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Enhancing Supply Chain Resilience through Artificial Intelligence: A Strategic Framework for Executives

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Abstract

In today's contemporary turbulent business environment, marked by disruptions ranging from natural disasters to global pandemic, supply chain resilience is crucial. This research addresses the pressing need to understand challenges faced by Indian supply chain executives by adopting AI-driven solutions for enhancing resilience. Analyzing data from 300 executives using ANOVA and t-tests reveals critical patterns in encountered barriers. Simultaneously, the study aims to fill gaps in existing literature by developing a strategic framework for executives. Using Structured Equation Modeling (SEM), it outlines best practices for integrating AI into supply chain operations, offering nuanced insights into strategic considerations and organizational barriers influencing AI adoption decisions. The research identifies a gap in comprehensive studies on challenges and decision-making factors specific to Indian executives adopting AI for supply chain resilience. By addressing this gap, the study enriches global discourse on AI in supply chain management and provides targeted guidance to Indian executives navigating AI-enabled operations. Ultimately, the research aims to empower executives with actionable insights to effectively leverage AI, enabling them to fortify supply chain resilience amidst India's evolving business dynamics.

JEL Code: *O32, M15, L23, L25, Q55.*

Keywords:

Supply Chain Resilience;
Artificial Intelligence (AI) Integration;
Executive Decision-making; Challenges in AI Adoption;
Strategic Framework;
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1- Introduction

In the contemporary landscape of supply chain management, where disruptions have become a norm rather than an exception, the integration of Artificial Intelligence (AI) stands out as a transformative force. This study, conducted exclusively in India, delves into the intricate dynamics surrounding the adoption of AI-driven solutions, with a dual focus on assessing challenges faced by supply chain executives and developing a strategic framework tailored for the Indian business environment. As global and local challenges, ranging from natural disasters to economic uncertainties, continue to test the resilience of supply chains, the role of AI in fortifying these critical networks becomes increasingly pivotal. The first objective of this research is to meticulously examine the challenges and barriers encountered by supply chain management executives in India during the adoption of AI-driven solutions. Through an in-depth assessment, this study seeks to unearth the specific hurdles that executives navigate in their pursuit of enhanced supply chain resilience.

Moving beyond diagnosis, the second objective is to craft a strategic framework that offers executives clear best practices and guidelines for the effective integration of AI technologies into supply chain operations. In the unique context of India's diverse business landscape, this framework aims to provide actionable insights, empowering executives to harness the full potential of AI for bolstering supply chain resilience. By homing in on the specific challenges and strategic imperatives within the Indian business milieu, this research not only contributes to the global conversation on AI in supply chains but also provides executives with a nuanced understanding of the local intricacies. The findings of

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this study aspire to equip supply chain executives in India with a roadmap for leveraging AI strategically, ensuring not only the survival but the thriving resilience of their supply chains in the face of evolving challenges.

Despite the increasing literature on AI applications in supply chain management, a significant research gap persists concerning the specific challenges and decision-making factors that executives encounter when adopting AI solutions to strengthen supply chain resilience. This study focuses on the supply chain executives organizational Barriers and adapting strategies for the AI integration.

2- Literature Review

2-1- Literature

The confluence of Artificial Intelligence (AI) and supply chain resilience has become a focal point in contemporary research as organizations grapple with the imperative of navigating uncertainties and disruptions. This literature review synthesizes existing knowledge on AI-driven solutions in supply chain management, concentrating on the challenges faced by executives and the formulation of strategic frameworks for effective integration.

2-2- Challenges in AI Adoption for Supply Chain Resilience

In 2023, the adoption of AI in supply chain management continued to face significant challenges despite its potential to enhance resilience and efficiency. A McKinsey report emphasized the difficulty in integrating AI into existing systems due to the complexity of dynamic trade-offs and real-time execution needs, highlighting the necessity for substantial technological investments and tailored AI solutions [1]. Similarly, Deloitte illustrated the transformative potential of generative AI, which can improve real-time risk assessment and scenario simulation, thereby streamlining supplier-buyer collaboration and reducing the manual effort required in risk management processes [2]. However, barriers such as change management, technical limitations, and human acceptance persist, as detailed in a study published in "Logistics". This study underscored the importance of continuous employee training and adaptation to new AI tools to overcome these barriers [3]. Additionally, KPMG stressed the critical need for a digital strategy aligned with business goals to ensure that AI implementations create value, calling for a balance of technological and human expertise [4]. These insights from 2023 build upon earlier findings, providing a comprehensive understanding of the multifaceted challenges in AI adoption for supply chain resilience. Zhang & Tao (2020) [5] emphasize that one of the primary challenges in AI adoption lies in overcoming technological barriers and integrating vast datasets seamlessly into existing supply chain systems. The study by Zhang & Tao (2020) [5] also underscores the importance of addressing workforce adaptation challenges, indicating that successful AI implementation requires a skilled and adaptable workforce.

Matheny et al. (2020) [6] shed light on the role of organizational culture in AI adoption, pointing out that cultural resistance can impede the effective assimilation of AI technologies into supply chain processes. Hofmann et al. (2019) [7] highlight resource constraints as a significant challenge in AI adoption, emphasizing the need for substantial investments in technology, expertise, and infrastructure to maximize the potential of AI-driven solutions. Beyond technical challenges, ethical considerations also play a crucial role. Bansal et al. (2023) [8] underscore the importance of addressing ethical concerns in AI adoption, emphasizing transparency, accountability, and responsible AI use in supply chains. Operationalization of AI within existing systems poses interoperability challenges. Benzidia et al. (2019) [9] note the importance of integrating AI technologies seamlessly with existing supply chain systems to ensure operational efficiency. Rjab et al. (2023) [10] highlighted cognitive barriers as crucial hurdles in AI adoption, emphasizing the need for executive education and awareness to facilitate a smoother transition towards AI-driven solutions. Addressing regulatory compliance is vital to AI adoption. Dora et al. (202) [11] stress the significance of navigating complex regulatory landscapes to ensure that AI implementation aligns with legal and ethical standards. Literature by Corbett and Klassen (2006) [12] warns against over-dependence on AI vendors, highlighting the importance of developing in-house capabilities to maintain control and flexibility in supply chain operations.

