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Modeling and Prioritizing Key Success Factors in Implementing the LARGE Supply Chain in Innovative Companies

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Abstract

In today's dynamic and complex world, supply chain management is recognized as one of the most critical success factors for organizations. The LARGE supply chain (Lean, Agile, Resilient, Green, and Ethical), with its novel approach, has been introduced as a powerful tool for enhancing business innovation, particularly in knowledge-based companies. The present study aims to model and prioritize the key success factors in implementing the LARGE supply chain in innovative companies. This study employs a mixed-methods (quantitative-qualitative) approach with an applied objective, examining a statistical population composed of academic experts, organizational specialists, and senior managers of knowledge-based companies. In the qualitative phase, data were collected through interviews with 15 experts, while in the quantitative phase, 384 questionnaires were distributed and analyzed using MAXQDA, SPSS, and SMART PLS software. Findings from the qualitative phase revealed that the paradigmatic model of the LARGE supply chain for business innovation consists of seven main concepts and 28 subcategories. The main concepts include advanced technologies in the supply chain, agility and flexibility, advanced forecasting and planning, innovation in processes and business models, customer orientation and transparency, collaboration and integration in the supply chain, and risk management and sustainability. This model encompasses six primary dimensions: causal conditions, contextual conditions, intervening conditions, strategies, and outcomes. In the quantitative phase, confirmatory factor analysis confirmed the fit indices of the model. Additionally, the results of the Friedman test identified the priority of key success factors. According to these findings, "advanced technologies in the supply chain," particularly the subcategory of "artificial intelligence and machine learning," were recognized as the most important factors. By presenting a comprehensive model and identifying key success factors, this research provides practical tools for improving supply chains and enhancing innovation in knowledge-based businesses. It also offers recommendations for managers and policymakers to leverage this model effectively.

Keywords: LARGE supply chain, business innovation, key success factors

1. Introduction

In developing countries, due to fragile institutional structures, the formation and sustained operation of a national innovation system always face challenges. One of the most effective players in contemporary technological environments is innovation, which has become essential for companies. Most organizations seek to generate new ideas to leverage knowledge in delivering new products and services to customers and stakeholders, thereby establishing the necessary infrastructure for innovation. The

concept of business innovation has received increasing attention in recent decades (Jamali et al., 2024). Innovation refers to the creation of a new product, service, or process that generates new value for customers and organizations (Jamali et al., 2024). Innovation can involve revolutionary or evolutionary changes in products, processes, business models, and organizational structures (Jamali & Karimi Asl, 2018; Ngo et al., 2022). It has been recognized as a key driver of competitive advantage in business (Ganter & Hecker, 2014; Moon-Talvan-Burbano et al., 2020).

The literature examining the relationship between innovation and supply chains has expanded significantly in recent years (Abdel-Basset & Mohamed, 2020; Anvari, 2021; Cohen & Rodgers, 2020; Ghazi Zadeh & Jamal, 2022; Izadiyar et al., 2020; Jamali et al., 2024; Liu et al., 2023; Mehri Babadi et al., 2022; Ngo et al., 2022; Shams & Salimi Zaviyeh, 2021; Sousa et al., 2020; Vafaei-Zadeh et al., 2020). Some researchers have linked innovation to various supply chain performance metrics, such as the interactive effect on performance (Chowdhury & Quaddus, 2015; Ghasemieh et al., 2015; Ghazi Zadeh et al., 2015; Izadiyar et al., 2020; Mehri Babadi et al., 2022) or other capabilities (Abdel-Basset & Mohamed, 2020; Jamali et al., 2015; Shams & Salimi Zaviyeh, 2021). However, a theoretical and empirical gap remains regarding the LARGE supply chain. Empirically, the relationship between the LARGE supply chain and innovation is still weak. Theoretically, the literature has not conceptualized the extent to which different LARGE supply chain functions act as catalysts for innovation.

Analyzing the implementation stages of the LARGE supply chain also contributes to understanding the importance of collaboration and interaction in achieving high levels of innovation (Abdel-Basset & Mohamed, 2020; Sadeghi Moghadam et al., 2019). These authors explain that implementing the LARGE supply chain consists of four stages: coherence, cognitive participation, collective action, and reflective monitoring. These stages encompass dissemination activities associated with the innovation diffusion process, which requires knowledge, persuasion, decision-making, implementation, and confirmation (Laínez & Puigjaner, 2012; Maleki et al., 2011; Shams & Salimi Zaviyeh, 2021). Dissemination activities necessitate interaction with internal stakeholders (employees or managers) but fundamentally also require engagement with external stakeholders (customers, suppliers, etc.) to facilitate the implementation process, enabling the company to gain knowledge, external participation, or new reflective oversight. Therefore, integrating stakeholders into the company enhances innovation (Honarvar & Rezaee, 2019; Liu et al., 2023; Moons et al., 2019).

