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Factors Affecting the Supply Chain Resilience and Supply Chain Performance

Aamir Hashmi[1*]

[*1] *Researcher, Faculty of Business and Management, Universiti Sultan Zainal Abidin, Gong Badak Campus, Kuala Terengganu, Malaysia*

**Corresponding Author Email: si1581@putra.unisza.edu.my*

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ABSTRACT

The key objective of this research study is to delve into the factors affecting supply chain resilience to enhance supply chain performance through the mediation of supply chain resilience. To perform this particular research, a quantitative method of research was applied. The process of data collection was performed by using the questionnaire technique. As it was impossible to collect data from every member of the targeted population thus, a sample of data was calculated using G*power software and obtained a sample size of 129 respondents. It was concluded that supply chain artificial intelligence, adaptive capability, and supply chain collaboration have a positive and significant influence on supply chain resilience and supply chain performance. At the same time, supply chain resilience also has a positive impact on supply chain performance. Thus, organizational and supply chain performance can be enhanced by adopting supply chain resilience and other organizational dynamic capacities. This particular research study provides insight to the practitioners and managers of manufacturing firms for improving their level of resilience in the supply chain. This specific research study plays a significant role in literature by highlighting the concept of supply chain resilience & supply chain performance of organizations.

Keywords: *Adaptive capability, Artificial intelligence, Supply chain collaboration, Supply chain performance, Supply chain resilience*

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Factors Affecting the Supply Chain Resilience and Supply Chain Performance

1. Introduction

At present times, every organization is at risk due to the conditions of disruptions (Chaudhuri et al., 2018). The firm's resilience is defined as a capability and competency of an organization to effectively handle unexpected and unforeseen situations that always act as a central element for the firm against any disruptive condition (Cheng & Lu, 2017; Shaheen, 2017). On the other hand, over time, the types and number of disruptions and challenges for businesses are increasing day by day, due to which the concept of resilience is gaining more attention for its adoption and have a great level of significance for organizations ad their management of supply chains (Fattahi et al., 2020). The disruptive supply chain of organizations may disturb the flow of services and products that the organization offers to their customers (Olivares-Aguila & ElMaraghy, 2021). Therefore, disturbance in the system of the supply chain can impose a negative impact on the performance of the firm in terms of lowering the level of stock returns and the firm's competitive position in the business environment (Ivanov & Dolgui, 2021).

Several disruptive events break down the continuous follow of products and services offered by the firms. Global supply chains faced disruption by several events, including the financial crisis of 2008, and 2016, the United Kingdom's decision to leave the European Union (Brexit), and the recent worldwide pandemic of Covid-19. Therefore, to handle disruptive conditions, the concept of supply chain resilience has gained considerable attention from practitioners (Queiroz et al., 2020). The many kinds of literature based on big data analytics have established the utilization of predictive analytics for discovering the sources that cause disruptions that ultimately improve firms' supply chain systems through resilience (Choi, 2020). The organizations need to develop analytical proficiencies to increase the resilience in SC through the effective utilization of knowledge of the resident firm; in that way, organizations can strengthen their existing abilities of information (Scholten et al., 2019; Wong et al., 2020). Supply chain firms are highly investing in enhancing the level of resilience in their systems by raising the capability to manage disruptions (de Sá et al., 2019) and the nonstop flow of critical supplies (Hendry et al., 2018). Effective capabilities of SC firms include forecasting and proactive management of SC threats and disturbance-creating factors and events (Baryannis et al., 2019).

Several studies found a positive relationship between the information, business, engineering, and analytics to build digitalization and risk of SC. Several developing technologies have the potential to enhance supply chain resilience and also have the competency to predict the SC risk through advanced product tracking applications, Artificial intelligence, industry 4.0 & additive manufacturing (Ivanov & Dolgui, 2021). In past research, many studies displayed the technique of AI as very encouraging and helpful in supporting effective decision-making within the SC and building proactive and analytical competencies (Belhadi et al., 2020; Dhamija & Bag, 2020; Anwar, 2022). The recognized perspective of AI to support the process of decision-making in SC activates an insightful reflection on how artificial intelligence can be utilized at a high level for accomplishing long-term & competitive performance in the supply chain in terms of innovation (Akter et al., 2020; Amjad et al., 2022). Whereas, previous research studies debated and claimed that process innovation religiously supports the concept of resilience in the supply chain while facing -an uncertain condition that ultimately results in enhanced supply chain performance (Akter et al., 2020; Kwak et al., 2018). Emerging innovation driven through artificial intelligence is more beneficial as it may speed up the decision process in prototyping, identifying, and testing solutions to disruptions (Paschen et al., 2020). This kind of decision process is an innovation that researchers call a design. The influence of invention that emerges through AI technology mainly strengthens the SC through sharing information, information processing & integration that exist in a firm's system has long been viewed as a complex factor in constructing supply chain resilience and enhancement of enhancing SC performance (Fosso Wamba & Akter, 2019; Rasheed, 2022). Existing research studies displayed that procedures of AI have been successful in encouraging innovation that offers solutions that ultimately lead to the enhanced firm's SC performance (Baryannis et al., 2019; Dubey et al., 2020).

In current situations, the concept of supply chains plays an immense role in changing technology and the business atmosphere. A continuous flow of information is essential for operating supply chains in a vibrant environment with many external and internal threats that continue to overpower and destroy the level of performance (Belhadi et al., 2021). Moreover, the researchers; Dubey et al. (2020), and Fosso Wamba and Akhter (2019) have identified the environment's vitality as a complex factor to be studied while handling the issue related to performance. As previously, the researcher didn't test the overall model's connection among artificial, adaptive capability, and supply chain collaboration with each other and its impact on supply chain resilience. To the best of our information and knowledge, this is the first research study that empirically examines the impact of Artificial intelligence on the performance of the supply chain by studying the mediating influence of supply chain resilience. This research study will consider these market uncertainties as a problem statement. To resolve this problem, the author will incorporate the concept of supply chain resilience; the main focus of this research will be to analyze the factors behind supply chain resilience and how it enhances supply chain performance. Therefore, the study will seek answer to the question of, Does the artificial intelligence, adaptive capabilities, and supply chain collaboration have significant effect on supply chain performance through supply chain resilience?