2-3- Strategic Frameworks for AI Integration in Supply Chain Operations

In 2023, the strategic frameworks for AI integration in supply chain operations have evolved to address the complexities and enhance the efficiency of modern supply chains. According to McKinsey, successful AI integration requires a comprehensive framework that includes robust data governance, cross-functional collaboration, and continuous monitoring and optimization of AI models to handle dynamic trade-offs and ensure real-time execution [1]. Deloitte's research highlights the role of generative AI in enabling proactive risk management and scenario simulations, which are critical components of a strategic AI framework aimed at enhancing supply chain resilience and efficiency [2]. Moreover, a study by KPMG underscores the importance of aligning AI initiatives with overall business strategies, emphasizing that strategic frameworks must incorporate clear value creation objectives and a balanced approach between technological and human expertise [4]. These insights from 2023 underscore the necessity of integrating AI strategically within supply chain operations to not only address current challenges but also to leverage AI's full potential for future resilience and efficiency. Gupta et al. (2022) [13] propose a strategic framework emphasizing the alignment of AI adoption with organizational goals, advocating for a clear vision and strategic coherence in the integration process. Chen et al. (2022) [14] suggest a phased implementation approach for AI integration, ensuring a gradual transition that

maximizes benefits and minimizes disruption to supply chain operations. Teece (2018) [15] advocates for the development of dynamic capabilities within organizations to effectively leverage AI technologies. Dynamic capabilities, including sensing, seizing, and reconfiguring, are critical for adapting to the evolving landscape of supply chain resilience. A perspective presented by Dubey et al. (2020) [16] emphasizes ecosystem collaboration in developing strategic frameworks. The study posits that collaboration with external partners and stakeholders is essential for creating a resilient AI-enabled supply chain ecosystem. Building on dynamic capabilities, Zhao et al. (2023) [17] propose a resilience-based framework that integrates AI technologies. This framework focuses on building adaptability and responsiveness to disruptions for a robust supply chain. Mentzer et al. (2008) [18] advocate for an agile supply chain strategy in the context of AI integration. This strategy emphasizes flexibility and responsiveness to market changes facilitated by real-time insights from AI systems.

2-4- India-specific Considerations in AI Adoption

In 2023, AI adoption in India has seen significant progress, driven by both government initiatives and private sector innovations. The Indian government, through NITI Aayog [19], has been emphasizing the responsible and ethical deployment of AI technologies. The National Strategy for Artificial Intelligence, updated in 2023, continues to focus on the principles of transparency, accountability, and inclusivity to harness AI's potential across various sectors, including agriculture, healthcare, and education [20]. Additionally, there has been a surge in AI startups, particularly in tech hubs like Bengaluru and Hyderabad, which are developing innovative AI solutions to enhance efficiency and decision-making processes in businesses [21]. Despite these advancements, challenges such as data privacy, ethical considerations, and the need for regulatory frameworks remain prominent. The Personal Data Protection Bill is a step towards addressing these issues by regulating data collection and ensuring compliance with global standards [21]. Moreover, industry giants like Google and Reliance are investing heavily in AI research and development, which further underscores the transformative potential of AI in India [22]. This dynamic environment highlights both the opportunities and challenges in realizing AI's full potential in the country. Marda (2018) [23] delve into the unique challenges faced by Indian enterprises, pointing to regulatory uncertainties as a critical factor influencing the pace and scale of AI adoption in the country. Misra et al. (2023) [24] emphasize the importance of culturally sensitive strategies in fostering AI adoption within Indian organizations, recognizing the diverse business landscape and cultural nuances. Mukherjee et al. (2022) [25] delve into digital infrastructure challenges unique to India, emphasizing the need for concerted efforts in improving digital infrastructure to facilitate the seamless integration of AI technologies. Kshetri (2017) [26] highlights skill shortages as a critical factor influencing AI adoption in India. The study suggests that addressing skill gaps through training and education is imperative for successful AI integration. Joshi et al. (2023) [27] emphasize the role of government initiatives in India's AI landscape, illustrating how policies and investments can catalyze AI adoption and innovation in the supply chain. Joshi & Sharma (2022) [28] shed light on the importance of developing localized AI solutions tailored to the Indian market. The study posits that culturally sensitive AI applications enhance the effectiveness of supply chain operations.

3- Research Problem and Research Objectives

In today's dynamic and unpredictable business environment, supply chains face numerous disruptions and challenges, ranging from natural disasters to economic fluctuations and global pandemics. These disruptions can have severe consequences on a company's operations and financial performance. While artificial intelligence (AI) has shown promise in mitigating supply chain risks and enhancing resilience, there is a critical need for research to investigate the specific challenges, strategies, and factors that influence executives' decision-making in adopting AI-driven solutions within their supply chain operations. This study aims to address this gap by exploring the key obstacles and opportunities that executives encounter in implementing AI for supply chain resilience and by developing a strategic framework that guides executives in harnessing the full potential of AI in this context.

While there is a growing body of literature on the application of AI in supply chain management, there remains a notable research gap regarding the specific challenges and decision-making factors faced by executives in adopting AI solutions to enhance supply chain resilience. Few studies comprehensively investigate the strategic considerations, organizational barriers, and best practices that are essential for executives to successfully integrate AI into their supply chain operations. While extant literature provides a robust foundation for understanding global challenges and strategic frameworks for AI adoption in supply chains, a noticeable gap exists concerning the Indian context. This study seeks to contribute by addressing this gap, offering nuanced insights into challenges faced by Indian executives and crafting a strategic framework tailored to the specific intricacies of the Indian business environment. Understanding this critical gap is imperative to provide guidance and insights to executives who are navigating the evolving landscape of AI-enabled supply chain management, and to ensure that AI technologies are effectively leveraged to enhance supply chain resilience.

