to “bounce forward” — to emerge stronger through adaptation and reform [6]. In the context of developing and resource-dependent economies, this evolution signifies a paradigm shift: resilience now depends on structural diversification, technological advancement, and human capital formation [7].

In oil-dependent economies, economic vulnerability is typically amplified by the volatility of global energy markets, fluctuating revenues, and limited diversification [8]. The overreliance on a single export commodity, as seen in Iran and other resource-rich nations, creates cyclical exposure that weakens fiscal stability and limits policy flexibility [9]. Comparative studies in the Middle East and Central Asia show that economies with a broader production base and stronger innovation ecosystems have weathered external shocks more effectively [10]. Azerbaijan’s post-oil reforms, for instance, have emphasized non-oil industrial development and the creation of new value-added chains, which have contributed to improved fiscal resilience and employment generation [10]. Similarly, Oman’s recent economic diversification and energy transition efforts demonstrate how institutional reforms and sectoral innovation can help oil-dependent nations reduce long-term vulnerability [11].

Iran’s economic resilience must therefore be understood within the dual framework of structural diversification and energy transition. The first dimension involves reducing dependency on hydrocarbons by promoting non-oil exports, entrepreneurship, and knowledge-based industries [7, 12]. The second requires embracing sustainable energy policies, improving efficiency, and integrating renewable energy sources to mitigate the risks associated with global decarbonization [13, 14]. This duality defines the challenge faced by Iran today: while its hydrocarbon wealth remains a key fiscal pillar, its sustainability depends on transforming this dependency into a platform for technological innovation and human capital development [15].

The notion of a “resistance economy”, which emerged as a strategic doctrine in Iran’s national development discourse, embodies this objective by advocating for economic self-sufficiency, localization of technology, and endogenous growth [3]. However, true resilience requires more than self-reliance; it demands institutional reform, global competitiveness, and technological sophistication. Countries that have integrated innovation policies and science-based governance frameworks tend to recover more rapidly from crises and sustain long-term growth trajectories [5, 6]. In this respect, Iran’s emerging network of knowledge-based companies, science parks, and technology incubators has shown potential as a resilience-enhancing factor [7].

Recent empirical research emphasizes the strong correlation between economic diversification and macroeconomic stability in oil-exporting countries. The lack of diversification exposes economies to commodity price cycles, whereas diversification stabilizes revenues and encourages capital mobility toward productive sectors [16]. In the Gulf region, nations such as the United Arab Emirates and Oman have undertaken structural reforms aimed at fostering renewable energy investment, sustainable urbanization, and industrial innovation [11]. Conversely, the delayed transition in economies like Iran and Iraq has perpetuated fiscal dependence and limited the adaptive capacity of domestic industries [17].

In Iran, the challenges of achieving economic resilience are compounded by international sanctions, financial isolation, and political instability in the region [18, 19]. The reconfiguration of geopolitical alignments—particularly the involvement of global actors in Middle Eastern energy corridors—has further constrained Iran’s export opportunities and technology access [20, 21]. Nonetheless, the same geopolitical pressures have encouraged Tehran to diversify its economic partnerships, strengthen trade with neighboring states, and promote South-South cooperation, thus gradually expanding the scope of its non-oil economic activities [22].

The experience of other energy-rich economies also provides valuable lessons. In Central Asia and Eastern Europe, where external shocks and sectoral dependencies have long constrained development, policy frameworks centered on resilience economics have yielded measurable results [6]. For instance, regional economies have utilized input-output modeling to anticipate disruptions in production networks, enhancing coordination between industrial and financial systems [8]. Iran’s similar attempt to build a resilient economy must therefore align with these principles, embedding flexibility within its production, trade, and fiscal systems.

The interconnection between energy transition and economic resilience is particularly salient. As global energy systems shift toward renewables and low-carbon alternatives, the economic models of hydrocarbon exporters face an existential transformation [13]. Studies highlight that energy transition policies—such as subsidy reform, efficiency incentives, and renewable investments—can catalyze structural diversification if integrated with broader development strategies [23, 24]. For Iran, implementing such policies entails balancing environmental commitments with growth imperatives, ensuring that new energy pathways complement rather than disrupt industrial and social stability [14].

Furthermore, economic resilience depends on the strength of institutional frameworks that govern resource allocation, innovation policy, and macroeconomic management [9, 25]. The absence of transparent and adaptive governance mechanisms often undermines the effectiveness of diversification policies. In Iran, institutional inertia and centralized control have historically limited responsiveness to shocks, resulting in inefficient policy adjustments [12]. However, a shift toward data-driven policymaking, fiscal decentralization, and entrepreneurial support can strengthen adaptive capacities and enhance systemic resilience [26].

The global context further complicates Iran's pathway toward resilience. The intersection of regional conflicts, environmental degradation, and post-pandemic economic recovery has intensified the need for integrated strategies that combine energy reform, industrial modernization, and social inclusivity [27]. For oil-dependent states, achieving such integration requires reconciling short-term fiscal pressures with long-term sustainability goals [11]. International experiences reveal that resilience-oriented strategies—such as building innovation clusters, enhancing export competitiveness, and investing in green technology—yield not only economic stability but also geopolitical leverage [20, 21].

