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Enterprise Architecture Development to Strengthen Sustainability in the Supply Chain

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a b s t r a c t

In contemporary international business, the significance of sustainability in supply chain operations has emerged as a prominent area of interest. The present study investigates the significant impact that Enterprise Architecture has on enhancing the sustainability of enterprise supply chains. By integrating Enterprise Architecture concepts in their entirety, this study presents a framework that empowers organizations to formulate sustainable sustainability strategies. Enterprise Architecture is utilized to identify, manage, and integrate supply chain critical elements that impact sustainability, such as waste management, energy efficiency, resource utilization, and the selection of sustainable business partners. This research demonstrates how progressive Enterprise Architecture implementation can contribute to the sustainability of supply chains, assist organizations in addressing environmental and social challenges, and generate long-term value for businesses and their business ecosystems by delineating an all-encompassing architecture. This study examines in depth how the application of Enterprise Architecture can catalyze achieving supply chain sustainability and provides companies with guidance on how to design and implement sustainable, structured sustainability strategies.

Kata Kunci:
Arsitektur Perusahaan; Rantai Pasok Perusahaan; Bisnis Berkelanjutan;
Memberdayakan Organisasi;
Strategi Keberlanjutan.

a b s t r a k

Dalam bisnis internasional kontemporer, pentingnya keberlanjutan dalam operasi rantai pasokan telah menjadi perhatian utama. Penelitian ini menyelidiki dampak signifikan Arsitektur Perusahaan terhadap peningkatan keberlanjutan rantai pasokan perusahaan. Dengan mengintegrasikan konsep Arsitektur Perusahaan secara keseluruhan, penelitian ini menyajikan kerangka kerja yang memberdayakan organisasi untuk merumuskan strategi keberlanjutan berkelanjutan. Arsitektur Perusahaan digunakan untuk mengidentifikasi, mengelola, dan mengintegrasikan elemen penting rantai pasokan yang berdampak pada keberlanjutan, seperti pengelolaan limbah, efisiensi energi, pemanfaatan sumber daya, dan pemilihan mitra bisnis berkelanjutan. Penelitian ini menunjukkan bagaimana penerapan Arsitektur Perusahaan yang progresif dapat berkontribusi terhadap keberlanjutan rantai pasokan, membantu organisasi dalam mengatasi tantangan lingkungan dan sosial, dan menghasilkan nilai jangka panjang bagi bisnis dan ekosistem bisnis mereka dengan menggambarkan arsitektur yang mencakup semua hal. Studi ini mengkaji secara mendalam bagaimana penerapan Arsitektur Perusahaan dapat mengkatalisasi pencapaian keberlanjutan rantai pasokan dan memberikan panduan kepada perusahaan tentang cara merancang dan menerapkan strategi keberlanjutan yang terstruktur dan berkelanjutan.

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1. Introduction

In the context of contemporary business, the significance of sustainability in supply chains has emerged as a pivotal topic of global consciousness [1]. Presently, there is a growing demand for organizations to incorporate sustainability into their operational strategies, with a specific emphasis on supply chain management [2]. Increasing environmental, social, and economic needs have prompted this action. The concept of sustainability has produced a heightened focus on resource efficiency, responsible waste management, environmental impact reduction, and ethical and social considerations throughout the entire supply chain. Despite a growing consciousness regarding sustainability, organizations frequently need help with attempting to integrate all-encompassing sustainability strategies into their supply chain activities. To incorporate sustainability principles into each stage of the supply chain, organizations must undertake substantial transformations in their resource management practices, supplier partnerships, and production process planning. Frequently, the intricacy of this matter hinders organizations from formulating comprehensive sustainability strategies. When confronted with this obstacle, it is critical to recognize that sustainability encompasses not only social and environmental responsibility but also the company's operational continuity. The implementation of a sustainability strategy within the supply chain contains more than mere environmental protection and adherence to social norms; it also ensures sustained business viability and competitiveness. As a result, organizations must undertake the implementation of sustainability strategies within their supply chain management with a comprehensive and unified approach.

