Journal of Industrial and Systems Engineering
Vol. 17, No. 3, pp. 122-144
Summer (July) 2025

A Sustainable Machine Learning Approach to Supply Chain Risk Management: A Case Study of Saipa Press

Zohreh Mousavi [1], Sadigh Raissi [2,*], Kambiz Jalali Farahani [3]

[1] *Department of Industrial Management, ST.C., Islamic Azad University, Tehran, Iran*

[2] *Department of Industrial Engineering, ST.C., Islamic Azad University, Tehran, Iran*

[3] *Department of Industrial Management, ST.C., Islamic Azad University, Tehran, Iran*

Abstract

Effective Supply Chain Risk Management in the Automotive Parts Industry has gained increasing importance due to technical complexity, dependence on multiple suppliers, and susceptibility to internal and external factors. The sustainability approach in this field not only reduces negative environmental and social impacts but also enhances the resilience of the supply chain. Therefore, this study was conducted to examine supply chain risk management with a sustainability approach at Saipa Press. This research is of a mixed type (qualitative-quantitative). In the qualitative phase, data were collected through semi-structured interviews with 10 industry and university experts who were selected purposefully. Based on the results, a conceptual model for risk management was outlined. In the quantitative phase, risk prioritization and assessment were conducted using machine learning algorithms (decision trees) and risk matrix analysis. The results showed that the most significant risks in Saipa Press's supply chain include fluctuations in raw material prices, supplier delays, demand instability, and regulatory changes. Utilizing the machine learning model significantly increased the accuracy of risk predictions and enabled the identification of hidden patterns in operational data. Furthermore, integrating the sustainability approach optimized production processes, reduced waste, and enhanced collaboration with suppliers. The findings of this study indicate that such an approach not only increases the resilience and competitiveness of the organization but also contributes to sustainable development by reducing negative environmental and social impacts. It is recommended that companies active in the automotive parts industry update their management strategies by investing in data-driven technologies.

Keywords: Supply Chain Risks, Saipa Press, Risk Matrix, Decision Tree

* Corresponding Author

ISSN: 1735-8272,

1- Introduction

A supply chain refers to the set of stages and processes that encompass the flow from production to the distribution of products to the end customer. This chain includes suppliers, manufacturers, distributors, and retailers, with the primary aim of delivering goods and services to customers most efficiently and effectively as possible (Kancs, 2023). Given the inherent complexities of supply chains, effective management is recognized as a key factor in business success. Different supply chains, depending on their importance, scope, and position, face a variety of risks. Supply chain risks are defined as factors that can negatively affect the performance and efficiency of the chain (Bahari & Moody, 2023). These risks may originate from internal or external sources and can be classified into several categories. Internal risks include issues such as production problems, defects in product quality, resource shortages, and financial difficulties. In contrast, external risks comprise economic fluctuations, market volatility, political crises, natural disasters, and disease outbreaks (Mzougui et al., 2020).

In light of the above, the automotive parts industry, as one of the essential and pivotal pillars of the automotive supply chain, plays a significant role in the economic and technological development of countries. Due to the rising demand for new vehicles, as well as the need to improve performance and reduce emissions, this industry is rapidly evolving (Aaradhana, 2020). The automotive parts supply chain refers to a set of stages and processes that include sourcing raw materials, manufacturing parts, assembling vehicles, and delivering them to end customers. Because of its technical complexities and the need for precise coordination between suppliers, manufacturers, and distributors, this chain is highly sensitive. Any disruption can lead to production delays, increased costs, and decreased product quality (Surya et al., 2019). Therefore, effective management of the automotive parts supply chain is crucial to maintaining competitiveness and meeting market demands.

Risks in the automotive parts supply chain can arise from various factors. Internal risks include issues such as defects in parts quality, shortages of human and financial resources, and disruptions in the production process. On the other hand, external risks encompass fluctuations in raw material prices, changes in laws and regulations, natural disasters, and global crises such as pandemics. These risks can have significant impacts on supply chain performance, which is why identifying and managing them is considered a priority for automotive companies. By employing preventive strategies and modern techniques, companies can enhance the resilience of their supply chains, improve overall performance, and reduce costs (Yoga et al, 2020).

Supply chain risk management refers to the process of identifying, assessing, and mitigating the negative impacts of these risks on supply chain performance. It may involve developing preventive strategies, diversifying supply sources, improving communication among supply chain partners, and utilizing advanced techniques such as data analytics and machine learning. Given the growing challenges and existing uncertainties, managing supply chain risks has become essential to maintaining the sustainability and competitiveness of businesses in today’s complex world (Wallner, 2023).

Moreover, supply chain risk management in the automotive parts industry should be pursued through a sustainability-oriented approach. This involves identifying and mitigating risks in ways that minimize negative impacts on the environment and society. Such an approach includes assessing the environmental impacts of parts production, using sustainable raw materials, and optimizing manufacturing processes to reduce waste and energy consumption. Considering the increasing attention to environmental and social issues, companies in the automotive parts industry need to integrate sustainability strategies into supply chain risk management—not only to achieve economic goals but also to preserve natural resources and improve the quality of life in local communities (Gabriela et al., 2020).

A sustainability-oriented approach to supply chain risk management also enables companies to be more resilient against market fluctuations and global crises. By developing closer relationships with suppliers and sharing information, companies can respond quickly to changes and prevent crises. Additionally, leveraging modern technologies such as data analytics and the Internet of Things allows firms to optimize their supply chains, enhancing transparency and efficiency.

In summary, this study aims to examine supply chain risk management with a sustainability perspective in the context of Saipa Press. The research gap addressed here is the lack of comprehensive and systematic studies integrating machine learning technologies into the processes of supply chain risk management in the automotive parts sector. Furthermore, given Saipa Press's role as a major player in Iran's automotive parts industry, there is a pressing need to explore the specific challenges and opportunities created by incorporating machine learning into supply chain risk management. Closing this gap can help researchers and managers identify and analyze these challenges, ultimately leading to effective solutions for improving supply chain performance and enhancing industry sustainability. Additionally, insights and results from implementing this approach in Saipa Press could serve as a model for other companies in the automotive parts industry. Accordingly, this research seeks to answer the question: What is the nature and scope of sustainability-based, machine learning–driven supply chain risk management at Saipa Press?

2- Literature Review

Supply chain risk management is the process of mitigating risks through collaboration, coordination, and the application of risk management tools among partners to ensure the continuity of operations alongside the long-term profitability of the supply chain (Faisal et al., 2007). It should be noted that risks cannot be eliminated from a supply chain; however, strategic approaches can be developed to manage them, provided that the dynamic relationships among risk-related variables in a supply chain are well understood (Faisal et al., 2006). The primary objective of supply chain risk management is to maximize the expected profit or minimize the expected loss when disruptions occur within the supply chain (Tang, 2006). Over time, risk management has evolved into an essential tool for addressing risk-related challenges in supply chain management. Generally, the process of supply chain risk management comprises four main components: risk identification, risk assessment, risk management decision-making and implementation, prioritization, and risk monitoring (Hallikas et al., 2004; Nozari et al., 2023).

It is evident that any supply chain, without proper and effective management, cannot operate strategically or yield tangible benefits for any company, regardless of its size or business type. The automotive supply chain, in particular, is a complex and dynamic system that has undergone substantial changes in recent years. Globalization, sustainability, technology, resilience, and collaboration are among the key considerations in today's automotive supply chains. While these aspects may seem complex, they also present opportunities for companies to improve their supply chain management practices and gain a competitive advantage. Further research is required to explore these dimensions in depth and to develop strategies to effectively address them within the context of the automotive industry.

To begin with, globalization has led to significant changes in automotive supply chains. It has created opportunities for companies to source parts and components from suppliers around the world. This development has resulted in cost reductions, increased competitiveness, and, at the same time, greater complexity in supply chain management (Christopher & Peck, 2004; Abdi et al., 2023;Nozari, 2022). In recent years, sustainability has also emerged as a critical issue in automotive supply chains. Automotive companies face mounting pressure to minimize their environmental impact, leading to a growing interest in sustainable supply chain management. Key sustainability concerns within supply chains include reducing greenhouse gas emissions, minimizing waste, and enhancing social responsibility (Carter & Rogers, 2008). Collaboration among supply chain partners has become a vital success factor in the automotive industry, as it can improve efficiency, lower costs, and drive innovation. However, collaboration can also be challenging due to cultural, linguistic, and business practice differences. Supply chain resilience has likewise grown in importance for the automotive sector in response to natural disasters and other disruptions. The automotive industry has been particularly affected by supply chain interruptions, such as the 2011 earthquake and tsunami in Japan. In response, companies are increasingly investing in resilience by diversifying their supplier base, improving risk management processes, and developing contingency plans (Christopher & Peck, 2004, Nozari, 2023).

The automotive industry supply chain, as a complex and multi-layered system, encompasses various stages from the production and procurement of raw materials to the final delivery of vehicles to customers. This chain includes raw material producers, multi-tier component suppliers, automobile manufacturers, dealers, and ultimately, customers. In general, a single vehicle consists of approximately 20,000 different parts, each playing a vital role in the overall performance of the vehicle. Consequently, the absence of even one component can completely halt the vehicle's assembly and transportation process.

The automotive supply chain typically includes three to five different tiers, with each tier comprising thousands of suppliers. These suppliers may operate in various fields such as electronic components, suspension systems, engines, and other key automotive systems. This multi-tiered structure enables automakers to leverage diverse sources while simultaneously reducing risks associated with parts procurement. Figure 2-3 clearly illustrates the overall view of the automotive supply chain and depicts the complex interactions among these layers and different suppliers. These interactions not only influence production quality and costs but also affect delivery time and customer satisfaction. Ultimately, effective management of the automotive supply chain is recognized as a key factor in the success and competitiveness of the automotive industry in the global market (Timothy, 2011).

