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Research Paper

An IoT-based sustainable supply chain framework and blockchain

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ABSTRACT

The increasing expansion of the needs of human beings and societies has caused various aspects of human life and societies to face serious challenges and be considered. Supply chain organizations operate in a market in today's global environment that is increasingly complex and dynamic in nature. Stable supply chains are inevitable to meet drastic changes in customer needs. Research has shown that manufacturing companies need to accelerate the shift from focus to sustainability and use technologies such as the Internet of Things (IoT) and blockchain to achieve the organization's goal. In this regard, by expanding the capabilities of the blockchain under the four main areas (1) designing incentive and tokenization mechanisms to promote green consumer behavior; (2) increase visibility throughout the product life cycle; (3) increase system efficiency while reducing development and operating costs; And (4) strengthen the monitoring of sustainability and performance reporting in supply chain networks; it can be seen that the supply chain based on these transformational technologies can play a colorful role in creating stability and a green and efficient supply chain. In this study, the potential opportunities in the IoT to create a sustainable supply chain are discussed. Also, based on this study, a framework has been proposed to show the relationships and effects of the constituent elements of a stable supply chain system based on the Internet of Things and blockchain. The conceptual framework is designed with an emphasis on sustainable development, collaboration and management and can provide a good perspective for implementing a sustainable supply chain based on technology.

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1. Introduction

The supply chain is a dynamic process that involves a continuous flow of materials, resources, and information across functional areas within and between members of the chain. Supply chain sustainability as a new and very effective sector has recently attracted the attention of researchers in the field of supply chain management. In addition to academia, communities, governments, businesses, international agencies, and nonprofits have become increasingly involved (Hong et al., 2022). Therefore, today, due to government regulations and increasing public awareness of sustainability issues, companies are trying to improve their sustainability performance and in order to increase sustainability, they must integrate sustainability issues with their supply chain activities. Sustainability refers to the transparent integration and achievement of social, environmental and economic goals of organizations through the effective coordination of processes within the organization (Davis-Sramek et al., 2022). Key aspects of sustainable supply chain management practices include the stability of the supply chain network and supply chain environment, the application of environmentally friendly strategies and the acceptance of social responsibility, so considering supply chain sustainability can be considered in addition to financial profitability, Considered and minimized adverse environmental effects as well as adverse social effects (Soni et al., 2022).

Sustainable supply chain management includes economic, social and environmental sustainability dimensions. Therefore, the concept of sustainable supply chain management is broader than green supply chain management, and green supply chain management is part of sustainable supply chain management (Manavalan & Jayakrishna, 2019). In recent years, the emergence of new technologies and major changes in global markets, has made the need to pay attention to sustainable supply chain management more than ever, so that various organizations to create, maintain their competitive position, have to use Supply chain management theories are sustainable.

Emerging technologies covered by Industry 4.0 provide new financial and business opportunities for supply chain networks: IoT, artificial intelligence, serverless computing, blockchain, robotics, biometrics, 3D printing, reality Augmented / virtual reality is one of the most important technologies that have transformed business processes and supply chain in recent years (Nahr et al., 2021). However, little attention has been paid to issues related to the sustainability of these emerging technologies, in particular helping organizations move towards a sustainable economy. Assuming that the main goal is to close the sustainability of the product life cycle, evolving technologies such as the Internet of Things and China Blockchain technology can reduce the obstacles to achieving this goal (Nozari et al., 2021). The presence of the Internet of Things in the fourth generation of industry increases the level of information sharing in the supply chain, which makes the product life cycle more transparent, facilitates the collection of new data types, and increases timely decision-making (Nozari et al (b)., 2021). Therefore, technologies such as the Internet of Things and the presence of Chinese blockchain technology play a very important role in sustainability. The four main capabilities of the Internet of Things and blockchain that can support sustainable supply chains are as follows:

1) Help reduce recall and restructure the product through its tracking capabilities,
2) Ease of tracking the actual product footprint and determining the exact amount of carbon tax that each company must pay;
3) Facilitate recycling behavior by encouraging people to participate in landfill-based recycling programs;
4) Improve the efficiency of trading plans by reducing fraud and improving system loyalty

For this reason, and considering the key roles that these transformational technologies have taken on in the development of sustainability in various areas of business as well as the supply chain, in this study, an attempt has been made to measure the dimensions of components and key indicators of impact. The transition to the CIS-based supply chain and IoT and so on has been explored and a conceptual framework has been put in

place to demonstrate the causal relationships of the factors influencing these intelligent systems (Caldarelli et al., 2021).