- To assess the key challenges and barriers faced by supply chain management executives in the adoption of AI-driven solutions for supply chain resilience.
- To develop a strategic framework for executives that outlines best practices and guidelines for the effective integration of artificial intelligence technologies into supply chain operations.

4- Research Methodology

Type of Study: This research adopts a mixed-methods approach, combining quantitative and qualitative analyses to comprehensively address the research objectives. A cross-sectional design is employed to capture a snapshot of the challenges faced by supply chain executives and to develop a strategic framework.

The population consists of supply chain executives from prominent companies in the logistics and supply chain industry in India. Stratified random sampling is employed to ensure representation from each company. The strata are formed based on the companies, and within each stratum, executives are randomly selected. Therefore, the sampling frame includes executives from Delhivery, Gati Limited, Allcargo Logistics, Aaj Enterprises, and Container Corporation of India Limited. A total of 300 supply chain executives will be selected for the study, with 60 executives from each of the five selected companies. The supply chain executives with decision-making roles and responsibilities related to technology adoption and strategic planning are included.

Structured survey questionnaires are designed to collect quantitative data on challenges faced during AI adoption. The questionnaire includes Likert-scale questions for statistical tests. Similarly, the in-depth interviews with a subset of executives will be conducted to gather qualitative insights into challenges and to inform the development of the strategic framework.

ANOVA and t-tests will be applied to analyze the quantitative data. ANOVA will identify differences in challenges among different companies, while t-tests will assess differences within companies. Structured Equation Modelling (SEM): SEM will be used for developing and validating the strategic framework based on identified best practices and guidelines. The research is planned to be conducted over a period of 7 months, including data collection, analysis, and reporting.

5- Results and Discussion

5-1- Data Analysis and Interpretation

In the intricate landscape of supply chain management, the effectiveness of strategic initiatives, particularly in the realm of technology adoption, is intrinsically linked to the characteristics and experiences of the professionals at the helm. Table 1 illuminates a comprehensive demographic profile of supply chain executives engaged in this study, providing a lens into the diversity and composition of this crucial cohort.

Table 1. Demographic Profile of Supply Chain Executives

Name of the Company	**No. of Executives**	**Percent**
Delhivery	60	20.0
Gati Limited	60	20.0
Allcargo Logistics	60	20.0
Aaj enterprises	60	20.0
Container Corporation of India Limited	60	20.0
Total	300	100.0
Age of the Executives	***No. of Executives***	***Percent***
25 -35	52	17.3
35 - 45	61	20.3
45 - 55	110	36.7
Above 55	77	25.7
Total	300	100.0
Gender	***No. of Executives***	***Percent***
Male	225	75.0
Female	75	25.0
Total	300	100.0
Educational Qualification	***No. of Executives***	***Percent***
Graduate	103	34.3
Postgraduate	89	29.7
Professional Degree	108	36.0
Total	300	100.0
Marital Status	***No. of Executives***	***Percent***
Married	185	61.7
Unmarried	115	38.3
Total	300	100.0

The demographic profile presented in Table 3 offers a holistic view of the supply chain executives participating in the study, providing valuable insights into their distribution across companies, age groups, gender, educational qualifications, and marital status. The even distribution of executives across Delhivery, Gati Limited, Allcargo Logistics, Aaj Enterprises, and Container Corporation of India Limited signifies a balanced representation from different companies. This ensures a diverse and comprehensive perspective on AI adoption challenges and strategic frameworks within the broader supply chain industry. The substantial presence of executives in the 45 - 55 age group, constituting 36.7% of the total sample, indicates a significant concentration of experienced professionals. This age group's prominence suggests that a considerable portion of the executives may bring substantial industry knowledge and expertise to the study. The higher representation of male executives, comprising 75% of the total sample, reflects a gender imbalance. This finding underscores an industry trend and emphasizes the need for initiatives to promote gender diversity in supply chain management, especially in decision-making roles related to AI adoption. The distribution across educational qualifications, with 36.0% holding professional degrees, 29.7% being postgraduates, and 34.3% being graduates, demonstrates a diverse educational background. This diversity ensures a varied set of perspectives and competencies among the supply chain executives participating in the study. The majority being married, constituting 61.7% of the total sample, indicates that a significant portion of the executives may have additional familial responsibilities. This factor could influence their decision-making regarding the adoption of AI-driven solutions, considering potential work-life balance considerations.

5-2- Cost and Investment Challenges

In the ever-evolving landscape of supply chain management, the integration of Artificial Intelligence (AI) stands as a transformative force, promising enhanced resilience and efficiency. However, this promising trajectory is not without its challenges, particularly in the realm of costs and investments. Table 2 delves into the nuanced perceptions of supply chain executives regarding these challenges, with a specific focus on the different dimension.

Table 2. The Cost and Investment Challenges of Executives in AI adoption with respect to demographic variables

Cost and Investment Challenges of Executives (CAI)	CAI with respect to Age of the Executives (ANOVA)		CAI with respect to Education of the Executives (ANOVA)		CAI with respect to Gender of the Executives (t-test)	
	F	Sig.	F	Sig.	t	Sig.
Substantial initial investment for the purchase of AI software and hardware (CAI 1)	2.174	0.001	3.896	0.002	3.007	0.003
Return on investment (ROI) for AI adoption in supply chain management can be challenging (CAI 2)	3.122	0.026	4.339	0.008	3.058	0.002
There is ongoing maintenance costs associated with AI systems (CAI 3)	4.433	0.003	2.831	0.011	2.254	0.015
Integrating AI solutions with existing systems and processes can be complex and costly (CAI 4)	3.290	0.018	3.498	0.006	4.377	0.006

***Hypothesis 1**:* There is no significant difference in executives' perceptions of the Cost and Investment Challenges required for AI adoption in supply chain management across different age groups, education levels, and genders.

