Analysis of the Effect of Energy Price Volatility on the Export Competitiveness of Iranian Industries

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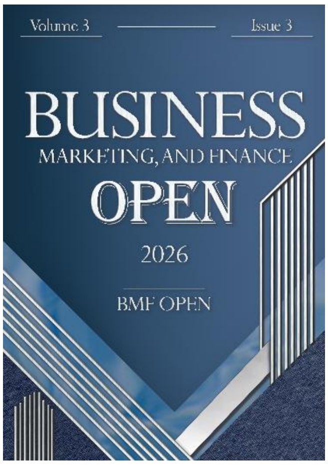

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Abstract: The present study aimed to analyze the effect of energy price volatility on the export competitiveness of Iranian industries and to examine the mediating roles of production cost pressure and pricing flexibility in this relationship. The study was conducted using an applied, quantitative, descriptive-correlational design with a structural equation modeling approach. The statistical population consisted of managers, export specialists, financial experts, production supervisors, and strategic planning professionals working in export-oriented industrial firms located in Tehran. Using purposive sampling and inclusion criteria related to professional experience and familiarity with export activities, 312 participants were selected as the final sample. Data were collected using a researcher-developed questionnaire and a secondary-data checklist related to energy prices, industrial costs, and export indicators. The questionnaire assessed energy price volatility, production cost pressure, pricing flexibility, export competitiveness, export market stability, and vulnerability to external shocks using a five-point Likert scale. Content validity was confirmed by experts in industrial economics and international trade, while reliability was verified through Cronbach's alpha coefficients above 0.70. Data analysis was performed using SPSS-27 and AMOS software through descriptive statistics, Pearson correlation analysis, multiple regression analysis, confirmatory factor analysis, and structural equation modeling. The findings indicated that energy price volatility had a significant negative relationship with export competitiveness ($r = -0.68$, $p < 0.01$) and pricing flexibility ($r = -0.52$, $p < 0.01$), while showing a significant positive relationship with production cost pressure ($r = 0.71$, $p < 0.01$) and vulnerability to external shocks ($r = 0.77$, $p < 0.01$). Multiple regression analysis demonstrated that energy price volatility significantly predicted export competitiveness ($\beta = -0.39$, $p < 0.001$). Structural equation modeling further confirmed that energy price volatility exerted both direct and indirect negative effects on export competitiveness through increased production cost pressure and reduced pricing flexibility. The final structural model demonstrated acceptable fit indices (CFI = 0.94, RMSEA = 0.067, SRMR = 0.049), confirming the adequacy of the proposed conceptual framework. The results demonstrated that instability in energy prices significantly weakens the export competitiveness of Iranian industries by increasing production costs, reducing strategic pricing flexibility, and intensifying firms' vulnerability to external economic shocks. Sustainable industrial competitiveness therefore requires coordinated energy, industrial, and trade policies aimed at improving energy efficiency, reducing dependence on volatile energy inputs, strengthening operational flexibility, and enhancing firms' resilience in international markets.

Keywords: Energy Price Volatility, Export Competitiveness, Iranian Industries, Production Cost Pressure, Pricing Flexibility, Industrial Exports, Energy Economics

1. Introduction

Energy has long been recognized as one of the most strategic inputs in industrial production and international trade. In modern economies, fluctuations in energy prices influence not only production costs and macroeconomic stability but also the competitiveness of firms operating in regional and global markets. Industrial sectors, especially energy-intensive industries, rely heavily on stable and affordable energy supplies to sustain productivity, maintain cost efficiency, and preserve export market positions. Consequently, volatility in energy prices has become one of the most important economic challenges affecting industrial development and export-oriented growth strategies across both developed and developing countries. Recent global developments, including geopolitical conflicts, post-pandemic supply chain disruptions, sanctions, trade restrictions, and uncertainty in global energy markets, have intensified concerns regarding the relationship between energy price instability and export competitiveness [1-3].

In recent decades, the international economy has experienced repeated episodes of energy market instability that have significantly influenced industrial performance and trade dynamics. Crude oil price shocks, fluctuations in natural gas prices, and uncertainty surrounding energy supply chains have increased production costs and weakened economic predictability for many industrial economies. Industrial firms that depend heavily on fossil fuels often face serious challenges in maintaining stable export prices and preserving competitiveness during periods of energy market turbulence. These challenges become even more severe in countries where industrial structures remain highly dependent on subsidized energy systems or resource-based production models. Studies have demonstrated that unstable energy prices can reduce industrial productivity, increase operational risks, weaken investment incentives, and undermine firms' capacity to compete internationally [4-6].

The concept of export competitiveness refers to the ability of firms or industries to produce goods and services that can successfully compete in international markets while maintaining or improving profitability, market share, and long-term growth. Export competitiveness depends on multiple factors, including technological capability, production efficiency, cost structures, exchange rates, institutional quality, infrastructure, innovation, and energy accessibility. Among these variables, energy prices occupy a particularly important position because they directly affect transportation costs, manufacturing expenses, supply chain efficiency, and pricing strategies. In energy-intensive industries such as petrochemicals, metals, cement, mining, and manufacturing, even moderate increases in energy prices may substantially reduce firms' ability to maintain competitive export prices. Therefore, energy price volatility is increasingly viewed not merely as a macroeconomic issue but also as a structural determinant of industrial competitiveness and trade sustainability [7-9].

The relationship between energy markets and industrial competitiveness has become more complex in the context of globalization and economic interdependence. Global supply chains require stable production environments and predictable cost structures, while energy price instability introduces uncertainty into industrial planning and international trade agreements. Recent crises, including the COVID-19 pandemic and geopolitical conflicts affecting global energy flows, have revealed the vulnerability of industrial economies to sudden energy disruptions. Financial markets, industrial sectors, and export activities have all been affected by these developments, highlighting the strategic importance of energy security and price stability in sustaining industrial competitiveness [1, 10, 11]. In many countries, firms have experienced declining export performance due to rising production costs and reduced flexibility in responding to foreign market conditions.

