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Identifying critical supply chain risks through social network analysis: ICT company in Iran

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Abstract

Identifying and evaluating supply chain risks is one of the most challenging issues related to supply chain risk management (SCRM). Many risks may threaten a supply chain, but upon the costs, managers had better pay attention to those with the highest impact. The paper advances to identify and rank Information and Communication Technology (ICT) supply chain risks and investigate their intereffects in a directed graph through the social network analysis approach and experts' opinions. Firstly, ICT supply chain risks were determined based on semi-structured interviews with organizational experts on the viable system model (V.S.M.). Then, they were asked to set a score between zero and five based on the impact of each risk on the other risks to assigning appropriate weight to edges. Finally, ICT supply chain risks were ranked based on centrality measures. The findings indicate that social and political conditions affect the ICT supply chain. As well as, the accuracy of the information and the emergence of new technologies are other factors that have the most significant impact on additional risks in the supply chain. We also situated the analysis on Tehran Internet Holding, a large company representative sales and after-sales service agent of Iran's most outstanding digital operator.

Keywords: Supply chain risk management, risk identification, risk ranking, social network analysis, viable system model, information and communications technology, key nodes, digital operator

1-Introduction

A risk is an incident that occurs from internal or external sources and impacts achieving the business objectives. Incidents can have a negative, positive, or both effect, but those with adverse effects are considered risks. Damage to factory machinery, fire, and credit losses can be among these incidents. Of course, it should be noted that in some cases, adverse effects can also be the results of apparently positive incidents, i.e., if customers demand a higher volume of the commercial unit's products while the production capacity of the retail unit is not able to respond, therefore, in such a situation, the customer's demand is not accepted. It may lead to losing loyal customers or at least a decrease in future orders. In the simplest case,

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risk can be considered uncertainty in future events. According to another definition, risk includes factors that lead to potential disruption in the network (Aloini et al., 2012).

It is also necessary to pay attention to and monitor the risk in the supply chain because they arise from the presence of new actors, new technologies, the increasing complexity of national and international laws, and changes in consumer behavior. Supply chain risk management (SCRM) is implementing strategies to manage joint and exceptional risks throughout the supply chain based on continuous risk assessment to reduce vulnerability and ensure continuity (Heckmann et al., 2015). In other words, risk management has five stages: risk identification, quantitative and qualitative analysis, strategy planning, risk monitoring, and risk control. The definition illustrates that identifying and continuously evaluating supply chain risks is essential for maintaining current functions and increasing efficiency. Therefore, if a proper strategy is not adopted to deal with supply chain risks, it is very likely that the supply chain efficiency in different layers will collapse, and various processes will fail. If we look at the supply chain history, it is clear that organizations have lost billions of dollars due to a lack of identification and appropriate preventive plans.

Identifying, evaluating, and mitigating the effect of risks on the supply chain is a continuous process that requires time and money. Also, reducing the impact of identified risks requires effective and appropriate strategies, sometimes involving up-to-date technologies. All of these impose high costs on supply chains. This reminds the need for risk ranking because focusing on all risks is inefficient and impossible. So it is essential to spend resources on the risks that control them will bring the most benefit. If crucial risks are identified, resources will be better allocated to deal with critical ones.

Another issue that must be considered is identifying risks that arise under the influence of political and social factors appropriate to a country. Since the US sanctions against Iran have affected all economic and international transactions in Iran, the domestic industries must pay attention to such a problem and examine the effect of these kinds of risks.

This study aims to identify, evaluate, and rank Information and Communications Technology (ICT) supply chain risks using Social Network Analysis (SNA). In this direction, the following goals will be pursued:

- Identifying risks related to the ICT supply chain using the literature review and interviewing experts in this field whose opinions will be collected through semi-structured interviews and questionnaires.
- Analyzing and ranking the risks identified through SNA.

The main innovations and achievements of the paper are:

1. This study proposes a comprehensive model for identifying and ranking the ICT supply chain risks.
2. The model considers in-degree, out-degree, closeness, betweenness, and eigenvector centralities, while previous studies only used degree centrality to rank risks.
3. The model has been implemented in one of Iran's most critical ICT product distributors.

The structure of the paper is organized as follows: the following section reviews risk assessment methods and social network analysis. The third section demonstrates the research methodology and introduces the data source. As well as the case study is introduced in this section. The fourth section analyzes the results. The paper summary, future research suggestions, and managerial achievements are stated in the final section.

2-Literature review

SCRM should be a strategic plan due to the supply chain's uncertainties and environmental risks (Gurtu and Johny, 2021). Therefore, risk assessment is vital. Gurtu and Johny theoretically analyzed scientific papers that contained the "risk" in their titles, keywords, or abstracts. They classified articles published into four sections: definitions of SCRM, risk diffusion, risk management, and risk identification (Gurtu and

Johny, 2021). Risk identification is one of the essential topics in the literature; due to the variety of techniques and methodologies, researchers have adopted different methods to assess risks.

In this section, the risk assessment methods are first demonstrated; after presenting the social network analysis, the papers that have utilized this method to rank supply chain risks are reviewed. At the end of this section, the research gap is discussed.

2-1-Risk assessment methods

Due to the high importance of the subject, several studies have been conducted to investigate supply chain risks by employing Multi-Criteria Decision-Making (MCDM) techniques. These techniques are used to choose the most appropriate option among several available options, and their distinguishing characteristic is that there is usually a countable number of predetermined options. The best option, according to MCDM, will be the one that provides the best value for each available characteristic. Among the most critical and standard techniques of MCDM, we can mention Analytic Hierarchy Process (AHP), Analytic Network Process (ANP), Decision Making Trial and Evaluation Laboratory (DEMATEL), Technique for Order-Preference by Similarity to Ideal Solution (TOPSIS), and Simple Additive-Weighting (Asadabadi et al., 2019).

Among the mentioned techniques, AHP is more prevalent in risk identification methodologies because the strength of this method is that it regularly organizes tangible and intangible factors and provides a structured but relatively simple solution to decision-making problems (Saaty, 1987). In the following, papers will be discussed in the field of risk management that have used MCDM methods to identify risks.

After careful research and detailed discussion, Badea et al. identified 16 risks of utilizing AHP. This research also offers five options for constructive collaboration between supply chain members: information-sharing collaboration, decision synchronization collaboration, incentive alignment collaboration, resource and skill-sharing collaboration, and knowledge management collaboration (Badea et al., 2014). Dua et al. mapped the effect of mitigating psychological, financial, social, physical, and performance risks in four industries: pharmaceutical, fast-moving consumer goods, precious metal, and automotive, utilizing blockchain technology and ranked them using fuzzy AHP (Dua et al., 2022). Dong and Cooper identified, evaluated, and ranked 31 risks for the Chinese manufacturing industry through the AHP technique (Dong and Cooper , 2016). Tsai, Liao, et al. calibrated outsourcing risks for retailers in Taiwan using the AHP technique (Tsai et al., 2008). Fazli, Kiani, et al. determined the risks of the crude oil supply chain and then applied the ANP method to evaluate the importance of each risk to find the best response strategy (Fazli et al., 2015). In another study, the impact of the Coronavirus pandemic on supply chains was investigated. Then a solution through ANP-TOPSIS was presented to let organizations indicate and prioritize their challenges to resist future problems (Magableh and Mistarihi , 2022). As well as, under the negative impact of the coronavirus pandemic on the supply chains, with an MCDM approach and using DEMATEL, a framework got presented that includes the strategic factors of flexible risk management, which was able to protect supply chains against future disruptions through operational capability (Das et al., 2021).