The Table 1 outlines the challenges related to costs and investments (CAI) in adopting Artificial Intelligence (AI) in supply chain management, specifically focusing on the costs and investments dimension. The data is further analyzed with respect to the age, education, and gender of the executives, employing ANOVA for age- and education related comparisons and t-tests for gender-related comparisons. The age wise (ANOVA) analysis reveals a significant difference in executives' perceptions based on age ($p<0.05$). This suggests that varying age groups might hold different perspectives on the costs and investments challenges required for AI adoption in supply chain management. The education wise findings (ANOVA) also indicate a significant difference based on education levels ($p<0.05$). This implies that executives with different educational backgrounds may have distinct views on the costs and investments challenges associated with AI technologies. The t-test results show a significant difference between male and female executives ($p<0.05$), suggesting that gender may influence perceptions of the costs and investments challenges in AI adoption. The findings reveals that the executives' perceptions regarding the cost and investment challenges associated with AI adoption in supply chain management, revealing variations based on age, education, and gender (reject null hypothesis). These insights provide a foundation for a targeted and customized approach in addressing these challenges for a more effective integration of AI solutions in the supply chain

5-3- Data Quality and Integration Challenges

Within the dynamic realm of supply chain management, the effective integration of Artificial Intelligence (AI) relies heavily on the quality and seamless integration of data. The Table 3 unravels the intricacies of executives' perceptions concerning the challenges encountered in Data Quality and Integration (DQI).

Table 3. The Data Quality and Integration Challenges of Executives in AI adoption with respect to demographic variables

Data Quality and Integration Challenges of Executives (DQI)	DQI with respect to Age of the Executives (ANOVA)		DQI with respect to Education of the Executives (ANOVA)		DQI with respect to Gender of the Executives (t-test)	
	F	Sig.	F	Sig.	F	Sig.
Making it challenging to aggregate and access the data needed for AI applications (DQI 1)	2.503	0.019	10.519	0.000	2.663	0.008
Managing large volumes of data efficiently can be challenging (DQI 2)	4.187	0.005	12.666	0.000	2.797	0.005
Ensuring data security and complying with privacy regulations can be complex (DQI 3)	2.238	0.014	11.767	0.000	4.544	0.000
Handling sensitive supply chain data can pose security and privacy risks (DQI 4)	4.093	0.004	10.131	0.000	2.286	0.023

Hypothesis 2: There is no significant difference in executives' perceptions of the Data Quality and Integration Challenges required for AI adoption in supply chain management across different age groups, education levels, and genders.

The Table 3 presents an analysis of the challenges related to Data Quality and Integration (DQI) faced by supply chain executives. The focus is on executives' perceptions of these challenges concerning their age, education, and gender. The age wise (ANOVA) analysis reveals a significant difference is observed across age groups ($p<0.05$), indicating that executives of different ages may perceive challenges differently regarding Data Quality and Integration for AI applications. The education wise (ANOVA) analysis reveals a significant difference are found based on education levels ($p<0.05$), suggesting that executives with different educational backgrounds may have varying perceptions of this specific data quality challenge. The gender wise (t-test) analysis reveals a significant difference male and female executive ($p<0.05$), suggesting that gender may influence views on the challenges of Data Quality and Integration. The findings reveals that the executives' perceptions regarding the Data Quality and Integration challenges associated with AI adoption in supply chain management, revealing variations based on age, education, and gender (reject null hypothesis).

5-4- Security and Privacy Concerns Challenges

In the dynamic landscape of contemporary supply chain management, the integration of Artificial Intelligence (AI) has ushered in unparalleled efficiency and innovation. However, this technological evolution is not without its complexities, particularly when it comes to Security and Privacy Concerns (SPC). The Table 4 presented encapsulates a detailed examination of executives' perceptions regarding specific challenges within the realm of Security and Privacy Concerns. As supply chain leaders grapple with the multifaceted dimensions of data security, the statistical insights provided through ANOVA and t-tests shed light on how these challenges vary across demographic dimensions, namely age, education, and gender.

Table 4. The Security and Privacy Concerns Challenges of Executives in AI adoption with respect to demographic variables

Security and Privacy Concerns Challenges of Executives (SPC)	SPC with respect to Age of the Executives (ANOVA)		SPC with respect to Education of the Executives (ANOVA)		SPC with respect to Gender of the Executives (t-test)	
	F	Sig.	F	Sig.	t	Sig.
Data breaches can result in significant financial losses and damage to an organization's reputation (SPC 1)	5.851	0.007	5.098	0.007	3.302	0.003
AI systems can be vulnerable to cyber-attacks, including hacking, malware, and other forms of cyber threats (SPC 2)	4.805	0.002	4.352	0.003	4.984	0.016
Malicious or negligent employees and contractors can pose a significant security risk (SPC 3)	3.834	0.011	4.871	0.008	3.325	0.006
Executives must ensure that AI-driven solutions are used ethically and do not infringe upon individual rights (SPC 4)	7.842	0.000	3.445	0.011	5.249	0.001

Table 4 provides a comprehensive analysis of the Security and Privacy Concerns (SPC) faced by supply chain executives in the context of AI adoption. This examination is further dissected with a focus on executives' age, education, and gender. The age wise (ANOVA) analysis reveals a significant difference is observed across age groups ($p<0.05$), indicating that executives of different ages may hold diverse perspectives on the potential consequences of challenges differently regarding Security and Privacy Concerns for AI applications. The education wise (ANOVA) analysis reveals a significant difference are found based on education levels ($p<0.05$), suggesting that executives with different educational backgrounds may have varying perceptions of this specific security and privacy concerns challenge. The gender wise (t-test) analysis reveals a significant difference male and female executive ($p<0.05$), suggesting that gender may influence views on the challenges of Security and Privacy Concerns. The findings reveal that the executives' perceptions regarding the Security and Privacy Concerns challenges associated with AI adoption in supply chain management, revealing variations based on age, education, and gender (reject null hypothesis). These findings contribute to a deeper understanding of the varied perspectives within the executive ranks and provide a foundation for targeted strategies in addressing security and privacy challenges in AI implementation.