Studies conducted in various national contexts confirm that energy price volatility significantly affects economic performance and industrial sectors. Research on Pakistan demonstrated that fluctuations in oil prices negatively affected stock market sectors closely connected to industrial activity and production costs [4]. Similarly, evidence from China indicated that crude oil price instability exerted strong effects on industrial and financial sectors, reducing predictability in economic planning and increasing uncertainty for manufacturing firms [5]. Research on Kenya also found that oil price volatility negatively influenced economic performance and market indicators, illustrating the broader economic consequences of unstable energy markets [12]. These findings collectively suggest that energy price fluctuations can weaken industrial confidence, reduce investment stability, and undermine export-oriented economic activities.

Energy dependency is another important factor shaping industrial competitiveness. Countries with high dependence on imported energy or unstable domestic energy markets are often more vulnerable to macroeconomic volatility and external shocks. Research conducted among OECD countries showed that energy dependency contributes significantly to macroeconomic instability and reduces economic resilience during global crises [2]. Similarly, studies focusing on energy-exporting countries found that energy demand security and sustainable energy management play important roles in maintaining international competitiveness [7]. These findings are particularly relevant for countries such as Iran, where industrial production is strongly connected to energy pricing policies and fluctuations in global energy markets.

Iran represents a unique case in the study of energy price volatility and export competitiveness. The Iranian economy is heavily dependent on oil and gas revenues, while many industrial sectors benefit from historically subsidized energy prices. Although subsidized energy has provided short-term advantages for domestic industries, fluctuations in global oil prices, sanctions, inflationary pressures, exchange rate instability, and domestic energy policy reforms have created substantial uncertainty for industrial firms. Energy-intensive industries in Iran, including petrochemicals, steel, aluminum, cement, and manufacturing sectors, rely heavily on predictable energy costs to sustain production efficiency and maintain export competitiveness. However, recent increases in energy tariffs, subsidy reforms, and volatility in global energy markets have intensified concerns regarding the sustainability of industrial exports.

The interaction between energy price volatility and export competitiveness becomes particularly important in economies characterized by structural dependence on natural resources. Resource-dependent economies often experience what is known as “commodity vulnerability,” where fluctuations in global commodity prices create instability in industrial production and trade performance. Research on Azerbaijan demonstrated that oil-dependent countries frequently face significant challenges in diversifying non-oil exports because fluctuations in energy markets distort investment incentives and weaken industrial diversification strategies [13]. Similar findings have been reported for Russia, where specialization in resource-based trade structures increased vulnerability to changes in the international economic environment [14]. Such evidence highlights the importance of industrial diversification and strategic energy management in maintaining sustainable export competitiveness.

Industrial policy also plays a central role in shaping the relationship between energy prices and export performance. Effective industrial policies can reduce vulnerability to energy shocks by encouraging technological upgrading, energy efficiency, diversification of production structures, and innovation-driven competitiveness. Comparative evidence from Brazil and Mexico demonstrated that industrial policy significantly influenced the co-evolution of trade structures, foreign investment, and industrial competitiveness [15]. Likewise, ecological planning and structural transformation policies have been identified as critical mechanisms for reducing economic dependence on volatile energy markets and improving long-term industrial sustainability [16]. These perspectives suggest that export competitiveness is not solely determined by market forces but also by institutional and policy frameworks shaping industrial adaptation to energy volatility.

Theoretical perspectives on competitiveness emphasize that industries capable of adapting to uncertainty and maintaining strategic flexibility are more likely to preserve competitive advantages in international markets. Inter-industry trade models demonstrate that business cycle fluctuations and cost instability significantly affect industrial dynamics and export structures [17]. Energy price volatility contributes to these fluctuations by increasing uncertainty in production planning and reducing firms' ability to maintain stable long-term contracts. This issue is especially important for export-oriented firms that compete in highly price-sensitive global markets where even small cost increases may reduce market share.

Another important issue concerns the relationship between energy prices and broader macroeconomic conditions. Rising energy prices often contribute to inflationary pressures, exchange rate instability, and reduced purchasing power, all of which affect industrial competitiveness. Studies focusing on Malaysia and China found that energy price dynamics influence economic growth, ecological systems, and industrial structures simultaneously [18, 19]. In Pakistan, uncertainty in power generation and industrial energy consumption contributed to de-industrialization and weakened industrial growth [20]. These findings demonstrate that energy volatility affects not only production costs but also broader structural dimensions of economic development and industrial sustainability.

Global geopolitical developments have further intensified the strategic significance of energy price stability. Trade conflicts, sanctions, and wars have disrupted global energy markets and increased uncertainty surrounding international trade relationships. The war-related disruption of Russia–European Union trade relations illustrated how geopolitical instability can transform energy markets and industrial competitiveness simultaneously [21]. Similarly, protectionist policies in critical mineral supply chains have been shown to exacerbate inequalities and distort the global energy transition process [3]. These developments are highly relevant for Iran, where geopolitical pressures and sanctions have significantly influenced energy exports, industrial financing, and international trade relationships.

Empirical studies also indicate that volatility in oil and gas markets influences financial systems, exchange rates, and external reserves. Research conducted in Nigeria demonstrated that oil market instability affected external reserves and economic stability over long historical periods [22]. Liquefied natural gas exports were likewise found to significantly influence exchange rate dynamics and macroeconomic performance [23]. In Turkey, oil and natural gas prices affected stock exchange indices and sectoral financial performance [24]. These findings collectively illustrate the interconnectedness of energy markets, financial systems, industrial sectors, and export activities.

The literature further shows that uncertainty plays a central role in determining firms' responses to energy market fluctuations. During periods of uncertainty, firms often delay investment decisions, reduce production expansion, and adopt defensive strategies aimed at minimizing risk exposure. The COVID-19 crisis demonstrated how uncertainty in the energy sector could rapidly spread across industrial and financial systems [10]. Such uncertainty weakens firms' confidence in long-term export planning and reduces their willingness to invest in innovation, technological upgrading, and market expansion. For countries seeking to strengthen industrial exports, understanding the mechanisms through which energy price volatility influences competitiveness therefore becomes critically important.