2. Literature Review

2.1 Dynamic Capability View Theory

DCV is a great tool to analyze the resilient potentiality required in awakening the tumultuous consequences, an addition of the RBV. The RBV emphasizes that the firm needs to evolve capacities to defeat trouble and to attain competitive advantage (Hashmi et al., 2021a). Nevertheless, a tradition of lacking a proper definition of capacities is set due to the occurrence of dynamic changes in changeable environments. A customary gap in RBV is addressed by DCV using designing adequate capabilities and resources to retaliate to the specific situation changes. Whereby, covering the mannerism of eventualities. Capacity and capability of a firm to construct, incorporate and rearrange firms' resources by applying the procedures adopted by the firm to tackle the environmental uncertainties and alterations and to outline new strategies of value-creation. An argument can be put forward that supply chains of firms need to develop or evolve dynamic capabilities to lessen the exposure in a changeable environment, which demands flexible capabilities for long-term survival. From the standpoint of DCV, the responsive and proactive capacities and capabilities of the SCRE can be elaborated. DCV necessitates that the organizations must bear the capacity and capability to incorporate, adjust and rearrange their resources and potentiality to deal with quickly altering environments. Proactive scanning concerning environmental changes and attaining requisite adaptability and flexibility should be accelerated by the firms (Rashid et al., 2022a). According to our study, is proportionate with the prevention of possible exposure in the supply chain and the proactive capacity of the supply chain to adjust environmental alters. In their findings, Hashmi et al. (2021b) emphasize that companies which are successful in the marketplace should rearrange their capabilities and resources speedily to retrieve capabilities during disruptive times. According to our argument, the reactive capability to rearrange facilities or amenities and competencies is essential to have for speedily recovering from disturbance.

The idea of "balanced resilience", is fundamentally the steadiness among raising costs to control susceptibilities and raising resilience capabilities. Based on the DCV, the significance of capacity/resource particularly and appropriate quantification to maintain lucrativeness by enhancing the flexibility balance. However, the existing literature furnished a model for resources, particularly of SCRE, the principles of resource quantification for SCRE are until now non-existent (Rashid et al., 2023). The fundamental assumption of this study is to enlarge the quantification aspect of dynamic capacities and elaborate on the circumstances of SCRE to fight obstacles arising from environmental unpredictability. It has been proposed in this study that measurement and description of dynamic capacities in conditions of responsive and proactive capabilities concerning SCRE. Therefore, this work supplied an important extension of the dynamic capacity hypothesis.

2.2 Supply Chain Resilience

The concept of resilience in the supply chain is defined as the capability that deals with uncertain and unexpected disruptive events. It also plays a role in recovering the disruption and quickly converting it into the original performance level or a new level that is necessary to maintain the anticipated market, financial and operating performance of the supply chain (Adobor, 2020). For the formation of resilience competencies and capability in the system of the supply chain, it is important for the firms to recognize and evaluate the nodes for risks and their strength of effects and chances of occurrence and how these uncertainties and risks can be identified (Chang et al., 2015; Dubey et al., 2018). Organizations adopt multiple techniques and strategies to maintain resilience in their supply chain system. Through some supply chain systems, in the starting period of the COVID-19 pandemic, the buffers of inventory and capacity were recognized as a cause of resilience on the other hand, other firms have used capacity of production that is underutilized for other products and medicines (Queiroz et al., 2020; Wong et al., 2020; Victory et al., 2022) as compared to a single source of supply, organizations with multi sourcing strategies achieved benefits from the element of resilience (de Sá et al., 2019).

2.3 Artificial Intelligence

For the last two decades, several firms in the business world are trying to adopt digitalization and advanced technologies in their processes. In recent times the application of industry 4.0 arise in the market of businesses (Wollschlaeger et al., 2017). Likewise, Artificial intelligence is the technique that has been identified and recognized as a valuable technology that can enable an effective level of communication aim between machines and certain devices used in firm processes and functions (Guzman & Lewis, 2020). As the system of supply chain consist of various complex tasks in that situation artificial intelligence has been utilized in firms to simplify operational activities by resolving issues by improving the speed and level of accuracy during the handling of a large amount of data and information (Schniederjans et al., 2020; Hunaid et al., 2022). The application of artificial intelligence is not new in the business market but its potential and capability have been recognized recently in the past few years. AI has the capability and competency to make agile & smart decisions in the system of SC for avoiding issues and also for resolving them. Therefore, a very effective system of AI helps firms enhancement of service quality & serving customers through safe and on-time deliveries of products and services (Schniederjans et al., 2020; Toorajipour et al., 2021). The application of AI facilitates a firm through computerized compliance that in response results in the minimization of cost and efficient performance of the firm through adding value to the network of the supply chain system (Treleaven & Batrinca, 2017; Ali, 2022). Artificial intelligence also has a positive influence on improving the predictive competencies that are necessary for estimating demand. Through the bots of AI, the engagement of customers as communication can be initialized. Through these bots, organizations can easily track the status of product deliveries and it further helps customers in engaging themselves with a team of customer support (Huang & Rust, 2021). Through automation AI application help in simplifying the deadly tasks of warehouse operations. To improve the efficiency and effectiveness of the supply chain system well-known companies like Alibaba & Amazon are using it to increase the level of productivity. In the field of the supply chain, every minute has great importance and the application of AI uses algorithms that efficiently support the supply chain systems by minimization of cost and time laps by improving deliveries and routes (Wen et al., 2018; Alam, 2022).