Maintaining and managing sustainability factors is a significant challenge in supply chain management. This includes efficient resource management, responsible waste management, energy efficiency optimization, and selecting sustainable business partners. Enterprise Architecture may help companies integrate sustainability into design, operations, and supply chain management. Enterprise Architecture can help describe a supply chain sustainability strategy. Enterprise Architecture allows companies to efficiently identify, manage, and integrate sustainability principles into every operational process. Enterprise Architecture helps implement holistic sustainability strategies by understanding the supply chain's structure and connections. Enterprise Architecture lets companies assess supply chain sustainability from every angle. This includes evaluating resource use, waste management, energy efficiency, and business partner collaboration to maintain sustainability values. Enterprise Architecture in supply chain management allows companies to change operations, improve processes, and meet sustainability goals. Using a holistic Enterprise Architecture [3], companies can optimize supply chains while prioritizing sustainability. Enterprise Architecture helps companies address sustainability issues with a structured approach, improving supply chain sustainability.

Despite the extensive exploration of the role of enterprise architecture in the context of supply chain sustainability in both academic literature and industry, there still needs to be more in its conceptual comprehension and practical execution [4]. The existing body of research on the implementation of enterprise architecture to support sustainability in supply chains still needs to be improved in its ability to offer a comprehensive understanding and practical solutions. Hence, the objective of this study is to examine the role and potential of enterprise architecture in enhancing sustainability within corporate supply chains. This study seeks to address the inquiry regarding the effective adoption and application of Environmental Assessment to incorporate sustainability into supply chains. Additionally, it aims to emphasize the innovative aspects and novel contributions that can arise from this approach.

This research aims to provide a comprehensive understanding of the design, implementation, and management of sustainable sustainability strategies in supply chains by examining various aspects associated with the adoption of Enterprise Architecture for supporting sustainability [5]. The effective adoption of appropriate Enterprise Architecture can provide companies with the opportunity to address

environmental, social, and economic challenges more efficiently, thereby generating sustainable and enduring value for both the company and its business ecosystem. The study encompasses two research questions, as indicated by the research inquiries. How does Enterprise Architecture improve enterprise supply chain management sustainability? Research Question 1. What are the tangible advantages of employing Enterprise Architecture to facilitate and uphold the sustainability of supply chains? Research Question 2.

2. Research Methods

TOGAF Framework

The Open Group Architecture Framework (TOGAF) is widely recognized as a prominent enterprise architecture framework utilized for the purpose of strategizing, formulating, and overseeing enterprise architecture endeavors. The framework mentioned above offers a systematic approach to the development of a comprehensive architecture that organizations can universally implement. In contrast, sustainability pertains to the implementation of business strategies that strive to uphold equilibrium among the environmental, social, and economic aspects of a company's operations. The supply chain encompasses a sequence of procedures surrounding the manufacturing and dissemination of goods or services, extending from the initial stages to the final stages. The interconnection among the TOGAF Framework, sustainability, and supply chains pertains to the utilization of the TOGAF framework as a means to conceive and administer supply chains that are more environmentally and socially sustainable. The TOGAF framework facilitates the development of comprehensive and enduring architectural plans for organizations by incorporating sustainability considerations throughout each phase of the process. Within the realm of supply chains, the utilization of TOGAF can facilitate the development of infrastructure that considers the optimization of resources, effective waste management, and seamless integration with business partners, all in alignment with the principles of sustainability. The TOGAF framework provides a methodical approach for recognizing and implementing adjustments in supply chains with the aim of advancing sustainability. Through the utilization of a well-documented and standardized methodology, organizations can integrate technologically and operationally sustainable solutions that are more environmentally conscious. For instance, the utilization of TOGAF can facilitate the incorporation of technologies that contribute to the reduction of waste or the enhancement of resource management systems, alongside the establishment of information flow mappings to promote sustainable collaboration with suppliers and business partners. Furthermore, the utilization of TOGAF facilitates the monitoring of sustainability performance within supply chains. Through the incorporation of sustainability elements into the architecture and processes outlined in the TOGAF framework, organizations can assess and track their performance in relation to sustainability objectives. This enables individuals to consistently set the effects of their actions, adapt their approaches, and pinpoint opportunities for enhancement. The utilization of the TOGAF Framework within the context of a supply chain holds significant significance as it facilitates the integration of sustainability considerations into the planning, administration, and assessment of an organization's supply chain [6] operations. This enables organizations to enhance their ability to develop solutions that promote sustainability, thereby establishing supply chains that are characterized by increased efficiency, environmental friendliness, and long-term sustainability.