Despite the growing body of international research on energy markets and industrial competitiveness, relatively limited empirical attention has been devoted to examining this relationship within the context of Iranian industries. Most existing studies have focused either on macroeconomic effects of oil prices or on financial market responses, while fewer investigations have directly analyzed how energy price volatility affects the export competitiveness of industrial firms. Moreover, the unique institutional and economic structure of Iran, including subsidy systems, sanctions, exchange rate instability, and dependence on energy-intensive industries, necessitates context-specific research capable of explaining the strategic consequences of energy market instability for industrial exports.

Given the importance of industrial exports for economic growth, foreign exchange earnings, employment generation, and economic diversification in Iran, investigating the impact of energy price volatility on export competitiveness possesses considerable theoretical and practical significance. Understanding this relationship may help policymakers design more effective industrial, energy, and trade policies aimed at reducing vulnerability to energy shocks and strengthening the resilience of export-oriented industries. It may also assist industrial managers in developing adaptive strategies for cost management, pricing flexibility, and long-term competitiveness in unstable energy environments.

Therefore, the present study aims to analyze the effect of energy price volatility on the export competitiveness of Iranian industries.

2. Methodology

The present study was conducted using an applied, quantitative, descriptive-correlational research design with an analytical approach. The main objective of the study was to examine the extent to which fluctuations in energy prices affect the export competitiveness of Iranian industries. Since energy costs constitute one of the major components of production expenses in many industrial sectors, especially energy-intensive industries, the study was designed to investigate both the direct and indirect effects of energy price volatility on export performance, price competitiveness, cost structure, production stability, market share, and the ability of firms to compete in international markets. The statistical population consisted of managers, senior experts, export specialists, financial managers, production managers, and strategic planning experts working in export-oriented industrial companies located in Tehran. Tehran was selected because many headquarters, export management offices, industrial associations, chambers of commerce, and decision-making units of Iranian industries are concentrated in this province. The sample included 312 participants selected from export-active industrial firms in Tehran through purposive sampling based on inclusion criteria. The inclusion criteria were at least three years of professional experience in industry, export, finance, production, or strategic management; direct familiarity with production costs and export processes; and employment in firms with active or recent export experience. Participants who provided incomplete questionnaires or lacked sufficient knowledge of the firm's export activities were excluded from the analysis. The final sample of 312 participants was considered adequate for multivariate statistical analysis and structural modeling, given the number of observed variables and the analytical objectives of the study.

Data were collected using a structured questionnaire and a secondary-data checklist designed to measure the main variables of the study. The questionnaire consisted of two main sections. The first section included demographic and organizational information, such as participants' gender, age, educational level, field of specialization, job position, years of work experience, type of industry, firm size, export experience, and the relative importance of energy costs in the firm's production process. These items were included to describe the characteristics of the sample and to control for firm-level and respondent-level differences that could influence perceptions of energy price volatility and export competitiveness. The second section included the main research constructs, namely energy price volatility, production cost pressure, pricing flexibility, export competitiveness, export market stability, and perceived vulnerability to external price shocks. Items were designed using a five-point Likert scale ranging from strongly disagree to strongly agree. Higher scores indicated greater perceived exposure to energy price volatility or stronger export competitiveness, depending on the direction of each construct. The items related to energy price volatility assessed the extent to which changes in fuel, electricity, gas, and other energy-related costs affected production planning, cost prediction, pricing decisions, investment decisions, and export contracts. The items related to export competitiveness measured the firm's ability to maintain competitive prices, preserve export market share, sustain product quality, respond to foreign competitors, manage delivery commitments, and adapt to international market requirements.

To strengthen the measurement of energy price volatility, a secondary-data checklist was also used. This checklist included annual and quarterly data related to domestic energy prices, industrial energy tariffs, exchange rate changes, production cost indices, export value, export volume, and sectoral export performance. These data were used to complement the questionnaire data and to provide an objective basis for interpreting the relationship between energy price changes and export competitiveness. The secondary data were organized according to industrial sector and time period, allowing the researcher to compare firms' perceptions with broader macroeconomic and sectoral trends. The content validity of the questionnaire was evaluated by a panel of university faculty members and industry experts familiar with international trade, industrial economics, energy economics, and export management. Based on their comments, unclear items were revised, overlapping items were removed, and the wording of several items was modified to improve clarity and conceptual precision. A pilot study was then conducted with 30 participants who were not included in the final sample. The internal consistency of the questionnaire was assessed using Cronbach's alpha, and all main constructs obtained acceptable reliability coefficients above 0.70, indicating satisfactory internal consistency. Construct validity was also examined through factor analysis before testing the main research model.

Data analysis was performed using SPSS version 27 and AMOS software. In the first stage, the collected questionnaires were screened to identify missing data, incomplete responses, outliers, and inconsistent answer patterns. Missing values were examined, and questionnaires with substantial missing responses were excluded from the final dataset. Descriptive statistics, including frequency, percentage, mean, standard deviation, minimum, and maximum values, were used to summarize demographic and organizational characteristics as well as the main research variables. The normality of the quantitative variables was assessed using skewness, kurtosis, and the Kolmogorov–Smirnov test. The reliability of the questionnaire was evaluated using Cronbach's alpha and composite reliability. To examine the validity of the measurement model, exploratory factor analysis and confirmatory factor analysis were applied. Factor loadings, average variance extracted, composite reliability, and model fit indices were used to determine whether the observed items adequately represented the latent constructs of the study.