2.4 Supply Chain Performance

In recent time a change has been observed in business to provide more choices to consumers by increasing the service offerings and product that generates further chances to overtake rivals (Um et al., 2017; Rasheed et al., 2022; Asif, 2022). Thus, this trend has been focused on by both practitioners and academics to enhance supply chain performance (SCP). The researchers claimed that the partners of the supply chain requisite to perform together to react to the modifications in requirements of customers. Moreover, even in the literature, it came into consideration that it is important not only to determine the method in which the partners of the supply chain are dynamic or energetic, but also the

method at which they struggle for consistency (Rashid & Amirah, 2017; Uddin, 2022). Moreover, for producing the element of value addition, the supply chain is an essential domain for any business firm. The element of value is added only when an improvement is observed in the performance of SC processes. In the system of supply chain management, value is generated through the implementation of coordination at a wider range (Rashid, 2016). While comparing the benefits of an enhancement in the performance of the supply chain the researchers claimed that the delivery process of products and the level of production were influenced because of increased labour cost & cost of raw material, increased manufacturing cost and also prolonged delivery of products and increase in the level of inventory. Following are the researchers Hashmi and Mohd (2020) that has explained the concept of supply chain performance as the selection of certain function that plays an important role in the performance of a supply chain system. For the aim of this particular research study, the performance of the supply chain can be explained as the capability of SC to perform activities cost-effectively but also to decrease costs for effectively meeting the needs of customers (Rashid et al., 2022b; Ayaz, 2022).

2.5 Hypothesis Development

2.5.1 Artificial intelligence, supply chain performance, and supply chain resilience

The researcher Grover et al. (2020) stated in a research study that the utilization of the technique of artificial intelligence results in the enhancement of the supply chain system. Further researchers argued that it also plays an important role in increasing the quality level of products, enhancing the satisfaction of the customer and also playing its part in the design & development of firm products and processes. Utilization of artificial intelligence results in improved operational performance of the organization than the engagement of the firm. In addition, Klumpp (2018) shows that integrated supply chain systems driven by artificial intelligence like self-driving systems, have a great effect and positively demonstrated that AI-driven SCI, such as self-driving systems, have great potential to encourage the performance of firm logistics and its functions of transportation. It is demonstrated in previous research studies that research frameworks based on artificial intelligence also support the decision-making of extensive distribution. Bottani et al. (2019). Related to this researcher argues that the 56% that occurs due to the out-of-stock situation is minimized because of the implementation of artificial intelligence. Moreover, the author like Dubey et al. (2020) explained that the technique of artificial intelligence arguably enhances the performance of an organization. According to the prospect of organization information processing theory (OIPT), we suggest that the implementation of artificial intelligence (AI) allows the supply chain to develop capabilities that are related to the processing of information (Srinivasan & Swink, 2018; Hashmi et al., 2020a). It permits them to interpret and allows them to acquire knowledge from complex info that is collected from several sources to reduce the chances of uncertainties in demands, availability of supply and capacities (Grover et al. 2020). Else, firms are forced to contain a great level of inventories or depend on human capabilities that are limited to compose a reactive supply chain that as result affects the profitability of the firm and speed of implementation (Dubey et al., 2020; Hashmi et al., 2020b). Overall, such conceptions and evidence of the adoption of artificial intelligence can be considered as the tool that effectively improves the performance of the supply chain. Hence a hypothesis proposed that:

The field of supply chain management is considered the most challenging domain that emphasized the interaction between different departments of the firm such as production, logistics and marketing. Thus success in the supply chain system mainly relies on the success of overall business sectors. As business practices are shifting continuously toward the lean practices and JIT phenomenon so various organizations are implementing this philosophy in logistics, operations and other globalized events such that numerous natural tragedies and unstable political environments, etc. To mitigate these challenges and issues, supply chains implement the concept of supply chain resilience in their systems to effectively deal with uncertain conditions (Hashmi et al., 2022a). In previous years, the technology of artificial intelligence has been introduced which proved itself to be valuable and very much important for supply chain systems. The technique of artificial intelligence is explained as the capability of a computer to freely and self-sufficiently resolve issues that they have not openly planned to address. According to previous research studies, the utilization of AI techniques will boost the economy to

around 13 trillion by the year 2030 and effectively boost the GDP of the world by about 1.2% each year. For several supply chain operations, practitioners used AI techniques in their firms. Most particularly, it facilitates organizations by making practical decisions. With time the AI technique is used for inventory management, demand forecasting, risk management & sustainable SCM. In addition, the researcher further explained that the tool of artificial intelligence also plays an important role in uncertainty and disruption like covid-19 (Lai et al., 2020).

In forecasting and projection, Artificial Intelligence is used effectively and efficiently. Organizations have a long-lasting wish to maintain both the demand and the supply. As artificial intelligence (AI) predicts the data, and automatically analyzes or processes the data or situation, a reliable and exact forecasting demand that the AI delivers. AI permits organizations to enhance their validation in the processing of orders and purchases thus, the minimization cost related to supply chain administration, warehousing, transportation etc. Additionally, it recognized the configuration and trends which assist in designing superior strategies related to retailing and manufacturing. For instance, most businesses use this tool in many ways like, they keep or stocking a specific amount of a particular product that they will sell out and also reduce waste. Artificial intelligence has given the permit to the manufacturers to incorporate in production as well as client feedback to improve the design of the product in real-time. The tools that are based on artificial intelligence provide supreme accountability in the supply chain. As, AI assists them in fast growth as they can improve or enhance the efficiency of engineering, prohibit faults, can shorten the phases of development and also increase safety by determining risky activities automatically, fall in the cost of inventory due to effective planning of supply and demand, it also increases the revenue with the great rate sales which directs to the optimization of price and also to the determination and so on (Rashid et al., 2020). Therefore, we hypothesized that

H1: Artificial intelligence significantly influence supply chain performance.

H2: Artificial intelligence significantly influence supply chain resilience.

H8: Adaptive capability significantly mediates the relationship between artificial intelligence and supply chain resilience.

H9: Supply chain resilience mediates the relationship between artificial intelligence and supply chain performance.