Another dimension of resilience lies in the capacity to manage external linkages within global value chains. As trade and investment patterns evolve under geopolitical competition, Iran must adapt to the realities of multipolar interdependence [15]. Collaborations with China under the Joint Comprehensive Plan of Action framework and emerging trade relations with neighboring countries represent efforts to integrate into alternative value chains while maintaining autonomy [18, 19]. These dynamics illustrate that resilience is not isolationist but relational—it requires strategic openness and diversification of partnerships to ensure economic continuity.

The knowledge-based economy (KBE) remains central to Iran's long-term economic strategy. By leveraging domestic intellectual capital, research institutions, and innovation ecosystems, Iran can strengthen its resilience against external shocks [7]. Empirical evidence confirms that investment in science, technology, and innovation directly correlates with improved employment rates, higher value-added production, and greater export flexibility [12]. Yet, such a transition demands structural reforms in finance, education, and regulatory environments to facilitate private-sector participation and reduce bureaucratic barriers [25].

At the macroeconomic level, resilience requires policies that balance stabilization and growth. Monetary and fiscal tools must be coordinated to mitigate inflationary pressures while encouraging productive investment [22]. In this regard, adaptive fiscal frameworks—such as countercyclical buffers and sovereign wealth funds—play a vital role in smoothing oil revenue fluctuations and financing diversification projects [1]. Moreover, effective trade policy should promote non-oil exports through targeted incentives, international market access, and technological upgrading [10].

Finally, economic resilience is not a static end-state but a continuous adaptive process shaped by feedback between shocks, policies, and institutional learning [4, 5]. Building resilience in Iran's economy requires a comprehensive integration of innovation, energy transition, and macroeconomic stabilization. It also demands empirical modeling to measure resilience indicators and identify the dynamic interactions among economic shocks, sectoral diversification, and knowledge-based growth [8].

Accordingly, the present study aims to measure and analyze the determinants of economic resilience in Iran's transition from an oil-based to a knowledge-based economy using the Structural Vector Autoregression (SVAR) model.

2. Methodology

The Structural Vector Autoregression (SVAR) model is used to analyze dynamic relationships and the effects of structural shocks on macroeconomic variables. By applying theoretical restrictions, this model identifies causal relationships and the responses of variables to shocks such as oil or monetary shocks. Using analytical tools such as impulse response functions (IRFs) and variance decomposition, it examines the magnitude and persistence of shocks. The SVAR framework is particularly suitable for analyzing economic resilience under unstable conditions, especially in the context of Iran. The estimation procedure includes the following steps: conducting stationarity tests (Augmented Dickey–Fuller test), determining optimal lag length using information criteria (AIC, HQ, BIC), identifying the structural form of the model through Cholesky decomposition, and performing dynamic stability tests (characteristic polynomial roots) to ensure that the model is both accurate and stable.

3. Findings and Results

The non-oil export resilience index is built from four sub-indices—growth of non-oil exports, the share of non-oil exports in total national exports, the share of Iran's non-oil exports in world exports, and the non-oil trade balance to GDP—all of which are positively associated with knowledge-based economy (KBE) indicators. Despite sanctions, non-oil exports have trended upward; however, the basket remains concentrated in raw or low–value-added goods and the share of knowledge-based items is still small, rendering resilience mostly quantitative and fragile. Principal components analysis (PCA) assigns the following weights to the standardized components: −0.083458 for growth of non-oil exports, 0.513259 for the non-oil share of national exports, 0.628284 for the non-oil share of world exports, and 0.578670 for the non-oil trade balance/GDP; applying these weights yields a composite path in which structural improvements (global share and non-oil trade balance) dominate the drag from volatile export growth. A one–standard-deviation positive shock to KBE export growth (expD) increases the non-oil export resilience index to about 2% by period 6 and then remains roughly flat through period 20; widening confidence bands at longer horizons suggest diminishing statistical precision.