In the inferential stage, Pearson correlation analysis was used to examine the preliminary relationships among energy price volatility, production cost pressure, pricing flexibility, export competitiveness, and export market stability. Multiple regression analysis was then applied to determine the predictive effect of energy price volatility on export competitiveness while controlling for firm size, export experience, industry type, and perceived energy intensity. In addition, structural equation modeling was used to test the overall conceptual model and to examine the direct and indirect pathways through which energy price volatility influenced export competitiveness. The mediating roles of production cost pressure and pricing flexibility were assessed in the model to determine whether energy price fluctuations reduced export competitiveness primarily through increased production costs and reduced pricing maneuverability. Model fit was evaluated using standard indices, including the chi-square to degrees of freedom ratio, comparative fit index, goodness-of-fit index, Tucker–Lewis index, root mean square error of approximation, and standardized root mean square residual. A significance level of 0.05 was used for all statistical tests. The results of the analysis provided the empirical basis for determining whether volatility in energy prices significantly weakened the export competitiveness of Iranian industries and whether this relationship differed according to industrial characteristics and firm-level conditions.

3. Findings and Results

A total of 312 questionnaires were distributed among managers, export experts, financial specialists, production supervisors, and strategic planning professionals working in export-oriented industrial firms in Tehran. After data screening and elimination of incomplete responses, all 312 questionnaires were retained for final analysis because the missing data rate was negligible and no questionnaire exceeded the exclusion threshold. The demographic analysis showed that 68.59% of the participants were male and 31.41% were female. Regarding educational level, 18.91% held bachelor's degrees, 61.54% held master's degrees, and 19.55% possessed doctoral degrees or equivalent professional qualifications. The mean age of the participants was 41.27 years (SD = 7.84), while the mean work experience was 13.62 years (SD = 5.93). In terms of industrial sector, participants represented petrochemical industries, steel and metal industries, cement and mineral industries, food manufacturing industries, automotive industries, chemical industries, and textile industries. Approximately 57.37% of respondents reported that energy costs accounted for a high or very high proportion of their firms' production expenditures. Furthermore, 63.46% of the firms had more than ten years of export experience, indicating that most participants possessed substantial familiarity with international market conditions and export-related challenges. Preliminary examination of the data demonstrated acceptable distributional characteristics, and no severe violations of normality assumptions were observed.

Table 1. Descriptive Statistics of the Main Research Variables

Variable	Mean	Standard Deviation	Minimum	Maximum	Skewness	Kurtosis
Energy Price Volatility	4.12	0.61	2.08	5.00	-0.42	-0.37
Production Cost Pressure	4.26	0.57	2.31	5.00	-0.58	-0.21
Pricing Flexibility	2.74	0.69	1.00	4.81	0.31	-0.48
Export Competitiveness	2.91	0.73	1.12	4.76	0.27	-0.56
Export Market Stability	2.83	0.71	1.05	4.68	0.35	-0.41
Vulnerability to External Shocks	4.03	0.64	2.14	5.00	-0.46	-0.29

The descriptive findings presented in Table 1 indicate that the participants perceived energy price volatility and production cost pressure at relatively high levels, with mean scores of 4.12 and 4.26, respectively. These findings suggest that fluctuations in domestic energy prices exerted substantial pressure on industrial firms, particularly regarding operational costs and financial predictability. In contrast, pricing flexibility demonstrated a comparatively lower mean score (M = 2.74), indicating that many firms experienced limited ability to adjust export prices in response to changing production costs. Similarly, export competitiveness and export market stability were evaluated at moderate-to-low levels, suggesting that energy-related instability may have weakened firms' ability to sustain competitive positions in international markets. The relatively high mean score for vulnerability to external shocks further confirms that industrial firms perceived themselves as highly exposed to macroeconomic and energy-related disruptions. The skewness and kurtosis coefficients for all variables fell within acceptable ranges, indicating satisfactory normality for subsequent parametric analyses.

Table 2. Pearson Correlation Matrix among the Main Research Variables

Variables	1	2	3	4	5	6
1. Energy Price Volatility	1					
2. Production Cost Pressure	0.71**	1				
3. Pricing Flexibility	-0.52**	-0.49**	1			
4. Export Competitiveness	-0.68**	-0.63**	0.59**	1		
5. Export Market Stability	-0.61**	-0.58**	0.54**	0.74**	1	
6. Vulnerability to External Shocks	0.77**	0.69**	-0.46**	-0.66**	-0.57**	1

The correlation analysis revealed several statistically significant relationships among the study variables. Energy price volatility showed a strong positive correlation with production cost pressure ($r = 0.71$, $p < 0.01$) and vulnerability to external shocks ($r = 0.77$, $p < 0.01$), indicating that increases in energy price instability were associated with greater financial and operational pressure on firms. Conversely, energy price volatility demonstrated significant negative relationships with pricing flexibility ($r = -0.52$, $p < 0.01$), export competitiveness ($r = -0.68$, $p < 0.01$), and export market stability ($r = -0.61$, $p < 0.01$). These findings suggest that unstable energy prices reduced firms' capacity to maintain stable export pricing strategies and weakened their competitive position in foreign markets. Production cost pressure was also negatively associated with export competitiveness and export market stability, implying that rising energy-related costs constrained firms' ability to sustain export performance. The positive relationship between pricing flexibility and export competitiveness ($r = 0.59$, $p < 0.01$) further demonstrates the importance of adaptive pricing capability for maintaining competitive advantages in international trade environments.

Table 3. Multiple Regression Analysis Predicting Export Competitiveness

Predictor Variable	B	SE	β	t	p
Constant	5.18	0.31	—	16.71	0.001
Energy Price Volatility	-0.47	0.08	-0.39	-5.84	0.001
Production Cost Pressure	-0.36	0.07	-0.31	-5.12	0.001
Pricing Flexibility	0.41	0.06	0.35	6.47	0.001
Vulnerability to External Shocks	-0.29	0.07	-0.24	-4.19	0.001

Model Statistics: $R = 0.79$, $R^2 = 0.62$, Adjusted $R^2 = 0.61$, $F = 124.38$, $p < 0.001$

The regression analysis demonstrated that the proposed model significantly predicted export competitiveness among Iranian industrial firms. The model explained approximately 62% of the variance in export competitiveness, indicating substantial explanatory power. Energy price volatility emerged as the strongest negative predictor of export competitiveness ($\beta = -0.39$, $p < 0.001$), demonstrating that firms experiencing higher levels of energy price instability reported significantly lower competitiveness in export markets. Production cost pressure also negatively predicted export competitiveness ($\beta = -0.31$, $p < 0.001$), suggesting that rising operational costs reduced firms' ability to compete internationally. In contrast, pricing flexibility positively predicted export competitiveness ($\beta = 0.35$, $p < 0.001$), indicating that firms capable of adapting pricing strategies more effectively were better able to preserve export performance despite energy market instability. Vulnerability to external shocks likewise exerted a significant negative effect on export competitiveness. Overall, the findings indicate that energy price volatility directly and indirectly undermines the competitive capabilities of Iranian industries by increasing production costs and reducing strategic flexibility.