2.5.3 Adaptive capabilities, supply chain collaboration, supply chain resilience, and supply chain resilience

The adaptive capability of a firm is defined as the maximum speed at which it can change its suggested portfolio. The maximum speed of change driven by the adaptive capacity of the firm might differ from the noticeable speed of change. The firm capability accounts for the ability of an organization to perform certain tasks and duties (Eshima & Anderson, 2017; Baloch & Rashid, 2022). The researchers & practitioners related to the adaptive capabilities to agility, flexibility and (Appelbaum et al., 2017; Koçyiğit & Akkaya, 2020; Park & Park, 2021). Adaptive capability is related to the concept that how speedily a firm is capable to variate its suggested portfolio to adapt according to the shifts of the environment. For maintaining environmental resilience, supply chain systems need to build their capacity through the management of adaptive strategies. the management of adaptive strategies delivers a framework for learning and understanding a system in a manner that effectively helps firms the enhancement of capacity for reducing and identifying uncertain and unexpected situations (Alzoubi & Yanamandra, 2020). Adaptive management strategies aim to build the capability to restructure the system in response to changing disruptive conditions (Um et al., 2017). The basic part of the management of adaptive capabilities involves a frequentative process of making decisions that are built to recognize and minimize uncertain and surprise events (Eshima & Anderson, 2017). The researchers Scholten et al. (2019) and Jain et al. (2017) claimed in their studies that the resilience of the supply chain is relatively based on adaptive capabilities. It reduces the influence of unpredicted happenings by

the preemptive recognition of strategies that allow the SC to adapt to the recovering after-effects and also improve the level of prior situations. Adaptive responses as well as adaptive planning both are dynamic factors in developing resilience in a supply chain which assists according to the urban perspective to adjust any uncertain condition. Moreover, the positive influence of adaptive capabilities in developing resilience in the supply chain through reducing the possibilities of challenging unscheduled events, and also it responds through preemptive plans to overcome the shock and reconstruct the state of the operations that is vigorous in the SC.

In the literature of previous research studies, it is simplified that to perform competitively in the business world, firms must have enough knowledge and information about the innovations and external business atmosphere. An open innovation-driven adaptive capacity act as a main conception that clarifies that an organization adapt strategies and other related things to be competitive in the market. The literature of earlier studies highlights the adaptive capabilities and collaboration of SC to be the most influential elements that are required to build supply chain resilience (Scholten et al., 2019; Jain et al., 2017). The term collaboration is defined as the ability to effectively perform working activities with other organizations. It also acts as a method and tool for developing the capacity of the supply chain for regeneration and growth (Tarigan et al., 2021). The concept of collaboration enables the members of the supply chain to effectively perform their tasks and also helps the firm efficiently deal with the problems that a firm cannot handle when it's operating alone in the business market (Ho et al., 2019). The practice of collaboration builds an adaptive capacity in the supply chain system and facilitates the firm through the creation and transfer the information throughout the system of a supply chain that enables the firm and its members to support each other while facing any disruptive situation (Basheer et al., 2019; de Sousa Jabbour et al., 2020). It also helps in avoiding disruptive situations and other issues through effective information sharing, using the strategy of mutual decision-making, arrangement of incentives & collaborative communication (Duong & Chong, 2020). The process of collaboration is the activity in which several individuals and departments work together to achieve the same goal and objective. In the field of supply chain management, it is essential to organize and arrange the activities, work routines and processes of the individual organization correspondingly to gain the proper benefits of collaboration (Alzoubi et al., 2020). Specifically while addressing the occasion or events of disturbance and disruption the element of resilience in the supply chain system cannot be accomplished until & unless firms collaborate in a very vibrant and synergetic way to respond effectively (Al-Doori, 2019; Jadhav et al., 2019; Um & Oh, 2020). This particular statement highlights the importance of collaboration which is very essential for achieving resilience in the supply chain. Therefore, it is hypothesized that:

H3: Adaptive capabilities significantly influence supply chain resilience.

H4: Adaptive capabilities significantly influence supply chain collaboration.

H5: Supply chain collaboration significantly influence supply chain resilience.

H10: Supply chain collaboration mediates the relationship between adaptive capability and supply chain resilience.

2.5.6 Supply chain collaboration, supply chain resilience, and supply chain performance

In earlier research studies, Alzoubi et al. (2020) explained that the concept of collaboration in the supply chain has been considered a priority in many manufacturing firms operating all over the world. In the literature of previous studies, it is mentioned that the SC collaboration has many benefits provided to the firm in the form of minimization of cost, increase in profitability, controlling inventory level and exact estimation or forecast of demand and supply (Al-Doori, 2019). Moreover, it is believed that the collaboration in supply chain plays a significant and positive role in the enhancement of supply chain performance. The researcher Jain et al. (2017) agree and added his statement that integration and collaboration in processes and activities of the supply chain generate benefits that include lessening lead time, minimizing the bullwhip effect, formation of distinctive and unique capabilities, enhancing the

level of flexibility, increase the satisfaction level of customer, enhance profitability and market share of the firm. But many organizations genuinely realized the need for collaboration among SC members (Adhikari & Bisi, 2020; Agyabeng-Mensah et al., 2020; Busse et al., 2016). Perhaps, many firms fail to build collaboration among SC members because of unwillingness to share quality information but apply effort and make a heavy investment (Ali & Haseeb, 2019). This kind of resistance destroys and minimizes the level of trust and commitment that is an essential part of collaboration in the field of supply chain and therefore the performance of SC. This situation shows and highlights the importance of commitment and trust to enhance the performance of the supply chain and develop the element of collaboration in SC (Wang & Hu, 2020). According to the perspective of small and medium enterprises, the factor of collaboration also has a positive impact on the performance of the supply chain. Thus we propose a hypothesis that

A supply chain network with an element of resilience in its system allows it to enhance the capabilities of an organization to face the disruptive situation. A resilient supply chain network also help firms to quickly respond to disruptions and recover them to normal condition which ultimately helps firm enhance their performance (Adobor, 2020; Scholten et al., 2019). It is clear from the existing literature that the firm which takes more time to respond to any disruptions incurs a great level of damage that result in a low-performance level of a firm. Moreover, in another research study, the phenomenon of resilience that relates to the concept of services in 3pl firms, the research found a positive impact on the performance of services. It can be claimed that the organization with more resilience in its supply chain system perform better to detect the main risks and threats that a firm face in the market. Moreover, it is found in many studies that the factor of resilience in the supply chain is positively associated with a high level of firm performance that occurs in terms of achieving competitive advantages and enhanced profitability. Through resilience, the organization also receive an element of customer satisfaction that they considered important performance outcomes (Govindan et al., 2015; Rashid et al., 2019). Moreover, resilience in the supply chain system of a firm acts as a capability and competitiveness that enables the firm to recover from the situation after a disruptive situation (Gligor et al., 2019). Thus, in various previous research studies, it is claimed that the concept of resilience in the supply chain plays a huge role in increasing supply chain performance (Gölgeci & Kuivalainen, 2020; Alrazehi et al., 2021; Muzammil, 2022).