Over the past three decades, the automotive industry has undergone substantial changes in its supply chain. Competitive pressures on Original Equipment Manufacturers (OEMs) have forced them to improve product quality, shorten product development time, and reduce production costs. Many Asian and Eastern European countries, with their low-cost and skilled labor, have provided attractive opportunities for minimizing supply chain costs.

However, globalization and outsourcing opportunities are accompanied by significant risks. These risks include cultural and language differences, exchange rate fluctuations, customs regulations and tariffs, quality issues, and political and economic instability. Furthermore, international logistics—which involve inventory management, border-crossing procedures, and transportation delays—bring about additional challenges that can impact product availability.

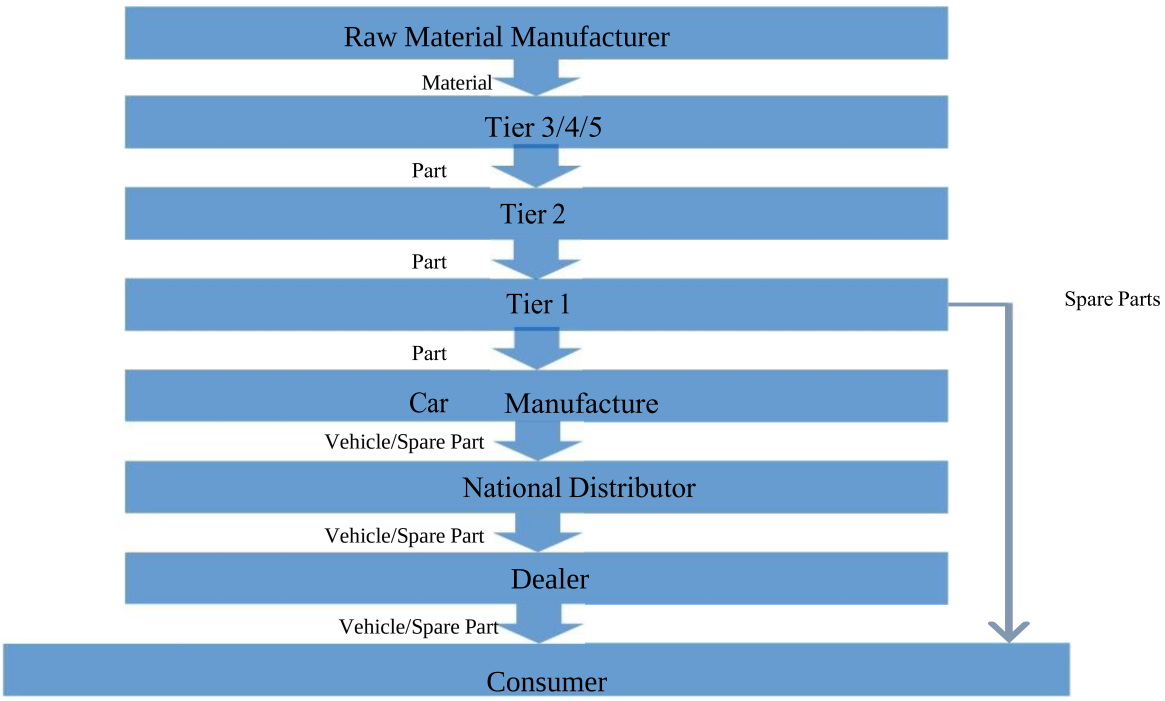

Fig 1. Automotive Supply Chain (Timothy, 2011)

Over the decades, the automotive industry has utilized various methods to reduce costs and achieve competitive advantage. Several common approaches employed in this regard include:

Adoption of Just-in-Time (JIT) principles: This approach contributes to creating optimized and cost-efficient supply chains in which parts and components are provided at the right time and in the required quantity, thereby preventing inventory build-up.

Single sourcing: Focusing on specific suppliers for a greater subset of components helps maximize scalability and reduce costs. This method enables manufacturers to establish closer relationships with their key suppliers and benefit from economies of scale resulting from large-volume purchases.

Outsourcing to developing countries: This strategy allows companies to lower production costs by relocating certain manufacturing activities to countries with low-cost labor, while simultaneously focusing on their core and strategic activities.

Globalization and expansion into international markets: This approach enables companies to access new markets and capitalize on global business opportunities.

Despite the advantages of these methods, it is important to note that they can also result in reduced inventory buffers, increased dependency on suppliers, greater supply chain complexity, and ultimately, heightened supply chain risks. These challenges can significantly affect the overall performance of the automotive industry and underscore the necessity for precise and strategic management (Thun &Hoenig, 2011; Nakashima & Sornmanapong, 2013).

In summary, the automotive industry is characterized as an economic sector with low margins, high production volumes, significant costs, a global supply chain, and multi-tier suppliers (Simchi-Levi, 2010; Singhal et al., 2011). Supply chains in this industry are deeply and extensively organized, encompassing various stages from raw material procurement to final vehicle delivery to customers. Cost-reduction efforts—such as JIT production, single sourcing, outsourcing, and globalization—considerably add to supply chain network complexity. At the same time, these complexities increase supply chain risks in the automotive sector. Automotive supply chain risks comprise a set of challenges arising from various sources, including raw material procurement, supply disruptions, production processes, storage, logistics, and distribution. These risks can have significant impacts on the performance and efficiency of the automotive industry, necessitating careful and strategic management to reduce vulnerabilities and enhance supply chain resilience. Consequently, understanding and managing these risks is essential for success and sustainability in today's competitive market.

A review of the literature indicates that numerous studies have identified and prioritized supply chain risks in the automotive industry. Shariati (2023), using supply chain risk analysis and a pairwise comparison questionnaire, identified three main risk clusters—material flow, money flow, and information flow—finding money flow risks to be the most critical, with manufacturing, exchange rate fluctuations, and system security ranked as the most important factors. Arshadi et al. (2022), employing fuzzy cognitive maps and interpretive structural modeling, ranked 13 risks in three categories—technical, strategic, and operational—highlighting five key risks: design errors, low motivation, shortage of financial resources and parts, and low productivity. Hosseinzadeh et al. (2019), combining the COSO model with social network analysis, identified critical risks for Saipa, showing that 48% of risks were concentrated in the financial–economic, supplier, informational, and transportation categories.

A review of international studies on risk and uncertainty management in the automotive supply chain reveals various approaches to enhancing resilience and performance. Wei (2024) emphasized that strong collaborative networks within the supply chain can enhance companies' robustness and competitiveness in complex, globalized contexts. Choi et al. (2023) modeled and analyzed the effects of production risks on automotive supply and transportation networks, offering recommendations for improving planning and market responsiveness. Bahari and Moody (2023) used the NSGA-II genetic algorithm to design a multi-product, multi-period optimization model for the automotive supply chain, addressing both quality and cost, and enabling efficient decision-making for cost reduction, quality improvement, and supply chain management enhancement.

3- Methodology

This study, aimed at managing supply chain risks with a sustainability approach, employed a sequential exploratory mixed-method design. In the first stage, a comprehensive review of the literature and previous research—including more than 90 domestic and international scholarly sources—was conducted to identify the concepts, definitions, constructs, and outcomes related to supply chain risks. This stage utilized library resources, academic articles, specialized books, and online databases to establish the theoretical framework and foundations for the research. Subsequently, based on the insights of ten selected experts in the field of supply chain management, the initial conceptual model of the study was developed. Purposive sampling was applied, and semi-structured interviews were conducted until theoretical saturation was reached.

In the next stage, the extracted components were analyzed and evaluated using the decision tree approach with the aid of RapidMiner software, version 7. Finally, the identified risks were classified and prioritized according to probability of occurrence and severity of impact within a risk matrix. This analytical process facilitated the identification of key risk domains and the development of strategies for sustainable supply chain risk management. Ultimately, qualitative and quantitative data were integrated to address the study's central research questions and objectives. The statistical population of this research consisted of senior managers in the automotive industry and professionals active in the automotive sector. Given the focus of this study on the automotive industry, in-depth, semi-structured interviews were conducted with experts, managers, and founders in the field. These experts possessed substantial experience and expertise in areas relevant to the research topic and were able to provide valuable and in-depth insights. As each participant had unique and diverse experiences, collecting their opinions and perspectives significantly enriched the research data. For sampling, non-probability purposive methods were employed. The following section presents the characteristics of the experts in the research domain.

Table 1. Characteristics of the Experts in the Research Domain

Percentage	frequency	feature
Age of research experts		
40	4	35 to 45 years
40	4	46 to 55 years
20	2	56 and above
Experts' work experience		
50	5	5 to 10 years
40	4	10 to 20 years
10	1	21 andabove
Experts' education		
10	1	Bachelor
50	5	Master
40	4	Doctorate and above
100	10	Total

3-1. Data Preparation

Operational Definition and Measurement of Sustainability

In this study, the sustainability attribute was assessed based on three dimensions:

- Economic sustainability: Ability of the supply chain to maintain cost-efficiency and profitability under the given risk scenario;
- Social sustainability: Potential to safeguard workforce well-being, customer satisfaction, and community relationships;
- Environmental sustainability: Extent to which operations can minimize resource use, emissions, and waste during disturbance recovery.

Each risk was evaluated by a panel of 10 experts using a structured questionnaire. For each dimension, experts assigned a score from 1 (very low sustainability) to 5 (very high sustainability). These three scores were averaged to obtain a composite sustainability index, which was subsequently normalized between 0 and 1 for analysis in RapidMiner.

For example, a risk with scores of Economic=4, Social=3, and Environmental=2 would yield a composite score of (4+3+2)/3 = 3, which corresponds to a normalized value of 0.60. This transparent scoring method ensures consistency across all 245 identified risks and allows direct comparability between sustainability values.