Table 4. Structural Equation Modeling Results for the Proposed Research Model

Path	Standardized Coefficient	Critical Ratio	p
Energy Price Volatility → Production Cost Pressure	0.74	10.83	0.001
Energy Price Volatility → Pricing Flexibility	-0.51	-7.96	0.001
Production Cost Pressure → Export Competitiveness	-0.37	-5.41	0.001
Pricing Flexibility → Export Competitiveness	0.42	6.27	0.001
Energy Price Volatility → Export Competitiveness	-0.33	-4.88	0.001
Vulnerability to External Shocks → Export Competitiveness	-0.28	-4.21	0.001

Model Fit Indices: $\chi^2/df = 2.41$, CFI = 0.94, GFI = 0.92, TLI = 0.93, RMSEA = 0.067, SRMR = 0.049

The structural equation modeling results confirmed the adequacy of the proposed conceptual model. All model fit indices were within acceptable thresholds, indicating satisfactory alignment between the theoretical framework and the observed data. Energy price volatility had a strong positive effect on production cost pressure and a significant negative effect on pricing flexibility, confirming that unstable energy markets reduce firms' ability to manage export pricing and operational planning efficiently. Production cost pressure exerted a direct negative effect on export competitiveness, while pricing flexibility demonstrated a significant positive effect. Moreover, energy price volatility maintained a direct negative impact on export competitiveness even after accounting for the mediating variables, suggesting that the relationship is both direct and indirect in nature. The results therefore support the assumption that fluctuations in energy prices impair export competitiveness through multiple economic and strategic mechanisms simultaneously.

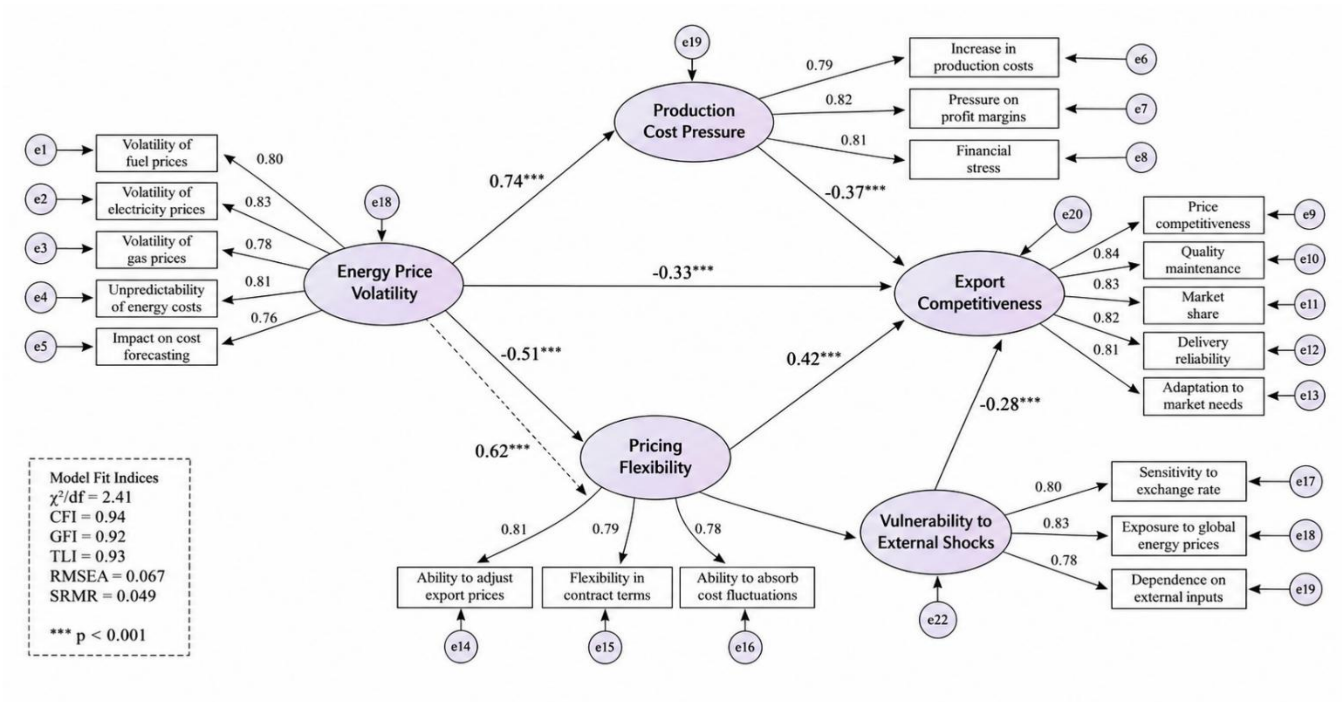

Figure 1. Structural Model of the Relationship between Energy Price Volatility and Export Competitiveness of Iranian Industries

The structural model illustrated in Figure 1 demonstrates the integrated pathways through which energy price instability affects the export competitiveness of Iranian industries. The figure conceptually confirms that energy price volatility increases production cost pressure, weakens pricing flexibility, intensifies firms' vulnerability to external shocks, and ultimately reduces export competitiveness and export market stability. The overall pattern of findings indicates that industries operating under unstable energy pricing conditions face greater challenges in maintaining long-term export performance, especially in highly competitive international markets where pricing precision, cost stability, and strategic adaptability are essential determinants of success. The figure further highlights the mediating role of operational and strategic variables, suggesting that the impact of energy price fluctuations is not limited to direct cost increases but also extends to managerial decision-making, investment confidence, and international market responsiveness.

