

A STUDY OF THE BEST PRACTICES AND PROCEDURES OF
RISK MITIGATION TECHNIQUES IN ELASTIC SUPPLY CHAIN
MANAGEMENT IN GOVERNMENT SECTOR IN JORDAN.
“A CASE STUDY ON ARAB POTASH COMPANY”

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PLAGIARISM

I hereby declare that all information in this document has been obtained and presented in accordance with academic rules and ethical conduct. I also declare that, as required by these rules and conduct, I have fully cited and referenced all material and results that are not original to this work.

Date: 15-05-2023

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DEDICATION

To my Grandfather's Soul

*It is only the greatest fathers that get the promotion to become great-grandfathers.
I am lucky you were among the greatest people on Earth. For everything you did for
me , you will always be remembered. See you in heaven...*

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ABSTRACT

A study of the best practices and procedures of risk mitigation techniques in Elastic Supply Chain management in Government Sector in Jordan.

“A Case study on Arab Potash Company”

Recently, managing risks in the supply chain has taken on great importance due to the vulnerability of the supply chain and the importance of mitigating any disruptions that can affect the business. In a world of highly changeable events, the number of upcoming risks is increasing, and managers' strategies to mitigate these risks should be studied and noted to help mitigate similar issues in the future. Risks in the supply chain tend to occur infrequently but can have significant consequences for a company. Supply chain management has been crippled by the coronavirus epidemic, affecting various sectors. The study aims to explore ways to overcome and mitigate the risks that have been faced during crises such as the coronavirus pandemic. The Arab Potash Company was chosen to be tested as a case study to highlight their success story during the past two years, how they managed to achieve profits, and what their flexible adaptation strategies were that helped them maintain resilience during the pandemic, especially with the importance of potash in the agriculture industry and how it was affected by the border ban and social distance. Data from the company was collected from different teams along with interviews with heads of departments to conclude the basic steps and procedures that can help in mitigating risks and maintaining resilience in the business. The quantitative method was then applied by conducting a survey to test the relationship between different types of risks and responsiveness, performance, technology, and integration to support the qualitative findings of the research. The aim of the dissertation is to focus on the best practices and procedures of supply chain management that can avoid risks and help businesses survive during crises, especially in supply chain management, and more specifically on the elastic supply chain in the government sector in Jordan.

Key words: Agriculture, Flexibility , Risk mitigation, Risk management ,Supply chain.

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LIST OF ABBREVIATIONS

AIOT	Artificial Intelligence Of Things
APC	Arab Potash Company
ASC	Agriculture Supply Chains
BCP	Business Continuity Plan
CAGR	Compound Annual Growth Rate
CPFR	Collaborative, Planning, Forecasting, And Restocking
CREA	Critical Risk And Error Analysis,
CSR	Corporate Social Responsibility
DAP	Diammonium Phosphate
DU	Demand Uncertainty
ECR	Efficient Consumer Response
ERM	Enterprise Risk Management
ERP	Enterprise Resource Planning
ETA	Event Tree Analysis
EVA	Economic Value Added
FAHP	Fuzzy Analytic Hierarchy Process
FAT	Factory Accepting Testing
FDA	Food And Drug Administration
FEPQPM	Fire-Explosion-Poisoning Quantitative Probability Model
FMEA	Failure Mode And Effects Analysis

FTA	Fault Tree Analysis
GDP	Gross Domestic Product
HTP	Hazard Totem Pole
IFA	International Fertilizer Association's
IT	Information Technology
JIT	Just-In Time
LOI	Letter Of Indemnity
MERS	Middle East Respiratory Syndrome
NPPs	Nuclear Power Plants
PAT	Positivist Agency Theory
PDEA	Probability Distribution Of Failure And Reliability
PM	Preventive Maintenance
PN	Petri Network
PPE	Personal Protective Equipment
QPM	Quantitative Performance Measures
QRA	Quantitative Risk Assessment
RBV	Resource-Based View
RFP	Request-For-Proposal
RM	Risk Management
RMP ¹	Risk Management Process
RMP ²	Risk Management Plan
ROA	Return On Assets

ROI	Return On Investment
SARS	Severe Acute Respiratory Syndrome
SC	Supply Chain
SCA	Supply Chain Agility
SCM	Supply Chain Management
SCOR	Supply-Chain Council 2008
SCRES	Supply Chain Resilience
SCRM	Supply Chain Risk Management
SCRMP	Supply Chain Risk Management Process
SCV	Supply Chain Viability
SRM	Sustainability Risk Management
SSCM	Sustainable Supply Chain Management
SU	Supply Uncertainty
TCE	Transaction-Cost Economics
UNFC	United Nations Framework Classification
USDA	United States Department Of Agriculture
USGS	United States Geological Survey
VMI	Vendor-Managed Inventory
WHO	World Health Organization
WTO	World Trade Organization

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1. CHAPTER ONE: INTRODUCTION

We live in a global business world where all organizations and enterprises are collaborating; the complexity of supply chains has increased due to short product life cycles, outsourcing, offshoring, or integration. With all these complexities, avoiding risks in supply chains is impossible. Therefore, the importance of risk in supply chain management can't be ignored and must be emphasized. It is an essential aspect of doing business that must be properly addressed for the success of the company. Risks are an unavoidable aspect of business operations, and having a plan to manage them reduces their impact. There are numerous studies on risk management, but few studies on supply chain risk management, which is why this topic is considered to be extremely fascinating and important for this study.

The study's primary goal is to highlight the importance of risk management in supply chain management. Another objective is to define the measures that should be taken in times of crisis to reduce vulnerability. The final objective is to examine the Arab Potash Company, the seventh largest company in the global potash and minerals industry, and how it has weathered the global coronavirus pandemic that has gripped the world since the end of 2019, while still making profits in the last two years. Other managers can learn from the company's example of risk management and supply chain planning by examining its track record.

As one of the most important crop fertilizers, understanding the potash supply chain is important for the agricultural sector. Potassium chloride is indispensable in many industrialized nations because, in addition to its main use as a fertilizer, it is also used for snow melting, aluminum recycling, and electroplating. In medicine, potassium chloride is used to treat hypokalemia and purify water. Because of the high risk of border bans, social distancing, and undersupply, which could affect farmers and lead to the world becoming food insecure, its importance to agriculture is the most pressing reason for investigation.

The study was conducted using a mixed methodology that included an intensive qualitative literature review, in-depth interviews with senior and middle managers from different departments of the Arab Potash Company, and data from within the company to compare departmental performance over six years, including before and after the pandemic.

The results are intended to provide managers with an overview of best practices and methods to reduce supply chain risks. Instead of viewing this threat as a catastrophic event that could bring down the global economy, companies can see it as an opportunity to reinvent themselves by becoming more resilient to supply chain disruptions.

1.1 AIM OF THE STUDY

The aim of the dissertation is to focus on the best practices and procedures of supply chain management that can avoid risks and help businesses survive during crises, especially in supply chain management, and to be more focused on the elastic supply chain in the government and private sectors in Jordan.

Although there are several Ph.D. or master's level dissertations prepared regarding risk mitigation techniques in supply chain management, there is currently no study that focuses on elastic supply chain management, nor on the effect of the COVID pandemic on the business and how managers dealt with it, how much their risk techniques were applicable or useful, or whether they had to come up with a new risk mitigation plan that could be a new handbook for managers working in this sector in such crises in the future. Therefore, the proposed dissertation will focus on an area that has not been studied before and has been studied on a very limited basis on a global scale, as it covers a new situation that is facing the whole world and everything is changing due to it.

1.2 ARAB POTASH COMPANY AS A CASE STUDY

The Arab Potash Company (APC) is a prominent potash producer in the Arab region and ranks as the seventh largest producer of potash globally in terms of volume. Jordanian enterprises have demonstrated a commendable history of prioritizing safety, governance, sustainable community development, and environmental protection.

APC is a pan-Arab company based in Jordan that was established in 1956. The company has been authorized by the Hashemite Kingdom of Jordan to extract, manufacture, and distribute Dead Sea minerals exclusively until 2058. APC is involved in several enterprises

related to Dead Sea salts and minerals, such as potassium nitrate and its various derivatives, bromine, and other products, in addition to potash.

The APC, which is among the major employers in Jordan, has a workforce of over 2,200 individuals distributed across Amman, Aqaba, and Al-Ghor Al-Safi area.

The operations of the Arab Potash Company (APC) are founded on a set of fundamental values, commonly referred to as core values. Customers, suppliers, shareholders, and regulators will all have complete access to information regarding the company's activities if it upholds the utmost standards of integrity. APC endeavors to maintain its position as one of the leading companies globally in mitigating work-related accidents and injuries. To achieve this objective, APC conducts regular assessments of its safety protocols across all its facilities, and strives to enhance them continually. APC's core objectives are centered on competitiveness and profitability, which are attained through a constant dedication to sourcing top-quality resources and optimizing operational efficiency.

1.3 INDUSTRY OVERVIEW

APC is a global potash producer that is reported to be the ninth largest potash producer in the world by volume by 2018 and the seventh largest producer in the world by 2020. In 2020, APC achieved a sales volume record of (2.55) Million tons, which is the highest in the Company's history. The COVID-19 pandemic has had an impact on APC's company, as it was critical to find mechanisms to ensure the continuation of production, transport, and export operations in light of the various lockdown measures and restrictions imposed by governments around the world. According to the World Health Organization (WHO), one of the strategies of mitigating the Coronavirus pandemic is the supply of healthy food. This imposed the greatest burden on the Company's board of directors and executive management, as it was critical to find mechanisms to ensure the continuation of production, transport, and export operations in light of the various lockdown measures and restrictions imposed by governments around the world.

Despite this, APC was a huge success during the Coronavirus Pandemic. The Executive Management of APC has devised a strategy plan and risk mitigation strategies to ensure the continuation of the Company's production and export operations. This includes measures for

dealing with the various risks that APC faces, such as the Jordanian government's minimal workforce labor instructions under the worldwide general safety and health requirement. The government also went to great lengths to assist APC in overcoming the barriers impeding the restoration of production and exporting during shutdown times. Despite the extraordinary demands and obstacles that the Company encountered, potash production achieved a record high of (2.62) million tons, and potash sales also reached a record high of (2.55) million tons, the largest in APC history.

The Company earned JOD 127 million in net profits in 2020, thanks to successful initiatives to reduce costs and increase production and sales. However, the decrease in profits from last year is due to the potash pricing mechanism being controlled by major producers and consumers. The Company was able to achieve this figure by contributing to the state's Coronavirus response measures, such as the "Himmat Watan" Fund, which received a donation of JOD (20) million. Additionally, APC's Corporate Social Responsibility (CSR) program received JOD (30) million in 2020, the most among Jordanian firms.

1.4 JORDANIAN ECONOMY OVERVIEW

Jordan is considered one of the most water-scarce countries in the world with a classification of an emergent economy where GDP per capita has been fluctuating up and down since 1970s.

Phosphates, potash, and other derivatives of these fertilizers are the backbone of Jordan's economy, along with tourism, remittances from abroad, and international aid. The World Bank reports that Jordan is starting to recover from the COVID-19 shock, with real GDP growing by 2.2% in 2021 after contracting by 1.6% the year before. The economy was able to reopen, and contact-intensive services, such as tourism, were able to revive, boosting growth to 2.5 percent in Q1-202. But headline inflation has accelerated due to increasing global commodity costs, and the job situation is still difficult. Unemployment is still higher than it was before the pandemic (22.6% in second quarter-2022), notably for women (29.4%) and young individuals (46.1% under the age of 25). The rate of employment remains modest (33.5% in second quarter-2022), particularly for women (14.2%), one of the lowest rates in the world.

The 2023 Index of Economic Freedom gives Jordan's economy a score of 58.8, placing it as the 93rd freest in the world. Compared to the previous year, its score is down 1.3 points. In the Middle East and North Africa area, Jordan ranks 5th out of 14 nations, with an overall score that is lower than the global average.

Rauf, M. *et al.*, 2020 made a research about the impact of Covid-19 on Jordanian economy, and they have advocated in their study that Pandemic will have a negative impact on the economy affecting GDP, especially in agriculture, industry and services with higher unemployment rate. And the study expected the economy to try to recover after the reopening.

Table 1 shows the Population, GDP, inflation and economic growth of Jordan from year 2017 till year 2022 according to the Focus Economics.

Table 1: Jordan Economic Data based on Focus Economics.

	2017	2018	2019	2020	2021
Population	9.8	10.0	10.1	10.2	10.3
GDP per capita (USD)	4,257	4,355	4,411	4,277	4,400
Inflation rate	3.3	4.5	0.8	0.3	1.3
Economic Growth	2.5	1.9	1.8	-1.6	2.2

2. CHAPTER TWO: LITERATURE REVIEW

The world is now in the age of supply chain competition, where companies no longer function alone but as a supply chain to establish models of value creation that are more responsive to dynamic markets, more consistent, and more reliable (Christopher, 2005). The fundamental competencies of a company are defined by its ability to develop and manage its supply chain to gain the maximum advantage in a market where competitive pressures are constantly fluctuating. Management strategies and innovative business models constantly emerge and perish as managers try to help their companies succeed in this less benign, soft, and predictable reality (Fawcett *et al.*, 2007). Today's global marketplace is best described as chaotic. Companies need to develop tactics to adapt to the increasingly seasonal fluctuations. The critical issue is how professionals respond to a changing business environment and what strategy can be executed to gain a competitive advantage in their supply chain. Resiliency, as a driver of competitive advantage, has the ability to adapt quickly to changes in the market and customer needs. Given the clear advantages of elasticity, companies face obstacles when it comes to taking the essential steps (Prater *et al.*, 2001).

To maintain a competitive advantage over their rivals, companies constantly monitor customer demand. SCM has gained importance as it relies on the movement of resources, information, and finance from supplier to consumer. The end consumer determines the success or failure of supply chains in the marketplace (Christopher & Towill, 2001). Getting the right product to the customer at the right time is not only the cornerstone of competitive success but also the key to sustainability. Therefore, it is important to consider customer satisfaction and market intelligence when developing a new supply chain strategy (Agarwal *et al.*, 2006). Global sourcing, a focus on time and quality-based competitiveness, and their respective contributions to the increasing unpredictability of the environment are driving the popularity of supply chain management. In our fast-paced corporate world, speed and quality are critical. A successful company must deliver flawless products on time. To meet these requirements, closer collaboration with suppliers and distributors is necessary (Tarofder *et al.*, 2010). A supply chain is a network of interconnected elements that links customers, suppliers, manufacturers, and services to efficiently handle the movement of materials, money, and information. Most companies know that SCM performance evaluation is

necessary to improve supply chain efficiency and effectiveness (Gunasekaran *et al.*, 2001). According to Lee and Billington (1995), supply chains are bundles of services that procure raw materials, transform them into final products, and then transport the final products to customers through a distribution system. To operate such a network, one needs to know exactly the optimization logistics or the exact amount of products needed at a given time and cost. Successful supply chain management depends heavily on the relationships with suppliers that form these networks.

Value-based competition in supply chain management is about partnering with customers and suppliers to achieve a strong position in the market. Creating value for customers, competitive advantage, and improved profitability for supply chain companies are the overarching goals of supply chain management. The aspects of value that customers can appreciate and the methods by which competitive advantage and improved profitability can be achieved are at the heart of this discipline. Collaboration among a company's employees creates value for the customer by reducing costs or increasing market efficiency in ways that most benefit the company's most important customers. The consumer creates value for themselves, not for the product or service as a whole. So for a company to compete by creating customer value, it must first identify and deliver the value that its customers consider most important to them. Companies in a supply chain can drive consumers to make choices and behave in ways that benefit the financial performance of the chain and the companies within it by delighting customers and gaining a competitive advantage.

2.1 PRINCIPLES OF SUPPLY CHAIN MANAGEMENT

According to "the "seven principles of supply chain management," published in 1996 by Anderson, D. *et al.*, And then republished in 2013, there are seven basic principles for every supply chain manager to follow in order to successfully create the required market value and achieve customer satisfaction and competitive advantage.

Managers are increasingly caught in a conflict between increasing customer demands and the demands of the business for productivity and profitability. Many have realized that handling supply chain management as a strategic variable helps prevent the rope from snapping.

Supply chains have recognized two important facts along the way:

First, they need to look at the entire supply chain, from suppliers to customers and all relationships in between (i.e., channel customers, such as distributors), taking a holistic view of the chain.

Secondly, it is about measurable results in revenue, asset utilization, and costs.

The seven supply chain principles are:

- align the supply chain with consumer needs.
- Create a logistics network that is tailored to the needs of specific consumer segments and maximizes profitability.
- Supply chain demand planning should be aligned with market incentives to ensure appropriate estimates and efficient resource allocation.
- Differentiate products closer to the customer and generate more sales throughout the supply chain.
- Manage resources strategically to minimize the total cost of producing products and services.
- Develop a strategy for the entire supply chain's IT, enabling decision-making at different levels and providing a consolidated view of the flow of products, services, and information.
- Integrate quality indicators for the flow of goods to ensure that collective effectiveness reaches the end consumer effectively and efficiently.

2.2 MODELS OF SUPPLY CHAINS

Supply chain management faces a major problem in dealing with uncertainty. Compared to models that implicitly formalize uncertainty, supply chain planning methods that exclude it are thought to produce weaker results. Supply chain management and maintenance are the core functions of logistics. This means that a basic understanding of the principles is necessary before understanding how best to move products from raw materials to end customers. And supply chain models are at the heart of this important knowledge.

According to the article by Vector (2021), there are six main types of supply chain management, and they are all crucial for any business, big or small. Some of the basic ideas, goals, and components of the supply chain are shared by all six models. Knowing the key differences between the various approaches will help you decide which model is ideal for your business and how it should be maintained. It is possible to categorize the six supply chain models into two groups. According to the articles by Rielly, D. (2021), published in Magaya, and Boutchard, J. (2021), published in Cascade, there are two types of models: those that focus on efficiency and those that focus on flexibility. Both are present in all models, although the emphasis is usually on one or the other. Both are present in all models, even if the emphasis is mostly on one or the other, as shown in Table 2.

Table 2. Models of Supply Chain developed by Researcher Based on Literature Investigation

Models of Supply chain management	
Supply Chain Efficiency Models	Supply Chain Responsiveness Models
Efficiency Chain Model: Continuous delivery-focused organizations can use the efficient chain model. In market-driven industries, production is based on sales predictions and competition is mostly price-based. This model often reduces costs with high asset utilization.	Agile Model: Agile is best for custom-goods companies. Flexible supply chain architectures emphasize reactivity. Companies in variable demand utilize it. This paradigm allows "made-to-order" production rather than pre-production. This strategy involves capacity for large orders and flexibility to fulfil buy orders in the smallest practical batches.
Fast-Chain Model: This method works for companies that need to change products frequently and release them before trends fade. Fashion-conscious customers care about how quickly a company updates its products to follow the latest trends. Fast-fashion refers to large fashion companies that use this	Flexible Model: Industries with large demand peaks and lengthy periods of low demand complement the flexible supply chain concept. This technique is easily switchable and can adjust internal production processes to client needs.

strategy. This model accelerates idea-to-market to reduce market mediation costs.	Seasonal or holiday-related enterprises profit from the flexible strategy.
Continuous-Flow Model: A classic supply chain model is continuous flow. This strategy works well for companies that make stable-demand, low-variation products. Industry-specific. Continuous replenishment ensures excellent service and low end-customer inventory.	Custom-configured Model: The custom-configured model has special parameters for assembly and manufacture. It mixes agile and continuous flow and works for product setups. Its asset-to-cost correlation is high. The custom configuration model employs the continuous flow model upstream and the agile model downstream. A furniture company that allows hardware and leg modification is an example.

Despite the similarities, the methodologies allow for the adoption of the supply chain model that best fits the needs of a particular sector. There is a supply chain model for your business based on consistency of demand, product customization and configuration, industry stability, and peaks and troughs in demand.

While there are different supply chain models, they all have the same goal: to create value, satisfy the end customer, increase productivity and efficiency, and reduce risk. Today, most companies follow a hybrid model, combining two or more models to ensure full optimization of their productivity and customer response.

One of the most important roles of supply chain models is to reduce or avoid risks that can disrupt the entire chain and cause the company loose time and money, resulting in the loss of a customer or even the entire company. Therefore, the importance of supply chain risk management has become a concept that plays an important role at strategic, financial, and even operational levels. According to Belyea (2000), Arntzen *et al.*, (1995), Aron (1998), & Brennan (1998), the supply chain essentially consists of two processes that link the processes of production and inventory planning with the processes of distribution and logistics, as shown in the figure.1 below. The flow of products and information in a company

can be improved by integrating the supply chain linkages into a fully functional system. A more efficient supply chain is the result. Whether a supply chain has links operated by many service providers or is managed by a single management link, integration is essential for continuous improvement. Supply chain integration aims to improve performance by integrating functions across the supply chain. Horizontal and vertical integration are the two most common forms of integration. When a company merges with another company, it is called horizontal integration, while vertical integration means that a company merges with another company that is involved in all elements of the production of a good, from raw materials to distribution. Since vertical integration of supply chains can reduce an inefficient, lengthy supply chain when insourcing and outsourcing decisions are made, experts agree that it can increase efficiency. According to Panayides P. (2006), integration can improve supply chain agility. The agility of an organization is defined by the Agility Forum as its ability to adapt to a constantly changing business environment (Agility Forum, 1994). Agility in a supply chain (SC) leads to increased adaptability and customer satisfaction, as this definition shows.

These steps are linked in the process of production planning and inventory control. The design and scheduling of manufacturing processes and the design and control of material handling are all part of production planning. The rules and processes for storing raw materials, work-in-process inventories, and generally finished goods are referred to as inventory control.

This is the way in which goods are recovered from the warehouse and delivered to shops. These goods can be delivered directly to retailers or to distribution centers, which then deliver them to retailers. This includes stock retrieval, transportation, and delivery of the products. These operations work together to form a supply chain. The design and management of these processes affect how well the supply chain works as a whole. As shown in Figure 1 below.

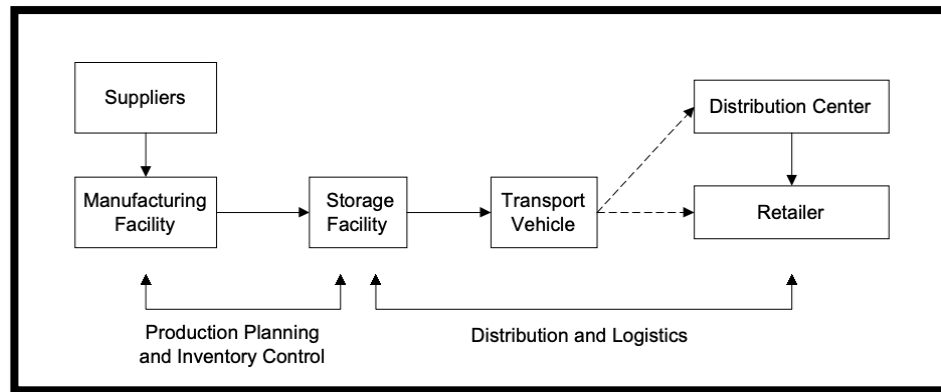


Figure 1. Supply Chain Design and Analysis: Models and Methods

2.3 SUPPLY CHAIN PERFORMANCE MEASURES

Proper performance measurement is critical to supply chain design and analysis. A performance measure is used to evaluate the overall efficiency and effectiveness of the system or to compare it with other systems. In the development of proposed systems, performance measures are used to determine the values of decision variables that result in the desired level of performance. There are several performance metrics that are critical for evaluating supply chain effectiveness and efficiency. These metrics are either qualitative or quantitative. The performance metrics mentioned in the literature can be used as triggers for decisions that affect production, distribution, logistics, inventory, and the number of buyers.

A performance measurement is separate from an efficiency measurement (performance evaluates the output, while efficiency evaluates the method by which the output is achieved). This combination of criteria can be used to evaluate the efficiency of the supply chain. According to Abu-Suleiman *et al.*, (2004), performance measures can be used to evaluate alternatives and provide decision criteria. The information gained through performance metrics can help companies make informed decisions and maintain and grow their market share. Feedback is an essential part of any process, according to Abu-Suleiman *et al.*, (2004). Managing company operations is facilitated by an effective supply chain performance evaluation system.

The feedback collected is used to examine current progress against expected or budgeted levels, facilitate benchmarking against manufacturing best practices, and identify poor

performance and opportunities for improvement. The input received is used. To modulate and evaluate a supply chain network exposed to a variety of hazards, a time-driven Petri net (PN) was used to incorporate risk management methods into the design, planning, and performance evaluation processes of the supply chain network of a Turkish organization. The PN has been used previously to modify dynamic supply chains and solve risk problems through real-time decision-making (Tungel & Alpan, 2010). In 2012, researchers developed a Bayesian network to prioritize the factors that influence the likelihood of accidents in dangerous goods shipments in China. They collected and evaluated 94 examples of Chinese transport accidents. They found that the three most important elements influencing dangerous goods transport accidents are human factors, transport vehicles and equipment, and dangerous goods packaging and loading.

To improve the quantification of organizational influences in human reliability analysis and to model the impact of organizational factors on human reliability, the fuzzy Bayesian network was used to identify the most likely causes of human failure and to prioritize the causes of human failure (Zhao *et al.*, 2012).

Deublein *et al.*, (2013) developed a unique model for predicting the occurrence of road accidents in their study. This approach is a synthesis of three statistical techniques: gamma-updating of the occurrence rate of injury accidents and injured road users, hierarchical multivariate Poisson-Lognormal regression analysis, and Bayesian inference algorithms. The approach was shown using data from Austria's rural highway network. It can take into account the critical role that human, management, and organizational risk factors play in major accidents in high-hazard industries. For this reason and to establish a connection between the concepts of safe work culture and corporate culture in nuclear power plants (NPPs), Bayesian networks were used in the Spanish NPP. As a result, it provides a framework for identifying prospective safety enhancement methods (Garca-Herrero *et al.*, 2013).

The STODET technique was created by Marhavilas and Koulouriotis (2012) as an alternative risk assessment framework that incorporates stochastic and deterministic processes. On the Greek Public Electricity Corporation, it is used. The introduction of a new full risk assessment procedure paired with real-world data about unwanted occurrences and accidents made this method an upgrade over previous risk assessment methodologies.

Supply chain flexibility is a critical factor in reducing supply chain risk (Sreedevi & Saranga, 2017); however, its impact on SCRM performance has not been experimentally studied. On the other hand, not all mitigation techniques are effective in increasing SCRM performance (Tomlin, 2006). Braunscheidel and Suresh (2009) argue that culture matters in SCRM. Despite its importance, little or no study has been done on how risk management culture affects proactive mitigation methods and SCRM performance. In an era of increasing global competitiveness, understanding risk management culture is critical for businesses. Furthermore, examining risk management culture may help us conceptualize the relationship between proactive mitigation techniques and SCRM performance, particularly in emerging nations. Faisal *et al.*, (2006) interviewed supply chain professionals and reviewed the literature. They chose eleven "tools of risk mitigation" that could potentially impact supply chain risk management. A supply chain's incentives and revenue sharing policies should be aligned. Strategic risk planning should include risk sharing and knowledge about risks. On the other hand, Ho *et al.*, (2015) classified risk reduction tactics into eight categories: macro-risk reduction, demand risk reduction, manufacturing risk reduction, supply risk reduction, transportation risk reduction, finance risk reduction, and general risk reduction. A risk mitigation strategy includes SC visibility, SC adaptability, supplier development, and inventory control. According to Kim *et al.*, (2013), building flexibility is considered a risk mitigation method in the supply chain.

Researchers categorize risk mitigation strategies into proactive and reactive. Proactive techniques include supplier development and management, supply chain contracts, and product and process management. Reactive tactics include disaster preparation and demand control (Ghadge *et al.*, 2012). While proactive tactics focus on the supply chain, reactive strategies focus on reducing difficult-to-control outsourcing risks. Supply chains must be proactive in dealing with risks. In disruption management, Ivanov *et al.*, (2014); Gunasekaran *et al.*, (2015) defined proactive management as "resilience, responsiveness-efficiency". Supply chain responsiveness has been recognized as a critical aspect for overcoming prospective and real interruptions in SCRM (Braunscheidel & Suresh, 2009). Responsiveness refers to the capacity to respond and adjust quickly to external stimuli, especially market and consumer demand (Sandberg & Jafari, 2018). Kim *et al.*, (2013) stressed that growing supply chain and market uncertainty and risk add to business complexity. Chopra and Sodhi (2004) noted that improving supply chain responsiveness

reduces delays and inventory concerns, which affect the firm's long-term viability. Moreover, Roh *et al.*, (2014) underlined that manufacturing strategies should aim to create strategic advantages by adapting to market movements. Supply networks that can't interpret future signals can't adapt to changing conditions or anticipate risks. So, in this study, efficiency is explained by responsiveness in SCRM. Resilience, responsiveness, and flexibility are the elements of proactive risk reduction techniques.

2.3.1 Qualitative Performance Measures

Qualitative performance indicators are those criteria for which there is no single clear numerical measurement, though other elements of them may be quantified. Criteria such as these have been highlighted as significant but are not included in any of the models assessed as customer satisfaction, a measure of how happy consumers are with the product or service they get. Customer satisfaction has three main components: Prior to the purchase of a product, a customer's satisfaction is measured by how satisfied they are with the service they received. Satisfaction connected with service components directly engaged in product distribution is called transaction satisfaction. Post-Transaction Appreciation refers to the customer's satisfaction with the product's assistance while it is in use.

Flexibility is the second parameter to be considered. The ability of the supply chain to adapt to changes in demand and supply As a result of the integration of information and material flow, all operations in the supply chain must be able to interact and convey commodities effectively. Finally, an effective approach to risk management There is inherent risk in every interaction in the supply chain. To what extent these risks are avoided by effective risk management is the subject of discussion. When and how often suppliers deliver raw materials on schedule and in excellent shape to production plants

2.3.2 Quantitative Performance Measures

Measures that may be expressed quantitatively are referred to as quantitative performance measures (QPM). There are two types of quantitative supply chain performance measures: those based on cost or profit, and those based on customer response.

It's possible to use cost-based measures for anything from cost minimization to profit maximization to inventory investment minimization.

Customer responsiveness measures include maximizing fill rates, minimizing product lateness, reducing customer response times, reducing lead times, and minimizing function duplication.

On the basis of the Quantitative Risk Assessment (QRA), the FEPQPM (Fire-Explosion-Poisoning Quantitative Probability Model) has been built in the chemical sector. In China, it has been used in a corporate storage tank. The FMEA (Failure Mode and Effects Analysis) is one of the approaches used in logistics risk management. To detect and eliminate possible failures or issues in products and processes using the FMEA risk assessment technique is frequently utilized. Many applications of FMEA may be found (Kutlu & Ekmekcioglu, 2012; Liu *l.*, 2012; Liu *et al.*, 2013).

Numerous risk management techniques can be identified based on the literature study. These approaches may be categorized into two categories: deterministic tactics (which include qualitative, quantitative, and hybrid techniques) and stochastic methodologies (which include the classic statistical approach and accident forecasting modeling). Researchers could perhaps recognize checklists, what-if analyses, task analyses, Hazard and Operational Analysis (HAZOP), Quantitative Risk Assessment (QRA), Critical Risk and Error Analysis (CREA), Fault Tree Analysis (FTA), Event Tree Analysis (ETA), Failure Mode and Effects Analysis (FMEA), Probability Distribution of Failure and Reliability (PDEA), Petri networks, and Bayesian networks, among others.

2.4 SUPPLY CHAIN EFFICIENCY MEASURES

Each point in the supply chain communicates with the others to ensure that the items moving through the chain are meeting the demands of both the vendors and the clients. There is a causal relationship between those components. To enhance the utilization of each component in the supply chain and simultaneously raise the value of its co-components, there must be a great deal of integration between the components (Qukula T., 2000). The performance of all components in the supply chain is negatively impacted by a weak supply chain link. Because of this, each component of the supply chain must be evaluated individually in order to determine the overall effectiveness of the chain. In order to improve supply chain efficiency, it is necessary to be able to measure it across all linkages. Supply

chain efficiency cannot be evaluated by analyzing individual transactions but rather by measuring the efficiency of the transactions collectively along the supply chain. This presents a difficulty for evaluation, according to Spekman, R. *et.al*, (1994). If one wants to measure supply chain efficiency, a model that covers every transaction that is relevant needs to be picked. That the assessment of efficiency is not always applied in a fair manner might be another hurdle to analyzing supply chain efficiency (Little, 1999). Supply chain efficiency can be mismeasured when an individual measurement is overstressed. There is a greater danger of this when there is no single entity that oversees the whole supply chain, according to Little (1999). Each link must be evaluated in terms of its exact value to the overall efficiency of the supply chain; therefore, the method devised must take this into account.

Customers are satisfied more effectively and efficiently by corporations than their competitors, according to the marketing perspective of Kotler, P. (1984). Because of this, corporations may benefit from reviewing their supply chains' efficacy and efficiency.

Supply chains exist for every commodity that a company deals in, and each one is unique. These supply chains contain specific characteristics that vary from sector to sector, according to Little (1999). As a result, the design of the supply chain should take into account the specific production and distinctive circumstances of each company (Little, 1999). Supply chain service providers must also utilize the same method of measuring efficiency in order to offer an accurate evaluation of the efficiency of their connections. As a result, corporations must adopt a model for evaluating supply chain efficiency that can be used across all of the chain's linkages. Another factor to consider when evaluating supply chain efficiency is how the supply chain is developed. If responsiveness, adaptability, and measurability are not planned into the system, supply chains that perform well for network throughput may become weak (Barloworld Logistics, 2005). As a result, supply chains must be meticulously planned.

Efficiency measurements, according to Potter, A., *et.al.*, (2002), must also be explicit in the type of data they look at. Quantitative measurements are the only ones that are commonly employed. Lambert and Pohlen (2001) state that supply chain efficiency assessment is hindered by the lack of a widely agreed-upon definition of supply chain management and the complications associated with overlapping supply chains. As a result, the lack of supply chain orientation, the difficulty of capturing assessment across various connections, the

inability to share information among corporations, and the inability to capture performance by product, customer, and supply chain make precise supply chain efficiency assessment more difficult. Furthermore, there is a lack of a method for creating supply chain efficiency measures that are relevant.

2.5 ESSENTIALS OF RISK MANAGEMENT

It is important to understand the meaning of risk in business in order to be able to deal with it and manage it in the most effective way.

2.5.1 Definition of Risk management

A risk is defined as "exposed to danger" in the Oxford English Dictionary, while risk is defined as "a likelihood or possibility of danger, loss, harm, or other unfavorable effects. The word "risk" is used here to denote the possibility of undesirable effects.

The Institute of Risk Management (IRM) defines risk as the mixture of an event's occurrences as well as its effects. Consequences can be both beneficial and detrimental. This is a simple definition that can be used in a variety of contexts. According to literature and the book Fundamentals of Risk Management by Hopkin, P. (2018), risk can be considered positive if it is treated as an opportunity, or it can be negative if it has a great impact on the business and can be seen as a threat.

A risk is defined by the Institute of Internal Auditors as the uncertainty of an event that could have a negative influence on the achievement of objectives. Furthermore, according to the Institute of Internal Auditors, risk is quantified in terms of its effects and likelihood. The term "risk" is defined significantly differently by various academic fields. Health and safety specialists use the term risk as a composite of probability and intensity, although this may not be adequate for further general risk management objectives.

2.5.2 Types of Risks

Risk can be beneficial, negative, or simply lead to inconsistencies. Risks are associated with opportunities, losses, or uncertainty for a company. Each risk has unique characteristics that necessitate management or investigation. Risks are categorized into four categories in

Hopkin's (2018) book: compliance (or mandatory), hazard (or pure), control (or uncertainty), and opportunity (or speculative). In general, organizations will attempt to reduce compliance, hazard, control, and opportunity risks. The book claims that there is no 'appropriate' way to divide risks. Risks are usually classified as pure or speculative. There are various arguments over risk management language. Regardless of the theoretical debates, it is critical that an organization selects the risk classification system that best suits its needs.

Several vulnerabilities can only lead to disastrous results. These are hazard risks or pure risks, and they are operational or insurable. Usually, corporations have a sensitivity for hazardous threats that must be handled within those boundaries. Fraud is one example of a hazardous risk that many firms confront. There are a number of different factors that can cause a situation to be uncertain. Control risks are typically related to project management. Generally, corporations will avoid controlling risks. Ambiguity about the project's benefits as well as delivery on schedule, budget, and specification Control risks are commonly managed to ensure that the company's outcome is within the targeted range. The goal is to narrow the gap between expectations and results, and organizations act accordingly, notably with market and commercial risks, to maximize returns. These are opportunity or speculative risks, and an organization's appetite for such risks will vary. Opportunity risks are related to risk-reward relationships. The goal is to take risks to obtain beneficial outcomes. Investing will be the focus of opportunity hazards.

According to Blackman, A. (2014), some threats might cause substantial losses or even bankruptcy. While major corporations have comprehensive "risk management" divisions, smaller firms do not. The article lists five sorts of risks:

1. **Strategic Risk:** It's the chance that your company's strategy becomes ineffective and your business fails to achieve its aims. Perhaps it's due to a formidable new competitor, shifting client demand, rising raw material costs, or other large-scale developments. Some companies, like Kodak, went bankrupt due to their inability to adapt. A smaller company focused on corporate photography solutions has emerged from bankruptcy, but it could have retained its dominance if it had done so sooner. Taking a smart risk doesn't have to be fatal. One of the most successful products ever created was the Xerox photocopier. Unlike Kodak, Xerox was able to adapt to the new technology and adjust its business model, allowing it to maintain its competitive

advantage. Xerox survived the strategic risk and built a multi-billion-dollar laser printing industry.

2. **Compliance risk:** A company's potential vulnerability to legal fines, financial forfeiture, and material loss as a result of its failure to comply with industry laws and regulations, internal policies, or recommended best practices is known as compliance risk.
3. **Operating risk** is a term used to describe the dangers and challenges that a corporation experiences in the course of carrying out its routine business operations, procedures, and systems. The human component substantially influences operational risk: errors or failures caused by staff actions or decisions
4. **Financial Risk** It is a threat that can cause capital losses for interested parties. It's possible to lose money on an investment or business enterprise. Credit, liquidity, and operational risks are some of the more typical financial hazards.
5. **Reputational risk:** destruction of a company's reputation when it fails to fulfill stakeholder expectations and is seen unfavorably. Small or large, it affects all businesses.

2.6 RISK CLASSIFICATION

Based on factors such as the span of time for impact and/or the expected intensity of risk, risks can be categorized into several classifications. They can also be divided depending on how quickly an event has had an effect once it has occurred. Classification might also be based on the risk's source. Depending on the source of the risk, it may be categorized as a counterparty or credit risk. Another technique to categorize risks is to take into account the nature of the consequences. Some risks can have a negative impact on the organization's finances, while others can have an influence on the organization's activities or infrastructure. A company's reputation, prestige, and perception in the marketplace can also be impacted by possible risks. According to the part or aspect of the organization that may be affected, risks can be categorized. People, buildings, procedures, and goods are all examples of hazards that can be categorized. It's critical for organizations to decide how they'll classify risks, whether they'll be based on the source, impact, or consequences. Depending on the nature of the business and its activities, each organization will choose the risk classification system that works best for them. As an added bonus, a number of risk management guidelines and frameworks provide a specific system for classifying risks. When a company

adheres to one of these standards, it is more likely to adhere to the recommended classification system.

Professionals must pick an appropriate method of categorizing risks for their company before making a final decision. Every business has its own unique needs when it comes to classification. To fully grasp the potential consequences of any given risk, it is likely that it will need to be classified in multiple ways.