Innovation sometimes results from proactive and pioneering strategies to gain a competitive advantage in large supply chains, while at other times, it emerges as a response to regulatory pressures or market competitiveness requirements. Consequently, in response to these pressures, organizations with large supply chains may modify their operational methods and resource utilization to achieve better outcomes related to increased productivity and innovation (Cohen & Rodgers, 2020; Izadiyar et al., 2020).

The management of the LARGE supply chain seeks to integrate lean, agile, resilient, green, and ethical approaches within supply chain management to maximize their individual benefits while simultaneously mitigating their limitations (Carvalho & Machado, 2011). With the globalization of markets, the survival of companies and organizations increasingly depends on enhancing competitiveness and achieving sustainable competitive advantage. To attain supply chain competitiveness, customer service must be prioritized. Today, competition has shifted from individual companies to supply chains. The management of the LARGE supply chain strives to integrate lean, agile, resilient, and green approaches within supply chain management to capitalize on their respective advantages while simultaneously addressing their shortcomings. Agile, lean, resilient, and green strategies are contemporary supply chain management approaches that, depending on existing methodologies, can help improve performance and enhance efficiency and effectiveness. The ability to integrate these four distinct management approaches within the supply chain is strategically significant but presents a major challenge (Shams & Salimi Zaviyeh, 2021; Van Wassenhove & Pedraza Martinez, 2012). Each of these strategies considers different approaches and methods to optimize supply chain performance, thereby serving as a catalyst for business innovation.

Nevertheless, a knowledge gap remains regarding the overall impact of LARGE supply chain management practices on business innovation performance. Theoretically, a positive impact has been proposed by several authors (Anvari, 2021;

Ghasemieh et al., 2015; Honarvar & Rezaee, 2019; Izadiyar et al., 2020; Jamali et al., 2024). Many proponents of the "case for innovation" argument draw upon the Ecological Modernization Theory (EMT) to suggest that implementing LARGE supply chain management practices fosters broader business innovation (Abdel-Basset & Mohamed, 2020; Anvari, 2021; Laínez & Puigjaner, 2012). This strand of literature, influenced by EMT, suggests that environmental innovation within supply chains triggers changes that occur when the strategic perspective on environmental management becomes increasingly institutionalized in policy and technology at both the macro level (e.g., government and society, such as new regulations) and the micro level (e.g., organizations, such as adopting green supply chain management) (Izadiyar et al., 2020; Ngo et al., 2022).

Green supply chain management practices encompass innovations in procurement, production, distribution, and logistics processes. Therefore, for the successful implementation of green supply chain management, companies must make significant efforts to modify or adapt their products, processes, and management systems, often necessitating the adoption of new business models. Business innovation processes are fundamental in making these efforts cost-effective and efficient (Amiri et al., 2018; Shams & Salimi Zaviyeh, 2021; Vafaei-Zadeh et al., 2020). Consequently, the adoption of green supply chain management practices, driven by EMT pressures, necessitates technological system changes within companies, requiring innovative processes across the supply chain. As green supply chain management practices mature, innovations in processes, products, organizations, and marketing develop and advance (Anvari, 2021; Ghazi Zadeh & Jamal, 2022; Izadiyar et al., 2020; Shams & Salimi Zaviyeh, 2021; Sousa et al., 2020; Vafaei-Zadeh et al., 2020). As a result, companies become more innovative in all aspects, not just in environmental considerations (Ghazi Zadeh et al., 2015; Laínez & Puigjaner, 2012; Maleki et al., 2011; Moons et al., 2019).

The LARGE supply chain paradigm, emphasizing agility, flexibility, resilience, and environmental adaptability, can serve as an appropriate framework for developing innovative supply chains. However, the absence of a comprehensive model outlining how to implement this paradigm within organizations highlights a significant gap. Given the research problem, the primary research question is: What are the key success factors in implementing the LARGE supply chain in innovative companies, and how can these factors be modeled and prioritized?

2. Methods and Materials

This study employs a mixed-methods approach (qualitative and quantitative). In terms of purpose, it is an applied research study, and in terms of data collection, it follows a descriptive-survey design. The qualitative phase utilizes inductive content analysis to extract key concepts, while the quantitative phase employs questionnaires and statistical analysis to examine relationships among variables. This combination of approaches enables the development of a comprehensive model for analyzing the LARGE supply chain and its role in business innovation.

The statistical population in the qualitative phase consists of academic experts and senior organizational managers associated with the supply chain. In the quantitative phase, managers and specialists from knowledge-based companies across the country are studied. Sampling in the qualitative phase is conducted using a purposive method until theoretical saturation is reached, whereas in the quantitative phase, Morgan’s table is used to determine the sample size, and at least 384 managers are randomly selected.

Various methods are employed for data collection, including semi-structured interviews with experts for the qualitative phase, a researcher-designed questionnaire for the quantitative phase, and document analysis for developing the theoretical framework. These tools help identify key components of the LARGE supply chain and its impact on innovation.

