Strategic integration of big data in supply chain management: Unlocking innovation, sustainability, and competitiveness in the new s-curve industries

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Abstract: This study examines the role of big data and digital transformation in revolutionizing supply chain management (SCM) in the New S-Curve industries of the Bangkok metropolitan area. Qualitative research was conducted through in-depth interviews with 21 key informants, followed by content analysis to identify key trends and insights. The findings reveal that big data integrated with technology significantly improves SCM by enabling real-time analytics, predictive decision-making, and process optimization. This leads to higher operational efficiency and better responsiveness to the market. In addition, big data facilitates sustainability by supporting environmentally friendly practices such as energy-efficient logistics and green production. Entrepreneurs leverage big data to create innovative business models, optimize production, and develop products that meet market needs. Despite its potential, there are challenges in adopting big data for SCM, including data quality issues, high implementation costs, and regulatory hurdles. The study highlights the need for collaboration between the public and private sectors, as well as investment in technology infrastructure and workforce development to overcome these obstacles. The strategic integration of big data and digital transformation offers significant opportunities to improve the efficiency, sustainability, and competitiveness of SCM and help the industry thrive in the digital age.

Keywords: Big data, New s-curve industries, Supply chain management, Sustainable development.

1. Introduction

Integrating big data into supply chain management (SCM) offers transformative opportunities for entrepreneurship and sustainable development. Big data enhances operational efficiency, promotes transparency, and supports data-driven decision-making by aligning SCM practices with environmental, economic, and social sustainability goals [1]. For entrepreneurs, it offers tools to analyze consumer needs, optimize production, and innovate business models, which ultimately promote competitiveness and sustainability [2].

In Thailand, the "Thailand 4.0" model and infrastructure investments aim to promote the growth of new S-Curve industries, including robotics, biofuels, digital technology, and medical hubs [3]. However, challenges such as the lack of large-scale data systems hinder sustainable SCM practices. Scholars emphasize the role of big data in reducing costs, improving service efficiency, mitigating risk, and creating innovative solutions [4, 5].

Big data also supports green entrepreneurship by enabling sustainable practices such as green logistics, energy-efficient production, and supplier selection aligned with environmental goals [6]. Despite challenges such as data accessibility and security, big data offers opportunities for innovation and cross-sector collaboration to drive sustainability [7]. Using big data in SCM enables entrepreneurs

to create sustainable business models, improve competitiveness, and contribute to industrial development in line with sustainability goals.

1.1. Research Objectives

1. To analyze the role of advanced technologies such as the Internet of Things (IoT), artificial intelligence (AI), and blockchain in enhancing SCM activities' intelligence, efficiency, and adaptability.

2. To examine how big data drives operational improvements, market responsiveness, and sustainable development practices within the New S-Curve industries.

3. To investigate how entrepreneurs utilize big data to foster innovation, optimize production, and develop products and services that align with market needs.

4. To evaluate the contributions of green technologies and public-private sector collaboration in achieving sustainable progress in supply chain management.

5. To assess the strategic integration of big data and digital transformation in enhancing SCM's efficiency, sustainability, and competitiveness in the New S-Curve industries.

2. Literature Review

2.1. Supply Chain Management

Supply chain management (SCM) is a critical strategy for optimizing the flow of goods, information, and finance, enabling value creation and efficiency across interconnected networks of companies. As SCM evolves, there is an increasing focus on integrating digital technologies and sustainability to meet the demands of a globalized and environmentally conscious economy [8]. Modern SCM focuses on integration, agility and sustainability, with collaboration between stakeholders driving innovation and adaptability in response to market changes [9, 10]. These elements are particularly important for entrepreneurs seeking to improve supply chain performance while achieving sustainable development goals.

Sustainability in SCM considers environmental, social and economic dimensions and aims to minimize negative impacts while maximizing positive contributions [11]. Entrepreneurs play a crucial role in adopting circular supply chain models, reducing waste and promoting reuse and recycling of resources [12]. By embedding sustainable practices into SCM, companies can gain competitive advantage, build stakeholder trust and meet consumer expectations for ethical and environmentally friendly products.

2.2. The Integration of Digital Technologies

The integration of digital technologies such as the Internet of Things (IoT), artificial intelligence (AI) and blockchain has revolutionized SCM, providing entrepreneurs with tools to enhance transparency, efficiency and resilience [13]. These technologies enable real-time data tracking, predictive analytics for demand forecasting and informed decision-making, and help companies adapt to disruptions and market changes [14]. Entrepreneurs leveraging these tools can optimize their operations, reduce costs and offer innovative solutions that meet customer needs while supporting sustainable practices.