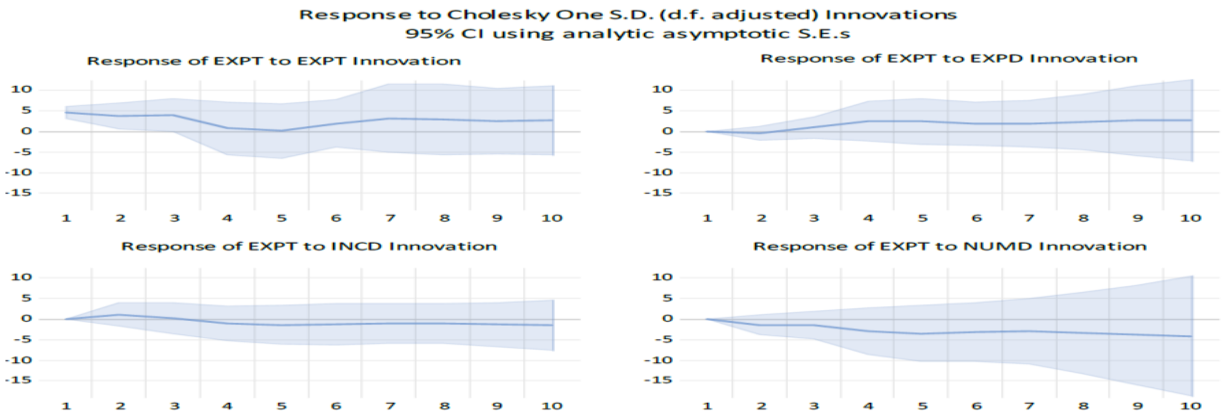

Figure 1. IRF—Non-oil export resilience to a KBE export-growth shock

The import resilience index (comprising import growth, import penetration as imports/GDP, and the shares of consumer and capital goods in total imports) is negatively related to KBE performance. From 2004 to 2024, sanctions, exchange-rate volatility, and restrictive trade policies generated instability in import dynamics; the 2018–2020 contraction in key inputs raised costs and strained production. Concentration on a few origin countries further reduced diversification and elevated exposure. PCA weights for standardized components are 0.157100 for import growth, 0.386986 for import penetration, 0.642480 for the consumer-goods share, and −0.642480 for the capital-goods share; the composite weakens when consumer-goods dependence rises and capital-goods share falls. An expD shock lifts the import resilience index by about 1% in period 3, then converges to zero by period 4 and stabilizes thereafter—an interpretable short-run co-movement as export upscaling temporarily pulls in imported intermediates.

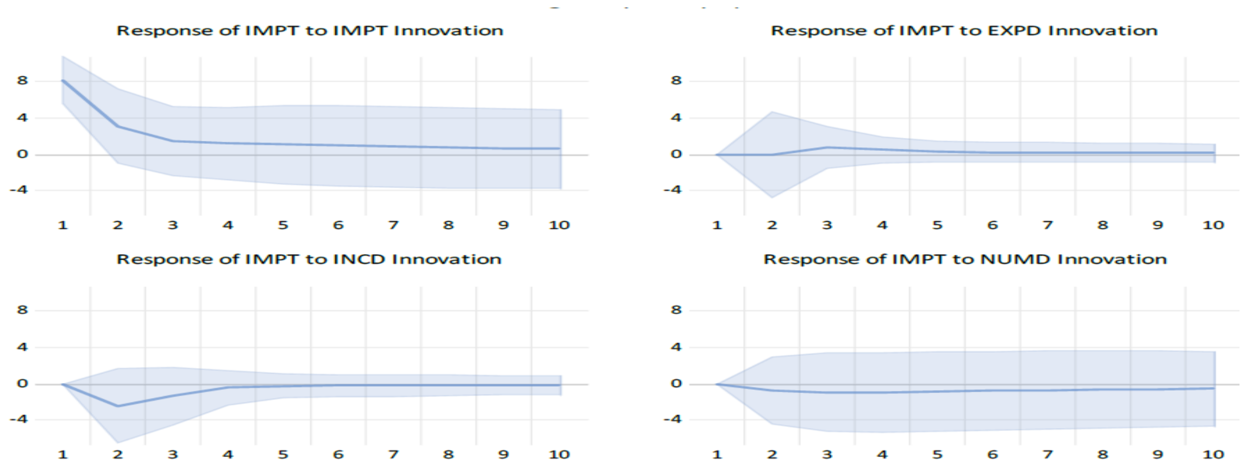

Figure 2. IRF—Import resilience to a KBE export-growth shock

The trade-globalization resilience index aggregates exports/GDP, exports/world output, imports/world output, the non-oil trade balance/GDP, and trade intensity (exports+imports)/GDP; each component is positively related to KBE. Nonetheless, Iran's position in trade globalization remains sub-optimal due to sanctions, financial frictions, infrastructure/institutional constraints, and limited trade agreements, which suppress participation in global value chains and the benefits of technology transfer. PCA assigns 0.484941 to exports/GDP, 0.331312 to exports/world output, 0.440594 to imports/world output, −0.478832 to the non-oil trade balance/GDP, and 0.481312 to trade intensity; the composite strengthens with export-led openness. A one–standard-deviation positive expD shock lifts the index by roughly 1.5% at period 2 before decaying to zero, consistent with an export-led openness channel.

Figure 3. IRF—Trade globalization resilience to a KBE export-growth shock

The trade-diversification resilience index uses four concentration-style sub-indices: the shares of the top five import items in total imports, the top five non-oil export items in total exports, exports to the top four destinations, and imports from the top four origins. Each concentration measure is negatively related to KBE (i.e., lower concentration/higher diversity aligns with stronger KBE). In Iran, concentration in natural resources and basic metals and narrow partner portfolios (e.g., Iraq, Afghanistan, Türkiye, China) increase exposure to external shocks. PCA weights are 0.454909 for the top-five import share, 0.574577 for the top-five non-oil export share, 0.408153 for the top-four export destinations share, and 0.544361 for the top-four import origins share; the composite improves as these concentration shares decline. A positive expD shock initially reduces the diversification resilience index by about 10% at period 2 (reflecting a short-run concentration effect), rebounds to approximately zero by period 3, and then drifts slightly positive with very small magnitude.