H6: Supply chain collaboration significantly influence supply chain performance.

H11: Supply chain resilience mediates the relationship between supply chain collaboration and supply chain performance.

H7: Supply chain resilience significantly influence supply chain performance.

H12: Adaptive capability and supply chain resilience have sequential mediation between the relationship of artificial intelligence and supply chain performance.

H13: Adaptive capability, supply chain collaboration, and supply chain resilience have sequential mediation between the relationship of artificial intelligence and supply chain performance.

3. Methodology

The research approach stated the plan n procedure of a research study that research is going to conduct or explore (Rashid et al., 2021). There are two research approaches which include the quantitative approach and the second is a qualitative research approach, while the third approach is the combination of both approaches. The objective of the qualitative study aimed to discover new perceptions/theories, whereas, in the quantitative approach the researcher is going to work with existing theories and test these theories to test the relationship among various variables. In a qualitative study, the data is collected by interviews, while in a quantitative study; data can be collected by experiments, surveys, questionnaires and observations. Moreover, in a quantitative study, data collect in numeric

form. As the present study was also based on the existing theories to analyze the relationship among several variables and the data was also collected by using a structured questionnaire and using survey technique. So this study adopts the quantitative research approach because the objective of a quantitative study is to test the existing theories (Das et al., 2021; Khan et al., 2022a; Basit, 2022). Data collection source highlights the nature of data which means how the researcher gathers data for research. These data collection sources are divided into two major types, one is the primary source and the other is a secondary source of data collection (Khan et al., 2022b). The primary data is termed as the newly collected data, while the secondary data has already been recorded for some other purpose. Further, primary data can be collected through experiments, observations, questionnaires, surveys and interviews with the individual respondent. On the other hand, the secondary source includes books, journals, annual reports and other internet sources. In this study, the data was collected by using primary sources and a survey questionnaire technique was used to gather data.

The population of the research study referred to a whole pool of individuals related to a specific sector. Asiamah et al.(2017) stated that the population has three types which include the general population, the target population and the accessible population. The entire pool of individuals related to the selected sector/industry is termed the general population, whereas, the targeted population stated those individuals who are most related to the research objective. The researcher also describes the accessible population which means those individuals who can easily participate in research by adding his/her response. In the current study, the general population contain whole individuals related to a selected sector i.e. employees related to manufacturing firms. This general population has narrowed down to the target population which is closely related to research objectives i.e. in the current study employees are related to the supply chain department in manufacturing firms. Moreover, the accessible population contain the reachable and feasible individuals who will participate in this study which includes the employees working in the pharmaceutical sector.

3.1 Sample and Sampling Procedure

The collection of data from the whole target population is not possible and feasible because it takes too much time and money. So to cope with this problem, the author suggested taking a sample from the target population that represents the whole population. However, there are two major techniques for sampling; these two techniques are probability sampling technique and non-probability sampling technique. Probability sampling is based on the pre-defined chance of choosing respondents for the sample while in non-probability sampling all individuals have an equal chance to be part of the sample (Khan et al., 2022c). The probability sampling technique has further types which include simple random sampling, stratified random sampling, cluster sampling and systematic sampling. On the other hand, non-probability sampling also contains several types, which include convenience sampling, snowball sampling, quota sampling and purposive sampling. In the current study, all respondent has an equal chance of participation in the research and the researcher also has not fixed the chances of selecting a sample size so non-probability sampling was used to take a sample. Moreover, non-probability sampling is further divided into four types; quota sampling, snowball, convenient, sampling and judgmental sampling. For sampling in the present study, convenient sampling was used for the sample.

3.2 Sample Size and Data Collection

The sample size stated the number of respondents participating in the data collection process by giving their responses (Agha et al., 2021; Rashid et al., 2021). It was also noted that the sample size should be measured as reliable and measured through authentic sources to get more accuracy in results (Hair et al., 2018). In the current study, the sample size was calculated using G*power software; it calculates sample size based on an appropriate statistical model and several predictors (Faul et al., 2009). The estimated sample size for this study was 129 respondents. The instrumentation used for data collection was a structured close-ended questionnaire that was developed by adapting constructs from existing studies. These constructs include artificial intelligence (AI), adaptive capability (AC),

Supply chain collaboration (SCC), supply chain resilience (SCR), and supply chain performance (SCP). The given below table 1 shows the constructs along with their sources.