Saberhoseini et al., (2022) combined the Neutrosophic analytical hierarchy process and TOPSIS to rank and categorize supply chain risks. They identified 17 risks and considered resilience, agility, and robustness criteria as effective strategies for dealing with threats. In another study, 15 barriers were identified in the sustainable supply chain by an integrated approach comprising AHP and Elimination and Choice Expressing Reality (ELECTRE) in the era of circular economy and Industry 4.0 summarised based cyber-physical systems, IoT, cloud manufacturing, and additive manufacturing. These barriers, identified through a literature review and experts' opinions, were compared through pairwise comparison employing Saaty's 9-point rating scale (Kumar et al., 2021).

Lei and MacKenzie (2019) utilized the dynamic Fault Tree Analysis (FTA) to assess supply chain risks. The Markov chain model and Monte Carlo simulation were also employed to evaluate the risks quantitatively. Wu, Jia, et al.(2019) set the risks associated with the supply chain of electric vehicles in China using fuzzy logic. This paper created a risk assessment index system for the electric vehicle supply chain, including three aspects and 15 related indicators. Then, they developed a risk assessment model based on fuzzy theories and performed it on the Chinese electric vehicle supply chain. The results showed that the risk level of electric vehicle supply chains in China is between standard and high. Qazi, Dickson, et al.(2018) utilizing semi-structured interviews and focus group sessions with risk management experts, developed and operationalized the supply chain risk network management process, in which risk interdependencies, multiple operational measures, and risk reduction strategies in a network were demonstrated. Trkman and McCormack (2009) designed a conceptual model for risk identification. Their conceptual model was designed according to the attributes of the supplier, performance, and specific operating environment in the supply chain. As well as the findings were demonstrated within the contingency theory. Kayis and Karningsih (2012) introduced a method for identifying supply chain risks. The paper aimed to develop a tool called Supply Chain Risk Identification System (SCRIS) to assist decision-makers in identifying existing risks and their interdependencies in the supply chain network by considering different process strategies.

All in all, the studies discussed are adequate if the number of risks is limited. As well as, these methods do not provide a comprehensive structure of risk failure. Although the importance and impact of risks on the performance of an organization or supply chain have been examined, these studies have been conducted regardless of the interactions risks may have in creating or forming other risks (Wang et al., 2021). Therefore, in recent studies, researchers have employed techniques that can tackle the issue of risk intereffects. Social network analysis is among them that analyzes natural phenomena based on graph theory. In follow, we introduce this approach and then review the papers conducted to identify supply chain risk through SNA.

2-2-Social network analysis

Social Network Analysis is the mapping and measuring relationships between individuals, groups, organizations, computers, or information processing institutions; In a network, nodes represent individuals and groups, and edges represent relationships or links between nodes. SNA is an approach to studying social structures on graph theory (Otte and Rousseau, 2002). SNA is a relational approach, meaning the relationships between and within the entities should be examined, not the entities' characteristics. The most important feature of this method is that it has shifted the focus from individuals and their attributes to pairs of individuals and their relationships (Hagen et al., 2018). There are two crucial steps in applying this method (Noroozian et al., 2022):

- Generating a network between nodes through the edges.
- Analyzing the results by employing SNA metrics.

Some crucial metrics in SNA are introduced in the following (Jackson, 2008).

- Degree: Degree is the number of links related to each node. Therefore, the degree of i node in the g network is:

  $$d_i(g) = \neq \{j: g_{ji} = 1\} = \neq N_i(g) \quad (1)$$

  In the directed graphs, in-degree and out-degree are defined to determine the link direction. In-degree is calculated according to equation.1, and the calculation of the out-degree corresponds to the expression $\neq \{j: g_{ji} = 1\}$.

- Network Density: Density is calculated by dividing the average degree by $n - 1$ where n is the number of network nodes.
- Network Diameter: Diameter is the maximum distance between nodes in a network.
- Average Path Length: Average path length is the average distance of network nodes from each other.
- Degree Distribution: The degree distribution of a network is defined as the distribution of edges between nodes in a network (Albert and Barabási, 2000):

$$p(k) = \frac{n_k}{n} \tag{2}$$

where n is the number of nodes and n_k is a node with a degree equal to k.

- Centrality Measures: To calculate centrality measures, equation.3 is considered (Bloch et al., 2023):

$$\text{C}: c_n \rightarrow R^n \tag{3}$$

Where $c_i(g)$ is the centrality of i node in the g network. Central nodes are considered the most critical nodes in the network. Scientists have introduced various centrality measures to identify the key nodes in the network. Four of the essential centrality measures are presented below:

- Degree Centrality: Degree centrality demonstrates that the more a node's degree, the more central or essential it is. In the normalized equation.4, $d_i(g)$ is the degree centrality of i the node (Bloch et al., 2023):

$$c_i^{deg}(g) = \frac{d_i(g)}{n-i} \tag{4}$$

- Closeness Centrality: Closeness centrality is determined based on the distance between nodes in the network (Bloch et al., 2023):

$$c_i^{cls}(g) = \frac{n-1}{\sum_{j \neq i} \rho_g(i،j)} \tag{5}$$

Where $\sum_{j \neq i} \rho_g(i،j)$ is the sum of the distances of i node and other nodes.

- Eigenvector Centrality: Eigenvector centrality measures the centrality and credit of the i node relative to its neighbors (Bonacich, 1972):

$$\lambda\, c_i = \sum_j g_{ij} c_j \tag{6}$$

Where λ is constant, positive, and is the eigenvalue of the adjacency matrix g_{ij}.

- Betweenness Centrality: Betweenness centrality indicates the importance of a node in connecting other nodes (Freeman, 2002):

$$c_i^{bet}(g) = \frac{2}{(n-1)(n-2)} \sum_{(j،k)، \, j \neq i، k \neq i} \frac{\nu_g(i:j،k)}{\nu_g(j،k)} \tag{7}$$

n is the number of nodes. As well as, $\nu_g(j،k)$ is the all shortest path from node j to k, and $\nu_g(i:j،k)$ is the all shortest path from node j to k passing through i.

2-2-1-Utilizing Social Network Analysis for Risk Assessment

The utilization of SNA in supply chain management research has developed since 2010 (Wichmann and Kaufmann, 2016). The advantages of using SNA are (Cross and Parker, 2004):

- Improvement of the effectiveness of operations or business units.
- Improvement of cross-coordination throughout the organization.
- Advancement of innovation in new product development or research and development.
- Facilitator of change on a large scale or integration.
- Talent management and leadership growth.
- Forming strategic partnerships or evaluating customer relationships.

