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Supply Chain Risk Management Analysis based on Resilience Capabilities (Comprehensive Structural Interpretive Modeling Approach)

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Abstract
This research aims to provide a model of the relationship structure of supply chain risk management dimensions based on the resilience approach in Iran's National Oil Products Distribution Company and in the gasoline supply chain. The statistical population includes 17 managers of Iran's National Oil Products Distribution Company who were selected by snowball method. The variables were identified through the multi-ground theory method and then localized using the fuzzy Delphi method. The output of this section has been the extraction of 13 main categories and 60 sub-categories, which are determined through the comprehensive interpretive structural model (TISM) method of the layers of interactive communication between the main categories of the research and a model in which the relationships and how the variables are affected are drawn. The results of the research showed that inherent risks, socio-political risks, and environmental risks are at the top of the model and have a greater impact on other risks. When supply risks, demand risks, and operational-process risks occur, they lead to the emergence of organizational risks by disrupting the organization's structure and processes. When a high level of risk occurs in the organization, it leads to disruption. Therefore, in order to respond to risks and control them, resilience capabilities have been provided. Resiliency dimensions including "flexibility", "speed and agility", "visibility and transparency", "collaboration and sharing" and "redundancy and efficiency" are affected by risks and react to control and manage them. This issue can help the supply chain achieve its goal, which is the timely supply of gasoline with good quality and reasonable cost.
Keywords: *Risk, Risk management, Supply chain, Resilience, Gasoline, Comprehensive Interpretive structural model*

Introduction

Supply chains connect producers and customers and facilitate the exchange of goods, money and information. With the increase in competition among companies and the expansion of supply chain complexities, disasters caused by supply chain risks have put great pressure on companies (Beck et al., 2023: 176). Since organizations are at risk in an environment of complexity and uncertainty, they must manage their supply chain, and if there is no proper plan and strategy to overcome these risks, these risks will damage the performance of the supply chain (Barbosa-Povoa & Pinto, 2023: 683). Supply chain risk management refers to a set of risk management responses that basically provide measures to face supply chain risks (Aljabhan, 2023: 414).

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Many company managers believe that a comprehensive program for supply chain risk management provides the basic infrastructure for sustainable competitive advantage. Meanwhile, in recent studies of the MIT Measurement Network, they found that even many large companies are not able to create rules and possible procedures for operations in complex and high-risk events. In fact, about sixty percent of the studied managers do not actively work in the field of supply chain risk management, nor do they believe in the effectiveness of factory risk management practices (Yang et al., 2022: 501). According to Joseph Fixel and colleagues, the main reason for the ineffectiveness of these methods is traditional risk management, which mainly focuses on identifying risks and statistical information, when many risks are unpredictable and unknown, and statistical information may not exist. It relies Traditional risk management considers only operational risks (Fiksel et al., 2013: 16).

According to a number of researchers, there are two types of risks in each supply chain: operational risks and disruption risks. Operational risks are related to inherent uncertainties, such as uncertainties in demand, supply, delivery waiting times, prices, quantity and quality of returned products. While disruption risks are mainly related to events with low probability of occurrence and high effects (Nyakam Nya & Abouaissa, 2023: 60). Disruption risks such as earthquake, fire, equipment failure, labor protest and terrorist campaign, although the probability of disruption risks is weak, when they occur, they have an important impact on business. To address this issue, the idea of supply chain resilience has attracted the most attention in recent years. Innes et al. state that since supply chain risks are intertwined, a resilient approach to risk reduction can moderate the risks of several supply chains (Ines et al., 2023: 776).

The important issue is that basically, some researchers consider resilience as reactive capabilities to be used after a disruption, and others have understood resilience as a proactive effort to prepare for disruptions. On the other hand, among the supply chains, the supply chain of oil and refinery products are considered to be one of the most important energy transmission networks in countries, where disruption and potential risks are increasing, and this issue can endanger the energy security of countries (Jahangiri et al., 2023: 92). Therefore, it is very important to pay attention to the risks and disruptions in these supply chains. Considering the shortcomings and advantages of each of the two approaches of risk management and resilience and considering the importance of the supply chain of petroleum products, it seems that using the above two approaches in the gasoline supply chain in an integrated manner can lead to synergy and improved performance. Supply chain. Therefore, the purpose of this research is to firstly identify the most important factors affecting supply chain risk management based on resilience and secondly to determine the structure of relationships and the way of interaction between factors in terms of influence and effectiveness in the form of a model based on the comprehensive structural-interpretive analysis (TISM) approach.

Literature Review

Risk, Supply Chain Risk Management

Today, technological progress, the globalization of economy and business, the intensity of environmental changes and the increase of uncertainty in the process of these changes have caused decisions to be made in situations with risk (Vieira et al., 2023: 41). The prerequisite for risk analysis is the identification of related uncertainties. In fact, decision-making in conditions of uncertainty leads to risk. In general, risk is a function of mistakes in doing work, the probability of risk occurrence, its consequences, and the level of knowledge of decision makers, so that with the increase of managers' awareness and knowledge, their perception of risk changes (Hu & Ghadimi, 2022: 961). All business activities include some types of risks that must be carefully managed. This is the function of risk management. The purpose of risk management is to reduce the harmful effects of an activity through conscious action to predict unwanted events and planning to avoid them (Munir et al., 2020: 337). Today, risk management is considered as an important factor in decision-making and an inherent part of management, and by increasing the ability to process information and communication, and by improving decision-making, it reduces losses and costs, and by increasing the efficiency of the organization, it improves organizational performance (Ghasemi et al.,, 2023: 25). Fierce competition in global markets, increased customer expectations and rapid development of information technology have led to shortening of product life cycle, increased transportation capacity and dynamic behavior of customers in terms of choice and demand. This has forced commercial companies to invest in their supply chain and has resulted in the continuous evolution of techniques for their effective management (Nsikan et al., 2023: 147). Since organizations are exposed to risks and risks in an environment with complexity and uncertainty, they must manage their supply chains. Today, supply chain risk management is one of the most important aspects of the supply chain (Xiao et al., 2023: 955).

Supply Chain Risk Management Process

While reviewing the research literature, the following three steps have been determined as the most basic and common steps in the supply chain risk management process:

1- Identification of risks: at this stage, by examining the supply chain, its separate activities and the relationships between them are defined, and finally, by systematic analysis of the above, risk areas are identified. The output of this step is a list of risks that the supply chain is facing. Risk identification is a complex process, there are always a large number of potential risks, some of which are unidentifiable. Using official tools and procedures for identification minimizes the sudden shock of encountering high-risk events (Kraude et al., 2022: 1173). By reviewing the research literature, the risks in Table 1 have been identified in different sources.