In the qualitative phase, data are analyzed using inductive content analysis, and the Delphi method is applied to validate findings. In the quantitative phase, data are examined through structural equation modeling (SEM) and exploratory and confirmatory factor analysis. These methods allow for the explanation of relationships among variables and the validation of the final research model.

3. Findings and Results

In the qualitative phase of this mixed-methods study, semi-structured interviews were conducted to examine the supply chain model as a driver of business innovation. The sample consisted of two main groups: academic and organizational experts. The academic experts included 10 to 12 individuals with doctoral degrees, holding positions ranging from assistant professor to full professor. The organizational experts comprised 8 to 10 individuals with master's degrees and managerial experience. Their roles in organizations varied from senior manager and CEO to research and development (R&D) and quality control managers. This combination allowed for a more comprehensive and in-depth analysis of the theoretical and practical aspects of the innovation-driven supply chain.

The qualitative findings revealed several key categories and subcategories related to the role of the LARGE supply chain in fostering business innovation. Table 1 presents the selective coding results from the qualitative phase of the study.

Table 1. Selective Coding of Qualitative Findings

Main Category	Subcategory	Open Codes
Advanced Technologies in the Supply Chain	Artificial Intelligence and Machine Learning	1. AI is used to enhance supply chain performance. 2. AI-based demand forecasting algorithms are implemented. 3. Intelligent algorithms optimize transportation routes. 4. AI detects consumption patterns.
	Internet of Things (IoT)	1. IoT technology is used for product tracking. 2. IoT sensors monitor temperature in transportation. 3. Warehouses are managed with IoT. 4. IoT data improves supply chain decisions.
	Blockchain	1. Blockchain tracks product origins. 2. Smart contracts are used with suppliers. 3. Blockchain enhances security and transparency in transactions. 4. Blockchain improves supply chain traceability.
	Big Data Analytics	1. Supply chain data is regularly collected and analyzed. 2. Big data improves decision-making. 3. Hidden patterns in supply chain data are identified. 4. Data analysis predicts and prevents disruptions.
Integrated Supply Chain Management	Integrated Management Platforms	1. A unified platform manages the entire supply chain. 2. Systems within the supply chain are well-integrated. 3. Managers access all supply chain data via a single dashboard. 4. The platform improves supplier and customer communication.
	Real-Time Tracking	1. Products and orders are tracked in real time. 2. Inventory is monitored continuously. 3. Real-time tracking supervises transportation. 4. Alerts notify of supply chain delays.
	Smart Inventory Management	1. The system accurately forecasts inventory replenishment needs. 2. Intelligent algorithms optimize inventory levels. 3. Smart inventory management reduces storage costs. 4. Automated replenishment orders are generated.
	Logistics Optimization	1. Advanced systems optimize transportation routes. 2. Loading processes are optimized for efficiency. 3. Costs and transportation times are minimized. 4. Order scheduling is optimized using advanced algorithms.
Innovation in Processes and Business Models	Process Reengineering	1. Supply chain processes are regularly reviewed and optimized. 2. Innovation extends beyond adopting new technologies. 3. Bottlenecks in the supply chain are eliminated. 4. Process reengineering improves operational efficiency.
	Agile Business Models	1. The business model is flexible to market changes. 2. Continuous business model evaluation occurs. 3. New revenue streams are created through innovation. 4. Agility provides a competitive advantage.
	Service Innovation	1. New value-added services are introduced. 2. Services are personalized for customers. 3. Advanced technologies enhance after-sales services. 4. Service innovation improves customer experience.
	Collaboration and Open Innovation	1. The organization participates in collaborative innovation projects. 2. Cooperation with startups fosters innovation. 3. The organization is part of an innovation ecosystem. 4. External ideas are incorporated into innovation efforts.
Risk Management and Sustainability	Risk Identification and Mitigation	1. Formal processes identify supply chain risks. 2. Risks are regularly assessed and prioritized. 3. Strategies mitigate key supply chain risks. 4. Risk management is integral to supply chain decision-making.
	Green Supply Chain	1. Actions reduce the supply chain's carbon footprint. 2. Renewable energy use has increased. 3. Products are designed with sustainability in mind. 4. Environmental sustainability is key in supplier selection.
	Corporate Social Responsibility (CSR)	1. Strict ethical standards are enforced. 2. Programs support local communities. 3. Fair labor conditions are ensured. 4. Sustainability performance is transparently reported.
	Supply Chain Resilience	1. The supply chain adapts quickly to changing conditions. 2. Supplier diversification strategies reduce dependencies. 3. Crisis management plans are in place. 4. Strategic stockpiling enhances resilience.
Customer Orientation and Transparency	Product Traceability for Customers	1. Customers track products at all supply chain stages. 2. Accurate delivery information is provided. 3. Product origin information is accessible. 4. Order tracking is available throughout the process.
	Product and Service Customization	1. Products are customized for individual customers. 2. Services are tailored to customer preferences. 3. Customer data is used to enhance offerings. 4. Customization increases customer satisfaction.
	Transparency in the Supply Chain	1. Production conditions are transparently reported. 2. Pricing policies are clear. 3. Supply chain performance data is shared with stakeholders. 4. Transparency fosters trust among customers and partners.
	Seamless Customer Experience	1. An integrated shopping experience is provided. 2. Systems ensure consistency across touchpoints. 3. Multi-channel customer support is available. 4. After-sales services are seamlessly integrated.
Advanced Forecasting and Planning	AI-Based Demand Forecasting	1. AI algorithms precisely forecast demand. 2. Market trends are analyzed for demand impact. 3. Forecasts are continuously updated. 4. AI-based predictions optimize production and inventory.
	Scenario Planning	1. Market scenarios are regularly evaluated. 2. Strategies are pre-developed for different scenarios. 3. Scenario planning enhances supply chain flexibility. 4. Planning results help mitigate strategic risks.