The classification of risks into short, medium, and long-term categories helps identify risks that are largely operational, tactical, and strategic in nature. As a starting point for additional risk understanding, this difference is helpful but not definitive. Short-term risks to strategic core processes and medium-term and long-term threats to operational core processes is highly present nowadays. In addition, it is necessary to make certain that all operations, tactics, and strategies are compliant. It's common for many businesses to see compliance risks in terms of a desire to reduce the risk. A short-term risk has the potential to have an immediate impact on the objectives, key dependencies, and important procedures. These hazards can have an immediate impact on business operations. The majority of short-term risks are hazards; however, this isn't necessarily the case in every situation. These risks are typically associated with unforeseen disruptions but may also be linked to cost control in the company. To sustain effective and efficient core processes that are concerned with normal operations, short-term risks usually have a negative influence on the ability of a company to do so. Short-term dangers must be mitigated. After a short delay, a medium-term risk can have an influence on the organization. Within months or at most a year following an event, a medium-term risk's influence is typically evident. In most cases, medium-term risks affect an organization's ability to maintain basic processes for the administration of tactics, projects, and other change initiatives. Projects, methods, upgrades, and other innovations are generally associated with these medium-term hazards. These medium-term dangers must be managed. A long-term risk has the potential to have a long-term influence on the company. Most of the time, the impact is felt between one and five years after the event has taken place. The ability of an organization to retain its fundamental strategy creation and delivery processes is frequently impacted by long-term threats. As a result, it is incorrect to assume that these risks are just associated with opportunity management. Operational and tactical risk can have a greater impact on a company's strategy and its ability to successfully implement that strategy than strategic risk. Long-term risks

can have a negative impact on a business, but they must be taken into account while developing a strategy.

A framework for the identification of risk is necessary in order to identify all of the threats facing a company. It is possible to discover similar hazards throughout the organization by using formal risk classification methods. Organizations can identify who should be in charge of devising a strategy to deal with comparable or related risks by classifying them. To sum it up, risk classification is critical because it allows an organization to determine its appetite for risk, capacity for risk, and overall exposure to risk for each risk, as well as for groups of related risks and generic risk types. This framework can be found in the firm risk scorecard, although there are many more risk classification systems out there to choose from. This scorecard takes into account a variety of risk factors, such as the likelihood of an event occurring, the likelihood of it having a negative or positive impact, the likelihood that the risk is one that can be controlled or avoided, and the organization's overall risk exposure and risk capacity. Financial, infrastructure, reputational, and marketplace risks can be categorized by the firm scorecard's headings. There are several ways in which this risk scorecard can be used for the identification of company objectives as well as the expectations of stakeholders. The scorecard is a valuable addition to the risk management tools and strategies currently in use. Analyzing the potential impact of each risk on the critical dependencies supporting each core process is how it is compiled. It is easier to identify important risks when using the firm's Risk Scorecard, which reduces the odds of missing them. It is up to the business to pick which risk classification system best suits its needs and requirements, as is the case with many other risk management decisions. For example, risks can be grouped according to the nature of the risk, the source of that risk, and/or the nature of their repercussions, as well as their impact period. Risk classification systems are tailored to the size, nature, and complexity of an organization. In the banking industry, for example, risk is typically divided into three categories: market, credit, and operational risk. The SWOT and PESTLE analyses are two more commonly used risk classification systems that can be used to structure risk assessment workshops.

2.7 PRINCIPLES OF RISK MANAGEMENT

RM means incorporating, adopting, as well as using methodologies, which all arise from genuine environmental sustainability concerns. In nearly all circumstances, the ideal approach entails more than just thinking creatively; managers are required to have assessments showing how and why they reached a judgment (or realized no decision was necessary). Structured, systematic, and timely analyses based on the best information and science are expected. RM is incremental, integrates learning and feedback, is intentional about procedures and practices, and clearly addresses uncertainty. RM is iterative to adapt to changing situations and ensure decisions are based on the correct data.

RM entails assessing and planning for future decisions ahead of time. RM can provide the foresight to meet decisions' temporal horizons. "Upstream" planning buys time, decreases uncertainty, and increases decision space. Time-sensitive decisions require upstream planning. Adopting these improvements at all organizational levels helps increase perspective and foresight. RM helps comprehend how risks cascade through organizational levels and how problem context, accessible information, and analytical demands vary.

According to Macgregor *et al.*, (2016), the basic principles of risk management are:

- Value-creating and value-protecting
- Integral to organizational processes
- Decision-making
- Addresses ambiguity Explicitly Systematic, timely Based on supplied data, customized to context
- Human and cultural variables are considered.
- Transparent, inclusive
- Is flexible, progressive, and change-responsive.

Based on their research, organizations can achieve accountability through risk management to achieve organizational sustainability and organizational learning. Based on learning from the outcomes of the decisions that have been made, They advocate four principles of accountability through risk management, which are sustainability, responsiveness, inclusivity, and materiality.

Risk assessment, risk management strategies, and risk communication are critical RM aspects (Figure 2). These aspects are interrelated and support one another, although they use different information sources and involve different people. Evidence-based information drives assessment. Policy and value-based information are used to evaluate and select risk management alternatives. Two-way communication exchanges science, values, and perceptions. Successful RM and the integration of these three parts hinge on the Forest Service developing organizational values and objectives.

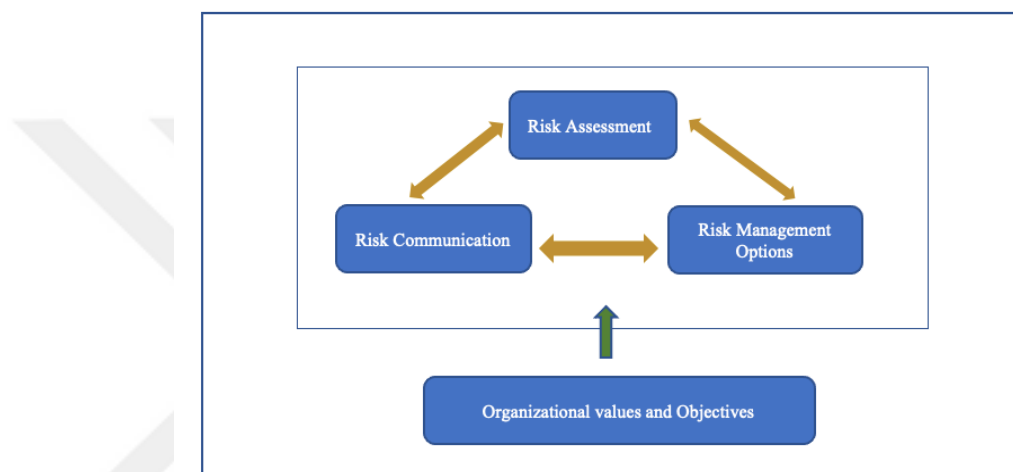


Figure 2. The interrelation between risk aspects and organizational values. Source: United states Department of Agriculture, 2016

2.8 SUPPLY CHAIN RISK MANAGEMENT

The terms "supply chain risk" and "supply chain risk management" are not well defined. Researchers would struggle to engage with professionals and acquire access to industry to conduct empirical investigations without a shared concept and an unambiguous definition. Furthermore, a standard definition aids researchers in identifying and evaluating the significance of all supply chain risks as well as the efficacy of supply chain risk management approaches. As a result, it's critical to get a precise description of these phrases (Sodhi *et al.*, 2012; Diehl & Spinler, 2013).

The concept of risk management in the supply chain has evolved rapidly over the last few decades and has become extremely important; in fact, according to Lavastre *et al.*, (2012); Juttner *et al.*, (2011)'s paper "Supply Chain Risk Management: Outlining an Agenda for

Future Research" was the first scientific research paper in supply chain risk management (SCRM); additionally, and according to Fekete (2012), risk management is an area with conflicting terms and no single definition. Lavaster *et al.*, (2012) and Juttner (2005) defined SCRM as "the detection and management of supply chain risk through a coordinated strategy among supply chain stakeholders in order to decrease supply chain vulnerability as a whole." The SCRM is critical for proactive management of business operations.

Gurutu, A., and Johny, J. (2021) wrote a review of SCRM literature explaining the different categorizations of supply chain risk management. They explained that there are two broad categorizations: one on the importance of strategy and risk management planning, and the other on disruptions. According to them, when there is a gap between these two concepts, there will be a lack of understanding of the cause of disruptions, which will lead to better risk management planning. Therefore, they advocated four categories of SCRM, as shown in figure 3 below.

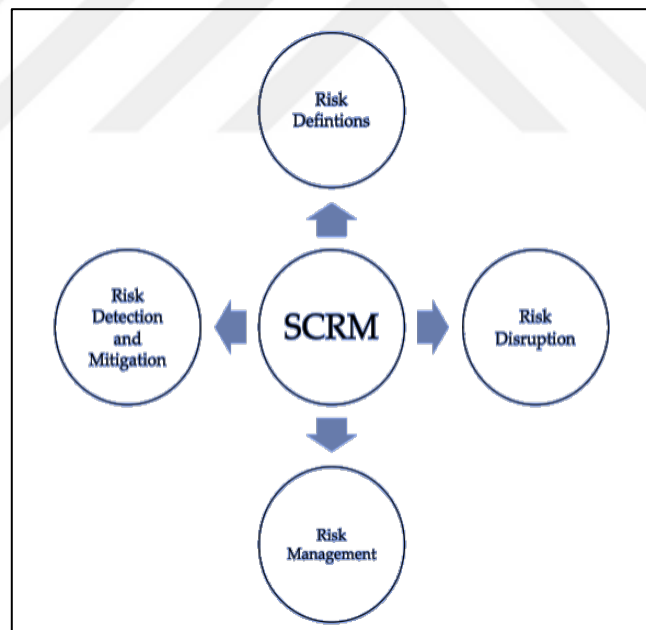


Figure 3. Supply chain risk management (SCRM) categories. Source: Supply chain risk management: Literature review.

Improper management can have a significant financial impact if it isn't well understood. More attention is needed to the risks associated with supply chain management and transportation. In order to effectively manage and enhance reporting and transportation, greater regional management and strategic planning are required. Validity, risky aptitude, and adequate and on-time delivery are all checked at ports as part of the logistics and supply chain. Shipment hiccups can have a ripple effect across the entire process, especially if the items are intended for use in other commodities. As a result, there are items that have a limited lifespan, which means that every hour of delay in delivery matters. This means that the numerous risks involved with product delivery and the shipping process need to be thoroughly studied, and the causes of delays need to be investigated and solved (Bichou *et al.*, 2013).

Assessing and identifying potential hazards associated with transportation and shipping operations using statistical and economic methods The decision-makers will be able to make better decisions about the number of risks to take after evaluating their risk appetite and the expenses associated with preventing the same through a thorough cost-benefit analysis. As a result, proper project planning might be beneficial in dealing with these issues (Alises *et al.*, 2014).

SCRM is described as managing channel partners to maintain profitability and continuity (Tang, 2007). Carter and Roger (2008) defined SCRM as the firm's ability to assess and manage supply chain risks. Delesse (2010), defines the SCRM as a method for recognizing, Analyzing, understanding, communicating, and managing risk-related concerns. The SCRM may also be seen as a collaborative and coordinated management amongst partners to achieve chain profitability. Lavastre *et al.*, (2014) found that the SCRM helps preserve its competitive edge. As controlling supply chain risks becomes more critical, research focuses on strategic problems, according to Ganguly and Guin (2011), and is making considerable strides in the logistics industry, as found by Wieland, A., and Wallenburg, M. (2012). It may be avoided or minimized, transferred or shared, or accepted as is. From this viewpoint, risk-taking efforts need all stakeholders to be included in the chain of knowledge. Supply chain management is the centralized management of the flow of goods or services from raw materials until they reach their final destination, and this flow of operations needs to be planned, executed, controlled, and evaluated. Even though the definition shows that the process is very smooth or simple, there are different factors or

disruptions that can cause delays in delivery or even damage to the product that can cost the business more time and money. All these factors and disruptions are called risks, and to avoid them, strategic planners and supply chain managers need to consider those risks and decide on a plan to avoid or mitigate them in order for the business not to face any losses or problems. (Jüttner *et al.*, 2003)

Based on the literature, every supply chain organization can face disruptions that are either manmade or caused by natural disasters that can have different consequences for the business, such as affecting the borders, ports, air transportation, or even damaging the reputation or reliability of the supplier. Moreover, it can affect the revenue of the business. As an example, for natural risks, see Hurricane Cindy in 2017, the Somalian pirate attack, and recently the major disruption that happened due to the pandemic of COVID-19 (Abdi *et al.*, 2019; Tian *et al.*, 2019 a, b; Paul and Chowdhury, 2020a; Chowdhury *et al.*, 2020; Paul & Chowdhury, 2020b; Rowan and Galanakis, 2020). In real-life situations, decision-makers must also weigh malfunctioning units generated along the supply chain since these problematic units hinder a supply chain's capacity to satisfy consumer demand (Nezhadrosan *et al.*, 2020). As a result, such a vital problem must be included to assist supply chain managers in their decision-making for supply chain disruption management.

To maintain supply chain continuity and long-term profitability, supply chain risk management is described as the act of collaborating, coordinating, and using risk management methods among partners. With the goal of managing supply chain risk, maintaining supply chain continuity, and maximizing profitability, SCRM is an organized and synergic process throughout the supply chain. Risk management is the practice of accepting a known or evaluated risk or taking action to mitigate the effects or chance of an undesirable event (Chang *et al.*, 2012). Risk management is the process of identifying and controlling risk (Alhawari *et al.*, 2012). As defined by ISO 31000 (2009), Risk management: principles and guidelines, risk management is a coordinated collection of actions and processes used to drive an organization and control the numerous risks that might hinder its capacity to fulfill goals. Based on the literature analysis, SCRM is a collaborative process amongst supply chain contributors to manage risks and mitigate their negative impacts. Risk management in the company ensures that decision-makers are aware of the risks and have prepared plans to avoid or mitigate disasters.

There are different techniques for implementing these processes depending on whether it is a proactive (foresee risks and apply measures to prevent negative impacts) or reactive approach following the occurrence of risks. In order to control supply chain risk, McCormack *et al.*, (2008) proposed three stages. The first step is to identify the risk by recognizing supply chain concerns. The second phase involves risk evaluation or assessment, which requires outlining major hazards that may be depicted in a risk portfolio with the metrics of likelihood of occurrence and harmful consequences. The third step is risk mitigation, which involves lowering the probability or significance of an event that occurs.

Long-term supply chain risk jeopardizes the survival of the business. Thus, supply chain risk assessment should be a formal aspect of decision-making at all levels (Christopher and Peck, 2004). It requires an organizational culture of risk management (RM). RM culture refers to SCRM-related ideas and values among supply chain members (Christopher & Peck, 2004; Fan *et al.*, 2017). According to Li *et al.*, (2015), exchange partners who have the same goal and vision are more likely to make relationship-specific investments. Determining partner values and behaviors is a vital component of SCRM and a facilitator of executing risk mitigation techniques (Kurniawan *et al.*, 2017).

Risk in supply chains has a direct effect on the financial status of the business, and it has always been the clearest and most direct way to measure or indicate the risk in any business, despite the fact that other variables exist through the chain. The management of supply chain risk is a developing and significant problem in our dynamic and interconnected society, yet conceptual frameworks that provide a clear meaning and normative guidance are just (Manuj & Mentzer, 2008). An article by Tummala, R., and Schoenherr, V. (2011) proposes a framework for administrators based on this research, delivering structure and decision support. An investigation of supply chain risk assessment and management was done. It has been found that using the Supply Chain Risk Management Process (SCRMP) improves the management of supply chain hazards. Risk identification, measurement, and assessment; risk evaluation; risk mitigation and contingency plans; and risk control and monitoring via data management systems are all components of the structured method. It's more likely that supply chains will fail to deliver the expected performance as global competition heats up and supply chains grow longer and more complicated. In order to ensure the safety of their supply chains, organizations need to plan for disturbances and prepare contingency plans. Supply chain interrelations must be studied, and possible risk factors must be identified, as

well as their probability, implications, and severity. Action plans for risk management can then be devised to avoid or, if that is not possible, mitigate, contain, and control the identified risks. Recent warnings and litigation by FDA (2008) for toy cars and pet food have shown the vulnerabilities of supply chains as well as the harshness of their consequences. To put it another way, risk is "the product of an interaction between the likelihood or frequency of an event taking place and the size of the event itself" (BS 4778, 1991). Supply chain risk is defined as an occurrence that has a negative impact on supply chain operations and hence its targeted performance indicators, such as chain-wide service levels and responsiveness (Zsidisin *et al.*, 2004).

A systematic risk management process (RMP) was established by Raiffa (1982); Hertz and Thomas, 1983). This RMP approach has been used to identify and analyze possible risk factors. The severity of the repercussions can be assessed, and risk mitigation techniques established by Kleindorfer & Saad (2005); Sinha *et al.*, (2004) provide other risk management methodologies. Techniques for estimating the likelihood of the occurrence of specified risk variables as well as the severity of associated effects must be in place. Using a modified Risk Management Process (RMP), it is recommended to identify, assess, and manage supply chain risks. The supply chain risk management process modifies this technique (SCRMP).

As mentioned in the literature, risk management has four basic steps and phases that start with identification of the risk, then assessment of these risks from low, moderate, to highly impactful risks, moving to the most important phase, which is the phase of dealing with these risks, which is called mitigation and can take different strategies like transfer, avoidance, buffering, control, or acceptance.

1. Phase one: risk identification

Risk identification entails determining all potential supply chain hazards linked to a specific issue. So that risk mitigation techniques may be implemented, vulnerable regions must be identified and their consequences recognized. Some strategies may seriously affect other risks (Chopra & Sodhi, 2004). Understanding supply chain risks and their interrelationships is crucial. By looking at hazards and resources, one can gain insight into the situation. Threats are forces that may cause harm to assets, people, or earnings. To begin, enumerate all potential hazards to the supply chain's performance. A threat assessment must

then be carried out for each entity that could potentially be affected. Methods for identifying SC risks include supply chain mapping, checklists or check sheets, event tree analysis, fault tree analysis, FMEA, and Ishikawa cause and effect analysis (Tummala *et al.*, 1994). While it is beyond the scope of this study to discuss each of these approaches in detail, they will be briefly defined and discussed below. The interested reader is referred to examples. First, supply chain mapping depicts the SC and its movement of goods, information, and money from upstream suppliers to downstream customers. A strategic supply chain map helps organizations manage and adjust their supply chains (Gardner & Cooper, 2003). Risks can be better identified after the supply chain is fully characterized. The second use of checklists or check sheets is to keep track of how often a failure occurs. These forms are used to collect data and build histograms. To rate a supplier's reliability and the risk of late deliveries, checklists could be used to record late deliveries. Third, event tree or fault tree studies graphically illustrate all possible outcomes triggered by an event. There are fundamental distinctions between the two types of trees, such as whether the diagram contains single or multiple event routes (Hollnagel, 2016). To plan for alternatives, one might map out the possible events and responses caused by a supply chain failure. Fourth, FMEA is a tool for identifying "potential risks during product manufacture and usage by the end user" at the design stage (Karim *et al.*, 2008). provide an overview of FMEA. Before committing to a supply chain, one may use this SC to assess what could go wrong and the severity of the consequences. Fifth, Ishikawa's cause-and-effect analysis includes brainstorming and exploring all probable causes and failure occurrences. Known as fishbone diagrams due to their structure, CEAs (Chase *et al.*, 2006) After identifying a supply chain failure, these diagrams could be utilized to determine the root cause.

In risk measurement, the effects of all probable SC hazards are determined. Consequences are the way or extent to which a danger exhibits its consequences on resources (Crockford, 1986). Liabilities incurred from damage repair expenses or injuries can manifest as loss of or damage to assets, income loss, cost overruns, schedule delays, or poor process performance. When SC risks are identified using a checklist, event tree, fault tree, FMEA, or even an Ishikawa analysis, their repercussions and severity levels can be assessed. Risks are divided into four categories based on frequency, severity, and predictability. Crockford classified repercussions as trivial, minor, medium, and huge. As a result, trivial effects occur frequently, are mild, and are predictable. Small repercussions are regular, mild, and

predictable, yet rare. Medium repercussions have a low frequency, a medium intensity, and a moderate predictability. Finally, huge repercussions have low frequency, high severity, and low predictability. This framework applies to our situation. "Trivial losses" are predicted losses that can be covered by normal operational budgets. Small losses may not be problematic unless their frequency exceeds that of a single "medium loss". "Medium losses" would not be a major worry if they occurred regularly, as their cost could be stated as an annual sum and preparations made. The most critical issue is a "large loss". These losses are unusual, but if they occur, they could be disastrous for the firm. The US Military Standard 882C is utilized to measure the severity of consequences (Military Standard, MIL-STD-882C, 1993).

2. Phase two: Risk assessment

Risk assessment is concerned with determining the likelihood of each risk factor and is identical to assessing uncertainty (Raiffa, 1982). It is possible to derive probabilistic models for relevant SC risks and effects from factual data that may be used to assess uncertainty. Nevertheless, if verifiable information is not accessible, it is possible to approximate distributions using knowledge, perception, opinions, and intuition. Probabilities can be derived with the help of methods such as the Delphi method or expert focus groups. Probability encoding and Monte Carlo simulations are two further methods for estimating parameters (Tummala *et al.*, 1994). Hurricane Katrina, for example, has a "rare" to "very rare" occurrence chance, whereas a later delivery has a "regular" to "infrequent" occurrence probability. There is a risk probability index allocated to each risk probability category, which can be used to calculate the risk exposure values.

3. Phase three: Risk mitigation [avoidance, acceptance, transfer, buffer]

In the risk mitigation and contingency plans component, action plans are developed to contain and control the risks (risk planning). Tummala and Mak (2001) have used the hazard totem pole (HTP) analysis as an evaluation technique and found it to be extremely useful. It's a helpful strategy since it ties together previously described characteristics of risk, such as severity and probability, in a logical way.

Risk mitigation action plans can be constructed once the risks have been recognized, their consequences assessed, and their probability determined. For this reason, the first step in risk planning is to estimate how much it will cost to adopt each of the preventative measures necessary to keep the identified SC risks under control and manageable. It is possible to decrease the risks of the supply chain by implementing measures such as buffer inventories and information technology, as well as by building strong working relationships with suppliers and downstream consumers (Swaminathan & Tomlin, 2007). Closer collaboration with trading partners, cost increases passed on to customers, the use of dual or multi-sourcing strategies and redundant suppliers, and performance-based contracts with suppliers and service partners are the most successful methods used to mitigate risks, according to findings from AMR Research's recent supply chain risk survey (Tohamy, 2009). These strategies are analyzed, and the best course of action is chosen. The relative cost of risk mitigation plans can also be taken into consideration while evaluating them.

In order to choose the most feasible risk mitigation plan, it is necessary to evaluate a number of different options (Elleuch *et al.*, 2014; Ghadge *et al.*, 2013; Kern *et al.*, 2012; Tummala & Schoenherr, 2011). The implementation expenses must be taken into account while selecting a strategy. In order to justify the strategy's expenditure, the chain must see a return on its investment. When implementing a risk treatment approach, the focus is on tackling the previously prioritized risks (Manuj *et al.*, 2014; Pujawan & Geraldin, 2009). As far as the eventual goal of this phase is concerned, one can see that the literature has a variety of approaches. It is clear that the goal is always to minimize the risk's overall implications. Moreover, it emphasizes removing or lowering the risk of real hazards, with an emphasis on a proactive approach (Aqlan & Lam, 2015). According to Kern *et al.*, (2012), this phase may be used to reduce the probability of the cause as well as its repercussions (impact reduction).

4. Phase four: risk monitoring and control

SCRMP's risk control and monitoring phase provides a final opportunity to evaluate progress made in implementing risk response action plans; corrective actions can be conducted if deviations arise in the SC's performance. Preventive interventions can be identified, and instructions can be provided for future improvement. Unusual or anomalous situations are reported, as are problems with the security clearance process. For example, a modular framework like this can be used in data management systems. SC risk factors,

consequences severity levels, risk probabilities and risk totem poles, government regulations and policies, and hazard totems Tummala and Mak (2011) have proposed a structured model for supply chain risk management that will be illustrated in Figure 4 below.

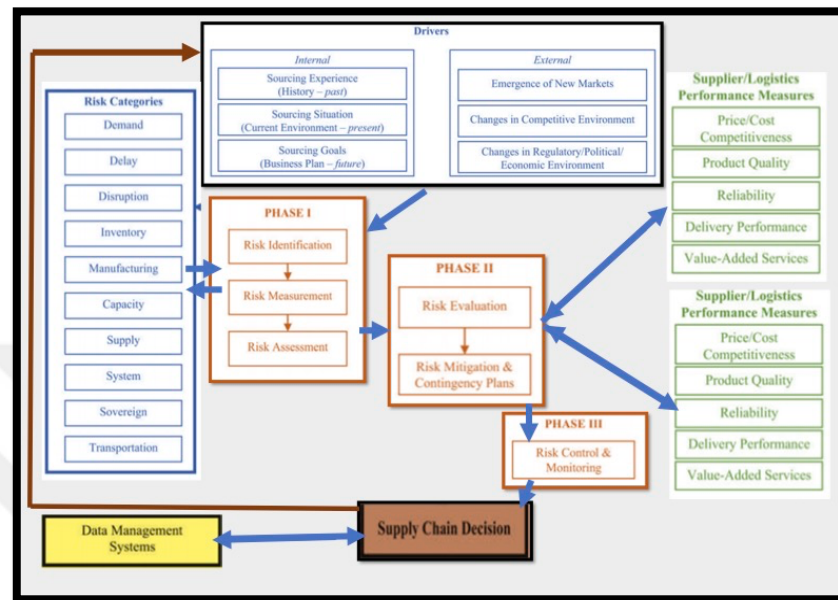


Figure 4. Supply chain risk management Processes. Published by Supply Chain Management: An International Journal.

According to literature, there is another classification for risks as: known risks and unknown risks. Known risks may be discovered, measured, and managed over time. For example, a supplier failure causing a supply interruption is a recognized risk. A supplier's business history helps predict its likelihood, and the impact on the business can be evaluated by the goods and marketplaces the supplier might disrupt. Newer hazards like supply chain security breaches may now be quantified using methods that analyze a company's IT infrastructure from the outside in.

Building a risk-management framework that defines which metrics are acceptable for gauging risks, "what good looks like" for each measure, and how to systematically collect and monitor these metrics should be a priority for organizations. This team can also detect risky regions that are difficult to describe (e.g., tiers of the supply chain where no visibility exists). This method can quantify unknown dangers.

Unknown risks are difficult or impossible to predict. Consider a long-dormant volcano suddenly erupting, disrupting a supplier you didn't realize was in your supply chain, or a cybersecurity flaw discovered in a vital electrical component's firmware. Even the most risk-averse managers may be unable to anticipate such events.

Reduce the possibility of unknown hazards and respond faster when they arise. This is crucial to maintaining a competitive advantage. Solid defenses and a risk-conscious culture may provide a business with this edge.

2.9 MANAGING KNOWN RISKS

Using organized problem solving and digital technologies, organizations may manage their known-risk portfolio in four steps, starting with Identifying and recording threats. A common method for identifying risks is to map and analyze all significant product value chains. Each supply chain node—suppliers, factories, warehouses, and transit routes—is then evaluated. Risks are tracked systematically and recorded in a risk register. We should also note portions of the supply chain that lack data and require additional examination. Followed by By creating a supply-chain risk framework and establishing an integrated risk management framework, each risk in the register should be graded on three dimensions: impact on the company, likelihood of occurrence, and preparation. The risk ratings indicate the organization's risk appetite. It's vital to create and utilize a rating system for all hazards. This allows prioritizing and aggregating threats to identify high-risk items and value-chain nodes.

Once a risk-management framework is developed, ongoing monitoring is vital to spotting potential threats. With the advent of digital technologies, even the most complicated supply chains can detect and track risk signs. This includes structural determinants such as geographic location and years of operation, as well as operational performance measurements such as "right first time" and deviation cycle durations.

Successful monitoring systems incorporate impact, probability, and readiness views. While one company may check production line variations to identify quality difficulties, another may monitor storm risk at its Puerto Rico operations. Regardless, an early warning system to identify the top risks is vital to minimizing, or at least limiting, the consequences

of their occurrence. In order to improve supply chain resilience and agility, a comprehensive governance structure must be established to analyze supply chain risks and specify mitigation actions. It is important to have a cross-functional risk board with representatives from all parts of the value chain. It often comprises line managers who also act as risk owners for their functions, identifying and mitigating risks. In most circumstances, a central risk-management department provides professional help in identifying and reducing risks.

A good board meets regularly to assess supply chain risks and devise mitigation strategies. The participants will then own the mitigating activities for their functional nodes. A board member who agrees to certify and onboard a new supplier for a vital component will own and execute that action. Many firms' risk boards will also provide recommendations to increase supply chain agility and resilience, such as reorganizing supply networks, lowering lead times, or working with suppliers to optimize their own operations. Increasing supply-chain agility may help firms plan for a wide variety of risks.

2.10 MANAGING UNKNOWN RISKS

Unknown risks are difficult or impossible to foresee, measure, or manage in the same way as recognized hazards. Building robust defenses, from request-for-proposal (RFP) wording to worker training, all contribute to a company recognizing and stopping unforeseen threats before they influence operations. One of the most important benefits of a risk-aware culture is the ability to respond rapidly when an unexpected risk threatens operations.

- Management and staff must feel free to share unpleasant news and lessons learned. This transparency generates a climate where concerns may be raised and addressed. When a risk event happens, the company must work harmoniously to resolve it quickly.
- Organizational risk tolerance must be clearly defined. It is crucial to decide which risks the company can accept and which ones it must reduce. A company's culture should also encourage the sharing of internal and external risk indicators.
- Reactivity The ability to recognize and respond promptly to environmental change is required. Create a climate of ownership where people feel accountable for their actions and decisions.

- Respect Individuals or groups should not take risks or engage in activities that profit them but hurt the organization.

2.11 SUPPLY CHAIN DURING COVID-19

For supply chains (SC), the COVID-19 crisis has caused a rapid and severe upheaval in the business environment and beyond, affecting and interrupting operations and SCs in terms of magnitude, sophistication, intensity, and length of effect. A new context has been revealed that goes beyond an immediate understanding of disruptions and may be regarded as a SC crisis marked by continuous, severe uncertainty about existing and future circumstances and extensions toward SC viability in the wake of the COVID-19 pandemic. When faced with 'super shocks' that can significantly alter operational circumstances for lengthy periods of time, it can be difficult to sustain a successful SC (Ivanov 2020a; El-baz & Ruel, 2021). The COVID-19 pandemic has uncovered research gaps in our understanding of super-disruptions, despite significant advances in this area. Survival and adaptability in the face of such disruptive changes need a particular quality, which we call SC viability (SCV) (Ivanov, 2021c).

In the face of the COVID-19 epidemic, supply chain viability (SCV) is a rising concept in operations management that is well recognized by practitioners (Ivanov, 2020b). SC resilience, a firm's capacity to recover from interruptions to satisfy consumer demand, assure goal performance, and sustain operations in sensitive situations, has become a study focus in recent decades due to a growing number of uncertainties and disruptions (Dubey *et al.*, 2019). There is a perception that a resilient system is one that can recover and re-establish itself in the face of adversity and return to its pre-disruption state. In the framework of a decision-making environment, the COVID-19 pandemic has posed fresh questions that frequently go beyond the scope of SC resilience. (Ivanov 2020a, b)

With the COVID-19 pandemic, businesses have been forced to re-evaluate their robustness in new ways, prompting the development of new theoretical frameworks to address this issue (Chowdhury & Quaddus, 2017). Craighead *et al.* (2020) draw on ten different theories—resource dependency, institutional theories, game theories, and others—to draw out research questions, offering ways for simultaneous transformation and

resilience, or transilience (which is the ability to simultaneously restore some processes and change often radically others).

2.12 GLOBAL SUPPLY CHAIN RISK MANAGEMENT

A competitive advantage can be gained through a company's global supply chain. Wider market investments, better financing options, more access to inexpensive labor and raw materials, arbitrage opportunities, and additional incentives provided by host governments all contribute to global business arrangements (Kogut & Kulatilaka, 1994). In addition to the advantages that drive companies to go global, managers face uncertainty and risk in global supply networks. In a stable global economy, a firm may have the lowest total costs, yet it may be the most vulnerable to supply chain disruptions. The risks and uncertainties that come with global supply networks are well documented. There have been numerous studies on risk management in multinational corporations (Carter & Vickery, 1989; Miller, 1992; Jüttner *et al.*, 2003); however, risk management has been relegated to the background until recently, when several researchers (Cavinato, 2004; Christopher & Lee, 2004). It is widely accepted that most organizations have policies in place to defend themselves from reoccurring low-impact hazards in their supply chains. Many people, on the other hand, overlook high-impact, low-probability threats. Managers can personalize risk-reduction strategies for their businesses by recognizing the range and interconnection of supply chain hazards. According to Hauser (2003), in today's increasingly complex world, risk-adjusted supply chain management can lead to enhanced financial performance and competitive advantage. As a result, both academics and practitioners must place a high value on better understanding global supply chain risk management.

Supply, demand, operational, and security risks are the four categories of vulnerabilities that have been identified in the literature (Christopher & Peck, 2004; Manuj & Mentzer, 2008). To summarize, supply risk is the distribution of outcomes related to adverse events in inbound supply that affect the focal firm's ability to meet customer demand (in terms of quantity and quality) within anticipated costs and times or cause threats to customer life and safety, using the definition of risk developed above and insights from interviews. A company's internal ability to generate goods and services, quality and timeliness of production, and profitability are all affected by operations risk, which is the distribution of

outcomes due to adverse events within the company. Customer demand risk is the distribution of outcomes connected to bad occurrences in the outward flows that affect a company's ability to attract new customers as well as its ability to meet demand. In the context of security risk, bad occurrences that affect human resources, operational integrity, and information systems may lead to results such as freight breaches, stolen data or proprietary knowledge, vandalism, crime, and sabotage. Risks are categorized as macroeconomic risks associated with significant economic shifts in wage and interest rates; policy risks associated with unexpected actions of national governments; competitive risks associated with uncertainty about competitor activities in foreign markets; and resource risks associated with unexpected differences in resource requirements in foreign markets. " Currency, transit time variability, forecasts, quality and safety risks, business disruption and survival, inventory risks, culture dependence risks, opportunism risks, oil price fluctuations, and risk events affecting suppliers and customers have been investigated as the most important concerns of global supply chain managers. Researchers have supported all of these risk occurrences, including (Birou & Fawcett, 1993; Cho & Kang, 2001; Zsidisin, 2003a, 2003b).

Global supply chains greatly benefit from flexibility since it aids in coordination and can provide the ability to deal with the significant levels of environmental and operational uncertainty that come with global operations in general. Firms that are more flexible outperform their less flexible rivals in the long run (Fawcett *et al.*, 1996). When a company is adaptable, it has the potential to expand its global reach while simultaneously improving its performance in comparison to the industry's top competitors. An inherent ability to adjust quickly to changes in conditions that cannot be predicted during the planning cycle is provided by a flexible supply chain. Rather than manufacturing the air conditioners themselves in India, a global business decided to assemble and sell the units. They bring the kits to India via another country. Whereas the tax incentives available to enterprises in India differ from state to state, each state has its own unique set of tax benefits. The assembly of air conditioners may be more cost-effective in one state over another in one year than in the following year. Nonetheless, there is a catch. When deciding how much tolerance to provide the supply chain, it's important to assess the level of risk it confronts.

According to Nembhard *et al.* (2005), a supply chain model was established that allows a manufacturing company to choose from a variety of suppliers, plants, and markets. With

the use of the real options method, they estimate the importance of flexibility and identify the best way to deal with it in the face of fluctuating currency exchange rates. They demonstrate that the value of operational flexibility can be greatly exaggerated if the time gap between choice and option implementation is not taken into account. They have a wider range of strategic risk management tools at their disposal. To summarize, supply chains that face significant demand or supply risks benefit from flexibility since it allows a firm to quickly and smoothly reallocate resources in response to change.

2.13 SUPPLY CHAIN VIABILITY AND ITS DIMENSIONS

As defined by Ivanov, 2020b, "Viable Supply Chain is a dynamically adaptable and structurally changeable value-adding network that can (i) respond quickly to positive changes, (ii) absorb negative events and recover after the disruptions, and (iii) endure amid times of long-term, worldwide disruptions by shifting resource uses and distributions to demands in response to internal and external changes in line with sustainable developments to secure the provision of goods and services."

The concept of SC resilience, originally conceived as a closed system "bounce-back" approach, may be expanded to include SCV by adopting an open system viewpoint that emphasizes "bounce-forward-and-adapt" strategies.

Based on the literature on the principles of stability, robustness, resilience, and viability, a systematic view of organizational structure and resources for supply chain viability It was suggested that the SCV notion is entrenched in many structures and resources. SCV also has dynamic design features that allow for rapid switching between several structural supply chain designs to accommodate fluctuating supply and demand (Eisenhardt & Martin 2000; Caniato *et al.*, 2013). Because it is difficult to forecast all future disruptions and fit supply chain designs to emerging events, Ivanov (2020b) emphasizes the necessity for proven and manageable adaptive mechanisms. Adaptive methods like dynamic design capabilities are useful. The time horizon is long because viability helps SCs accomplish sustainability goals (Queiroz *et al.*, 2020) and endure disturbances. The literature has several concepts about "time". Ivanov & Dolgui (2020b) defined "long-term" as "no set time window" while assessing SCV. There is also discussion about operational chores that might enhance SCV. This synthesized Ivanov (2020b) SC ecosystem framework is as follows:

- Structural and resource dimensions that include
 1. Organization contracts
 2. Information and technology adaptation
 3. Financial management
 4. Process management
- Dynamic capabilities dimension
- Time window dimension
- Operational dimension.

2.14 SUPPLY CHAIN RISK CATEGORIES

According to literature, risks in supply chain management can be divided into two main types: external and internal. Internal risks include late delivery of products or goods, financial risks, errors and mistakes that are done by humans working in the supply chain, and poor estimation in planning, while external risks include risks that are caused by factors outside the supply chain such as hurricanes, wars, regulations, and financial crises.

Hessam and Savoji (2011) have defined supply chain risks into different categories: financial, strategic, risks of information and communication technology, human resources and equipment errors, and lastly, environmental risks, asserting that the last type is the most influential factor because it can change governmental laws and procedures that can affect the business massively. Working in highly risky environments can indicate making decisions or taking steps without knowing the exact consequences of them. There is always a risk of loss in every decision made, but it can also mean there is an opportunity for growth, making profit, or gaining a competitive advantage over rivals.

Snyder and Shen (2006) concentrated primarily on market-driven risk. In any circumstance, the problem is related to having insufficient supply to meet demand, and whether the imbalance occurs due to too much consumption or too little production may be unimportant. They suggested that almost all of the common thinking concerning demand uncertainty (DU) is incorrect when it comes to supply uncertainty (SU). As a consequence, they proposed doing studies on supply chains under SU in order to detect their interactions and develop techniques for reducing supply risk.

According to Tang (2005), one of the major issues in supply chain risk management is the gap between theoretical knowledge and implementation. Tang claims that numerous businesses have undertaken bold steps such as lease production and market diversification. Tang indicated that these efforts might be useful in a stable situation; nonetheless, they can strengthen supply networks by making them more sensitive to various forms of disturbance induced by environmental uncertainties.

According to Kilgore (2004), when a company implements a standard cost-cutting plan in its supply chain strategy, it typically increases the chance of failure or increases the total cost of the operation. Kilgore recommended that enterprises develop a risk-adjusted supply chain strategy and that firms use an empirical risk mitigation technique, which combines risk management and cost reduction into a single continuous cycle, in order to mitigate risk. According to Jüttner *et al.* (2003), risk reduction tactics include the following: (1) prevention, (2) control, (3) engagement, and (4) elasticity (adaptability).

An organization's ability to be effective requires that SCRM be a management function of inter-organizational character and intimately linked to the strategic and operational realities of the activity at hand. Collaboration and the formation of joint and shared transversal processes with industry partners are key to effective SCRM. According to Lavastre *et al.*, (2012), researchers employed a combination of face-to-face interviews, surveys, and statistical analysis in their research. The Fuzzy Analytic Hierarchy Process (FAHP) is used to identify the most critical supply chain risks and the corresponding risk management strategies for a Turkish iron and steel company based on an empirical study of 142 general managers and logistics and supply chain managers in 50 different French companies. Compared to environmental hazards, this study's findings suggest that supply and operational risks are more critical (Sofyalioglu & Kartal, 2012).

Risk management has four phases (Tungel & Alpan, 2012; Giannakis & Louis, 2011):

- Identifying risks is the first step in ensuring the supply chain runs smoothly.
- Risk assessment refers to assigning the likelihood of occurrence of the occurrences. After this phase, the hazards are evaluated as unlikely, improbable, moderate, probable, and extremely probable.
- Risk management is the process of selecting and implementing the best risk mitigation plan.