4- Results

4-1. Identification of Supply Chain Risks through Theoretical and Empirical Analysis

In this study, after multiple rounds of review and refinement of scholarly articles and theses, a number of sources were excluded from the analysis process. The sampling method for selecting studies was purposive sampling, and two criteria—inclusion and exclusion—were applied to select suitable texts. These criteria were also used to determine the accuracy, validity, and significance of the reviewed research, thereby enabling more precise evaluation and selection.

The initial database search yielded 123 studies relevant to sustainability-oriented supply chain risk management. The screening process consisted of three main stages: Title and abstract review: Studies clearly unrelated to supply chain risk management or the automotive sector were excluded. Full-text assessment: Studies lacking empirical data, methodological rigor, or explicit sustainability metrics were removed. Duplication and relevance check: Duplicate records and studies focusing solely on theoretical frameworks without practical application to supply chain contexts were excluded.

Inclusion criteria: (a) Empirical or case-based analysis related to automotive supply chains; (b) Explicit integration of sustainability factors (environmental, social, or economic); (c) Publication in peer-reviewed journals or conference proceedings; (d) Availability of full text in English or Persian.

Exclusion criteria: (a) Studies outside the 2010–2025 publication range; (b) Non-peer reviewed sources; (c) Incomplete data or insufficient methodological description; (d) Studies focusing on unrelated sectors without transferable insights to automotive supply chains.

At this stage, after four rounds of refinement, out of 123 studies, 107 were excluded, and 22 studies were selected for data analysis. The identified risks were subsequently classified into primary and secondary risks, as presented in Table 2:

Table 2. Classification of Identified Risks from the Review of Previous Studies.

Row	Main risks	Sub-risks	Identified risks	References
1	Supply risks	Risks associated with supply	Supply shortages, dependence on single suppliers, and potential threats and vulnerabilities in .the supply chain	Mola (2024); Anujji et al(2024)
2		Price, quality and delivery risks	Price fluctuations, difficulties in managing cooperation between .manufacturers and suppliers	Stewart (2024); Zho(2018)
		Financial and supplier risks	Financial and supplier risks .and support	Alavi and Shekarani (2023); Zand Hesami and Savouji (2012); Wang et al. (2025); Mehrmanesh and Safavi (2020)
3	Demand risks	Demand-related risks	Uncertainty in demand for new products and sudden .increases in demand	Zhou (2018); Bababik et al. (2023); Wang et al. (2025); Kashif (2024); Anoji et al(2024)
4		End-customer risks	Risks related to customer .needs and behaviors	Stewart (2024); Mazaheri et al .(2011)
5	Production hazards	Production and transmission risks	Risks related to the production and delivery process and difficulties in optimizing contracts and .supplier capacity	Mazaheri et al. (2011); Wang et al. (2025); Safavi et al. (2023); Mehrmanesh and Safavi(2020)
6		Industry-specific hazards	Risks related to the specific characteristics of each .industry	Bababik et al. (2023); Yaahu(2024)
7	Logistics risks	Logistics risks	Unexpected incidents, road congestion, carrier force, and .delivery delays	Wang et al(2025)

8		Risks related to the delivery process control system	Problems in managing the transportation network and .unavailability of information	Wang et al. (2025); Yaahu (2024); Mehrmanesh and Safavi (2020); Mohammadi and Shojaei (2016)
9	Information risks	Information risks	Lack of traceability and verification of claims and excessive environmental .pressures	Haifen(2023)
10		Information and Communication Technology Risks	Cyber threats and lack of adequate training for the .parties involved	Mola (2024); Harihora and Dimitrova(2024)
11	Financial and strategic risks	Financial risks	Risks associated with the costs of implementing sustainable strategies and their impact on sustainable .supply chain performance	Haifen (2023); Alavi and Shekarani (2023)
12		Strategic risks	Risks related to policies and .governance issues	Yahyazadeh Far et al(2017)
13	Environmental and social risks	Environmental risks	The spread of solid, liquid, and gaseous waste throughout supply chains, causing economic, social, .and environmental harm	Esfahani et al. (2020); Yahyazadeh Far et al. (2017); Yaahu (2024); Harihora and Dimitrova (2024)
14		Social risks	Political instability and .climate change	Mola (2024); Harihora and Dimitrova (2024); Esfahani (2020) .et al

Based on the results of Table 2, supply chain risks are classified into two main categories and sub-categories, each of which can affect the overall performance of the supply chain in different ways.

The main categories include supply risks, demand risks, production risks, logistics risks, information risks, financial and strategic risks, and environmental and social risks. These risks can directly influence supply chain operations. For example, supply risks may involve issues such as shortages of raw materials, price volatility, and product quality problems, all of which directly impact the production and delivery of goods. Similarly, demand risks may stem from uncertainty in customer needs or sudden changes in demand, which affect production planning and inventory management.

On the other hand, the sub-categories refer to risks associated with each of the main categories and may act as contributing factors that intensify the principal risks. For instance, risks related to supply may include problems with suppliers and financial resources, which may lead to delivery delays and reduced quality. Logistics and information risks involve transportation process issues and lack of access to accurate, timely information, potentially causing disruptions in the supply chain. Finally, environmental and social risks refer to challenges arising from environmental pressures and societal expectations, which may affect a company’s reputation and operational performance.

Effective management of these risks requires precise identification and strategic planning aimed at reducing the supply chain’s vulnerability.

Identifying supply chain risks is one of the critical steps in supply chain management, requiring in-depth analysis of texts derived from interviews. Such analysis can reveal weaknesses and threats within the supply chain. By examining the views and experiences of various actors involved, a clearer understanding of existing challenges and risks emerges. This insight enables managers to formulate appropriate strategies to mitigate these risks.

Subsequently, the analysis of interview transcripts can uncover common patterns and recurring concerns among supply chain stakeholders. These patterns may involve issues such as delays in supply, price fluctuations, and logistical challenges. By identifying these patterns, organizations can manage risks more effectively and develop more optimal solutions to address them.

In sum, identifying supply chain risks through interview-text analysis can enhance overall supply chain performance and increase resilience. With a deeper understanding of vulnerabilities, organizations can design optimized processes and sustainable strategies that not only help reduce risks but also improve the efficiency and productivity of the supply chain.

Before delving into the detailed discussion of the risks identified from the interview texts, the following points are presented in this section.

Table 3. Frequency of Risks Based on Interview Texts (245 Risks)

Code System	**First interview**	**Fifth interview**	**Fourth interview**	**Tenth interview**	**Second interview**	**Third interview**	**Sixth interview**	**Ninth interview**	**Eighth interview**	**Seventh interview**	**TOTAL**
Sanctions Risks						0%					0%
Market Risks						1%	3%		2%	1%	1%
Legal Risks				5%		2%	2%	5%	7%		2%
Customer Loyalty Risks		2%	3%	7%		1%	4%	7%	6%	6%	3%
Supply Risks				2%							0%
Price risks		2%	1%	1%		0%	3%	0%	0%		1%
Social risks											
Product quality risks		1%		2%	1%	1%	2%	2%	2%	2%	1%
Time risks			4%		1%					1%	1%
Strategies	13 %	12 %	4%		11%				6%	3%	5%
Consequences	7%			4%	13%			10 %	6%	7%	5%
Licensing risks	3%										0%
Energy access risks	2%					1%					0%
Information risks	2%			4%	4%	2%	3%				2%
Technical risks	4%				4%	1%					1%
Communication risks						1%					0%
Human risks	2%	2%	3%		1%	13%	6%			4%	4%
Technological risks	1%		5%			2%				2%	1%
Environmental risks	1%	2%	2%	2%		17%	2%	1%			4%
Financial risks	2%					0%					0%
Social risks											
Legal and political risks											
Logistics risks	6%	1%	2%	3%	3%		3%	2%	2%	4%	3%
Production risks	25 %	2%	3%		3%						3%
Raw material supply risks	9%	4%	2%	3%	10%	1%	8%	2%	4%	3%	4%
Demand risks		3%	3%	5%		0%	1%	1%		2%	1%
NOT CODED	23 %	68 %	70%	61%	52%	57%	66 %	69 %	66%	65 %	58 %
CODED	77 %	32 %	30%	39%	48%	43%	34 %	31 %	34%	35 %	42 %
WHOLE TEXT	100 %	100 %	100% (1,748)	100% (2,345)	100% (4,407)	100% (5,076)	100 %	100 %	100% (2,460)	100 %	100 % (28,

	(2,840)	(2,579)					(2,215)	(2,642)		(2,409)	721)

The main risks are presented in the table below, based on their frequency:

Table 4. Key risks, consequences, and identified supply chain strategies (24 key risks)

Main risks	Frequency	Percentage	Percentage (valid)
Raw material supply risks	10	100.00	100.00
Logistics risks	9	90.00	90.00
Customer loyalty risks	8	80.00	80.00
Product quality risks	8	80.00	80.00
Price risks	7	70.00	70.00
Human risks	7	70.00	70.00
Environmental risks	7	70.00	70.00
Demand risks	7	70.00	70.00
Strategies	6	60.00	60.00
Consequences	6	60.00	60.00
Legal Risks	5	50.00	50.00
Information Risks	5	50.00	50.00
Market Risks	4	40.00	40.00
Technology Risks	4	40.00	40.00
Production Risks	4	40.00	40.00
Time Risks	3	30.00	30.00
Technical Risks	3	30.00	30.00
Energy Access Risks	2	20.00	20.00
Financial Risks	2	20.00	20.00
Sanctions Risks	1	10.00	10.00
Supply Risks	1	10.00	10.00
License Risks	1	10.00	10.00
Communication risks	1	10.00	10.00
Social risks	0	0.00	0.00
Cultural risks	0	0.00	0.00
Legal and political risks	0	0.00	0.00
DOCUMENTS with code(s)	10	100.00	100.00
DOCUMENTS without code(s)	0	0.00	-
ANALYZED DOCUMENTS	10	100.00	-

Based on the above results, the supply chain risks in Saipa Press, as perceived by the company's experts, comprise a set of challenges and threats that can affect the performance and efficiency of the supply chain.