Table 2 presents the main categories, subcategories, and final concepts identified in the study, illustrating how the LARGE supply chain functions as a driver of business innovation.

Table 2. Main Categories, Subcategories, and Final Concepts of the Study

Main Category	Subcategories	Concepts
LARGE Supply Chain as a Driver of Business Innovation	Advanced Technologies in the Supply Chain	- Artificial Intelligence and Machine Learning - Internet of Things (IoT) - Blockchain - Big Data Analytics
	Integrated Supply Chain Management	- Integrated Management Platforms - Real-Time Tracking - Smart Inventory Management - Logistics Optimization
	Innovation in Processes and Business Models	- Process Reengineering - Agile Business Models - Service Innovation - Collaboration and Open Innovation
	Risk Management and Sustainability	- Risk Identification and Mitigation - Green Supply Chain - Corporate Social Responsibility - Supply Chain Resilience
	Customer Orientation and Transparency	- Product Traceability for Customers - Product and Service Customization - Transparency in the Supply Chain - Seamless Customer Experience
	Advanced Forecasting and Planning	- AI-Based Demand Forecasting - Scenario Planning - Inventory Optimization - Product Lifecycle Management
	Collaboration and Integration in the Supply Chain	- Supplier Collaboration - Information Sharing - Joint Product Development - Supplier Relationship Management
	Agility and Flexibility	- Rapid Response to Market Changes - Agile Supply Chain - Change Management - Mass Customization

To validate the smart supply chain model as a driver of business innovation, the triangulation method was employed. This approach involves the convergence of primary data, theoretical literature, and practical experiences to confirm the proposed model.

First, primary data were collected through open, axial, and selective coding. These data were then compared with existing research literature related to advanced technologies, integrated management, process innovation, risk management, customer orientation, and other components of the smart supply chain. Finally, practical experiences of companies in implementing related technologies and the success derived from these experiences were incorporated into the model analysis. This process ensured that the model was validated with strong evidence from all three perspectives, confirming the need to address practical challenges and standardization in its implementation.

The paradigmatic model of the LARGE supply chain integrates key factors that contribute to business innovation, emphasizing technological advancements, agility, sustainability, and customer-centric strategies. This model serves as a comprehensive framework for companies seeking to enhance their supply chain efficiency and innovation capabilities.

In the quantitative phase of this mixed-methods study, a questionnaire was used as the data collection tool to assess the supply chain as a driver of business innovation. The questionnaire consisted of 24 questions covering advanced technologies, integrated management, process innovation, risk management and sustainability, customer orientation and transparency, advanced forecasting and planning, supply chain collaboration and integration, agility, and flexibility. Respondents rated each question on a Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree).

Additionally, demographic data from the sample of 384 participants included characteristics such as gender, age, education level, work experience, organizational position, company sector, company size, years of operation, and annual revenue. These demographic data provide a broad distribution of characteristics among managers in knowledge-based companies, contributing to subsequent research analyses.

For the analysis of the quantitative data, an independent t-test was conducted to examine differences across groups, allowing for statistical validation of the research findings.

The results of the one-sample t-test for the subvariables related to the smart supply chain are presented in Table 3, which includes the mean, standard deviation, t-statistic, degrees of freedom, and p-value for each variable.

Table 3. Results of the One-Sample t-Test for Subvariables

Subvariable	Mean	Standard Deviation	t-Statistic	Degrees of Freedom	p-Value
Artificial Intelligence and Machine Learning	3.842	0.721	11.685	383	0.001
Internet of Things (IoT)	3.756	0.689	10.963	383	0.001
Blockchain	3.512	0.798	6.416	383	0.001
Big Data Analytics	3.967	0.654	14.785	383	0.001
Integrated Management Platforms	3.689	0.735	9.372	383	0.001