- Risk monitoring is the final phase in risk management, when the system is supervised to assess the effectiveness of remedial measures and find prospective dangers not identified in the previous processes.

In order to identify and manage risks, management policies, processes, and practices are used systematically. There are different techniques for implementing these processes depending on whether they are proactive or reactive. In order to control supply chain risk, McCormack *et al.*, (2008) proposed three stages. The first step is to identify the risk by recognizing supply chain concerns. The second phase involves risk evaluation or assessment, which requires outlining major hazards that may be depicted in a risk portfolio with the metrics of likelihood of occurrence and harmful consequences. The third step is risk mitigation, which involves lowering the probability or significance of an event that occurs.

2.15 SUPPLY CHAIN RESPONSIVENESS AND RESILIENCE

According to Kim and Cavusgil (2009), the ability of the supply chain to respond quickly and effectively to risk is critical for success. Supply chain responsiveness has been shown to have a direct correlation with export performance, market performance, and business performance in previous empirical studies (Hallavo, 2015; Qrunfleh & Tarafdar, 2013). Reducing supply chain risks is likely to be easier for the company if it can adjust to the shifting demands of its partners (Kim & Cavusgil, 2009). A company's competitive edge will be enhanced if it can respond quickly and effectively to partner behavioral unpredictability. Manufacturing responsiveness, operation responsiveness, and customer responsiveness are all examples of supply chain responsiveness (Hallavo, 2015). This study explores SC responsiveness at the supply chain partnership (i.e., both seller and buyer) level rather than the individual business level. According to Kim & Cavusgil (2009); Ayoub & Abdallah (2019), the firm's SC is its capacity to adapt quickly and effectively to changing buyer-seller demands and market circumstances. A firm's responsiveness comes from the inside, from its SC. Supply chain risk mitigation solutions to adapt quickly to changing buyer-seller demands and market conditions The firm, its SC members, and their collective efforts enable a firm to be responsive. Firms can achieve responsiveness through collaborating with suppliers, exchanging information with consumers, or using modern production technologies (Roh *et al.*, 2014). Interorganizational resources, such as socio-

relational and techno-process integration, are advocated by Roh *et al.*, (2014) for effective implementation of a responsive supply chain strategy. Thus, supply networks might gain a competitive edge by being responsive.

In the literature, Resilience is defined as an organization's capacity to adjust quickly to change (Sezen, 2008). As a strategic reaction to competition and uncertainty (Hallavo, 2015; Kurniawan *et al.*, 2017). Given that investing in flexibility entails risks and costs for businesses, ensuring appropriate flexibility has become critical (Rojo *et al.*, 2016). Existing studies explore the topic of flexibility. Sreedevi and Saranga (2017) identified three main supply chain risks: supply, manufacturing process, and delivery. To reduce these risks, they investigated supply flexibility, production flexibility, and logistic flexibility. Although it has several classifications and subcategories, some scholars contend that flexibility should be seen as a whole value-adding system (Vickery *et al.*, 1999). SC flexibility is defined as the supply chain's capacity to adapt and respond to disturbances and threats. Supply chain flexibility is critical in a complex and unpredictable environment. Many organizations have expanded supply chain flexibility to respond quickly to environmental changes and risks (Merschmann & Thonemann, 2011). Furthermore, SC flexibility can improve long-term financial (Shou *et al.*, 2018) and operational performance (Yu *et al.*, 2018). According to Hallavo (2015), the more a corporation focuses on supply chain flexibility, the better. However, Rojo *et al.*, (2016) claim that SC flexibility is mostly investigated from the firm's perspective, not the supply chain as a whole.

To explore the resilience of supply networks in general and the factors that contribute to supply chain risks, an empirical investigation of supply chain risk management techniques in the German automobile sector was conducted. The results of the probability-impact matrix analysis indicate that enterprises with a high implementation degree do better in the supply chain (Thun & Hoenig, 2012).

Supply chain resilience allows a disrupted supply network to recover and be more robust than before (Christopher & Peck, 2004; Brusset & Teller, 2017). SC resilience is more than a reactive competence, as it enables SC member businesses to both face challenges and opportunities. Furthermore, it is an essential component of comprehensive risk management strategies (Bevilacqua *et al.*, 2018; Golgeci & Kuivalainen, 2019) and creates a competitive advantage. Members of a supply chain are responsible for building resilience in their firms and enhancing system resilience (Golgeci & Kuivalainen, 2019). Increasing exposure to

supply chain risk has increased the need for enterprises to strengthen SC resilience (Chang *et al.*, 2015), and risk is often related to resilience (Baryannis *et al.*, 2019). So, researchers study factors affecting SC resilience. Such as the link between social capital, absorptive ability, and supply chain resilience, empirically linked external integration, adaptability, and resilience. (Brusset & Teller, 2017)

2.16 SUSTAINABLE RISK MANAGEMENT

The term "sustainability risk management" (SRM) refers to an approach to business that balances financial objectives with environmental principles. SRM enhances this synergy to sustain and grow a business while minimizing environmental impact. Global and national code coverage is what drives SRM adoption.

SRM-implemented companies assess each business process's environmental impact and then reduce it. IT manages sustainability data and automates audits and reporting. Management can spot supply chain, operations, and production concerns with an efficient SRM framework. Emerging challenges include renewable energy, non-renewable resource depletion, and changing government restrictions.

Risk analysis is the key to dealing with risk in business and is important to risk mitigation and reduction, two tenets of a solid business strategy. Without research and analysis, it is hard to deal with potential risks or even know about many of them. Numerous schools of thought and bodies of knowledge have contributed vast amounts of theory and professional guidance to the field of risk analysis, each of which emphasizes a unique strategy or set of tools. One thing that has become abundantly evident in modern times, nevertheless, is that a business may greatly lessen its risk by concentrating on, or at least including it in its analysis of, its sustainability.

Risk management has become a dynamic field of study thanks to the development of new technologies and methods and the growing concern for sustainability in the modern world. Researchers are also looking into how risk management can help businesses and projects become more sustainable. This is because businesses and projects are shifting their focus from the short term, where projects were seen as ends, to the long term, where projects are seen as ways to reach sustainability goals.

Quoted by Dan R. Anderson:

"Sustainability risk is a newly emerging risk area and, I believe, one of the critical risk areas of the 21st century."

Sustainability issues are especially likely to cause problems in supply chains (Lee & Vachon, 2016). These problems can have a wide range of negative effects, including monetary losses from things like falling demand and fines for polluting the environment, as well as damage to a company's reputation from bad press.

Due to higher frequency, longer recovery times, and the focal firm's accountability for unethical concerns and any actions at every supply chain layer, risk management is crucial (Christopher & Holweg, 2011). Despite this, neither the nature of the connection between sustainability and risk concerns in supply chains in general nor the impact of such difficulties in times of demand volatility and uncertainty are well understood. (Lee & Vachon, 2016)

According to one definition, sustainable supply chain management is "the strategic, transparent integration and achievement of an organization's social, environmental, and economic goals in the systematic coordination of key organizational business processes for improving the long-term economic performance of an individual company and its supply chains" (Gungor & Gupta, 1999). Literature shows that SSCM results in better organizational performance. However, due to their high resource consumption and short product life cycles, several sectors present specific problems for sustainable management. Cost and risk savings, as well as organizational desire or owner commitment to sustainability, are often stated as primary motivations for incorporating sustainability into supply chains (Walker & Jones, 2012). Market and sustainability risks, such as falling demand or consumer boycotts, which can lead to an unexpected loss of competitive advantage, can be mitigated through sustainability integration, which also reduces operational risks by avoiding pollution clean-ups and penalties, saves money on energy and materials, and improves relationships with a wide range of stakeholders (Walker & Jones, 2012). Some of the factors identified in the sustainability literature as impeding companies' efforts to implement SSCM are globalization, outsourcing, geographically longer and extended supply chains, and a lack of visibility and control (Carter & Rogers, 2008).

In recent years, it has become more important to manage the environmental, social, and economic effects of goods and supply chain activities. Sustainable design and cleaner

production have become key ways to do this. Design has been discussed in the supply chain literature as a primary tool to respond to rapidly changing market needs (Parker *et al.*, 2008), shorten product development time, boost product quality, learn from and benefit from supplier technology for supply chain responsiveness, and cut costs, risks, and production times. For this reason, designers nowadays must think about more than just the bottom line when creating new products; they must also think about how their creations will affect the world around them (Fargnoli *et al.*, 2014). Early supplier participation in design, information exchange, and collaboration with supply chain partners is also recommended by sustainability literature (Zsidisin & Smith, 2005; Sharifi *et al.*, 2006).

Recent changes in the industry show that supply chain sustainability and risk management go hand in hand. Giannakis and Papadopoulos (2016) found that companies with large global supply chains are more likely to have bad things happen. This was demonstrated by the child labor controversy at Nike in Southeast Asia, which had a significant impact on the company's bottom line and its public image (Quarshie *et al.*, 2016). Sustainability-related risks may have negative financial consequences such as fines for environmental pollution or harm to corporate reputation that could result in a loss of sales (Lee & Vachon, 2016), but these are not the same as delays or disruptions in supply, which is how Giannakis and Papadopoulos (2016) distinguished them.

According to the report that was published by WBCSD (2016), sustainability is altering the trajectory of many significant corporate operations recently, including material sourcing, location selection for new facilities, product and process innovation, talent acquisition, and organizational development. Managing sustainability risks can be difficult for some businesses because their leaders don't fully grasp the nature of these risks or how they could affect the company. 89% of experts in the fields of risk management and sustainability acknowledge, based on surveys and group discussions, that sustainability risks might have a major effect on businesses.

Better supply chain resilience may be achieved by firms that have a firm grasp of the sustainability risks inherent in their supply chains (Xu, Ming *et al.*, 2019). When it comes to social and environmental sustainability, supply chain sustainability risk management in particular broadens the scope of supply chain risk management.

Supply chain sustainability risk management includes social and environmental sustainability considerations. Based on sustainable hazards, supply chain risks are economic, social, environmental, technological, and institutional. Sustainable development and risk management emphasize the need to safeguard supply chain sustainability and address supply chain hazards.

2.17 AGRICULTURE SUPPLY CHAINS

Agriculture supply chains involve operations such as farming (cultivating land for crop production), processing or manufacturing, testing, packaging, storage, shipping, distribution, and marketing (Tsolakis *et al.*, 2014). Supply chain management, manufacturing and process management, and demand management through a competitive distribution channel are all part of ASCs (Chandrasekaran & Raghuram, 2014). ASCs include food acquisition, processing, and manufacturing organizations; distribution and corporate bodies; intermediaries; food producers; hotels and restaurants; and merchants and brand owners. Depending on the study context, multiple scholars have used the term ASC, such as food supply chain (Zirham & Palomba, 2016), agriculture value chain (Brewin, 2016), post-harvest supply chain (Mvumi *et al.*, 2016), fruit supply chain (Glowacz and Rees, 2016), and agri-business supply chain (Bhagat & Dhar, 2011). Supply chains in agriculture cover a wide range of activities, from growing crops to storing and transporting them. Depending on product type and stakeholder engagement, they are also divided into six levels. Seasonal produce, varying manufacturing lead times, limited product standardization and product quality, and trade and inventory storage constraints all contribute to ASCs' exposure to severe disruptions. These flaws put the ASCs at risk of serious interruptions (Van der Vorst *et al.*, 2000). In order to improve the chain's performance, agri-food companies and managers will benefit from better risk management by better understanding the complex nature of agri-food supply chain risk. The risks in the ASC have a negative impact on service levels, responsiveness, and costs, just like in any other supply chain (Tummala & Schoenherr, 2011). All ASCs must understand the many threats and their origins, as well as their interdependencies and their ripple effects, in order to effectively manage the risks that might have a significant influence on their operational performance. The main goal of an ASC practitioner is to decrease economic losses and improve supply chain performance by

selecting and implementing the most appropriate set of strategies through the creation and implementation of adequate risk mitigation methods and tactics.

All agricultural operations rely on fertilizers. The fertilizer industry mines and processes raw minerals, including phosphate ores, potassium salts, and sulfur ores, then manufactures mineral fertilizers from them. Over the last century, the use of fertilizers has expanded dramatically. According to the International Fertilizer Association's (IFA) Public Summary Short-Term Fertilizer Outlook 2020–2021, the overall fertilizer nutrient demand in 1950 was estimated at around 20 million tons, compared to about 190 million tons in 2019 and 2020. For 2020–2025, the worldwide fertilizer market is expected to develop at a CAGR (compound annual growth rate) of 3.8 percent, bringing its total value to USD 155.80 billion in 2019. Mordor Intelligence (2020) Since fertilizer applications must be made annually to sustain yields, demand has historically remained robust, according to the Yara Corporate Release (2020). The COVID-19 epidemic has made forecasting growth for the 2020–2021 crop year and beyond more challenging than normal. Most international countries have had to pursue government-led actions, disrupting the food chain and supply networks and affecting the fertilizer business (Yara Corporate Release, 2020). Even in times of crisis, the foundations of the fertilizer sector remain solid. The increased usage of fertilizers in agricultural production to meet rising food demand drives demand. It was predicted that farmers would only be able to produce half of the present world food supply if mineral fertilizers were not available (World Bank Brief, 2020).

Financial market variables ensure that the need for fertilizers grows at a consistent pace around the world. In order to maintain a consistent worldwide fertilizer use pattern, the following criteria are critical: The growth of the world GDP (Knoema, World GDP, 2020) and the loss of land suitable for farming (Phosagro, 2020) are among the factors affecting the global population. However, the current price of fertilizer is neither excessive nor exceptionally low. Price increases are expected by the year 2020. It is expected that the price of Triple Superphosphate, DAP (Diammonium Phosphate), Potassium Chloride, and Urea would all decrease below the average in 2020, with the lowest price recorded in January 2020 (239 USD/T) for DAP and in December 2019 (238 USD/T) for DAP before the pandemic. This shows that the pandemic period had no effect on the global fertilizer business, as fertilizer prices have been continuously dropping over the last nine years and stayed at average or slightly lower levels throughout the COVID-19 pandemic in 2020.

Yara International, the world's largest fertilizer company with a regional organizational structure, and Nutrient, the Canadian Fertilizer Company formed in 2017 through the merger of PotashCorp and Agrium (Canada), have all stated that the operation through COVID-19 remains stable and demand across the global fertilizer market remains high (Nutrient News Release, 2020; Woodroof, 2020; Yara Corporate Release, 2020). There was a very stable supply chain during the epidemic for leading fertilizer firms from outside the United States. Decreased selling prices were offset by increased sales volumes and lower costs of products sold. Using Nutrient as an example, in the second quarter of 2020, the cash cost per ton of potash was 52 USD, which was a record low (Nutrient News Release, 2020).

In the midst of the epidemic, leading Russian fertilizer firms report solid performance, and supply networks and distribution routes are resilient as well. With solid sales momentum and revenue marginally down from last year, Phosagro, one of the world's major phosphate fertilizer companies, has declared its operations sustainable. The reduced DAP costs in 2020 might be seen as a positive outcome. EuroChem Group AG has announced that the company's half-year results for 2020 are about on par with those of 2019, despite the COVID-19 pandemic's impact. Russia's fertilizer industry is able to produce high-quality goods at competitive prices because it has access to unique natural resources, including phosphate ore and potassium carbonate (Dmitrieva *et al.*, 2017; Phosagro. Official Website, 2020).

As a result of the aforementioned, we may conclude that fertilizer firms have not experienced major revenue losses. Because fertilizers are critical to food security and nutrition (Policy Brief: The Impact of COVID-19 on Food Security and Nutrition, 2020), this is largely due to the fertilizer industry's ability to operate with stability and competitive advantage in a volatile environment. But this is also due to the fertilizer industry's competitive advantages and strategies. Other uncontrollable factors (agricultural policy, trade regulations, supply and demand balances, regional differences in agronomy, etc.), which have the potential to have a significant impact on market price volatility for mineral fertilizer, have been studied previously (Dmitrieva *et al.*, 2017). Fertilizer sector turbulence has been found to be possible to set at the fourth (discontinuous) and occasionally the fifth (unpredictable) levels (Ansoff & Sullivan, 1993).

Analysis of the evolution and prospects of different segments in the fertilizer industry, as well as analysis of phosphate and potash resources and reserves (Cooper *et al.*, 2011; Mew,

2016), has emerged in recent years. A variety of management topics, including capital investment and the efficiency of top phosphate rock mining enterprises, have been examined in other articles (Mew *et al.*, 2018). Recent research in this field has highlighted the relevance of the fertilizer supply chain's foundations and views in several aspects. (Geissler *et al.*, 2019).

Research on COVID-19 and its impact on business has been done recently by Verma and Gustafsson (2020) as an issue that needs to be addressed. Some of them deal with broad economic issues and adapting to a new environment during and following the epidemic (Seetharaman, 2020). Some studies have looked into the ability of sectors to withstand economic downturns (Wang *et al.*, 2020). No studies have been identified that particularly examine fertilizer firms working under COVID-19 settings, despite the large number of scientific articles devoted to various areas of the mineral fertilizer industry's growth and to COVID-19. This demonstrates the study's relevance and timeliness. Traditionally, a competitive advantage has been defined as a characteristic that provides a firm with an edge over its competitors in terms of both profitability and return on invested capital. According to literature, a company's competitive edge is a trait that sets it apart from the competition and ensures that it continues to thrive and expand (Smith & Flanagan, 2006).

Globalization and intense business competition have made it more difficult to gain and maintain competitive advantages (Eisenhardt & Martin, 2000), as nearly all of them—resources, technologies, information, market opportunities, competencies, etc.—can be copied and replicated by competitors. As a result of D'Aveni and Sooducho-Pelc's research on the topic of building competitive advantages, two key methods for identifying the sources of competitive advantages have been identified: the market (competitive positioning) perspective and the resource-based view (RBV) (Wernerfelt, 1984; Peteraf, 1993; Barney, 2001). These methods have been studied in the context of developing long-term competitive advantages by Evans (2016) and Maury (2018). Many studies have attempted to show how the two viewpoints affect a company's performance at the same time.

Competitive advantages can be categorized based on how sustainable they are (sustainable vs. non-sustainable) (May & Stahl, 2017). According to this view, sustainability is a characteristic of an advantage that shows whether or not it can be copied by competitors. Academic arguments on the long-term viability of competitive advantages are common. It is not uncommon for researchers to focus on durable competitive advantages (Takala *et al.*,

2013). Sustainable competitive advantage is defined by some writers as "above-average long-term performance" (Porter, 1985).

Resources must have four characteristics to be classified as having sustainable competitive advantages in Barney's framework (1991). One cannot use replacements that are both uncommon and valued but neither scarce nor imitable as strategic alternatives (non-substitutable). According to this theory, a VRIO framework is used to categorize competitive advantages and identify the ones that are long-lasting. As a result of the examination, we can say that academics have done a good job studying competitive advantages and how they affect businesses' operations and long-term viability, as well as their capacity to compete in the marketplace.

The fertilizer sector has historically benefited from a number of other aspects, which we'd like to call your attention to. Cost reduction has long been regarded in scientific literature as the primary source of competitive advantages (Arovuori & Karikallio, 2009). In the past, mining corporations have sought competitive advantages by using their unique raw material holdings. Product diversification and the creation of distribution networks (Wilson *et al.*, 2015) or even supply chains have been cited as alternative sources of competitive advantages in this field by Geissler *et al.* (2015). Researchers discovered that fertilizer companies base their strategies on diversification of production and complex processing of mineral raw materials; increasing extraction levels of useful components; utilizing a wide range of feedstocks; and expanding the supply chain and infrastructure to minimize the negative effects of factors dependent on price fluctuations and boost competition (Ramanauskas *et al.*, 2014). Backward and forward integration of the supply chain can be achieved by mergers, acquisitions, and/or overseas investments. No research has been done on the importance of competitive advantages for fertilizer firms in light of the worldwide developments now taking place. An investigation of fertilizer firms' dependable operation during the COVID-19 pandemic, as well as their existing and new competitive advantages, as well as a new role played in the crisis and post-crisis period, is the goal of this article.

2.18 COVID-19 AND ITS IMPACTS ON AGRICULTURE SUPPLY CHAIN

COVID-19 has had a significant influence on all nations worldwide and has resulted in several disruptions to the global supply chain (Ivanov 2020; Choi 2020; Govindan *et al.*, 2020). Compared to the Great Depression of the 1930s, the current pandemic, COVID-19, has imposed an economic shock that is so severe that more than 170 nations would face negative per capita GDP growth (IMF 2020). When it comes to epidemics like SARS (severe acute respiratory syndrome), MERS (Middle East Respiratory Syndrome), and the Ebola outbreak of 2013, the world has seen many of them before. Each of these breakouts was a serious occurrence on its own. A pandemic that started in Wuhan and spread to the rest of the world has turned out to be one of the deadliest in our history. The WHO has received reports of 17,660,523 confirmed COVID-19 cases, including 680,894 fatalities, during the current epidemic (WHO 2020). Several analysts have already labeled this epidemic a catastrophic calamity that will have a significant negative impact on the world economy.

Agriculture supply chains in developing and third-world nations face enormous dangers post-COVID-19, as agriculture and agricultural imports are strongly reliant on these countries. On the demand and supply sides, the Food and Agriculture Organization (FAO 2020) says that COVID-19 is influencing ASCs. Because the supply and demand of food are interlinked, global food security is in jeopardy (Siche, 2020). In the early stages of the pandemic, governments throughout the world are relying on non-pharmaceutical measures such as social distancing rules and civic lockdowns to stop the virus from spreading. A major strike to the economy has been dealt by preventing people from going to work, meeting with one another, or socializing with each other (Barichello, 2020). Bans on international travel, border checks, and the export of food products have all been implemented. No part of the world will be spared as COVID-19 puts to the test the resiliency of global health systems, and there is no end date for the lockdowns and the resulting economic harm.

Because fisheries, meat products, and high-value crops are labor-intensive in agriculture supply chains, lockdowns have a negative impact on the labor market. They are having difficulty harvesting, processing, and selling agricultural products because of restrictions on the migration of migrant laborers. As a result of COVID-19, global food imports and exports have been significantly affected. Agricultural products, which account for a large portion of the fresh food chain, have also been hit hard by the current labor market conditions. As a

result of trade restrictions, reefer containers are clogging up major ports throughout the world. Consequently, goods are being redirected to smaller ports, costing logistics companies a significant amount of money (Hey, 2020). As a result, supply chain organizations globally are confronting a crisis in dealing with COVID-19 while having the most up-to-date technology tools at their disposal. In this uncertain circumstance, there is a need for supply-chain researchers and practitioners to get in-depth insights on the present impact of COVID-19 on ASCs. This component of COVID-19-caused hazards has been studied only in a few studies (Ker, 2020; Hobbs, 2020) and has concentrated on ASCs and the qualitative aspects of risk management but has not quantified the present implications for enterprises operating in ASCs.

Businesses worldwide have been affected by the COVID-19 epidemic (Choi, 2020). Global supply chains have been severely disrupted and destroyed due to this crisis, according to Ivanov (2020). As a consequence of COVID-19's influence on the agricultural sector, trade obstacles and export limitations have been imposed, which have significantly affected global agricultural business and the credit market. The developing markets' relative prices, asset prices, and energy costs have all fallen precipitously as a result of the COVID-19 issue. The growing costs of capital have a serious influence on the capital-intensive agriculture industries. The World Trade Organization (WTO) forecasts that the economy and trade will decrease between 13 and 32 percent in 2020, according to the most recent data. Figure 5 below shows the agricultural trade estimates for COVID-19 and the years following. Varying operating possibilities are indicated, such as hopeful (V shape, represented by a solid blue colored line), less optimistic (U shape, represented by a dotted blue colored line), and pessimistic (L shape, represented by a dotted orange colored line). Risk mitigation techniques for good ASC supply chain management must be proactive as global food supply chains become more sophisticated. Consequences of supply chain collaboration or failures might cause risks to occur in the system as a whole (Kleindorfer & Saad, 2005). As a result of COVID-19, Paulo Farias and dos Santos Gomes (2020) emphasize that the last links in the ASCs must be attentive in managing the food industry in order to prevent ASC contamination and the spread of the virus. Hobbs (2020) examined the potential supply-side (labor shortages, transportation interruptions) and demand-side (consumer panic purchasing behavior, changes in consumption patterns) hazards in the food supply chain during the COVID-19 pandemic. COVID-19 will face a number of threats to sustained agricultural

production, as outlined by Galanakis (2020). For example, Torero (2020) discusses how the ASC instabilities affect food safety. However, due to concerns about trust and transparency, Stephens *et al.*, (2020) state that lockdowns and community social distance have left little room for discovering appropriate domestic alternatives in the medium term. According to Hailu (2020), a dramatic drop in the demand for processed foods as a result of border closures and trade restrictions has caused supply and demand shocks in the food production industry. There are concerns raised by Brewin (2020) about the dangers that oilseed processors face as a result of possible labor shortages, which might lead to bottleneck situations between crushers and millers, which would then impair retail and distribution in ASCs. According to Stockford (2020), COVID-19's influence on storage and transportation would lead to higher procurement prices, which might delay the ASC. As per Kerr (2020), agricultural commerce and 'landowners' cash flows might be negatively affected by the current epidemic. When China's COVID-19 shutdown as well as the consequent decline in North American demand due to trade restrictions have produced a shortfall of cargo containers for the backhaul to Asia, Shih (2020) reports on the issue. For example, COVID-19-induced workforce concerns, limited container shipping movements, and legal bans on transportation services are all investigated in Gray (2020). A study by Haley *et al.*, (2020) examines the health and security problems experienced by migrant labor in ASCs and suggests methods to avoid them.

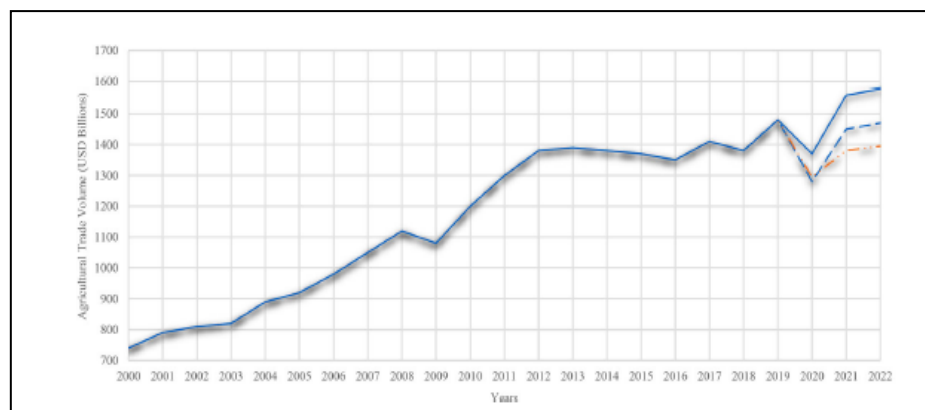


Figure 5. Impact of Covid-19 on global agriculture supply chain. Source: International journal of logistics: research and applications.

Table 3 below shows the sources of risks that could appear in agriculture supply chains and their impact according to the literature and as mentioned in the research on agriculture supply chain risks and covid-19 by Sharma, R. *et al.* (2020).

Table 3. Sources of risks in agriculture supply chain. Source: International Journal of Logistics Research and Applications

Major risk dimensions	Sources of risks	Impact of Risk on ASC Phase	Relevant Studies
Supply-side (S)	Supplier quality problems (S1)	Farming and Agri inputs	Meyer-Aurich and Karatay (2019); Joffre, Poortvliet, and Klerxx (2019)
	Payment default by supplier for the availed services (transportation, wages etc.) (S2)	Storage, Packaging, Distribution	Ker (2020)
	The underperformance of logistics providers (S3)	Storage, Distribution	Behzadi et al. (2017); Bloemhof et al. (2015)
	Supply shortages (S4)	Production and Harvest, Processing	Boyabatli, Nguyen, and Wang (2017); Shukla and Naim (2018)
Demand-side (D)	Uncertain & unanticipated demand (D1)	Distribution and Retail	Liu et al. (2018)
	Inadequate information on demand (D2)	Production and Harvest, Storage, Distribution and Retail	de Janvry and Sadoulet (2020)
	Changes in food safety requirements (D3)	Processing and Packaging	Ortega and Tschirley (2017)
	Transportation issues (D4)	Storage, Distribution	Gray (2020); Badraoui, Van der Vorst, and Boulaksil (2020);
Logistics and infrastructural (L&I)	Inadequate road infrastructure (L1)	Storage, Distribution	Gray (2020); Badraoui, Van der Vorst, and Boulaksil (2020);
	Increase in fuel costs (L2)	Processing, Production, and Harvest	Li et al. (2019)
	Lack of transportation infrastructure (L3)	Storage	Wesana et al. (2019)
	Conflicts, labour disputes, labour shortages (L4)	Production and Harvest, Processing, Packaging	Adelaja and George (2019)
Policy and regulatory (P&R)	Lack of infrastructure and service units (L5)	Storage, Processing	Lemaire and Limbourg (2019)
	Uncertain monetary, fiscal, tax policies (P1)	Farming and Agri inputs	Yazdani, Gonzalez, and Chatterjee (2019)
	Uncertain legal policies and enforcements (P2)	Farming and Agri inputs	Verdonk (2019)
	Uncertain trade and market policies (P3)	Storage	Mittenzwei et al. (2017)
Financial (F)	Uncertain land policies and tenurial systems (P4)	Farming and Agri inputs	Bellemare et al. (2020)
	Lack of financial support (F1)	Farming and Agri inputs, storage	Long, Blok, and Coninx (2016)
	Delays in accessing financial support (F2)	Farming and Agri inputs	Nyamah et al. (2017)
	Uncertain credit support (F3)	Farming and Agri inputs, processing	Makate et al. (2019)
Biological and environmental (B&E)	Uncertain interest and exchange rate policies (F4)	Farming and Agri inputs, packaging	Kamble, Gunasekaran, and Gawankar (2020)
	Pests, diseases, yield losses (B1)	Farming and Agri inputs	Savary et al. (2019)
	Contamination related to inadequate sanitisation and illnesses (B2)	Farming and Agri inputs, Processing, Packaging	Bozkurt et al. (2020)
	Contamination affecting food safety (B3)	Processing, Packaging	Hou et al. (2020); Gray (2020); Dani and Deep (2010)
Management and operational (M&O)	Degradation of processed food products (B4)	Processing, Packaging	Deng et al. (2020)
	Poor management decisions (M1)	Farming and Agri inputs, Production and Harvest, Storage, Processing, Packaging, Distribution, and Retail	Zhao et al. (2020); Xu and Long (2020)
	Poor quality control (M2)	Production and Harvest, Processing, Packaging, Storage	Ali et al. (2019)
	Planning and forecast errors (M3)	Distribution and Retail	Golmohammadi and Hassini (2019)
Weather-related (W)	Use of outdated inputs (M4)	Farming and Agri inputs, Processing, Packaging	Mangla et al. (2018b)
	Periodic deficit/ excess rainfall (W1)	Farming and Agri inputs	Michler et al. (2019)
	Extreme drought (W2)	Farming and Agri inputs	Dai et al. (2020)
	Flooding (W3)	Farming and Agri inputs, storage	Li et al. (2019)
Political (PO)	Extreme winds/ cyclone (W4)	Farming and Agri inputs	Roy et al. (2019)
	Political instability/ crisis (PO1)	Farming and Agri inputs	Komarek, De Pinto, and Smith (2020)
	Trade interruptions/ restrictions (PO2)	Storage, Distribution	Gray (2020); Ker (2020)
	Changes in the political environment (PO3)	Farming and Agri inputs	Thomson (2019)
	Legislation risks (PO4)	Farming and Agri inputs	Verdonk (2019)

3. CHAPTER THREE: SUPPLY CHAIN RISK MANAGEMENT AND IMPORTANT THEORIES

Numerous concepts have been conceptualized, leading to the formulation of various applicable theories. The aforementioned theories encompass agency theory, systems theory, resource-based view and dynamic capabilities, network perspective theory, and numerous others. The previous concepts are applicable across various segments of the supply chain and, in some cases, throughout the entire supply chain. Consequently, a comprehensive clarification of the relationship between supply chain management and these key theories is expounded upon in the subsequent sections.

3.1 DYNAMIC CAPABILITIES AND RESOURCE BASED VIEW IMPACT ON SUPPLY CHAIN MANAGEMENT

Investigating closely into supply chain management, we notice the massive role of resources and capabilities in maintaining resilience in the whole chain. Many scholars have based their research on this topic on the importance of resources-based view theory and the dynamic capabilities concept, as they emphasize the importance of the inimitable and valuable resources and capabilities of the business that will respond to and adapt to any change that can disrupt the business and re-allocate the resources and capabilities in a way to mitigate the risk and avoid any disruption, especially in times of crisis (Barney, 1999). Despite business limits, numerous scholars have used the idea of dynamic supply chain capacities to assess ways supply chain stakeholders deploy interoperations to build and/or adjust capacities in response to market trends (Aslam *et al.*, 2020). Resource-based views and dynamic capabilities provide a useful paradigm for investigating how businesses organize their resources and capabilities in response to supply chain threats (Fan & Stevenson, 2018; Chowdhury & Quaddus, 2017). Firms must restructure organizational resources and capabilities in this light (Eddleston *et al.*, 2008) to rapidly react to the effects experienced by disruptive hazards.

To meet rapidly evolving circumstances, DC organizations must be able to incorporate, create, and reconfigure internal and external competences. According to Augier & Teece (2009); Katkalo *et al.*, (2010), it represents a step forward in the resource-based view (RBV)

since it emphasizes creating value rather than simply acquiring it. There are several ways in which value may be created through such activities as product development, new business models, and new organizational structures and supply chain networks (Ambrosini & Bowman, 2009). Because of the DC's dynamic accumulation, replenishment, and transformation of resources into new skills, these activities may flourish during difficult periods when change is pervasive (Li *et al.*, 2009; Blome *et al.*, 2013). The three segments and sub-segments of a company's DCs are as follows: sensing the recognition and evaluation of risks and opportunities, seizing the deployment of resources to achieve competitive advantage, and transforming the ongoing regeneration of physical and intangible assets" (Bleady *et al.*, 2018).

Because SCA (Supply chain Agility) supports sensing and mobilizing resources to keep up with the changes, it may be thought of as a DC. SCA has been effectively used as a conceptual element for a better understanding of DC segments, and Chiang *et al.*, (2012); Gligor *et al.*, (2016) advocate that SCA fulfills the completion of the requirements in the microgrids. A connection between agility and DC theory may be drawn by none other than Teece, the man who developed DC theory. An unknown occurrence like the COVID-19 pandemic requires agility, Teece *et al.*, (2016) say; the DC framework is a viable paradigm from which to draw practical guidance. A viable option for furthering our understanding of SCA procedures during the COVID-19 issue may be found in DC theory.

According to Ponomarov (2012), businesses generate value by utilizing resources that are both valuable and scarce. These resources are then turned into capabilities, which may lead to favorable performance results. When faced with the unpredictability of a changing environment, a company's individual capabilities become more dynamic as a result. Figure 6 depicts a theoretical framework that is similar to the one shown in Figure 6.

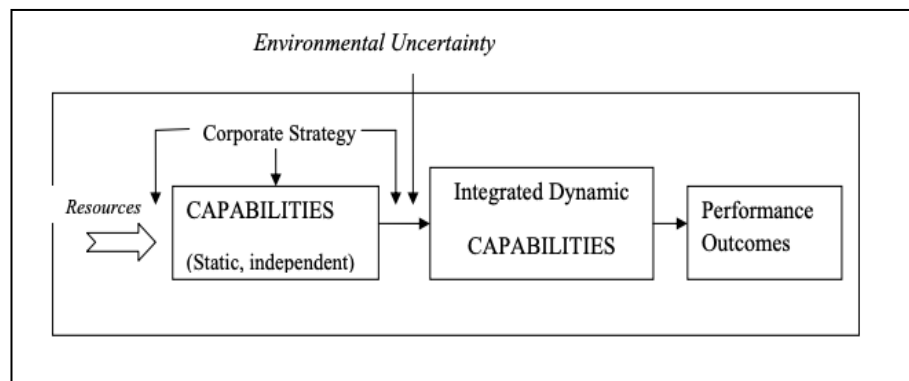


Figure 6 .Theoretical Framework for ability of dynamic capabilities in facing disruptions. Source: Antecedents and consequences of supply chain resilience: a dynamic capabilities perspective.

3.2 SYSTEMS THEORY AND SUPPLY CHAIN MANAGEMENT

Risks in the supply chain can harm a company's operations. Some of these risks may be created by issues within the firm, such as poor planning and coordination procedures in the supply chain, such as quality concerns with a supplier, or by external events, such as a natural disaster or terrorist attack. Natural catastrophes and economic development Product quality, operational and asset costs, delivery reliability and lead time, and manufacturing flexibility can all be affected by supply chain risks (Schonsleben, 2007). For the first time, supply chain risk management (SCRM) was included in the most recent edition of SCOR (Supply Chain Council 2008).

The increasing relevance of risk management drives the need for operations risk management. As a consequence, risk management efforts across the entire organization have increased, from integrated enterprise risk management to new areas like risk management in services. Supply chain risk management (SCRM) is a critical component of the new field of enterprise risk management (ERM) (Olson & Wu, 2008).

System thinking and system-oriented management are proven methods for dealing with complexity. Supply chain risk management (SCRM) solutions now used by corporations often lack a comprehensive understanding of the supply chain risk condition. A supply chain risk structure model and a supply chain risk dynamics model are used in the modeling process. For SCRM, the structure model is a system model that displays the main variables and their relationships to each other. The risk structure model's various states can be

represented using the dynamics model, a state machine; thus, it can help comprehend supply chain risk dynamics.

Supply chain risks are potential disruptions in inter-organizational logistics generated by process-inherent or external sources (Juttner *et al.*, 2003; Norrman & Jansson 2004). Globalization and lean supply chains have had a significant impact on the commercial success of various organizations in recent years. These trends have exposed companies to supply chain risks such as the failure of overseas suppliers, quality issues, or unanticipated variations in client demand.

As a logical consequence, SCRM research has been more robust in recent history (Zsidisin, 2003; Cigolini & Rossi, 2006; Peck, 2006). The existing literature largely involves problem descriptions and case studies from industrial incidents; however, few approaches to managing supply chain risks contain parts of system theory.

Cranfield University's approach to SCRM is particularly application-oriented and centered on the three processes of detection, evaluation, and mitigation (Cranfield University School of Management 2003a, Cranfield University School of Management 2003b). It is also based on the four layers of value stream, asset and infrastructure dependency, organization-wide network, and environment that Peck (2005) employs a system thinking approach. Risk analysis is thus based on this paradigm. After mapping the supply chain and gaining knowledge of the system, the technique highlights that supply chain risks can only be recognized and assessed after mapping the supply chain and gaining an understanding of the system. An additional approach to SCRM is shown by a case study conducted on Ericsson, the Swedish communications corporation (Norrman & Jansson 2004). Using system theory to analyze and quantify the impact of a supplier's failure on a corporation is implicit in this method. Supply network risk can be mapped, identified, assessed, and managed through a framework proposed by Harland *et al.*, (2003). To determine the likelihood of an event and the resulting financial impact, the system's supply chain must be represented using scenarios. According to Hallikas *et al.*, (2001), there is a mutual risk management process that takes place in addition to the risk management process for each particular organization. The inter-organizational system view is incorporated into the process.

Despite the fact that all of these approaches implicitly use system theory, they only target single supply chain issues and can therefore be seen as a first step towards system-oriented SCRM. Although systems thinking is an effective technique for managing complexity, it has not been explicitly applied to SCRM in the extant literature, with the exception of Peck (2005). Second, there are no comprehensive models of SCRM that take into account both the underlying causes and the changing nature of these hazards. The models are not shown to be incorporated into a risk management process framework or to be used realistically in SCRM, which is a third problem.