4-2. Risk Categorization via Decision Tree

In today's business world, risk management is recognized as one of the fundamental pillars of organizational and commercial success. Considering the complexity of business and economic environments, identifying and categorizing risks is essential for making intelligent and optimal decisions. RapidMiner software, with its advanced data analytics and machine learning tools, enables users to identify and classify different types of risks. Using sophisticated algorithms, the software analyzes data, uncovers hidden patterns, and helps managers gain a clearer understanding of the existing risks.

RapidMiner's capabilities enable the use of various techniques, including cluster analysis, regression, and decision trees, to categorize risks based on their characteristics and impacts. This classification not only facilitates risk identification but also empowers organizations to develop appropriate strategies for managing and mitigating these risks. Consequently, RapidMiner serves as an effective tool in risk management, enabling organizations to move toward their objectives with greater confidence and resilience in the face of upcoming challenges.

The decision tree is one of the most popular techniques in machine learning and data analysis, used for modeling decision-making processes. This method employs a tree-structured model that hierarchically splits the dataset, with each node of the tree representing a specific feature or question used in decision-making. As one moves deeper into the tree, the data is partitioned into smaller subsets until reaching a final decision or class.

To ensure transparency and reproducibility of the analysis, a sample of the dataset used in the quantitative phase is presented in Table 3. The dataset comprised 245 identified supply chain risks, each evaluated based on three main attributes: Occurrence Probability, Impact Severity, and Sustainability Resilience. These attributes were derived from expert scoring in the qualitative phase and transformed into numerical values through a structured coding process. The values were normalized between 0 and 1 before being loaded into RapidMiner for decision tree analysis.

This hierarchical and visual clarity makes decision trees highly interpretable, allowing users to follow the decision logic easily. Furthermore, decision trees can effectively uncover patterns and complex relationships within the data, serving as a powerful tool for classification and prediction. In this research, the decision tree operators within RapidMiner were utilized as follows:

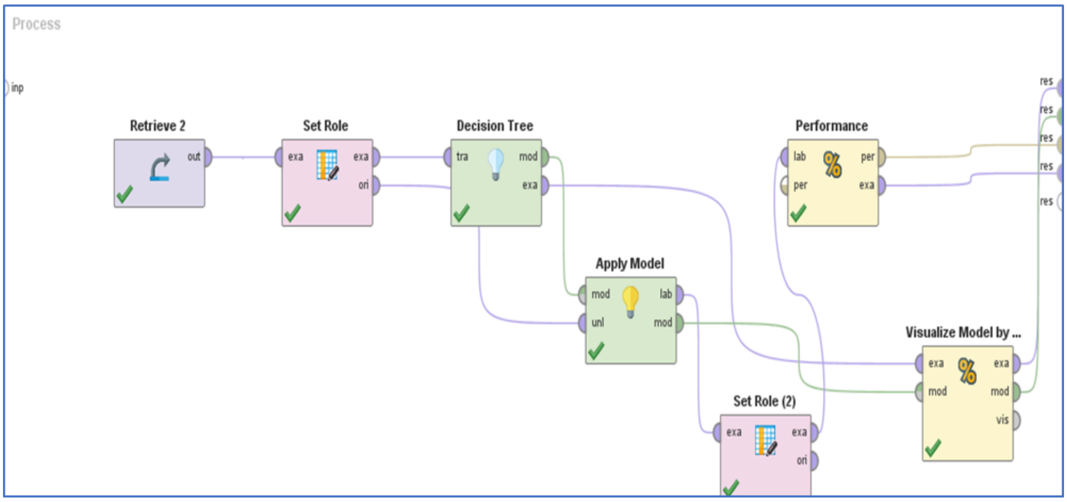

Fig 2. Decision tree operators in RapidMiner software

The results of risk classification based on the decision tree are as shown in the following diagram:

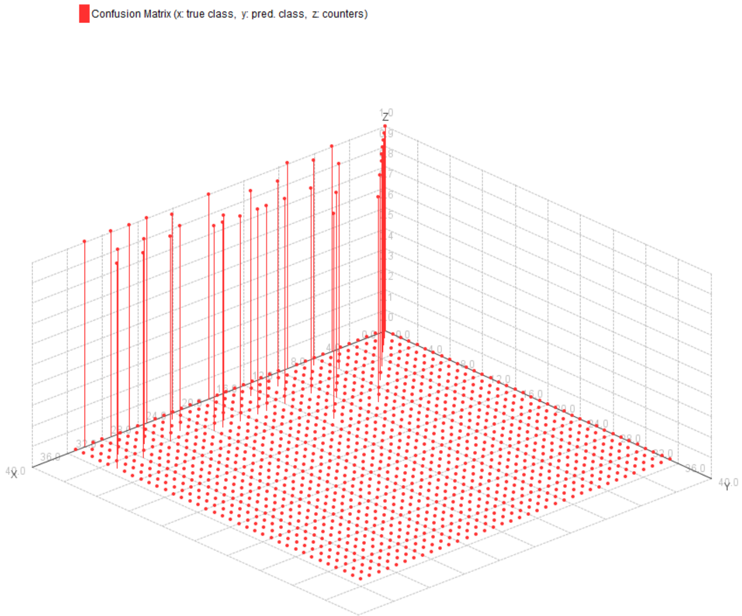

Fig 3. Performance operator in Rapidminer

This three-dimensional chart illustrates the confusion matrix generated from applying the decision tree model for risk classification. In this visualization:

X-axis: Represents the actual class.

Y-axis: Represents the predicted class.

Z-axis: Indicates the number of instances the model counted for each actual–predicted class combination.

The tall red columns along the diagonal line—where the actual and predicted classes match—represent correct classifications. The taller and more concentrated these columns are along the diagonal, the higher the model's accuracy. Given the high density and height of these diagonal columns, it can be inferred that the decision tree model correctly assigned a large portion of the data to their proper classes.

Columns located off the diagonal indicate misclassifications (cases where the model predicted the wrong class). In this case, these columns appear short and scattered, which implies a relatively low classification error rate.

The 3D view helps in spotting differences in sample distribution between classes. If certain diagonal columns are noticeably short, it indicates that the model struggled to distinguish that specific class from others. In this chart, the column heights appear fairly balanced, suggesting relatively consistent performance across classes.

This point is particularly important for risk type classification, as a misclassification in one category could weaken the relevance of a decision or mitigation strategy.

Overall, the output indicates that the decision tree model in RapidMiner, given the data's structure and features, provided accurate classifications and successfully identified and categorized a large share of risks. Nevertheless, a closer numerical analysis of the 2D confusion matrix and metrics such as precision, recall, and prediction accuracy would be necessary for a full performance evaluation.

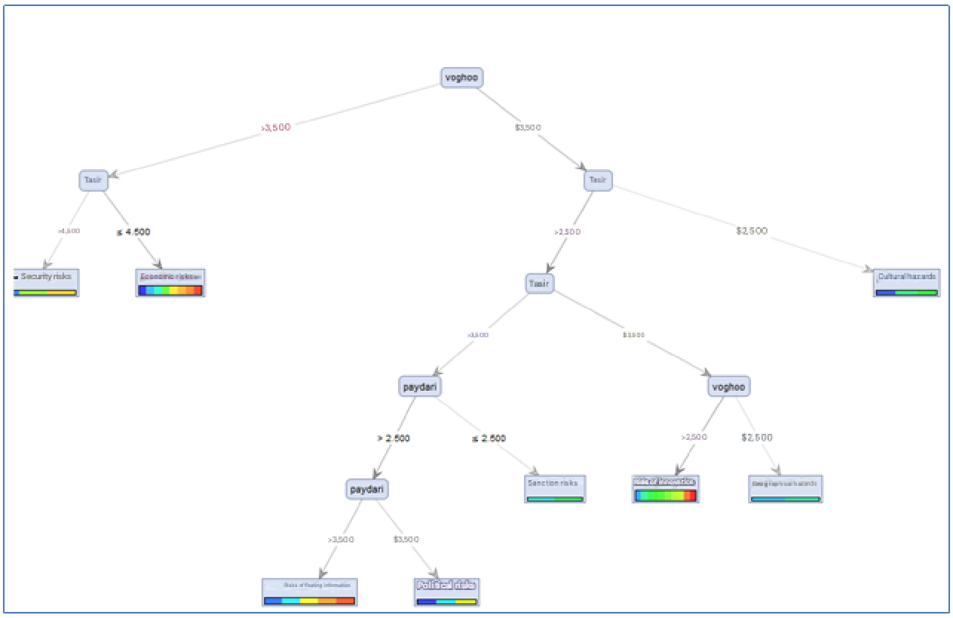

Fig 4. Decision Tree of Supply Chain Risks

The data presented in this decision tree examines various risks under different conditions. These risks are classified into main and sub-categories, each exerting its own specific effects on organizations and society.

In the following section, a more comprehensive analysis of each of these branches is provided.

1. **Cybersecurity Risks**

Conditions of Occurrence: Identified when voghoo (occurrence) exceeds 3.500 and tasir (impact) exceeds 4.500.

Impacts: Such risks can result in the loss of sensitive data, service disruptions, and damage to organizational reputation. They also incur high costs for recovery and security enhancement. These risks have become increasingly critical in today's digital environment.

2. **Economic Risks**

Conditions of Occurrence: Identified when tasir is less than or equal to 4.500.