Table 1.
Identification of supply chain risks

Risk	Resource
Supply risks	Rinaldi et al., 2022, Soyer et al., 2023
Demand risks	Kraude et al., 2022
Operational/process risks	Beck et al., 2023
Political/social risks	Munir et al., 2020
Organizational risks	Vieira et al., 2023
Environmental risks	Nyakam Nya & Abouaissa, 2023
Inherent risks	Lu & Chen 2022, Wang et al., 2023

1- Risk assessment: after identifying risks, the next stage is risk analysis. At this stage, the most important risks should be prioritized based on their effects so that managers can decide where to focus resources (Latifiee & Shafiee, 2023). In addition, risks in the supply chain are interdependent and therefore should not be identified as an isolated event. Because any attempt to reduce one risk can lead to the reduction or increase of other risks; By identifying the interrelationships between the possible risks of the supply chain, the balance between alternate strategies is understood. Therefore, getting a general picture of supply chain risks and the relationships between them is necessary because this leads to a more effective and comprehensive risk reduction strategy (Rinaldi et al., 2022: 81);

2- Designing appropriate responses to face risks: At this stage, the manager considers different ways to face risks. The output of this stage is the planned responses to face each risk. The three main activities are focused on the important steps, but it is clear that they do not give a complete and integrated picture. In fact, there are additional front steps to create and prepare the scene and additional back steps to maintain systems, monitor and monitor incidents, and control risks (Lu & Chen, 2022: 101).

The Resilience of the Supply Chain

Challenges and risks can lead to failure and interruption in the supply chain of companies. Disruption in the supply chain is an event that leads to disruption of the flow of production of goods or services and servicing in the supply chain (Babu & Yadav, 2023: 766). In order to reduce the effect of these disturbances, supply chains should be multidimensional and multilevel, in other words, the supply chain should be designed in such a way that it can provide an efficient response in the face of events and the ability to recover to its original state or recover after a disturbance, or It can even create better conditions (Soyer et al., 2023: 8). This feature means the existence of resilience in the structure of the supply network, the resilience of the supply chain is the ability to recover after an unfavorable situation and is a critical capability for success and the key to developing a sustainable strategic plan that enables the company to produce better results than competitors (Chen, 2023: 541). In fact, a company that reacts to a disruption (failure) better than its competitors can improve its position in the market. Resilience is a concept that cannot be directly or indirectly observed but can be inferred by observable items. The building blocks of resilience (capabilities) describe how preparedness for supply chain events, response and recovery can be developed. Enablers also facilitate the achievement of resilience in the supply chain (Wang et al., 2023: 93). By reviewing the research literature, elements of resilience (capabilities) are given in Table 2.

Table 2.
Resilience capabilities

Resiliency dimensions in the supply chain	Definition	Resource
Flexibility	Being flexible in matters and creating alternative ways	Ines et al., 2023, Babu& Yadav, 2023, Chen, 2023
Speed and agility	The speed with which the supply chain can recover from a disruption, in other words, the ability to quickly return to normal operating mode.	Nyakam Nya & Abouaissa (2023), Hu & Ghadimi, 2022, Yang et al., 2022
Visibility and transparency	It shows the information of institutions and events of the supply chain. It guarantees the existence of confidence in the supply chain and prevention of rework, prevention of ineffective decisions and prevention of inappropriate expectations in risk conditions.	Soyer et al., 2023, Wang et al., 2023, Nsikan et al., 2023
Collaboration and sharing	The desire of the members to unite and integrate their forces when disruption occurs, cooperation leads to reducing uncertainty and increasing preparedness against incidents, cooperation with partners	Munir et al., 2020, Vieira et al., 2023
Efficiency and redundancy	The ability to produce products with minimal resources	Sorooshian et al., 2023, Gervais et al., 2023

According to the review and clarification in the theoretical literature and research background, the authors, considering the concept of supply chain risk management and examining its relationship with exposure to risks (response to risk) as well as the existing research gap, designed the conceptual model of the current research based on Figure 1:

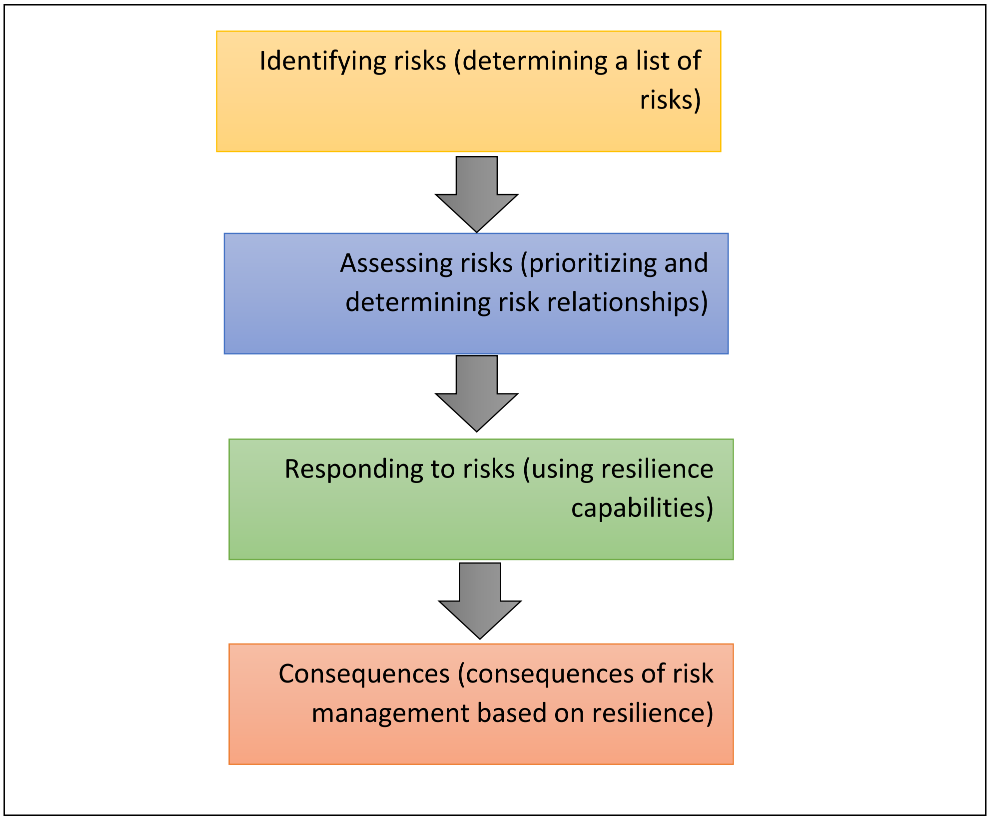


Figure 1. *Conceptual model of research*

The Findings of El Baz et al., (2023) research titled: "Predicting the effects of supply chain resilience and robustness on COVID-19 impacts and performance: Empirical investigation through resources orchestration perspective" showed that the significantly positive influence of resources orchestration on SCRE and SCRO and the role of the latter in mitigating the pandemic disruption impacts. Notwithstanding, depending on whether the measures are objective or subjective, the effects of SCRE and SCRO on financial performance vary. Overall, this paper presents empirical evidence of the influence of both of SCRE and SCRO on pandemic disruption impacts and financial performance. Furthermore, this research provides insights to guide practitioners and decision makers regarding resources orchestration and the deployment of SCRE and SCRO.