2. Sustainable supply chain

There is a lot of discussion about sustainable supply chain management. Researchers have portrayed sustainable supply chain management to achieve a balance between financial returns, social performance, and environmental concerns, and have argued that sustainable supply chain management should maintain relationships in which anthropology, political science, Psychology and sociology interact with the natural sciences and are managed and interpreted in policy development. Sustainability has become an important issue for companies that consider social and environmental issues in their strategies. Today, companies are aware of the importance of sustainability responsibility in their development, and the environmental sustainability of any organization is impossible without applying sustainable supply chain management practices. Figure (1) shows a conceptual model for a sustainable supply chain. In this figure, it can be seen that the scope of sustainable supply chain management is no longer limited to individual, economic, social or environmental goals, but to their integration in all operations. In the supply chain.

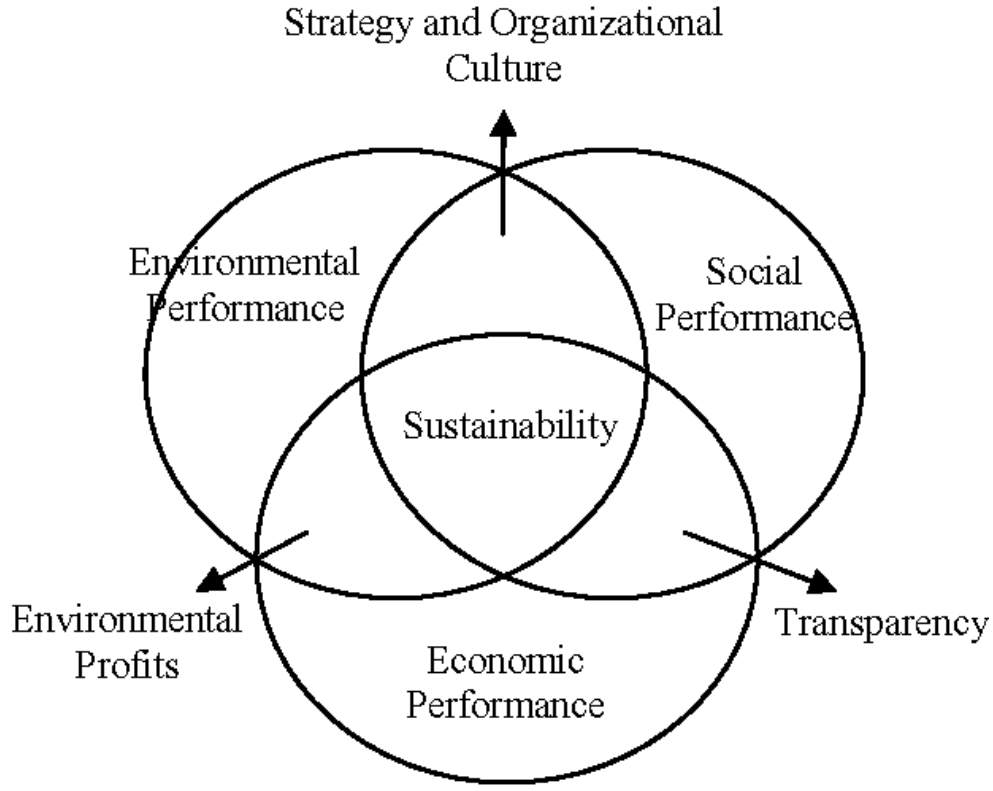

Fig. 1. Dimensions of sustainable supply chain (Xu and Cong, 2011)

Concerns of governmental and non-profit organizations, people, especially environmentalists, about global warming, depletion of natural resources, use of non-renewable resources and increased industrial activity in developed and emerging economic societies, have led many shareholders to Focus on sustainable business development. In recent years, corporate, social and environmental responsibility has become part of the goals of production and service organizations and has positively become the rule of organizational activities. There are also other factors that lead organizations to use sustainable supply chain management, especially in the upstream parts of the supply chain. These factors can be internal or external (Aliahmadi et al., 2015). External factors include legal regulations, the nature of the business, competitors and shareholder actions. Internal factors include senior management perspectives, sustainable incentives for suppliers, and customer needs.