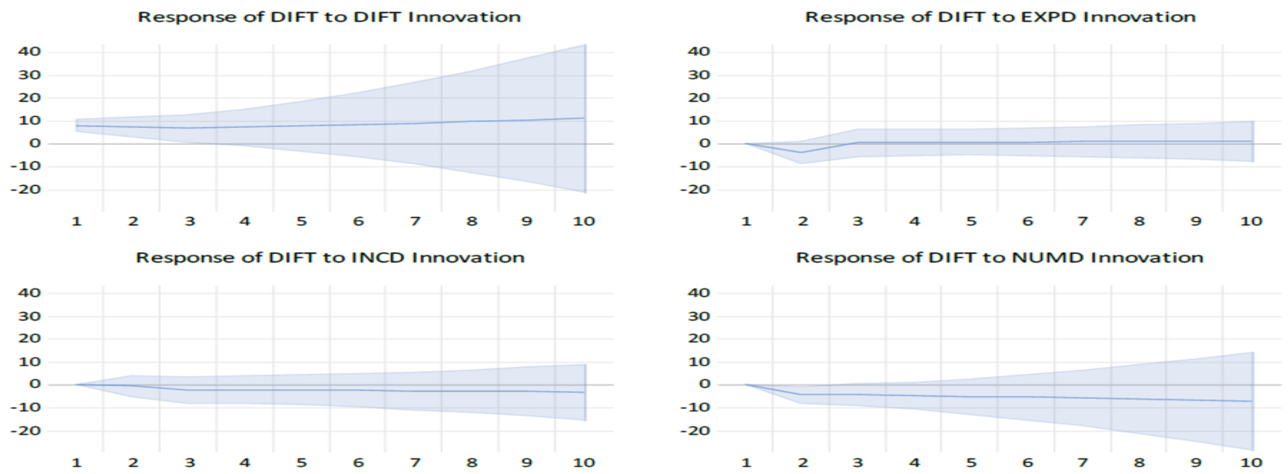

Figure 4. IRF—Trade diversification resilience to a KBE export-growth shock

The macroeconomic stability resilience index (unemployment rate, inflation rate, misery index) is negatively related to KBE; stronger KBE typically coincides with lower unemployment, lower inflation, and a lower misery index. Persistent inflation, exchange-rate volatility, policy uncertainty, and fiscal deficits, however, complicate planning and elevate risk premia. Following a positive expD shock, the macro stability index falls by about 4% at period 2, returns to near zero by period 3, turns modestly positive, then declines again after period 6 and converges to zero—indicating short-run frictions around rapid export expansions before re-equilibration.