Furthermore, SNA analyzes many risks simultaneously concerning each other and presents more repeatable results. Li, Zobel, et al. examined the relationship between network characteristics and supply chain flexibility using social network analysis under risk diffusion conditions. The results showed that network characteristics affect productivity (Li et al., 2020). Ongkowijoyo and Doloi (2018) presented a new model for recording, plotting, and simulating the diffusion pattern of risk effects and interdependencies upon network analysis. The model was employed in the water supply infrastructure system. One hundred twenty-six people in eight stakeholder groups were used to collect data to identify 30 risky events. As a result, in addition to introducing a new model for identifying and categorizing risks in the supply chain, risks related to the water supply network were identified and submitted . Kim, Choi, et al. (2011) modeled a system of connected buyers and suppliers as a network, showing how to use SNA to examine the structural features of supply networks. They implemented their model on a car supply network, demonstrating that this model was complementary to the models used in previous studies. Zschache (2012) utilized agent-based simulations to track the formation of public goods and network characteristics such as density and strength of ties to design a model validated using empirical data. Liu, Wei, et al. (2020) categorized the intelligent supply chain risks into actors', technical, and environmental risks. They evaluated the risks identified through SNA and identified critical risks utilizing the MCDM technique. Luo, Qiping Shen, et al. (2019) developed a network of chain risks through SNA, identified practical risks, and provided the necessary management solutions. Using data collected over ten months in the OLIO app and through SNA, it was concluded that traditional supply chains were inefficient because they could not investigate the relationship between entities (Harvey et al., 2020).

Due to the literature, it can be understood that researchers are not satisfied with one method to identify and rank supply chain risks and try to take advantage of the multi-methods combination. As well as the number of risks identified in research has been between ten and 50. Some of them studied a real case; a few have provided risk management solutions, and only Dong and Cooper provided a model to identify, evaluate, and mitigate supply chain risks (Dong and Cooper, 2016). MCDM, mathematical modeling, and artificial intelligence techniques are among the standard methods utilized in SCRM, each of which has its advantages in examining specific aspects of supply chain management. Also, upon empirical studies in SNA and supply chain, the subject is a new topic with research importance. Paying more attention to supply chain networks can be synonymous with economic efficiency, reducing financial costs and facilitating access to financial services. Besides the benefits of the SNA approach, it also allows researchers to inspect the intereffect of risks that have been ignored in previous methods. On the other hand, the ICT supply chain is a case study analyzed with very little research.

2-3- Research gap

According to a review paper by Pournader et al. (2020), the studies conducted in SCRM in the last two decades can be divided into 11 clusters:

1. Behavioral risks in supply management: The researchers have dealt with trust, power, buyer-supplier relationships, and supply managers' cognition and its impact on decision-making. The dominant methodology in this cluster is case analysis and qualitative research.
2. Supply chain risk assessment and mitigation: Most papers discuss decision-making and mitigation capabilities. Qualitative, case study, quantitative, experimental, and mixed-methods research have all been referenced in this cluster.
3. Business continuity and resilience management: The general topic for this cluster relates to reactive responses to risk and guaranteeing business durability through appropriate resilience management activities. There are no salient methodological frameworks for this cluster.
4. Behavioral operations and supply chain risks: The SCRM scholars have investigated behavioral operations and their implications for supply chain risk. The newsvendor problem is among the most favorite topics among researchers (Zhang and Siemsen, 2019). Due to the nature of the topic, the dominant method of data collection has been behavioral experiments. As well as, The main frameworks employed have been germane to behavioral models of biases and heuristics, decision-making under risk, and the theory of behavioral operations.
5. Supply chain performance risks: The role of supply chain disruptions in the stock price performance of firms in the supply chain and the role of justice among buyer-supplier relationships have been

mainly discussed in this cluster. Organizational justice has been associated with the dominant frameworks.

6. Supply risk management: Topics in this field are management and supply chain risk mitigation. Risk/ inventory pooling, dual sourcing, operations and order diversification, contracting, and insurance have been the most prominent solution to mitigate or manage supply chain risks. The topic has mainly studied analytical models.
7. Resource dependence risk: Dependence on supplier resources, customer dependency, and creating value besides dependency have been popular topics. This cluster's most common data collection methods are survey analysis and archival data.
8. Humanitarian operations and disaster relief: The role of public-private partnerships in this domain has been mainly discussed. A resource-based view has also been the most common framework.
9. Supply network complexity and disruptions management: The impact of complexity on supply chains has been studied in this cluster. Empirically oriented quantitative and multiple regression analyses have been favorite frameworks among scholars.
10. Intuition and expertise in risk management decisions: Most studies in this cluster have involved behavioral studies on intuition, expertise, and judgment.
11. Metaheuristics and logistics risk management: Employing heuristic and metaheuristic models in optimization and tackling problems have been among this cluster's most common research topics. Ant colony algorithm, Tabu search heuristic, simulated annealing, and genetic algorithm have been among the most popular.

Pournader, et al. (2020) elaborate that sustainability issues in SCRM, cognitive risks in supply decisions, behavioral forecasting risks, resource dependence risks, and intuition, expertise, and judgment models are emerging topics in the literature. As well as, due to the coronavirus pandemic, which has caused prominent disruptions to the global economy, several papers have appeared to assess the effect of such disorders on organizations, businesses, and supply chains (Schoenherr et al., 2020). However, the mitigation strategies have not been well investigated and still need scientific efforts.

In order to analyze scientific papers, we also set 50 relevant keywords to the topic that would provide the maximum coverage of the Scopus database, i.g., supply chain risk, supply chain vulnerability, supply chain risk management, supply chain resilience, sustainability risk, etc.Two thousand recent articles were analyzed using R programming language and the Bibiliometrix library.

The supply chain's emerging topics and research gaps are shown by Pournader et al. (2020) review paper. According to numerous studies on risk assessment to manage risks, risk management analysis seems critical. As well as, the approaches and models presented had some limitations, but the evaluation of supply chains through SNA is attractive and has had high research importance (Wichmann and Kaufmann, 2016) and (Rodriguez-Rodriguez and Leon, 2016).

Although SNA has been utilized in some studies as an effective tool in assessing supply chain risks, these studies are few, and the number of risks identified has not been large enough. Furthermore, evaluating traditional supply chains necessitates a practical solution to avoid existing risks. Therefore, assessing supply chain risks utilizing SNA and analyzing intelligence's impact on the network has excellent research importance.

Although a few papers have examined ICT supply chain risks (Boyens et al., 2015) and (Osunji, 2021), no study has been conducted to rank and evaluate ICT supply chain risks. That is worth mentioning that the study of supply chain risks in domestic industries has been neglected. This study examines a list of risks in the supply chain network of mobile operators' products in Iran as a case study. This supply chain consists of many components that interact with each other. The complexities of this supply chain network state themselves as risks that affect the performance of the supply chain. So, we combined Viable System Model (V.S.M.) and SNA to inspect the ICT supply chain risks of one of the biggest ICT suppliers in Iran. ICT supply chain risks are identified by conducting a semi-structured interview designed on the VSM, and through SNA, the network of risks is generated; then, based on network centrality measures, the types of risks that have the most significant impact on supply chain performance are evaluated and ranked. Accordingly, it can help manage ICT supply chain risks by providing critical risks.