4. Discussion and Conclusion

The present study aimed to analyze the effect of energy price volatility on the export competitiveness of Iranian industries. The findings demonstrated that energy price volatility exerted significant negative effects on export competitiveness, pricing flexibility, and export market stability, while simultaneously increasing production cost pressure and firms' vulnerability to external shocks. The results of the correlation, regression, and structural equation modeling analyses consistently confirmed that instability in energy markets weakens the ability of industrial firms to sustain competitive positions in international markets. The findings further indicated that production cost pressure and pricing flexibility played important mediating roles in the relationship between energy price volatility and export competitiveness. These results suggest that fluctuations in energy prices affect export performance not only directly through rising operational costs but also indirectly by reducing firms' strategic flexibility and increasing uncertainty in industrial planning.

One of the most important findings of the study was the significant negative relationship between energy price volatility and export competitiveness. Firms experiencing higher levels of energy market instability reported lower levels of competitiveness in international markets. This finding can be explained by the fact that industrial competitiveness depends heavily on cost predictability, production continuity, and stable pricing strategies. When energy prices fluctuate unpredictably, firms face difficulties in determining production costs, negotiating long-term export contracts, and maintaining stable pricing structures for foreign customers. Such instability reduces firms' ability to compete effectively against producers operating in more stable economic environments. This finding is consistent with previous studies indicating that fluctuations in oil and energy prices negatively affect industrial and financial performance [4, 5, 12]. Similarly, research conducted in Nigeria showed that oil price volatility significantly weakened real-sector performance by increasing economic instability and reducing productive efficiency [6]. The current findings therefore reinforce the argument that energy price instability constitutes a major structural obstacle to sustainable export competitiveness in energy-intensive economies.

The study also found that production cost pressure significantly mediated the relationship between energy price volatility and export competitiveness. Firms facing unstable energy prices reported substantial increases in production costs, which in turn reduced their ability to maintain competitive export prices. This finding is theoretically consistent with cost-based models of international competitiveness, which emphasize that production efficiency and cost control are fundamental determinants of export performance. In many industrial sectors, particularly petrochemical, metal, cement, and manufacturing industries, energy represents a major component of total production costs. Consequently, fluctuations in fuel, electricity, and gas prices directly increase operational expenditures and reduce profit margins. Similar conclusions have been reported in studies examining the effects of crude oil price fluctuations on industrial sectors and economic performance [5, 24]. The results are also aligned with research demonstrating that energy dependency contributes significantly to macroeconomic volatility and industrial vulnerability [2]. Therefore, unstable energy pricing mechanisms may create long-term barriers to industrial competitiveness by undermining firms' cost structures and limiting their ability to compete in price-sensitive export markets.

Another important finding concerned the role of pricing flexibility in maintaining export competitiveness. The results showed that firms with greater pricing flexibility were better able to preserve export competitiveness despite energy market instability. Pricing flexibility refers to the ability of firms to adjust prices, contract terms, and production strategies in response to changing market conditions. Industrial firms operating in volatile energy environments often require adaptive pricing systems that allow them to absorb cost fluctuations without losing export market share. However, the findings of the present study demonstrated that energy price volatility significantly reduced firms' pricing flexibility, thereby weakening their competitiveness. This result can be explained by the fact that unpredictable energy costs reduce managerial confidence and complicate long-term export planning. Firms become less capable of offering stable prices to international buyers and may therefore lose competitiveness to foreign rivals with more predictable cost structures. These findings are consistent with research emphasizing the importance of industrial policy and structural adaptation in shaping trade competitiveness [8, 15]. They also support the argument that strategic flexibility and adaptive industrial capabilities are essential for sustaining export performance in uncertain economic environments.

The findings additionally revealed that vulnerability to external shocks negatively affected export competitiveness. Firms exposed to exchange rate instability, global energy price fluctuations, and dependence on imported inputs reported lower levels of export performance and market stability. This result reflects the interconnected nature of global trade systems and energy markets. In economies heavily dependent on energy revenues or imported technologies, external economic disturbances may rapidly influence production costs, export revenues, and industrial stability. The findings correspond with previous research conducted on resource-dependent economies, which demonstrated that fluctuations in commodity markets increase economic vulnerability and weaken industrial diversification efforts [13, 14]. Likewise, studies on global trade disruptions and geopolitical uncertainty emphasized that instability in energy supply chains significantly affects international competitiveness and industrial resilience [3, 21]. In the Iranian context, sanctions, exchange rate fluctuations, and dependence on energy-intensive production systems may intensify the negative effects of global energy volatility on export activities.

The structural equation modeling results provided additional support for the conceptual framework of the study. The findings demonstrated that energy price volatility exerted both direct and indirect effects on export competitiveness. The direct effect indicates that unstable energy prices immediately reduce firms' ability to maintain competitive export performance. At the same time, indirect effects through production cost pressure and pricing flexibility reveal that energy volatility also influences managerial and operational dimensions of industrial activity. These findings are theoretically significant because they demonstrate that export competitiveness is influenced not only by external market conditions but also by internal organizational capacities to adapt to uncertainty. This perspective aligns with research emphasizing the importance of industrial adaptation, structural transformation, and resilience-oriented economic policies [16, 17]. Firms capable of improving operational flexibility, energy efficiency, and strategic responsiveness may therefore be more successful in mitigating the adverse effects of energy market instability.