The Findings of Lekha Karmaker et al., (2023) article titled: "Analyzing supply chain risk factors in the small and medium enterprises under fuzzy environment: Implications towards sustainability for emerging economies" showed that the the fuzzy TISM imply that the “lack of enthusiasm in top management regarding sustainable practices” is the most significant factor. Besides that, lack of skilled and educated workers, lack of knowledge about modern technologies, labor strikes, and political instabilities are also some crucial risks that may hinder the sustainable development and smooth operation of SMEs. Fuzzy MICMAC analysis confirms that all identified risk factors are interrelated. The study insights can guide managers to successfully identify the risk factors for achieving long-term sustainability and operational resilience and can enhance policymakers' ability to formulate proactive and efficient mitigation strategies.

The Findings of Ehtesham Rasi et al., (2023) article titled: "Designing an Optimal Selection Model of Transportation Network in A Multi-level Supply Chain Using Game Theory" showed that the answer provided by the game theory for the value of the objective function was less than the answers of the transport problem, despite the deficit penalty.

The Findings of Nikounam Nezami et al., (2023) article titled: "Managing Perishable Goods Supply Chain Disruptions during the Covid-19 Pandemic (Systematic Approach)" showed that The network analysis also disclosed that resilience and sustainability are the key themes in the clusters.

The Findings of Tanveer et al., (2023) research titled: "A fuzzy TOPSIS model for selecting digital technologies in circular supply chains" showed that A fuzzy Technique for Order Performance by Similarity to Ideal Solution (TOPSIS) technique is adopted to evaluate these technologies since it constitutes a reliable managerial tool when vagueness impacts the smooth operation of the supply chain. Results indicate the ranking order of the investigated digital technologies (CPS>IoT>CM>BDA) as well as the circular benefits and the supply chain attributes imparted upon implementing these technologies. Such benefits and attributes are provided to assess the impact of these digital technologies on a circular economy. Lastly, the perspective of the selection process affected by other factors, such as the enterprise's extroversion level and its internal structure, are discussed.

The Findings of Yao et al., (2023) article titled: "A model of the enterprise supply chain risk propagation based on partially mapping two-layer complex networks" showed that the propagation threshold is related to network topology, the risk information disclosure awareness of enterprises, and the risk awareness of enterprises. Specifically, the stronger the risk information disclosure awareness and the greater the risk awareness of enterprises, the smaller the scale of supply chain risks eventually formed and the lower the threshold of risk outbreak. In addition, the influence of information disclosure awareness on the final developed risk scale is more significant than that of risk awareness. Finally, the simulation results further verify the model's feasibility.

The Findings of Ehtesham Rasi et al., (2023) article titled: "A Mathematical Model to Optimize Cost, Time in The Three echelon Supply Chain in Post COVID 19 pandemic" showed that he differences found between the genetic algorithms (GAs) and the LP approaches can be explained by handling the constraints and their various logics. To deal with ambiguity in the reverse logistics network, a fuzzy approach has been applied. To solve the problem in large dimensions, meta-heuristic algorithms of Cuckoo and Genetic were employed by applying MATLAB software. In order to compare two optimization algorithms, a series of sample problems have been generated then the results of two algorithms were compared and superiority of each of them was discussed.

The Findings of Gervais et al., (2023) article titled: "Risk-based due diligence in supply chains: The case of silver for photovoltaics" showed that the supply of silver powder, paste, PV cells, and modules is found to be highly concentrated. These supply chains are linked to substantial ESG risks, mostly nested in fabrication and manufacturing, some of which have worsened over time. Over 87% of the silver used in PV transits through at least one country with a very high risk factor. Reshoring the PV industry to the EU can partially de-risk supply.

The Findings of Kahkonen et al., (2023) research titled: "Practices and strategies for sustainability-related risk management in multi-tier supply chains" showed that in multi-tier supply chains, companies need direct and indirect collaboration and direct and indirect monitoring practices for managing sustainability-related risks emanating from not only their first-tier suppliers but also lower-tier suppliers.

The Findings of Azadnia et al., (2023) research titled: "Green hydrogen supply chain risk analysis: A european hard-to-abate sectors perspective" showed that the empirical evidence which corroborates with previous studies that European countries should endeavour to create comprehensive and supportive standards and regulations for green hydrogen supply chain implementation.

The Findings of Rehman et al., (2022) article titled: "Manufacturing planning and control driven supply chain risk management: A dynamic capability perspective" showed that the MPC activities effectively respond to SCU and act as an enabler of preventive and reactive SCRM. Furthermore, the paper finds that MPC activities drive operational performance through effective SCRM. Also, the findings suggest that preventive risk management practices impact operational performance only through reactive risk management. Finally, the paper enriches the literature by identifying and discussing the theoretical and managerial significance of the role of MPC activities in the association between SCU, risk management practices, and firm performance.

The most important innovations of this research are:

Examining the most important dimensions of resilience in the supply chain;

Examining the best approach to respond to risks and control them in the supply chain;

Presenting the relationship structure model of supply chain risk management dimensions based on the resilience approach in Iran's National Oil Products Distribution Company;

Investigating the impact of supply chain risk management based on the resilience approach in Iran's National Petroleum Products Company.

Methodology

In terms of purpose, the present research is practical because it was done with the aim of improving processes and methods and can help solve the problems of organizations. On the other hand, this research is descriptive-exploratory because by reviewing the theoretical research literature, the effective factors in supply chain risk management based on resilience have been described and identified. The method of collecting information is combined and done with the multi-grounded theory method. The data collection tool for the fuzzy Delphi and TISM stages is a researcher-made questionnaire. The statistical population of the research is the experts of Iran's National Oil Products Distribution Company, 17 managers and heads, who were selected by snowball method and available. In the snowball method, first a few people are selected based on certain criteria (including criteria for selecting experts, theoretical mastery, at least 10 years of practical experience, additional educational qualifications, willingness and ability to participate in research and accessibility). Then these people are asked to introduce people who have the desired criteria. In the research organization, the operation of transporting gasoline products from supply sources to fuel supply centers (stations) is considered as a three-level supply chain according to Figure 2. The levels of the chain in this case include suppliers, distributors and retailers (fuel stations).