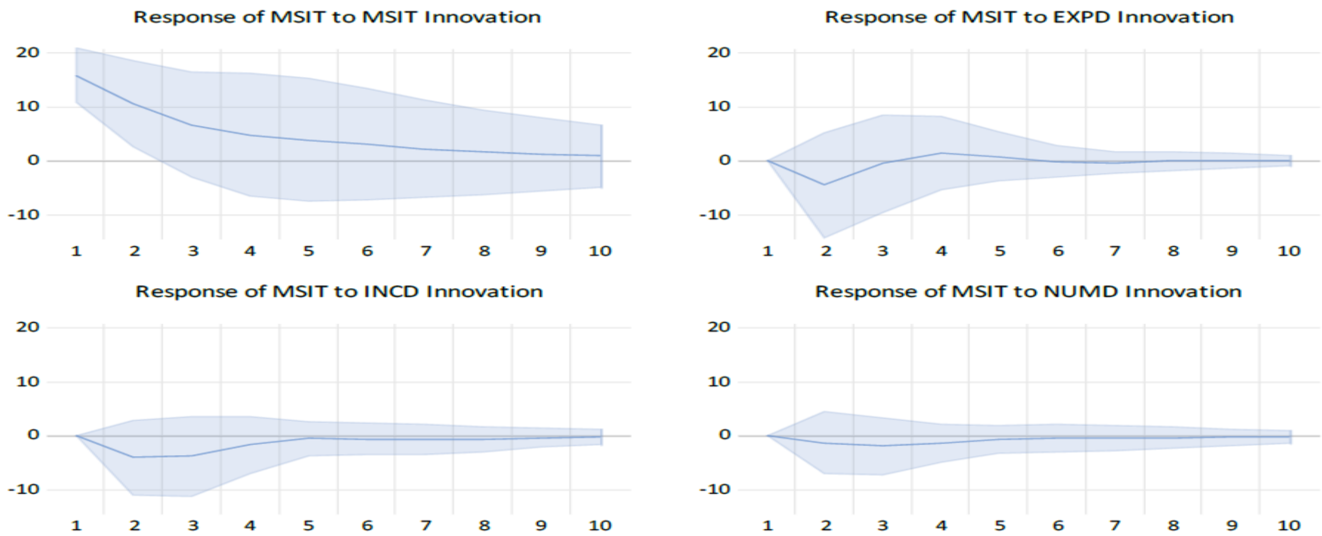

Figure 5. IRF—Macroeconomic stability resilience to a KBE export-growth shock

Stationarity diagnostics confirm that all variables are integrated of order one. Specifically, for levels versus first differences (MacKinnon p-values), non-oil export resilience (expT) is 0.1168 at level and 0.0142 at first difference; import resilience (impT) 0.2604 and 0.0001; trade-globalization resilience (intT) 0.3958 and 0.0001; trade-diversification resilience (difT) 0.1678 and 0.0001; macro stability resilience (msiT) 0.3123 and 0.0023; KBE firm growth (numD) 0.8226 and 0.0035; KBE sales growth (incD) 0.1328 and 0.0004; and KBE export growth (expD) 0.8522 and 0.0000, validating Johansen–Juselius cointegration analysis across models.

Table 1. Unit-root tests (levels vs. first differences, MacKinnon p-values)

Series	Level p-value	First Difference p-value
Non-oil export resilience (expT)	0.1168	0.0142
Import resilience (impT)	0.2604	0.0001
Trade globalization resilience (intT)	0.3958	0.0001
Trade diversification resilience (difT)	0.1678	0.0001
Macro stability resilience (msiT)	0.3123	0.0023
KBE firm growth (numD)	0.8226	0.0035
KBE sales growth (incD)	0.1328	0.0004
KBE export growth (expD)	0.8522	0.0000

Lag-length selection supports parsimonious dynamics tailored to each index. For the non-oil export model, the preferred lag is 2 based on LR = 43.74933*, FPE = 2.22×10^{9}*, AIC = 32.47765*, SC = 34.25839*, and HQ = 32.72319* at lag 2 (versus lag 1: LogL = −279.488, FPE = 3.53×10^{9}, AIC = 33.27649; lag 0: LogL = −309.776, FPE = 1.63×10^{10}, AIC = 34.86404). For the import model, the preferred lag is 1 (LogL = −296.2523; FPE = 2.27×10^{10}*; AIC = 35.13915*), noting that SC and HQ at lag 0 are 35.43177* and 35.26119*. For the trade-globalization model, the preferred lag is 1 (LR = 29.69466*; FPE = 4.51×10^{9}*; AIC = 33.52035*; HQ = 33.65677*), with SC at lag 0 = 34.22464*. For the trade-diversification model, the working lag is 1 (LR = 32.09271*; FPE = 1.77×10^{10}*; HQ = 35.02337*), although AIC marginally prefers lag 2 (34.81987*); parsimony and comparability support lag 1. For macro stability, the preferred lag is 2 (LR = 41.86932*; FPE = 2.12×10^{10}*; AIC = 35.06815*; SC = 36.05745*; HQ = 35.20456*).

Table 2. Optimal lag selection (concise summary; * indicates criterion selection)

Model	Preferred Lag	Key Criteria Supporting
Non-oil export resilience (expT)	2	LR, FPE, AIC, SC, HQ
Import resilience (impT)	1	FPE, AIC
Trade globalization resilience (intT)	1	LR, FPE, AIC, HQ
Trade diversification resilience (difT)	1	LR, FPE, HQ (AIC≈2 lags)
Macro stability resilience (msiT)	2	LR, FPE, AIC, SC, HQ

Cointegration analysis for the non-oil export resilience model identifies one cointegrating vector by both Trace and Max-eigen tests. The Trace statistic is 70.6491, exceeding the 5% critical value of 47.8561 with p = 0.0001, and the Max-eigen statistic is 54.4425, exceeding 27.5843 with p = 0.0000. The estimated long-run relation (dependent variable: non-oil export resilience) shows positive and statistically meaningful long-run coefficients of 1.6965 on KBE firm growth (numD) and 0.3830 on KBE export growth (expD), while KBE sales growth (incD) does not display a significant positive effect. In the short-run error-correction specification, the reported lagged coefficients are 0.0176 on expD(−1) with standard error 0.0468 and t = 0.37648, −0.1029 on incD(−1) with standard error 0.0102 and t = −10.0698, and 2.5146 on numD(−1) with standard error 0.7628 and t = 3.29647; the constant is −29.3125.

Table 3. Johansen cointegration—Non-oil export resilience (expT)

Test	Statistic	5% Critical Value	p-value	Decision
Trace	70.6491	47.8561	0.0001	1 cointegrating vector
Max-eigen	54.4425	27.5843	0.0000	1 cointegrating vector

For the import resilience model, both tests indicate no cointegration at the 5% level. The Trace statistic for r = 0 is 46.7087 (p = 0.0638), with subsequent values 26.2085 (p = 0.1226), 7.8662 (p = 0.4798), and 0.4943 (p = 0.4820). The Max-eigen statistics are 20.5002 (p = 0.3075), 18.3423 (p = 0.1175), 7.3719 (p = 0.4461), and 0.4943 (p = 0.4820). A long-run relation is nevertheless reported for comparability: impT = −0.3538 expD + 0.0136 incD + 0.6760 numD, implying a negative association with expD and positive associations with incD and numD. Short-run error-correction coefficients (reported) are −0.3538 on expD(−1) with standard error 0.0838 and t = −4.22229, 0.0136 on incD(−1) with standard error 0.0330 and t = 0.40974, and 0.6760 on numD(−1) with standard error 1.8995 and t = 0.35589; the constant is −34.3457.