Table 1: Instrumentation

Constructs	Adapted Items	Sources
AI	5	(Dubey et al., 2020)
AC	3	(Tarafdar & Qrunfleh, 2017)
SCC	3	(Dubey et al., 2020)
SCR	5	(Yu et al., 2019)
SCP	4	(Srinivasan & Swink, 2018)

4. Data Analysis

The statistical analysis applied in this study includes descriptive statistics to check the univariate normality, reliability analysis to test the internal consistency of data, and bivariate correlation analysis will be applied to examine the multicollinearity issue. The regression analysis will be used to test the proposed hypothesis (Haque et al., 2021). Descriptive statistics was ascertained for analyzing the normality of data. It consists of mean, standard deviation, skewness, and kurtosis. Hair et al. (2018) stated that to fulfil the univariate normality, skewness and kurtosis values should be in the range of $\pm$2.5. The given below Table 2 illustrates the descriptive statistics. The calculated outcomes presented in table 2 affirm that the construction supply chain performance (SCP) (Mean=3.53, S.D=0.78) has the maximum skewness (sk=0.936), while the construct Artificial intelligence (AI) (Mean=0.403, S.D=0.75) has the least skewness (sk= 0.403). Besides this, the construct Supply chain collaboration (SCC) (Mean=3.60, S.D=0.70) has the maximum kurtosis (k=1.271), whereas, the construct Artificial intelligence (AI) (Mean=0.403, S.D=0.75) has the least kurtosis (k=0.069). Since all these results are not the out of range (i.e. $\pm$2.5). Further, Hair et al. (2018) stated that there is a possibility of error in responses collected from respondents and the data collection process. The collected data should have internal consistency; it was examined by the application of reliability analysis. The value of reliability should be at least 0.70 or greater. The results presented in above table 2 illustrate that the construct maximum reliability value (Alpha = 0.784) is for measurement scale Adaptive capability (AC) (Mean =3.60, S.D=0.72) whereas the least reliability (Alpha =0.725) is for construct Supply chain resilience (SCR) (Mean=3.54, S.D=0.74). Since these outcomes illustrate that all measurement scales have at least 0.70 reliability all adapted constructs used in this study are reliable for this study.

Table 2: Descriptive statistics

Construct	Mean	Std. Dev.	Skewness	Kurtosis	Standardized Cronbach's Alpha s
AC	3.60	0.72	-.464	.364	.784
SCC	3.60	0.70	-.773	1.271	.759
SCR	3.54	0.74	-.738	.217	.725
SCP	3.53	0.78	-.936	1.233	.764

Correlation analysis emphasizes the strength of association among each pair of a variable. According to Hashmi et al. (2021a), the minimum correlation among each pair of a variable should not be less than $\pm$0.30 and the maximum correlation among each pair of the variable should not be absolute. According to the calculated outcomes presented in given above table 3 shows that the strongest relationship (r=0.562) is between supply chain performance (SCP) and supply chain resilience (SCR), while the weakest association (r=0.303) is among supply chain performance (SCP) and adaptive capability (AC). Since these values illustrate that the association among each pair of constructs is not below $\pm$0.30 and also not absolute, these outcomes affirm that the constructs used for the present study have less chance of multicollinearity issue (Hashmi et al., 2021a).

Table 3: Bivariate correlation

Construct	AI	AC	SCC	SCR	SCP
AI	1				
AC	.436**	1			
SCC	.436**	.408**	1		
SCR	.535**	.353**	.514**	1	
SCP	.447**	.303**	.360**	.562**	1

** Correlation is significant at the 0.01 level (2-tailed).

4.1 Convergent Validity

The construct validity was tested by the application of convergent and discriminant validity. Convergent validity was applied to examine the inter-item relationship and the acceptability criteria for convergent validity include composite reliability (Hair et al., 2018), which should not be less than 0.70 and the loading factor should not be less than 0.40. Further, the AVE for each construct should not be less than 0.50 (Fornell & Larcker, 1981). The results in table 4 indicate that the factor loading of all items is not less than 0.40, and composite reliability (CR) for adaptive capability, artificial intelligence, supply chain collaboration, supply chain performance and supply chain resilience is not less than 0.70. Furthermore, the Ave for all constructs is also not less than 0.50. So the convergent validity was established for all constructs. The summarized outcomes for the mentioned criteria are illustrated in table 4.

Table 4: Convergent validity

Construct	Items	Factor Loading	AVE	CR
Adaptive capability	AC1	0.770	0.563	0.795
	AC2	0.746		
	AC3	0.736		
Artificial intelligence	AI1	0.639	0.512	0.839
	AI2	0.687		
	AI3	0.776		
	AI4	0.761		
	AI5	0.705		
Supply chain collaboration	SCC1	0.700	0.542	0.779
	SCC2	0.709		
	SCC3	0.794		
Supply chain performance	SCP1	0.760	0.582	0.848
	SCP2	0.777		
	SCP3	0.717		
	SCP4	0.796		
Supply chain resilience	SCR2	0.727	0.544	0.826
	SCR3	0.822		
	SCR4	0.720		
	SCR5	0.672		

4.2 Discriminant Validity

The discriminate validity was ascertained to test the discrimination in all constructs used in this study. It was examined through the method given by (Fornell & Larcker, 1981). According to this method, the square root of AVE should not be less than the correlation among each pair of variables. The given mention above table 5 illustrates the discriminant validity in which the square root of AVE is presented in the diagonal. The outcomes show that the square root AVEs for AC, AI, SCC, SCP and SCR is higher than the correlation value of each pair of a construct. Thus the acceptable criteria for discriminant validity have been fulfilled.

Table 5: Discriminant validity

Construct	T_AC	T_AI	T_SCC	T_SCP	T_SCR
AC	0.751				
AI	0.445	0.715			
SCC	0.406	0.443	0.736		
SCP	0.307	0.468	0.366	0.763	
SCR	0.331	0.545	0.487	0.545	0.737

Moreover, the Heterotrait-monotrait ratio of correlation (HTMT) was also applied to analyze the discriminant validity of the construct. The results are presented in table 6, this method is the updated approach of Fornell & Larcker (1981) in PLS-SEM to examine the discriminant validity of the construct. The acceptance criteria stated that the value of HTMT among each pair of constructs should be less than 1.00 and not greater than 0.90 and also lower than 0.85. Thus, the outcomes presented in the given below matrix show that all HTMT values are not greater than one so it fulfilled the discriminant validity standard.