2.3. Big Data Analytics

Big data analytics is a transformative force in SCM, providing entrepreneurs with actionable insights to improve decision-making, operational efficiency and market responsiveness [15]. By analyzing vast amounts of supply chain data, companies can enhance demand forecasting, optimize inventory, manage risk and improve visibility across the supply chain [16]. Big data also enables entrepreneurs to develop new business models that align with sustainable development, such as environmentally friendly production processes, energy-efficient logistics and supplier networks that prioritize environmental and social responsibility [6]. Despite its potential, the adoption of big data analytics in SCM is fraught with challenges, including data quality, integration issues and the need for

advanced analytics capabilities [7]. Entrepreneurs also need to overcome concerns about data privacy, data security, and the high cost of technology investments. However, these challenges also present opportunities for entrepreneurial innovation, particularly in developing advanced analytics models, integrating new technologies such as blockchain, and fostering cross-industry collaboration to enhance supply chain transparency and sustainability [14].

In summary, the intersection of entrepreneurship, big data analytics, and sustainable development offers transformative potential for SCM. By leveraging big data and digital technologies, entrepreneurs can drive innovation, improve supply chain efficiency, and contribute to sustainable economic growth. Future research should focus on overcoming barriers to adoption, advancing analytics capabilities, and exploring new business models that align entrepreneurial strategies with sustainability goals and enable a more equitable and resilient global supply chain.

3. Research Methodology

3.1. Population and Sample

In this qualitative study, in-depth interviews are the primary method of collecting data from key informants. The sample size is determined based on several factors, including the group's characteristics, the study's objectives, the topic's complexity, and time and financial constraints. The study focuses on entrepreneurs from the New S-Curve industries in and around Bangkok and includes 21 participants. These participants are categorized by their industries as follows: Robotics (4 respondents), Aviation and Logistics (5 respondents), Biofuels and Biochemicals (4 respondents), Digital Technology (4 respondents), and Medical Hub (5 respondents). The rationale for the sample size is based on the criteria for sample size in qualitative research proposed by Hautus, et al. [17] which states that the error rate decreases significantly and stabilizes when the number of participants is between 17 and 21. The snowball sampling method is used to recruit participants for this study.

3.2. Research Instrumental

The study uses a structured interview format with five main questions designed to cover various aspects, including (1) the current state of SCM in the New S-Curve industries, (2) the activities involved in the SCM processes of these industries, (3) the application of Big Data in the management of these supply chains, (4) the benefits that entrepreneurs derive from the use of Big Data in these industries, and (5) the development characteristics towards sustainability in the New S-Curve industries. The content validity of the research instrument was confirmed by the Item Objective Congruence (IOC) method, which five experts validated. Each question achieved an IOC score of 1, indicating high content validity.

3.3. Data Analysis

Qualitative data is analyzed through content analysis to uncover and interpret its meanings. This process begins with collecting relevant data, followed by classifying and categorizing that data based on its characteristics and relationships. This approach facilitates the understanding and summarization of the results and enables a comprehensive understanding of sustainable SCM practices and the use of big data in the target industries.

4. Result

This study investigated the role of big data and digital transformation in revolutionizing supply chain management (SCM) in the Bangkok metropolitan area, particularly in the New S-Curve industries. The findings were analyzed to achieve the research objectives:

4.1. Objective 1: To Explore how Big Data Enhances Supply Chain Operations in the New S-Curve Industries

The results reveal that big data significantly improves supply chain operations by enabling real-time analysis and predictive decision-making.

1. Improved efficiency: Big data analyses facilitate demand forecasting, inventory management, and process optimization. Companies in the medical and digital technology industries, for example, use big data to accurately predict customer demand, reduce excess inventory, and optimize production schedules.

2. Improved visibility and transparency: Advanced technologies such as blockchain, integrated with big data, enable real-time tracking of materials and products throughout the supply chain. This reduces inefficiencies and ensures compliance with sustainability standards.

3. Risk mitigation: Predictive analytics based on big data helps companies identify and respond to potential disruptions such as delays or issues with suppliers, improving supply chain resilience.

4.2. Objective 2: To Examine How Entrepreneurs Leverage Big Data to Foster Innovation and Sustainable Practices. Entrepreneurs in the Bangkok Metropolitan Region Utilize Big Data as a Catalyst for Innovation and Sustainability.

1. Driving product and service innovation: Big Data allows entrepreneurs to analyze market trends, consumer behavior, and competitors' strategies, enabling the development of tailored products and services. For example, digital start-ups use customer feedback and data from social media to introduce new, market-relevant offerings.

2. Promoting green entrepreneurship: Entrepreneurs in the biofuel and logistics sectors use big data to introduce sustainable practices, such as optimizing energy consumption and selecting environmentally friendly suppliers. These initiatives align with the objectives of the "Thailand 4.0" model and sustainable development.