Impacts: Economic risks include market fluctuations, price changes, and supply chain disruptions. They can lead to lower revenues, rising costs, and ultimately reduced profitability. Additionally, they can cause unemployment and social discontent.

3. **Political Risks**

Conditions of Occurrence: Identified when paydari (sustainability) is less than or equal to 3.500 and tasir is between 2.500 and 3.500.

Impacts: Political risks may involve changes in government policies, economic sanctions, and political instability. Such changes can significantly affect trade and the economy, potentially resulting in social and economic instability.

4. **Sanction Risks**

Conditions of Occurrence: Identified when paydari is less than or equal to 2.500.

Impacts: Sanctions can reduce exports and imports, thus decreasing national revenue. They can also escalate tensions and cause social dissatisfaction.

5. **Information Technology Risks**

Conditions of Occurrence: Identified when paydari exceeds 3.500 and tasir is between 2.500 and 3.500.

Impacts: Issues in IT infrastructure can disrupt daily organizational operations. These disruptions may cause data loss and reduced employee productivity.

6. **Innovation Risks**

Conditions of Occurrence: Identified when voghoo is between 2.500 and 3.500 and tasir is less than or equal to 3.500.

Impacts: Innovation risks can lead to misalignment with market needs and shifts in consumer behavior. Such risks may reduce competitiveness and result in lost business opportunities.

7. Geographical Risks

Conditions of Occurrence: Identified when voghoo is less than or equal to 2.500 and tasir is less than or equal to 3.500.

Impacts: Geographical risks may create difficulties in sourcing raw materials and disrupt the supply chain. These issues could lead to higher costs and lower product quality.

8. Cultural Risks

Conditions of Occurrence: Identified when tasir is less than or equal to 2.500.

Impacts: Cultural risks can drive changes in consumer behavior and market demand. These changes can reduce demand for specific products and increase social dissatisfaction.

The data indicates that different risks are identified under varying conditions, requiring careful monitoring and appropriate management. Organizations should closely track these risks and develop effective strategies to prevent and mitigate their negative impacts. By gaining deeper insight into these risks, organizations can achieve sustainable growth and strengthen their resilience against challenges.

In the following section, the model's performance evaluation criteria are presented:

```
accuracy: 80.22%
spearman_rho: 0.537
kendall_tau: 0.538
absolute_error: 0.078 +/- 0.034
relative_error: 9.78% +/- 8.41%
relative_error lenient: 7.78% +/- 3.41%
```

Fig 5. Model accuracy

Although the model achieved an overall accuracy of 80.22%, the correlation coefficients Spearman's rho = 0.537 and Kendall's tau = 0.538 indicate a moderate positive monotonic association between the predicted and actual risk classes, suggesting that higher predicted risk levels generally align with higher observed values. The absolute error of 0.078 ± 0.034 reflects relatively small average deviations in the normalized risk scores, while the relative error of 9.78% ± 8.41% implies that predictions deviate by less than 10% from actual values on average. Under a lenient matching criterion, the relative error drops further to 7.78% ± 3.41%, highlighting strong predictive consistency. However, the moderate correlations—rather than very high correlations—suggest the presence of residual noise or unmodeled variability in certain risk cases, likely attributable to factors not captured in the input feature set or to non-linear patterns better addressed by ensemble or hybrid modelling techniques.

Based on the new results presented, the following analysis can help better understand the model's performance:

1 .Accuracy

This value indicates the model's good performance in identifying and classifying risks. An accuracy above 80% clearly shows that the model has been able to make correct predictions.

2 .Correlation (Spearman's rho and Kendall's tau)

Negative values of these indices indicate a lack of positive correlation between predictions and reality. This means that the predictions are not only incorrect but may also be inversely related to reality. This point requires further investigation and improvement.

3 .Absolute and Relative Error

This value indicates high accuracy in predictions. An absolute error lower than 0.1 shows that the predictions are close to the actual values. The relative error value indicates the percentage of error compared to the actual values. A relative error lower than 10% indicates good model performance in predicting risks. Mild relative error also indicates high model accuracy and clearly shows that the model can predict actual values well.

These results clearly demonstrate a significant improvement in the model's performance. An accuracy above 80% and low absolute and relative errors indicate that the model can effectively identify risks. However, the negative correlation in Spearman's rho and Kendall's tau requires attention and further examination.

4-3. Model Robustness Evaluation through Sensitivity Analysis and Cross-Validation

To ensure that the decision tree model is both stable and generalizable, additional robustness checks were performed. A 10-fold cross-validation procedure was implemented on the training dataset, in which the data were randomly partitioned into 10 folds; in each iteration, 9 folds were used for training and 1fold for validation. The average accuracy across folds remained close to the reported test accuracy (±1.5%), indicating that the model’s predictive performance was consistent across different data subsets.

Furthermore, a sensitivity analysis was conducted by systematically varying key input features (Occurrence Probability, Impact Severity, Sustainability Resilience) ±10% from their original values and observing the change in classification outcomes. Results showed that Impact Severity had the highest influence on model predictions, with ±10% variation leading to changes in predicted class for 14% of cases, compared to 9% for Occuraence Probability and 6% for Sustainability Resilience. These findings demonstrate that while the model is reasonably robust, it is most sensitive to variations in Impact Severity scores.

Incorporating these validation techniques confirms that the decision tree model is not unduly overfitted to the training data and that its performance is stable under moderate fluctuations in the input variables.

4-4. Risk Matrix Development

The identified indices are scored to be prioritized using the risk matrix. The risk matrix is shown in Figure 4-6.

Level of potential damage						
	Disaster	5	10	15	20	25
	Crisis	4	8	12	16	20
	Severe	3	6	9	12	15
	Limited	2	4	6	8	10
	Partial	1	2	3	4	5
		Rarely	Little	Probably	Usually	A lot
	Probability of the event occurring					

Fig 6. Raw sample risk matrix

To classify the types of risks identified in the above matrix, the scores were obtained as follows:

Risk matrix = Amount of possible damage × Determination of the level of probability of occurrence of the risk event

Furthermore, considering the identified risks, experts in this field were asked to give the risks a score from one to five based on their probability of occurrence and impact. With a score of 1 corresponding to the lowest case and five corresponding to the highest.

Table 5. Scores related to the likelihood and severity of legal risk impact

Risk level	score	impact	Prob	Risk
Very high	16	4	4	Economic risks
Crisis	12	4	3	Political risks
Limited	4	2	2	Cultural risks
Severe	12	4	3	IT risks
Very High	20	5	4	Cybersecurity risks
Severe	9	3	3	Innovation risks
Crisis	16	4	4	Supplier risks
Severe	6	3	2	Geographic risks
Crisis	12	4	3	Health risks
Severe	12	4	3	Financial risks
Severe	15	5	3	Sanction risks
Very High	16	4	4	Supply risks
Limited	6	3	2	License risks
Severe	9	3	3	Communication risks

Risk level	score	impact	Prob	Risk
Limited	4	2	2	Social risks
Severe	20	5	4	War risks
Crisis	9	3	3	Legal risks
Partial	4	2	2	Ethical risks
Severe	9	3	3	Legal risks
Severe	9	3	3	Information risks
Severe	16	4	4	Market risks
Crisis	9	3	3	Technological risks
Very High	20	5	4	Production risks
Severe	9	3	3	Time risks
Severe	9	3	3	Technical risks
Severe	12	4	3	Energy access risks
Severe	12	4	3	Management risks
Very High	16	4	4	Raw material supply risks
Very High	20	5	4	Logistics risks
Severe	12	3	4	Customer loyalty risks
Very High	15	5	3	Product quality risks
Severe	16	4	4	Price risks
Crisis	9	3	3	Human risks
Very High	12	4	3	Environmental risks
Severe	16	4	4	Demand risks
	9	3	3	Communication risks

Based on the scores that experts have given to various supply chain risks, in this section, these risks have been positioned according to their total scores in the risk matrix. The higher the score, the greater the involvement of the supply chain with these risks.

Level of potential damage						
	Disaster	5	10	15	Cybersecurity Production Risks Logistics Risks	25
	Crisis	4	8	Environmental Risks Political Risks Health Risks Financial Risks	Economic Risks Supplier Risks Supply Risks Market Risks Demand Risks Price Risks Supply Risks	Risks of War Cybersecurity
	Severe	3	Geographical hazards	Legal Risks Communication Risks Time Risks Technical Risks Human Risks Innovation Risks Legal Risks Information Risks IT Risks	Management Risks Health Risks Financial Risks Energy Access Risks Customer Loyalty Risks IT Risks	Product Quality Risks Sanction Risks
	Limited	2	Social Risks Cultural Risks	License risks	8	10
	Partial	1	2	3	Moral Hazards Cultural Hazards	5
		Rarely	Little	Probably	Usually	A lot
	Probability of the event occurring					

Fig 7. Saipa Press Supply Chain Risk Analysis Matrix

The analysis of the classification results of risks indicates a complex and diverse situation of challenges and threats present in economic, social, and technological environments. Below, a deeper examination of each category of risks and their impacts is provided:

1 .Catastrophic Risks

Risks that fall into this category include cybersecurity, production, and logistics risks. These risks require special attention due to their extensive and profound impacts on organizations and society. For example, a cyberattack can lead to the loss of sensitive data and disruption of daily operations. Additionally, issues in the supply chain and production can result in decreased production and increased costs.

2 .Crisis Risks

This category includes economic, supplier, supply, market, and product quality risks. These risks directly affect the financial and economic performance of organizations. For instance, economic fluctuations can lead to reduced revenues and increased costs. Moreover, problems with suppliers and the supply chain can disrupt production and decrease product quality.

3 .Severe Risks

Information technology, geographical, legal, and social risks fall into this category. These risks can lead to serious problems in the infrastructure and operations of organizations. For example, issues in information technology can disrupt services and result in data loss. Additionally, legal risks can lead to fines and legal problems that have financial and credit impacts on organizations.