Real-Time Tracking	3.823	0.702	11.724	383	0.001
Smart Inventory Management	3.745	0.718	10.376	383	0.001
Logistics Optimization	3.901	0.681	13.236	383	0.001
Process Reengineering	3.578	0.769	7.515	383	0.001
Agile Business Models	3.712	0.743	9.579	383	0.001
Service Innovation	3.689	0.752	9.158	383	0.001
Collaboration and Open Innovation	3.645	0.785	8.211	383	0.001
Risk Identification and Mitigation	3.867	0.692	12.525	383	0.001
Green Supply Chain	3.534	0.812	6.576	383	0.001
Corporate Social Responsibility	3.467	0.835	5.592	383	0.001
Supply Chain Resilience	3.789	0.723	10.907	383	0.001
Product Traceability for Customers	3.912	0.675	13.515	383	0.001
Product and Service Customization	3.845	0.708	11.932	383	0.001
Transparency in the Supply Chain	3.767	0.731	10.487	383	0.001
Seamless Customer Experience	3.923	0.669	13.796	383	0.001
AI-Based Demand Forecasting	3.878	0.687	12.781	383	0.001
Scenario Planning	3.689	0.752	9.158	383	0.001
Inventory Optimization	3.856	0.703	12.167	383	0.001
Product Lifecycle Management	3.712	0.743	9.579	383	0.001
Supplier Collaboration	3.845	0.708	11.932	383	0.001
Information Sharing	3.801	0.715	11.202	383	0.001
Joint Product Development	3.645	0.785	8.211	383	0.001
Supplier Relationship Management	3.778	0.728	10.684	383	0.001
Rapid Response to Market Changes	3.934	0.663	14.084	383	0.001
Agile Supply Chain	3.889	0.684	12.989	383	0.001
Change Management	3.723	0.739	9.787	383	0.001
Mass Customization	3.678	0.759	8.928	383	0.001

The results of this test indicate that all subvariables related to the smart supply chain significantly influence business innovation. The table presents the mean and standard deviation of each variable, along with the t-statistic and p-value to confirm the significance of the differences. All p-values are less than 0.05, indicating a statistically significant relationship between the variables and business innovation.

To examine the factors influencing the LARGE supply chain as a driver of business innovation, a second-order confirmatory factor analysis was conducted. The results indicate that all examined factors have a significant effect on the LARGE supply chain as a driver of business innovation. This conclusion is based on p-values of 0.001 for all factors, demonstrating statistical significance at a confidence level of 99.9%.

These findings highlight that organizations aiming to foster innovation through the LARGE supply chain must adopt a comprehensive and multidimensional approach. This approach should include integrating advanced technologies, managing risks effectively, addressing customer needs, fostering intra-supply chain collaboration, implementing advanced planning strategies, innovating business models, and maintaining organizational agility.

Table 4 presents the results of the confirmatory factor analysis for the main and subcategories of the study, including factor loadings, t-values, average variance extracted (AVE), composite reliability (CR), and Cronbach's alpha.

Table 4. Confirmatory Factor Analysis for Main and Subcategories

Main Category	Subcategory	Question	Factor Loading	t-Value	AVE	CR	Cronbach's Alpha
Advanced Technologies in the Supply Chain	Artificial Intelligence and Machine Learning	Q1	0.82	15.3	0.71	0.88	0.86
		Q2	0.85	16.2			
		Q3	0.87	17.1			
		Q4	0.83	15.7			
	Internet of Things (IoT)	Q1	0.80	14.8	0.69	0.87	0.85
		Q2	0.84	16.0			
		Q3	0.86	16.8			
		Q4	0.81	15.2			
	Blockchain	Q1	0.79	14.5	0.68	0.86	0.84

		Q2	0.83	15.7			
		Q3	0.85	16.4			
		Q4	0.82	15.4			
Innovation in Processes and Business Models	Process Reengineering	Q1	0.80	14.8	0.69	0.87	0.85
		Q2	0.83	15.7			
		Q3	0.85	16.4			
		Q4	0.82	15.3			
	Agile Business Models	Q1	0.79	14.5	0.68	0.86	0.84
		Q2	0.82	15.4			
		Q3	0.84	16.0			
		Q4	0.81	15.1			
Risk Management and Sustainability	Risk Identification and Mitigation	Q1	0.82	15.3	0.71	0.88	0.86
		Q2	0.85	16.2			
		Q3	0.87	17.1			
		Q4	0.83	15.7			
	Green Supply Chain	Q1	0.80	14.8	0.69	0.87	0.85
		Q2	0.84	16.0			
		Q3	0.86	16.8			
		Q4	0.81	15.2			
Customer Orientation and Transparency	Product Traceability for Customers	Q1	0.80	14.8	0.69	0.87	0.85
		Q2	0.83	15.7			
		Q3	0.85	16.4			
		Q4	0.82	15.3			
	Product and Service Customization	Q1	0.79	14.5	0.68	0.86	0.84
		Q2	0.82	15.4			
		Q3	0.84	16.0			
		Q4	0.81	15.1			
Advanced Forecasting and Planning	AI-Based Demand Forecasting	Q1	0.82	15.3	0.71	0.88	0.86
		Q2	0.85	16.2			
		Q3	0.87	17.1			
		Q4	0.83	15.7			
	Scenario Planning	Q1	0.80	14.8	0.69	0.87	0.85
		Q2	0.84	16.0			
		Q3	0.86	16.8			
		Q4	0.81	15.2			
Collaboration and Integration in the Supply Chain	Supplier Collaboration	Q1	0.80	14.8	0.69	0.87	0.85
		Q2	0.83	15.7			
		Q3	0.85	16.4			
		Q4	0.82	15.3			
Agility and Flexibility	Rapid Response to Market Changes	Q1	0.82	15.3	0.71	0.88	0.86
		Q2	0.85	16.2			
		Q3	0.87	17.1			
		Q4	0.83	15.7			
	Agile Supply Chain	Q1	0.80	14.8	0.69	0.87	0.85
		Q2	0.84	16.0			
		Q3	0.86	16.8			
		Q4	0.81	15.2			