Supply Chain

From inception to completion, the supply chain comprises a multitude of interconnected stages, including procurement, manufacturing, storage, and distribution of products or services. A variety of entities include the supply chain [7][8], including suppliers of raw materials, manufacturers, distributors, retailers, and final consumers. Every stage within this supply chain is critical for the successful delivery of a product or service to the market, as well as for the efficient flow of information, materials, and associated funds. Effective collaboration and coordination among diverse entities is critical in the supply chain. A precise comprehension of consumer requirements, accurate forecasting of demand, and judicious supplier selection are elements that contribute to the operation of an effective supply chain. Furthermore,

information technology assumes a more significant function in integrating supply chains by enabling enhanced visibility pertaining to supply, demand, and operational effectiveness.

Technological advancements have further broadened the scope of the supply chain concept to encompass sustainability values in addition to commercial transactions. In contemporary supply chains [9], consideration is extended beyond operational efficiency and financial gains to encompass the social and environmental ramifications of each decision and action. This entails responsible waste management, resource conservation, and partnerships with suppliers who adhere to rigorous sustainability criteria. Considering this concept's development, contemporary supply chains must exhibit enhanced flexibility, adaptability, and responsiveness. This necessitates the collaborative effort of all supply chain entities to establish an ecologically sustainable, socially responsible, and economically viable system. In a time when sustainability is becoming an increasingly recognized concern, a prosperous supply chain not only ensures uninterrupted operations but also effectively communicates robust sustainability principles throughout each phase.

The implementation of Enterprise Architecture in the supply chain plays an important role in supporting sustainability. EA provides a comprehensive framework for designing, managing, and integrating an organization's information technology infrastructure in a structured manner. In the context of supply chains, EA enables organizations to identify and design solutions that support sustainability principles in every operational aspect. One of EA's main contributions to sustainability in supply chains is through better process mapping. EA allows companies to understand and analyze each stage in the supply chain thoroughly, from raw material suppliers to end consumers. With this mapping, companies can identify opportunities to improve sustainability, such as more efficient use of resources, better waste management, or increased collaboration with business partners who are committed to sustainability.

In addition, EA facilitates the integration of technologies that support sustainability in the supply chain. By designing an integrated IT architecture, companies can adopt technologies that enable waste reduction, energy efficiency, and better visibility into sustainability performance. For example, the use of IoT sensors to monitor resource usage, the implementation of automated waste management systems, or collaboration platforms to manage sustainability with suppliers. Enterprise Architecture also enables companies to monitor and evaluate their sustainability performance in the supply chain. By integrating sustainability aspects into their IT architecture and processes documented in Enterprise Architecture, companies can measure the impact of their changes, assess their progress against sustainability goals, and identify areas that require further improvement. Implementing Enterprise Architecture helps create a more sustainable supply chain by providing a comprehensive view, supporting technology integration, and structured performance monitoring of sustainability aspects. This enables companies to effectively integrate sustainability values into their supply chain design and operations, establishing supply chains that are efficient, responsive, and sustainable in the long term.

3. Results and Discussion

The research conducted on Enterprise Architecture Development to Enhance Sustainability in the Supply Chain presents a chapter devoted to looking at the results and figuring out what they mean. This section provides recommendations that primarily emphasize the incorporation of Development, Security, and Operations components. The objective of this proposal is to enhance the overall resilience of the supply chain [10]. The concept of integrating development (Development) prioritizes the ongoing pursuit of innovation, while the security aspects (Security) are responsible for safeguarding vital data and processes. To achieve a smooth integration between processes, technology, and sustainability, it is suggested to implement efficient and sustainable operations. The integration of these three elements will yield a comprehensive framework for attaining resilience and sustainability objectives within the supply chain.

Proposed Application Architecture

The application architecture under consideration encompasses three fundamental components: Development, Security, and Operations. The objective of this plan is to facilitate system support within the supply chain, with a particular emphasis on fostering sustainable system development. The incorporation of Development, Security, and Operations (Dev-Sec-Ops) is imperative in establishing a system that is both effective and enduring within the framework of the supply chain. The integration of Development elements within the application architecture serves as the foundation for ongoing innovation. This entails the construction of a system that fulfills not only present requirements but also encompasses strategic provisions for system modifications that facilitate growth and flexibility over an extended duration. The architectural integration of the development process enables the incorporation of novel functionalities, updates, and enhanced capabilities while ensuring the overall integrity and security of the system. This integration is visually represented in Figure 1.