5-5- Strategic Framework based on the Challenges

Developing a strategic framework for executives based on the challenges identified (Data Quality and Integration - DQI, and Security and Privacy Concerns - SPC) involves creating a structured plan to address these challenges and enhance supply chain resilience through AI adoption. Structural Equation Modelling (SEM) is a powerful statistical technique that used by the researchers to analyze complex relationships among variables. Here, the researchers building a SEM model related to strategic framework (framework based on Research practices, Benchmark, Set of key principles, Technology stack, and Address the skills and talent) and the identified challenges (Data Quality and Integration - DQI, and Security and Privacy Concerns - SPC).

These hypotheses represent the structural paths in a Structural Equation Model (SEM) where the Dependent Variable (SFE - Strategic Framework for Executives) is influenced by three independent variables (CAI - Cost and Investment, DQI - Data Quality and Integration, SPC - Security and Privacy Concerns). The values in the Table 5 are the estimates, standard errors, critical ratios, and p-values associated with these paths.

Table 5. The relationship between Strategic Framework and the Challenges

Hypotheses						
Dependent Variable	**←**	**Independent Variable**	**Estimate**	**S.E.**	**C.R.**	**P**
SFE	←	CAI	0.179	0.028	6.3929	***
SFE	←	DQI	0.378	0.116	3.2586	***
SFE	←	SPC	0.278	0.033	8.4242	***

Hypothesis 4: There is no significant impact of Cost and Investment challenges on the development of the Strategic Framework.

There is a significant positive relationship between Cost and Investment (CAI) and Strategic Framework Effectiveness (SFE). The estimate of 0.179 indicates that for each unit increase in CAI, SFE is expected to increase by 0.179 units. The critical ratio (C.R.) of 6.3929, along with the p-value is less than .05; indicate that this relationship is statistically significant. So, there is a significant impact of Cost and Investment challenges on the development of the Strategic Framework.

Hypothesis 5: There is no significant impact of Data Quality and Integration challenges on the development of the Strategic Framework.

There is a significant positive relationship between Data Quality and Integration (DQI) and Strategic Framework Effectiveness (SFE). The estimate of 0.378 indicates that for each unit increase in DQI, SFE is expected to increase by 0.378 units. The critical ratio (C.R.) of 3.2586, along with the p-value is less than .05; indicate that this relationship is statistically significant. So, there is a significant impact of Data Quality and Integration challenges on the development of the Strategic Framework.

Hypothesis 6: There is no significant impact of Security and Privacy Concerns challenges on the development of the Strategic Framework.

There is a significant positive relationship between Security and Privacy Concerns (SPC) and Strategic Framework Effectiveness (SFE). The estimate of 0.278 indicates that for each unit increase in SPC, SFE is expected to increase by 0.278 units. The critical ratio (C.R.) of 8.4242, along with the p-value is less than .05; indicate that this relationship is statistically significant. So, there is a significant impact of Security and Privacy Concerns challenges on the development of the Strategic Framework.

All the three hypotheses indicate statistically significant positive relationships between the independent variables (CAI, DQI, SPC) and the dependent variable (SFE). The critical ratios are well beyond the conventional thresholds, and the p-values are very low (less than 0.05), providing strong evidence to support these relationships in the context of the Structural Equation Model.

5-6- Model Validity

In the Structural Equation Modelling (SEM), the evaluation of model fit is paramount to ascertain the effectiveness of the proposed theoretical framework in explaining observed data. In order to lay the groundwork for examining the relationship between construct dimensions and their items, "construct validity" for dimensions related to Strategic Framework based on the Challenges (Figure 1). The values determine the model's suitability for the information in Table 6.