As part of supply chain risk management, new strategies for handling disruptions are being developed. To manage a company's portfolio of risks, SCRM developed from ERM, the paradigm (Gordon *et al.*, 2009). It is challenging to capture risk behavior that is multidimensional and interrelated. Through a multitude of techniques, locations, ownership changes, and transportation modes, raw materials are transformed into completed products in the process of reaching the final customer (Handfield & Ernest, 2002; Stecke & Kumar, 2009). These strategies help identify supply chain disruptions. Modern supply chain trends include globalization, decentralization, outsourcing, and just-in-time (JIT) manufacturing. Increased exposure points have resulted. Supply chain systems require a complete picture of the linked nodes in order to determine the locations of network failure points. Interdependent entities and processes make up the supply chain system's complexity. SCRM literature stresses system-oriented and holistic risk management in complex, unpredictable, and volatile global contexts (Tang & Musa, 2010). By taking systemic circumstances into account, systems thinking can provide a rigorous and structured approach to risk management. As a system of systems', supply chain systems must be viewed. In order to understand a system's dynamic, complex, and interdependent nature, one must use systems thinking (Sterman, 2000). Through idea generation, execution, and evaluation, this study examines supply chain risks.

For supply chain risk management to be effective, it is necessary to do empirical research. In the early days of SCRM research, qualitative research was applied to several empirical investigations and conceptual models. Several studies have used algorithm-based quantitative modeling to address supply chain network disruption concerns. In order to deal with large-scale, dynamic, and challenging optimization problems, modern evolutionary algorithms are used. Controlling supply chain interruptions has shown potential for real

decisions (Hult & Craighead, 2010), game theory (Xiao & Yang, 2008), and simulation (Wu & Olson, 2008; Kim *et al.*, 2006). Qualitative and quantitative research methods are employed by SCRM. Individual or dyadic risks are the subject of these studies. Modeling dynamic and complicated circumstances is made easier using the systems-oriented approach, adding to the already existing body of SCRM knowledge by devising a quantitative risk assessment approach that is both systematic and comprehensive.

When it comes to the supply side, supply chain risk management (SCRM) is an essential component of enterprise risk management (ERM). Managing supply chain risk is analogous to managing project and enterprise risk in that both have interconnected network nodes working towards a common goal. Kleindorfer and Saad (2005) claim that in the past, integrated ERM was used to address operational risk or disruption risk. ERM and SCRM principles are adhered to throughout the risk modeling process. Enterprise risk management is a strategy-setting process that aims to detect and manage potential threats to the business in order to ensure that defined goals are met (COSO, 2004). Even though risk management research has expanded into various fields, such as financial risk management, healthcare risk management, project risk management, supply chain risk management, and so on, little emphasis has been paid to aligning ERM and SCRM methods (Harland *et al.*, 2003; Handfield & McCormack, 2007).

Supply chain risks are well covered in SCRM literature, but actionable advice on how to deal with them in the short and long term is scarce as there is a lack of focus on supply chain risks. Experts recommend a systematic approach to risk management. Risk management in the supply chain, according to Colicchia and Strozzi (2012), must be dynamic. The first step in risk management is to identify the risks. According to a review of the literature on SCRM, supply chain problems can be addressed using both qualitative and quantitative research methods. Various strategies are employed, including conceptual, empirical, and case-study-based approaches. SCRM has recently been studied using mathematical modeling and simulation. Systems thinking and system dynamics can be used to thoroughly investigate supply chain risk. Complex and dynamic networks can benefit from risk modeling. Using dynamic models, researchers and practitioners can identify supply chain failure points and manage risks. A thorough examination of the supply chain is necessary to identify and mitigate risks.

Managing risk is becoming an increasingly important part of supply chain management (SCM). Systemic interrelationships drive the traditional risk management method used to identify and reduce risks throughout the supply chain. An organization's risk management process (SCRM) includes all of these steps (Hallikas *et al.*, 2004). The SCRM literature is full of references to risk classification and identification. An organization's vulnerability to risks is assessed, and risk mitigation techniques are devised as part of the risk assessment process. One of the most fundamental functions of risk management is to assess the risks. Chaudhuri *et al.*, (2013) recommend addressing supply chain risks during product development because of supply chain uncertainty. Supply chain risk analysis has been the subject of numerous interdisciplinary studies. An analytical hierarchy is used to model supply chain risk assessment by Wang *et al.*, (2012). Multi-stage influence diagrams, Monte Carlo approaches, interpretive structural modeling, and partial least squares methods have been used by academics to test supply chain risk assessment models. Operations and economic restrictions, however, limit the ability to identify risk in supply chains (Pai *et al.*, 2003). In order to effectively mitigate risk, a well-known global consultancy says that risk assessment in industry should be based on past experience and forward-looking analysis (Price Waterhouse Coopers, 2008).

To understand systems thinking, one must have the ability to comprehend all aspects of the world in terms of their interconnectedness. Systems thinking is used to conceptualize and understand system interactions. According to Sterman (2000), learning about a complex system might be difficult. A "method to promote learning in complicated systems" is called "system dynamics" System conceptualization necessitates systems thinking from the first idea to the final decommissioning of the system; systems thinking provides a clear path to success (Forrester 1994). Data from both qualitative and quantitative sources can be used in system conceptualization and modeling (Luna-Reyes & Anderson, 2003).

Quantitative supply chain risk modeling, systematic research design methodology, and a holistic risk management framework all capture hazards' total behavioral performance (Ghadge *et al.*, 2013). For risk management, SCRM provides a methodical methodology. Using data from the past, the method forecasts how future dangers will expand. Practitioners can better understand supply chain disruptions when they take a holistic approach to risk management. A single risk variable can be tracked over time using the framework, or many

risk variables can be accounted for. Risk management concepts, methods, and designs can be improved through research. The dynamic character of risk behavior is captured by systems thinking.

3.3. ORGANIZATIONAL LEARNING

Supply chain success criteria are the primary focus of operations management. Using "strategic" assets and abilities may help organizations improve their performance, according to the RBV by Wernerfelt (1984). Strategic resources are limited, valuable, and difficult to copy (Barney, 1991). In strategic management and marketing, it is suggested that firms with certain resources can gain and maintain a competitive advantage over their competitors. Although supply management specialists appreciate the relevance of resources, the usefulness of strategic resources is unknown.

Hult et al. (2003) investigate the strategic resource of supply management learning in organizations. When new information is learned, it has the potential to change one's behavior. An entity is said to have learned if its information processing has affected its future actions. Huber (1991) advocated that supply management procedures are complex and dynamic; therefore, learning can lead to competitive advantages. In this sense, education might be seen as a focus on supply chain management. Poor supply chain management may limit a business's capacity to offer external customers real value. Supply management relies heavily on learning as an intangible resource. There are four "orientations" to learning: team, systems, learning, and memory. These four "orientations" combine to form the composite phenomenon we call learning. Learning, as a strategic resource, can also have an impact on supply management success.

It is possible that supply management players (internal SBU customers, corporate buyers, and external suppliers) have a natural predisposition to develop new, behavior-enhancing knowledge because of a strategic resource (learning) that represents this proclivity. Since its inception in the 1950s, the RBV has undergone numerous revisions. According to Wernerfelt (1984), an organization's rivalry and performance are dependent on strategic resources. These strategic resources are crucial. It's hard to replicate or replace strategic assets like patents and high-quality reputations. Many studies have looked at organizational capabilities as well as organizational assets, the re-deployment of brands, and sales forces. Due to supply

management's multifaceted character, organization-centric resources might not be necessary. Despite the fact that supply management members do not share a common corporate affiliation, learning may serve as a bonding component to help them succeed (Das & Teng, 2000). Organizational learning can help supply management. Strategic resources have three characteristics that Barney (1991) discusses: Customer-valued outputs are the first requirement for any resource. Especially in supply management, learning tends to overcome this barrier to progress. As Meyer (1993) points out, fast cycle times require a paradigm of learning that emphasizes the importance of a learning-focused approach. Supply management relies on learning as a source of information and behavior that is geared toward satisfying internal and external customers. There should be no close substitutes for a critical resource. Learning is both a process and a structure that must be followed in order to succeed (Slater & Narver, 1994). In order to change one's behavior, one must acquire new knowledge. The ability of the organization to integrate new wisdom is a structural component of learning (Garvin, 1993). The most successful supply management businesses are those that constantly learn and adapt (Hurley & Hult, 1998). Not many businesses can meet both of these requirements (Slater & Narver, 1995). Learnability is critical to supply management success. It should be difficult to get or replicate a critical resource. This third condition appears to be met through learning. In the wake of previous experiences, organizations alter their conduct. Other organizations can see the actions that occur, but they cannot see the unique history that underlies learning. Learning appears to be a necessary part of life. It's impossible to transfer or buy learning because it's ingrained in the company's DNA.

The supply management process dictates the selection of first-order learning indicators (Crossan et al., 1999; Easterby-Smith, 1997). There are four "orientations" of learning that arise from Hult et al., (2000) supply management studies. Practical learning markers include an emphasis on collaboration, systems thinking, and retaining information. It's a supply management member's responsibility to focus on cross-functional collaboration and shared vision, systems orientation, the value of learning in supply management, and knowledge distribution among all of its members in order to maximize the value of learning in the supply management process (memory orientation).

Defined:

- Team orientation is the degree to which the main supply management unit emphasizes collaboration and cooperation in supply management activities and decisions.
- Systems orientation is the degree to which the supply management unit emphasizes interconnectivity and mutual dependency.
- Memory orientation is the degree to which members of the focused supply management unit stress the diffusion and maintenance of supply management information. Team, systems, learning, and memory aren't strategic resources in and of themselves, but they do help amplify the impact of the ones that already exist. Developing a "learning" strategic resource in this research requires these aspects, but they are not adequate. A comprehensive learning theory, according to Easterby-Smith (1997), is an impossibility. Instead, create a discipline-specific learning framework. In this case, there are four categories. Learning outcomes (acquisition, dissemination, interpretation, and storage of information) predicted by Huber (1991) should be affected by cultural learning. It would be a blunder to assume that organizational learning is merely the sum of individual member learning. Organizations, not brains, possess cognitive and memory processes.

Organizations grow and change in the same way that individuals do. The collective memory of an organization serves as a repository for past practices, mental maps, traditions, and beliefs. Learning has an impact on relationship commitment and client orientation. In a supply management system, the involvement of multiple people in the learning process increases dedication to the relationships and knowledge of (internal and external) customers, resulting in an increased focus on the client. Cycle duration and total performance are affected by learning. Supply management performance is typically measured in terms of cycle time and the impact supply management operations have on an organization's overall functioning.

3.4 AGENCY THEORY AND SUPPLY CHAIN MANAGEMENT

Although agency theory has been widely employed throughout the previous four decades in a variety of disciplines, little research has been done on how agency theory might be used to explain relationships between organizations within the supply chain (SC). When one party (the principal) delegated control and decision-making over specific duties to another party (the agent), the principle of agency came into play (Eisenhardt, 1989). The grasp of how agency theory informs economic relations has been greatly enhanced by seminal contributions from scholars like Ross, Mitnick, Jensen and Meckling, and Eisenhardt, among others. Several academics have used the notion of agency to explain relationships in several fields, including economics and finance, information technology, and management. SCM experts are increasingly interested in applying agency theory to understand how supply chain players manage risks, align incentives, and form connections, such as Ritchie *et al.*, (2008). Even though Stock's (1997) approach to the use of agency theory in logistics may be traced back to the 1960s and 1970s (Eisenhardt, 1989), However, its roots may be traced back to studies on economic risk analysis, where it began by addressing a prevalent problem in organizations: satisfaction of personal dissonance and its impact on risk-sharing behavior. An example of this can be seen in a theoretical framework's acknowledgment of the requirement to manage a wide range of difficulties under unpredictable circumstances. Modern agency theory is based on the work of Mitnick and Ross (1973) and incorporates political science and economics, expanding its application beyond simple contract relations. Many other fields, including sociology, management, and the theory of business, adopted and employed agency theory after Mitnick and Ross.

Work is delegated in agency relationships when one party (the principal) hands over the reins to another party (the agent). When an agent acts for the principal, he or she acts as the principal's representative or employee. While the profit maximization approach and self-interest survive, the focus of agency theory centers on creating the most efficient contract governing the principal-agent relationship. The contract is used as a metaphor to represent agency interactions (Jensen and Meckling, 1976), and it is designed based on the agent's outcome or behavior. In agency relationships, the principle tries to minimize costs by specifying, rewarding, monitoring, and policing the agent's behavior, while the agent tries to maximize benefits and reduce principal control (Fleisher, 1991). It is essential for any

principal-agent interaction to effectively manage agency challenges such as information acquisition (or communication), preference mismatch (or conflict of interest), effort (or moral hazard), and capability (or adverse selection).

Agency theory advances are essentially focused on two important lines of inquiry: principal-agent research and positivist agency theory. It has typically been assumed that the principal and the agent will try to maximize their positions by interpreting the contract in their own way, as discussed above in this section on agency theory. Much of the advancement in principal-agent research can be attributed to the work of economists, who employed self-interest, bounded rationality, and agent risk aversion as the primary criteria for mathematically modeling relationship formation.

To address many of the problems in principal-agent research, the Positivist Agency Theory (PAT) has evolved (Eisenhardt, 1989). As a result, PAT strives to integrate political science, expert agency, the law of agency, and sociology into a unified framework that conceptualizes how business and government relationships evolve and recommends a course of action as to how they may be properly performed. Shapiro (2005). PAT also explains how to avoid challenges related to the separation of control from ownership (Halldorsson & Skjott-Larsen, 2006). PAT can explain non-rational agent (and principal) behavior, such as an expert agent's reluctance to disclose important information to its principal due to a lack of confidence in SC connections. partly motivated by these works, they have only partially helped us grasp SC connections.

The importance of organizational theory in explaining, describing, and forecasting complex organizational behaviors has been recognized by many researchers in the field of SCM. In addition, these academics have been crucial in exposing the literature's strong bias toward transaction-cost economics (TCE) (Burgess *et al.*, 2006). TCE contends that the price of a product or service should include all costs that are not explicitly stated (Williamson, 1981). A buyer and supplier's relationship may have hidden expenses, such as time spent creating the relationship, the drafting of contracts by a lawyer, or travel between multiple sites. Reduce transaction exposure through accounting for all organizational expenses (including transaction and production costs), which is the explicit goal of TCE. Alternatively, SC ties are often intangible, and TCE does not adequately explain social, political, legal, and behavioral dynamics in the context of these relationships. In the context

of a make-or-buy decision, TCE only considers the cost of the various trade-offs, which mostly implies tangibility.

Since TCE involves assumptions about how connections are constructed and what forms of leverage occur, it is fundamentally flawed. According to literature, TCE fails to take into account two important factors: contractual obligations and the way transaction costs are diffused in the SC. The second issue is related to SC control and, more specifically, to the frequency with which smaller players are able to have significant influence by manipulating the structure of SCs. Second-tier agents can readily control time, quality, risk, and flexibility in some of the most valuable supply chains (Ketchen & Hult, 2007a). Agency theory may be able to alleviate some of the inadequacies of TCE when it comes to understanding the dynamics of the SC connection. They argue that transaction cost dilemmas, where rational and non-rational behavior happen, may be explained by agency theory, which gives a framework for analyzing how individuals (individually and collectively) in SC behave in these situations. In addition, agency theory can help managers understand SC behavior by focusing on the following issues: the development of inter- and intra-organizational relationships; the maintenance of complex relationships between suppliers and customers (e.g., vendors and third-party logistics providers); the dynamics of risk sharing, capital outlay, power, and conflict between channel intermediaries; and identifying the costs and benefits.

There have been claims outside of SCM research that the combined use of TCE and agency theory can be more promising (Williamson, 1981). However, there have also been questions raised about accepting them as complementary theories. The reasonable and irrational responses of actors in the SC to transaction cost dilemmas can be explained by agency theory, which can be applied to individuals as well as groups within the SC. As a result, network partners' anomalous behaviors can be analyzed, and counterbalancing therapies can be developed. Because of this, a trusting climate may be maintained in commercial interactions. In addition, it is a priceless tool for managers who are continually dealing with complicated organizational behaviors inside their SC (such as re-engineering their supplier/customer relationships) to either increase or decrease their tolerance threshold.

Outbound and incoming procedures and techniques like vendor-managed inventory (VMI), just-in-time (JIT), collaborative planning, forecasting, and restocking (CPFR), ERP,

and efficient consumer response can all benefit from the findings of this paper (ECR). Using any of these methods necessitates a great deal of work and power delegation among the principals and agents involved in the SC. Agent-specific criteria can be met through dynamic contractual relationships, ensuring the successful implementation of SC procedures and activities. By adapting their contract decision-making to include social, economic, and political factors, managers might use the idea of agency to help them make more informed decisions about incentivization, information sharing, and goal congruence. When examining the above-mentioned practices from the perspective of SC relationships, researchers could make use of agency theory.

Collaborative management of supply chains can be viewed as the integration of multiple principals and agents based on information exchange, goal congruence, and incentive alignment, according to a study by Fayezi *et al.*, (2012) on the relationship between agency theory and supply chain management. Goal conflict and information asymmetry can be manipulated to create beneficial outcomes through successful collaboration in future research. To sum it up, the theory of agency can explain how participants in the SC deal with transaction cost issues when rational and non-rational behavior coexist.

3.5 TECHNOLOGY AND SUPPLY CHAIN MANAGEMENT

The term "supply chain technology" refers to any digital applications that aid in the management and efficient operation of the supply chain. Each link in the supply chain may benefit from the vast volumes of data collected by supply chain technology in order to fine-tune their operations, introduce novel procedures, increase their efficiency, or prepare for the future.

There is a vast array of supply chain technologies in use today, each with its own level of sophistication and potential impact. Supply chain technologies range from the very simple to the extremely complex, with the former including things like artificial intelligence and robots to facilitate immediate data entry and communication. While the latter are undeniably more impressive, every piece of technology in the supply chain serves an important function and should not be taken for granted. Technology can help improve waste management and inventory management, provide full automation to supply chain procedures, and improve customer support responsiveness.

3.5.1 Information technology and Supply chain management

Inaccuracies and inefficiencies in the information flow plagued supply chain networks. To keep up with the demands of globalization, businesses have had to reassess how they interact, integrate technology, broaden the scope of their commercial transactions, and use IT applications to improve their supply chain procedures. This concept of supply chain management (SCM) dates back to the early 1950s and includes everything a business does, including procuring raw materials and delivering products to customers (Silver *et al.*, 1998). Because of the increasing complexity of data, supply networks are becoming increasingly vulnerable to uncertainty risk" (Hillman & Keltz, 2007). Integrating supply chains is fundamental to the goals of supply chain management. With the help of IT-enhanced supply chain management, critical business processes, items, and money may be tracked and controlled in and out of networked environments (Stroeken, 2000; Mabert *et al.*, 2001; Sanders & Premus, 2002). There have been numerous studies on the relationship between IT and SCM, including ways to improve communications by increasing interactivity between businesses and their customers, reducing the "Bullwhip effect" in supply chains, and developing new business models, processes, and methods for disseminating data. The ability to make informed decisions across the whole supply chain based on complete data (Simchi-Levi *et al.*, 2003) It is impossible to run a successful business without IT systems, e-commerce apps, and inter-organizational systems. CPFR, inter-organizational information systems, online ordering, supply chain management, and information technology (Van Donk, 2008), supply chain coordination and integration, spreadsheet-based vendors, and the role of IT in supply chain management are some of the topics covered in this article. Successful supply chains rely on reliable, well-integrated data systems that connect all parts of the organization.

In order for clients to get the final product and service packages they need from suppliers, they must manage a chain of interconnected enterprises. In the context of supply chain management. To achieve the goal of seamless integration and coordination, supply chain networks can share information with each other so that drivers can operate together. Supply chains can improve operational efficiency and reduce risk by giving information to decision-makers as and when they need it. This includes both hardware and software in the context of information technology. Because of this, IT is critical to ensuring that product quantity and quality meet customer demand by integrating suppliers, manufacturers, distributors, and

retailers. IT An important benefit of SCM is the capacity of a company's supply chain to react quickly to market changes and obtain critical information (Tummala & Schoenherr, 2008). IT in supply chain management (SCM) serves as a single point of contact for data, decision-making based on supply chain data, and coordination with other organizations. Decision support, collaboration, and transaction execution are all functions of IT in SCM (Auramo *et al.*, 2005). Suppliers should anticipate profiting from standardizing business processes and improving data accuracy, availability, visibility, and processing capabilities, which will allow them to communicate with other supply chain partners outside of the network and increase collaborations. In addition to "computer-assisted" forms of crime like hacking and phishing and "computer-focused" forms like hate crimes and telemarketing and internet fraud, there has been an increase in cybercrime as a result of the use of technology in the supply chain.

Cybercrime and digital crime are only a few of the many names used to describe crimes committed through the use of computers. As a result, IT in supply chain management is deemed essential (Davenport & Brooks, 2004). Supply chain management and reducing electronic hazards rely heavily on IT (SCM). Information technology (IT) is a critical component of today's successful businesses committed through the use of computers. As a result, IT in supply chain management is deemed essential (Davenport & Brooks, 2004). While efficiency is preserved, the supply chain's resiliency and robustness are improved. Supply chain management (SCM) is becoming increasingly popular as a technique for enhancing a company's competitiveness in global markets (Bayraktar *et al.*, 2009). Advances in information technology and scientific management have made it possible for a growing number of companies to obtain, distribute, and utilize data more affordably. Improved supply chain integration and adaptability can be achieved through the use of IT. Supply chain stakeholders are focusing on IT collaboration in order to increase supply chain transparency and efficiency, according to Zhou (2009). Integrated information systems and enabling technology have made it possible to seamlessly integrate supply chains, eliminating issues such as subpar supplier performance, shifting consumer expectations, and fluctuating business conditions. There are still significant barriers to investing in new IT throughout the supply chain, despite the fact that such coordinated efforts can create differentiated value that a single firm cannot do alone (Dutta *et al.*, 2007).

According to recent studies, using information technology in business is beneficial. Increased productivity can be achieved by allowing for the open exchange of information. The return on investment in information systems is still unclear. The synergistic impacts of IT with other organizational elements, including firm strategy, mass customization, and supply chain management, are considered to be overlooked by IT value studies. Information software is not a stand-alone business due to its dependence on other firm assets (Andersen *et al.*, 2001). There is a significant amount of ambiguity due to the important traits of autonomy, social ability, reactivity, and pre-activity that technologies possess". Incorporating IT into SC's operations is regarded as having increased the company's ability to create value. With the influence it has on the SC's expenses, quality, delivery, and flexibility, IT also impacts the SC's bottom line. It is becoming increasingly common in the IT sector to find a direct correlation between the use of IT in supply chain management (SCM) and the reduction of costs and cycle times. The industry's clock speed has a significant impact on the relationship between IT use and supplier network performance. Research by Narasimhan and Kim (2001) reveals that some types of IT systems, such as those that help firms improve production processes while also controlling costs and keeping track of stock levels in warehouses and other storage places, are more suitable for SCM.

SCM researchers (Sarpola *et al.*, 2005) examined the role of transaction processing, supply chain planning, order monitoring, and delivery coordination using IT in three different ways. It was found that all three groups used IT in SCM. To further analyze these varied IT usage types, we looked into the reasons for their existence. According to the research, the three primary tasks of information technology in supply chain management were motivated by a variety of factors. IT's transaction processing role in SCM is driven by elements such as human labor and costs, information quality, information transmission speed, and transaction volume. It was also thought that the long-term viability of the company partnership was a critical feature in the application of information technology. Cross-organizational procedures such as VMI were found to be the driving force behind IT in supply chain planning and coordination. The focus on business projects and the consolidation of in-transit resources were found to drive order tracking and delivery coordination.

3.5.2 Blockchain and Supply Chain Risk Management

It is becoming increasingly necessary for SCM to use cutting-edge digital innovation tools like blockchain technology in terms of cost, quality, speed, dependability, risk reduction, long-term sustainability, and flexibility. Blockchain technology is predicted to increase performance, as advocated by Kshetri, (2018). When it comes to supply chain management, blockchain technology is most commonly viewed as a tool that gives supply chain managers more control over how their supply chains are run. For many organizations, early adoption costs are the most important consideration, but they often overlook other aspects, such as how to implement blockchain technology in an efficient and effective manner. The risk of integrating digital technology into supply chain management (SCM) should be examined because digital technology impacts SCM and SCM is affected by disruption threats.

According to Akram, *et al.*, (2020), a reduction in supply chain risk is achieved by implementing blockchain technology. A study published by Zheng, K., *et al.*, (2021) indicated that technological resources have often been the main reasons for not integrating blockchain technology yet in the spaceship supply chain. In addition to technical concerns, the implementation of blockchain technology poses larger obstacles to the food supply chain in terms of costs and privacy hazards (Kumar, A., *et al.*, 2020).

Recent research has focused on the positive aspects of blockchain technology but has not paid much attention to the "dark stories" of applying blockchain technology in supply chain management (SCM). In order to choose tactics that are appropriate for the organization's capacity and resources, the supply chain participants must understand the risk beforehand. Consequently, integrative research is relevant to solving problems and confronting new ones. When it comes to a difficult topic, an integrated literature review pointed out the need to recognize the issues surrounding it (Webster & Watson, 2002). It is possible to justify authors' assertions about the need to address a problem by conducting an integrative review, allowing for the identification of the gap and the development of future research.

Traditional supply chain challenges may be solved by using blockchain technology in supply chain management (SCM). In spite of this, the benefits of using blockchain in the supply chain outweigh the risks. The implementation of blockchain in SCM comes with

unknown hazards, despite its potential to change stakeholder management in the digital era. In order for supply chain actors to determine the risk that is closest to their organization's nature, it is critical to comprehend the hype around blockchain technology and recognize the possible risk.

Several studies have raised concerns about the poor results of using blockchain technology (Kumar, A. *et al.*, 2020; Yoon, J. *et al.*, 2020). Risks are scattered and difficult to identify; they're often stated in a more indirect manner. Risk can have a distinct connotation depending on the context in which it is used. A risk is described as an unexpected incident that cannot be controlled or anticipated even though the events are known in advance by Mills, (2001). On the other hand, Risk can be defined as an unanticipated event that may occur throughout the course of the operation. There is a risk of making a decision that has disappointing outcomes. Unexpected macro- or micro-level situations in the supply chain can lead to operational, tactical, or strategic-level failures or abnormalities, which are all forms of risk.

In the words of Zheng *et al.*, (2021); Sahebi *et al.*, (2020); and Zhou *et al.*, (2020), the major risks in implementing blockchain technology in SCM are based primarily on the technological development that is characterized by high implementation costs and technological interference, threats to traditional jobs, and legal uncertainties. SCM blockchain implementation comes with a number of possible risks, all of which are part of the "price" the company may have to pay for using the technology.

A study by Rasi, *et al.*, (2022) on blockchain technology and risk in supply chain management reviewed the literature and identified seven risk categories for applying blockchain technology in SCM. Categorizing the risk helps supply chain actors recognize the most frequent risk indicated by the previous researcher that will impede blockchain implementation and enable the organization to remedy the risk within its capacity. Risks include financial, security, privacy, technological, regulatory, fraud, and operational.

According to Bag *et al.*, (2020), the financial risk is any cost associated with adopting, maintaining, and transacting the technology. Every organization will maximize output while reducing expenditures. Blockchain technology gives organizations many benefits. However, integrating blockchain into the supply chain has considerable financial concerns. Every

company values financial performance. Blockchain's uncertain succession poses a risk to the company, based on Reda, M. *et al.*, (2020). Financial risk threatens a business with technological upheavals and market volatility. Technological developments push the organization to adjust, though. Implementing blockchain may require technical and specialized knowledge, as indicated by Wang, Y., *et al.*, (2019). Financial risk affects implementation and maintenance. In the implementation stages, supply chain members must have significant financial resources to embrace blockchain technology and processes, establish a new infrastructure, and engage skilled staff to operate blockchain technology. During maintenance, supply chain players must control operation costs, increase income, and upskill the existing workforce to retain employees. Early blockchain implementation is risky. At this point, expensive infrastructure and systems must be built. The maintenance stage incurs fees a few times a year to ensure system efficiency. If a corporation lacks internal experts, it hires outsiders. If the corporation wants its own experts, some staff will be sent through expensive and time-consuming training.

Security concerns affect supply chain participants' efforts to control hazards. Supply chain actors must strengthen structural privacy against cyberattacks. Incapable digital technologies may impair product distribution, prompting supply chain operators to invest in blockchain technology that solves SCM difficulties. New technology will reduce security risks in the long term. Therefore, supply chain actors must invest in the most relevant blockchain technology. Supply chain efficiency requires other parties to use blockchain technology. Manufacturers, distributors, and retailers must use blockchain technology to synchronize supply, assembly, and maintenance.

Sharing data with participants poses privacy risks. Information leakage, authentication difficulties, and accessibility difficulties posed a privacy risk. When a company needs to select what information and knowledge to protect from openness, blockchain information leaks occur. In the supply chain environment, the actors' main concern is establishing a complicated system to preserve vital information among partners (Kembro, J. *et al.*, 2014). Privacy risk can affect data protection and transactions—the failure to protect private data yields the benefits of blockchain technology in SCM. Digital systems can't edit data, so removing private or superfluous information is difficult. Unethical supply chain members could access private information to damage supply chain networks.

Technology risk will affect supply chain operations in two instances. First, skill demand. For example, operation management demands blockchain-savvy technical staff. Skilled workers are few. Blockchain's intricacy requires skilled professionals. Failure to hire skilled workers will hinder blockchain implementation. Even though the company has the means to use blockchain in SCM, the lack of a skilled technical team would reduce efficiency. Blockchain technology isn't standalone. Blockchain implementation requires human intelligence. Second, supply chain members' unwillingness to use blockchain technology increases technological risk. Digital technology will replace SCM soon. The supply chain participants' unwillingness to adopt blockchain technology early on will increase technological risk afterwards. Rasi, R.Z. *et al.*, (2022). Regulatory risks in blockchain technology will harm the country's supply chain members. The use of blockchain technology will modify rules, upsetting product logistics and delivery. A change in regulations leaves supply chain participants with only the local country's regulatory compliance. A supply chain combines logistics, vendor management, and procurement.

Smart contracts in blockchain-based SCM are likely to impact the supply chain the most. Smart contracts raise fraud risks for SCM actors. Public information in supply chain networks allows hackers to access private information, such as digital identities, allowing them to make bogus contracts and transactions. Hackers may make a contract using another person's identity. The digital identity owner may face reputational concerns, and supply chain actors like the manufacturer and wholesaler will lose money. Unable to recognize a hacked system, it will hurt innocent parties, probably wholesalers or merchants. Fraud requires legal intervention. Innocent people must confirm that digital identity isn't allowed, creating worries about how they might protect themselves. The contractual fraud risk will also affect wholesalers. If innocent people weren't involved in the bogus transaction, the wholesaler may have to pay them. Hackers' fraud risk affects all supply chain members. To successfully deploy blockchain technology in SCM, supply chain actors must increase data privacy and security. Hiring blockchain experts and training the workforce to spot fraud smart contract red flags can help supply chain participants reduce fraud risk.

Supply chain players' failure to resolve concerns internally typically causes operational risk. Lack of management vision is one hurdle to blockchain implementation in green SCM, according to a study by Bag, *et al.*, (2020). The organization must have a clear vision for blockchain technology and convince supply chain members to invest. Supply chain

members' fear of blockchain's operational hazards is propelling its introduction. Another recent study using blockchain technology in markdown sponsor contracts indicated little profit for manufacturers. Implementation expenses increase the likelihood of manufacturer and merchant losses. Another study by Nguyen *et al.*, (2020) on blockchain integration in container shipping found interesting results. The usage of blockchain technology exposes supply chain members to operational risks from bogus ledger transactions, fraudulent smart contracts from stolen digital certificates, and cargo degradation owing to hardware failures in delivering perishable commodities in real-time.

Adopting blockchain technology in SCM is risky for three main reasons: inability to manage internal difficulties, lack of management vision, and supply chain member anxiety. First, internal difficulties like insufficient resources to operate in the digital environment would hinder the organization's plans to use blockchain technology. Suppose supply chain actors don't invest in relevant technological systems or digitally savvy workers. Then, the operations can't be run on the blockchain. Missing technology or resources will hinder deployment. Second, the absence of management vision to embrace blockchain early won't help supply chain operators stay relevant. The organization's failure to operate digitally early on will pose issues later on, given that a competitor has already embraced blockchain technology. Fear of blockchain technology among supply chain members also hinders SCM blockchain adoption. The supply chain participants' hesitation generally stems from the high cost of implementing blockchain technology. Supply chain participants' unwillingness to use blockchain will disrupt operational efficiencies and increase revenues. To remain competitive, supply chain players must build a negotiated partnership and mutual agreement with supply chain participants on cost-sharing and benefits

4. CHAPTER FOUR: THE IMPORTANCE OF POTASH

Potash, pronounced pot-ash, is the common name for potassium-containing salts employed as fertilizer. Potash enhances plant water retention, boosts agricultural yields, and modifies the sensory and nutritional profiles of several plant species. The agricultural industry is the largest consumer of potash. Potash is also used in a wide variety of other applications, such as in the manufacturing of industrial chemicals, animal food, soap, food, water softening, road de-icing, pH correction, explosives, medicines, and glass. Since potash is so crucial to agriculture, any problems with its distribution would have far-reaching effects on the food supply.

4.1 POTASH EARLY HISTORY

It was first used to describe the vaporized byproduct of leaching wood chips in water, and the word "potash" was coined. When the ash evaporated, it left behind "pot ashes," which were potassium-rich and were employed as plant fertilizer. Samuel Hopkins was given his first patent in the United States in 1790 for potash-making equipment and methods (Paynter & Bolland, 1990). Germany was the primary source of potash fertilizer for the United States in the early 1900s. The U.S. Congress approved the U.S. Department of Agriculture (USDA) in the early 1900s due to a potash scarcity and dependency on foreign potash imports (Turrentine & Shoaff, 1919). It was decided by Congress in 1916 that the USDA would be given more freedom to conduct studies on commercial potash production technologies. In 1917, an experimental facility was built in Santa Barbara, California, that was capable of processing 90.72 metric tons of raw kelp per day. It soon became clear that wood chips and kelp could not supply the demand for fertilizer, and massive geologic sources of potash eventually replaced them as the primary source of potash for US potash producers.

Prior to the Common Era, the Middle East and China used salt lakes to mine and use halite, while ancient (Permian) sylvite was first found and produced in Germany 200 years ago due to the significance of salt resources for human survival and development in ancient and contemporary times. Since Usiglio (1849) first made his comprehensive salt analysis series from Kara-Bugaz saltwater evaporation, salt science has been progressing for at least 169 years. In 1877, Ochsenius came up with the "sandbank idea" for salt and potash deposits

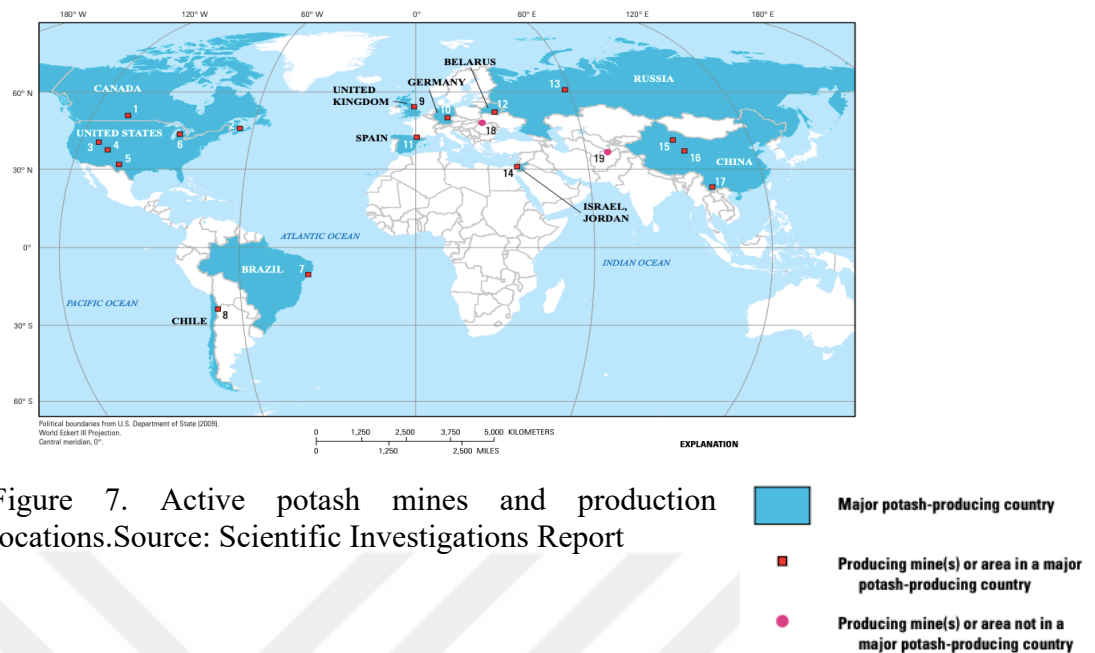
in the ocean. When considerable volumes of evaporated materials, like halite, are involved, saltwater is required. This has been generally accepted and dominated academics for more than a century. According to Walther, (1894), the "desert theory" did not recognize seawater replenishment; however, the "preparation basin-dry salt-lake" potash deposits thesis, "bull-eyes type," "tears type," and so on, have been incorporated into potash theoretical models during the 1960s–80s, as well as that in the Mediterranean, for example. The dispersal of potash deposits, as well as salt-lake brine containing potash that has been discovered on six continents, is now unbalanced and inconsistent (Cocker *et al.*, 2016). Major marine craton salt basins of the Cambrian to Tertiary eras are the primary source of world potash supplies. Many different blocks and orogenic belts make up the salt basins of China, each having its own unique characteristics that may be compared to those of other basins. Large continental and marine salt basins were formed as a result of the Cenozoic plateau collision mineralization during the late cratonization period of salt basins in China, and much of this is "para platform" in nature, formed by large intermediate blocks between active belts where the impact of adjacent orogenic belts is powerful. A combination of the above factors has led to unique metallogenic tectonic environments and salt deposits in China's marine and continental salt basins: salts formed multiple times in different epochs; salt formed by migration and accumulation; salts had a diverse material composition; salt deformation occurred late; salt that is deep buried and in a liquid state; and salt ores that are mainly liquid. It was only after the late collision of the Tibet Plateau with mainland China that continental lithium, potassium, boron, and other salt deposits such as these occurred on land. Salt resources like lithium and potash can only be discovered via exploration of China's salt deposits' geological features. The western region of the Qaidam Basin has seen significant advances in exploration and prospecting based on the development of China's continental potash deposits theory in recent years. Because the Marine Salt Basin is so old and has undergone such extreme transformation, it is difficult to find potash. However, significant progress has been achieved due to the advent of new knowledge, technology, and discoveries.

4.2 POTASH SUPPLY CHAIN

Potash is a critical component in delivering balanced soil fertilization, and as a result, the business expects long-term growth. As the world population continues to grow, the need for food crops is expected to climb as well. Owing to the dwindling farmland due to urbanization, there is a greater need for potash-based fertilizers, which in turn leads to more effective farming methods. However, supply and demand fundamentals haven't changed, and the markets are beginning to recover.

Potassium minerals are often reddish-pink in color, delicate, and very moist. Carnallite, sylvite, and sylvinite are three economically significant potash minerals. In animals, plants, and people alike, potassium plays an array of critical roles in metabolism and growth. Therefore, potash is mostly used in the production of fertilizers. KOH, potassium nitrate (KNO₃), and potassium carbonate are only some of the potassium-based compounds that are made with potash minerals as their starting point (K₂CO₃). Medicine, glass, explosives, pyrotechnics, ink, bleaching agents, soaps, dyes, and textiles are just a few of the many uses for these compounds.

Production of K₂O-equivalent potash in 2010 was around 33 million metric tons (Jasinski, 2011a). Potash production in Canada (9.5 million metric tons of K₂O equivalent in 2010) is followed by Russia, Belarus, China, Germany, Israel, and Jordan, as seen in the following figure. 7 (Jasinski, 2011b). K₂O equivalent output was at least 1 million metric tons in each of these nations in 2010; other countries produced less than 1 million metric tons apiece. Potash demand is largely driven by its usage in fertilizers for the production of food and biofuels. As the global population grows, dietary preferences shift, and arable land shrinks, the demand for potash fertilizer minerals rises (Magen, 2010a, b). As a result of the rise in demand, potash prices have risen, and new potash sources have sparked interest. Potash deposits have been investigated in over 40 places during the last 5–10 years, with at least 20 of those sites beginning development. In addition to data accessible since potash exploration activities in the 1960s and early 1970s, this latest exploration and development gives additional data on the global occurrence and geology of potash.