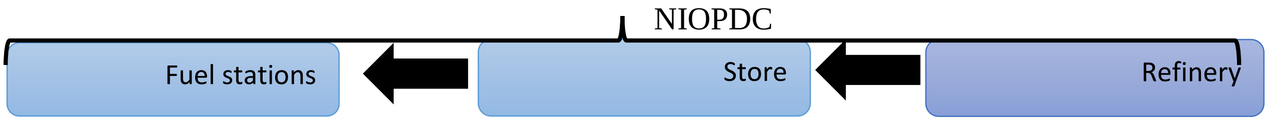


Figure 2. *Three-level gasoline supply chain*

In this research, the effective factors in supply chain risk management based on resilience were identified using the multi-ground theory method. This method can be considered as a modified or developed method of Grand Theory. Having a broad mind to empirical data, which is one of the strengths of GT, is also preserved in MGT, but in MGT, existing theories are also used. MGT states that if the researcher ignores existing theories, there is a risk of reinventing the wheel. Researchers often develop new knowledge based on existing knowledge and believe that it is important to make connections between existing research and evolving theory during the theory building period. Existing theories can be used as a useful factor and supporting empirical data to form a new theory. It should be noted that the process of multi-ground theory is a back-and-forth process between existing theories and experimental data, and this process continues until data saturation. Then the identified factors were screened by the fuzzy Delphi method and less important factors were removed. The fuzzy Delphi method is basically done by repeating and providing feedback until a group consensus is reached. In this method, decision-makers are asked to specify their opinions in the form of a question or an index based on a certain spectrum. This process takes place in different rounds to reach a consensus, which is usually achieved in three Delphi rounds. The implementation of this method in a fuzzy environment or in other words fuzzy Delphi overcomes the uncertainties of the decision-making problem (Campagner et al., 2021: 776).

Finally, the layers of interactive communication between the research variables and a model in which the structure of relationships and the way of interaction between the variables are known, are drawn through the comprehensive structural-interpretive modeling method (TISM). Structural-interpretive modeling is an evolutionary learning process that deals with the relationship between the concepts of a problem through the interpretation of the opinions of a group of experts and creates a comprehensive structure of the concepts of a complex set by understanding the direct and indirect relationships between specific cases and in addition to specifying precedence And the influence of the elements on each other determines the direction of the relationship of the elements of a complex set in the hierarchical structure. In general, structural-interpretive modeling shows the specified relationships along with the overall structure in a diagram model. Interpretive-Structural Modeling, or TISM for short, is an enhanced and extended ISM method, which as a more comprehensive method can determine the layers of interactive communication between research indicators. In the TISM technique, the limitation of ISM is solved by using the interpretive matrix tool, in which the causal thinking is taken from the experts at the time of data collection and revealed in the interactive matrix (Sorooshian et al., 2023: 71). Also, Meek Meek is a systematic analysis that describes the ISM using a matrix and additionally categorizes the variables based on their driving power and dependence. It also determines the prioritization of elements to achieve the immediate long-term benefits of the organization. The main steps of the TISM method are shown in Figure (3):

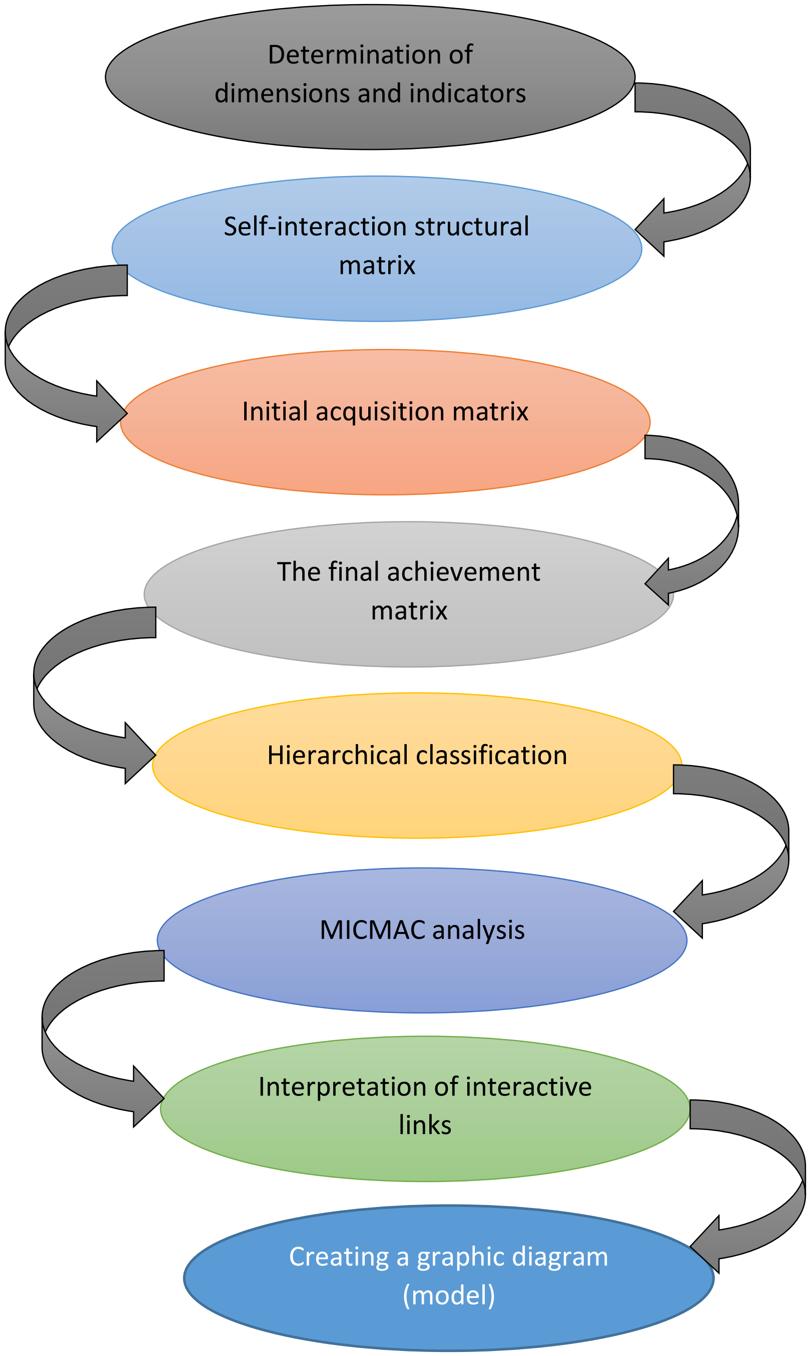


Figure 3. *TISM implementation steps*

Findings

The findings of the research based on the theoretical framework of the research and according to the steps of the TISM method (Figures 1 and 3) are as follows:

Step 1: Determining dimensions and indicators: In this research, in order to collect data, in the first step, using the multi-grounded theory method, the research topic published in reputable journals was examined. For this purpose, articles, books, researches and websites of reputable foreign and domestic organizations were reviewed and the process of searching and selecting articles was done based on the PRISMA protocol. This protocol provides preferred reporting items for systematic reviews and meta-analyses. Based on this, first, 258 studies and texts related to the subject were identified. Then the found documents were examined qualitatively. The indicators studied in evaluating the use or non-use of articles are: reliable sources, published from 2003 onwards and the use of key words risk, risk management, supply chain, resilience, gasoline. In this way, 64 studies were finally selected. On the other hand, using semi-structured interviews and using the snowball sampling method, interviews were conducted with experts familiar with the gasoline supply chain and familiar with risk management and resilience issues. The sample members were selected based on certain conditions and criteria, including the selection criteria of experts, theoretical mastery, practical experience, willingness and ability to participate in research and accessibility. According to the nature of the foundational data theory method, the sample size is not predetermined. Rather, at first, we use the purposeful sampling method and then use theoretical sampling to advance to the theoretical saturation stage. Therefore, in this section after saturation, the number of experts (number of sample members) was 17 people. Finally, during the coding process and several back-and-forth processes between referring to the research literature and interviewing experts, the factors affecting the research model were determined, and then using the fuzzy Delphi method, the identified factors were screened and the most important aspects and indicators of the research were identified according to Table 3.