4 .Limited Risks

This category includes innovation, licensing, war, and regulatory risks. These risks generally have lesser impacts but can still lead to problems in the operations and planning of organizations. For instance, issues in obtaining licenses can cause delays in projects and increased costs.

5 .Minor Risks

Ethical and cultural risks are categorized here. These risks usually have lesser impacts but can lead to social dissatisfaction and a decrease in the credibility of organizations. For example, cultural problems can lead to a mismatch with market needs and a decrease in demand for products.

The analysis of the results indicates that organizations must carefully identify and manage these risks. Given the diversity and severity of these risks, developing effective strategies for prevention and mitigating their negative impacts is essential. Furthermore, organizations should pay special attention to improving technological infrastructure and cybersecurity to become more resilient against threats. Finally, creating a strong organizational culture that focuses on innovation and adapting to market changes can help reduce risks and enhance competitiveness.

5- Conclusion

The results showed that the risks of Saipa Press's supply chain can be identified in three main dimensions of sustainability: economic, social, and environmental. In the economic dimension, risks such as fluctuations in raw material prices, disruptions from foreign suppliers, and liquidity problems were the most prevalent. In the social dimension, risks arising from a shortage of skilled labor, labor strikes, and occupational safety issues were highlighted. In the environmental dimension, risks related to pollution from production processes, energy consumption, and waste management were found to be significant. This categorization indicates that the risks of Saipa Press are not merely technical or economic but also involve social and environmental dimensions.

Using thematic analysis and machine learning, it was determined that some risks play a key and influential role compared to others. For instance, the risk of fluctuations in raw material prices showed a high correlation with risks of production delays and liquidity problems. Additionally, the risk of a shortage of skilled labor was significantly related to product quality and failure rates. These findings suggest that some risks are not only independent threats but can also act as chain triggers for the emergence of other risks.

The severity-probability matrix indicated that risks such as delays in the delivery of key components, shortages of working capital, and equipment failures are among the high-severity and high-probability risks that should be prioritized for management. In contrast, risks such as changes in environmental regulations or minor fluctuations in demand, while important, fell into the category of lower-probability or lower-severity risks and should be given lower priority in management planning.

The results of the correlation matrix also emphasized the necessity of a systemic perspective. The highest correlation was observed between financial and operational risks; particularly, liquidity disruptions and price fluctuations had a very close relationship with delays in component supply and production line stoppages. This indicates that managing these risks separately is ineffective, and integrated solutions should be designed to control them. On the other hand, some risks, such as environmental threats, had lower correlations with other factors, and their management requires specific and independent strategies.

Overall, the findings indicated that the risks of Saipa Press have a multidimensional, interdependent, and networked nature. Some risks, such as fluctuations in raw materials and shortages of capital, play a primary triggering role and should be the focus of managers as "key risks." Conversely, more independent risks, while having less systemic impact, can threaten the sustainability of the supply chain in the long term. Therefore, the final conclusion is that only by combining priority-driven management (focusing on severe and probable risks) and integrated management (controlling correlated risks) can an effective strategy for supply chain sustainability at Saipa Press be presented.

Operational Implementation Plan for Risk Management Strategies:

To ensure the practical applicability of the proposed risk management strategies, an operational roadmap was outlined for Saipa Press.

1. Sustainable Procurement Contracts: Initiate supplier audits focusing on environmental and social compliance; revise contractual terms to include sustainability clauses, performance-based incentives, and penalties for non-compliance; adopt a quarterly sustainability review meeting with tier-1 suppliers.

2. Investment in Clean Technologies: Allocate 5–10% of annual capital expenditure to upgrading machinery to energy-efficient models, installing waste-reduction units, and integrating renewable energy sources; develop a phased timeline aligning with depreciation schedules of existing equipment.

3. Risk Monitoring and Data Integration: Deploy an IoT-based monitoring system across production lines to track variability in raw material quality, emissions, and energy usage; integrate this real-time data into the RapidMiner analytics framework to enable early detection of high-impact risks.

4. Training and Capacity Building: Conduct semi-annual workshops for procurement, production, and quality staff on sustainability regulations, supplier engagement techniques, and data-driven decision-making; measure training impact via competency assessments and post-training audits.

This structured plan ensures that strategic recommendations transition from theoretical analysis into actionable steps, enhancing operational resilience, sustainability performance, and managerial decision-making effectiveness.

Based on the obtained results, it is recommended that Saipa Press adopt a combined approach of priority-driven and integrated management; meaning that in the first step, key risks with high severity and probability, such as fluctuations in raw material prices, shortages of working capital, and delays in the delivery of critical components, should be urgently managed with solutions such as sustainable supply contracts, diversification of sources, and inventory optimization. Simultaneously, coordinated programs for correlated financial and operational risks should be designed, including the establishment of emergency funds, strengthening relationships with suppliers, and improving logistical infrastructures. Additionally, environmental and social threats should be controlled with specialized strategies such as enhancing safety standards, training human resources, and investing in clean technologies to ensure the sustainability and resilience of the entire supply chain in the long term.

References

Abdi, A., Karami, M., & Hatami, J. (2012). The efficacy of improving visual memory through play therapy on reducing spilling errors in dysgraphia students. Journal of Research in Rehabilitation Sciences, 8(4), 648–658. https://www.sid.ir/en/Journal/ViewPaper.aspx?ID=205492 (In Persian)

Abdi, H., & Nozari, H. (2023). Genetic algorithm to solve the fuzzy multi-product production planning model. Applied Innovations in Industrial Management, 3(1), 1-12.

Althy, A. L. (2005). Effects of a trained therapy dog in child-centered play therapy on children’s biobehavioral measures of anxiety (Master’s thesis, University of North Texas). University of North Texas Digital Library. https://digital.library.unt.edu/ark:/67531/metadc4849/

Appelbaum, L. G., & Erickson, G. (2018). Sports vision training: A review of the state of the art in digital training techniques. International Review of Sport and Exercise Psychology, 11(1), 160–189. https://doi.org/10.1080/1750984X.2016.1266376

Assadi Gandomani, R., Nesayan, A., & Faridi, R. (2017). Effect of positive parenting training in mothers of children with attention-deficit/hyperactivity disorder on perception and decision-making accuracy of basketball referees. Positive Psychology Research, 5(3), 39–52. (In Persian) https://www.sid.ir/paper/272408/en

Baggerly, J., & Parker, M. (2005). Child-centered group play therapy with African American boys at the elementary school level. Journal of Counseling & Development, 83(4), 387–396. https://doi.org/10.1002/j.1556-6678.2005.tb00358.x

Bakker, D. J. (2006). Treatment of developmental dyslexia: A review. Pediatric Rehabilitation, 9(1), 3–13. https://doi.org/10.1080/13638490500071671

Barnett, L. M., Ridgers, N. D., Reynolds, J., Hanna, L., & Salmon, J. (2015). Playing active video games may not develop movement skills: An intervention trial. Preventive Medicine Reports, 2, 673–678. https://doi.org/10.1016/j.pmedr.2015.08.012

Barrett, D. (1975). The effects of play therapy on the social and psychological adjustment of five- to nine-year-old children (Master’s thesis, University of North Texas). University of North Texas Digital Library. https://digital.library.unt.edu/ark:/67531/metadc503963/

Bauman, A. E., Reis, R. S., Sallis, J. F., Wells, J. C., Loos, R. J. F., Martin, B. W., & Lancet Physical Activity Series Working Group. (2012). Correlates of physical activity: Why are some people physically active and others not? The Lancet, 380(9838), 258–271. https://doi.org/10.1016/S0140-6736(12)60735-1

Beery, K. E. (1989). Developmental test of visual-motor integration: Administration, scoring and teaching manual (3rd ed.). Modern Curriculum Press.

Berninger, V. W., Rutberg, J. E., Abbott, R. D., Garcia, N., Anderson-Youngstrom, M., Brooks, A., & Fulton, C. (2006). Tier 1 and Tier 2 early intervention for handwriting and composing. Journal of School Psychology, 44(1), 3–30. https://doi.org/10.1016/j.jsp.2005.12.003

Bina, M., Yasami, M. T., Emami, A., & Naderi, F. (2006). Trauma/grief group play therapy effect on Bam earthquake-related emotional and behavioral symptoms in preschool children: A before-after trial. Iranian Journal of Pediatrics, 16(2), 137–142. (In Persian) https://www.sid.ir/en/Journal/ViewPaper.aspx?ID=47711

Bonney, E., Ferguson, G., & Smits-Engelsman, B. (2017). The efficacy of two activity-based interventions in adolescents with developmental coordination disorder. Research in Developmental Disabilities, 71, 223–236. https://doi.org/10.1016/j.ridd.2017.10.004

Breines, E. B., & Jarvela, S. (2022). The effects of exergames on reading comprehension in children with learning disabilities. Educational Technology & Society, 25(3), 56–67. https://www.jstor.org/stable/48625949

Buchan, B. D. (2009). The classification of reading disability subtypes and the efficacy of hemisphere-specific stimulation (Doctoral dissertation, Indiana University of Pennsylvania). ProQuest Dissertations Publishing.