3- Methodology

Considering the numerous studies conducted in risk assessment and supply chain intelligence to manage risks, analyzing this topic in a comprehensive and general model seems very important. The paper's methodology is divided into three sections; first, the case study is introduced, then risk identification is provided, and the semi-structured interview conducted based on VSM is demonstrated. The third section describes risk ranking through SNA.

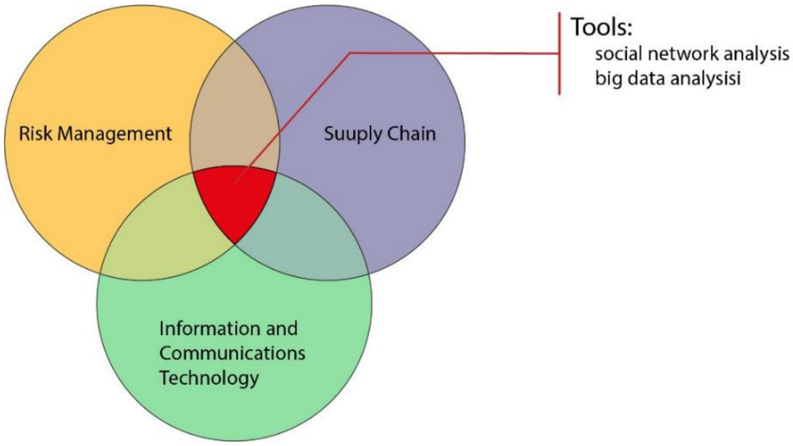

Fig 1. The ranks of the ICT supply chain risks' through SNA

3-1- Case study

Due to the high consumption of mobile phone operators' products such as SIM cards, charge cards, modems, etc., agility and efficiency in the supply chain are very important. If these products do not reach the consumer at the right time, the operator will face many financial and non-financial losses. This points out the importance of risk identification in the competitive environment of today's market.

Tehran Internet Company as the most critical ICT products distributor of M.T.N. Irancell, which began its activity in 1999, faced many problems in the supply chain of the ICT products when it entered the market. Some of the ICT supply chain issues the company has experienced are stated below:

1. Unhealthy competition between the distribution companies leads to the reduction of the charge card price in the market and underselling.
2. Improper distribution of charge cards in different parts of the country due to various reasons such as weather, closed shop sales, lack of commodities on holidays and non-working hours, etc. These problems cause lost sales.
3. The increasing transportation and distribution cost continuously reduce the profit of the sales layers. Due to the physical nature of the products and the distribution network, the network's vulnerability to unstable transportation costs in the country is significantly high.
4. The customer must leave home or work to purchase charge cards.
5. The cost of producing physical charge cards is higher than electronic ones for the operator.
6. The low quality of the produced charge cards, which sometimes get discarded due to the lack of correct scratching by the customer.
7. Warehouse costs for the distribution network and ensuring the security of keeping a massive volume of charge cards.
8. Failure to properly monitor the distribution of products sold in the distribution network by the operator due to various brokers in this area and, as a result, lack of transparency for decision-makers.
9. Due to high distribution costs, there is a lack of products in rural, remote, and inaccessible areas.

10. Lack of coordination and control in capillary distribution due to the high cost and extensiveness of the distribution network.
11. Customers' dissatisfaction due to the expensive sales of the last vendor.
12. If the distribution system's performance is not satisfactory to the company, it cannot react appropriately and quickly.
13. The high risk of running out of charge card stock in the area and the time-consuming for redistribution.
14. It is challenging to decide on the number of distributors' orders due to the costs associated with each order and the costs of maintaining the inventory of the products in different areas of the country.
15. A high risk of theft and loss of the charge cards in the distribution process between different sales layers.
16. Inability to manage the liquidity of sales layers by the distributor.
17. Economic turbulence and the effects of annual inflation on distribution quality and costs.
18. The dependence of charge card distribution on other retail products, such as cigarettes, because the distributors of both products are standard at the sites of sale.

All these challenges raised for the supply chain are derived from a set of risks that threaten the supply chain's objectives. In a competitive environment, dealing with all these risks is impossible. One of the essential parameters in risk management is cost management. Due to numerous risks, allocating optimal resources to critical ones is essential. Risk identification and ranking determine the superiority of each risk based on relevant indicators, and as a result, it is possible to provide an appropriate response for each one. Therefore, resources should be spent on those with the most significant impact on network productivity.

Suppose Tehran Internet Company aims to maintain its competitiveness in the market; Therefore, the risks that threaten the ICT supply chain and affect transportation costs, improper distribution, and lack of demand should be identified to prevent customer dissatisfaction and loss of market share. Additionally, considering Iran's political and economic crisis in the last decade and the increase in the number of international sanctions, identifying ICT supply chain risks will help this large-scale company significantly against financial losses.

This paper identifies ICT risks in semi-structured interviews with the company's experts. Utilizing actual data related to one of the largest product supply chains of mobile operators in Iran can be considered one of the most important innovations of this research.

3-2- Risk identification

Today, complexity and uncertainty have created complex conditions for organizations. The organizational environment faces increasing dynamism and change, and organizations constantly change their goals according to the surrounding environment. Choosing the proper organizational structure is one of the essential prerequisites. The approach chosen to design the organizational structure in these conditions should understand the internal and external complexity of the organization. One of the models based on complexity management is VSM, which originated from organizational cybernetics. VSM models organizational structure in which an autonomous system can produce itself, i.e., it is made up of a viable system that is made of viable systems (Hoverstadt and Bowling, 2002, May). This model can be utilized to design a new viable system or diagnose the existing system's drawbacks.

When this model is utilized as a diagnostic tool, its purpose is to examine the organization's current structure, problems, and shortages to achieve viability due to its structural nature. Owing to the diagnostic and structural nature of VSM and its functionality in complex environments, we conducted the interview based on VSM to identify risks.

A unique feature of VSM is that it conceptualizes everything from policy to operation units and their relationship to each other and the environment. This feature makes VSM a valuable model for structuring the system and identifying problems and bottlenecks from the highest system level to each subsystem level (Adham, 2012). A viable system is a combination of five linked subsystems that may be mapped onto aspects of organizational structure (Beer, 1981). The system will be compromised if one or more of these subsystems do not exist or have the inadequate capacity or if their interactions are disrupted (Jose, 2012). The subsystems of a viable system are illustrated in figure 2 and table 1 based on the nervous system.

Based on the risks identified in previous studies, we categorized risks into 13 categories: financial and economic risks, information technology risks, human resources planning risks, market and industry risks, sales planning risks, financial and organizational planning risks, quality and communication risks, distribution risks, legal risks, supply planning risks, supplier risks, shipping risks, and shopping and trading risks.