The results of the study are also consistent with broader macroeconomic theories linking energy prices to economic growth and industrial development. Previous studies have shown that fluctuations in energy markets affect inflation, exchange rates, investment behavior, and industrial productivity simultaneously [18, 19]. In Pakistan, uncertainty in industrial energy consumption contributed to de-industrialization and weakened manufacturing competitiveness [20]. Similarly, studies on Gulf economies demonstrated that oil price declines and pandemic-related disruptions significantly affected long-term economic performance and industrial sustainability [11]. The findings of the current study extend this literature by specifically demonstrating how energy price instability affects export competitiveness at the industrial-firm level within the Iranian context.

Another important implication of the findings concerns the role of energy security in sustaining industrial competitiveness. Energy security refers to the stable availability of affordable energy resources necessary for production and economic activity. The present study demonstrated that uncertainty in energy pricing reduces firms' confidence in production planning and export investment. This finding is consistent with studies emphasizing that energy demand security significantly influences international competitiveness among industrial economies [7]. When firms lack confidence in future energy costs, they may postpone investment decisions, reduce production expansion, and limit export commitments. Consequently, unstable energy policies may discourage long-term industrial development and weaken national export capacity.

The study also highlights the strategic importance of industrial diversification and structural transformation. Economies that rely excessively on resource-intensive exports may become highly vulnerable to fluctuations in global energy markets. Research has shown that diversification of trade structures and industrial upgrading contribute to more stable economic growth and stronger competitiveness [8, 15]. In Iran, many export-oriented industries remain highly dependent on low-cost energy advantages rather than technological innovation and productivity growth. While subsidized energy may temporarily support industrial expansion, long-term competitiveness requires investment in technological modernization, energy efficiency, innovation, and value-added production systems. The findings therefore suggest that sustainable competitiveness cannot rely solely on energy subsidies or resource abundance but must be supported by broader structural reforms and industrial modernization strategies.

Furthermore, the findings demonstrate the importance of policy coordination between energy, industrial, and trade sectors. Energy pricing policies implemented without consideration of industrial competitiveness may unintentionally reduce export performance and weaken economic resilience. At the same time, artificially suppressing energy prices may create inefficiencies, discourage innovation, and increase fiscal pressures. Therefore, policymakers face the complex challenge of balancing energy market reforms with industrial support mechanisms. Similar concerns have been discussed in studies examining the relationship between energy transitions, ecological planning, and industrial adaptation [16, 25]. Effective policy frameworks should therefore encourage gradual energy reforms while simultaneously supporting industrial upgrading and competitiveness enhancement.

The findings of this study possess important practical implications for industrial managers and policymakers in Iran. Industrial firms operating in unstable energy environments may need to adopt more flexible production systems, diversify export markets, improve energy efficiency, and strengthen risk management capabilities. Firms that rely excessively on energy-intensive production methods may face increasing difficulties in sustaining export competitiveness under volatile market conditions. Consequently, strategic investment in technological innovation, renewable energy integration, and operational flexibility may become essential for long-term industrial sustainability.

One limitation of the present study was its reliance on cross-sectional data collected from industrial firms located in Tehran, which may limit the generalizability of the findings to all industrial sectors and regions of Iran. In addition, the study relied partly on self-reported perceptions of managers and experts regarding export competitiveness and energy price volatility, which may have been influenced by subjective interpretations or organizational conditions. The research also focused primarily on industrial firms and did not separately analyze specific export sectors such as agriculture, services, or technology-based industries. Moreover, broader geopolitical and institutional variables influencing export competitiveness, including sanctions and international trade restrictions, were not directly incorporated into the statistical model.

Future studies are recommended to employ longitudinal research designs to examine how changes in energy pricing policies influence export competitiveness over time. Comparative studies across different industrial sectors and provinces could also provide deeper understanding regarding sector-specific vulnerability to energy market fluctuations. Future researchers may additionally investigate the moderating roles of technological innovation, renewable energy adoption, organizational resilience, and government support policies in reducing the negative effects of energy price volatility. Expanding the analysis to include international comparative perspectives among energy-exporting countries may further contribute to the development of more comprehensive theoretical models explaining the relationship between energy markets and export competitiveness.

From a practical perspective, policymakers should design balanced energy pricing strategies that reduce excessive industrial vulnerability while preserving economic efficiency and sustainability. Industrial firms should invest in energy-efficient technologies, diversify energy sources, strengthen strategic planning systems, and develop adaptive pricing mechanisms capable of responding to volatile market conditions. Export-oriented industries may also benefit from government-supported risk management programs, technological modernization initiatives, and financial incentives aimed at improving productivity and reducing dependence on unstable energy inputs. Strengthening coordination between industrial, trade, and energy policies may ultimately improve the resilience and competitiveness of Iranian industries in international markets.

Authors' Contributions

Authors equally contributed to this article.

Ethical Considerations

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

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Conflict of Interest

The authors report no conflict of interest.

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References

[1] C. Basdekis, A. G. Christopoulos, I. Katsampoxakis, and S. Xanthopoulos, "Trends and Challenges After the Impact of COVID-19 and the Energy Crisis on Financial Markets," *Energies,* vol. 17, no. 15, p. 3857, 2024, doi: 10.3390/en17153857.

[2] A. K. Sahu and M. K. Mahalik, "Unwrapping the Intricate Interplay Between Energy Dependency and Macroeconomic Volatility in <scp>OECD</Scp> Countries," *Economic Papers a Journal of Applied Economics and Policy,* vol. 43, no. 4, pp. 389-410, 2024, doi: 10.1111/1759-3441.12429.

[3] Y. Zhu, "Protectionism in Critical Minerals Supply Chains Exacerbates Inequalities in the Global Energy Transition," 2025, doi: 10.21203/rs.3.rs-7357362/v1.

[4] Q. N. Ahmed, S. A. A. Rizvi, H. A. Naeem, and S. Ahmed, "Is Oil Prices Volatility Taking Toll: Sectoral Analysis of Pakistan Stock Exchange," *Journal of Organisational Studies and Innovation,* vol. 10, no. 3, pp. 1-16, 2023, doi: 10.51659/josi.22.177.