The results of the confirmatory factor analysis indicate that all examined subcategories demonstrate strong factor loadings, t-values above 14, and AVE values above 0.68, ensuring the validity of the measurement model. The composite reliability (CR) values are above 0.86, and Cronbach's alpha values exceed 0.84, confirming high internal consistency across the constructs. These findings validate the structural integrity of the LARGE supply chain model as a driver of business innovation.

The Friedman test is a non-parametric statistical method used for comparing and ranking multiple dependent groups. In this analysis, the Friedman test was employed to rank the main and subcategories in the field of supply chain management. This ranking helps in understanding the relative importance of each category from the respondents' perspective. The results of this test can assist managers and researchers in prioritizing strategies and focusing on key aspects of supply chain management.

Table 5. Friedman Test and Ranking of Main and Subcategories

Rank	Main Category	Mean Rank	Subcategory	Mean Rank
1	Advanced Technologies in the Supply Chain	6.82	Artificial Intelligence and Machine Learning	3.75
2	Agility and Flexibility	6.45	Internet of Things (IoT)	3.62
3	Advanced Forecasting and Planning	5.98	Big Data Analytics	3.58
4	Innovation in Processes and Business Models	5.76	Agile Supply Chain	3.55
5	Customer Orientation and Transparency	5.43	AI-Based Demand Forecasting	3.51
6	Collaboration and Integration in the Supply Chain	5.21	Rapid Response to Market Changes	3.48
7	Risk Management and Sustainability	4.35	Process Reengineering	3.45
			Product and Service Customization	3.42
			Supplier Collaboration	3.39
			Transparency in the Supply Chain	3.36
			Supply Chain Resilience	3.33
			Blockchain	3.30
			Service Innovation	3.27
			Scenario Planning	3.24
			Information Sharing	3.21
			Inventory Optimization	3.18
			Change Management	3.15
			Green Supply Chain	3.12
			Agile Business Models	3.09
			Seamless Customer Experience	3.06
			Product Traceability for Customers	3.03
			Joint Product Development	3.00
			Product Lifecycle Management	2.97
			Supplier Relationship Management	2.94
			Risk Identification and Mitigation	2.91
			Collaboration and Open Innovation	2.88
			Corporate Social Responsibility	2.85
			Mass Customization	2.82

$\chi^2 = 278.45$, df = 6, $p < 0.001$ (for main categories)
$\chi^2 = 523.67$, df = 27, $p < 0.001$ (for subcategories)

The results of the Friedman test indicate a significant difference in the relative importance of the main and subcategories in supply chain management. At the main category level, advanced technologies and agility hold the highest importance, while subcategories such as artificial intelligence and machine learning rank the highest. This suggests that organizations should focus on adopting advanced technologies, increasing agility, and emphasizing innovation and collaboration, while also ensuring effective risk management and sustainability.