Table 3.
The most important indicators and dimensions identified

Dimensions	Components
Supply risks	Weakness in infrastructure
	Quality matters
	Lack of production capacity
	Lack or limitation in feed and spare parts
	Equipment breakdown and wear
Operational risks and processes	Low productivity of manpower
	Inefficiency of managers' decisions
	Poor relationships between supply chain members
	IT infrastructure and automation
	Product transportation risks
Demand risks	Variable pattern of gasoline consumption by people
	Lack of fuel supply centers in the country
	Financial issues of the holders
	The poor performance of the station holders in fuel supply
Political/social risks	International sanctions
	Strikes and civil unrest
	Gasoline smuggling
	Cyber attacks
Inherent risks	Volatile nature and loss of original properties in the long term
	Safety hazards and the flammability nature of gasoline
	The nature of gasoline pollution and its effects on the environment
Environmental risks	Natural disaster
	Epidemic and infectious diseases
Organizational risks	Resistance to the implementation of risk management
	Inappropriate organizational structure

Dimensions	Components
	Low level of knowledge and skills of employees
Flexibility	Sourcing strategies to enable replacement of suppliers in emergency situations
	Labor training
	Strategic surplus inventory and capacity
	Flexibility in transportation methods
	Increasing domestic production capacity by establishing a small oil refinery
	Meritism in recruitment and appointment
Speed and Agility	Formation of emergency crisis management teams
	Providing performance control programs and service speed in fuel supply centers
	Providing incentive plans and rating the performance of fuel stations
	Compilation of safety requirements and instructions, training
Visibility and Transparency	Obligation to contracts for supply of food and products
	Creating visibility and transparency in raw material inventory and product production process
	Visibility of inventory of reservoirs and the amount of sales of supply centers to predict demand
Collaboration and Sharing	Promote a culture of cooperation to reduce risk among members
	Optimizing IT systems to improve communication
	Organized communication between the private and public sector (using the private sector)
	Implementation of knowledge management system in the organization
	Profit and loss sharing
Redundancy and Efficiency	Preparation of instructions for maintenance services and preventive repairs
	Vaccination of those involved in the gasoline supply chain and compliance with health protocols
	Improving gasoline quality and establishing quantitative and qualitative gasoline control systems
	Increasing security and efficiency by updating and upgrading hardware and software systems
	Implementation of the green supply chain network (compatible with the environment) in the supply chain
	Providing guidelines for the storage conditions of gasoline products and monitoring the accuracy of implementation
	Providing support plans to provide financial resources and budget for fuel stations
	Terms and Conditions
	Empowering domestic companies by improving the skills of domestic specialists
	Creating a culture of optimal fuel consumption
	Facilitating the implementation of oil industry development plans through the support of the monetary and banking system
	Pricing policy by the government
The consequence of supply chain risk management based on resilience	Supplying gasoline with smooth and continuous flow with quality and reasonable cost
	Satisfying the general public
	Creating environmental benefits
	Gain benefits for stakeholders

Step 2: Creating a self-interactive structural matrix (SSIM): a researcher-made questionnaire is designed as a pairwise comparison and is distributed among the members of the target community. Pairwise comparison between individual variables is done in row and column form. For this purpose, the experts answered the effectiveness of each of the dimensions on the other dimensions in the form of no effect (0), very little effect (1), little effect (2), high effect (3) and very high effect (4) and the sum of the answers of 17 experts It was calculated from the managers of the National Oil Products Distribution Company and the structural matrix of internal relations was obtained. Table 4 shows the structural matrix of the internal relationships of the dimensions.

Table 4.
Matrix of internal relations structure

Dimensions	Indicator	Supply risk	Operational risk	Demand risk	Political risk	Contingent risk	Environmental risk	Organizational risk	Flexibility	Speed and Agility	Visibility and Transparency	Collaboration and Sharing	Redundancy	Consequences
Supply risk	A1	0	50	48	35	37	50	55	65	60	61	57	55	53
Operational risk	A2	55	0	66	50	46	47	57	48	61	66	57	54	54
Demand risk	A3	41	35	0	39	40	44	52	66	63	64	54	53	67
Political risk	A4	60	57	62	0	32	45	53	60	64	50	59	63	63
Contingent risk	A5	62	55	59	44	0	0	59	57	54	56	60	66	65
Environmental risk	A6	63	58	54	41	50	0	65	49	56	58	64	61	55
Organizational risk	A7	35	33	45	40	34	50	0	65	58	55	58	64	54
Flexibility	A8	41	34	42	34	38	50	47	0	45	30	24	24	52
Speed and Agility	A9	44	50	50	36	42	44	45	44	0	33	35	50	62
Visibility and Transparency	A10	48	45	34	42	41	42	43	41	47	0	42	48	63
Collaboration and Sharing	A11	50	48	35	35	40	41	34	35	50	31	0	45	64
Redundancy	A12	50	43	39	41	35	34	35	38	50	35	44	0	57
Consequences	A13	41	44	45	40	32	33	36	30	50	42	40	46	0

Step 3: Obtaining the initial achievement matrix: The structural self-interaction matrix (SSIM) must be converted into a binary matrix (zero and one) called the initial achievement matrix. Then, the sum of the effects of the elements was compared with the threshold limit of 51, which was the result of multiplying the average limit of the pairwise comparison questionnaire by the number of experts, and the primary achievement matrix is set as Table 5.