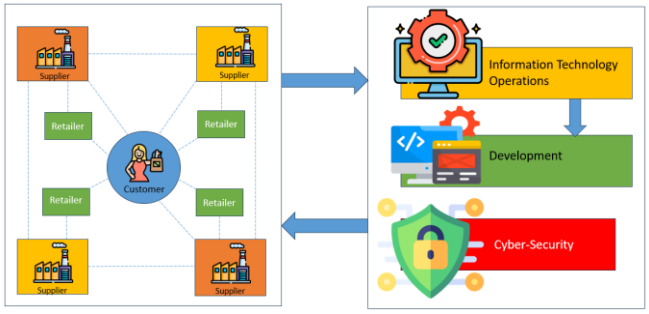

Figure 1. Application Architecture

Security is an integral component of the Supply Chain system's sustainability. The primary considerations in the development of an application architecture are privacy, data protection, and transaction security. Mitigating the potential disruptions to the entire supply chain caused by data leaks and cyber attacks can be accomplished by implementing robust security measures for systems. Supply Chain systems can achieve a greater degree of security and dependability through the tight integration of security elements into their architecture. Security must be prioritized throughout the application development process to prevent system compromise. By prioritizing data protection, secure transactions, and information privacy, supply chain systems can enhance their resilience against potential external threats. This measure aids in the prevention of potential vulnerabilities that may be capitalized upon by unauthorized entities, thus strengthening the integrated supply chain's overall dependability and efficiency.

A crucial component in constructing a sustainable supply chain system is operations. The efficiency and sustainability of the processes operating within the system are of utmost importance. This entails the oversight, control, and enhancement of overall system performance. A more environmentally sustainable system can be established through the implementation of sustainability principles that guide system operations, including waste reduction and resource efficiency. By adopting a sustainable approach to operations management, one can discern potential avenues for waste reduction, resource optimization, and environmental impact mitigation. By integrating efficiency principles into each phase of the operational process, it is possible to mitigate our carbon emissions, enhance our awareness of energy consumption trends, and establish more efficient waste management approaches.

Furthermore, by conducting ongoing monitoring and analysis of system performance, it is possible to pinpoint specific domains that could benefit from enhancements in sustainability. This may entail enhancing operational procedures, adjusting technological systems, or integrating environmentally sustainable practices into daily operations management. By emphasizing sustainability and efficiency in system operations, we not only foster a more streamlined work environment but also contribute to the development of a more ecologically sound supply chain system in its entirety. These principles not only contribute to the long-term objective of environmental sustainability but also yield immediate advantages in terms of cost reduction and enhanced operational effectiveness.

The convergence of these three components—Development, Security, and Operations (Dev-Sec-Ops)—becomes the foundation of a sustainable supply chain system. The objective is to develop a Supply Chain system that is more resilient to changes,

watertight against digital security risks, and environmentally sustainable by suggesting an application architecture that integrates these three elements. Beyond being a technological framework, the Dev-Sec-Ops methodology also encompasses a culture and set of processes that uphold the tenets of ongoing improvement. Collaboration between the development, security, and operational teams must ensure that security and operational considerations are incorporated into each system development phase. This establishes a robust groundwork for the expansion and long-term viability of the suggested supply chain infrastructure.