4.3 SUPPLY FROM THE SOURCE OF ORIGIN

Potash is a critical component in delivering balanced soil fertilization, and as a result, the business expects long-term growth. As the world population continues to grow, the need for food crops is expected to climb as well. Owing to the dwindling farmland due to urbanization, there is a greater need for potash-based fertilizers, which in turn leads to more effective farming methods. However, supply and demand fundamentals haven't changed, and the markets are beginning to recover.

To supply food crops with potassium, potash is mined all over the world. Potassium chloride, potassium-magnesium chloride, potassium sulfate, and potassium nitrate are all water-soluble salts produced by evaporite-hosted potash deposits. The most typical host for strata-bound and halokinetic potash deposits are thick layers of evaporitic salt that form a laterally continuous stratum in sedimentary evaporite basins. As many as 100 billion metric tons of potassium oxide (K_2O) can be found in potash-bearing basins. The Elk Point Basin in Canada, the Pripyat Basin in Belarus, the Solikamsk Basin in Russia, and the Zechstein Basin in Germany are all examples of these deposits. It is usual practice in agriculture and horticulture to refer to potassium in the form of potash as a fertilizer. This element is prevalent in the earth's crust, making up around 2.8 percent of the planet's mass (Rudnick, 2003). Bedded evaporite deposits contain potash minerals. They are usually chloride (Cl) or

sulfate (SO₄)-based compounds with various quantities of potassium, magnesium, and calcium.

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4.3.1 Discovery

In 2013, the Minerals4EU initiative found that the majority of potash exploration in the EU was concentrated in Spain and the United Kingdom. However, it's possible that additional EU nations may have been explored when no information was supplied in the poll (Minerals4EU, 2015). Potash exploration is now concentrated in Canada, Ethiopia, Eritrea, and the Republic of Congo, as well as Australia, the United States, and Brazil. While some of these plans may be put on hold for the foreseeable future due to the current eight-year low price of potash (Mining Journal, 2016).

4.3.2 Extractive Metallurgy, Mining, and Processing

Conventional mining technologies, like those used to mine coal, are employed to recover potash from deep underground reserves (mechanized longwall mining). It is also possible to extract potash from mine workings by injecting a heated brine to dissolve the potash on-site, followed by pumping the resultant solution to the surface and recrystallizing the potash by evaporation (PotashCorp, 2016). Solution mining is the term used to describe this type of research.

Crushing and grinding the potash ore releases the potash minerals; at this stage, clay minerals are also removed from the ore (desliming). Potash minerals are separated from unwanted salt minerals (like halite) by froth-floatation; the potash minerals are dried and size-graded; and finally, further purification takes place by dissolving the potash minerals in hot brine to remove impurities (isulfate). Fertilizers and potassium chemicals can be made from the high-purity precipitate that is generated after cooling (PotashCorp, 2016).

4.3.3 Reserves of Natural Resources

Efforts to compare potash deposits across EU member states or the world have failed because there is no uniform standard for evaluating resources and reserves. The USGS gathers information on the number and quality of mineral resources but does not directly quantify reserves, and firms or governments do not directly disclose reserves to the USGS. Mineral resource and reserve reports may be published on a regular basis by individual corporations, but the reporting techniques used depend on the location of the operation, the company's name, and the needs of the stock market. As exploration and mining progress, reserve and resource statistics are always changing, are consequently affected by market circumstances, and should be monitored constantly.

As far as potash resources and reserves go, there isn't any comprehensive data available for Europe. Minerals4EU, an EU-wide collection of potash resource and reserve data, does not give a full picture of Europe's potash resources. There are several estimations based on various reporting codes and non-comparable datasets utilized by different nations (e.g., historic estimates, inferred reserve figures only, etc.). Many of Europe's reported resources are based on historical estimations that are of little economic value now. In some cases, the UNFC system may not be able to show the data for these. Experts, on the other hand, can make very accurate predictions.

Potash is a mineral that may be found in abundance across the world. The United States Geological Survey estimates that the world's potash resources are around 250 billion metric tons (USGS, 2016). Spain, Germany, and the United Kingdom are all known to have potash deposits in Europe. However, the UNFC reporting system does not include statistics on them. Because data collection in Germany is the duty of sub-national entities, no data for Germany are reported (Minerals4EU, 2015).

4.4 POTASH PRODUCTION WORLDWIDE

Approximately 34 million tons of potash (K_2O content) are mined from 12 nations each year. However, only three nations account for over 60% of global production: Canada (30%), Russia (17%), and Belarus (15%). China, Israel, Jordan, and Chile are some of the world's most prominent producers as well. Around 4.2 million metric tons of worldwide supply are accounted for by European production, mostly from Germany (9%), Spain (2%), and the United Kingdom (1%). (BGS, 2016). Figure 8 depicts global potash production from 2010 to 2014.

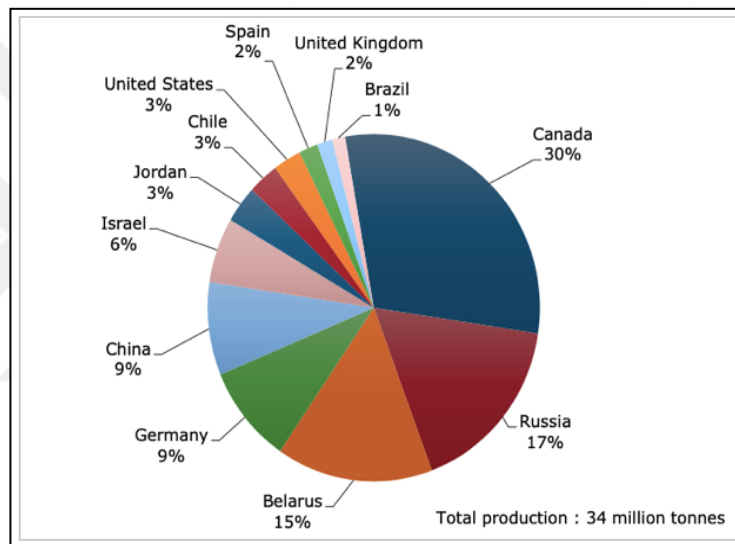


Figure 8. Global mine production of potash, average 2010–2014 (Data from BGS World Mineral Statistics database - BGS, 2016)

5. CHAPTER FIVE : RESEARCH QUESTION AND METHODOLOGY

Supply chain management has increasingly used the concept of risk (Lavastre *et al.*, 2012). To construct well-founded SCRM models, Khan and Burnes (2007) suggest that research on SCRM must be integrated into bigger risk studies. The creation of multi-research groups looking at diverse views of SC risk internationally is also suggested by Christopher *et al.* (2011).

The primary objective of this mixed-methods (qualitative and quantitative) case study was to learn from Arab Potash's successful managers how to minimize the impact of supply chain risks on the company's overall performance (Frels & Onwuegbuzie, 2013). The study's research design was a single case study, which allowed researchers to better understand and collect data on how participants used risk mitigation strategies in the supply chain (Yin, 2012). Risk and supply chain managers at Arab Potash in Amman were the intended audience. The use of a case study required an intensive study of the phenomenon in order to fully understand and explain the risk-mitigation tactics of the supply chain.

The study's goal is to add to the growing body of empirical evidence in SCRM. The study will start with a main research question, "How was Arab Potash able to mitigate the risk of supply chain disruption during the Corona Virus?" that leads to several subquestions that are listed as follows:

- What are the procedures and techniques applied by Arab Potash to avoid and mitigate risk in supply management?
- How do the managers identify and classify the risks that need to be avoided?
- How do the managers design and implement the risk mitigation strategies?
- Were the managers ready to deal with the COVID-19 risk, or was it something unplanned for and they had to come up with totally new changes?
- What was the effect of the pandemic on the business plan?
- What are the future procedures that were identified to survive any upcoming risk, such as the pandemic?

According to Greene *et al.*, (1989) and Bryman (2006), mixed methods of sequential bases could be employed for several reasons, one of which is expanding knowledge and research. Based on this, the study starts with an exploratory qualitative study, according to

the book of Yin, R. (2018), with mixed sources of data between primary and secondary data. The sources of data for the qualitative part are archived records and information obtained as a result of structured in-depth interviews with managers from strategic and operational levels, documents, and on-site observations (if possible) in order to be able to develop a whole picture about the best practices and procedures about risk mitigation in the supply chain during crises. The interviews are structured with open-ended questions, and the collected data is coded and analyzed using content analysis software to ensure an accurate understanding of the best practices and compare their answers with the supported data to test the level of implementation and match between plan and reality to outline the most efficient strategies to mitigate any upcoming risk in supply chain management. Moreover, the highlighted topics that need to be tested and investigated are responsiveness, flexibility, supply and demand, strategy and implementations, cost and risk control, deliveries and repeated orders, profits, and sales with the supply chain culture. As for the archived data, all the reports that have been done by the organization have been collected, analyzed deeply using qualitative analysis to test performance, and highlighted as the most important procedures that had a major effect on the SCRM during COVID-19. Documents include all the documents and data that the organization will support the research with and analyze. Moreover, the qualitative part methodology will be shown in simple blocks in Figure 9, and the types of data used in analysis are shown in Figure 10 below.

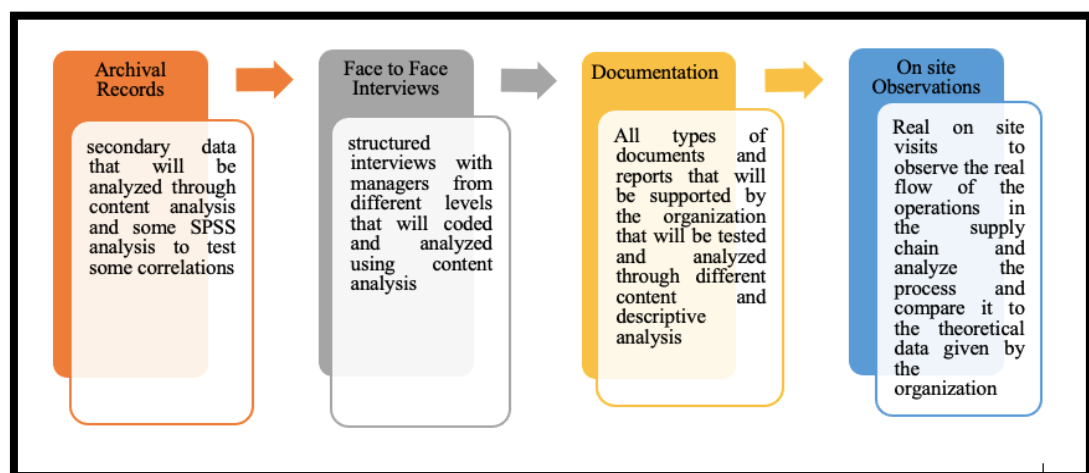


Figure 9. Conceptual model of the qualitative study. (Developed by the researcher)

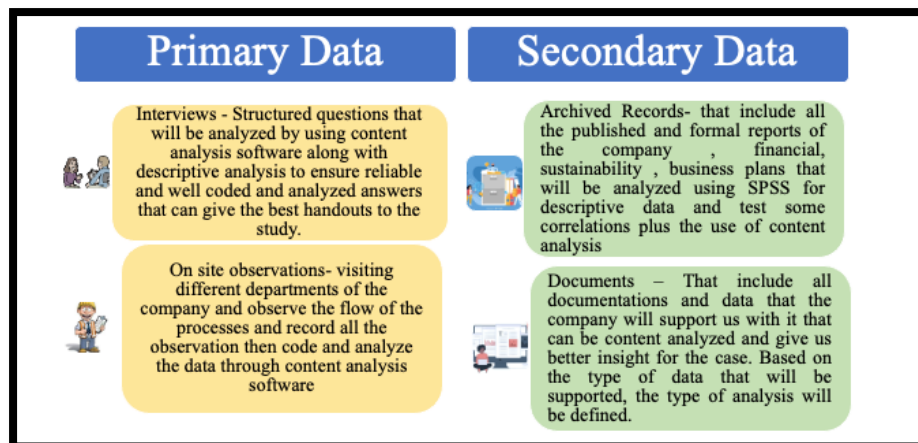


Figure 10.Types of data that will be used on the case study. (Developed by the researcher)

The study is on different stages: the first stage is on the strategic level, then the operational level analysis starts from the risk identification, risk assessment, mitigation, and control procedures that are followed by the two levels and tests the compatibility between the theoretical and practical procedures that are done. Started with the qualitative deep analysis, followed by descriptive quantitative analysis that supported the findings from the first stage, as shown in figure 11 below.

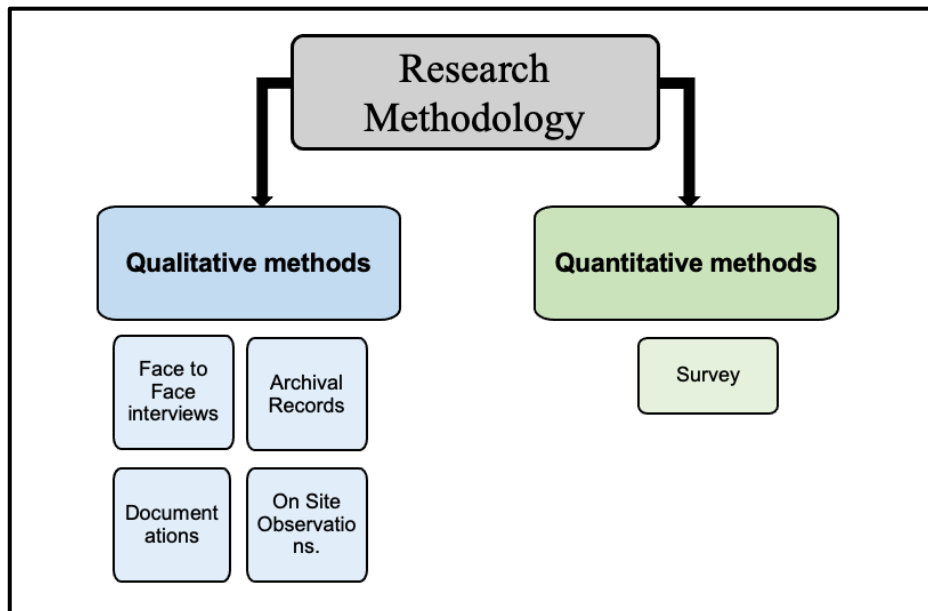


Figure 11. The research design diagram (developed by Researcher)

The interview questions attempt to investigate the steps taken by the company to identify, assess, and then control risk. They also probe how the management was prepared to face the pandemic and how they managed to turn the threat into an opportunity.

The time frame for the research lasted for more than a year to study the past two years of the company's achievements, plans, and strategies compared to the years before and the current year. The first phase of analysis starts with a purposive sample, which is directed at a small group of managers from different departments in the organization.

For the second phase of analysis and building up on the qualitative analysis and results, a quantitative semi-structured survey is designed to investigate more the relationship between demand, supply, and manufacturing risk and operational responsiveness and performance, in addition to the relationship between integration and technology, with a random sampling from the company of APC.

Different software for analysis is used throughout the study, as for qualitative analysis, content analysis software such as Atlas.ti. is used to thoroughly analyze the different types of data, as shown in figure 10 below. For the second phase of quantitative analysis, SPSS is used to explore the descriptive characteristics of the sample, and then exploratory factor analysis is run to explore construct characteristics. Later, analysis involves correlation and hypothesis testing.

A review of the literature was done to obtain scales that represent seven constructs. In order to find items that accurately capture what was found in the literature, High Performance and Responsiveness of Manufacturing Project Database Measurement is adapted from earlier studies done by Qi, Y. *et al.* (2017), Kazancoglu, *et al.* (2022), and Jajja, M. *et al.* (2018). One of the primary study directions in SC management is integration and technological constructs; earlier studies have thoroughly proven these ideas. (Zhao *et al.*, 2015).

On the basis of the objectives of this study, the main hypotheses will be:

H1. There is a positive relationship between demand risk, supply risk, manufacturing risk, and operational performance in order to manage risk.

H2. There is a positive relationship between demand risk, supply risk, manufacturing risk, and operational responsiveness in order to manage risk.

H3. There is a positive relationship between demand risk, supply risk, manufacturing risk, and integration in order to manage risk.

H4. There is a positive relationship between demand risk, supply risk, manufacturing risk, and technology in order to manage risk.

To test these hypotheses, the following conceptual model has been constructed, as shown in figure 12 below.

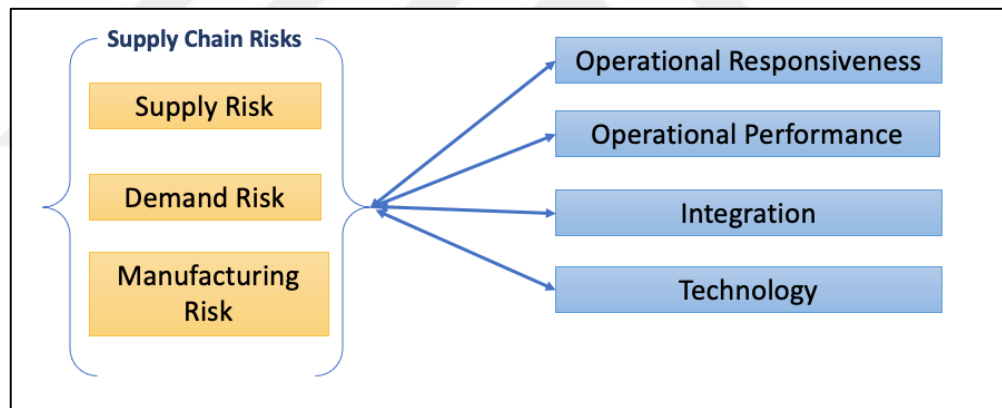


Figure 12. Conceptual Research Model (Developed by the researcher)

Table 4 below shows the suggested survey questions adopted from previous studies. For evaluating the research variables, a multi-scale model will be used to improve the credibility and accuracy of measurements. A Likert scale of 5 stages from strongly agree to strongly disagree will be used, which was adopted from previous research on the impact of risk on supply chain performance and responsiveness with the moderating effect of integration and technology. Furthermore, it was adjusted to meet the research goals and requirements. Data analyzed to measure correlation and reliability tests of variables evaluate the relation between different types of risks and organizational performance and responsiveness with the effect of integration and technology dimensions.

Table 4. Survey measurement scale adopted from literature

Measurement Construct	Focus of the study	Survey Questions	Source from literature
Integration	• Product integration • Process integration • Information integration • Strategic integration • Functional integration	• Meetings are regularly held to share improvement ideas with our suppliers. • Our suppliers are encouraged to continuously improve their production processes. • Our vision and supply chain policy are shared with suppliers. • Assistance is provided when our suppliers try to improve their processes • Functions are well integrated in our plant. • Problems between functions are easily solved. • Functional coordination in our plant works well. • Our business strategy is implemented without conflicts between functions. • There were difficulties dealing with some partners during	• Qi, Y.; Huo, B.; Wang, Z.; Yeung, H.Y.J. (2017). "The impact of operations and supply chain strategies on integration and performance". <i>Int. J. Prod. Econ.</i>, 185, 162–174. • Kazancoglu, I., Ozbiltekin-Pala, M., Mangla, S. K., Kazancoglu, Y., & Jabeen, F. (2022). Role of flexibility, agility and responsiveness for sustainable supply chain resilience during COVID-19. <i>Journal of Cleaner Production</i>, 132431. • Jajja, M. S. S., Chatha, K. A., & Farooq, S. (2018). Impact of supply chain risk on agility performance: Mediating role of supply chain integration. <i>International Journal of Production Economics</i>, 205, 118-138. •

		lockdown that affected the business.	
Operational Performance	• Manufacturing cost • Quality • Flexibility • Innovativeness • Customer service	• The inventory policy was adapted to avoid stock problems. • Transportation modes and methods were changed during Covid-19 pandemic. • A new product or service has been developed in accordance with the pandemic conditions during Covid-19 pandemic. • Different cost policies were applied during Covid-19 pandemic. • Changes in production planning (lengthened or shortened) were applied during Covid-19 pandemic. • Quality of product was not affected during the pandemic. • Risk mitigation plans and continuity actions were taken effectively during the pandemic.	• Qi, Y.; Huo, B.; Wang, Z.; Yeung, H.Y.J. (2017). "The impact of operations and supply chain strategies on integration and performance". <i>Int. J. Prod. Econ.</i>, 185, 162–174. • Kazancoglu, I., Ozbiltekin-Pala, M., Mangla, S. K., Kazancoglu, Y., & Jabeen, F. (2022). Role of flexibility, agility and responsiveness for sustainable supply chain resilience during COVID-19. <i>Journal of Cleaner Production</i>, 132431. • Jajja, M. S. S., Chatha, K. A., & Farooq, S. (2018). Impact of supply chain risk on agility performance: Mediating role of supply chain integration. <i>International Journal of Production Economics</i>, 205, 118-138.

Technology	• Inventory	• Our company uses real-time inventory information and analytics in managing the supply chain. • New technological investments were made during Covid-19 pandemic. • New AI systems and machine learning will be added to the system. • All the work is digitized and documented on real time servers. • There was no problem during the lockdown working with the system from home.	• Qi, Y.; Huo, B.; Wang, Z.; Yeung, H.Y.J. (2017). "The impact of operations and supply chain strategies on integration and performance". <i>Int. J. Prod. Econ.</i>, 185, 162–174. • Kazancoglu, I., Ozbiltekin-Pala, M., Mangla, S. K., Kazancoglu, Y., & Jabeen, F. (2022). Role of flexibility, agility and responsiveness for sustainable supply chain resilience during COVID-19. <i>Journal of Cleaner Production</i>, 132431.
Demand Risk	• Delivery • Flexibility • Agility	• Changes in production planning (lengthened or shortened) were applied during Covid-19 pandemic. • Raw material variety was enhanced during Covid-19 pandemic. • There was a decrease in demand in terms of the market during Covid-19 pandemic.	• Qi, Y.; Huo, B.; Wang, Z.; Yeung, H.Y.J. (2017). "The impact of operations and supply chain strategies on integration and performance". <i>Int. J. Prod. Econ.</i>, 185, 162–174. • Kazancoglu, I., Ozbiltekin-Pala, M., Mangla, S. K., Kazancoglu, Y., & Jabeen,

		• Effective solutions have been produced for sudden increases in demand during Covid-19 pandemic. • Effective solutions have been produced for sudden decreases in demand during Covid-19 pandemic. • A logistics system that can quickly respond to dynamic demands was established during Covid-19 pandemic. • We always deliver on time to our customers. Our customers are connected to us by JIT systems.	F. (2022). Role of flexibility, agility and responsiveness for sustainable supply chain resilience during COVID-19. <i>Journal of Cleaner Production</i>, 132431. • Jajja, M. S. S., Chatha, K. A., & Farooq, S. (2018). Impact of supply chain risk on agility performance: Mediating role of supply chain integration. <i>International Journal of Production Economics</i>, 205, 118-138.
Supply Risk	• Delivery • Supplier incapability • Supply base • Supplier opportunism • Mutual understanding	• Our suppliers deliver to us on just-in-time basis. • There was a delay in delivering raw materials and spare parts. • Late delivery affected our supply chain processes. • Partners understand our goals for supply chain management.	• Qi, Y.; Huo, B.; Wang, Z.; Yeung, H.Y.J. (2017). "The impact of operations and supply chain strategies on integration and performance". <i>Int. J. Prod. Econ.</i>, 185, 162–174. • Kazancoglu, I., Ozbiltekin-Pala, M., Mangla, S. K., Kazancoglu, Y., & Jabeen,

		• Our supply base is quite small, compared with our competitors. • Our suppliers fairly treat us in making important decisions. • We had gain new suppliers during covid-19 • Partners understand that we expect them to continuously improve their supply chain operations.	F. (2022). Role of flexibility, agility and responsiveness for sustainable supply chain resilience during COVID-19. <i>Journal of Cleaner Production</i>, 132431. • Jajja, M. S. S., Chatha, K. A., & Farooq, S. (2018). Impact of supply chain risk on agility performance: Mediating role of supply chain integration. <i>International Journal of Production Economics</i>, 205, 118-138.
Manufacturing Risk	• Strategic • Human-Relations • Inventory • Machines and raw materials	• Manufacturing strategy is effectively implemented. • Risk mitigating techniques were developed proactively. • During covid-19 there were a lot of strategic changes as a responsive manner. • Social distances and health precautions were taken to the maximum. • Supervisors monitored and detected abnormal	• Qi, Y.; Huo, B.; Wang, Z.; Yeung, H.Y.J. (2017). "The impact of operations and supply chain strategies on integration and performance". <i>Int. J. Prod. Econ.</i>, 185, 162–174. • Kazancoglu, I., Ozbiltekin-Pala, M., Mangla, S. K., Kazancoglu, Y., & Jabeen, F. (2022). Role of flexibility, agility and responsiveness for

		health conditions to take actions and ensure the pandemic won't spread. • There is no substitute for our production technology. • We had a shortage of raw materials that impacted the machines and the production of Potash.	sustainable supply chain resilience during COVID-19. Journal of Cleaner Production, 132431. • Jajja, M. S. S., Chatha, K. A., & Farooq, S. (2018). Impact of supply chain risk on agility performance: Mediating role of supply chain integration. International Journal of Production Economics, 205, 118-138.
Operational Responsiveness	• Innovation • Delivery • transportation	• Innovative products or services suitable for pandemic conditions were launched. • Transportation modes and methods were changed. • Delivery times were changed. • Collaboration was established between supply chain members. • New technological investments were made.	• Qi, Y.; Huo, B.; Wang, Z.; Yeung, H.Y.J. (2017). "The impact of operations and supply chain strategies on integration and performance". Int. J. Prod. Econ., 185, 162–174. • Kazancoglu, I., Ozbiltekin-Pala, M., Mangla, S. K., Kazancoglu, Y., & Jabeen, F. (2022). Role of flexibility, agility and responsiveness for sustainable supply chain resilience during COVID-

			19. Journal of Cleaner Production, 132431. Jajja, M. S. S., Chatha, K. A., & Farooq, S. (2018). Impact of supply chain risk on agility performance: Mediating role of supply chain integration. International Journal of Production Economics, 205, 118-138.
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Figure 13 below is the proposed research model of quantitative analysis part.

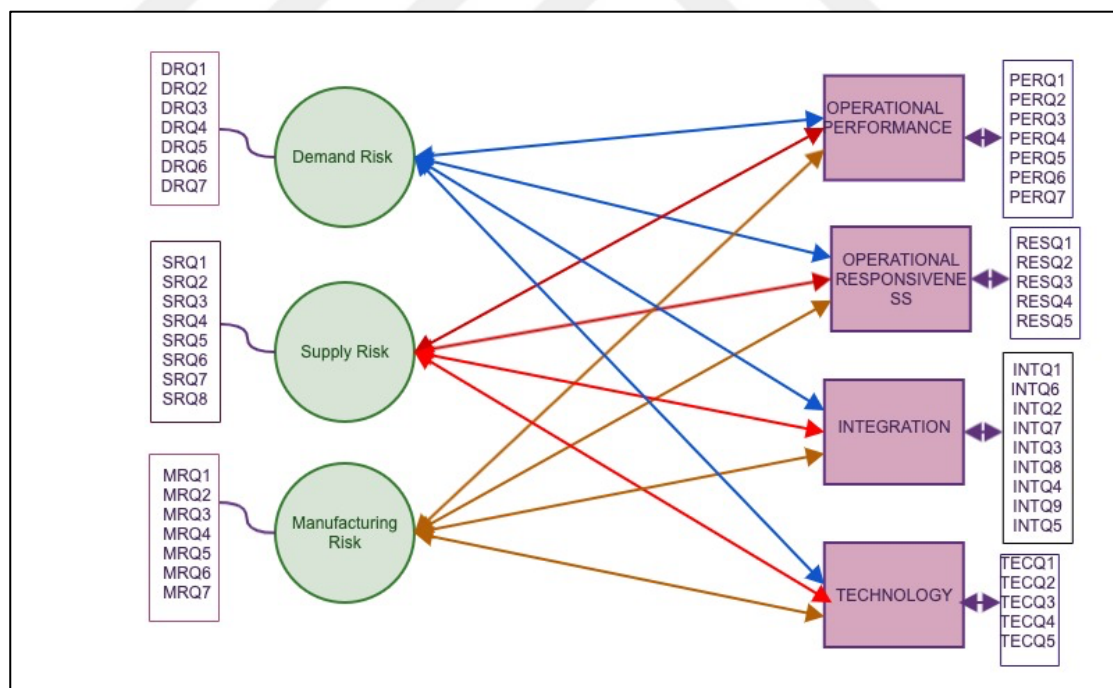


Figure 13. The proposed research model of quantitative analysis part (Devolved by the Researcher)

5.1 RESEARCH DESIGN

The primary objective of this study was to investigate the impact of supply chain risk mitigation strategies on business performance through a case study. Case studies, grounded theory, narrative research, participatory action research, and phenomenology are all examples of qualitative research designs (Bernard, 2013).

For this study, grounded theory was not appropriate because the purpose of the research was not to develop a new theory but rather to examine existing theories. Based the book of Yin, (2009) single case study was chosen for this study to explore the successful actions and strategies that was applied by APC to mitigate and manage all recurring risks during the pandemic of Corona Virus. In a case study, it is common to use more than one type of evidence to support the conclusions. Yin (2012) identified six different types of evidence: documentation, archival records, interviews, direct observations, participant observations, and physical artifacts. When attempting to answer how or why questions, single-case study research was the preferred method.

It was decided to use a mixed method of both qualitative and quantitative methods after conducting a review of the academic and professional literature. Open-ended responses from the participants were critical to determining the impact of risk mitigation strategies. According to Lin *et al.*, (2012), data were gathered through interviews and archival records in order to get a better understanding of the facts. Case study research was chosen over other mixed methods research designs in order to investigate the ways in which managers mitigate the impact of supply chain risk on business performance.

Qualitative researchers face a challenge in determining the saturation point, especially when there are no established guidelines for determining data or theoretical saturation. In order to obtain adequate and saturation-level understanding and insight, chain-purposeful sampling was used to identify participants in the qualitative part (O'Reilly & Parker, 2012). When the information gleaned from the interviews starts to sound the same, the point of saturation has been reached. It took a total of ten interviews to reach theme saturation in this study. Qualitative studies call for a minimum sample size of 10+3 participants, and we were able to complete our interviews with them (Francis *et al.*, 2010).

Evolving from the results of the qualitative study, a more deep quantitative analysis based on a survey method was applied to measure constructs of the study and confirms the qualitative findings.

5.2 METHODS OF STUDY

This study used a mix of qualitative and quantitative approaches to reach its primary research question's objectives. For a long time, qualitative research has been a vital part of business research (Bernard, 2013). Analysis and interpretation were part of the qualitative research process. The accuracy of the findings and the use of a structured process ensured the validity of the qualitative approach, while the consistency of the research approach increased the reliability of the findings (Thomas & Magilvy, 2011). When quantitative or qualitative research alone is unable to answer the research question, the use of mixed methods allows for a more complete picture to be formed. Mixed methods will be used whenever possible to examine any of the supply chain risk mitigation strategies. For the study of participants' views, the qualitative research method was a good fit because it focuses on uncovering members' emotional and symbolic dimensions (Rowley, 2012). And followed by confirmatory quantitative analysis to support the qualitative findings.

5.3 POPULATION AND SAMPLING

Separate sampling and populations were used for the qualitative and quantitative components of the study since they were conducted by separate researchers methods.

5.3.1 Population and sampling for qualitative study

In the first phase of the study, purposeful sampling, in which individuals are selected for inclusion in the study based on their distinctive traits, was used (Wahyuni, 2012). Researchers Francis *et al.*, (2010) concluded that 10+3 participants were considered sufficient for the study, given its nature as well as its methodology. In this study, a sample of 10 participants was utilized to understand the ways managers employ to control supply chain risk, even if a smaller sample is adequate. Despite the large population, only a small number of employees in any given department have any direct knowledge of or interaction

with the supply chain. As compared to other sampling strategies, chain intentional sampling yields the most accurate picture of the population. In addition, obtaining a more precise sample size is simpler when the attributes are the same. Sampling processes, the depth of interview data, the depth of inquiries, and validity are more important in qualitative research than the sample size (Chenail, 2011). For this qualitative case study, the focus was on Arab potash supply chain managers in Jordan.

Participation in the qualitative study was limited to managers who were involved in the company's supply chain decision-making process. Additionally, the interview was done over Zoom, which preserved a peaceful working environment for the participants. Interviews were conducted in a quiet room to ensure that there was no variance in the data-gathering environment. The same questions were asked in order to ensure that the data was collected in a consistent manner. Semi-structured interviews were conducted first, followed by an examination of corporate records. Participants who are part of the organization and knowledgeable about the problem or phenomenon being studied are represented by chain purposive sampling (Kindstrom *et al.*, 2012). Managers at an APC company in Jordan involved in developing strategic plans for risk processes met the criteria for participation in this study. Full-time supply chain managers were the focus of the study's participants. In Table 5 below the demographics of the respondents will be shown as it was noted all respondents were males.

Table 5. Demographics of Respondents for qualitative study

Respondent	Position	Age	Experience
Respondent 1	Director of Maintenance	60-65	37 years
Respondent 2	Strategic planning advisor	55-60	Recent
Respondent 3	IT Director	40-45	17 years
Respondent 4	Strategic planning manager	35-40	11 years
Respondent 5	Procurement Director	40-45	5 years
Respondent 6	Planning and Engineering manager	60-65	37 years
Respondent 7	Senior Marketing Operation Director	50-55	24 years
Respondent 8	Engineering Project Manager	40-45	10 years
Respondent 9	Head of Strategic Planning	40-45	11 years
Respondent 10	Technical Director	45-50	>15 years

5.3.2 Population and Sampling for quantitative analysis

For the second phase of quantitative analysis represented by surveys, participants were different employees at APC working in different administrative departments. Surveys were distributed to them randomly on a sample size of 300, and the responses came in at 162, representing a %53.3 response rate, which is considered a good percentage rate that could give us good results and a conclusion for the study. The respondent's experience is between 4 years to more than 15 years as shown in figure 22. Female responses compares to male responses are indicating that female working power in the company is less than male power but this is reasonable with the economic working labor data for Jordan. Ages are between 25 to more than 65 showing that the company is making sure that they have dynamic and experienced capabilities at the same time making sure to acquire new skills.

After getting the go-ahead from HR, the company allowed us to conduct interviews via Zoom during working hours with participants who had agreed to participate and distributed surveys between departments to get random responses from employees who work in different areas of the company, which would help us build a better overview of the full picture. By reassuring the participants of the study's confidentiality and building trust by explaining the use of a consent form with a strict academic code of ethics, a working relationship with the participants was established. Compliance with Yeditepe University's ethical standards and Turkish Higher Ministry of Education regulations on ethical standards ensured adequate ethical protection. Participants in the study were safeguarded by the IRB guidelines of Yeditepe University.

5.4 DATA COLLECTION TOOLS

In the following sections, data collection methods for each type of analysis are described in detail: In quantitative analysis, a separate set of tools is employed to acquire data from those used for qualitative analysis.

5.4.1 Data Collection Tools for qualitative analysis

A semi-structured interview plus archival records that are supported by APC are the primary methods used to gather data for the qualitative study (Pezalla *et al.*, 2012). Supply chain management concepts aid in the understanding of the research question. Zoom was

used to conduct an interview with the participants. Participant views and understanding of strategies for reducing supply chain risk were also discussed at this meeting. Qualitative data was analyzed using Atlas.ti software. In order to draw conclusions and make recommendations, the interviewees' responses were coded and analyzed using the software. To answer the research questions, themes were developed through in-depth interviews with participants.

Participants were asked interview questions and follow-up questions in order when they met on the day of the interview. Their consent was obtained prior to the interview being taped. In order to verify the participants' responses, they were asked to repeat their answers. To conduct this semi-structured interview, the Zoom platform was used to conduct face-to-face interviews with the participants. For transparency, Atlas.ti was used in the coding process. Investigating and uncovering obscured phenomena by following the stages of data collection for responsive interviews (Rubin & Rubin, 2011). In order to form a conversational partnership with the interviewee, it was necessary to establish a reciprocal relationship and display respect in order to obtain trustworthy and valid meaning. The questions for the interview are stated in section 5.5. Some results and conclusions were drawn based on the data collected from the annual and sustainability reports of the company from 2017 to 2021.

5.4.2 Data Collection Tools for Quantitative analysis

For the quantitative part of the analysis, a multi-scale model was used to improve the credibility and accuracy of the measurements. A Likert scale of five stages was used from strongly agree to strongly disagree, which was adapted from previous research done on the impact of demand risk, supply risk, and manufacturing risk on operational responsiveness and performance with the moderating effect of integration and technology (Qi, Y. *et al.*, 2017; Kazancoglu *et al.*, 2022; Jajja. *et al.*, 2018). SurveyMonkey.com was used to design and collect responses. The collected data were exported to SPSS for coding and analysis. Correlation tests have been applied to test hypotheses, and a deep descriptive factor analysis has been done to ensure the reliability and validity of the measurement scales.

5.5 INTERVIEW QUESTIONS

- What are the steps or protocols that the company usually use to deal with risks? What are the steps that the company use to plan, assess, mitigate or avoid risk?
- is your strategy of dealing with risks are reactive or proactive? In other words, is it planned within the strategy of the business or will be treated as it appears?
- Was Arab Potash ready for the disruptions of Covid-19?
- How did the company deal with the new situation? What are the steps or strategies that the company used during the pandemic to mitigate the risk?
- How did the pandemic affect the supply chain processes? And which process in the supply chain was affected the most?
- What are the challenges that were faced mostly during Covid-19?
- Are these strategies and steps applicable with all risks that have similar impact on supply chain?
- Who are the responsible parties for planning risks?
- Is there an integration and clear information sharing within departments? Was that applicable during the pandemic?
- Social distancing and health care protocols have impacted all business sectors during the pandemic. How did it affect your manufacturing and supply chain procedures? How much did it affect your business?
- Did the boarder closure and all the new legal and environmental changes affected the delivery time, quality of product, credibility and relations with clients?

Interview Questions that were used in a research on impact pathway research opportunities for a more resilient post-covid-19 supply chain – closing the gap between research findings and industry practice done by Hoek, (2020)

1. Is your company increasing inventories and reducing a focus on lean in favor of agility?
2. If so in what way? (if needed, inquire about extending payment terms, negotiating discounts, joint mitigation efforts)
3. Is your company considering technologies to address supply chain challenges? (if needed, inquire about blockchain and digitization)

4. Is your company planning changes to its supply chain for after the COVID-19 pandemic? If so, what are they?

5.6 ORGANIZING DATA

An analysis was done on the data gathered from the participants. categorizing and labeling information to make it easier to locate and reference (Bernard, 2013). The participants' responses were analyzed using Atlas.ti software for the qualitative part. It was transcribed and translated from the interview responses and coded for themes. It is essential to the qualitative research process to code and organize data. Major categories with headings and subsections were used to organize the responses. The code book was created and added to the appendix.

On the other level of analysis, survey data were coded and analyzed using SPSS software for the responses on a Likert scale from 1 for strongly disagreeing to 5 for strongly agreeing in order to make analysis more feasible.

5.7 ANALYSIS OF DATA

Some qualitative researchers find it difficult to provide convincing analyses based on empirical data interpretation. The analysis was facilitated by research into risk mitigation strategies and concepts discussed in the literature. In this study, Arab Potash Company's supply chain risk mitigation strategies were examined in light of business performance during the pandemic. Process information coding is a critical component of qualitative data analysis (Bernard, 2013). Reading and listening to the recorded responses were the first of the steps used to analyze the data. starting with labeling and categorizing themes that emerged from the research, then identifying the connections between themes, and using data to categorize themes into appropriate headings. followed by creating a detailed structural description of the tactics used by participants. The next step was to examine the topics in order to gain clarity and write up the results. As stated by Qu and Dumay (2011), the data was acquired, evaluated, and interpreted in an objective and consistent manner. For the purposes of the overall study, all responses provided by respondents were recorded. The data gathered was free of any slant or bias.