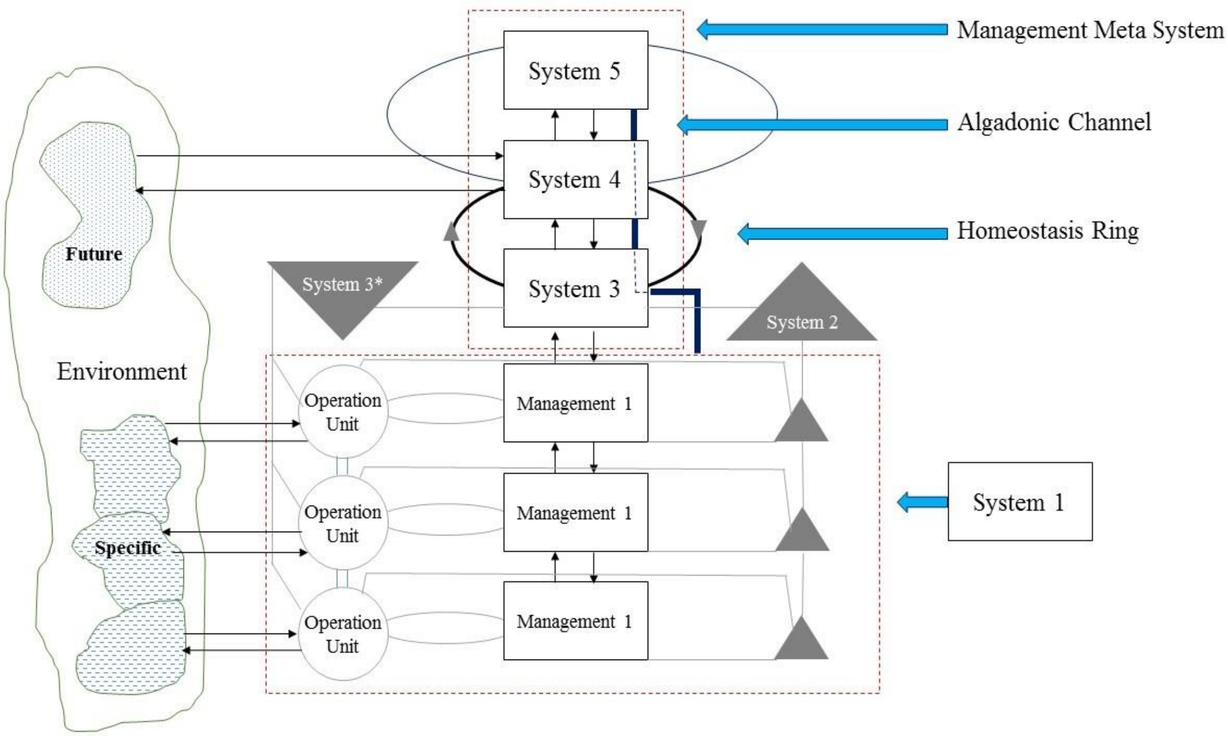

Fig 2. Subsystems of a viable system (Hoverstadt and Bowling, 2002, May)

Table 1. VSM Subsystems based on the Nervous System

Subsystem	Description	Compliance with the Nervous System
System 1, implementing subsystem	It is responsible for primary activities, production, and delivery of goods and services of the organization to the appropriate environment. This system performs tasks directly related to the organizational goals (Jose, 2012).	Muscles of the human body
System 2, coordination subsystem	This system provides a coordination function and harmonizes all organizational units (Jose, 2012).	Sympathetic nervous system
System 3, integration subsystem	This system is responsible for managing the set of operating units of System 1. System 3 is responsible for controlling System 1 and managing human resources and financial services. This system prepares and announces an integration plan to system 1 (Jackson, 2003).	Base brain
System 3*, audit subsystem	It is a supportive subsystem for system 3, and its primary mission is to gain information about how system 1 works and monitor it (Warren, 2002).	Parasympathetic nervous system
System 4, intelligence or development subsystem	The responsibility of this system is related to the future and the organization's external environment. Identifying environmental challenges and opportunities in the internal and external environment of the system and transferring them to system information of systems 3 and 5 is another responsibility of this system (Adham et al., 2012).	Diencephalon in brain
System 5, policy subsystem	This system is called the identity or policy subsystem. System 5 has the most authority in the organization and is the only part controlling the interaction of relations between systems 3 and 4. System 5 responsibilities include determining the organization's vision, mission, and goals (Jose, 2012).	Brain cortex

We interviewed the experts based on the structure proposed by VSM. It was a top-down interview in which we asked the interviewees to identify the risks based on the risk categories framework at their level or lower levels because they may not be aware of risks related to the higher levels. After identifying unique risks in each category, they were asked to determine a score between zero and five based on the impact of each risk on the other risks they defined. The scores were interpreted as bellows:
0: without impact, 1: a little impact, 2: it has impact, 3: no opinion, 4: high impact, 5: very high impact.

Finally, the risks identified and the scores considered edge weights between the nodes. When experts' opinions about the weight and impact of the risks were close to each other, the average weight was set; otherwise, we arranged a meeting with all the experts to determine the exact weight of the risks. We implemented this step in all five parts of the organizational structure and finally identified the specific ICT supply chain risks.

3-3- Risk ranking

SNA was utilized to rank the risks identified by the experts. Each of the risks was considered the network node, and the edge's direction between them presented the direction of the effect. Figure 3 illustrates the step of directed network generation.

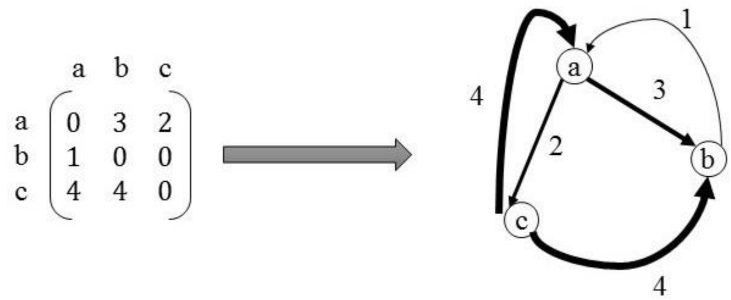

Fig 3. Directed network generation based on adjacency matrix. a, b, and c are the supply chain risks. If one affects the other, a weight equal to the experts' decision is assigned to them. Zero means that there is no direction from the source node.

In previous studies, risk assessment and ranking were based only on two centrality measures: In-degree and Out-degree. Each centrality measure has a specific definition and interpretation and examines a type of importance that the others ignore. This paper calculated in-degree, out-degree, closeness, betweenness, and eigenvector centralities for each risk. We finally compiled the results of the centrality measures with experts' opinions. The results of the research are presented in the next chapter.

4- Results

According to the experts, 86 risks were identified and classified into financial and economic (table 2), information technology (table 3), human resources planning (table 4), market and industry (table 5), sales planning (table 6), financial and organizational planning (table 7), quality and communication (table 8), distribution (table 9), legal (table 10), supply planning (table 11), supplier (table 12), shipping (table 13), and shopping and trading (table 14) categories.