Technology Architecture

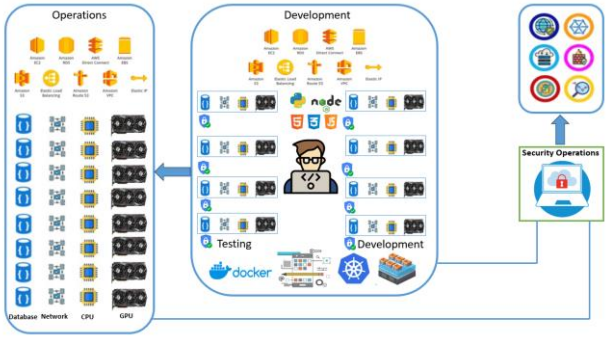

Figure 2. Technology Architecture

The utilization of technology is of paramount importance in the establishment and preservation of a sustainable supply chain. The primary consideration in establishing a sustainable supply chain process is the technological architecture, which serves as the fundamental basis. Figure 2 illustrates the technical framework that serves as the essential infrastructure for enabling streamlined and environmentally conscious supply chain operations. The security aspect is a crucial component of this technology architecture as it serves as the primary safeguard for ensuring the integrity of data, networks, and all systems within the supply chain. Ensuring security is not merely a matter of importance but rather a fundamental requirement when it comes to effectively managing sensitive and critical information pertaining to the supply chain. The mitigation of security breaches can be achieved by implementing a robust security layer encompassing both data protection and the overall system. This encompasses not only endeavors to mitigate unauthorized access but also the management of risks associated with potential cyber-attacks that have the potential to impede the transmission of information and the seamless operation of supply chain procedures.

The role of security in system development is crucial for maintaining the relevance and responsiveness of existing systems in the face of evolving developments. In an era characterized by swift transformations, the process of system development facilitates the capacity to accommodate and modify according to the requirements of users. By incorporating pertinent and valuable functionalities, the system can sustain its efficacy and efficiency in facilitating sustainable supply chain operations. The ever-evolving landscape of supply chains frequently gives rise to novel challenges. In the dynamic context of supply chain management, the utilization of suitable technology and adaptability to change are crucial factors for sustaining competitiveness and upholding a high standard of performance. The primary foundation for ensuring the efficient operation of supply chain processes lies in the implementation of system management that possesses the capability to swiftly adapt to alterations in the business environment and technological advancements. Within the given context, Figure 2. The concept of Technology Architecture encompasses more than just a graphical representation of the interconnections between technical components. It also serves as a crucial framework for implementing sustainable strategies that effectively support the supply chain. The integration of robust security measures and agile system development capabilities constitutes a fundamental cornerstone in the construction of a system that can effectively facilitate a supply chain that is both efficient and sustainable over an extended period.

Discussion

How does Enterprise Architecture improve enterprise supply chain management sustainability? (RQ 1).

The incorporation of Enterprise Architecture plays a pivotal role in enhancing the sustainability of supply chain management within organizations. Within this particular context, Enterprise Architecture serves as a strategic framework that facilitates the integration and comprehensive administration of an organization's

information technology systems. Enterprise Architecture offers a robust framework for comprehending, strategizing, and executing alterations in supply chain operations to bolster sustainability factors. Process mapping is a prominent approach employed by EA to enhance sustainability in the domain of supply chain management. Enterprise architecture enables organizations to conduct comprehensive evaluations of the complete supply chain, spanning from its initiation to completion. This process facilitates a deep understanding of operational processes and aids in the identification of specific areas within the supply chain that can be enhanced in terms of sustainability. Through the utilization of this mapping technique, organizations are able to discern areas of vulnerability within the supply chain that necessitate enhancement in order to attain sustainability objectives. These objectives encompass the judicious utilization of resources, conscientious management of waste, and the establishment of collaborative relationships with business partners who align with sustainability principles.

Moreover, enterprise architecture serves as the fundamental basis for the implementation of alterations in operational practices. By incorporating sustainability principles into the field of architectural design, EA facilitates the ability of companies to modify and restructure their operations in order to align with environmentally conscious practices. This encompasses the implementation of waste reduction measures, the enhancement of energy efficiency practices, and the adoption of revised business partner strategies aimed at facilitating the achievement of sustainability objectives. Enterprise Architecture offers a holistic perspective on the various components of the supply chain and their role in promoting sustainability, thus empowering organizations to make well-informed choices. Furthermore, EA plays a role in facilitating the monitoring and measurement of sustainability performance. The implementation of an organized framework in the form of Environmental Accounting facilitates the systematic collection of data pertaining to sustainability, encompassing factors such as resource utilization, emissions, and various environmental consequences. This enables organizations to consistently monitor their sustainability performance, identify areas requiring improvement, and gauge their progress toward sustainability objectives. Enterprise Architecture serves as both a technological tool and a fundamental driver for strategic transformation, facilitating the long-term viability of an organization's supply chain. Companies need Enterprise Architecture to provide a holistic view, facilitate change, and monitor performance to build a sustainable supply chain.

What are the tangible advantages of employing Enterprise Architecture to facilitate and uphold the sustainability of supply chains? (RQ 2).