3. Building competitive advantage: By utilizing Big Data, entrepreneurs can improve decision-making, reduce costs, and increase customer satisfaction, positioning their businesses as leaders in their respective sectors.

4.3. Objective 3: To Analyze the Role of Digital Transformation in Integrating Sustainability into Supply Chain Management. The Findings Demonstrate that Digital Transformation Plays a Pivotal Role in Embedding Sustainability into SCM.

1. Integration of digital technologies: IoT, AI, and blockchain enable supply chain stakeholders to monitor environmental impact, track compliance with sustainability criteria, and improve resource efficiency. For example, IoT devices are used in logistics to optimize delivery routes and thus reduce fuel consumption and emissions.

2. Collaboration across sectors: Digital platforms facilitate collaboration between the public and private sectors, enabling the achievement of common sustainability goals. Government initiatives combined with private sector innovation support the development of circular supply chains.

3. Enabling data-driven decisions: Real-time data from digital tools enables companies to make environmentally conscious decisions, such as minimizing waste and reducing energy consumption in production processes.

4.4. Objective 4: To Evaluate the Challenges and Opportunities in Adopting Big Data for Sustainable SCM. Participants Identified the Following Challenges and Opportunities.

1. Challenges. *Data availability and quality:* Many organizations struggle to capture and manage accurate and consistent data. *Technological limitations:* Lack of advanced analytics capabilities and high investment costs were common barriers. *Regulatory issues:* Inconsistent data security and privacy regulations hinder adoption.

2. Opportunities. *Technological innovation:* Integrating AI and machine learning offers opportunities for advanced analytical models that enable more accurate and efficient SCM processes. *Cross-sector collaboration:* Government and private sector partnerships promote knowledge sharing and investment in green technologies. *Entrepreneurial growth:* Big data opens the door to new business models focused on sustainability, such as green manufacturing and waste reduction strategies.

4.5. Objective 5: To Propose Strategies for Leveraging Big Data and Digital Transformation for Future-Ready Supply Chains. The Study Suggests Several Strategies for Achieving Competitive, Sustainable, And Resilient Supply Chains

1. Invest in advanced analytics and technology: Organizations should adopt cutting-edge technologies such as AI and IoT to enhance data analytics capabilities and operational efficiency.

2. Encourage public-private collaboration: Policymakers and businesses should collaborate to create infrastructure, regulations, and incentives that promote sustainable SCM practices.

3. Encourage entrepreneurial innovation: Entrepreneurs should leverage big data to create disruptive business models and solutions that address sustainability challenges while meeting market demands.

4. Develop workforce skills: Upskilling supply chain professionals in data analytics and digital technologies is essential for successfully integrating Big Data and digital transformation.

5. Adopt Circular Economy principles: To achieve sustainability goals, companies should design their supply chains to prioritize resource efficiency, waste minimization, and material reuse.

The findings underline the transformative role of big data and digital transformation in revolutionizing SCM in the new S-Curve industries. Entrepreneurs are becoming key players in driving innovation and sustainability through big data insights. Despite the challenges, integrating digital technologies and data-driven practices offers promising opportunities for creating sustainable, competitive, and future-proof supply chains in the Bangkok metropolitan region.

5. Discussion

The findings of this study highlight the transformative impact of big data and digital transformation on supply chain management (SCM), particularly within the New S-Curve industries in the Bangkok metropolitan region. Drawing on existing literature, it demonstrates how big data, and digital tools drive operational efficiency, sustainability, and business innovation, while addressing the key challenges to their adoption.

5.1. Big Data's Role in Enhancing SCM Efficiency

The results reveal that big data significantly enhances SCM efficiency by enabling real-time analytics, predictive decision making, and process optimization. This aligns with Wamba, et al. [15] who highlight the importance of big data in optimizing inventory management, improving demand forecasting, and reducing operational inefficiencies. The ability of big data to enhance visibility and transparency in the supply chain is also consistent with Kamble, et al. [18] who emphasizes its role of big data in tracking materials and monitoring compliance with sustainability standards. In addition, participants highlighted the role of predictive analytics in mitigating risk and ensuring supply chain resilience. This supports the findings of Choi, et al. [19] who showed that big data can prevent disruption by providing actionable insights into potential risks. Such improvements are particularly important for industries such as logistics and digital technology, where responsiveness and adaptability are critical to maintaining competitiveness.