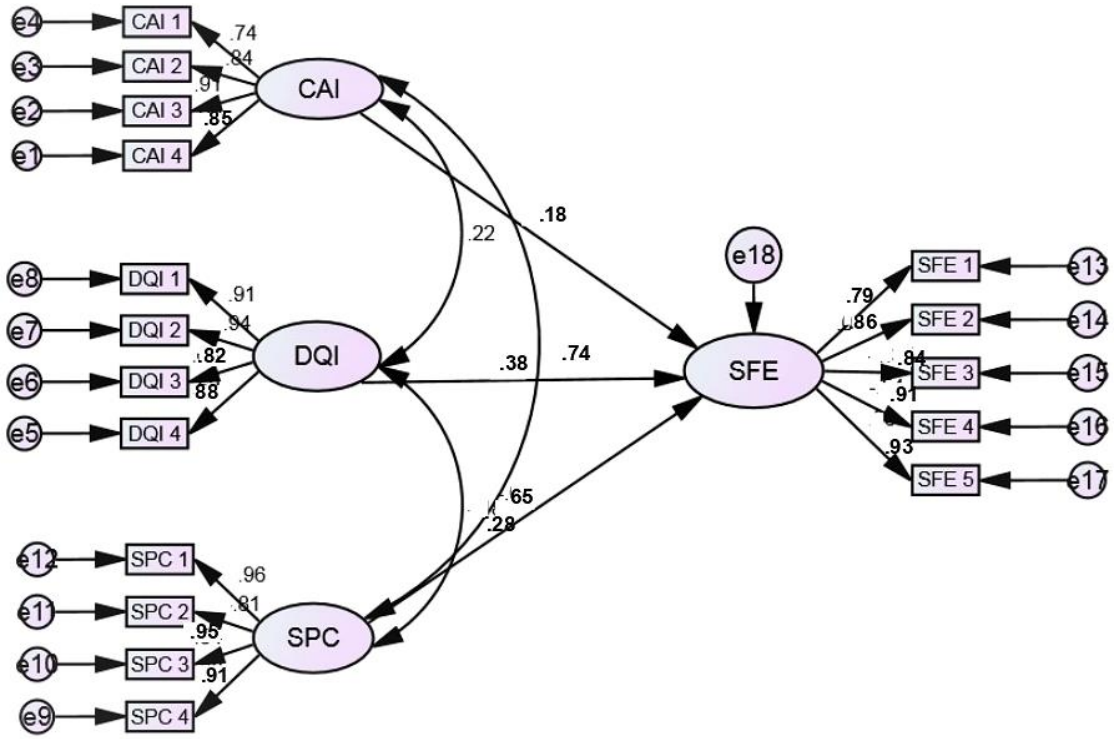

Figure 1. Strategic Framework based on the Challenges

Table 6. Model Fit Measures related to Strategic Framework and the Challenges

Model Fit Indices	Reference	Threshold Limit	Estimated Value	Interpretation
Normed Chi-Square	Jackson (1998) [29]	< 3	598.88/ 241-CMIN/DF = 2.484	Excellent
CFI	Shi et al. (2018) [30], Pavlov et al. (2021) [31], and Xia & Yang (2018) [32]	> 0.90	0.943	Acceptable
GFI	Shi et al. (2018) [22], Pavlov et al. (2021) [31], and Xia & Yang (2018) [32]	>0.90	0.928	Good
IFI	Shi et al. (2018) [22], Pavlov et al. (2021) [31], and Xia & Yang (2018) [32]	>0.90	0.919	Good
NFI	Shi et al. (2018) [22], Pavlov et al. (2021) [31], and Xia & Yang (2018) [32]	>0.90	0.922	Good
RMSEA	Hooper (2008) [33]	< 0.08	0.054	Acceptable
SRMR	Pavlov et al. (2021) [31]	< 0.06	0.043	Excellent

The appropriate model's indices are shown in Table 7. According to the model fit requirements, the GFI, IFI, NFI, and CFI values should be greater than 0.9, the goodness of fit to degrees of freedom ratio should not be greater than 3, and the RMSEA should be less than 0.08. A better model fit is indicated by a lower SRMR. A decent model is one with values of RMSEA of less than 0.08 and CMIN/DF of less than 3

Table 7. Reliability and Validity of the Model related to Strategic Framework and the Challenges

	CR	AVE	MSV	Max R(H)
CAI	0.903	0.701	0.491	0.837
DQI	0.937	0.789	0.622	0.888
SPC	0.949	0.825	0.680	0.908
SFE	0.904	0.750	0.562	0.866

The table provides information on various measures used in assessing the quality and reliability of latent constructs within a Structural Equation Model (SEM). Composite Reliability represents the reliability of the latent constructs in the model. Values above 0.70 are generally considered acceptable. All constructs (CAI, DQI, SPC, SFE) exceed this threshold, indicating good reliability. Average Variance Extracted measures the amount of variance captured by the construct relative to the amount due to measurement error. Values above 0.50 are often deemed acceptable. In this case, all constructs meet or exceed this criterion, suggesting good convergent validity. Maximum Shared Variance

assesses the extent to which a construct shares more variance with other constructs in the model than it does with its own measures. Lower values are preferred, and in this case, all constructs exhibit values indicating good discriminant validity. Maximum Redundancy assesses the amount of variance in the latent variable that is accounted for by its indicators. Higher values suggest good reliability and convergent validity. All constructs demonstrate high MaxR(H) values, indicating strong relationships between the latent variables and their indicators. At last, the values across Composite Reliability, Average Variance Extracted, Maximum Shared Variance, and Maximum Redundancy collectively suggest that the latent constructs (CAI, DQI, SPC, SFE) in the SEM are reliable, exhibit good convergent validity, and have strong discriminant validity. These indices contribute to the overall robustness of the measurement model within the SEM.

5-7- Findings, Suggestions and Recommendations

The supply chain executives face various challenges in adopting AI-driven solutions, including concerns about initial investments, return on investment (ROI), ongoing maintenance costs, and the complexity of integrating AI with existing systems and processes. The study may uncover specific obstacles to enhancing supply chain resilience through AI, such as issues related to data quality and integration, security and privacy concerns, and the need for a strategic framework that guides executives in the effective integration of AI technologies. The research likely identifies the need for a strategic framework to guide executives in integrating AI into supply chain operations effectively. This framework may encompass best practices, guidelines, and actionable insights tailored to the unique challenges and opportunities in the Indian context. Despite challenges, the research may indicate a positive impact of AI adoption on supply chain resilience. Executives might recognize the potential of AI in mitigating risks associated with disruptions, improving decision-making, and enhancing overall supply chain performance.

This study suggests that supply chain executives invest in the education and training of their teams to enhance their understanding of AI technologies. This can help overcome challenges related to the complexity of AI integration and foster a culture of innovation within the organization. Similarly, suggest initiatives to improve data quality and integration processes within the supply chain. This might involve implementing data governance practices, ensuring data security, and enhancing the efficiency of data management systems to address challenges identified in the study.

The researchers recommended a comprehensive strategic framework that outlines best practices and guidelines for the effective integration of AI technologies into supply chain operations. This framework should be tailored to the unique challenges and opportunities within the Indian supply chain context. Alongside, encourage collaboration with AI solution providers and technology partners. This could involve forming strategic alliances with technology companies specializing in supply chain AI solutions, fostering innovation through joint projects, and staying abreast of the latest advancements in AI technology.

6- Conclusion

In conclusion, this study delves into the challenges and opportunities faced by supply chain management executives in adopting artificial intelligence (AI) solutions to bolster resilience in the dynamic and unpredictable business landscape. The research, conducted among 300 supply chain executives in India, aimed to assess key barriers, develop a strategic framework, and contribute to the existing literature on AI applications in supply chain management. A pivotal outcome of this study is the development of a strategic framework tailored for supply chain executives. This framework encapsulates best practices and guidelines, equipping executives with actionable insights for the effective integration of AI technologies into supply chain operations. The strategic framework serves as a roadmap, addressing organizational barriers and providing a foundation for resilient supply chain management.

As supply chain dynamics continue to evolve, the study's implications extend beyond academia to practical applications. Executives can leverage the strategic framework and recommendations to navigate the complexities of AI adoption, fostering a resilient supply chain capable of withstanding disruptions and ensuring sustained business success. While this study provides valuable insights, avenues for future research include exploring the long-term impact of AI adoption on supply chain resilience, assessing the scalability of the strategic framework across diverse industries, and delving into the evolving regulatory landscape governing AI applications in the Indian context.