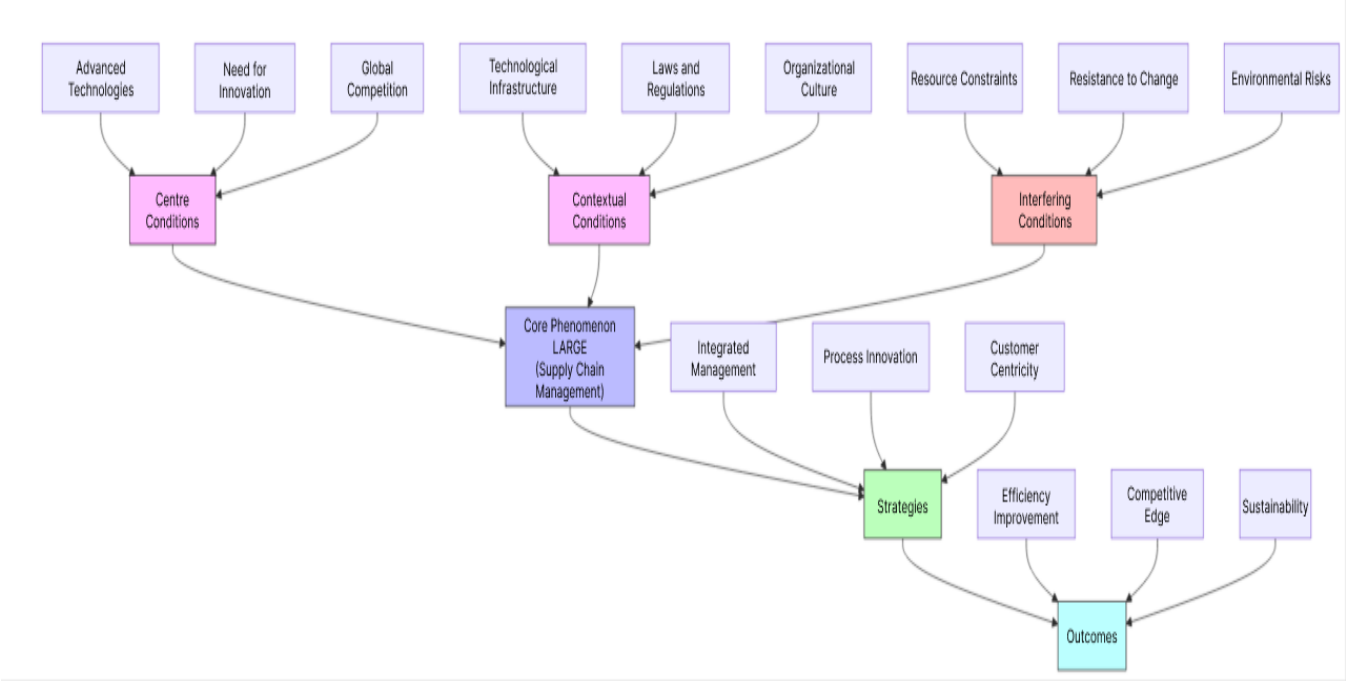

Figure 1. Final Model of the Study

4. Discussion and Conclusion

This study examines the role of the LARGE supply chain as a driver of business innovation. In today's turbulent and competitive world, the supply chain is no longer merely a support process but has become a key element in creating competitive advantage and fostering innovation in businesses. This study aims to present a comprehensive model for a better understanding of the role of the LARGE supply chain in promoting innovation and business transformation.

The proposed model in this study consists of six main categories, each addressing different aspects of the LARGE supply chain. These categories include causal conditions, contextual conditions, intervening conditions, strategies, outcomes, and the central category. Each of these main categories contains multiple subcategories and concepts that delve deeper into various dimensions of the LARGE supply chain.

In the causal conditions section, the primary focus is on advanced technologies in the supply chain. This section examines the role of technologies such as artificial intelligence, machine learning, the Internet of Things (IoT), blockchain, and big data analytics in enhancing supply chain performance. These technologies enable more accurate demand forecasting, route optimization, product tracking, and improved decision-making.

The contextual conditions refer to integrated supply chain management. This section includes concepts such as the use of integrated management platforms, real-time tracking, smart inventory management, and logistics optimization. These contextual factors enable more efficient management of the entire supply chain, from suppliers to end customers.

In the intervening conditions section, the focus is on risk management and sustainability. This section addresses issues such as risk identification and mitigation, establishing a green supply chain, corporate social responsibility, and supply chain resilience. These factors play a crucial role in ensuring the sustainability and flexibility of the supply chain in response to environmental and social challenges.

The strategies examined in this model are divided into two main sections: innovation in processes and business models and agility and flexibility. These strategies include concepts such as process reengineering, developing agile business models, service innovation, collaboration and open innovation, rapid response to market changes, and mass customization.

The outcomes of this model are categorized into three main sections: customer orientation and transparency, advanced forecasting and planning, and collaboration and integration in the supply chain. These outcomes encompass concepts such as product traceability for customers, product and service customization, AI-based demand forecasting, inventory optimization, supplier collaboration, and joint product development.

Ultimately, the central category of this model is the LARGE supply chain as a driver of business innovation. This category demonstrates how all the elements and concepts mentioned in the model ultimately lead to the creation of an advanced and innovative supply chain that acts as a driving force for innovation and transformation across the entire business.

This comprehensive model helps organizations gain a better understanding of the strategic role of the supply chain in the digital era and enables them to leverage it as a tool for creating competitive advantage and fostering business innovation.

The findings of this research and the proposed recommendations for utilizing the LARGE supply chain as a driver of business innovation align with existing theoretical foundations and research in this field.

The integration of advanced technologies in the supply chain, proposed as the first recommendation, aligns with Schumpeter's theory of technological innovation. Schumpeter believed that technological innovation is the driving force of economic development. In the context of the supply chain, multiple studies, such as the research by Li et al. (2018), have demonstrated that integrating advanced technologies like artificial intelligence and IoT in the supply chain can significantly improve performance and foster innovation.

The establishment of an integrated supply chain management platform aligns with the theory of integrated information systems. This theory posits that information integration across an organization can lead to improved decision-making and performance. Studies showed that integrated supply chain management platforms significantly enhance organizational agility and flexibility (Abdel-Basset & Mohamed, 2020; Cohen & Rodgers, 2020; Izadiyar et al., 2020; Mehri Babadi et al., 2022; Moons et al., 2019; Sadeghi Moghadam et al., 2019; Sousa et al., 2020).