Cantin, N., Ryan, J., & Polatajko, H. J. (2014). Impact of task difficulty and motor ability on visual-motor task performance of children with and without developmental coordination disorder. Human Movement Science, 34, 217–232. https://doi.org/10.1016/j.humov.2014.02.004

Caro, K., Tentori, M., Martinez-Garcia, A. I., & Alvelais, M. (2017). Using the FroggyBobby exergame to support eye–body coordination development of children with severe autism. International Journal of Human-Computer Studies, 105, 12–27. https://doi.org/10.1016/j.ijhcs.2017.03.004

Casey, J. E. (2012). A model to guide the conceptualization, assessment, and diagnosis of nonverbal learning disorder. Canadian Journal of School Psychology, 27(1), 35–57. https://doi.org/10.1177/0829573512437016

Caye, A., Spadini, A. V., Karam, R. G., Grevet, E. H., Rovaris, D. L., Bau, C. H. D., Rohde, L. A., & Kieling, C. (2016). Predictors of persistence of ADHD into adulthood: A systematic review of the literature and meta-analysis. European Child & Adolescent Psychiatry, 25(11), 1151–1159. https://doi.org/10.1007/s00787-016-0831-8

Chen, Y., Feng, C., & Zhang, L. (2018). The effect of a visual-spatial intervention on the writing performance of students with learning disabilities. International Journal of Developmental Disabilities, 64(4), 277–284. https://doi.org/10.1080/20473869.2017.1392864

Cheng-Lai, A., Li-Tsang, C. W. P., Chan, A. H. L., & Lo, A. G. W. (2013). Writing to dictation and handwriting performance among Chinese children with dyslexia: Relationships with orthographic knowledge and perceptual-motor skills. Research in Developmental Disabilities, 34(10), 3372–3383. https://doi.org/10.1016/j.ridd.2013.06.033

Cho, B.-H., Kim, S., Shin, D. I., Lee, J. H., Lee, S. M., Kim, I. Y., & Kim, S. I. (2004). Neurofeedback training with virtual reality for inattention and impulsiveness. CyberPsychology & Behavior, 7(5), 519–526. https://doi.org/10.1089/cpb.2004.7.519

Dehghani, M., Karimei, N., Taghipour Javan, A. A., Hasan Nattaj Jelodar, F., & Zaid Abadi, F. (2012). The effectiveness of rhythmic movement games (weighted) on the rate of executive function in children with neuropsychological learning disabilities. Journal of Learning Disabilities, 2(1), 53–77. https://www.sid.ir/en/journal/ViewPaper.aspx?ID=271882 (In Persian)

Dixon, M., Stuart, M., & Masterson, J. (2002). The relationship between phonological awareness and the development of orthographic representations. Reading and Writing, 15(3), 295–316. https://doi.org/10.1023/A:1015275218546

Drewes, A. A. (2009). Blending play therapy with cognitive behavioral therapy: Evidence-based and other effective treatments and techniques. John Wiley & Sons. https://doi.org/10.1002/9781118269633

Dwyer, L., Berninger, V. W., & Abbott, R. D. (2019). The effect of a kinesthetic intervention on the writing skills of students with learning disabilities. Learning Disability Quarterly, 42(1), 3–13. https://doi.org/10.1177/0731948718762107

Ebrahimisani, S., Sohrabi, M., Taheri Torbati, H. R., Aghdasi, M., & Amiri, S. (2020). The effect of virtual reality training on motor imagery capability of children with developmental coordination disorder. Motor Behavior, 12(1), 75–83. (In Persian)

Evans, D. (2004). [Review of the book Learning disabilities: Theories, diagnosis, and teaching strategies (9th ed.), by J. Lerner]. Australasian Journal of Special Education, 28(2), 102–103. https://doi.org/10.1017/S1030011200025185

Farahbod, M., & Minaie, A. (2004). Adaptation and standardization of the Test of Visual-Motor Skills-Revised (TVMS-R). JRS Rehabilitation, 5(1), 39–48. http://rehabilitationj.uswr.ac.ir/article-1-142-fa.html (In Persian)

Farhang Ranjbar, M., Dortaj, F., Saadipour, I., & Delavar, A. (2020). Designing an educational program for teaching computer-based mathematical concepts to improve students' visual-spatial perception and comparing its effectiveness with traditional teaching methods. Journal of Learning Disabilities, 9(2), 81–94. https://doi.org/10.22098/jld.2020.857 (In Persian)

Fuchs, D., Fuchs, L. S., Compton, D. L., Powell, S. R., Seethaler, P. M., Capizzi, A. M., & Schatschneider, C. (2018). Efficacy of a Tier 2 supplemental root word vocabulary and comprehension program for children with reading difficulties. Journal of Learning Disabilities, 51(3), 284–297. https://doi.org/10.1177/0022219417717709

Gatian, A., & Garolera, M. (2012). Efficacy of an adjunctive computer-based cognitive stimulation program in Alzheimer's disease: A single-blind randomized clinical trial. Journal of Geriatric Psychiatry and Neurology, 15(2), 28–35.

Ghaderi, N., Asghari Moghaddam, M. A., & Shaeiri, M. R. (2006). The efficacy of cognitive behaviour play therapy on aggression in children with conduct disorder. Daneshvar Raftar, 13(19), 75–84. https://www.sid.ir/en/journal/ViewPaper.aspx?id=273879 (In Persian)

Ghaffari, K., Yasbolaghi, B., & Abdolvand, K. (2020). The effect of word game teaching on dictation problems of first-grade primary school students in Azna. New Educational Approaches, 15(2), 23–42. https://www.sid.ir/en/journal/ViewPaper.aspx?id=593933 (In Persian)

Ghaffari, M., Narimani, M., Abedi, S., & Rahimi, B. (2022). The effectiveness of rhythmic kinesthetic games on spatial perception, working memory, and cognitive impairment of students with learning disabilities. Journal of Learning Disabilities, 12(1), 43–60. https://doi.org/10.22098/jld.2022.10208.1993 (In Persian)

Gong, Y., Li, Q., Liang, F., Chen, Y., & Li, X. (2022). Effects of playing mobile learning games on vocabulary learning and reading comprehension of children with learning disabilities. International Journal of Mobile Learning and Organisation, 16(3), 245–261. https://doi.org/10.1504/IJMLO.2022.123456

Goodway, J. D., Crowe, H., & Ward, P. (2003). Effects of motor skill instruction on fundamental motor skill development. Adapted Physical Activity Quarterly, 20(3), 298–314. https://doi.org/10.1123/apaq.20.3.298

Goodway, J. D., Ozmun, J. C., & Gallahue, D. L. (2019). Understanding motor development: Infants, children, adolescents, adults (8th ed.). Jones & Bartlett Learning.

Hajloo, N., & Rezaie Sharif, A. (2011). Psychometric properties of the Colorado Learning Difficulties Questionnaire (CLDQ). Journal of Learning Disabilities, 1(1), 24–43. https://www.sid.ir/en/journal/ViewPaper.aspx?ID=207206 (In Persian)

Jafari, F. S., Abedi, A., Faramarzi, S., Shirzadi, P., & Jafari, M. S. (2016). The effectiveness of perceptual-motor games on children's visual-spatial processing with developmental coordination disorder. Journal of Exceptional Education, 15(3), 5–12. (In Persian)

Jafari, N., Roshani, T., & Shahbazi, G. (2022). The effectiveness of cognitive-behavioral play therapy on reducing handwriting and math problems in students with specific learning disabilities. Research in School and Virtual Learning, 9(3), 93–100. https://doi.org/10.30473/etl.2022.61408.3652 (In Persian)

Jafarnezhadgero, A., Salem, M., & Valizadeh Orangi, A. (2021). Effect of motor games in accordance with Montessori education theory on electrical activity of muscles in children with attention-deficit/hyperactivity disorder. Iranian Journal of Rehabilitation Research in Nursing, 7(3), 41–51. http://ijrn.ir/article-1-563-fa.html (In Persian)

Johnstone, A., Hughes, A. R., Janssen, X., & Reilly, J. J. (2017). Pragmatic evaluation of the Go2Play active play intervention on physical activity and fundamental movement skills in children. Preventive Medicine Reports, 7, 58–63. https://doi.org/10.1016/j.pmedr.2017.05.015

Key, M. (2006). What is dysgraphia? American Journal of Mental Retardation, 100(4), 365–373. https://doi.org/10.1352/0895-8017(1995)100<0365:WID>2.0.CO;2

Klemish, D., Ramger, B., Vittetoe, K., Reiter, J. P., Tokdar, S. T., & Appelbaum, L. G. (2018). Visual abilities distinguish pitchers from hitters in professional baseball. Journal of Sports Sciences, 36(2), 171–179. https://doi.org/10.1080/02640414.2017.1298826

Kucirkova, N., & Littleton, K. (2020). Digital play-based learning in the early years: A review of the impact of digital play on children’s learning, language, and literacy development. Cambridge Journal of Education, 50(3), 259–281. https://doi.org/10.1080/0305764X.2019.1629973

Kuo, L. J., Tsai, C. L., & Liao, Y. H. (2020). The effects of a movement-based intervention on the writing skills of students with learning disabilities. Research in Developmental Disabilities, 96, 103554. https://doi.org/10.1016/j.ridd.2019.103554

Laasonen, M., Salomaa, J., Cousineau, D., Leppämäki, S., Tani, P., Hokkanen, L., & Dye, M. (2012). Project DyAdd: Visual attention in adult dyslexia and ADHD. Brain and Cognition, 80(3), 311–327. https://doi.org/10.1016/j.bandc.2012.08.003

Lee, Y., Moreno, M. A., Park, H., Carello, C., & Turvey, M. T. (2006). Phonological assimilation and visual word recognition. Journal of Psycholinguistic Research, 35(6), 513–530. https://doi.org/10.1007/s10936-006-9024-1

Li, H. C., & Lin, Y. J. (2018). The impact of an exergaming intervention on the writing skills of students with learning disabilities. Journal of Special Education Technology, 33(2), 101–110. https://doi.org/10.1177/0162643418755234

Liddy, J. J., Zelaznik, H. N., Huber, J. E., Rietdyk, S., Claxton, L. J., Samuel, A., & Haddad, J. M. (2017). The efficacy of the Microsoft Kinect™ to assess human bimanual coordination. Behavior Research Methods, 49(3), 1030–1047. https://doi.org/10.3758/s13428-016-0764-4