This study proposes that supply chain executives prioritize investments in educating and training their teams to deepen their comprehension of AI technologies. Such initiatives aim to tackle challenges associated with the intricate integration of AI and cultivate an innovative organizational culture. Additionally, it recommends enhancing data quality and integration processes within the supply chain. This could entail implementing robust data governance practices, ensuring data security, and optimizing data management systems to effectively address the identified challenges.

7- Declarations

7-1- Data Availability Statement

The data presented in this study are available in the article.

7-2- Funding

The author received no financial support for the research, authorship, and/or publication of this article.

7-3- Institutional Review Board Statement

Not applicable.

7-4- Informed Consent Statement

Not applicable.

7-5- Conflicts of Interest

The author declares that there is no conflict of interest regarding the publication of this manuscript. In addition, the ethical issues, including plagiarism, informed consent, misconduct, data fabrication and/or falsification, double publication and/or submission, and redundancies have been completely observed by the author.

8- References

[1] McKinsey Insights. (2023). Succeeding in the AI supply-chain revolution. McKinsey & Company, New York, United States. Available online: https://www.mckinsey.com/industries/metals-and-mining/our-insights/succeeding-in-the-ai-supply-chain-revolution (accessed on July 2024).

[2] Deloitte. (2024). Generative AI-powered supply chain resilience. Deloitte, London, United Kingdom. Available online: https://www2.deloitte.com/us/en/blog/business-operations-room-blog/2023/generative-ai-in-supply-chain-resilience.html (accessed on July 2024).

[3] Hangl, J., Behrens, V. J., & Krause, S. (2022). Barriers, Drivers, and Social Considerations for AI Adoption in Supply Chain Management: A Tertiary Study. Logistics, 6(3), 63. doi:10.3390/logistics6030063.

[4] KPMG. (2023). GenAI in Supply Chain. KMPG, Amstelveen, Netherlands. Available online: https://kpmg.com/kpmg-us/content/dam/kpmg/pdf/2023/genai-supply-chain-final-secured.pdf (accessed on July 2024).

[5] Zhang, J., & Tao, D. (2020). Empowering things with intelligence: a survey of the progress, challenges, and opportunities in artificial intelligence of things. IEEE Internet of Things Journal, 8(10), 7789-7817. doi:10.1109/JIOT.2020.3039359.

[6] Matheny, M. E., Whicher, D., & Israni, S. T. (2020). Artificial intelligence in health care: a report from the National Academy of Medicine. JAMA, 323(6), 509-510. doi:10.1001/jama.2019.21579.

[7] Hofmann, E., Sternberg, H., Chen, H., Pflaum, A., & Prockl, G. (2019). Supply chain management and Industry 4.0: conducting research in the digital age. International Journal of Physical Distribution & Logistics Management, 49(10), 945-955. doi:10.1108/IJPDLM-11-2019-399.

[8] Bansal, C., Pandey, K. K., Goel, R., Sharma, A., & Jangirala, S. (2023). Artificial intelligence (AI) bias impacts: classification framework for effective mitigation. Issues in Information Systems, 24(4), 367-389. doi:10.48009/4_iis_2023_127.

[9] Benzidia, S., Makaoui, N., & Bentahar, O. (2021). The impact of big data analytics and artificial intelligence on green supply chain process integration and hospital environmental performance. Technological forecasting and social change, 165, 120557. doi:10.1016/j.techfore.2020.120557.

[10] Rjab, A. B., Mellouli, S., & Corbett, J. (2023). Barriers to artificial intelligence adoption in smart cities: A systematic literature review and research agenda. Government Information Quarterly, 40(3), 101814. doi:10.1016/j.giq.2023.101814.

[11] Dora, M., Kumar, A., Mangla, S. K., Pant, A., & Kamal, M. M. (2022). Critical success factors influencing artificial intelligence adoption in food supply chains. International Journal of Production Research, 60(14), 4621-4640. doi:10.1080/00207543.2021.1959665.

[12] Corbett, C. J., & Klassen, R. D. (2006). Extending the horizons: Environmental excellence as key to improving operations. Manufacturing and Service Operations Management, 8(1), 5–22. doi:10.1287/msom.1060.0095.

[13] Gupta, S., Ghardallou, W., Pandey, D. K., & Sahu, G. P. (2022). Artificial intelligence adoption in the insurance industry: Evidence using the technology–organization–environment framework. Research in International Business and Finance, 63, 101757. doi:10.1016/j.ribaf.2022.101757.

[14] Chen, L., Jia, F., Steward, M. D., & Schoenherr, T. (2022). The role of technology in enabling circular supply chain management. Industrial Marketing Management, 106, A1-A6. doi:10.1016/j.indmarman.2022.05.013.

[15] Teece, D. J. (2018). Profiting from innovation in the digital economy: Enabling technologies, standards, and licensing models in the wireless world. Research Policy, 47(8), 1367–1387. doi:10.1016/j.respol.2017.01.015.

[16] Dubey, R., Gunasekaran, A., Childe, S. J., Bryde, D. J., Giannakis, M., Foropon, C., ... & Hazen, B. T. (2020). Big data analytics and artificial intelligence pathway to operational performance under the effects of entrepreneurial orientation and environmental dynamism: A study of manufacturing organisations. International journal of production economics, 226, 107599. doi:10.1016/j.ijpe.2019.107599.

[17] Zhao, J., Lee, J. Y., Camenzind, D., Wolcott, M., Lewis, K., & Gillham, O. (2023). Multi-component resilience assessment framework for a supply chain system. Sustainability, 15(7), 6197. doi:10.3390/su15076197.

[18] Mentzer, J. T., Stank, T. P., & Esper, T. L. (2008). Supply Chain Management and Its Relationship to Logistics, Marketing, Production, and Operations Management. Journal of Business Logistics, 29(1), 31–46. doi:10.1002/j.2158-1592.2008.tb00067.x.

[19] NITI Aayog. (2023). National Strategy for Artificial Intelligence. NITI Aayog, New Delhi, India. Available online: https://www.niti.gov.in/sites/default/files/2023-03/National-Strategy-for-Artificial-Intelligence.pdf (accessed on July 2024).