Process reengineering and the development of agile business models are consistent with Kotter's change management theory and the theory of organizational agility. The development of a comprehensive risk management and sustainability system aligns with supply chain risk management theory and organizational sustainability theory. These theories highlight the importance of identifying, assessing, and managing risks while considering social and environmental aspects in the supply chain. Studies demonstrated that organizations implementing comprehensive risk management and sustainability systems in their supply chains achieved superior performance and sustainable innovations (Abdel-Basset & Mohamed, 2020; Anvari, 2021; Izadiyar et al., 2020; Liu et al., 2023).

The development of a customer-centric and transparency strategy aligns with relationship marketing theory and organizational transparency theory. These theories emphasize the importance of fostering long-term relationships with customers and providing transparent information to stakeholders. Studies study found that organizations implementing customer-centric and transparent strategies in their supply chains achieved higher customer satisfaction and more successful innovations (Chowdhury & Quaddus, 2015; Honarvar & Rezaee, 2019; Liu et al., 2023; Miri Rami et al., 2022; Ramesh et al., 2010; Raoufinia et al., 2019; Udofia et al., 2021).

The implementation of advanced forecasting and planning systems aligns with data-driven decision-making theory and scenario planning theory. These theories emphasize the importance of leveraging data and advanced analytics for decision-making and preparing for various future scenarios. Studies showed that organizations using advanced forecasting and planning systems in their supply chains achieved superior performance in inventory management and demand responsiveness (Abdel-Basset & Mohamed, 2020; Anvari, 2021; Izadiyar et al., 2020; Mehri Babadi et al., 2022; Moons et al., 2019; Sadeghi Moghadam et al., 2019; Vafaei-Zadeh et al., 2020).

Strengthening collaboration and integration in the supply chain aligns with organizational network theory and Porter's competitive advantage theory. These theories emphasize the importance of inter-organizational collaboration and value co-creation. Studies found that organizations with stronger collaboration and integration within their supply chains generated more innovations and achieved superior performance (Abdel-Basset & Mohamed, 2020; Anvari, 2021; Izadiyar et al., 2020; Vafaei-Zadeh et al., 2020).

Creating a culture of agility and continuous innovation aligns with Schein's organizational culture theory and Chesbrough's open innovation theory. These theories highlight the importance of fostering an organizational culture that supports innovation and change while leveraging both internal and external resources for innovation. Studies found that organizations embedding agility and continuous innovation in their supply chains were more effective in adapting to environmental changes and generating innovations (Abdel-Basset & Mohamed, 2020; Laínez & Puigjaner, 2012; Liu et al., 2023; Sousa et al., 2020).

Based on the proposed model, the following practical recommendations are suggested for utilizing the LARGE supply chain as a driver of business innovation:

1. Integrating advanced technologies into the supply chain: Organizations should develop a comprehensive strategy for integrating advanced technologies such as artificial intelligence, IoT, blockchain, and big data analytics into their supply chains.
2. Establishing an integrated supply chain management platform: Organizations should implement a unified platform that enables real-time tracking, smart inventory management, and logistics optimization.
3. Reengineering processes and developing agile business models: Organizations should review and reengineer their supply chain processes to enhance agility and flexibility while fostering innovation.
4. Developing a comprehensive risk management and sustainability system: Organizations should implement strategies for risk identification and mitigation, green supply chain development, corporate social responsibility initiatives, and supply chain resilience.
5. Developing a customer-centric and transparency strategy: Organizations should enhance product traceability, personalize offerings, and increase transparency throughout the supply chain.
6. Implementing advanced forecasting and planning systems: Organizations should integrate AI-driven demand forecasting, scenario planning, inventory optimization, and product lifecycle management.
7. Strengthening collaboration and integration in the supply chain: Organizations should focus on building long-term relationships with suppliers, sharing information, developing joint products, and managing supplier relationships effectively.
8. Creating a culture of agility and continuous innovation: Organizations should cultivate an agile organizational culture that promotes rapid response to market changes, supply chain flexibility, and continuous improvement.

Given the study's limitations, the following recommendations are proposed for future research:

1. Comparative analysis of the LARGE supply chain model across different industries.
2. Examining the impact of emerging technologies on the performance of the LARGE supply chain.
3. Developing a dynamic model of the LARGE supply chain that adapts to rapid environmental and technological changes.
4. Analyzing the role of knowledge management in improving the efficiency of the LARGE supply chain.
5. Identifying risks associated with the LARGE supply chain and proposing effective management strategies.

These recommendations provide a roadmap for further exploration of the relationship between the LARGE supply chain and business innovation, contributing to the advancement of knowledge and practical applications in this field.

Ethical Considerations

All procedures performed in this study were under the ethical standards.

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Conflict of Interest

The authors report no conflict of interest.

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