The implementation of Enterprise Architecture facilitates and sustains supply chain sustainability in a number of tangible ways. One of the most apparent advantages is enhanced supply chain comprehensive mapping. EA offers a broad perspective on the interconnections, workflow, and structure of the supply chain. This enables organizations to identify critical points that impact sustainability with greater efficiency, such as suboptimal waste management, inefficient resource utilization, or collaboration limitations with business partners who need to support sustainability. This mapping enables organizations to develop more precise and quantifiable strategies for enhancing or substituting components of the supply chain that do not contribute to sustainability. Additionally, EA facilitates the implementation of changes in a more streamlined manner. By comprehending the interrelationships among the various components comprising the supply chain, organizations can develop more cohesive and environmentally conscious solutions that promote sustainability. EA facilitates the adoption of new technologies, the improvement of operational processes, and the modification of environmentally detrimental business practices by providing a framework for such endeavors. Such measures may encompass the adoption of technological solutions that facilitate waste reduction, the establishment of more sustainable alliances, or the implementation of resource management systems that are more streamlined.

Furthermore, EA offers advantages with regard to the monitoring and assessment of sustainability performance. Organizations can acquire and evaluate

sustainability-related data more methodically and exhaustively by implementing EA. This enables organizations to consistently assess their advancements toward sustainability objectives, gauge the effects of implemented modifications, and pinpoint areas that necessitate additional focus. The capacity for ongoing monitoring affords organizations the chance to modify their approaches to be more responsive to potential future challenges or changes. In general, the implementation of Enterprise Architecture contributes to the sustainability of the organization's supply chain in several tangible ways. Effective performance monitoring capabilities, enhanced mapping, and streamlined change implementation are a few of the ways in which EA is evolving into a potent instrument for designing, managing, and improving more sustainable supply chains.

Related Work

Prior studies have investigated the application of Enterprise Architecture in the context of supply chains. These studies emphasize the significance of EA's involvement in the design of sustainable IT infrastructure, the mapping of supply chain processes, and the facilitation of technology integration to enhance operational efficiency and risk management. It has been demonstrated that the integration of EA into supply chains enhances an organization's comprehension of sustainability and its sustainability performance. The study proposes a blockchain-based model to address credit data barriers in the supply chain financial credit system. The model uses a consensus mechanism to store and share data, improving security and efficiency. This approach enhances the supply chain financial credit system and facilitates supply chain financing [11]. This study presents a trust transitivity model that utilizes blockchain technology as a solution to the financial limitations encountered by small and medium-sized manufacturing enterprises (SMMEs). In addition to accounting for both direct and indirect trust, the model implements a dynamic weight allocation approach to reward and punishment. The rationality of the model is validated by means of numerical illustrations [12]. This research investigates the implementation of Information and Communication Technology (ICT) in electronic agriculture, with a specific emphasis on the grape wine supply chain. Key factors examined include disintermediation, traceability, price, trust, compliance, and coordination [13]. To optimize performance for networked supply chains (NSCs), this paper proposes a BD architecture; the BD architecture proposed in this paper balances quantitative and qualitative criteria. By taking serial and parallel network configurations into account, it seeks to improve external value to customers and increase internal value for shareholders [14]. A smart contract-based supply chain traceability framework protects privacy and allows digital signature and verification. Customers and others have traceability, auditability, anonymity, and a single product ID with this system [15]. This study examines RFID-integrated blockchain technology in circular tea supply chain management to improve transparency and traceability and discusses managerial and social implications [16].

4. Conclusion

The research on Enterprise Architecture Development to Enhance Sustainability in the Supply Chain focuses on the incorporation of Development, Security, and Operations components to enhance the overall resilience of the supply chain. The application architecture, which includes Development, Security, and Operations, is crucial for establishing a system that is effective and enduring. Security is an integral component of the supply chain system's sustainability, focusing on privacy, data protection, and transaction security. By prioritizing security measures, supply chain systems can enhance their resilience against external threats and prevent system compromise. Operations are another crucial component of a sustainable supply chain system, requiring oversight, control, and enhancement of overall performance. Sustainability principles guide system operations, including waste reduction and resource efficiency. Continuous monitoring and analysis of system performance can identify areas for improvement, leading to cost reduction and enhanced operational effectiveness. Technological architecture is also essential for establishing a sustainable supply chain, with security being a crucial component. The technology architecture ensures the integrity of data, networks, and systems, and the system can adapt to

changes in the business environment and technological advancements.

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