As a result, the findings and recommendations were not influenced by personal knowledge or experience. Good use of the topic as well as tying it into the story by posing questions that go directly to the heart of the matter. Results and analysis included a categorization of themes. Procedures for ensuring data integrity and improving coding, theme development, analytical rigor, and study findings' reliability and validity were put into practice. When all of the information has been gathered and analyzed. The data collected from the participants was analyzed to discover the best ways to reduce the impact of supply chain risk. Verification of results to ensure they are in line with the contingency theory of Fit's interview questions

Going one extra mile in the study and enriching the findings of the qualitative data, a survey was conducted to study the relations between risk in different areas and the responsiveness and performance of the company and check the ability of the employees and management of APC to respond and perform in times of risk appearance and their ability to maintain sustainability and resiliency. Results were collected, coded, and analyzed to test hypotheses.

5.8 RELIABILITY AND VALIDITY

Both reliability and validity are terms that pertain to the accuracy of a measurement: The amount to which the same findings may be achieved by doing the same method several times is what is meant by the term "reliability" when referring to measurements. When discussing the accuracy of a measurement (i.e., whether or not the results are representative of the construct being measured), the word "validity" is typically employed. Reliability and validity measures in qualitative methods are different from quantitative methods as will be discussed in different sections below.

5.8.1 Part One: Qualitative part reliability and validity

A finding's repeatability is an indicator of reliability in qualitative research. consistency in the instrument used to measure the results equated to high levels of reliability (Ihantola & Kihn, 2011). Following the methods and consistency with other researchers, the study's validity was established. The interview questions were reviewed to eliminate ambiguity and to ensure that the same questions were asked to all potential participants. Each participant

had the same questions asked of them in the interview, so there were no ambiguities in the questions. In order to ensure the study's validity, transcripts of each participant's responses were diligently and independently transcribed for consistency. For qualitative research to be valid and reliable, the data collected had to be adequate and interpretable without bias. In-depth, open-ended, semi-structured interviews with respondents were subjected to triangulation techniques in order to ensure the validity of the findings. Credibility, transferability, and confirmability are three criteria proposed by Thomas and Magilvy (2011) for evaluating the validity of qualitative research. The term "transferability" refers to the extent to which a study's findings can be applied to other organizations facing a similar problem.

For data collection purposes, it's helpful to confirm that the interview questions are valid. In this way, the interpretation of the results can be trusted more (Burton & Mazerolle, 2011). The literature was consulted, and the data included reviews of relevant documents to ensure consistency, increasing confidence in the findings. In this study, all of the significant decisions regarding research design were outlined. Credibility, dependability, confirmability, transferability, and authenticity are all necessary for the study to be taken seriously in order to ensure validity. In order to increase the study's confirmability, audit trails were used. Research findings will be described in great detail to allow comparisons between different research sites, and the transferability area will include a detailed explanation of each finding (Marshall & Rossman, 2014). The study's transferability was enhanced by providing readers with information that enables them to determine if the findings can be applied to their own organizations.

Saturation is a fluid concept that changes depending on a variety of factors, one of which is the study's stated objectives. Some of the variables include the homogeneity of the participants and the interviewer's dexterity (O'Reilly & Parker, 2013). when the 10th participant provided the same information and there was no new information in the interviews. Saturation was reached when no new information could be gleaned. By making notes on the transcript and checking verbatim transcriptions, themes were established.

5.8.2 Part Two: Quantitative part reliability and validity

For the quantitative part of the analysis, reliability assesses the consistency between the research's measuring variables and the accuracy with which they were calculated. The reliability tests are performed to make sure the testing variables are correct. The work is based on earlier research and the researchers' developing practices. Even if just a few tests look at the validity and consistency of variables, the degree to which they may reliably acquire findings is the primary predictor of validity for stable, authentic variables. Validation checks can demonstrate the accuracy of experimental parameters. The study fits requirements and is credible since it sheds light on various research themes and predictions about risk management and how APC managed to enhance their performance and responsiveness to the recurring risks to achieve corporate goals. Based on these measures, it seems that the elements included in this study directly relate to the topic at hand and may meaningfully help answer the research question and appropriately characterize the whole thing. The analyses are also looking at how integration and technology relate to the demand, supply, and manufacturing risks and their relations with operational performance and responsiveness.

For the validity of the research measurement variables, a component factor analysis has been done using the Kaiser-Olkin-Mayer (KMO) Test for Sampling Adequacy. The minimum level required for any given scale to pass this test is 0.5. The results in Table 6 show the values of KMO, which indicate that the research is adequate and the analysis can be run according to Hutcheson and Sofroniou (1999). Kaiser (1974) has recommended a bare minimum of 0.5. Based on this, a value of KMO equal to or greater than 0.5 will be considered acceptable.

Table 6. KMO Values (Validity measures)

Measurement Scales	KMO Test
Demand Risk	0.81
Manufacturing Risk	0.75
Supply Risk	0.82
Operational Performance	0.78
Operational Responsiveness	0.74

Technology	0.82
Integration	0.86

Having proved the validity of the finding and that the study can be run, An exploratory factor analysis of seven main scales has been performed along with the demographic scales, and a deep question-by-question factor analysis has been performed. The reliability scores of the scales have been calculated by using internal consistency coefficients (Cronbach's alpha). Additionally, whether the variables of the study are normally distributed has been tested, and descriptive statistics of these variables have been presented. The relationships between the variables have been analyzed using the Pearson product-moment correlation test. According to Cortina (1993), a value above 0.7 is acceptable, and values of 0.8 are considered very good. Nakip and Yaras, (1997) have listed a Cronbach's alpha value of above 0.6 to be accepted as reliable, and since all the values for the reliability tests of the research measurement scales show values of above 0.6, the study is considered to be reliable.

5.9 QUALITATIVE ANALYSIS USING ATLAS.TI

The software of Atlas.ti was chosen for coding and analyzing the interview responses and other qualitative data and documents that were supported by the company.

5.9.1 Development of Themes

After creating the codes and reading through them a code network was created using Atlas.ti and showed in figure below that helped in building the following themes. As shown in figure 14 below.

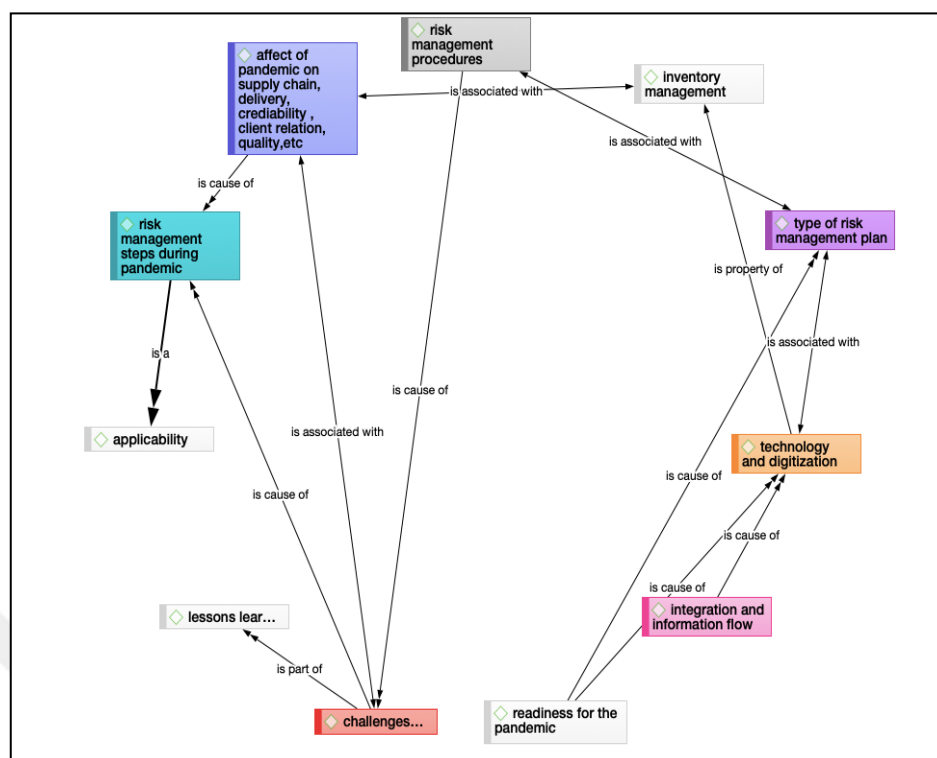


Figure 14. Code networks developed using Atlas.ti

• **Theme One: Risk Management Planning steps at APC before and during the pandemic.**

Based on the interview responses, all respondents have claimed that the responsible team for risk management and planning was formerly done by a risk management team that was part of the audit team, but lately it has been separated as a whole separate department that is doing better and clearer risk management steps and more mature plans to reduce the impact of any risk. The basic strategy for the company is to avoid or prevent the loss from happening by being proactive for the known and expected risks and reactive when it comes to unknown risks such as disasters and what happened during the pandemic. And based on the respondents, having the responsiveness skill and the right skilled employees with high-experienced management have managed to help the APC come out of the pandemic risk with success. Researchers categorize risk reduction strategies into proactive and reactive measures. Proactive measures include supply chain contracts, product management, and supplier development and management. Reactive techniques include disaster preparedness and demand control (Ghadge *et al.*, 2012). Proactive strategies focus on the supply chain,

whereas reactive solutions lessen outsourcing risks. Proactively control supply network hazards. Proactive management is "resilience-responsiveness-efficiency" in disruption management (Ivanov *et al.*, 2014; Gunasekaran, 2015). The ability of a supply chain to respond promptly to SCRM disturbances is crucial (Braunscheide & Suresh, 2009). Responding quickly to external stimuli (particularly market and customer demand) is responsiveness (Sandberg & Jafari, 2018).

One respondent's answer was quoted as:

"The company has a proactive plan to deal with all risks that might happen, but they are also skilled to respond to any unplanned risk that might appear out of the blue, such as the pandemic, which was something not planned for in the whole world."

Another respondent said that the company is taking all the steps and procedures to ensure there are no risks that will have a major impact on the business. But sometimes we might face a new situation that has not been planned for, and only at this time will the risk management move to reactive risk management.

Quoting from the risk manager in the company:

"Whenever possible, risks are identified and treated ahead of time." However, the company ensures considerable operational reliance to ensure business continuity for events out of its sight."

When it comes to the steps and procedures that the company follows to control or avoid risks, the respondents have all ensured that each department will have a risk identification report for their project and their department that will be entered into a risk register system and reported to the risk committee of the company. Then all identified risks will be assessed as having a high, medium, or low impact and categorized depending on their impact and size to be treated in a proper way, either by avoiding, eliminating, or controlling them.

Respondent 5 has expressed in his own words, "It's one of the most important steps that the company is considering while managing any department, especially when we are dealing with warehouses and inventory, as they are essential to the business, and having a shortage in any of the materials or spare parts can cause the business a temporary shutdown, which can cost us more damages. Based on this crucial importance for procurement and inventory risk management, we have a risk register and our inventory management systems that show

the most important materials and spare parts and their importance to the business, and based on this, we plan the stock needed and the period that it will cover to make sure that we don't have any shortages."

Respondent 7's answer was: "As a risk that is concerned with logistics and marketing, there are certain steps and protocols to be assessed annually. The major risk that we might face as a marketing and sales department is that we have certain known risks like volatility of prices, risk of demand, risk of losing a supplier, or risk of losing a customer, so our first step is risk categorization, then ranking the risk according to its importance and its occurrence, and then we would set a certain plan to mitigate and avoid each risk or prevent this risk from happening."

Quoting from respondent 10 :

"There is a certain process of risk assessment that is reviewed and updated continuously that covers all probable risks that might appear and lists the possible solutions and risk avoidance strategies in order to minimize the impact of these risks on any process. The steps of the risk management or risk assessment process are mainly concerned with ensuring sustainable business processes, safety of labor, quality of product, supply chain and delivery processes, a sustainable and reliable reputation, and client relations. For Arab Potash, we are depending on export by 95%, so we have to make sure we don't have any risk in the inventory or raw materials such as chemical materials or even the delivery and shipping process."

To sum up the steps and list them as the risk management reported:

Process owners submit a risk identification form to the risk management department; the form contains a brief description of the risk, its impact, its likelihood of occurrence, and any other relevant information.

- The risk management team obtains any additional information that might be needed and proceeds to get the needed approvals to include the risk in the company risk register.
- The risk management team evaluates the risk level considering the category it falls into based on the prespecified limits in the company's risk appetite statement.

- Process owners provide a set of potential controls to mitigate the risk to an acceptable level.
- The risk management team follows up with process owners to ensure controls are deployed properly.

Those procedures and steps were applied by the company before the pandemic or in normal situations where there was no global disturbance like the pandemic. When the pandemic of COVID-19 started, the whole world was impacted by the changes that happened, starting with the lockdown and border closure that had a major impact on business and especially the supply chain, creating different kinds of risks such as demand risk, supply risk, inventory risk, and shipping risk that needed certain action plans to be taken.

According to APC, the company have a certain risk management plan for such a kind of risk, as no one within the last 50 years has faced such a risk. But they had a strike risk mitigation plan that was employed and updated in their new responsive plan. The department managers claimed in their responses that the successful management of the company and the loyalty and experience of the employees had led them to come up with responsive action plans with a very short time to adapt to the disturbances in the chain.

When interviewing managers from different departments, each department explained their risk response plan to the pandemic according to their situation and the impact of the pandemic on their part of the chain. But they all claimed that once the pandemic started in the world, they were always up to date with all the changes that were going on around the world, so they expected the lockdown and the risks that might be faced once the pandemic started spreading in Jordan or the impact reached their business. An emergency risk team was assigned by top management to deal with the situation. All department managers were asked to define possible risks, assess their impact on the business, and suggest possible ways to mitigate and reduce the risks. Every department submitted their report to the risk team, and a whole response plan was then created to deal with the new situation.

Respondent 10 has reported that the emergency risk team has asked them to list all possible risks that their department might encounter, so they listed the supply risk, inventory risk, and price risk for the materials. Then, as a suggestion, they have listed all possible suppliers that could be reached out to and made sure the materials are available. Inventory stock for the mechanical spare parts and strategic chemical materials has been checked, and

the critical ones to be supplied do not have any demand or price risk. Moreover, he added that since they decided to keep running the business and with the new social distances and health protocols, they divided the working labor into three shifts to maintain social distances, and all health care protocols and hygiene were taken care of. The company brought a medical lab to the field location to make sure that the working laborers were always running tests on a daily basis or even more than once a day if one of the symptoms appeared. Moreover, there was continuous awareness-raising among the working force to take care of their hygiene and general safety precautions for COVID-19. The company has made sure that there are enough masks, gloves, and even sanitizers at the field and even at the working force houses to ensure their health and that of their families.

According to Respondent 7, the response plan was different, as the respondents explained: "For our department and for the billing, certificates, and documentation problems, we have assigned a few employees of the IT department who are responsible for documentation and certification, and we have supported them with laptops to work from home. We have also assigned another team of a few members that will be following up at the office. The remotely working team is responsible for issuing, printing, and putting stamps on the papers and getting them ready to be transferred by the office team to the needed destination.

For the bills of lading that have to be sent by courier, the department of marketing had made an arrangement for the truck drivers that are moving materials daily between Amman and Aqaba to work as couriers for the bills of lading to be delivered to the ship's captain.

For the shipping and cargo companies, also they tried to coordinate with them to prepare their work at home, then we sent one of our employees to bring the papers and finish the work as permits were not given to everyone.

Marketing Department has arranged some procedures to ensure delivery on time to the end user and in case the bill of lading was late to be delivered as we have faced some problems with courier sometimes, if for example that ship reached a delivery destination and the bill of lading was not there the captain cannot unload the ship so there will be a delay in delivery so what we did is, if we have secured payment for the shipment through the bank; we can make an agreement with the ship captain as a contract that the captain can unload the ship even if the bill of lading is not delivered yet against a letter of indemnity (LOI) this is

accepted if it was sent to the customer and a copy to the captain so in this case the ship can be unloaded and the same process can be done to trucks by what we call telex release to clear the shipment."

Based on the response of Respondent 1, "ABC is taking extreme care about risk management, and there is a separate department that is called emergency and risk management that takes care of assessing, planning, and controlling all types of risks that might appear.

TRA, or what is known as a task risk assessment, is a starting procedure that the risk management team always applies to all the business procedures in order to assess risk, set a plan to manage it, and avoid any losses or problems in the project. Recently, we contracted an outsourced risk management company with a known company called Young Risk that will help us assess all the processes, starting from supply and ending with the end-user shipping process, to draw a more detailed risk plan for the entire company. The company has a strategy of job rotation and on-the-job training to ensure that all the manpower is ready and familiar with all operations to be ready to run the business when they have less manpower."

He added, "How did the company deal with the new situation? We started by dividing manpower into two groups (Group A and B) to ensure their effectiveness and efficiency by not loading all the manpower with all work. This was specifically in the areas where the manufacturing field is located. (alkarak, alghor).

For senior workers, we had one for each location and specific job, so we had one superintendent, one supervisor, and one engineer for all of the five locations of our processes instead of five. For running processes, we focused on critical equipment and single-line jobs that have a major impact on the business if anything wrong happens to them, and we made a preventive maintenance operation to be proactive and make sure that the equipment has no fault whatsoever. During COVID-19, we performed preventative maintenance on the critical equipment for 24 hours.

Usually, in a normal situation, the maintenance department runs the PM (preventive maintenance) for all the machines and equipment, but during COVID, with the low manpower, we followed the run-to-fail method for the non-critical lines to avoid extra costs and also because we don't have enough manpower to do the preventive maintenance for all

the lines, so we kept it for critical only. Also, by running the equipment until it fails, we are guaranteeing spare parts because there is limited supply due to the border closure and lockdown.

Also, they made sure that the limited working staff were the best of the best, who can work very hard for long hours, are very talented and experienced, and have a higher tolerance for pressure.

For spare parts, the team have made a plan to fix the spare parts that can be fixed and re-used by what we call "re-conditioning, and we have also gotten spare parts from local suppliers. Also, the team have made an upgrade for all stand-by equipment to ensure that we have running equipment once we have a failed one."

The team of project and construction has contributed to planning a complete risk action plan during the pandemic. It started with identifying the risks and evaluating each one, prioritizing the risks that need to be dealt with and the ways to avoid every risk, and then, after categorizing each risk and its impact as long-term or short-term impact and intensity of the impact on the business (high, medium, and low), developing a risk management plan to deal with every risk. Through the project management software, we usually control and monitor the project progress according to the plan and make sure no risk is occurring.

Also, grouping projects according to their geographical location means that each group of projects shares almost the same conditions: Al-Ghour site (inside plants and outside plants), Amman headquarters, township, and Aqaba site.

Consequently, in the identification of the risks, it is to be highlighted that the risk management plan is a live document and needs to be revisited from time to time (assumed to be on a monthly basis) to review any new risks and assessment techniques, methodologies, and recommendations. Risk identification might also be repeated at key milestones in projects or whenever there is a significant change to any project or its operating environment.

The risk management plan has been qualified into qualitative and quantitative risk management. For qualitative risk management, risks are categorized according to their sources or causes, and the probability that each risk will occur and the effect of each

individual risk on the project objectives are studied. Risks have been classified into the following main categories.

1: People (internal or external)

2: Machines, materials, and instruments (internal and external)

3: Area (project location)

Later for quantitative risk management, determining the impact and probability of each risk numerically by analyzing the combined effect of identified individual project risks and other sources of uncertainty on the overall project's affection by COVID-19

There was a general action plan for risk management during the pandemic for the project and construction teams, as follows:

- As part of daily TBT to all employees on site, contractor's safety officers should remind people of the risk factors, proper practices, and protective behaviors to protect themselves from infection and to maintain a good level of hygiene, in addition to encouraging employees to self-monitor themselves for signs and symptoms of COVID-19.
- Maintain regular housekeeping practices for projects, including routine cleaning and disinfecting of surfaces, equipment, and other elements of the work environment.
- Each construction area shall include a designated room with closable doors to serve as an isolation room until potentially sick people can be properly removed from the worksite.
- Implement flexible work hours, staggering shifts, and break times that reduce the total number of employees in the project at a given time.
- Control the way in which employees consume their food and provide disposable cups for drinking water.
- Expanding the capacity of on-site medical facilities, where the contractor is obliged to provide at the site gate a digital thermometer and first aid kits to check the laborer's body temperature and do the required first aid if necessary.
- It is recommended that each contractor have a certain specified route between the main gate and the construction site, and he is not allowed to take any other route.

Vehicles and equipment are to be operated by one person, and if it is necessary to change the driver, then the vehicle should be properly cleaned and sterilized before being used by others. The same is to be applied for construction tools. For delivery of material to the site, drivers should be tested at the main gate, and if there are no symptoms and the driver has a passing permit, he is allowed to get in the site following a specified route.

Procedures and guidelines issued by the Ministry of Labor are to be implemented in conjunction with these action plans. The directorate includes four main sections: construction, development, civil works, and expansions. Each department is to be isolated from other departments through the following procedure:

Each department (floor) is closed, entrance is allowed only for authorized persons, and post boxes are to be kept outside departments.

Physical contact with people is controlled, and APC staff who are working in direct contact with contractor labor on site are moved to a separate building in order to minimize their contact with office staff. Virtual communication through phones and Skype will be considered for meetings and discussions.

The civil works department (as in high contact with others) is not to get in physical contact with other sections.

A special committee responsible for monitoring contractors' adherence to proper practices is also separated in a designated operation room and should not interact physically with other staff.

Establish a new clinic or medical unit for emergency cases in Alhussien housing to cover APC employees and contractors after normal duty hours. This unit shall be equipped with the basic requirements and qualified medical staff to deal with urgent cases.

APC, in coordination with the contractor, should be ready to change some work practices if needed to maintain critical operations (look for alternative suppliers, temporarily suspend some operations, postpone starting new projects).

GPS tracking system: APC can study the implementation of electronic bracelets or certain phone applications to monitor, track, and record the movement of people inside and outside the APC plant.

Summing up the actions that have been taken during the pandemic:

Steps

- Setting business objectives for the strategies, which included employees' safety and wellbeing, customer satisfaction, business continuity, and supporting governmental efforts.
- Identifying critical operations, assets, employees, and stakeholders is the minimum business continuity requirement.
- Implementing international health guidelines to ensure employees' safety.

Strategies

- Operations strategies included run to fail and carrying out critical operations in-house, like manufacturing spare parts.
- Human resources strategies included expanding job activities and reducing the degree of specialization.

The APC business management response plan due to COVID-19 that was published by Nsour, M., & Al-rjoub, S., (2021) has concluded all the major actions and strategies that have been taken during the pandemic in Table 7.

•Theme Two: Challenges faced during the Pandemic of Covid-19 and its impact on the supply chain.

COVID-19's supply chain study is, by nature, in its beginnings. Few microstudies exist, and those that do rely on theoretical explanations of COVID-19. Based on an assessment of the existing literature, certain findings indicate new paths for future investigation. Nevertheless, the current discourse on global supply chains is missing the supply chain-related issues and mitigation methods that enterprises confront because of COVID-19. Supply chain managers have also been prompted to reconsider their supply chain tactics as a result of these challenges in order to minimize future disruptions. Many aspects of supply chain operations, as well as interactions across layers and the policies of businesses in networks of linked relationships, were disturbed by the COVID-19 epidemic.

Global supply chains have been impacted by the coronavirus pandemic in a number of ways, from the demand side to the logistics side (Mishra *et al.*, 2021; Sharma and Kumar, 2021). Enterprises were hit by supply disruptions; for example, exports of face masks ceased when the virus swept throughout India. Several businesses were also harmed by a drop in demand. Despite a rise in the demand for critical goods, concerns have been raised over the possibility of supplies being delayed, goods being delayed from being secured, trips being disrupted unexpectedly, and workers being short-staffed (due to the reverse migration of laborers from cities). That means that supply and demand gaps have grown. Just-in-time inventory management (JIT) was common practice in supply chain management prior to the COVID-19 period. The COVID-19 pandemic has shown that this method does not adequately prepare global supply networks for major disruptions, such as those caused by the pandemic itself (Govindan *et al.*, 2020). Risk management and mitigation measures have only grown in importance as a result of the coronavirus pandemic's impact on global supply chains.

When it comes to APC, the major challenges that have been faced by the company have been on the supply side, inventory, and transportation. All these challenges, based on the interview responses, were mostly due to the lockdown and border closures in some countries. Moreover, the new social distance and health protocols, along with the need for permits to go out during the lockdown that has been enforced due to the pandemic, have pressured the company to lower the number of laborers, which will impact production. Adding to this, some of the employees had to work remotely, which shaped the business flow and the documentation system.

Most of the responses have explained that the most impacted side for them was the supply side, and they got late delivery for spare parts, electronic chips, and some chemical materials or construction materials. However, they managed to overcome these obstacles by reaching out to local suppliers or manufacturing the part themselves. It also impacted the inventory as a consequence for the chain. Based on Biswas & Das ,2020; Hippold, 2020), barriers in the supply chain include restrictions on imports and local transportation, as well as routes that require detours because of prohibited zones, which all result in slower movement of goods and longer lead times.

Respondent 7 has expressed the challenges as follows: "The most critical challenge that we faced was the lockdown for the first three months of the pandemic, and this affected issuing the clearing certificate as we needed physical papers to be issued that would help customers and also the bills to be issued to the banks. We tried to issue e-labels that were not accepted by abroad banks, and we needed some papers to be issued physically, not online.

During the lockdown and before the permits, most of the shipping and cargo companies couldn't open, so we had to contact them and coordinate with them to work from home.

The department has something called a bill of lading that is considered a receipt of delivery, and these bills of lading have to be signed by the captain of the cargo ships. These bills were refused by banks to be electronic, so we had a challenge transmitting these papers. So, the biggest challenge we faced was with documentation and the issuing of certificates."

The response of respondent 1 was: "One of the greatest challenges that we faced during COVID was the lockdown that happened in Jordan and the whole world according to COVID." And most of our deals and orders have to be exported and shipped internationally, so any delay in delivering the project on time will cost a lot, so the top management conducted an emergent meeting and decided to keep the business running and started setting and planning procedures to make that happen.

The first step was getting permission for minimum manpower and longer working hours to move from one city to another and get the business done on time. We have also faced a challenge with the spare parts supply due to lockdown and border closures."

Respondent 5 said, "The most critical challenge that we faced was the lockdown for the first three months of the pandemic. Although we were able to get government permits for our manpower to work and move freely, the permits at the beginning of the pandemic were only for 10% to 20% of the manpower, which was a great challenge for the APC to be able to produce and deliver the potash to the end user on time. Also, the challenge with the procurement of the spare parts was that we were importing them from different countries, and due to the global lockdown and the border closing, we were not able to receive some orders on time, so we had to find a local or near-shore supplier".

Also, customs clearance was challenging during that period due to limited permits for suppliers.

He added also that inventory was increased, and as a consequence, the cost also increased, but it was for our benefit.

Moreover, the trucks' drivers were very limited during the lockdown, so we had to outsource the drivers during the lockdown, and we were able to get a permit for the drivers as our transportation and production increased during the pandemic. So, I would say there was a challenge in the internal logistics, but we were able to mitigate the risk."

Respondent 3 has listed the challenges as follows:

- a higher pressure on the support team to be responsive to the employees who are working remotely to help them with the new situation.
- Also, another pressure on the infrastructure servers is to be responsive to all the coming data.
- The data center team lost access to the servers in case of any problems or changing tapes needed during the lockdown before we got the permits.
- Not all the employees had laptops before, which forced us to buy laptops for the employees to work remotely, which added a new asset to the company.

Respondent 4 has listed the challenges as follows:

- slower processes at the beginning.
- The challenge of supporting some departments with laptops and getting them ready
- Preparing the cloud to give access to the business systems from a distance.
- Courier services for the paper work, bills, and banking work
- inventory management by increasing the safety stock for spare parts and strategic materials.
- The integration was not very efficient between departments at the beginning, and we had to come up with all the needed channels and platforms to ensure higher integration and information flow.
- The shipping processes, documentation, and billing
- Sustainability planning was needed.

Based on the APC Business Response Management Plan during the COVID report by Nsour, M. and Al-Rjoub, S. (2021), the management has understood the importance of keeping the APC business running due to its major impact on Jordan's economy and because of the importance of its product, which is a very important part of the global agriculture supply chain. The impact of stopping the business will be huge. The response plan started by mapping out all the challenges and listing them in Table 7, assigning each problem to a certain department concerned with it in order to identify relevant parties and resources to build communication protocols for the many levels and functionalities of APC. Each challenge has a set of responses that each responsible entity is expected to carry out.

Table 7. APC major challenges during Covid-19 and their response action plan. Source: Business Intelligence. Studies in Systems, Decision and Control

APC Major Challenges	
Board of Directors and Executive Management	• Keep operations in the face of most economic sectors closure. • Ensure Fulfilling the company CSR and the national role. • Lack of conclusive information about coronavirus COVID-19 in the early days of the outbreak. • Ensure full compliance with governmental directions and requirements • Ensure employees and their family's safety and wellbeing
Companywide Challenges	• Companywide process re-Engineer to match available resources, comply with regulatory requirements, and external environment developments.
Health and Safety Challenges	• Ensure employees' _safety without having any COVID-19 infected cases.

	• Ensure company readiness to handle and contain any infection spread.
Operational Challenges	• Lack of workforce enough to operate plants and equipment. • Risk of Interrupting off-site activities such as equipment manufacturing and steel fabrication. • Risk of leaving construction sites unsecured. • Risk of delays in project engineering and construction activities. • Risk of extra costs related to contract deferrals. • Risk of losing warranties for delivered equipment. • Risk of delays in inspections, commissioning, and testing due to travel restrictions.
Financial Challenges	• Pay vendors for supplies of goods and services. • Prepare Letters of Credit (LC) hard copies. • Prepare payroll and deposits.
Human Resources Challenges	• Ensure manpower availability. • Ensure enough residence and daily needs for employees.
Logistics Challenges	• Movement restrictions in the face of employees, inbound/outbound goods, and documents.
Procurement Challenges	• Secure strategic goods/services needed to maintain operations continuity.

IT Challenges	• Expiration of Microsoft license, and ORACLE ERP support agreements. • Ensure proper remote working and communications without disruptions. • Ensure the effectiveness of IT business continuity and disaster recovery plans. • Provide continuous IT support. • Ensure taking backup tapes and adequate data centre conditions.
Medical Challenges	• Ensure sufficiency of the medical services capabilities and procedures.

To support the finding with literature, a recent study has been done on the Supply chain management during and post-COVID-19 pandemic: Mitigation strategies and practical lessons learned by (Raj, A. *et.al*, 2022) has summarized the challenges of supply chain management during the corona virus in the following figure 15.

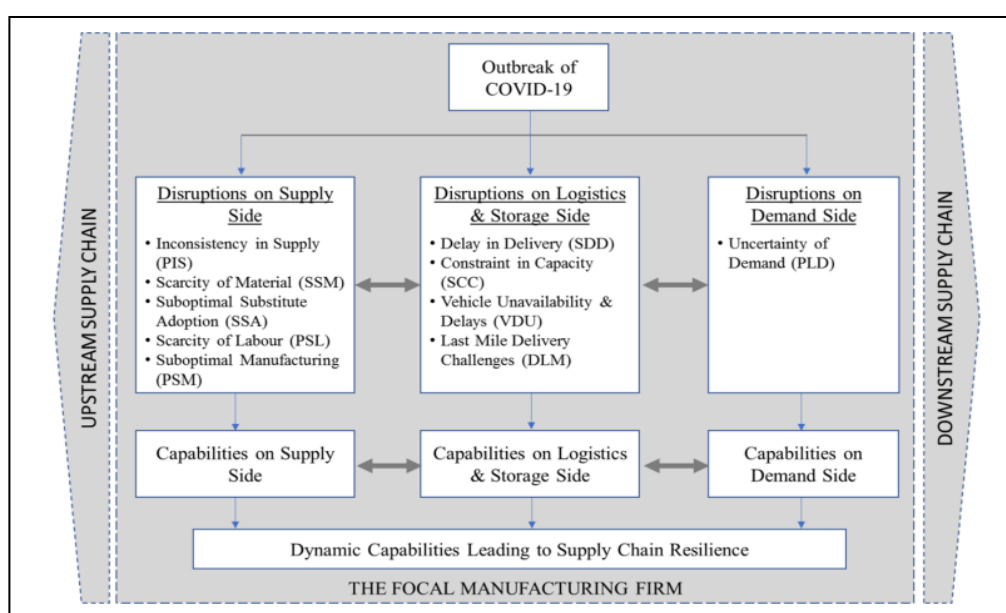


Figure 15. Supply Chain Challenges. Source :Journal of business research

- **Theme Three: Technology and digital Transformation after the pandemic**

COVID-19 has disrupted our lives and nearly every industry. Virtual services include healthcare and education. However, we are not yet at a place where we can "remotely" experience food, clothing, raw materials, health care supplies, etc. With this unparalleled pressure and breakage of supply chains comes unprecedented strain and breakage of supply chains. Failure to address crucial supply chain concerns could cause food shortages and global instability.

This is the first global supply chain disruption in decades, and businesses must adapt. Trade conflicts, nationalism, and local production could become the norm in the future; therefore, corporations must re-architect their supply chains to minimize disruption and economic value loss.

In the Forbes Finance Council article Goel, A. (2021) on the importance of technology in supply chains during the pandemic of coronavirus, it was revealed that 85% of global supply chains faced a drop in operations during the pandemic, and 6% shut down entirely, according to McKinsey & Company. Indeed, these are dark times. In these turbulent times, logistics firms are turning to modern technologies (cloud, digital, Internet of Things, and data analytics) to achieve the agility they require and have a better chance of not only surviving but prospering.

An article by Alicke, K., *et al.* (2021) that was published by McKinsey & Company on how the pandemic has shifted the supply chain. They ran a survey to investigate supply chain risk strategies. They reported that because of the virus, risk is now at the top of everyone's priority list at work. More than nine in ten respondents (95 percent) said businesses now have formal processes in place to manage supply chain risk. 59% of businesses claim they have implemented new supply-chain risk management techniques in the last year. In contrast, just a small percentage (4% of respondents) have created a new risk-management function from the start.

At APC, technology plays an important role in running their daily processes and integrating all the departments and parts of the supply chain together in a centralized and transparent way. However, they had to make some changes to their technology procedures and systems in order to adapt to the new situation and keep the business running during the whole pandemic. The respondents reported that the aid of technology and social networking

platforms was a huge help at the time of lockdown and in moving some businesses to work remotely. It helped them keep the information flowing and kept them updated about the business processes. They were able to communicate and discuss the new situation and possible solutions.

The IT team was able to move the system during the pandemic to a cloud instead of normal local servers to give the employees access to work remotely. Also, the respondents explained that their real-time visible system helped them act according to the disturbances and see the shortages with a complete integration between departments such as procurement, inventory, maintenance, and sales. However, the pandemic has shed light on the weaknesses of the supply chain and has accelerated the pace of digital transformation of the whole supply chain process.

Respondent 3 has responded with "a huge change. A great emphasis on the technology transformation of the whole business. A new contract with companies like Siemens, who are going to help us make the digital transformation for the whole business. Also, plans for automation and the use of artificial intelligence in the machines to be ready for any upcoming abnormal risk, or what's called AIOT (artificial intelligence of things), The company now depends more on the cloud than on normal servers. Also, machine learning is now being studied to be implemented in the system."

Also, Respondent 2 explained that "we are currently putting together a detailed digital transformation strategy for the entire APC operations to address all challenges, including supply chain challenges, and how technology can help with them." The maintenance director has informed us that during the pandemic they managed to prepare a whole room to remotely run all the machines in case the lockdown continued, and it can help keep the business running with the minimum manpower.

Automated systems and data analytics can help companies improve supply chain resilience, compliance, risk management, and recycling management. Companies will be able to identify supply chain issues such as delays, violations, and a lack of information with the use of AI and intelligent systems. Thomson Reuters says data analytics boost supply chain efficiency by validating data, discovering anomalies, benchmarking processes, allowing mobile reporting, and offering real-time route optimization, improved demand forecasts, and inventory management. As a result of the implementation of blockchain, there

will be greater openness and accountability in the supply chain. Blockchain technology has the potential to enhance data management in the supply chain and streamline interactions between suppliers, buyers, exchanges, and transporters. These technologies are essential for improving supply chain visibility.

The visibility of supply chain issues has been identified by Christopher and Lee (2004) as a critical determinant of risk management. The genuine deployment of supply chain visibility began with the digitization of supply chains. As a result of the cutting-edge digital transformation, large technology companies now have complete insight into their supply chains. End-to-end visibility is, in fact, a significant driver and capability of resilient supply chains, according to previous studies (Queiroz *et al.*, 2019; Sharma *et al.*, 2020; Wamba *et al.*, 2020). Supply chain visibility in pandemic conditions is a new area of study, though.

• Theme Four: Organizational Learning and Lessons Learned

On an unprecedented scale, the COVID-19 epidemic has impacted the operational environment of numerous businesses and supply networks (Queiroz *et al.*, 2020). To survive in today's very volatile and unpredictable business climate, companies have had to adapt. A key supply chain management perspective that has emerged from the epidemic is "resilience." Companies have spent a lot of time grappling with this idea.

As far as risk is concerned, supply chain interruptions fall into the unknown" category. The date and location of a risk occurrence can't be predicted for this type of risk. However, tiny and large-scale unknown hazards exist and cannot be totally eliminated from supply chains (Hudecheck *et al.*, 2020). Supply chain activities have been severely disrupted by the COVID-19 epidemic, which was caused by an unknown risk (Paul & Chowdhury, 2020). During the COVID-19 outbreak, manufacturing capacity declined due to social distancing restrictions and lockdowns (Paul *et al.*, 2021a); transportation and distribution networks were hampered; the supply of vital products was disturbed; and social and environmental sustainability practices were affected (Majumdar *et al.*, 2020). As a result of the COVID-19 outbreak's numerous adverse effects on supply chains, the global financial crisis has reached new heights (Kinatender *et al.*, 2021).

As a result of the COVID impact, the supply chain has been disrupted in both the upstream and downstream directions, increasing the robustness of the chain in the process (El Baz & Ruel, 2021; Deloitte, 2020; Sharma *et al.*, 2020). COVID's supply chain response

to resilience is a mixed bag. Several corporations have demonstrated resilience through improved forecasting and adaptiveness, potentially leading to a faster recovery. A lack of supply chain resilience response strategies, on the other hand, left many manufacturing supply networks unprepared for such a crisis (Scala & Lindsay, 2021). Researchers have emphasized several proactive and reactive supply chain resilience strategies for supply chain managers, such as "agility," "collaboration," "adaptability," "reconfigurability," "flexibility," "redundancy," and "viability," to prepare and recover for an unknown risk (such as the COVID pandemic response). Specific proactive supply chain resilience strategies, such as inventory risk mitigation, backup supply and transportation infrastructures, omnichannel distribution, flexible production technologies, agile collaboration, and data-driven real-time monitoring and visibility systems, have been advocated for by research to survive and recover through the pandemic or post-pandemic "new normal" commercial environment (Hosseini & Ivanov, 2020; Scala & Lindsay, 2021).

The COVID-19 pandemic outbreak has impacted long-term social and environmental structures. Human well-being, including social and mental health, education, and employment, has been threatened by the epidemic. Employees, suppliers, and customers are under increasing pressure to pay more attention to their well-being (Sharma *et al.*, 2020). Plastic waste management has become more difficult as a result of the pandemic's impact on consumer habits and the consequent rise in the use of personal protective equipment (PPE) and food packed in plastic (Vanapalli *et al.*, 2021). Research also suggests that the COVID-19 epidemic presents a possible opportunity for firms to make more true and honest contributions to addressing global social and environmental issues (He & Harris, 2020).

In order to ensure better decision-making and faster recovery, digitizing a supply chain necessitates extensive use of technology. Technology has the potential to improve resiliency while decreasing disruptions (Katsaliaki *et al.*, 2021). Technological innovations may assist a business in better monitoring and managing the risks associated with its supply chain (Sharma *et al.*, 2020). Industry (artificial intelligence, big data analytics, cloud services) technologies, including blockchain, machine learning, robotics, and three-dimensional (3D) printing, can be used to more quickly ramp up planning and forecasting, data analytics, product design, manufacturing, and distribution, which is essential during recovery to enhance supply chain resilience and sustainability (Sarkis, 2020). Technology may improve supply chain collaboration, swiftly capture market data, reduce distance between customers

and supply chain partners, and boost the ability to quickly respond to market demands. As a result of the COVID disruption, several supply chains have diversified their product portfolios, creating new goods based on current technology and expertise. 3D printing manufacturing has been examined as a way to meet the needs of pandemic frontlines by organizations (Larraneta *et al.*, 2020). The use of these technologies can be critical to improving supply chain visibility and efficiency, as well as reducing supply chain risk (Deloitte, 2020).