Table 4. Johansen cointegration—Import resilience (impT)

Test	Statistic	5% Critical Value	p-value	Decision
Trace	46.7087	47.8561	0.0638	No cointegration
Max-eigen	20.5002	27.5843	0.3075	No cointegration

Trade-globalization resilience exhibits one cointegrating vector by both tests. The Trace statistic is 48.1893 ($p = 0.04649$) and the Max-eigen statistic is 29.6036 ($p = 0.0271$), each exceeding its respective 5% critical value. The reported long-run specification is intT = −0.1644 expD + 0.0275 incD − 0.0495 numD; as discussed in the source, the magnitudes 0.1644 (expD) and 0.0495 (numD) are interpreted as positive contributions in the long run, while incD does not exhibit a significant positive effect. In the short run, the reported coefficients are −0.1640 on expD(−1) with standard error 0.0306 and t = −5.36272, 0.0275 on incD(−1) with standard error 0.0117 and t = 2.33605, and −0.0495 on numD(−1) with standard error 0.7037 and t = −0.07040; the constant is −25.2267.

Table 5. Johansen cointegration—Trade globalization resilience (intT)

Test	Statistic	5% Critical Value	p-value	Decision
Trace	48.1893	47.8561	0.04649	1 cointegrating vector
Max-eigen	29.6036	27.5843	0.0271	1 cointegrating vector

Trade-diversification resilience also shows one cointegrating vector. The Trace statistic is 48.4984 ($p = 0.0434$) and the Max-eigen statistic is 28.7871 ($p = 0.0349$), both above the 5% critical values. The long-run relation is difT = 0.9445 expD − 0.0291 incD + 1.7621 numD, implying positive and meaningful long-run effects of expD (0.9445) and numD (1.7621), while incD is not significantly positive. Short-run error-correction estimates report 0.9445 on expD(−1) with standard error 0.1423 and t = 6.63464, −0.0291 on incD(−1) with standard error 0.0521 and t = −0.55949, and 1.7621 on numD(−1) with standard error 3.1728 and t = 0.55537; the constant is −107.5005.

Table 6. Johansen cointegration—Trade diversification resilience (difT)

Test	Statistic	5% Critical Value	p-value	Decision
Trace	48.4984	47.8561	0.0434	1 cointegrating vector
Max-eigen	28.7871	27.5843	0.0349	1 cointegrating vector

In the macroeconomic stability model, the Trace test points to one cointegrating vector while the Max-eigen test does not. The Trace statistic for $r = 0$ is 48.7126 ($p = 0.0414$), whereas the Max-eigen for $r = 0$ is 23.3991 ($p = 0.1570$), below the 5% threshold. The reported long-run equation is msiT = 0.3392 expD + 0.0689 incD + 4.3680 numD, indicating positive long-run associations with all three KBE variables; the source text notes an internal inconsistency regarding the significance of incD, which is retained here verbatim. In the short-run representation, coefficients on expD(−1), incD(−1), and numD(−1) are 0.3392 (standard error 0.0545; t = 6.22104), 0.0689 (0.0229; t = 3.00279), and 4.3680 (1.2105; t = 3.60829), respectively; the constant is −98.3864.

Table 7. Johansen cointegration—Macroeconomic stability resilience (msiT)

Test	Statistic	5% Critical Value	p-value	Decision
Trace	48.7126	47.8561	0.0414	1 cointegrating vector
Max-eigen	23.3991	27.5843	0.1570	Not significant

Synthesizing across indices, KBE dynamism—especially the growth of KBE exports (expD) and the formation of KBE firms (numD)—is associated with stronger non-oil export and trade-globalization resilience, gradual improvements in diversification following a short-run concentration dip, and mixed but interpretable macro-stability responses (short-run frictions followed by re-equilibration). Import resilience exhibits a short-lived positive co-movement with export surges, reflecting imported inputs during scaling, while its longer-run behavior aligns with reduced external dependence as capital-goods shares recover and consumer-goods reliance recedes.

4. Discussion and Conclusion

The findings of this study, based on the Structural Vector Autoregression (SVAR) model, reveal several significant relationships between the dynamics of Iran's knowledge-based economy (KBE) and various dimensions of economic resilience. The results demonstrate that the growth of knowledge-based companies and their exports has a substantial positive effect on non-oil export resilience and trade globalization resilience, while their influence on macroeconomic stability and trade diversification is mixed. These results indicate that the expansion of the KBE contributes meaningfully to enhancing Iran's capacity to withstand and adapt to economic shocks, particularly those related to oil price volatility and international sanctions. The positive impulse responses of non-oil export resilience and trade globalization to KBE export growth confirm that innovation-driven sectors play a decisive role in strengthening the country's adaptive capacity. This aligns with the theoretical foundations of resilience economics, which emphasize that innovation and knowledge diffusion enhance structural flexibility and accelerate post-shock recovery [1, 4].