[20] Ahlawat Associates. (2023). Impact of Artificial Intelligence in India: Opportunities and Challenges. Ahlawat Associates, New Delhi, India. Available online: https://www.ahlawatassociates.com/blog/the-growing-impact-of-artificial-intelligence-in-india-opportunities-and-challenges (accessed on July 2024).

[21] Analytics Vidhya. (2023). The Era of Gen AI: A New Beginning. Analytics Vidhya, Gurgaon, India Available online: https://www.analyticsvidhya.com (accessed on July 2024).

[22] EY Saudi Arabia. (2023). Generative AI's potential to accelerate India's digital transformation. EY, Riyadh, Saudi Arabia. Available online: https://assets.ey.com/content/dam/ey-sites/ey-com/en_in/topics/gen-ai/2023/12/ey-gen-ai-report.pdf (accessed on June 2024).

[23] Marda, V. (2018). Artificial intelligence policy in India: a framework for engaging the limits of data-driven decision-making. Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences, 376(2133), 20180087. doi:10.1098/rsta.2018.0087.

[24] Misra, S. K., Sharma, S. K., Gupta, S., & Das, S. (2023). A framework to overcome challenges to the adoption of artificial intelligence in Indian Government Organizations. Technological Forecasting and Social Change, 194, 122721. doi:10.1016/j.techfore.2023.122721.

[25] Mukherjee, S., Chittipaka, V., Baral, M. M., Pal, S. K., & Rana, S. (2022). Impact of artificial intelligence in the healthcare sector. Artificial Intelligence and Industry 4.0, 23-54. doi:10.1016/B978-0-323-88468-6.00001-2.

[26] Kshetri, N. (2017). The economics of the Internet of Things in the Global South. Third World Quarterly, 38(2), 311-339. doi:10.1080/01436597.2021.2013116.

[27] Joshi, P., Tewari, V., Kumar, S., & Singh, A. (2023). Blockchain technology for sustainable development: a systematic literature review. Journal of Global Operations and Strategic Sourcing, 16(3), 683-717. doi:10.1108/TQM-07-2020-0160.

[28] Joshi, S., & Sharma, M. (2022). Sustainable performance through digital supply chains in industry 4.0 era: amidst the pandemic experience. Sustainability, 14(24), 16726. doi:10.3390/su142416726.

[29] Jackson, D. L. (2003). Revisiting sample size and number of parameter estimates: Some support for the N: q hypothesis. Structural equation modeling, 10(1), 128-141. doi:10.1207/S15328007SEM1001_6.

[30] Shi, D., Lee, T., & Maydeu-Olivares, A. (2018). Understanding the Model Size Effect on SEM Fit Indices. Educational and Psychological Measurement, 79(2), 310–334. doi:10.1177/0013164418783530.

[31] Pavlov, G., Maydeu-Olivares, A., & Shi, D. (2021). Using the Standardized Root Mean Squared Residual (SRMR) to Assess Exact Fit in Structural Equation Models. Educational and Psychological Measurement, 81(1), 110–130. doi:10.1177/0013164420926231.

[32] Xia, Y., & Yang, Y. (2019). RMSEA, CFI, and TLI in structural equation modeling with ordered categorical data: The story they tell depends on the estimation methods. Behavior Research Methods, 51(1), 409–428. doi:10.3758/s13428-018-1055-2.

[33] Hooper, D., Coughlan, J., & Mullen, M. R. (2013). The servicescape as an antecedent to service quality and behavioral intentions. Journal of Services Marketing, 27(4), 271–280. doi:10.1108/08876041311330753.

Appendix I: Questionnaire

- To assess the key challenges and barriers faced by supply chain management executives in the adoption of AI-driven solutions for supply chain resilience.
- To develop a strategic framework for executives that outlines best practices and guidelines for the effective integration of artificial intelligence technologies into supply chain operations.

Name:

Designation:

Company Name:

1. Age Group:

25-35 ( ) 35-45 ( ) 45-55 ( ) Above 55 ( )

2. Gender:

Male ( ) Female ( ) Other ( )

3. Educational Qualification:

Graduate ( ) PG ( ) Professional Course ( )

4. Marital Status:

Married ( ) Unmarried ( )

5. Cost and Investment:

		Strongly Agree (5)	Agree (4)	Neutral (3)	Disagree (2)	Strongly Disagree (1)
5.1	Substantial initial investment for the purchase of AI software and hardware					
5.2	Return on investment (ROI) for AI adoption in supply chain management can be challenging					
5.3	There is ongoing maintenance costs associated with AI systems					
5.4	Integrating AI solutions with existing systems and processes can be complex and costly					

6. Data Quality and Integration:

		Strongly Agree (5)	Agree (4)	Neutral (3)	Disagree (2)	Strongly Disagree (1)
6.1	Making it challenging to aggregate and access the data needed for AI applications					
6.2	Managing large volumes of data efficiently can be challenging					
6.3	Ensuring data security and complying with privacy regulations can be complex					
6.4	Handling sensitive supply chain data can pose security and privacy risks.					

7. Security and Privacy Concerns:

		Strongly Agree (5)	Agree (4)	Neutral (3)	Disagree (2)	Strongly Disagree (1)
7.1	Data breaches can result in significant financial losses and damage to an organization's reputation					
7.2	AI systems can be vulnerable to cyber-attacks, including hacking, malware, and other forms of cyber threats					
7.3	Malicious or negligent employees and contractors can pose a significant security risk.					
7.4	Executives must ensure that AI-driven solutions are used ethically and do not infringe upon individual rights					

8. Strategic Framework for Executives:

		Strongly Agree (5)	Agree (4)	Neutral (3)	Disagree (2)	Strongly Disagree (1)
8.1	Research best practices and successful case studies related to AI integration in supply chain management					
8.2	Benchmark against industry leaders to understand what works and what doesn't.					
8.3	Define a set of key principles that will guide AI integration, such as transparency, data security, ethics, and scalability					
8.4	Define the recommended technology stack and infrastructure required for AI integration					
8.5	Address the skills and talent required for successful AI adoption					