Table 5.
Primary achievement matrix

Dimensions	Indicator	Supply risk	Operational risk	Demand risk	Political risk	Contingent risk	Environmental risk	Organizational risk	Flexibility	Speed and Agility	Visibility and Transparency	Collaboration and Sharing	Redundancy	Consequences
Supply risk	A1	1	0	0	0	0	0	1	1	1	1	1	1	1
Operational risk	A2	1	1	1	0	0	0	1	0	1	1	1	1	1
Demand risk	A3	0	0	1	0	0	0	1	1	1	1	1	1	1
Political risk	A4	1	1	1	1	0	0	1	1	1	0	1	1	1
Contingent risk	A5	1	1	1	0	0	0	1	1	1	1	1	1	1
Environmental risk	A6	1	1	1	0	0	1	1	0	1	1	1	1	1
Organizational risk	0	0	0	0	0	0	0	1	1	1	1	1	1	1
Flexibility	0	0	0	0	0	0	0	0	1	0	0	0	0	1
Speed and Agility	0	0	0	0	0	0	0	0	0	1	0	0	0	1
Visibility and Transparency	0	0	0	0	0	0	0	0	0	0	1	0	0	1
Collaboration and Sharing	0	0	0	0	0	0	0	0	0	0	0	1	0	1
Redundancy	A12												1	1
Consequences	A13	0	0	0	0	0	0	0	0	0	0	0	0	1

Step 4 stage: creating the achievement compatibility matrix: the achievement matrix is transformed into the achievement compatibility matrix (final achievement matrix) by examining the transferability of the relationship between the dimensions. Transferability is formed according to the assumption that if agent A is related to B and B is also related to C, then A is necessarily related to C. At this stage, all the secondary relationships between the dimensions are checked and the final achievement matrix is obtained according to Table 6. In this research, the Boolean rule (0*0=0, 0*1=0, 0*0=0, 1*1=1) is used. In this table, compatible cells are marked with *. Also, in this matrix, the power of penetration (score 1 obtained from the row) and the degree of dependence (score 1 obtained from the column) of each variable are shown. The influence of each variable is the final number of dimensions that can play a role in creating them. The degree of dependence is the final number of dimensions that cause the creation of the said variable.

Table 6.
The final achievement matrix

Dimensions	Indicator	Supply risk	Operational risk	Demand risk	Political risk	Contingent risk	Environmental risk	Organizational risk	Flexibility	Speed and Agility	Visibility and Transparency	Collaboration and Sharing	Redundancy	Consequences	Penetration power
Supply risk	A1	1	0	0	0	0	0	1	1	1	1	1	1	1	8
Operational risk	A2	1	1	0	0	0	0	1	1*	1	1	1	1	1	10
Demand risk	A3	0	0	1	0	0	0	1	1	1	1	1	1	1	8
Political risk	A4	1	1	1	1	0	1	1	1	1	1*	1	1	1	11
Contingent risk	A5	1	1	0	0	1	0	1	1	1	1	1	1	1	
Environmental risk	A6	1	1	1	1	1	1	1	1*	1	1	1	1	1	11
Organizational risk	A7	0	0	1	1	1	0	1	1	1	1	1	1	1	11
Flexibility	A8	0	0	0	0	0	1	1	1	1	1	1	1	1	7
Speed and Agility	A9	0	0	0	0	0	0	1	1	1	1	1	1	1	2
Visibility and Transparency	A10	0	0	0	1	0	0	1	1	1	1	1	1	1	2
Collaboration and Sharing	A11	0	0	0	1	0	0	1	1	1	1	1	1	1	2
Redundancy	A12	0	0	0	0	0	0	0	1	0	0	0	1	1	2
Consequences	A13	0	0	0	0	0	0	0	0	1	0	0	0	1	2
Dependency power		5	4	5	1	1	1	7	8	8	8	8	8	13	

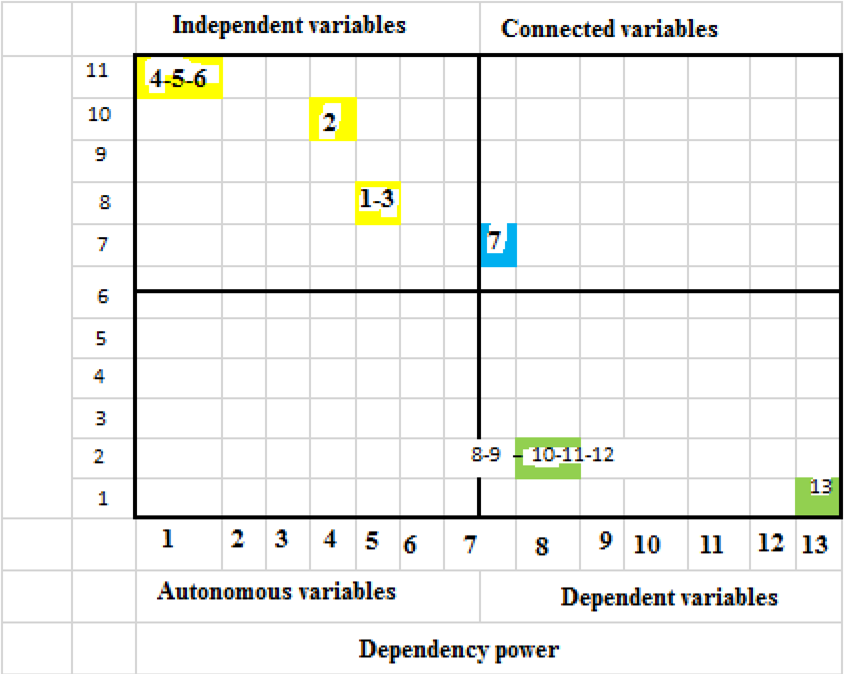
Step 5: Hierarchical division of the achievement matrix: leadership power (Dr) and dependence power (Dp) of each dimension of resilience-based supply chain risk management based on the achievement compatibility matrix was carried out in stage 4 and according to the suggestion of Karimi Shirazi et al. (2017). From the result of the difference between the driving power (Dr) and the dependence power (Dp), the level is determined in such a way that the variable that has the lowest (Dr-Dp) is the first level, and in the same way, the higher the (Dr-Dp) is in Higher levels are segmented. The above calculations are shown in Table 7. Therefore, based on the results of this table, the dimensions were placed in six levels.

Table 7.
Leveling dimensions of supply chain risk management model based on resilience approach

Dimensions		(DR)	DP	Dr-Dp	Level	Result
The consequence of risk management	A13	1	13	-12	1	Dependent
flexibility	A9	2	8	-6	2	Dependent
Speed and agility	A8	2	8	-6	2	Dependent
Visibility and transparency	A10					
Collaboration and sharing	A11	2	8	-6	2	Dependent
Redundancy and efficiency	A12	2	8	-6	2	Dependent
Organizational risks	A7	7	7	0	3	Connected
Supply risks	A1	8	5	3	4	Independent
Demand risks	A3	8	5	3	4	Independent
Operational risks and processes	A2	10	4	6	5	Independent
Political/social risks	A4	11	1	10	6	Independent
Contingent risks	A5	11	1	10	6	Independent
Environmental risks	A6	11	1	10	6	Independent

Step 6: MICMAC analysis: In this step, by using MICMAC analysis, the type of variables will be determined according to their influence and effectiveness on other variables, and after determining the power of influence (influence) and the power of dependence (effectiveness) of the variables of the management model Supply chain risk based on the resilience approach, all dimensions can be classified in one of the four clusters of the dimension effect matrix method.