The significant long-term relationship between the number of knowledge-based companies (numD) and non-oil export resilience supports the hypothesis that diversification through high-tech and medium-tech industries can reduce Iran's vulnerability to external shocks. As the SVAR results show, a one-unit increase in the growth of knowledge-based firms leads to a 1.69-unit increase in the non-oil export resilience index, highlighting the pivotal contribution of entrepreneurial dynamism to economic sustainability. This finding resonates with previous empirical evidence that links knowledge-intensive activities with export competitiveness and resilience [7, 9, 25]. According to [12], expanding the innovation ecosystem and supporting private-sector participation in research and development are essential for maintaining export growth under sanction-induced constraints. Similar to the experiences of Azerbaijan and Oman, Iran's economic resilience improves when policy shifts favor the development of non-oil industries and export diversification [10, 11].

The observed improvement in trade globalization resilience following positive shocks to KBE export growth also corroborates the view that technological advancement and international integration reinforce each other. The SVAR results show that shocks to knowledge-based exports yield an immediate increase of about 1.5% in the trade globalization index before stabilizing, suggesting that innovation enhances Iran's participation in global value chains. These results are consistent with [5], who argued that economic resilience depends on a region's adaptive capacity to embed innovation into its global economic interactions. Moreover, the outcome parallels findings from cross-country analyses demonstrating that economies with higher levels of technological capability and diversified export portfolios achieve more stable growth trajectories despite external volatility [6, 8].

In contrast, the results for the import resilience index present a more complex picture. While the short-term impulse responses suggest that KBE expansion temporarily increases import resilience due to rising demand for imported intermediate goods, the long-run relationship between KBE variables and import resilience is not statistically significant. This finding can be interpreted in the context of Iran's structural import dependency, where many high-tech industries rely on imported capital goods and raw materials. Similar challenges have been identified in studies of energy-exporting economies that face constraints in domestic production capacity and financial openness [15, 22]. The temporary positive impact on import resilience may reflect transitional adjustments as knowledge-based sectors expand, consistent with [24], who observed that early stages of industrial transformation often increase external dependence before localization processes take hold.

The results for trade diversification resilience demonstrate a dual pattern. In the short term, positive shocks to KBE exports reduce diversification, indicating an initial concentration effect, possibly because new knowledge-based firms target specific regional markets with limited product range. However, in the long run, the SVAR estimates reveal significant positive effects of both knowledge-based firm growth and exports on trade diversification resilience. This long-term improvement highlights the gradual structural transformation of Iran's export composition. It aligns with the experience of countries that achieved diversification through sustained innovation policies, such as Malaysia and the UAE, as discussed by [11] and [16]. These results also echo [9], who emphasized that knowledge-based diversification reduces the amplitude of economic fluctuations and increases systemic adaptability.

Macroeconomic stability resilience presents another interesting dimension. The study found that KBE growth has a positive long-run association with macroeconomic stability, although short-term fluctuations may temporarily destabilize inflation and employment. These short-run instabilities are typical of economies undergoing technological transition, where structural shifts alter labor demand and investment patterns. [13] argued that such transitional volatility is an unavoidable part of energy-dependent economies adapting to knowledge-based frameworks. Nevertheless, the long-run positive coefficients for KBE indicators suggest that institutional learning and innovation-driven growth eventually contribute to a more stable macroeconomic environment. This is consistent with [25], who identified a long-term equilibrium between knowledge-based growth and reduced economic vulnerability in Iran during the period from 1996 to 2013.

The overall results of this research confirm that **economic resilience is a multidimensional construct**—it is shaped not only by structural diversification but also by institutional learning, technological absorption, and policy adaptation. The SVAR model reveals that KBE variables significantly explain variance in the resilience indices, particularly in the domains of non-oil exports and trade globalization. The positive role of innovation-driven sectors is also emphasized by [2], who proposed that post-disaster economic recovery depends on flexibility, redundancy, and adaptive learning—principles that mirror the mechanisms observed in Iran's emerging knowledge-based sectors. The impulse-response analysis further reinforces the notion that shocks from KBE expansion have sustained positive effects on export-related resilience, whereas their effects on macroeconomic and trade stability are transitory but trend toward equilibrium.

These results also have clear policy implications. They underline the necessity for Iran to shift from a reactive economic strategy to a proactive diversification policy that links innovation, entrepreneurship, and non-oil sector development. [3] highlighted that Iran's concept of a "resistance economy" can achieve sustainability only when coupled with scientific and technological advancement. Similarly, [10] and [11] demonstrated that coordinated fiscal and industrial reforms are key to unlocking the potential of non-oil sectors in resource-dependent economies. The findings from this study confirm that without a deliberate policy shift toward knowledge-based industrialization, Iran's resilience will remain fragile and heavily dependent on exogenous oil revenues.