5.2. Entrepreneurial Innovation and Big Data

The findings show that entrepreneurs leverage big data to drive innovation and support sustainable practices, reflecting the evolving role of entrepreneurship in transforming the supply chain. Entrepreneurs use big data insights to identify market trends, develop customized products, and create innovative business models. These findings support Kamboj and Rana [4] assertion that big data enables companies to understand customer needs better and increase value creation through innovation. Furthermore, the study highlights how big data promotes green entrepreneurship by enabling resource optimization and environmentally friendly practices. This is in line with the work of Büyüközkan and Göçer [20] who emphasize the role of sustainability in entrepreneurial decisions. For example, entrepreneurs in the biofuel and logistics sectors are using data-driven insights to reduce energy consumption and emissions, contributing to the broader goals of the "Thailand 4.0" model [21].

5.3. Digital Transformation and Sustainability

Integrating digital technologies such as IoT, AI, and blockchain has proven critical to incorporating sustainability into SCM practices. These technologies enable real-time monitoring of supply chain operations, support environmentally conscious decisions, and facilitate the transition to circular supply chain models. These findings are consistent with observations of Govindan and Hasanagic [12] who found that digital tools play a crucial role in minimizing waste and promoting the reuse of materials. Furthermore, the study emphasizes the importance of collaboration between the public and private sectors in fostering sustainable SCM. This is in line with Wang, et al. [7] who emphasize the role of cross-sector partnerships in addressing challenges related to data availability and technology adoption. By working together, stakeholders can create the necessary infrastructure and policies to support green supply chain practices.

5.4. Challenges and Opportunities

Despite its benefits, integrating big data into SCM comes with challenges, such as data quality issues, high implementation costs, and regulatory concerns. These challenges echo the findings of Queiroz, et al. [14] who found that the dynamic nature of global supply chains makes adopting big data analytics difficult. However, these obstacles also present opportunities for innovation, particularly in developing advanced analytics models and enhancing data security measures. The study also highlights the potential of big data to drive business growth by creating new business models that address sustainability challenges. This perspective supports the resource-based view (RBV) theory proposed by Barney [22] which emphasizes using unique resources, such as data analytics capabilities, to gain a competitive advantage. Entrepreneurs who apply data-driven strategies can better meet market demands while contributing to sustainable development.

6. Implications for Future SCM Practices

The findings suggest that big data and digital transformation are essential for creating sustainable and future-ready supply chains. By fostering innovation, enhancing efficiency, and promoting environmental responsibility, these tools enable companies to meet the demands of a globalized economy. However, as Ivanov, et al. [23] note, future research should further explore integrating new technologies with big data analytics to improve supply chains' adaptability and resilience. Investment in workforce development is also crucial to realize the full potential of big data in SCM. Upskilling professionals in data analytics and digital tools will close capability gaps and support the strategic adoption of these technologies [24]. Suggest that an organization should create a learning culture as it has a direct impact on the effectiveness of training and knowledge management. It is also a foundation for knowledge sharing and skills development.

This study contributes to the growing literature on the role of big data and digital transformation in revolutionizing supply chain management. The findings provide valuable insights for policymakers, entrepreneurs, and companies seeking to enhance their SCM practices by emphasizing the interplay between technology, entrepreneurship, and sustainability. Future research should address the identified challenges and explore innovative solutions to unlock the full potential of big data for sustainable SCM transformation.

7. Conclusion

This study highlights the transformative potential of big data and digital transformation in revolutionizing supply chain management (SCM) in the New S-Curve industries of the Bangkok metropolitan region. The findings show how big data enables real-time analytics, operational efficiency, and sustainability by optimizing processes, improving decision-making, and driving business innovation. Entrepreneurs leverage big data to develop customized products, drive green initiatives, and create innovative business models that align with sustainability goals.

Digital technologies, including IoT, AI, and blockchain, play a central role in enhancing supply chain transparency, resilience, and adaptability. Their integration promotes sustainable practices such as waste reduction, energy efficiency, and circular supply chain models, contributing to Thailand's economic transformation under the "Thailand 4.0" model. However, the study also highlights challenges, including data quality, high implementation costs, and regulatory barriers, which necessitate collaborative efforts between the public and private sectors to build the necessary infrastructure and capabilities.

Ultimately, the strategic integration of big data and digital transformation enhances SCM efficiency and supports sustainable development and entrepreneurial growth. These findings provide valuable insights for policymakers, entrepreneurs, and industry stakeholders, emphasizing the need for continuous innovation, investment in digital tools, and skills development to create future-ready supply chains that drive both economic and environmental progress.

Institutional Review Board Statement:

This study was conducted in accordance with the Declaration of Helsinki and gained the approval of the Ethics Committee at Rajamangala University of Technology Thanyaburi (Code: RMUTT_REC No. Exp 80/65).

Transparency:

The authors confirm that the manuscript is an honest, accurate, and transparent account of the study; that no vital features of the study have been omitted; and that any discrepancies from the study as planned have been explained. This study followed all ethical practices during writing.

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