[5] S. M. Hashmi, F. Ahmed, Z. Alhayki, and A. A. Syed, "The Impact of Crude Oil Prices on Chinese Stock Markets and Selected Sectors: Evidence From the VAR-DCC-GARCH Model," *Environmental Science and Pollution Research,* vol. 29, no. 35, pp. 52560-52573, 2022, doi: 10.1007/s11356-022-19573-5.

[6] J. S. Ogede, "Does Oil Price Volatility Impact on Nigeria's Real Sector? Evidence From ARDL Model," *Jurnal Ekonomi Dan Studi Pembangunan,* vol. 12, no. 2, p. 143, 2020, doi: 10.17977/um002v12i22020p143.

[7] H. Nyga-Łukaszewska and T. M. Napiórkowski, "Does Energy Demand Security Affect International Competitiveness? Case of Selected Energy-Exporting OECD Countries," *Energies,* vol. 15, no. 6, p. 1991, 2022, doi: 10.3390/en15061991.

[8] G. Dosi, F. Riccio, and M. E. Virgillito, "Specialize or Diversify? And in What? Trade Composition, Quality of Specialization, and Persistent Growth," *SSRN Electronic Journal,* 2022, doi: 10.2139/ssrn.4072719.

[9] K. Anderson, "Agriculture in a More Uncertain Global Trade Environment," *Agricultural Economics,* vol. 53, no. 4, pp. 563-579, 2022, doi: 10.1111/agec.12726.

[10] J. J. Szczygielski, J. Brzeszczyński, A. Charteris, and P. R. Bwanya, "The COVID-19 Storm and the Energy Sector: The Impact and Role of Uncertainty," *SSRN Electronic Journal,* 2021, doi: 10.2139/ssrn.3816893.

[11] M. Shehabi, "Modeling Long-Term Impacts of the COVID-19 Pandemic and Oil Price Declines on Gulf Oil Economies," *Economic Modelling,* vol. 112, p. 105849, 2022, doi: 10.1016/j.econmod.2022.105849.

[12] B. K. Bureti and T. Olweny, "Oil Price Volatility and Economic Performance in Kenya: An Analysis of the Nairobi Securities Exchange Index," *strategicjournals.com,* vol. 10, no. 2, 2023, doi: 10.61426/sjbcm.v10i2.2659.

[13] S. Valiyeva, "Non-Oil Export Challenges of Oil Countries in Case of Azerbaijan," *Ekonomika Apk,* vol. 319, no. 5, pp. 77-90, 2021, doi: 10.32317/2221-1055.202105077.

[14] A. Pushkarev, N. Davidson, O. Mariev, and N. Luft, "Specialization of Russia in International Trade: Development in the Changing International Environment," 2020, doi: 10.20472/efc.2020.014.012.

[15] A. Pineli and R. Narula, "Industrial Policy Matters: The Co-Evolution of Economic Structure, Trade, and FDI in Brazil and Mexico, 2000–2015," *Journal of Industrial and Business Economics,* vol. 50, no. 2, pp. 399-444, 2023, doi: 10.1007/s40812-023-00262-4.

[16] É. Espagne and G. Magacho, "Planification Écologique Et Changement Structurel," *Revue De L Ofce,* vol. N° 176, no. 1, pp. 175-201, 2022, doi: 10.3917/reof.176.0175.

[17] W. Lechthaler and M. Mileva, "Inter-Industry Trade and Business Cycle Dynamics," *Macroeconomic Dynamics,* vol. 28, no. 8, pp. 1739-1767, 2024, doi: 10.1017/s1365100524000014.

[18] U. Razi, S. Afshan, C. W. H. Cheong, and A. Sharif, "Dynamic Connection Between Energy Prices, Malaysia's Economic Growth, and Ecological Footprint: An Evidence From Morlet Wavelet Approach," *Geological Journal,* vol. 59, no. 3, pp. 1000-1017, 2023, doi: 10.1002/gj.4906.

[19] S. Mo and T. Wang, "Synergistic Effects of International Oil Price Fluctuations and Carbon Tax Policies on the Energy–Economy–Environment System in China," *International Journal of Environmental Research and Public Health,* vol. 19, no. 21, p. 14177, 2022, doi: 10.3390/ijerph192114177.

[20] B. Yasmin and W. Qamar, "The Role of Power Generation and Industrial Consumption Uncertainty in De-Industrialising Pakistan," *The Pakistan Development Review,* pp. 517-536, 2022, doi: 10.30541/v52i4ipp.517-536.

[21] L. Tajoli, "Too Much of a Good Thing? Russia-Eu International Trade Relations at Times of War," *Journal of Industrial and Business Economics,* vol. 49, no. 4, pp. 807-834, 2022, doi: 10.1007/s40812-022-00232-2.

[22] G. C. Nwadike, B. O. C. Omogo, and C. S. Alamba, "Frustration in Oil Market Price Effect on External Reserves in Nigeria 1970-2017," *J Econ Managem Res,* pp. 1-15, 2021, doi: 10.47363/jesmr/2021(2)135.

[23] K. J. Udoudo, I. E. Kalu, and K. Oduola, "Impact of Liquefied Natural Gas Exports on the Nigerian Exchange Rate: An ARDL Cointegration Approach, 2000 to 2021," *Am. J. Appl. Stat. Econ.,* vol. 3, no. 1, pp. 1-14, 2023, doi: 10.54536/ajase.v3i1.2216.

[24] N. Akbulaev, B. Alïyeva, and S. Rzayeva, "Analysis of the Influence of the Price of Raw Oil and Natural Gas on the Prices of Indices and Shares of the Turkish Stock Exchange," *Pénzügyi Szemle = Public Finance Quarterly,* vol. 66, no. 1, pp. 151-166, 2021, doi: 10.35551/pfq_2021_1_8.
[25] I. Tambari and P. Failler, "Determining if Oil Prices Significantly Affect Renewable Energy Investment in African Countries With Energy Security Concerns," *Energies,* vol. 13, no. 24, p. 6740, 2020, doi: 10.3390/en13246740.