Table 2. The risks identified associated with the "Financial and Economic" category

Number	Risk
R1	Fluctuations in financial markets
R2	Global economic crises
R3	War and terrorist attacks
R4	Contractual problems arising from the renewal of US sanctions against Iran
R5	Debt and credit rates
R6	Liquidity problems
R7	Exchange rate fluctuations
R8	Financial Problems
R9	Weakness in budgeting and allocation of financial resources
R10	Riots and protests inside the country

Table 3. The risks identified associated with the "Information Technology" category

Number	Risk
R1	Weak information infrastructure
R2	Lack of access to information
R3	Lack of effective expansion of information policy network
R4	The intellectual property of information and information systems
R5	Relying on information technology to implement decisions and processes
R6	Failure of information systems and processes
R7	Poor information accuracy
R8	Lack of effective integration of information policies
R9	Selection of inappropriate software to implementation of specific processes
R10	Outsourcing and information sharing

Table 4. The risks identified associated with the "Human Resources Planning" category

Number	Risk
R1	Changes in government policies (price control, setting the minimum wage, etc.)
R2	Weakness or inability to create job motivation
R3	Weakness in developing appropriate policies and working methods
R4	Island performance of units
R5	Return rate fluctuations
R6	Inexperienced and untrained workforce
R7	Weakness in the execution procedure of work processes
R8	Change or relocation of key personnel
R9	Cultural issues
R10	Poor communication between units

Table 5. The risks identified associated with the "Market and Industry" category

Number	Risk
R1	Weakness in forecasting and responding to market demand
R2	Weaknesses in marketing
R3	Lack of ability to predict the market and industry changes
R4	Financial strength and consumer purchasing power
R5	Technology changes
R6	Rapid changes in production technology

Table 6. The risks identified associated with the "Sales Planning" category

Number	Risk
R1	Incorrect demand forecast
R2	Bullwhip effect
R3	Rapid changes in customer expectations
R4	Weakness in forecasting and responding to market demand
R5	Lack of ability to predict the market and industry changes

Table 7. The risks identified associated with the "Financial and Organizational Planning" category

Number	Risk
R1	Non-receipt of financial claims from customers
R2	Banks' contractionary and expansionary policies
R3	Change in competitive advantage
R4	Poor workforce training

Table 8. The risks identified associated with the "Quality and Communication" category

Number	Risk
R1	Customers' dissatisfaction with the quality of goods
R2	Lack of proper supervision at the process execution site
R3	Not to use up-to-date technologies
R4	Improper support system
R5	Poor customer relationship system
R6	Lack of transparency about tariffs

Table 9. The risks identified associated with the "Distribution" category

Number	Risk
R1	Delay in delivery of the final product to customers
R2	Lack of carrying capacity
R3	Weakness in forecasting and responding to market demand
R4	Low variety of shipping methods
R5	Distribution at the wrong site

Table 10. The risks identified associated with the "Legal" category

Number	Risk
R1	Increase labor costs
R2	Administrative formalities and transportation planning
R3	Opening foreign currency credit problems
R4	Increase tariffs and customs regulations
R5	Rising prices for fuel and energy carriers
R6	Organizational corruption
R7	Changes in government policies (price control, setting the minimum wage, etc.)

Table 11. The risks identified associated with the "Supply Planning" category

Number	Risk
R1	Terms of monopoly or multilateral monopoly in the supply market
R2	Lack of timely supply of requested items
R3	Wrong order delivery
R4	Commitment of suppliers
R5	Lobbying through competing companies and joint suppliers
R6	Dependence on a supplier
R7	Product design changes
R8	Capacity and responsiveness of alternative suppliers
R9	Wrong ordering
R10	Process weakness in the suppliers' acceptance process

Table 12. The risks identified associated with the "Supplier" category

Number	Risk
R1	The exit of suppliers from the business environment
R2	Supplier production capacity limit
R3	The bankruptcy of the supplier
R4	Opportunistic suppliers
R5	Inability to share information with suppliers
R6	Wrong choice of suppliers

Table 13. The Risks Identified Associated with the "Shipping" Category

Number	Risk
R1	Increase shipping costs
R2	Improper shipping of products
R3	Improper shipping in the company's internal warehouse
R4	Shipping selective method
R5	Shipping capacity limit
R6	Long shipping routes
R7	The limited capacity of ports and railways
R8	Shipping machinery failure

Table 14. The risks identified associated with the "Shopping and Trading" category

Number	Risk
R1	Customs clearance
R2	Sanctions
R3	The emergence of new or foreign competitors
R4	Global economic crises
R5	Contractual problems arising from the renewal of US sanctions against Iran

To validate the importance of the risks obtained, we checked the financial reports between 2006-2011[2]:

- The cost of a lost, stolen, or defective charge card was equal to the annual loss of 10 billion Rials.
- The underselling cost of the charge card caused the company to be failed to earn 20 billion Rials annually.
- Inability to predict demand and improper distribution due to wasting 20 billion Rials annually.
- Risk due to credit validation and annual waste of 1200 billion Rials.
- The cost and risk of warehousing and shipping goods equal the annual cost of 40 billion Rials.
- The cost of printing a charge card was equal to 10 billion Rials per year.
- The direct charge card distribution cost was 30 billion Rials annually.
-

As a result of the financial reports show that the preparation, supply, and distribution of physical goods is a considerable cost for traditional supply chains.

The directed graph obtained from the impact of the risk on each other is very complicated (because the huge number of edges and arcs), so we can not present it in this paper. Since the direction of edges signifies the impact path, we favored the directed graph over the undirected graph because the direction of impact was important to us. Each of the 86 risks is considered a node, and the edge's direction indicates the impact of each risk on the other risk. Also, the size of the nodes depends on the importance and impact of other network risks.

Table 15 presents the centrality measures for each of the risks in the ICT supply chain. If a risk is affected by other risks, it has a higher in-degree centrality. IN-degree centrality identifies vulnerable risks that should be maintained from the damage of other risks. In-degree centrality was calculated by considering the weight of the edges, which means that the number of edges was counted, and the weight of the edges in determining the importance of a node was considered. The same method was applied for out-degree centrality. Nodes with higher out-degree centrality have the most influence on other nodes and affect them. Betweenness centrality considers a risk the most important and has the highest intermediary role between two risks, and closeness centrality defines a risk as necessary that has more access to the rest of the network of risks. Eigenvector centrality was employed to measure the impact of a node on a network. It delegates a relative index value to all nodes upon connecting with high-index nodes. It means a risk linked to more important risks is identified as critical (Saxena and Iyengar, 2020).

Table 15. Risks centrality measures

Risk	In-degree	Out-degree	Closeness	Betweenness	Eigenvector
Sanctions	15	240	0.720339	24.73823	0.011373
War and terrorist attacks	3	239	0.732759	7.114352	0.00238
Contractual problems arising from the renewal of US sanctions against Iran	48	199	0.685484	964.5627	0.105118
Riots and protests inside the country	41	186	0.702479	210.2921	0.020296
Not to use up-to-date technologies	110	166	0.559211	169.6984	0.389205
Technology changes	29	158	0.639098	30.55028	0.033916
Rapid changes in production technology	46	156	0.634328	349.7947	0.162353
Weak information infrastructure	82	155	0.562914	37.22461	0.272485
Lack of access to information	90	154	0.57047	45.7696	0.274062
Selection of inappropriate software to implementation of specific processes	62	154	0.574324	61.84887	0.242547
Poor information accuracy	109	152	0.574324	99.02549	0.421231
Island performance of units	86	152	0.555556	33.70692	0.308054

[2] . This financial and statistics report was prepared for the CEO of Tehran Internet Company in 2011. Please note that during the report period, 1 US Dollar was equal to about 10000 Rials.