The empirical evidence also supports the idea that Iran's KBE-driven resilience is constrained by geopolitical, institutional, and structural factors. Sanctions have limited international cooperation and technology transfer, while domestic institutional rigidity has slowed the translation of innovation into large-scale industrial output [18, 19]. Nevertheless, the adaptive behavior observed in Iran's technology and entrepreneurship sectors demonstrates latent potential for recovery and innovation-led resilience. This reflects the evolutionary perspective of regional resilience proposed by [4] and further elaborated by [5], emphasizing that resilience is not the absence of vulnerability but the capacity for adaptation and transformation through learning.

The findings are also in line with global energy transition trends. As energy exporters worldwide face growing decarbonization pressures, resilience increasingly depends on their ability to diversify energy portfolios and innovate within the renewable sector [13, 23]. The Iranian case mirrors this global shift: while its hydrocarbon sector remains vital, the gradual rise of green technologies, biorefineries, and knowledge-intensive industries signals a potential transition pathway [28]. As [24] emphasized, integrating sustainable development goals into energy policy is a critical precondition for achieving balanced growth in oil-dependent nations. Hence, Iran's economic resilience strategy must be embedded within its broader energy transition policy, balancing immediate fiscal needs with long-term sustainability [14].

In comparison with regional patterns, the study's results are consistent with [22], who reported that sectoral fluctuations in Iran between 2010 and 2021 were primarily driven by uneven growth across oil, manufacturing, and service sectors. The present findings extend this insight by showing that knowledge-based firms can mitigate these sectoral imbalances by fostering inter-sectoral linkages and promoting innovation spillovers. [26] also noted that economic shocks tied to geopolitical tensions, such as the Israel–Iran conflict, can be softened through investment diversification and technology-led resilience. Thus, strengthening the KBE not only enhances Iran's economic adaptability but also contributes to its geopolitical stability and international positioning [20, 21].

Overall, the discussion indicates that Iran's transition from an oil-based to a knowledge-based economy has measurable positive effects on multiple dimensions of economic resilience. The SVAR analysis provides empirical evidence that innovation-driven growth stimulates export diversification, enhances trade integration, and supports macroeconomic balance over time. However, these benefits are neither automatic nor evenly distributed—they require sustained policy commitment, institutional reform, and strategic investment in human and technological capital [7, 12]. As global economic structures evolve toward decarbonization and digitalization, Iran's resilience will increasingly depend on its ability to embed innovation, reduce energy dependence, and cultivate adaptive governance systems that foster long-term competitiveness [11, 16].

This study has several limitations that should be acknowledged. First, the use of secondary macroeconomic data constrained the ability to capture micro-level dynamics such as firm-level innovation performance, entrepreneurial risk behavior, or knowledge transfer efficiency. The reliance on aggregate indices may obscure regional variations in resilience capacity across different provinces of Iran. Second, while the SVAR model effectively identifies dynamic interactions and causal patterns among variables, it is inherently sensitive to model specification and lag selection, meaning that alternative identification structures could yield slightly different results. Third, due to data limitations, the study focuses primarily on economic indicators, while institutional and environmental dimensions of resilience—such as governance quality, social capital, and environmental sustainability—were not quantitatively assessed. Finally, external shocks such as sanctions or political instability were treated as exogenous variables, though their complex feedback loops with domestic policy and global markets could merit a more sophisticated modeling approach in future research.

Future research could expand this study by incorporating micro-level data on knowledge-based companies, including R&D investment, innovation output, and employment patterns, to better understand the transmission mechanisms between innovation and resilience. Further comparative studies among Middle Eastern and Central Asian economies would provide valuable cross-national insights into how similar resource-dependent countries manage structural transformation and resilience building. Additionally, integrating environmental resilience indicators—such as renewable energy investment, carbon intensity reduction, and climate adaptation measures—would allow for a more holistic understanding of sustainable resilience. Advanced econometric approaches, including panel cointegration and dynamic stochastic general equilibrium (DSGE) models, could also be applied to test the robustness of the relationships identified here. Finally, qualitative analyses involving policy experts, entrepreneurs, and regulators could complement quantitative findings and offer more context-sensitive interpretations of Iran's transition toward a knowledge-based and resilient economy.

To enhance Iran's economic resilience, policymakers should prioritize the institutionalization of innovation policies within fiscal and industrial frameworks, ensuring consistent support for knowledge-based firms and export diversification initiatives. Expanding access to finance for startups, reforming intellectual property systems, and improving science–industry collaboration are essential for deepening the knowledge-based ecosystem. The government should also pursue a balanced energy transition strategy that reduces reliance on oil revenues while promoting investment in renewables, energy efficiency, and green technologies. Enhancing trade partnerships, particularly with emerging economies in Asia and Eurasia, can further integrate Iran into global value chains and reduce its exposure to sanctions. Lastly, fostering a culture of adaptive policymaking—based on data, transparency, and participation—will be crucial in ensuring that resilience is embedded not only in economic structures but also in governance practices.

Authors' Contributions

Authors equally contributed to this article.

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Declaration of Interest

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Ethical Considerations

All procedures performed in this study were under the ethical standards.

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