1. Self-directed (autonomous) variable: dimensions with weak driving power and weak dependence are located in the autonomous part and are generally separated from the system. No dimension is located in this area and this is a sign of correlation and connection between dimensions.
2. Dependent variable: The second category has variables that have low guiding power and strong dependence. Six variables include the consequences of risk management, flexibility, speed and agility, visibility and transparency, cooperation and sharing, and redundancy and efficiency. These resilience variables mainly result in success in supply chain risk management, which risks affect them.
3. Connected variable: This category includes variables with strong driving power and dependence. In this group, the variable of organizational risks is located.
4. Independent variable: The fourth category has variables with strong guiding power and weak dependence. These variables guide the system and need more attention. In this research, six variables include supply risks, demand risks, operational risks and processes, political/social risks, inherent risks and environmental risks in this category.



Matrix 1. *Classification of dimensions based on influence and dependence using the MICMAC method*

Step 7: Interpreting interactive links: TISM has been used in this research in order to further interpret relationships in terms of causal thinking. In the TISM technique, the limitation of ISM is solved by using the interpretation matrix tool, where the causal thinking is taken from the experts at the time of data collection and revealed in the interactive matrix. The final ISM diagram becomes a binary interaction matrix showing all relationships with an entry of "1". Then, through the knowledge base in the form of an interpretive matrix, indirect relationships are also identified and it is indicated in the matrix with 1 entry in italics. In the knowledge base, experts analyze the underlying relationship between each pair of variables and explain how to reach the dependent variable. An expert must check [n(n-1)] number of comparisons.

Table 8.
Interactive matrix

Dimensions	Indicator	Supply risk	Operational risk	Demand risk	Political risk	Contingent risk	Environmental risk	Organizational risk	Flexibility	Speed and Agility	Visibility and Transparency	Collaboration and Sharing	Redundancy	Consequences
Supply risk	A1	0	0	0	0	0	0	1	0	0	0	0	0	0
Operational risk	A2	1	0	1	0	0	0	1	0	0	0	0	0	0
Demand risk	A3	1	0	0	0	0	0	1	0	0	0	0	0	0
Political risk	A4	0	1	1	0	0	0	0	0	0	0	0	0	0
Contingent risk	A5	0	1	0	0	0	0	0	0	0	0	0	0	0
Environmental risk	A6	0	1	1	0	0	0	0	0	0	0	0	0	
Organizational risk	0	0	0	0	0	0	0	0	1	1	1	1	1	0
Flexibility	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Speed and Agility	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Visibility and Transparency	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Collaboration and Sharing	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Redundancy	A12	0	0	0	0	0	0	0	0	0	0	0	0	1
Consequences	A13	0	0	0	0	0	0	0	0	0	0	0	0	0

Then, the information obtained from the interaction matrix is used to derive the TISM diagram. The nodes of the graph are retrieved by interpreting the elements that are placed in the interaction matrix. Annotation is depicted in the cells of the annotation direct interaction matrix next to the corresponding links in the structural model. This leads to the formation of a general interpretation of the structural model shown in Figure 5. In this model, the indirect effect that is not specified in ISM modeling is shown in TISM.

Step 8: creating a graphic diagram of the supply chain risk management model based on resilience. Based on this, the TISM model for supply chain risk management based on resilience is as follows:

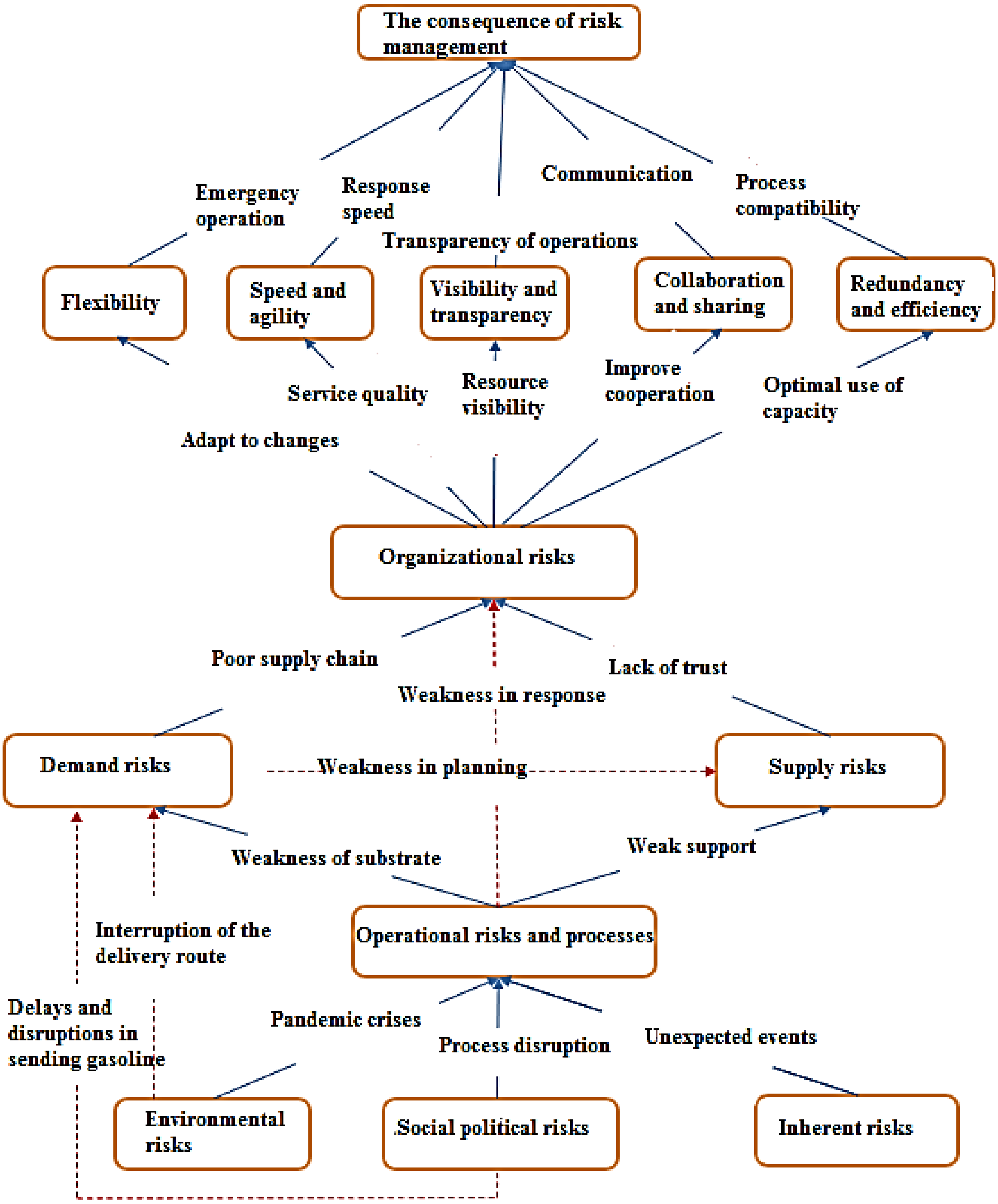


Figure 5. *TISM model for supply chain risk management based on resilience approach*

Discussion and Conclusion

Risks in the supply chain are interdependent. Because any attempt to reduce one risk can lead to the reduction or increase of other risks; By identifying the relationships between supply chain risks, the balance between alternative strategies is understood. Therefore, achieving the structure of supply chain risk communication and the relationships between them is necessary because this leads to more effective and comprehensive risk reduction strategies. According to Figure 5, in the TISM model, environmental risks, political/social risks and inherent risks are at the highest level of the model and do not depend on other risks. These risks are not related to each other. For example, inherent risks related to the nature of gasoline cannot be compared to natural risks such Natural disasters or infectious diseases can have an effect, and it cannot affect the social risks caused by society's problems or vice versa, but these three risks are included in the base of the model since they have a great effect on the system. While these risks have a high effect on other risks, they do not accept much effect from them, this issue can also be seen in the MICMAC analysis. The findings of Gervais et al (2023) research, which was conducted in the field of supply chain risk analysis, also show that social-political risks have a high impact on other risks.