According to APC, COVID disruptions have pushed the company to speed up the pace of the digital transformation and enhance AI technology, big data, and fully automated systems in order to be proactively prepared for any upcoming risks. Moreover, they have developed a whole business management response plan toward agility and resilience to ensure the sustainability and robustness of the business.

Better awareness of health and safety procedures has been emphasized, along with new human resource management practices such as the importance of rotation and continuous training. Based on the response of respondent 1, he explained that they added a strategy for job rotation and on-the-job training to ensure that all the employees know how to run all the systems in case of a low manpower situation and are able to run all the systems with the minimum manpower all the time and be ready for all situations. Furthermore, a good amount of inventory stock increase was added for at least 6 to 10 months to avoid any shortages in spare parts or critical chemical materials.

The business continuity report of APC that has been prepared by Nsour, M., and Al-Rajoub, S. (2021) has summed up the lessons learned during the pandemic as the following:

- Develop a comprehensive BCP or RMP.
- Properly set and distribute workforce numbers to meet business processes and needs.
- Develop policies, procedures, and infrastructure for a remote working environment.
- Develop policies, procedures, and infrastructure for a paperless management system.
- deploy a face recognition attendance system.
- Encourage and promote job rotation practices.
- Secure enough contingency cash amounts on all company premises at all times.
- Consider more robust modes of transportation for the product by adopting a more feasible trucking outsourcing model to improve availability.

- Consider more efficient remote FAT in collaboration with major equipment suppliers for APC.
- institutionalize risk management practices at APC.
- Document and disseminate the whole set of risk management actions and RMP in APC during COVID-19.

5.10 QUANTITATIVE DATA ANALYSIS

In this part, quantitative data analysis for survey questions was performed using SPSS software to measure the constructs of the study. An exploratory descriptive analysis and normality analysis have been performed separately for each question separately, as shown below, and another exploratory factor analysis has been performed for each of the Demand Risk, Manufacturing Risk, Supply Risk, Operational Performance, Operational Responsiveness, Technology, and Integration scales. In factor analysis, attention has been paid to ensuring that the KMO value is above 0.60 and the Bartlett sphericity test probability value (p) is below 0.05. In addition, attention has been paid to ensuring that the extraction value for each item is over 0.40 and the eigenvalue is over 1.00. Items loaded on more than one factor and the difference in factor loading values below 0.20, that is, overlapping items, have been excluded from the scale. In addition, in cases where only one item has been loaded on a factor, the item has been removed from the scale.

The sample size was 162 respondents from people working at APC who had been asked 55 questions. Started with demographic questions to check their age, experience, contract type, and department where they work.

Each question's responses have been coded based on a Likert scale from 1 to 5, where 1 indicates "strongly disagree", 2 for "disagree", 3 for "Neither agree nor disagree", 4 for "agree" and finally 5 for "strongly agree".

5.10.1 Factor Analysis of the Demand Risk Scale

According to the factor analysis findings of the Demand Risk scale, which consists of 7 questions (DRQ1 to DRQ7), the KMO value has been found to be 0.81 and the p value of the Bartlett sphericity test has been found to be less than 0.05 (chi-square test statistic = 502.56; degrees of freedom = 21; p -value 0.000).

Extraction values for 7 items in the scale are presented in Table 8 below. Findings in the table indicate that the criteria values are met because all values are above 0.40. Scores greater than 0.4 are considered stable (Guadagnoli & Velicer, 1988).

Table 8. Extraction Scores of the Demand Risk Scale

Items	Initial	Extraction
DRQ1	1.000	0.66
DRQ2	1.000	0.68
DRQ3	1.000	0.17
DRQ4	1.000	0.72
DRQ5	1.000	0.53
DRQ6	1.000	0.60
DRQ7	1.000	0.52

When the Scree Plot graph presented in Figure 15 is examined, it is seen that there is only 1 factor with an Eigenvalue above 1.00 and there is a significant break after the 1st factor. Therefore, it is understood that the scale consists of a single factor structure.

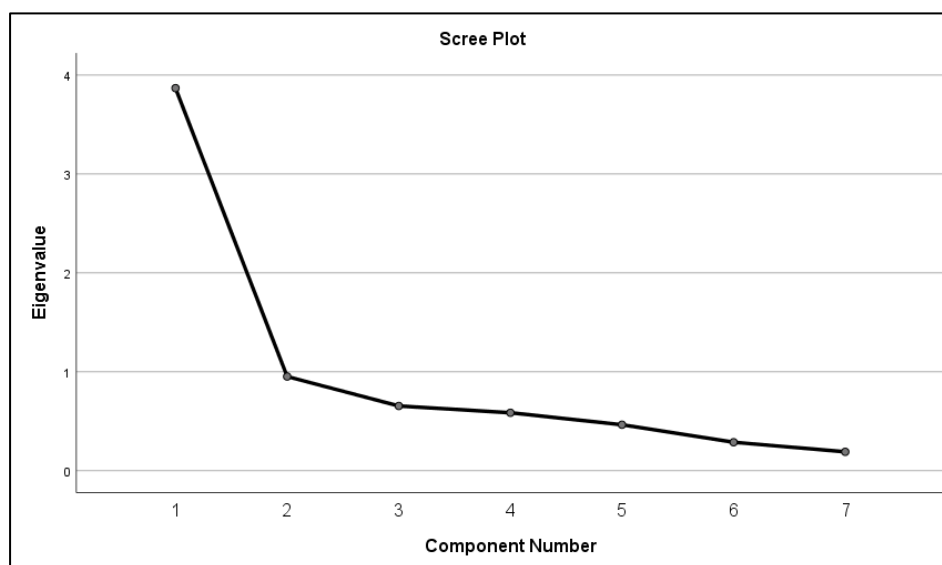


Figure 16. Demand Risk Scale Factor Analysis Scree Plot Chart

The factor analysis has shown that 7 items of the Demand Risk scale formed a single factor structure, and this single factor structure explained 55.25% of the variance. The factor loading of each item is shown in Table 9. In addition, the internal consistency reliability (Cronbach's alpha) coefficient of the scale is also shown in the table. Cronbach's alpha has been found to be 0.85, and since this value is over 0.70, the scale was accepted as reliable (Nakip & Yaraş, 2017).

Table 9. The Demand Risk Scale Factor Analysis Results

	Items	Statements	Factor Loadings
Factor 1	DRQ1	Changes in production planning (lengthened or shortened) were applied during Covid-19 pandemic.	0.81
	DRQ2	Raw material variety was enhanced during Covid-19 pandemic.	0.82
	DRQ3	There was a decrease in demand in terms of the market during Covid-19 pandemic.	0.41
	DRQ4	Effective solutions have been produced for sudden increases in demand during Covid-19 pandemic.	0.85
	DRQ5	Effective solutions have been produced for sudden decreases in demand during Covid-19 pandemic.	0.73

	DRQ6	A logistics system that can quickly respond to dynamic demands was established during Covid-19 pandemic.	0.77
	DRQ7	We always deliver on time to our customers. Our customers are connected to us by JIT systems.	0.72
Cronbach's alpha=0.85; Explained variance %55.25; Item number=7			

5.10.2 Factor Analysis of the Manufacturing Risk Scale

According to the factor analysis findings of the Manufacturing Risk scale, which consists of 7 statements (MRQ1 to MRQ7), the KMO value has been found to be 0.75 and the p value of the Bartlett sphericity test has been found to be less than 0.05 (chi-square test statistic = 488.65; degrees of freedom = 21; p -value 0.000).

Extraction values for seven items in the scale are presented in Table 10. Findings in the table indicate that the criteria values are met because all values are above 0.40. (Guadagnoli & Velicer, 1988).

Table 10. Extraction Scores of the Manufacturing Risk Scale

Items	Initial	Extraction
MRQ1	1.000	0.67
MRQ2	1.000	0.61
MRQ3	1.000	0.77
MRQ4	1.000	0.78
MRQ5	1.000	0.68
MRQ6	1.000	0.50
MRQ7	1.000	0.79

When the Scree Plot graph presented in Figure 17 is examined, it is seen that there are 2 factors with an Eigenvalue above 1.00 and there is a significant break after the 2nd factor. Therefore, it has been understood that the scale consisted of a two-factor structure.

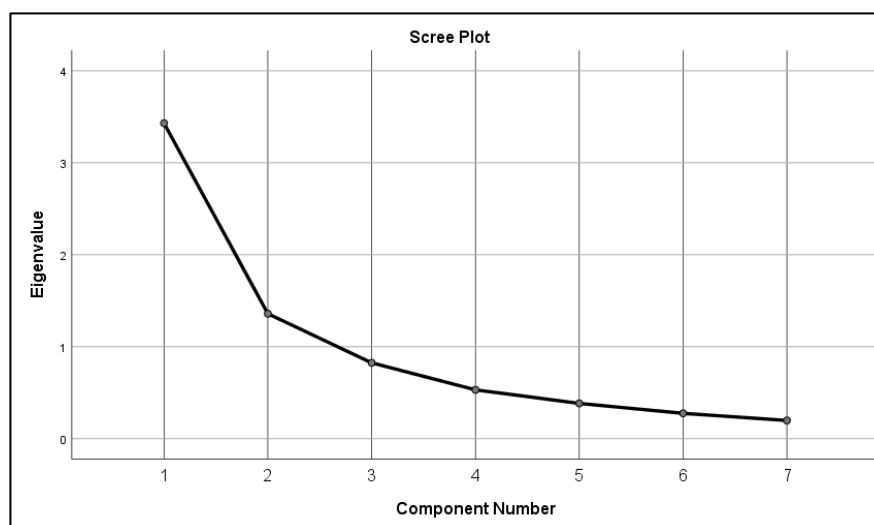


Figure 17. The Manufacturing Risk Scale Factor Analysis Scree Plot Chart

The factor analysis has shown that seven items of the manufacturing risk scale form a two-factor structure, and this two-factor structure explained 68.40% of the variance. The factor loading of each item in each factor is shown in Table 11 below. Since there is no overlapping item, no item is removed. In addition, the internal consistency reliability (Cronbach's alpha) coefficients for each factor in the scale are also shown in the table. Cronbach's alpha for factor 1 is 0.65, and Cronbach's alpha for factor 2 is 0.86. Since these values are close to or above 0.70, the scales are accepted as reliable (Nakip & Yaraş, 2017). These two factors of the manufacturing risk scale are named Manufacturing Inventory Risk and Manufacturing Strategy Risk.

Table 11. The Manufacturing Risk Scale Factor Analysis Results

	Items	Statements	Factor Loadings
Factor 1 (Manufacturing Inventory Risk)	MRQ1	Manufacturing strategy is effectively implemented.	0.81
	MRQ7	We had a shortage of raw materials that impacted the machines and the production of Potash.	0.88
Cronbach's alpha=0.65; Explained variance %22.35; Item number =2			
Factor 2 (Manufacturing Strategy Risk)	MRQ2	Risk mitigating techniques were developed proactively.	0.74
	MRQ3	During covid-19 there were a lot of strategic changes as a responsive manner.	0.86

	MRQ4	Social distances and health precautions were taken to the maximum.	0.87
	MRQ5	Supervisors monitored and detected abnormal health conditions to take actions and ensure the pandemic won't spread.	0.82
	MRQ6	There is no substitute for our production technology	0.70
Cronbach's alpha=0.86; Explained variance %46.05; Item number =5			

5.10.3 Factor Analysis of the Supply Risk Scale

According to the factor analysis findings of the Supply Risk scale, which consists of 8 questions (SRQ1 to SRQ7), the KMO value has been found to be 0.82 and the p value of the Bartlett sphericity test has been found to be less than 0.05 (chi-square test statistic = 638.65; degrees of freedom = 28; p -value 0.000).

Extraction values for eight items in the scale are presented in Table 12. Findings in the table indicate that the criteria values are met because all values are above 0.40. (Guadagnoli & Velicer, 1988).

Table 12. Extraction Scores of the Supply Risk Scale

Items	Initial	Extraction
SRQ1	1.000	0.65
SRQ2	1.000	0.67
SRQ3	1.000	0.77
SRQ4	1.000	0.80
SRQ5	1.000	0.51
SRQ6	1.000	0.73
SRQ7	1.000	0.67
SRQ8	1.000	0.65

When the Scree Plot graph presented in Figure 18 is examined, it is seen that there are 2 factors with an Eigenvalue above 1.00 and there is a significant break after the 2nd factor. Therefore, it has been understood that the scale consisted of a two-factor structure.

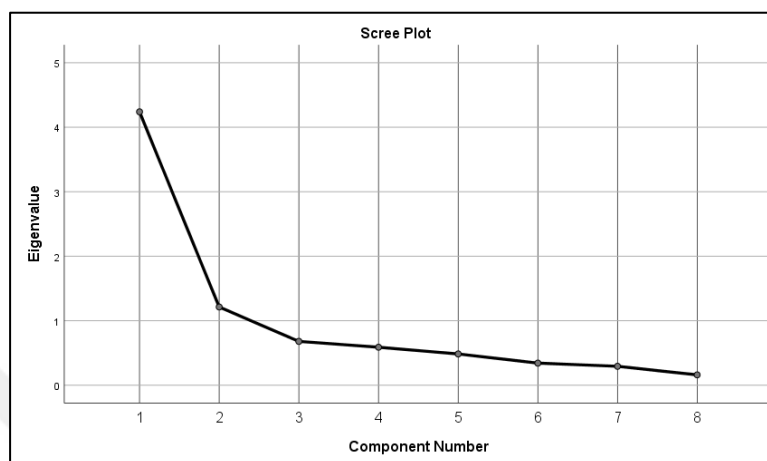


Figure 18. The Supply Risk Scale Factor Analysis Scree Plot Chart

The factor analysis has shown that 8 items of the supply risk scale formed a two-factor structure, and this two-factor structure explained 68.15% of the variance. The factor loading of each item in each factor is shown in the table below. Since there is no overlapping item, no item is removed. In addition, the internal consistency reliability (Cronbach's alpha) coefficients for each factor in the scale are also shown in Table 13. Cronbach's alpha for factor 1 is 0.88, and Cronbach's alpha for factor 2 is 0.73. Since these values are above 0.70, the scales are accepted as reliable (Nakip & Yaraş, 2017). These two factors of the supply risk scale are named Supplier Relationship Risk and Supplier Delivery Risk.

Table 13. The Supply Risk Scale Factor Analysis Results

	Items	Statements	Factor Loadings
Factor 1 (Suppliers Relation Risk)	SRQ1	Our suppliers deliver to us on just-in-time basis.	0.81
	SRQ4	Partners understand our goals for supply chain management.	0.83

	SRQ6	Our suppliers fairly treat us in making important decisions.	0.82
	SRQ7	We had gain new suppliers during covid-19.	0.69
	SRQ8	Partners understand that we expect them to continuously improve their supply chain operations.	0.76
Cronbach's alpha=0,88; Explained variance %52,99; Item number =5			
Factor 2 (Suppliers Delivery Risk)	SRQ2	There was a delay in delivering raw materials and spare parts.	0.80
	SRQ3	Late delivery affected our supply chain processes.	0.87
	SRQ5	Our supply base is quite small, compared with our competitors.	0.62
Cronbach's alpha=0.73; Explained variance %15.16; Item number =3			

5.10.4 Factor Analysis of the Operational Performance Scale

According to the factor analysis findings of the Operational Performance Scale, which consists of 7 questions (PERQ1 to PERQ7), the KMO value has been found to be 0.78 and the p value of the Bartlett sphericity test has been found to be less than 0.05 (chi-square test statistic = 493.93; degrees of freedom = 21; p -value 0.000).

Extraction values for seven items in the scale are presented in Table 14 below. Findings in the table indicate that the criteria values are met because all values are above 0.40. (Guadagnoli & Velicer, 1988).

Table 14. Extraction Scores of the Operational Performance Scale

Items	Initial	Extraction
PERQ1	1.000	0.57
PERQ2	1.000	0.48
PERQ3	1.000	0.53

PERQ4	1.000	0.54
PERQ5	1.000	0.50
PERQ6	1.000	0.59
PERQ7	1.000	0.72

When the Scree Plot graph presented in Figure 19 is examined, it is seen that there is only 1 factor with an Eigenvalue above 1.00, and there is a significant break after the 1st factor. Therefore, it has been understood that the scale consisted of a single factor structure.

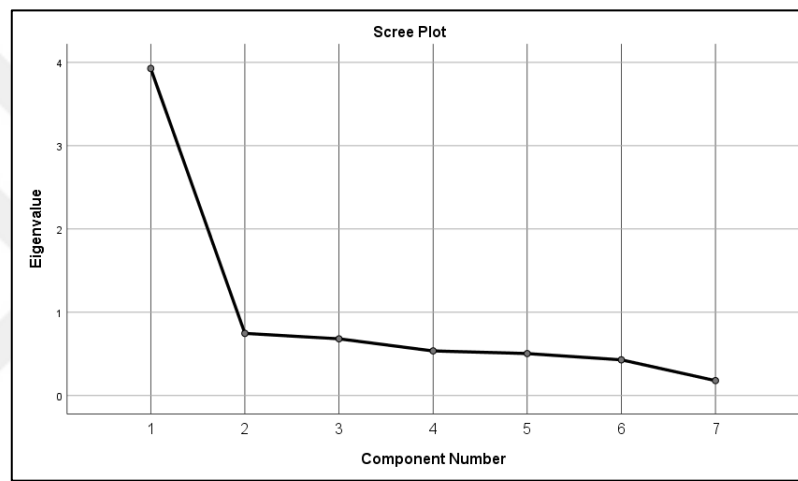


Figure 19. Operational Performance Scale Factor Analysis Scree Plot Chart

The factor analysis has shown that 7 items of the operational performance scale form a single factor structure, and this single factor structure explained 56.10% of the variance. The factor loading of each item is shown in the table below. In addition, the internal consistency reliability (Cronbach's alpha) coefficient of the scale is also shown in Table 15. Cronbach's alpha has been found to be 0.87, and since this value is over 0.70, the scale is accepted as reliable (Nakip & Yaraş, 2017)

Table 15. The Operational Performance Scale Factor Analysis Results

	Items	Statements	Factor Loadings
Factor 1	PERQ1	The inventory policy was adapted to avoid stock problems.	0.75
	PERQ2	Transportation modes and methods were changed during Covid-19 pandemic.	0.69
	PERQ3	A new product or service has been developed in accordance with the pandemic conditions during Covid-19 pandemic.	0.73
	PERQ4	Different cost policies were applied during Covid-19 pandemic.	0.74
	PERQ5	Changes in production planning (lengthened or shortened) were applied during Covid-19 pandemic.	0.71
	PERQ6	Quality of product was not affected during the pandemic.	0.77
	PERQ7	Risk mitigation plans and continuity actions were taking effectively during the pandemic.	0.85
Cronbach's alpha=0.87; Explained variance %56.10; Item number =7			

5.10.5 Factor Analysis of the Operational Responsiveness Scale

According to the factor analysis findings of the Operational Responsiveness Scale, which consists of 5 questions (RESQ1 to RESQ5), the KMO value has been found to be 0.74 and the p value of the Bartlett sphericity test has been found to be less than 0.05 (chi-square test statistic = 309.70; degrees of freedom = 10; p -value 0.000).

Extraction values for five items in the scale are presented in Table 16. Findings in the table indicate that the criteria values are met because all values are above 0.40. (Guadagnoli & Velicer, 1988)

Table 16. Extraction Scores of the Operational Responsiveness Scale

Items	Initial	Extraction
RESQ1	1.000	0.43
RESQ2	1.000	0.63
RESQ3	1.000	0.45
RESQ4	1.000	0.71
RESQ5	1.000	0.72

When the Scree Plot graph presented in Figure 20 is examined, it is seen that there is only 1 factor with an Eigenvalue above 1.00 and there is a significant break after the 1st factor. Therefore, it has been understood that the scale consisted of a single factor structure.

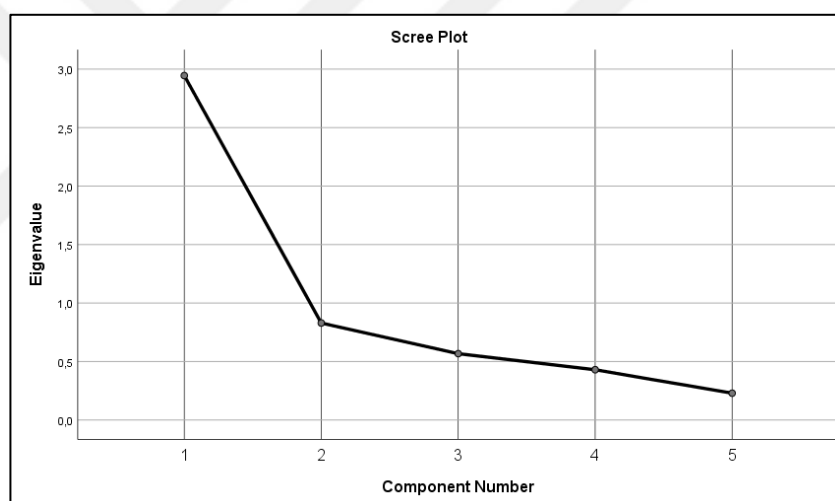


Figure 20. Operational Responsiveness Scale Factor Analysis Scree Plot Chart

The factor analysis has shown that five items of the operational responsiveness scale form a single factor structure, and this single factor structure explained 58.89% of the variance. The factor loading of each item is shown in Table 17. In addition, the internal consistency reliability (Cronbach's alpha) coefficient of the scale is also shown in the table. Cronbach's alpha has been found to be 0.81, and since this value is over 0.70, the scale is accepted as reliable (Nakip & Yaraş, 2017).

Table 17. The Operational Responsiveness Scale Factor Analysis Results

	Items	Statements	Factor Loadings
Factor 1	RESQ1	Innovative products or services suitable for pandemic conditions were launched.	0.66
	RESQ2	Transportation modes and methods were changed.	0.79
	RESQ3	Delivery times were changed.	0.67
	RESQ4	Collaboration was established between supply chain members.	0.84
	RESQ5	New technological investments were made.	0.85
Cronbach's alpha=0.81; Explained variance %58.89; Item number =5			

5.10.6 Factor Analysis of the Technology Scale

According to the factor analysis findings of the Technology scale, which consists of 5 questions (TECQ1 to TECQ5), the KMO value has been found to be 0.82 and the p value of the Bartlett sphericity test has been found to be less than 0.05 (chi-square test statistic = 403.53; degrees of freedom = 10; p -value 0.000).

Extraction values for five items in the scale are presented in Table 18. Findings in the table indicate that the criteria values are met because all values are above 0.40. (Guadagnoli & Velicer, 1988).

Table 18. Extraction Scores of the Technology Scale

Items	Initial	Extraction
TECQ1	1.000	0.62
TECQ2	1.000	0.62
TECQ3	1.000	0.74
TECQ4	1.000	0.81
TECQ5	1.000	0.51

When the Scree Plot graph presented in Figure 21 is examined, it is seen that there is only 1 factor with an Eigenvalue above 1.00 and there is a significant break after the 1st factor. Therefore, it has been understood that the scale consisted of a single factor structure.

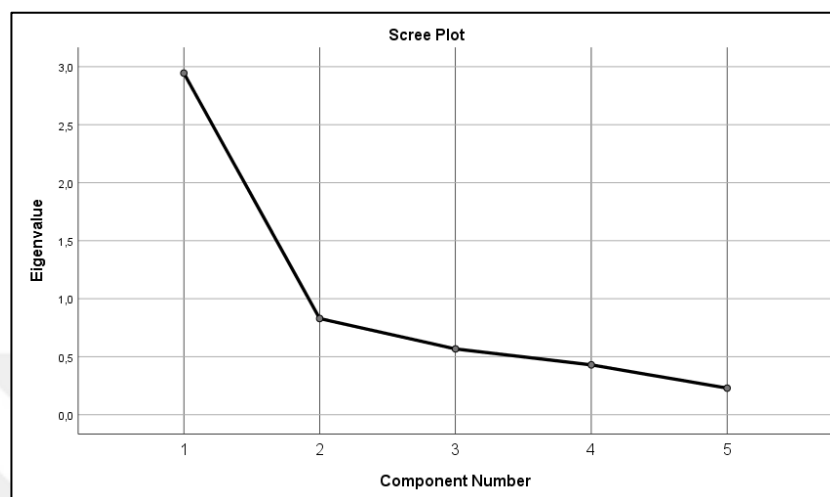


Figure 21. Technology Scale Factor Analysis Scree Plot Chart

The factor analysis has shown that 7 items of the technology scale form a single factor structure, and this single factor structure explained 66.03% of the variance. The factor loading of each item is shown in Table 19. In addition, the internal consistency reliability (Cronbach's alpha) coefficient of the scale is also shown in the table. Cronbach's alpha has been found to be 0.87, and since this value is over 0.70, the scale is accepted as reliable (Nakip & Yaraş, 2017).

Table 19. The Technology Scale Factor Analysis Results

	Items	Statements	Factor Loadings
Factor 1	TECQ1	Our company uses real-time inventory information and analytics in managing the supply chain.	0.79
	TECQ2	New technological investments were made during Covid-19 pandemic.	0.79
	TECQ3	New AI systems and machine learning will be added to the system.	0.86

	TECQ4	All the work is digitized and documented on real time servers.	0.90
	TECQ5	There was no problem during the lockdown working with the system from home.	0.71
Cronbach's alpha=0.87; Explained variance %66.03; Item number =5			

5.10.7 Factor Analysis of the Integration Scale

According to the factor analysis findings of the Integration Scale, which consists of 9 questions (INTQ1 to INTQ9), the KMO value has been found to be 0.86 and the p value of the Bartlett sphericity test has been found to be less than 0.05 (chi-square test statistic = 1021.42; degrees of freedom = 36; p -value 0.000).

Extraction values for nine items in the scale are presented in Table 20. Findings in the table indicate that the criteria values are met because all values are above 0.40. (Guadagnoli & Velicer, 1988).

Table 20. Extraction Scores of the Integration Scale

Items	Initial	Extraction
INTQ1	1.000	0.66
INTQ2	1.000	0.85
INTQ3	1.000	0.77
INTQ4	1.000	0.66
INTQ5	1.000	0.77
INTQ6	1.000	0.60
INTQ7	1.000	0.72
INTQ8	1.000	0.75
INTQ9	1.000	0.76

When the scatter plot graph presented in Figure 22 is examined, it is seen that there are 2 factors with an Eigenvalue above 1.00, and there is a significant break after the 2nd factor. Therefore, it has been understood that the scale consisted of a two-factor structure. However, it has been found that the INTQ5 item is loaded on both factors, and the difference in factor loadings is less than 0.20 (0.69 and 0.54); in other words, it is overlapping. Likewise, it has

been found that the INTQ6 item load on both factors and the difference in factor loadings are less than 0.20 (0.58 and 0.52); in other words, they are overlapping. It is also true for INTQ7 items (0.62 and 0.59). Starting with the INTQ7 item, which has less difference, these items have been removed from the scale, respectively, and the factor analysis has been repeated. In the calculations made after the INTQ7 and INTQ6 items have been removed from the scale, it has been seen that the INTQ5 item is no longer overlapping, and this item is kept in the scale. In this last calculation, since it has been seen that the INTQ9 item has been loaded on Factor 2 alone, this item has also been removed from the scale. Factor analysis is repeated with the remaining six items on the scale.

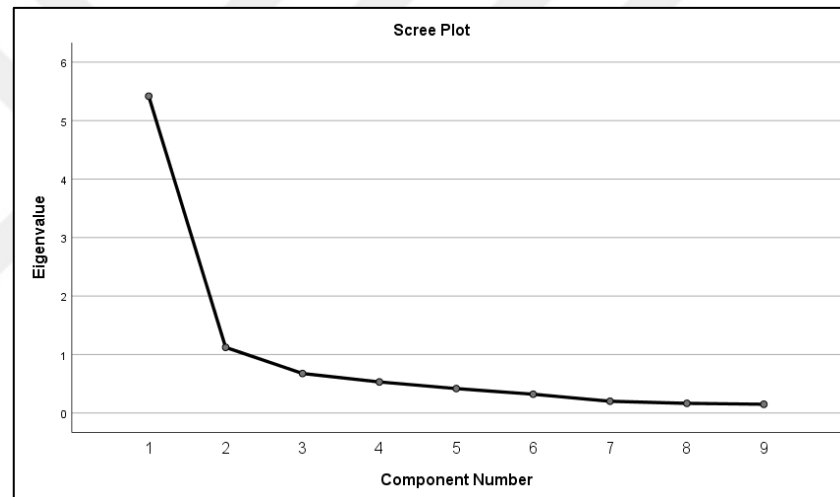


Figure 22. The Integration Scale Factor Analysis Scree Plot Chart

The final factor analysis has shown that six items of the integration scale form a single factor structure, and this single factor structure explains 70.72% of the variance. The factor loading of each item is shown in Table 21. In addition, the internal consistency reliability (Cronbach's alpha) coefficient of the scale is also shown in the table. Cronbach's alpha has been found to be 0.92, and since this value is over 0.70, the scale is accepted as reliable (Nakip & Yaraş, 2017).

Table 21. The Integration Scale Factor Analysis Results

	Items	Statements	Factor Loadings
Factor 1	INTQ1	Meetings are regularly held to share improvement ideas with our suppliers.	0.80
	INTQ2	Our suppliers are encouraged to continuously improve their production processes.	0.87
	INTQ3	Our vision and supply chain policy are shared with suppliers.	0.88
	INTQ4	Assistance is provided when our suppliers try to improve their processes.	0.83
	INTQ5	Functions are well integrated in our plant.	0.82
	INTQ8	Our business strategy is implemented without conflicts between functions.	0.84
Cronbach's alpha=0.92; Explained variance %70.72; Item number =6			

Furthermore, in Table 22 below, the minimum and maximum values of the nine variables used in the research model, as well as the arithmetic means and standard deviations, are given. The table also shows the results of the normality analysis of these nine variables. Skewness and kurtosis values have been used for normality analyses. While skewness gives information about whether the distributions around the mean are asymmetrical or not, kurtosis gives information about whether the distributions are normal, peaked, or flattened. A value of "0" for skewness indicates that the distribution is not positively or negatively biased and that the distribution is normal. A kurtosis value of "0" also indicates that the distribution is not peaked or broadened but is normal. Values close to "0" for both measures are considered ideal. Hair *et al.*, (2010) and Byrne (2010) have stated that in the social sciences, if the skewness value is in the range of 2 and the kurtosis value is in the range of 7, the distributions can be considered normal. According to table.19 below, the minimum and maximum values of the nine variables used in the research model, as well as the arithmetic means and standard deviations, are given. The table also shows the results of the normality analysis of these nine variables. Skewness and kurtosis values have been used for

normality analyses. While skewness gives information about whether the distributions around the mean are asymmetrical or not, kurtosis gives information about whether the distributions are normal, peaked, or flattened. According to Brown (2006), skewness levels between -3 and +3 are considered acceptable, whereas kurtosis values between -10 and +10 are considered suitable.

Table 22. Normality Analysis and Descriptive Statistics

Variables	Min.	Max	$\bar{X}$	Ss	Skewnes	Kurtosis
Demand Risk	1.00	4.71	3.60	0.69	-2.23	6.79
Manufacturing Inventory Risk	1.00	5.00	2.62	0.93	0.14	-0.20
Manufacturing Strategy Risk	1.00	5.00	3.89	0.77	-2.20	6.27
Suppliers Relation Risk	1.00	5.00	3.63	0.73	-1.91	5.25
Suppliers Delivery Risk	1.00	5.00	3.26	0.85	-0.80	0.64
Operational Performance	1.00	5.00	3.88	0.74	-1.88	5.48
Operational Responsiveness	1.00	5.00	3.61	0.73	-1.76	5.24
Technology	1.00	5.00	3.63	0.78	-1.48	3.36
Integration	1.00	5.00	3.90	0.80	-1.44	3.65

According to the findings in Table 22, it has been found that the lowest perceived risk is manufacturing inventory risk (2.62) and the highest perceived risk is manufacturing strategy risk (3.89). The findings have shown that the operational performance level is 3.88. Since this value is close to the statement *I agree with* in the questionnaire, it can be said that the level of agreement with the statements about operational performance is high. Findings have shown that the operational responsiveness level is 3.61. Since this value is between the expression *I agree* and the expression *Neither agree nor disagree*, but closer to the expression *I agree*, it can be said that the level of agreement with the statements about operational performance is relatively high. It has been determined that the level of agreement

with the statements about integration (3,90) is higher than the level of participation in the statements about technology (3,63).

When the skewness values in the table are examined, it is seen that these values are between or very close to the criterion values of 2. Likewise, it is seen that the kurtosis values are within the range of 7. Based on these findings, it has been accepted that the distribution of the data is normal.

Based on Table 23 below, each question's mean, skewness, and kurtosis values were analyzed separately to confirm the normality and most perceived responses as found in the table 19 above.

Table 23. Descriptive analysis of items and Normality tests

Questions	MEAN	skewness	Kurtosis
Integration			
INTQ1. Meetings are regularly held to share improvement ideas with our suppliers.	4.02	-1.403	2.09
INTQ2. Our suppliers are encouraged to continuously improve their production processes.	4.09	-1.308	2.264
INTQ3. Our vision and supply chain policy are shared with suppliers.	3.9	-1.305	2.251
INTQ4. Assistance is provided when our suppliers try to improve their processes	3.92	-1.469	3.3
INTQ 5. Functions are well integrated in our plant.	4.03	-1.093	0.975
INTQ 6. Problems between functions are easily solved.	3.49	-1.073	0.367
INTQ 7. Functional coordination in our plant works well.	3.74	-1.358	1.481
INTQ 8. Our business strategy is implemented without conflicts between functions.	3.72	-0.751	0.056
INTQ 9. There were difficulties dealing with some partners during lockdown that affected the business.	3.82	-0.423	-0.631
Operational Performance			
PERQ1.The inventory policy was adapted to avoid stock problems.	3.89	-1.108	1.538
PERQ2.Transportation modes and methods were changed during Covid-19 pandemic.	3.77	-0.904	0.555

PERQ3.A new product or service has been developed in accordance with the pandemic conditions during Covid-19 pandemic.	3.60	-0.771	0.292
PERQ4.Different cost policies were applied during Covid-19 pandemic.	3.75	-1.045	1.430
PERQ5.Changes in production planning (lengthened or shortened) were applied during Covid-19 pandemic.	3.68	-0.682	-0.180
PERQ6. Quality of product was not affected during the pandemic.	4.37	-1.950	3.455
PERQ7. Risk mitigation plans and continuity actions were taking effectively during the pandemic.	4.17	-1.677	3.480
Technology			
TECQ1. Our company uses real-time inventory information and analytics in managing the supply chain.	3.89	-1.289	2.468
TECQ2.New technological investments were made during Covid-19 pandemic.	3.65	-0.869	0.783
TECQ3. New AI systems and machine learning will be added to the system.	3.58	-0.632	0.726
TECQ 4. All the work is digitized and documented on real time servers.	3.48	-0.928	0.612
TECQ 5. There was no problem during the lockdown working with the system from home.	3.52	-0.914	0.311
Demand Risk			
DRQ1. Changes in production planning (lengthened or shortened) were applied during Covid-19 pandemic.	3.70	-0.928	0.863
DRQ2. Raw material variety was enhanced during Covid-19 pandemic.	3.44	-0.592	0.578
DRQ3. There was a decrease in demand in terms of the market during Covid-19 pandemic.	2.99	-0.441	-0.507
DRQ4. Effective solutions have been produced for sudden increases in demand during Covid-19 pandemic.	3.89	-1.450	3.264
DRQ5. Effective solutions have been produced for sudden decreases in demand during Covid-19 pandemic.	3.75	-1.356	2.340
DRQ6. A logistics system that can quickly respond to dynamic demands was established during Covid-19 pandemic.	3.81	-1.216	1.845
DRQ7. We always deliver on time to our customers. Our customers are connected to us by JIT systems.	3.61	-0.897	1.685

Supply Risk			
SRQ1. Our suppliers deliver to us on just-in time basis.	3.9	-0.734	0.167
SRQ2. There was a delay in delivering raw materials and spare parts.	3.72	-0.746	0.033
SRQ3. Late delivery affected our supply chain processes.	3.26	-0.356	-0.671
SRQ4. Partners understand our goals for supply chain management.	3.84	-1.641	3.659
SRQ5. Our supply base is quite small, compared with our competitors.	3.00	-0.074	-0.244
SRQ6. Our suppliers fairly treat us in making important decisions.	3.53	-0.717	1.456
SRQ7. We had gain new suppliers during covid-19	3.66	-1.230	2.520
SRQ8. Partners understand that we expect them to continuously improve their supply chain operations.	3.78	-1.534	3.532
Manufacturing Risk			
MRQ1.Manufacturing strategy is effectively implemented.	2.65	0.392	-0.403
MRQ2. Risk mitigating techniques were developed proactively.	3.80	-1.034	1.289
MRQ3.During covid-19 there were a lot of strategic changes as a responsive manner.	3.87	-1.332	2.414
MRQ4.Social distances and health precautions were taken to the maximum.	4.28	-2.247	6.730
MRQ5.Supervisors monitored and detected abnormal health conditions to take actions and ensure the pandemic won't spread.	4.19	-1.541	2.162
MRQ6. There is no substitute for our production technology.	3.30	-0.530	-0.059
MRQ7. We had a shortage of raw materials that impacted the machines and the production of Potash.	2.59	0.333	-0.629
Operational Responsiveness			
RESQ1.Innovative products or services suitable for pandemic conditions were launched.	3.38	-0.555	-0.044
RESQ2.Transportation modes and methods were changed.	3.60	-1.005	0.676
RESQ3. Delivery times were changed.	3.47	-0.762	0.430
RESQ4. Collaboration was established between supply chain members.	3.79	-1.223	2.656

RESQ5. New technological investments were made.	3.81	-1.363	3.019
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For The demographics questions were tabulated below in table 24 and analyzed as percentages and pie charts.

Table 24. Demographics Questions

Demographic Questions
Q1. About how long have you been in your current position?
Q2. What's your employment status?
Q3. In which department you are currently working?
Q4. What's your age?
Q5. Sustainable planning has played a great role in mitigating risks during the pandemic
Q6. Integrating sustainability into each phase of the system has added value to the strategic risk planning
Q7. Sustainability is the future of risk management and control

Question 1 responses in Figure 23 indicate that %36 of employees at APC have 0–4 years of experience, followed by %29.81 for employees who have experience of more than 15 years, which was followed by %26.92 for 5–10 years' experience, indicating that the people working in the company are very experienced and skilled people.

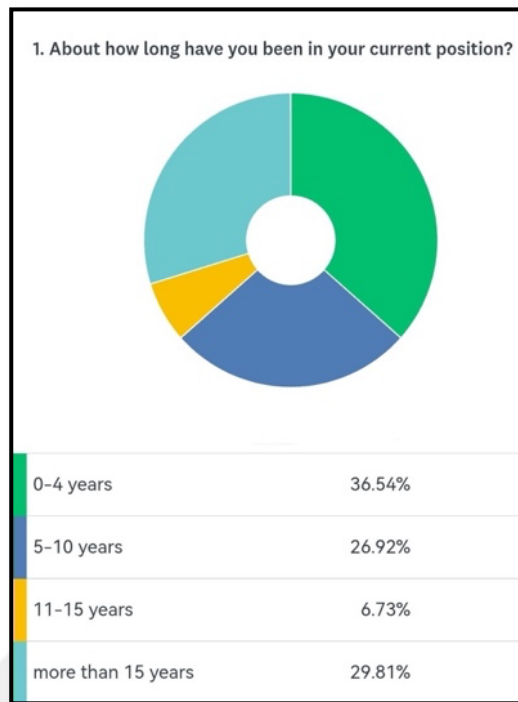


Figure 23. Employee's Experience

Question 2 responses indicate that %94 of the employees is working with full time job contract and non-part time contractor at all as shown in figure 24.