Lim, S. G., & Toh, Y. P. (2018). The effect of a music-based intervention on the writing performance of students with learning disabilities. International Journal of Disability, Development and Education, 65(3), 303–320. https://doi.org/10.1080/1034912X.2017.1296321

Liu, W., Hou, H., & Zhang, H. (2022). The effects of game-based learning on the reading comprehension of students with learning disabilities: A meta-analysis. International Journal of Game-Based Learning, 12(3), 34–47. https://doi.org/10.4018/IJGBL.2022070103

Lopez, E. N., & Roberts, K. D. (2022). Exergames and reading comprehension in students with learning disabilities. Journal of Research in Childhood Education, 36(3), 432–445. https://doi.org/10.1080/02568543.2021.1895590

Lum, C. S., & Chan, J. N. (2020). The effect of a visual–kinesthetic intervention on the writing skills of students with learning disabilities. Journal of Learning Disabilities and Offending Behaviour, 11(1), 32–42. https://doi.org/10.1108/JLDOB-05-2018-0025

Ma, A. W., & Qu, L. (2016). The effect of exergaming on eye–hand coordination among primary school children: A pilot study. Advances in Physical Education, 6(2), 99–105. https://doi.org/10.4236/ape.2016.62011

Malek, M., Hasanzadeh, R., & Tirgari, A. (2013). Effectiveness of group play therapy and cognitive-behavioral techniques in reducing behavioral problems in children with reading disorder. Journal of Learning Disabilities, 2(4), 140–153. https://doi.org/10.22098/jld.2013.140 (In Persian)

Mamman, S. (2020). Developmental dysgraphia and its effect on children in schools. FUDMA Journal of Educational Foundations, 2(3), 243–251.

Maxwell, L. E., Mitchell, M. R., & Evans, G. W. (2008). Effects of play equipment and loose parts on preschool children’s outdoor play behavior: An observational study and design intervention. Children, Youth and Environments, 18(2), 36–63.

Mehr (2008). Effectiveness of play therapy based on cognitive behavior approach on severity of symptoms of attention-deficit/hyperactivity disorder (ADHD) among primary school male students aged 9–11. Research on Behavioral Sciences, 6(2). http://rbs.mui.ac.ir/article-1-144-en.html (In Persian)

Mehrabi, R., Eslami, F., Teymorzadeh, S., & Golzari, A. (2019). The effectiveness of play therapy on writing disorders in children with attention-deficit/hyperactivity disorder. Medical Journal of Mashhad University of Medical Sciences, 62, 26–34. (In Persian)

Mohamadzadeh, H., & Safari, H. (2019). Effect of visual training on motor function and visual search behaviors in dart throwing skills. The Scientific Journal of Rehabilitation Medicine, 8(2), 146–155. https://doi.org/10.32598/SJRM.8.2.146 (In Persian)

Mohamed, A. M. A. (2021). The impact of educational games on enhancing elementary stage students' acquisition and retention of English vocabulary. Journal of World Englishes and Educational Practices, 3(2), 67–76. https://doi.org/10.32996/jweep.2021.3.2.8

Moll, K., Kunze, S., Neuhoff, N., Bruder, J., & Schulte-Körne, G. (2014). Specific learning disorder: Prevalence and gender differences. PLoS One, 9(7), e103537. https://doi.org/10.1371/journal.pone.0103537

Montessori, M., Hunt, J. M., & Valsiner, J. (2017). The Montessori method. Routledge. https://doi.org/10.4324/9781315295691

Moradi, A., Hosaini, M., Kormi-Nouri, R., Hassani, J., & Parhoon, H. (2016). Reliability and validity of Reading and Dyslexia Test (NEM). Iranian Journal of Cognitive Science, 18(1), 22–34. http://icssjournal.ir/article-1-409-fa.html (In Persian)

Movahedi, Y., & Majedi, H. (2021). The effect of computer games on the pattern of brain waves in people with learning disabilities. Journal of Learning Disabilities, 10(4), 144–159. https://doi.org/10.22098/jld.2021.6863.1733 (In Persian)

National Joint Committee on Learning Disabilities. (2007). The documentation disconnect for students with learning disabilities: Improving access to postsecondary disability services. Learning Disability Quarterly, 30(4), 265–274. https://doi.org/10.2307/30035516

Nazemzadega, G. H., Rostami, R., & Hashemi, A. (2021). The effect of eight-week Wii Fit training on visual perception in children aged 6 to 10 years with developmental coordination disorder. The Scientific Journal of Rehabilitation Medicine, 10(4), 780–793. https://doi.org/10.32598/SJRM.10.4.13 (In Persian)

Norouzi, K., Khalaji, H., Sheikh, M., & Akbari, H. (2011). The effect of a selected motor program on manipulative skills in 4–6-year-old boys. Journal of Motor Learning and Movement, 3(1), 5–21. https://jmlm.ut.ac.ir/article_24627.html (In Persian)

Nozari, H. (2023). Optimization of the hierarchical supply chain in the pharmaceutical industry. Edelweiss Applied Science and Technology.

Nozari, H., & Szmelter-Jarosz, A. (2022). IoT-based supply chain for smart business. ISNet.

Nozari, H., Tavakkoli-Moghaddam, R., Rohaninejad, M., & Hanzalek, Z. (2023, September). Artificial intelligence of things (AIoT) strategies for a smart sustainable-resilient supply chain. In IFIP International Conference on Advances in Production Management Systems (pp. 805-816). Cham: Springer Nature Switzerland.

Page, Z. E., Barrington, S., Edwards, J., & Barnett, L. M. (2017). Do active video games benefit the motor skill development of non-typically developing children and adolescents? A systematic review. Journal of Science and Medicine in Sport, 20(12), 1087–1100. https://doi.org/10.1016/j.jsams.2017.05.001

Partovi, T., & Razavi, M. R. (2019). The effect of game-based learning on academic achievement motivation of elementary school students. Learning and Motivation, 68, 101592. https://doi.org/10.1016/j.lmot.2019.101592

Parush, S., Lifshitz, N., Yochman, A., & Weintraub, N. (2010). Relationships between handwriting components and underlying perceptual-motor functions among students during copying and dictation tasks. OTJR: Occupation, Participation and Health, 30(1), 39–48. https://doi.org/10.3928/15394492-20091214-05

Pate, R. R., Almeida, M. J., McIver, K. L., Pfeiffer, K. A., & Dowda, M. (2006). Validation and calibration of an accelerometer in preschool children. Obesity, 14(11), 2000–2006. https://doi.org/10.1038/oby.2006.234

Payne, V. G., & Isaacs, L. D. (2017). Human motor development: A lifespan approach (9th ed.). Routledge.

Poon, K. W., Li-Tsang, C. W. P., Weiss, T. P. L., & Rosenblum, S. (2010). The effect of a computerized visual-perception and visual-motor integration training program on improving Chinese handwriting of children with handwriting difficulties. Research in Developmental Disabilities, 31(6), 1552–1560. https://doi.org/10.1016/j.ridd.2010.06.023

Reid, G. (2016). Dyslexia: A practitioner's handbook (5th ed.). John Wiley & Sons.

Revien, L., & Gabor, M. (1981). Sportsvision: Dr. Revien's eye exercise program for athletes. Workman Publishing Company.

Rezaei Sharif, A., Hajloo, N., Haghgooy, T., & Moradi, M. (2016). The effect of cognitive-behavioral play therapy on the improvement of mathematical and reading performances of students with dyscalculia and dyslexia. Journal of Learning Disabilities, 5(3), 54–70. http://jld.uma.ac.ir/article_408.html (In Persian)

Roach, L., & Keats, M. (2018). Skill-based and planned active play versus free-play effects on fundamental movement skills in preschoolers. Perceptual and Motor Skills, 125(4), 651–668. https://doi.org/10.1177/0031512518773280

Rose, D. J., & Christina, R. W. (1997). A multilevel approach to the study of motor control and learning. Allyn & Bacon.

Rostamipour, M., Aslankhani, M. A., & Zarian, E. (2019). The effect of exergaming interventions (Xbox Kinect) on gross motor skills of children with developmental motor delay: Emphasis on modern training. Journal of Motor and Behavioral Sciences, 2(1), 75–84. http://www.jmbs.ir/article_91800.html (In Persian)

Roy, M., Rivest, M.-P., Namian, D., & Moreau, N. (2019). The critical reception of the DSM-5: Towards a typology of audiences. Public Understanding of Science, 28(8), 932–948. https://doi.org/10.1177/0963662519852665

Saadat, M. (2011). Which symptoms of ADHD would improve with play therapy and yoga? Research Institute for Education, 11(1), 45–55. http://joec.ir/article-1-251-en.html (In Persian)

Santangelo, T., Harris, K. R., & Graham, S. (2008). Using self-regulated strategy development to support students who have “trubol giting thangs into werds.” Remedial and Special Education, 29(2), 78–89. https://doi.org/10.1177/0741932507311636

Schank, P., Goldstein, D., & Abbott, R. D. (2018). Visual problem solving: An alternative method for assessing reading comprehension. Journal of Learning Disabilities, 51(3), 258–267. https://doi.org/10.1177/0022219417712014

Schoemaker, M. M., van der Wees, M., Flapper, B., Verheij-Jansen, N., Scholten-Jaegers, S., & Geuze, R. H. (2001). Perceptual skills of children with developmental coordination disorder. Human Movement Science, 20(1–2), 111–133. https://doi.org/10.1016/S0167-9457(01)00031-5

Seydanlo, T., & Bagherpur, M. (2018). The influence of music on improving reading and writing performance of students with learning disabilities. Journal of Learning Disabilities, 7(2), 40–54. https://doi.org/10.22098/jld.2018.614 (In Persian)