According to the presentation model, environmental risks due to epidemic crises affect operational risks and processes, and if we want to mention an example in this regard, we can mention the epidemic of Corona disease that occurred in the years 2018-2022 and is one of the examples of environmental risks. One of the measures taken by the government at the beginning of the epidemic of this disease was to impose restrictions on vehicle traffic, which affected transportation risks, which are examples of operational and process risks. This issue was also mentioned in the study of El Baz and et al (2023), who investigated the role of supply chain risk management in reducing the effects of disruptions on the resilience and strength of the supply chain during the outbreak of COVID-19. Environmental risks are indirectly related to demand risks through the interruption of goods access. For example, the occurrence of events such as storms, floods, and earthquakes may lead to the closure of communication routes and disrupt the transfer of fuel to fuel supply centers. Also, according to the presented model, political-social risks indirectly and by causing interruptions and delays in operations have an effect on demand risks, which are at the third level of the model, as an example of how the occurrence of any risk can lead to In case of other risks, we can refer to the epidemic of corona disease in recent years, the application of health protocols to control the epidemic at fuel stations had led to the slowness of fueling services to customers (from the risk indicators of demand) or by imposing laws restricting traffic and Prohibition of traffic in this direction has greatly reduced the amount of stall sales and led to the risk of financial issues for stall holders (one of the demand risk indicators) as well as the risk of the variable pattern of gasoline consumption by the people.

In the fifth level, the model of operational risks and contract processes directly affects the risks of demand and supply in the fourth level and indirectly affects the organizational risks in the third level.

The results of Mik Mak analysis also confirm the power of influence and influence of operational risks and processes on the risks of their previous levels. Based on the presented model, when the risks of supply, demand and process and operations occur, it causes a disruption in the organizational structure for fuel supply and the organizational processes are weakened and chaos occurs in the work processes of the organization. In the second level of the resilience variables model, there are "flexibility", "speed and agility", "visibility and transparency", "collaboration and sharing" and "redundancy and efficiency". The dimensions determined for resilience in the second level of the model, with the findings of the research of Lekhakarmaker et al. (2023) who conducted a research on supply chain risks and resilience strategies in the electricity industry and the research of Yao et al. (2023) which as network characteristics And the resilience of the supply chain is aligned under the conditions of risk diffusion. These resilience variables are affected by risks and act to respond and control them. For example, the indicators "the existence of several feed suppliers in the fuel supply chain" and "possibility of changing suppliers in emergency situations" and "emergency inventory", which are all indicators of flexibility, provide solutions in line with supply risk management and can lead to Increasing the resilience of the organization when risks occur. Finally, in the first level of the model, there is the variable "resiliency-based supply chain risk management outcome" which is the result of resilience-based risk management. This finding shows that if the organization can manage the risks and disruptions caused by them using resilience capabilities, the supply chain is expected to achieve its desired goals. This variable is in the category of dependent variable in the Meek Mak analysis, which is consistent with the results of the TISM model, indicating the high effectiveness of this variable among other variables.

The aim of this research was to provide a model of the relationship structure of supply chain risk management factors based on the resilience approach in Iran's National Oil Products Distribution Company and in the gasoline supply chain. In order to achieve the mentioned goal, identifying the risks of the gasoline supply chain and the relationships governing these risks, as well as identifying the dimensions of resilience in order to respond to the control and management of risks and extracting the relationships governing these two categories (risk and resilience) and the consequences of risk management were carried out. . Identifying these relationships can improve the process of responding to risks and resilience in the organization. Identification of the components of the model (gasoline supply chain risks as well as dimensions of resilience) was done by studying the theoretical research literature and interviewing experts with the multi-ground theory method, and fuzzy Delphi method was used to screen and determine the most important components. Then, through the comprehensive structural-interpretive modeling method (TISM), the layers of interactive communication between the main components of the research were determined and a model was drawn in which the relationships and how the effects between the variables are known. The results of the research showed that the risks of the gasoline supply chain are generally in seven main categories, including supply, demand, operational-process, political-social, nature, environmental and organizational risks. Also, resilience capabilities are in five main categories including flexibility, speed and agility, visibility and transparency, cooperation and sharing, redundancy and efficiency, which are determined as dependent variables to control risks. Based on the results of MICMAC and TISM, nature risks, political/social risks and environmental risks are at the highest level of the model and have a high impact on other risks and when supply risks, demand risks and process and operation risks occur (level 5 and level 4 risks). in the model) by disrupting the organizational structure and processes, they lead to the emergence of organizational risks (level 3). From the relationship between risks, it can be concluded that the occurrence of a risk in the supply chain can lead to the occurrence of other risks, and therefore supply chain risks should not be viewed as an isolated event. In this model, the higher the risks are, the greater the impact on the level risks. They have their predecessors. According to this model, resilience capabilities are at level 2 and are more effective than higher levels, i.e. risks. When a high level of risk occurs in the organization, it leads to disruption in the organization, and therefore, in order to respond to risks and control them, resilience capabilities have been added to the second level of the model.

Resiliency dimensions including flexibility, speed and agility, visibility and transparency, cooperation and sharing, redundancy and efficiency are affected by risks and react to control and manage them. This issue can help the supply chain achieve its goals. The consequences of risk management are based on resilience in the first level of the model. Therefore, the more risks can be reduced through the use of resilience capabilities, the resilience will increase and lead to the achievement of the organization's goals. At the end, the output model was checked with several experts. Experts confirmed the results of the model.

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Limitations and Suggestions

The results of this research are highly comprehensive due to the use of reliable and up-to-date sources and localization through questionnaires and interviews conducted during the research, and on the other hand, the identification of effective factors in the gasoline supply chain and the relationships between them, and its application in the national company. Distribution of Iran's petroleum products can be practical and useful, but due to the differences that the supply chain of gasoline in Iran has with other countries and other goods (including the strategic nature of gasoline, its exclusive supply by the government, subsidized prices, etc.)) may not have proper generalizability and its results cannot be easily used for other companies and goods or in other countries. Therefore, it is suggested that the model presented in this research be tested in the supply chain of gasoline in other countries as well as the supply chain of other products and the results be compared with this research.

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