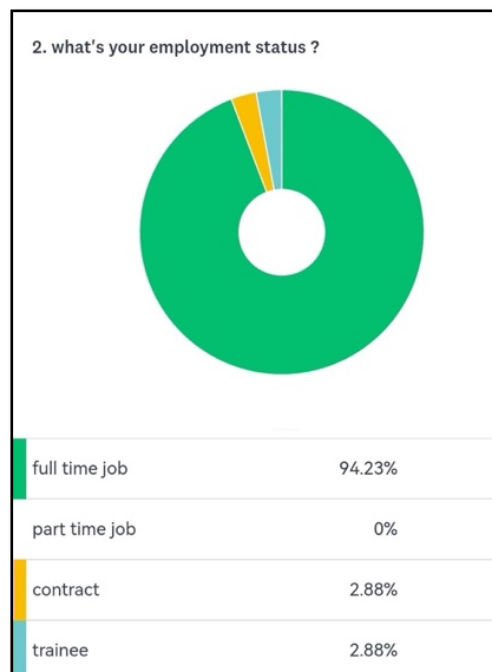


Figure 24. Employment status

Question 3 in figure 26 shows the different departments where respondents work and their percentages, while question 4 in figure 26 confirms question 1 as it indicates that %43 of people working at APC are from ages 45–54, followed by %25.9 of age 25–35, proving that people working in the company are highly experienced and skilled people.

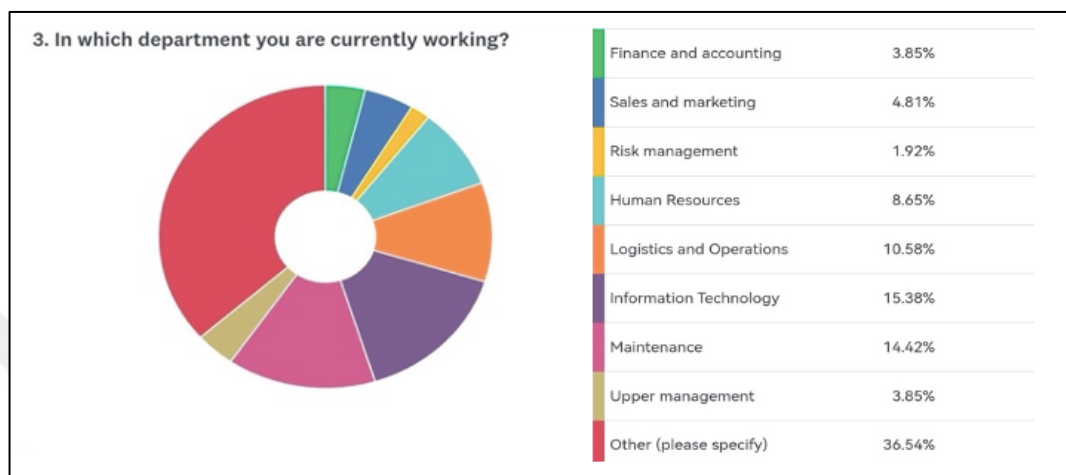


Figure 25. APC's departments responses

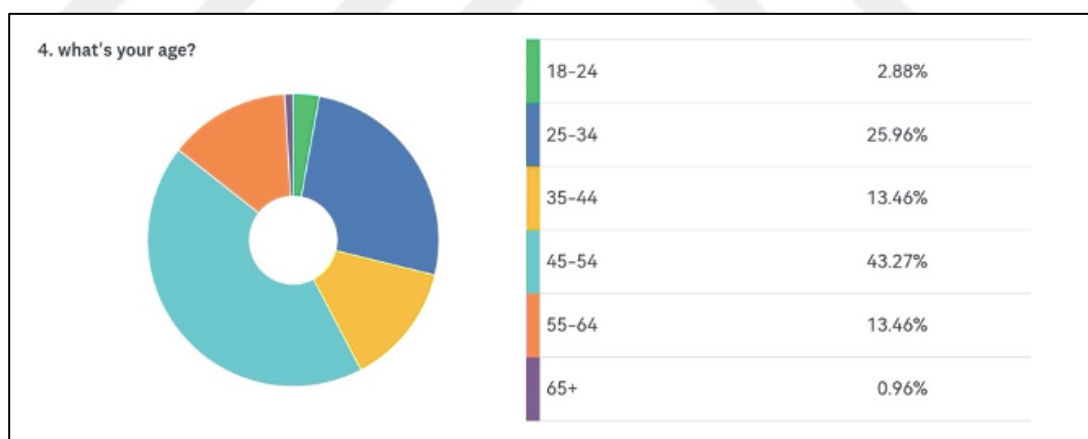


Figure 26. Employee's Age range

Questions 5 through 7 were intended to check the importance of sustainability risk management, showing a %94 in its role of mitigating risk, %93 of adding value to strategic risk planning, and %94 of seeing it as the future for risk control, as shown below in figure 27.

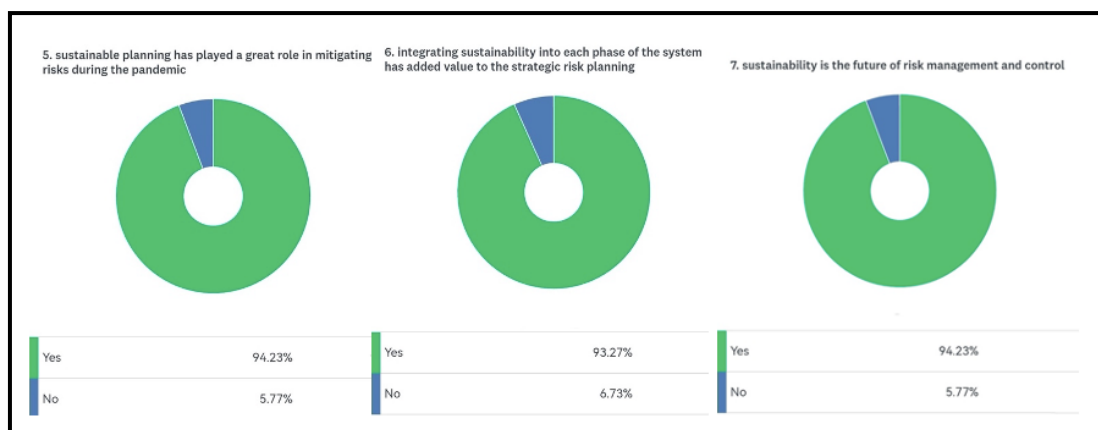


Figure 27. Sustainability risk management

5.11 CORRELATIONS ANALYSIS RESULTS

In this section, the relationships among the demand risk, manufacturing strategy risk, manufacturing inventory risk, supplier relationship risk, supplier delivery risk, operational performance, operational responsiveness, technology, and integration variables have been analyzed, and the results are shown in Table 25 below.

Table 25. Relationship Analyses

	DR	MIR	MSR	SRR	SD	OP	OR	T	I
DR	1								
MI	0.47*	1							
MS	0.79*	0.24*	1						
SR	0.88*	0.41*	0.73	1					
SD	0.55*	0.58*	0.36	0.52	1				
OP	0.81*	0.30*	0.79	0.74	0.4	1			
OR	0.79*	0.39*	0.74	0.79	0.5	0.8	1		
T	0.83*	0.47*	0.77	0.81	0.4	0.7	0.7	1	
I	0.73*	0.38*	0.77	0.71	0.4	0.7	0.6	0.7	1

DR: Demand Risk, MIR: Manufacturing Inventory Risk, MSR: Manufacturing Strategy Risk, SRR: Suppliers Relation Risk, SDR: Suppliers Delivery Risk, PO: Operational Performance, OR: Operational Responsiveness, T: Technology, I: Integration.

** The relationship between the variables is significant at the 0.01 level.

According to the findings in Table 22 above, there are significant positive relationships between demand risk, manufacturing strategy risk, manufacturing inventory risk, supplier relationship risk, supplier delivery risk, and operational performance ($r = 0.81$ and $p 0.05$, respectively; $r = 0.30$ and $p 0.05$; $r = 0.79$ and $p 0.05$; $r = 0.74$ and $p 0.05$; $r = 0.49$ and $p 0.05$). In other words, when there is an increase in demand risk, manufacturing strategy risk, manufacturing inventory risk, supplier relationship risk, and supplier delivery risk perception levels, an increase in operational performance perception levels is also observed, so H1 was proved to be valid and accepted.

Similarly, there are positive and significant relationships between demand risk, manufacturing strategy risk, manufacturing inventory risk, supplier relationship risk, supplier delivery risk, and operational responsiveness ($r = 0.79$ and $p 0.05$, $r = 0.39$ and $p 0.05$, $r = 0.74$ and $p 0.05$, $r = 0.79$ and $p 0.05$, $r = 0.58$ and $p < 0.05$, 0.05 , respectively). In other words, when there is an increase in demand risk, manufacturing strategy risk, manufacturing inventory risk, supplier relationship risk, and supplier delivery risk perception levels, an increase in operational responsiveness perception levels is also observed. Hence, H2 was proved to be correct and accepted.

There are also significant positive relationships between demand risk, manufacturing strategy risk, manufacturing inventory risk, supplier relationship risk, supplier delivery risk, and technology ($r = 0.835$, $r = 0.475$, $r = 0.775$, $r = 0.815$, $r = 0.425$, respectively). In other words, when there is an increase in demand risk, manufacturing strategy risk, manufacturing inventory risk, supplier relationship risk, and supplier delivery risk perception levels, an increase in technology perception level is also observed. And based on these findings, H3 was also proven to be right and accepted.

There are also positive and significant relationships between demand risk, manufacturing strategy risk, manufacturing inventory risk, supplier relationship risk, supplier delivery risk, and integration ($r = 0.735$, $r = 0.385$, $r = 0.775$, $r = 0.715$, $r = 0.445$, respectively). In other words, when there is an increase in demand risk, manufacturing strategy risk, manufacturing inventory risk, supplier relationship risk, and supplier delivery risk perception levels, there is an increase in integration perception level, which makes H4 acceptable.

The findings in the table have shown that the variables demand risk, manufacturing strategy risk, manufacturing inventory risk, supplier relationship risk, and supplier delivery

risk have positive and significant relationships among themselves. In other words, the increase in the perception level of any of these risk types is seen as an increase in the perception level of the others.

5.12 QUANTITATIVE SUPPLY CHAIN PERFORMANCE MEASURES

The primary purpose of performance assessment is to provide useful information that helps businesses better satisfy their clients' needs and achieve their long-term objectives. Customer satisfaction may be a good indicator of a company's performance; therefore, it's crucial to track how well their expectations are being met. Organizational practices, techniques, and resources along the supply chain may be measured for their efficiency and effectiveness using supply chain performance metrics. To some extent, it lays the groundwork for comprehending the entire system, influencing participant and stakeholder behavior, and providing data on the effectiveness of the supply chain as a whole.

Based on the literature, cost, return on assets (ROA), sales, asset turnover, return on investment (ROI), market share, inventory turnover, profit margin, revenue growth, economic value added (EVA), and cash-to-cash cycle are the most widely used metrics for measuring financial performance, as found in research by Galankashi, M., and Rafiei, F. (2021). For APC Supply Chain Performance, performance was measured by financial outcomes that were stated in the company's annual reports since 2017.

Based on the annual reports of the company, at APC, staff turnover reached 4.8% at the end of 2021. In addition, APC set a new sales record of 2.631 million tons of potash, compared to 2.553 million tons in 2020. Another one of APC's successes is that the company's earnings have reached JOD 217 million, an increase of 71% over the previous record of JOD 127 million in 2020.

The figure 28 below shows the increase ratios between years 2020 and 2021, showing an increase in gross margin of 10%10 and the liabilities decreasing by 2%, and profit margin increasing by 6%.

#	Ratio	2021	2020
1	Gross Margin	49%	39%
2	Total Liabilities to Assets Ratio	19%	17%
3	Profit Margin	33%	28%

Figure 28. increase ratios of APC in two years

At the end of 2021, a share of Arab Potash Company (APC) stock had risen in value from its closing price of JOD (21) in 2020 and JOD (20.45) in 2019 to a total of JOD (26.22). The following graph in Figure 29 displays the closing price of APC shares (2019–2021). In June 2021, the share closing price of the corporation hit a record high of JOD 33.

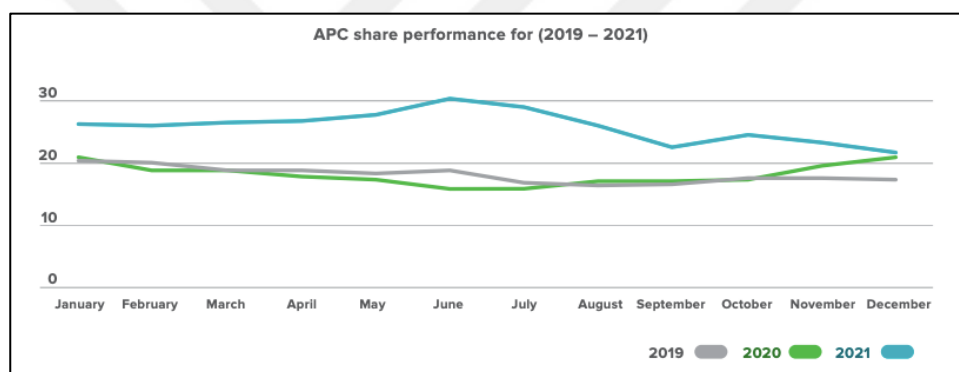


Figure 29. the closing price of APC shares (2019 – 2021)

The table 26 below shows in numbers how APC has performed every year since 2017 until 2022. The table includes yearly production in tons, sales of potash in tons, sales revenues, gross profit, shareholder's equity, return on assets, and return on shareholder's equity.

Table 26. APC performance from year 2017 - 2021

	2017	2018	2019	2020	2021	2022
Potash Production – thousand ton	2,32	2,436	2,486	2,62	2,563	2,684
Potash Sales – thousand ton	2,36	2,439	2,408	2,553	2,631	2,621
Consolidated Sales Revenue	423,277	482,727	504,608	456,169	648,01	1,268,192
Potash Sales Revenue	364,332	427,156	459,824	395,113	583,937	1,206,224
Gross profit	104,755	166,697	226,179	179,355	316,556	913,402
Profit from Operations	58,337	106,033	150,483	102,293	238,501	738,012
Net Profit After Tax	89,843	124,874	151,695	126,89	216,717	601,228
Shareholders' Equity	807,885	845,095	891,701	932,777	1,067,410	1,575,328
Return On Assets	10%	13%	14%	11%	18%	38%
Return On Shareholders' Equity	10%	15%	17%	14%	22%	46%

According to the reports, the company's performance has improved, which reflects better decision-making processes and improvements in supply chain management that were reflected directly in the annual reports by increased sales and revenues and better equity. Noticeably, the proactive strategies in managing risks and the overall supply chain strategies are paying off their results, and as reported by the managers, they will pay off more in the future. According to the annual report of 2022, APC has managed to outperform the past years with better performance, higher sales, and the highest product sales in the company's history after they stated their strategic themes and managed to make the risk department separate from the auditing department as it was before, and they have managed to do continuous assessments of risks in order to plan and overcome any upcoming possible risks that can impact the business. The following chart in Figure 30 summarizes what has been mentioned in Table 27.

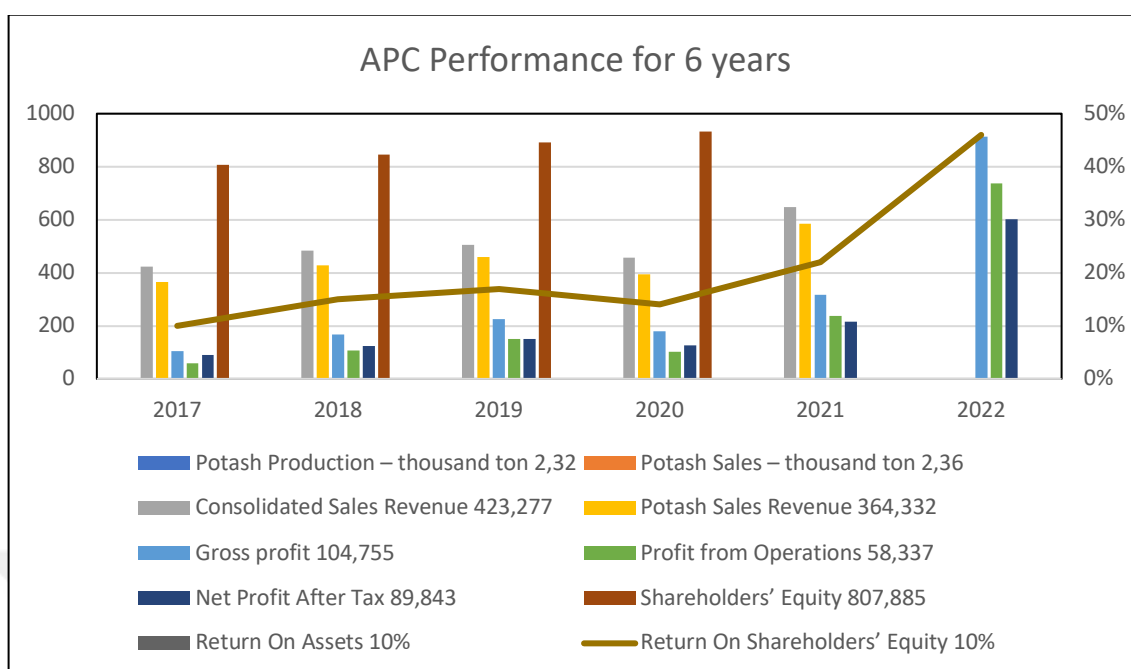


Figure 30. APC performance from year 2017- 2022

The figures 31 through 36 below show the effect of performance on sales revenue over the years. They show that APC has increased their sales, profits, and ROE, and all these are high indicators of APC's improved performance and productivity.

According to the annual reports presented by APC, there are three strategic themes applied at the company: short- to medium-term plans, medium- to long-term plans, and short- to long-term plans. According to these themes, the company will strengthen its core and prepare for inevitable change.

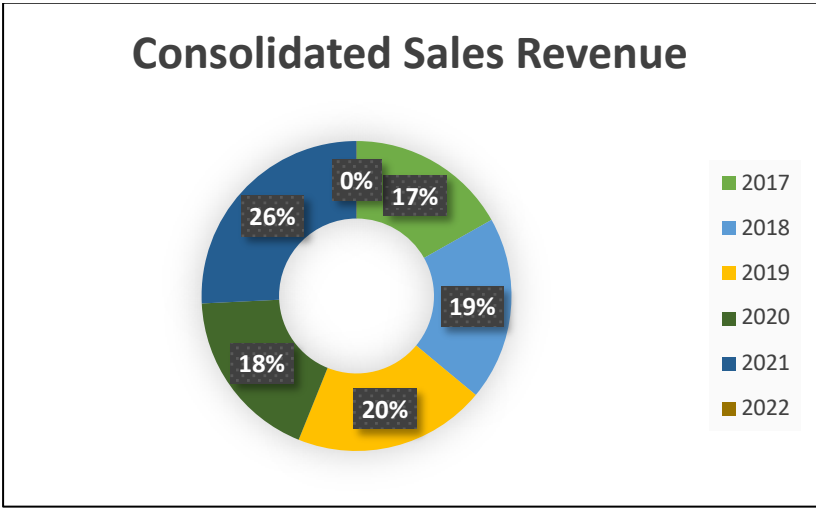


Figure 31. Consolidated sales revenue of APC

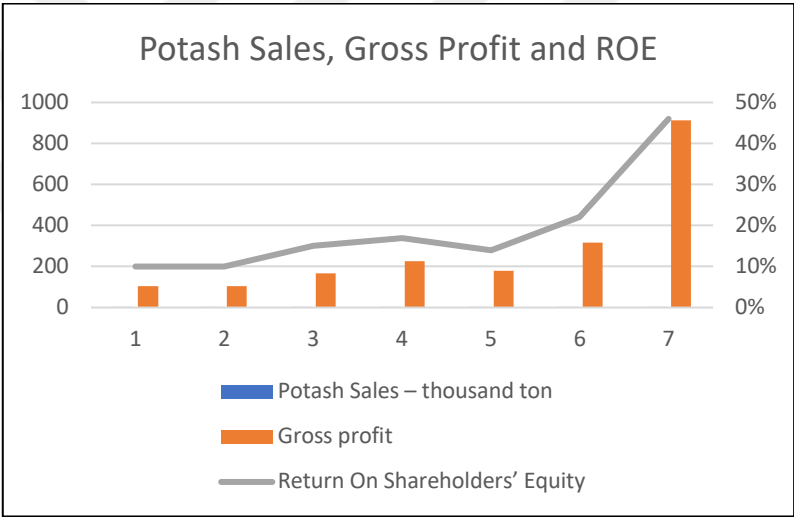


Figure 32. Potash sales, gross profit and ROE for APC

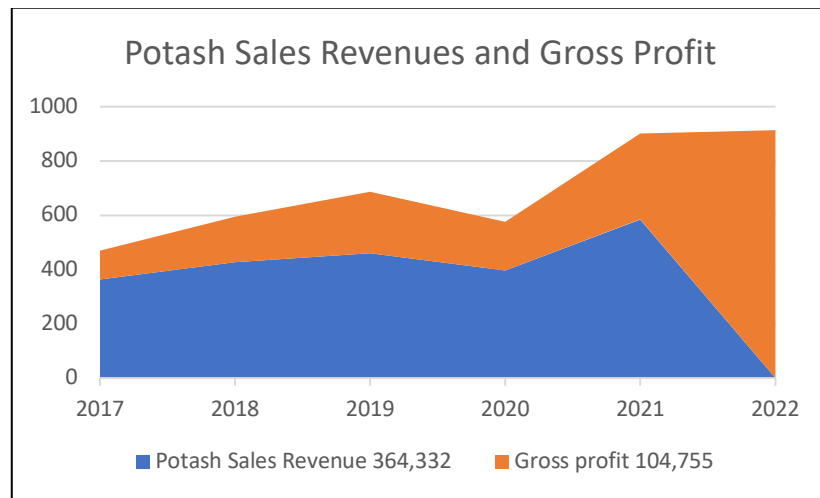


Figure 33. Potash sales revenue and gross profit of APC

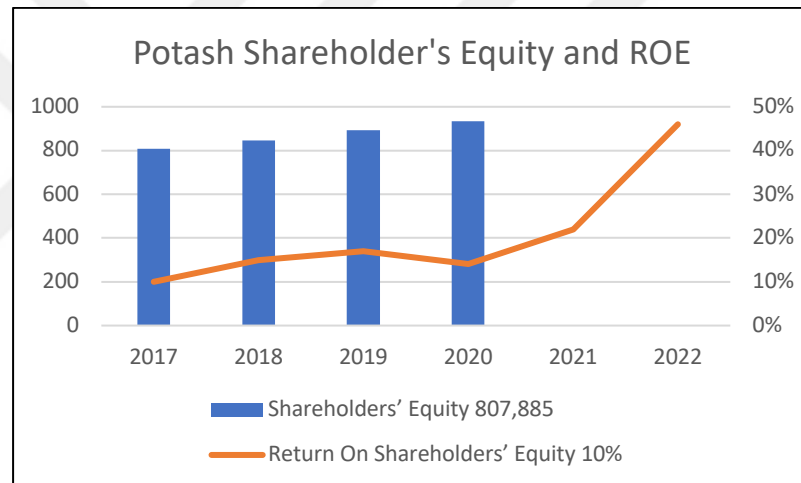


Figure 34. Shareholder's Equity and ROE for APC

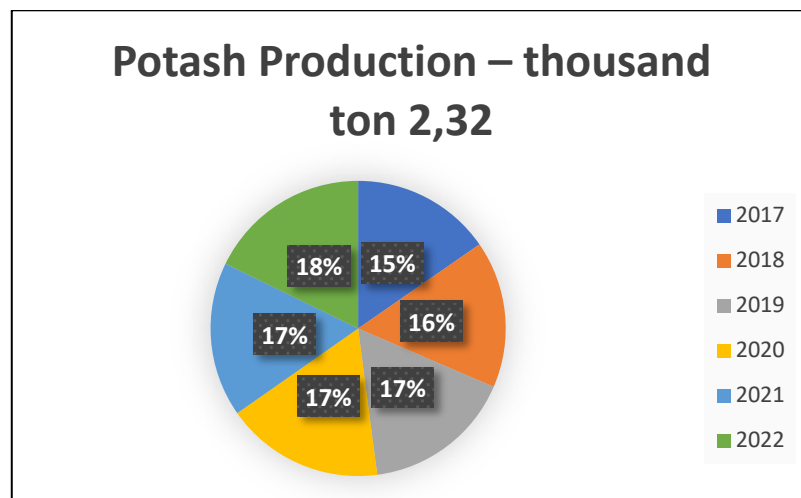


Figure 35. Potash Production of APC.

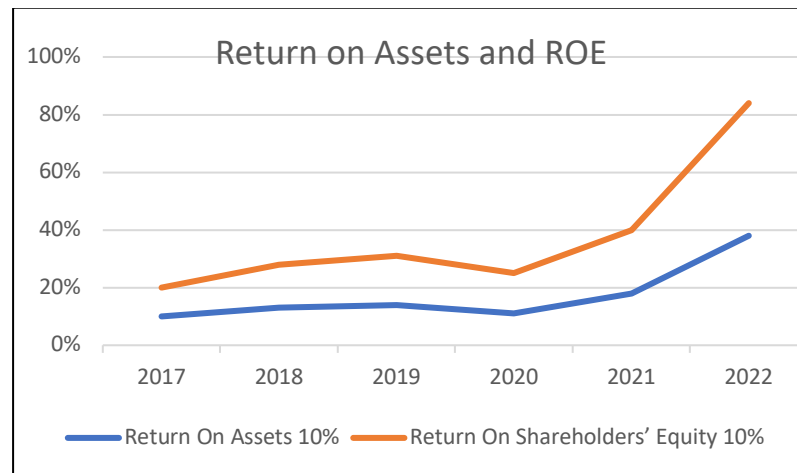


Figure 36. Returns on Shareholder's Equity and Returns on Assets for APC

6. CHAPTER SIX: THESIS DISCUSSION

The purpose of this research was to examine the risk mitigation tactics and procedures utilized by APC to manage or overcome high-impact hazards like the COVID-19 pandemic. Several business sectors throughout the world have been affected by the consequences of COVID-19, such as the lockdown, social distance, and border closure, which have led numerous enterprises to incur enormous losses or even fail. In order to prevent such concerns, a number of businesses utilized various strategies to overcome the situation.

Potash is mainly used as a fertilizer, and any disturbance to this business will have an impact on the agriculture output. APC was selected due to its achievements throughout the epidemic. Their mitigating measures were studied in depth during the course of the study.

Risks have been classified differently based on their source, whether they are external or internal, financial, technological, reputational, compliance, operational, or fraud risks. Any of the aforementioned sorts of hazards can have a significant impact on the organization if they are not effectively analyzed and managed. Nevertheless, recognizing these risks at a preliminary phase can assist business managers in turning these threats into opportunities that could result in greater revenues for the organization, as was the case with APC during COVID-19.

It was determined that APC was able to complete all of its goals throughout the pandemic as a result of its comprehensive cooperation procedures and proactive tactics, which allowed the firm to identify all of the risks it faces, categorize their impact, develop response measures, and implement them effectively. The exploratory research found that APC is an ambidextrous organization that simultaneously employs proactive and reactive techniques. The strategic management of the company has established proactive strategies that can deal with any type of known risk, as well as procedures to deal with each risk. Additionally, the management has ensured that they have qualified personnel who are well-trained and experienced to respond to any new, unknown threat, as well as a backup plan for the situation.

APC has a comprehensive plan for all external and internal threats that their company may face on a daily basis. In addition, they had planned for unforeseen or extremely unusual occurrences, such as strikes and protests, which aided them during the pandemic because

some of the events were comparable, such as a labor shortage that might create delivery delays, low productivity, and a poor reputation. Due to these preemptive initiatives and the establishment of an emergency department during the pandemic, APC was able to convert the majority of the dangers into opportunities to boost productivity, improve technology, increase sales, profitability, and market share. As seen, the pandemic was a significant move that demonstrated how the APC workforce collaborates for a better purpose. as busy as a beehive, with everyone working around the clock to ensure that the epidemic poses no threat and, if anything, serves as an incentive for everyone to do their absolute best.

In the business world, risks cannot be eliminated or prevented completely, but they may be controlled or reduced to a level where they pose no threat. This means that strategic managers need to think about the many risks their industry faces during a project, the potential consequences of each risk, and the means by which these risks might be mitigated or even avoided. In addition, it is the responsibility of every business to maintain a competent and well-trained workforce that can perform well under stress and uncertainty.

6.1 SUMMARY AND CONCLUSION

Based on the literature and the interviews that have been done with the managers of departments in APC, along with the documents that have been collected from the company, it was concluded that in order for supply chain risk management to be effective and for any business to mitigate such unplanned and heavy impact risks, they have to be ambidextrous to create the needed resiliency in a volatile environment.

As the global business environment becomes increasingly complicated and unpredictable, it is revealed through occasional discontinuities rather than continuous shifts. Technological and social transformations, economic and political situations, present and potential competitors, and the COVID-19 pandemic drive these changes. Complex global supply chains are prone to instability. The developing disturbance creates problems along the SC and increases the firm's risk it is revealed through occasional discontinuities rather than continuous shifts. Technological and social transformations, economic and political situations, present and potential competitors, and the COVID-19 pandemic drive these changes. Complex global supply chains are prone to instability. The developing disturbance creates problems along the SC and increases the firm's risk. When supply chain disruptions

occur, it is critical that organizations have an effective response plan in place that can be implemented quickly and at a low cost (Kochan and Nowicki, 2018). Supply chain resilience (SCRES) provides the ability to prepare for, adapt to, respond to, and quickly recover from unexpected events (Ali *et al.*, 2017).

To put it another way, SCRES is the supply chain's ability to be prepared for unexpected risk events, respond quickly to potential disruptions, and return to its original state or grow by moving into a new, more desirable one so that it can improve customer service, market share, and financial performance. When it comes to SCRES, it is important to note that it recognizes both the ability to withstand extreme events and the ability to adapt to new circumstances, which is a responsive capability for the performance of an organization as well as an important aspect of its survival (Brusset & Teller, 2017).

As a result of these conflicts, organizational ambidexterity (OA) is seen as a phenomenon that threatens the long-term viability of companies. If an organization is capable of doing two things at the same time, it is described as having the ability to pursue two different strategic orientations at the same time (Clauss *et al.*, 2020) or the ability to concurrently explore and exploit (O'Reilly & Tushman, 2013). Organizational Ambidexterity draws heavily on the dynamic capability notion (O'Reilly & Tushman, 2011; Yan *et al.*, 2016; Popadiuk *et al.*, 2018) and incorporates paradoxes into a single complex construct (Claudia & Mihaela, 2019). This type of organization is ambidextrous, meaning it focuses on both new possibilities and old certainty (March, 1991). In the context of an organization or an alliance, this idea focuses on the trade-offs between exploration and exploitation. Wei *et al.* of these conflicts, organizational ambidexterity (OA) is seen as a phenomenon that threatens the long-term viability of companies. If an organization is capable of doing two things at the same time, it is described as having the ability to pursue two different strategic orientations at the same time (Clauss *et al.*, 2020) or the ability to concurrently explore and exploit (O'Reilly & Tushman, 2013).

In the context of an organization or an alliance, this idea focuses on the trade-offs between exploration and exploitation. Wei *et al.*, (2014) claim that exploration and exploitation operations appear to be contradictory yet are significantly connected.

Aslam *et al.*, (2020) define SC ambidexterity as the ability to adapt supply chain design to market changes while aligning the motivations of supply chain partners. Study results

show that OA was critical in producing SCRES during and following the COVID-19 epidemic. SCRES tactics established during the COVID-19 pandemic were based on both exploitation and exploration approaches in SCM. In addition, the proactive and reactive aspects of the SCRES strategy are reflected in the highlighted practices. They will become more proactive following the COVID-19 epidemic, centered on either exploitation or exploration.

Ambidextrous firms are needed in today's fast-changing business environment in order to achieve long-term success or even survival (Bahar & Akhtar, 2020). Because of the constantly changing nature of the environment, it is imperative that the right amount of effort is put into both exploiting resources and exploring new ones in order to achieve maximum efficiency. According to Simsek (2009); Kassotaki *et al.*, (2019); and Aslam *et al.*, (2020) OA can improve organizational performance and SCRES. The best strategy for a company in uncertain times is to focus on activities that allow it to leverage its current strengths and discover new ones.

Based on the quantitative analysis, it was found that APC employees were highly responsive when any kind of risk appeared, and their performance was significantly increased in times of risk in order to maintain the quality and production of their product and ensure delivery of shipments on time. Sustainable risk management in APC, with the importance of integration and collaboration between departments with the help of technology, has played a great role in managing risks and ensuring the high performance of the company in all situations.

The study was able to offer broad rules that can assist businesses in overcoming threats in any situation. The main guidelines are as follows:

- First, every organization must design a strategic business theme that encompasses short-, medium-, and long-term goals and then convey these themes to all divisions with clear actions and a vision.
- Second, the talent-strategic HR department must ensure that the organization has the appropriate skills and workforce in order to develop and preserve its sustainability. In addition, ensuring that employees have the latest technology and training required for their employment And as a result, the company will be continuously prepared to

invent new ways to drive the business to greater success and greater accomplishments. Training and directing all upper and intermediate management personnel so that they are prepared to respond to any unexpected incident with expertise and a high degree of responsibility

- Third, having a department of strategic risk management that is responsible for creating scenarios for all potential and uncommon dangers and developing a plan to overcome or minimize them. Additionally, having frequent risk assessments and control actions to ensure that all operations are running smoothly and that nothing will negatively impact the firm
- Fourth, technology and digitization: today, any firm must be fully digitized and employ cutting-edge technological advancements that make it ready to perform under all conditions.
- Fifth, create highly integrated systems that may consistently contribute to the organization's success in order to improve communication across all levels of management and between departments.
- Sixth, have a sustainable management planning to ensure resilience, stability and robustness in the business as it is considered very important in supply chain risk management.
- Lastly, have a diversified business model portfolio in order to minimize and mitigate risks in supply chains.

6.2 LIMITATIONS AND FUTURE RECOMMENDATIONS.

On-site inspections were not feasible because of the pandemic situation and social distance regulations in place at the time of the investigation. Further, it was difficult to visit some of the business sites outside of Amman due to the nature of the business.

This thesis is fundamentally an exploratory one-case study with qualitative content analysis. The second quantitative section merely helps to support the major assumptions that attempt to investigate the relationships between variables. Further empirical investigations

with larger sample numbers will be necessary to assess the questionnaires' quantitative reliability and validity. Hence, redundancy and the possibility of multicollinearity may be avoided. This will also pave the way for future research models to incorporate and examine the potential moderating impacts of technology and integration factors. Furthermore, a survey might be conducted to assess risk mitigation measures that have been applied in the private sector, other sectors, or nations, or even to improve the results of the APC case study.

Given that Russia is one of the world's top producers of potash, the current scenario in the Russian-Ukrainian war is causing a fresh disruption in the potash supply chain. Potash demand and supply may be significantly impacted by the present political climate, and this influence can be studied.

Studying how culture affects risk mitigation methods and tactics in Jordan or the Middle East is another suggestion.

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APPENDIX

ATLAS.ti Report

APC risk plan

Codes

Report created by zainab beirouty on 27 May 2022

Effect Of Pandemic On Supply Chain, Delivery, Creditability , Client Relation, Quality,
Etc

Created: 16.05.2022 by zainab beirouty, Modified: 27.05.2022 by zainab beirouty

Linked Codes:

← is associated with – ● challenges during covid

← is associated with – ○ inventory management

– is cause of → ● risk management steps during pandemic

Groups:

Effect of pandemic on supply chain

APC breif

Created: 27.05.2022 by zainab beirouty, Modified: 27.05.2022 by zainab beirouty

Applicability

Created: 16.05.2022 by zainab beirouty, Modified: 16.05.2022 by zainab beirouty

Linked Codes:

← is a – ● risk management steps during pandemic

Groups:

◊ risk management plannning

Challenges During Covid

Created: 16.05.2022 by zainab beirouty, Modified: 16.05.2022 by zainab beirouty

Linked Codes:

– is associated with → ● Effect of pandemic on supply chain, delivery, crediability,
client relation, quality,etc

– is part of → ○ lessons learned

← is cause of – ● risk management procedures

– is cause of → ● risk management steps during pandemic

Groups:

◊ Effect of pandemic on supply chain

Changes To The Supply Chain After The Pandemic

Created: 16.05.2022 by zainab beirouty, Modified: 16.05.2022 by zainab beirouty

Groups:

Integration And Information Flow

Created: 16.05.2022 by zainab beirouty, Modified: 27.05.2022 by zainab beirouty

Linked Codes:

– is cause of → ● technology and digitization

Groups:

◊ risk management **planning**

Inventory Management

Created: 16.05.2022 by zainab beirouty, Modified: 16.05.2022 by zainab beirouty

Linked Codes:

– is associated with → ● **effect** of pandemic on supply chain, delivery, **creditability**, client relation, quality, etc

← is property of – ● technology and digitization

Groups:

◊ risk management **planning**

Job Responsibilities

Created: 16.05.2022 by **Zainab Beirouty**, Modified: 16.05.2022 by **Zainab Beirouty**

Linked Codes:

– is associated with → ● type of risk management plan

Groups:

◊ risk management **planning**

Lessons Learned

Created: 27.05.2022 by **Zainab Beirouty**, Modified: 27.05.2022 by zainab beirouty

Linked Codes:

← is part of – ● challenges during covid

Readiness For The Pandemic

Created: 16.05.2022 by zainab beirouty, Modified: 16.05.2022 by zainab beirouty

Linked Codes:

– is cause of → ● technology and digitization

– is cause of → ● type of risk management plan

Groups:

◊ affect of pandemic on supply chain

Risk Management Procedures

Created: 16.05.2022 by zainab beirouty, Modified: 16.05.2022 by zainab beirouty

Linked Codes:

– is cause of → ● challenges during covid

← is associated with – ● type of risk management plan

Groups:

◊ risk management planning

Risk Management Steps During Pandemic

Created: 16.05.2022 by zainab beirouty, Modified: 27.05.2022 by zainab beirouty

Linked Codes:

← is cause of – ● Effect of pandemic on supply chain, delivery, **credibility**, client relation, **quality, etc**

– is a → ○ applicability

← is cause of – ● challenges during covid

Groups:

◊ **effect** of pandemic on supply chain

Risk Planning Team

Created: 16.05.2022 by zainab beirouty, Modified: 27.05.2022 by zainab beirouty

Groups:

◊ risk management **planning**

Technology And Digitization

Created: 16.05.2022 by zainab beirouty, Modified: 27.05.2022 by zainab beirouty

Linked Codes:

← is cause of – ● integration and information flow

– is property of → ○ inventory management

← is cause of – ○ readiness for the pandemic

– is associated with → ● type of risk management plan

Groups:

◊ risk management planning

Type Of Risk Management Plan

Created: 16.05.2022 by zainab beirouty, Modified: 16.05.2022 by zainab beirouty

Linked Codes:

- ← is associated with – ● Job responsibilities
- ← is cause of – ○ readiness for the pandemic
- is associated with → ● risk management procedures
- ← is associated with – ● technology and digitization

Groups:

✧ risk management planning

APC risk plan

Code links

Report created by zainab beirouty on 27 May 2022

- ✧ affect of pandemic on supply chain, delivery, crediability , client relation, quality,etc
- – is cause of → ● risk management steps during pandemic
- ✧ challenges during covid → – is associated with → ● affect of pandemic on supply chain, delivery, crediability , client relation, quality,etc
- ✧ challenges during covid → – is part of → ○ lessons learned
- ✧ challenges during covid → – is cause of → ● risk management steps during pandemic
- ✧ integration and information flow → – is cause of → ● technology and digitization
- ✧ inventory management → – is associated with → ● affect of pandemic on supply chain, delivery, crediability , client relation, quality,etc
- ✧ Job responsibilities → – is associated with → ● type of risk management plan
- ✧ readiness for the pandemic → – is cause of → ● technology and digitization
- ✧ readiness for the pandemic → – is cause of → ● type of risk management plan
- ✧ risk management procedures → – is cause of → ● challenges during covid
- ✧ risk management steps during pandemic → – is a → ○ applicability
- ✧ technology and digitization → – is property of → ○ inventory management
- ✧ technology and digitization → – is associated with → ● type of risk management plan
- ✧ type of risk management plan → – is associated with → ● risk management procedures