Table 6: HTMT ratio

Construct	AC	AI	SCC	SCP	SCR
AC					
AI	0.638				
SCC	0.690	0.658			
SCP	0.443	0.587	0.542		
SCR	0.501	0.706	0.750	0.721	

4.3 Testing Overall Model

The proposed tested model has three independent variables which are adaptive capability (AC), artificial intelligence (AI), and supply chain collaboration (SCC), and one dependent variable is supply chain performance (SCP). Whereas there is one mediating variable which is supply chain resilience (SCR). The output of the estimated path model is presented in given below Figure 1. Structural equational modeling (SEM) was applied to test the proposed hypothesis of this study. The results of SEM were based on the Beta, p-values of the hypothesis path and confidence interval (LL and LU) (Hair et al., 2018). The confidence interval (CI) illustrates the values of the upper level (UL) and lower level (LL) but it is required that the value should not overlap to zero among each level (Hashmi et al., 2021). Whereas, before moving forward to overall model testing it should be confirmed that all the adapted constructs have no issue with multicollinearity. Hair et al., (2018) state that if the correlation among each pair of variables is not less than 0.30 and not greater than 0.90 then it can be safely assumed that variables have no issue with multicollinearity. Thus, it was carefully assumed that the path coefficient analysis and hypothesis testing can proceed. Bootstrapping with 500 resamples was applied to test the hypothesis. The results presented in table 7 illustrates that all the direct hypotheses have been accepted, excepted the hypothesis H3 and H6. Meanwhile, the bootstrapping with 500 resamples was applied to test the hypothesis for indirect effect among dependent and independent variables. The calculated results presented in table 7. The results show that all the mediators significantly mediates the relationship between exogenous variables and the endogenous variables as there is no zero straddling in between the LL and UL of the variables. Moreover, the sequential mediation is occurring between the tested variables.

Table 7: Results of the structural model

Structural Path	Beta	T statistics	*P*	LL	UL
H1: AI -> SCP	0.223	2.454	0.014	0.043	0.395
H2: AI -> SCR	0.399	5.903	0.000	0.261	0.528
H3: AC -> SCR	0.033	0.460	0.646	-0.106	0.180
H4: AC -> SCC	0.406	6.473	0.000	0.284	0.531
H5: SCC -> SCR	0.296	4.475	0.000	0.166	0.430
H6: SCC -> SCP	0.081	0.975	0.330	-0.075	0.253
H7: SCR -> SCP	0.384	4.314	0.000	0.207	0.553
H8: AI→AC→SCC	0.181	4.238	0.000	0.110	0.278
H9: AI→SCR→SCP	0.194	4.494	0.000	0.119	0.288
H10: AC→SCC→SCR	0.092	1.935	0.053	0.008	0.194
H11: SCC→SCR→SCP	0.120	3.262	0.001	0.059	0.203
H12:AI →AC→SCR→SCP	0.068	1.992	0.046	0.008	0.144
H13: AI→AC→SCC→SCR→SCP	0.114	3.291	0.001	0.053	0.186

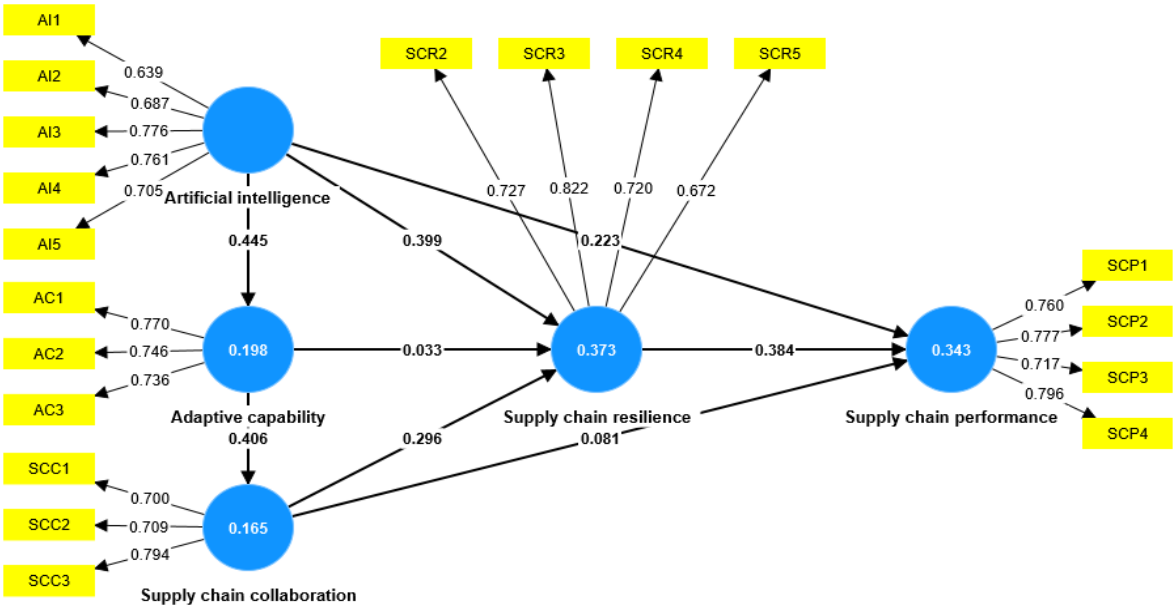

Figure 1: SEM path diagram

5. Conclusion and Discussion

This particular research study aims to investigate the factors affecting supply chain resilience to enhance supply chain performance through the mediation of supply chain resilience. This particular research was conducted according to the perspective of the manufacturing industry located in Karachi, Pakistan. This particular research was mainly based on the existing theory of Supply chain resilience. In the current research study, the influence of certain factors which include artificial intelligence, adaptive capabilities, and supply chain collaboration was investigated on SC Resilience. Also, the research model shows the influence of supply chain resilience on the overall performance of SC. To perform this particular research, a quantitative method of research was applied. The process of data collection was performed by using the questionnaire technique. As it was not possible to collect data from every member of the targeted population thus a sample of data was calculated by using G*power software and obtained a sample size of 129 respondents. To obtain more accurate results the developed questionnaire was distributed to the target population and a total of 206 responses were collected. The obtained data were analyzed by using structural equational modeling through using smart PLS4 software which the results of overall research were obtained. After analyzing data, it was observed that all the proposed hypothesis has positive and significant outcomes except hypothesis two and hypothesis six. It was concluded that the supply chains' artificial intelligence, adaptive capability and supply chain collaboration have a positive and significant influence on supply chain resilience and supply chain

performance, while supply chain resilience also has a positive influence on supply chain performance. Thus, the organizational, as well as the supply chain performance, can be enhanced by adopting supply chain resilience and other organizational dynamic capacities.