Table 15. Continued

Risk	In-degree	Out-degree	Closeness	Betweenness	Eigenvector
Global economic crises	22	151	0.643939	191.6889	0.018035
Lack of effective integration of information policies	82	150	0.574324	32.7082	0.291815
Lack of effective expansion of information policy network	83	147	0.555556	49.62288	0.308449
Inexperienced and untrained workforce	69	145	0.602837	206.4578	0.206585
Failure of information systems and processes	137	144	0.559211	116.6114	0.430603
Poor communication between units	92	139	0.555556	64.96724	0.357069
Outsourcing and information sharing	75	139	0.52795	166.2405	0.272861
Lack of proper supervision at the process execution site	132	138	0.541401	338.2288	0.585523
Product design changes	61	138	0.566667	246.3862	0.150795
Weakness in the execution procedure of work processes	112	133	0.562914	73.23182	0.395997
Weakness in budgeting and allocation of financial resources	93	133	0.555556	94.82706	0.395508
Weakness in developing appropriate policies and working methods	127	119	0.534591	180.9196	0.404114
Rapid changes in customer expectations	49	119	0.534591	21.19307	0.042657
Fluctuations in financial markets	34	117	0.57047	28.13016	0.016095
Financial Problems	126	112	0.52795	188.0285	0.32509
Exchange rate fluctuations	29	110	0.57047	14.35872	0.014713
The emergence of new or foreign competitors	26	109	0.541401	73.28223	0.105619
Poor workforce training	70	103	0.494186	68.52977	0.24684
Lack of ability to predict the market and industry changes	95	97	0.518293	30.07546	0.343654
Increase shipping costs	206	94	0.521472	403.9077	0.749245
Weakness in forecasting and responding to market demand	155	93	0.497076	82.43774	0.585941
Liquidity problems	86	93	0.512048	109.6977	0.260155
Inability to share information with suppliers	76	93	0.480226	33.45918	0.296208
The intellectual property of information and information systems	25	90	0.534591	24.37203	0.070133
Rising prices for fuel and energy carriers	28	89	0.551948	4.870972	0.016479
Terms of monopoly or multilateral monopoly in the supply market	133	81	0.508982	515.0849	0.780512
Low variety of shipping methods	94	79	0.482955	66.2382	0.298891
Changes in government policies (price control, setting the minimum wage, etc.)	33	78	0.541401	7.50395	0.016479
Increase labor costs	129	75	0.491329	62.93963	0.364933
Relying on information technology to implement decisions and processes	19	74	0.515152	7.413155	0.052252
Organizational corruption	5	74	0.544872	39.66091	0.003882
Bullwhip effect	62	73	0.477528	63.74521	0.104254
Change in competitive advantage	28	71	0.515152	35.72182	0.137173
Incorrect demand forecast	151	68	0.459459	36.88183	0.491593
Weakness or inability to create job motivation	76	60	0.477528	54.31781	0.317007
Non-receipt of financial claims from customers	78	59	0.456989	118.4401	0.286267
Shipping selective method	190	58	0.459459	75.15237	0.725113
Poor customer relationship system	163	58	0.438144	96.18605	0.747772
Debt and credit rates	61	58	0.485714	31.78918	0.217833
Administrative formalities and transportation planning	117	50	0.391705	36.48326	0.420705
Shipping machinery failure	33	50	0.445026	6.337592	0.132508
Shipping capacity limit	84	49	0.440415	22.71846	0.346638
Lack of carrying capacity	105	48	0.425	22.45758	0.404263
Wrong choice of suppliers	72	48	0.5	151.497	0.275664

Table 15. Continued

Risk	In-degree	Out-degree	Closeness	Betweenness	Eigenvector
Distribution at the wrong site	160	47	0.429293	35.07367	0.682142
The limited capacity of ports and railways	8	46	0.397196	0.297439	0.002643
Long shipping routes	145	44	0.435897	72.86873	0.687648
Change or relocation of key personnel	21	43	0.461957	9.031864	0.038298
Increase tariffs and customs regulations	41	41	0.435897	3.244275	0.02037
Improper support system	175	38	0.431472	89.04017	0.786576
Lobbying through competing companies and joint suppliers	47	38	0.480226	63.66495	0.142829
Customers' dissatisfaction with the quality of goods	136	33	0.452128	272.6416	0.860724
Process weakness in the suppliers' acceptance process	85	33	0.418719	32.89095	0.317811
Capacity and responsiveness of alternative suppliers	40	32	0.406699	5.408766	0.062768
Weaknesses in marketing	134	31	0.384615	12.24893	0.558281
Dependence on a supplier	104	31	0.414634	29.34153	0.361357
The bankruptcy of the supplier	99	31	0.410628	26.15822	0.228789
Delay in delivery of the final product to customers	256	29	0.408654	130.102	1
Opportunistic suppliers	114	29	0.461957	177.8924	0.332931
Banks' contractionary and expansionary policies	24	29	0.480226	0.252538	0.012196
The exit of suppliers from the business environment	85	27	0.412621	25.29389	0.223874
Financial strength and consumer purchasing power	28	27	0.406699	0.269511	0.010128
Wrong order delivery	72	26	0.377778	8.778299	0.340297
Commitment of suppliers	76	21	0.433673	57.66303	0.186954
Improper shipping in the company's internal warehouse	69	20	0.381166	3.553351	0.392206
Opening foreign currency credit problems	44	20	0.459459	25.93023	0.061625
Improper shipping of products	184	18	0.371179	14.01745	0.730416
Supplier production capacity limit	80	17	0.372807	21.48566	0.23949
Wrong ordering	65	17	0.372807	3.330812	0.294482
Customs clearance	101	15	0.352697	12.53545	0.222967
Cultural issues	19	15	0.393519	87.31478	0.064063
Lack of timely supply of requested items	168	12	0.425	279.0321	0.599943
Return rate fluctuations	70	11	0.431472	7.074158	0.214135
Lack of transparency about tariffs	53	9	0.354167	8.434443	0.255713

By considering in-degree as a measurement, delay in delivery of the final product to customers, increase shipping costs, shipping selective method, improper shipping of products, improper support system, lack of timely supply of requested items, poor customer relationship system, distribution at the wrong site, weakness in forecasting and responding to market demand, and incorrect demand forecast are risks that are affected by the other risks and can disturb the ICT supply chain. Since in the traditional supply chain, product distribution was based on physical goods; it was expected that transportation methods and severe weather conditions that jeopardized product delivery and increased costs would be identified as key risks. It is reported that products got burned, theft or delivery agent got murdered, and the products were never delivered to the final consumer. In addition, due to heavy rain or snow, distributors have to send their products by other means, which causes costs to increase. As well as, according to Irancell's report, between 11:30 pm till 2:00 am is the peak of internet consumption; if a client's internet charge runs out, he cannot charge it at that moment which decreases the consumption by 7%. It all shows that the key risks identified make sense. Also, weakness in forecasting and responding to market demand is a significant risk that should be considered more during holidays.

Sanctions, war, and terrorist attacks, contractual problems arising from the renewal of US sanctions against Iran, riots, and protests inside the country, not to use up-to-date technologies, technology changes, rapid changes in production technology, weak information infrastructure, lack of access to information, and election of inappropriate software to implementation of specific processes are risks which trigger the other network risks. Risks that arise from political conflicts and related to new technologies and information are critical risks that affect the network. These are among those risks control of which are beyond the authority of organizational managers and affect the entire network of risks, i.g., the 1401 protests in Iran, which disrupted the Internet, caused the income of Tehran Internet Company to decrease by 40%. Also, the effect of sanctions, in addition to economic transactions, is on the import of updated servers and software, the lack of which can negatively impact the organization's infrastructure.