All the proposed hypothesis was consistent with existing studies as all the hypothesis were retained except hypothesis H2 and hypothesis H6. The research hypothesis "Artificial intelligence positively associated with supply chain resilience" was retained and answered to research question one: Does artificial intelligence has a relationship with supply chain resilience? Was match with existing literature? For instance, tools that are based on artificial intelligence provide supreme accountability in the supply chain. As, AI assists them in fast growth as they can improve or enhance the efficiency of engineering, prohibit faults, can shorten the phases of development and also increase safety by determining risky activities automatically, fall in the cost of inventory due to the effective planning of supply and demand, it also increases the revenue with the great rate sales which directs to the optimization of price and also to the determination and so on. The research hypothesis "Artificial intelligence positively associated with supply chain performance" was retained and answered to research question two: Does artificial intelligence has a relationship with supply chain performance? was matched with existing literature. According to the prospect of organization information processing theory (OIPT), we suggest that the implementation of artificial intelligence (AI) allows the supply chain to develop capabilities that are related to the processing of information (Srinivasan & Swink, 2018). It permits them to interpret and allows them to acquire knowledge from complex info that is collected from several sources to reduce the chances of uncertainties in demands, availability of supply and capacities (Grover et al., 2020). Else, firms are forced to contain a great level of inventories or depend on human capabilities that are limited to compose a reactive supply chain that as result affects the profitability of the firm and speed of implementation (Dubey et al., 2020). Overall, such conceptions and evidence of the adoption of artificial intelligence can be considered as the tool that effectively improves the performance of the supply chain.

The research hypothesis "Artificial intelligence positively associated with adaptive capabilities" was retained and answered to research question three: Does artificial intelligence has a relationship with adaptive capabilities? Was matched with existing literature. For instance, Earlier research studies clarify that the application of artificial intelligence constitutes a well-organized way of regenerating the element of additivity through learning and understanding the external atmosphere in that way they form a complex system more systemized, adaptive, flexible and reconfigurable at a higher level. Moreover, the technique of artificial intelligence is a facilitating way that supports adaptive systems' new generations of advancement. The research hypothesis "adaptive capabilities positively associated with supply chain collaboration" was retained and answered to research question five: Does adaptive capabilities has a relationship with supply chain collaboration? Was matched with existing literature. For instance, the literature of earlier studies highlights the adaptive capabilities and collaboration of SC to be the most influential elements that are required to build supply chain resilience (Scholten et al., 2019; Jain et al., 2017). For that reason, in this research study, adaptive capacity and SC collaboration are used as a factor that enables SC resilience driven by the capabilities of artificial intelligence.

The research hypothesis "supply chain collaboration positively associated with supply chain resilience" was retained and answer to a research question six: Does supply chain collaboration has a relationship with supply chain resilience? was matched with existing literature. For instance, in addressing the occasion or events of disturbance and disruption the element of resilience in the supply chain system cannot be accomplished until & unless firms collaborate in a very vibrant and synergetic way to respond effectively. This particular statement highlights the importance of collaboration which is very essential for achieving resilience in the supply chain. The research hypothesis "supply chain resilience positively associated with supply chain performance" was retained and answered to research question eight: Does supply chain resilience has a relationship with supply chain performance? Was matched with existing literature. For instance, Through resilience, the organization also receive an element of customer satisfaction that they considered important performance outcomes (Govindan et al., 2015). Moreover, resilience in the supply chain system of a firm acts as a capability and

competitiveness that enables the firm to recover from the situation after a disruptive situation (Gligor et al., 2019). Thus, in various previous research studies, it is claimed that the concept of resilience in the supply chain plays a huge role in increasing supply chain performance (Gölgeci & Kuivalainen, 2020).

5.1 Research Implications

This particular research study provides insight to the practitioners and managers of manufacturing firms for improving their level of resilience in the supply chain. The concept of supply chain resilience receives a high level of attention and became famous among managers of the firm because the concept of a resilient supply chain increases the capability and feasibility of SC. Resilience in the supply chain also enables the SC partners to achieve their goals and also increase their competitiveness and benefits. The most essential practical implication of this research is that it will help in emerging strong resources and trajectory views for managing strategies are the main factors of resilient SC. Through this, associated parties can widely concentrate on those practices that may increase the supply chain performance of an organization.

This particular research study plays a significant role in literature by highlighting the concept of supply chain resilience & supply chain performance of organizations. Particularly this research study associates the factors affecting supply chain resilience which include artificial intelligence, adaptive capability and supply chain collaboration. The theoretical context of the model can be used in other forms of inter-organizational relationships including resilience in the supply chain. Moreover, it also extends the knowledge of factors affecting supply chain resilience by incorporating artificial intelligence, adaptive capability and supply chain collaboration as independent variables for supply chain resilience. However, the supply chain performance can be enhanced through the enhancement of a supply chain resilience system.

5.2 Limitations and Recommendations

There are a few important limitations and recommendations that are important and considerable to discuss specifically for this research study. This particular research study suffers from various limitations. To conduct this study, the required literature review was not as available or limited to confirm the validity of content scales. The current research study mainly concentrates on finding the influence of include artificial intelligence, adaptive capability and supply chain collaboration, further research studies would clarify the differences in different target segments by considering other variables i.e. operating frontier, trajectory and absorptive capacity. To obtain meaningful outcomes it is important to use a large sample size. To validate the content in an improved way future research must extend the validation of content by combining to get validation of content. Further future research on this topic can find out whether alternative variables influence the linkages that exist between artificial intelligence, adaptive capability and supply chain collaboration and proactive and reactive dimensions SC resilience. It is essential and recommended for future research to have an extended sample size.

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