War and terrorist attacks, sanctions, riots and protests inside the country, contractual problems arising from the renewal of US sanctions against Iran, global economic crises, technology changes, rapid changes in production technology, inexperienced and untrained workforce, selection of inappropriate software to implementation of specific processes, and poor information accuracy are the risks has more access to the rest of the network with higher closeness centrality. The result is close to the risks identified through out-degree centrality. Risks triggered by political issues and related to IT are critical risks that are more accessible to the other risks in the network. One of the risks identified as one of the critical risks through the closeness centrality measure is the inexperienced and untrained workforce. It shows that inexperienced resources can influence the network of risks so that other risks become closer, bringing irreparable costs to the organization. We suggest that managers can monitor the workforce through business intelligence tools and prevent problems from arising. Also, the use of inappropriate software generated due to sanctions and the inappropriate implementation of specific processes that can be reduced by utilizing process mining are among the identified risks that cause other risks to be closer.

Contractual problems arising from the renewal of US sanctions against Iran, terms of monopoly or multilateral monopoly in the supply market, increase shipping costs, rapid changes in production technology, lack of proper supervision at the process execution site, lack of timely supply of requested items, customers' dissatisfaction with the quality of goods, product design changes, riots and protests inside the country, and inexperienced and untrained workforce are the risks that have the leading intermediary role between other risks. The emergence of a monopoly can pose problems in many distribution networks. One of the well-identified risks at this stage is customer dissatisfaction. In the traditional supply chain, the final consumer is in contact with the local sellers, who are either stall owners or grocers; therefore, there is no guarantee for the customer in case of damage to the charge card, and since the use of the charge card is dependent on scratching it, there is a possibility of erasing the credit code in many cases. In all these cases, the customer's complaint would go nowhere. Product design changes are another risk with high betweenness centrality, which is a costly risk in the physical supply of goods because the costs of distribution and packaging of goods are also affected by changing the design of the size of charge cards by the operator.

Delay in delivery of the final product to customers, customers' dissatisfaction with the quality of goods, improper support system, terms of monopoly or multilateral monopoly in the supply market, increase shipping costs, poor customer relationship system, improper shipping of products, shipping selective method, long shipping routes, and distribution at the wrong site has a high impact on the network because they are linked to more critical risks.

The supply chain is a process affected by social and political conflicts. As the results indicate, problems arising from social and political conflicts can trigger risks that threaten the supply chain. As well as in the ICT supply chain, information accuracy and the emergence of new technologies have an essential role that can affect the other risks in the network.

Finally, the results of this study were presented to the organization's managers and experts. Firstly, the outputs of the in-degree made sense to them based on their experiences, i.e., it was predictable that the final product and its shipping methods are among the risks that are affected by many factors. As well as, the financial reports, which cannot be presented in this research due to confidentiality, demonstrated that the risks associated with sanctions and new technologies had the most significant impact on the organization's performance.

We can mention two essential contributions. First, unlike the previous papers conducted to rank the risks through SNA, we employed more centrality measures for the first time to rank the risks identified. As the results show, some centrality measures indicate some risks as important ones, while others cannot rank them as necessary due to the specific feature of each centrality measure. Second, due to the importance of the identified risks, appropriate strategies should be presented to mitigate them, and many of the identified cases can be eliminated with methods based on intelligence. However, there are risks in the supply chain, such as sanctions, war, terrorist attacks, the emergence of new technologies, etc., which are beyond the authority of managers and organizational decision-makers. So all risks identified cannot be mitigated or eliminated from the chain.

5- Conclusion

In this paper, utilizing VSM, we categorized organizational experts into five sections to conduct a semi-structured interview; the result identified 86 risks germane to the ICT supply chain. In continuation, SNA was used to rank the risks identified and discover the critical ones. For this purpose, we utilized in-degree, out-degree, closeness, betweenness, and eigenvector centrality measures, while previous studies employed in-degree and out-degree measures. We conducted the study in one of Iran's most influential ICT product distributors. Since the company is representative sales and after-sales service agent of Iran's most significant digital operator, Irancell, they needed to identify and mitigate the supply chain risks. Because the data source was collected from a reputable company, the other SCRM scientist and ICT supply chain decision-makers will take advantage of the results.

The salient constrain of previous studies, which had primarily used MCDM techniques, was that they would not consider the intereffect of risks and the tangible interactions that risks may have in creating or forming other risks; therefore, it was not possible to achieve a model that provides a more accurate estimate of reality. In order to tackle this problem, we employed SNA to study the interaction large number of risks simultaneously on a graph.

The findings demonstrated that social and political conflicts generally create these risks, and to prevent the chain from environmental threats, managers should always consider the impact of information accuracy and the appearance of emerging technologies. It was also confirmed that final product and shipping methods are among the vulnerable risks that should be maintained from the impact of other risks.

Although the identification of risks in this research has been carried out with great care and holding numerous brainstorming sessions, since experts' opinions have been the primary source of risk identification, there is a possibility of ignoring hidden risks that affect the supply chain. This case can be considered one of the limitations of the study.

One of the literature gaps is that supply chain risks in domestic industries have not been addressed well. Due to the issues caused by sanctions that limit the use of up-to-date technologies for organizations and affect international affairs, and the impact of inflation, which affects both the income of the employees and the reduction of consumption, unusual conditions have been created in the country, which necessitates the identification of risks in the other industries according to the political and social conditions of Iran.

On the other hand, start-up companies should pay more attention to identifying the risks because if they are unaware of environmental threats and do not adopt a suitable strategy, they will quickly fail in the market and lose the competition.

That is worth mentioning that the model proposed in this research may be used in similar work areas and supply chains of different industries for future studies. As well as we aim to mitigate the impact of top-rated risks in this paper through intelligent methods and asses the result of their mitigation via financial reports.

5-1- Managerial achievements

Peter Drucker says that what cannot be measured cannot be managed. In this research, a method has been presented to identify and rank supply chain risks. Identifying, evaluating, and mitigating the effect of risk on the supply chain is a continuous process that requires time and money. If the organizational managers want to spend all their money to eliminate all the risks in the chain, they have to pay more costs because some risks are more critical than others, and it is not logical to provide equal time and money to deal with all the threats; Therefore, risks should be ranked. By presenting a method based on social network analysis, organizational managers can become aware of the importance of risks according to the interpretation obtained from each centrality measure and spend their resources on dealing with the most important ones.

Identifying and ranking risks acts like a flashlight that guides organizations in the dark and keeps them from going astray and wasting resources. This insight is not created in an organization unless there is a process and holistic view of the value chain, and one of the ways to achieve a process view is to interview the stakeholders. On the other hand, interviews with stakeholders provide the possibility to identify hidden risks. If these risks are not distinguished correctly, they will cause the supply chain to break. Organizations must assign a strategic committee to identify risks to execute the continuous risk assessment process.

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