Resistance to change is always seen in all organizations. Resistance comes from several sources: senior management, finances, location, system capacity, culture, type of business, supply chain structure, costs, operational objectives, human resources, and knowledge management. Some of the most important barriers to supply chain include: financial costs, rate of return, senior management commitment, supplier's organizational culture, production capacity, human resources, supply chain structure, geographical location and size of supplier companies, and more.

The use of sustainable supply chain management is important for the organization to be competitive in terms of price, quality, reliability, flexibility and accountability. The benefits of sustainable supply chain management include customer satisfaction, quality, innovation, trust, resource speed, optimal inventory, flexibility, leadership time and cost control. Today, considering the concept of sustainability in supply chain network design, due to the effects of the growing global population on the environment and the consequent increase in human activities, has become an important issue for organizations, governments and people, especially environmentalists.

In the following, the capabilities of these transformational technologies in supply chain sustainability will be discussed, which are: 1) promoting green behavior, 2) increasing the product life cycle, 3) improving the efficiency of operations and systems, and 4) improving sustainability reporting and monitoring.

3. The role of the Internet of Things and blockchain in the supply chain

The Internet of Things, in addition to being a revolutionary technology for all industries; It has also demonstrated its potential in processes such as supply chain. Management, forecasting and monitoring applications help managers improve the operational efficiency of their company distribution and increase transparency in their decisions. So more than ever, the benefits of using the Internet of Things are evident in the supply chain (Aliahmadi et al., 2022). Because a wide range of IoT applications are used in supply chain management. This facilitates the tracking and monitoring of goods and creates more transparency in the communication and planning process. All areas of the complex supply chain process can be improved with the Internet of Things (Kshetri, 2021).

Tracking and monitoring is one of the main goals of IoT deployment in supply chain management. This technology allows warehouse and fleet managers to track their shipments and inventory. However, the IoT has more potential for the supply chain. Various advances in IT capabilities have changed the face of the industry more rapidly than in the past decade (Ghahremani-Nahr et al., 2022). The adoption and implementation of information technology is one of the methods that applies a distinct competitive personality to companies and the supply chain. Adoption of information technology and its efficient implementation can improve cooperation between supply chain members through the rapid transfer and distribution of accurate information and the use of information systems and increase the efficiency of the supply chain (Jabbour et al., 2020).

Another transformative technology that has had a great impact on the business environment in recent years is blockchain technology. A blockchain is a distributed data structure, a distributed edge in which data is shared over a peer-to-peer network. Network members are nodes that communicate with each other and data from a pre-protocol Designated without a central reference, distributed edges can be either decentralized with respect to equal rights for all users, or centralized and offer specific rights to specific users (Končar et al., 2020). Because blockchains are designed as distribution systems, they are resistant to information manipulation and are very suitable for product supply and distribution networks. Blockchain, as part of efficient technologies in corporate supply chains; It builds trust, transparency and consensus among all stakeholders, provides benefits for each player, and ensures flexible business outcomes. The potential of blockchain goes far beyond cryptocurrency applications and is now a fundamental mechanism Improve

supply chain efficiency and effectiveness. Concentrate on a system without the need for exclusivity (Szmelter-Jarosz et al., 2021). Blockchain technology allows for the documentation and submission of all documents, and as a result, facilities such as complete tracking and tracing of the places where goods are located, how to prepare, purchase, allocate and use them (Mangla et al., 2022).

Obviously, the use of this technology improves transparency and accountability and facilitates the process of authentication of goods and materials received. In addition to accelerating the flow of goods, timely delivery of products and greater transparency in logistics activities are the benefits that are provided by the adoption of this technology to all stakeholders in the chain. Also in such circumstances, vertical integration of industries is more important because the costs of moving products between intermediaries decrease with increasing transparency (Khan et al., 2022). In a traditional hierarchical supply chain network, the flow of data across the network often mimics the shape of the flow of goods. In a distributed general ledger environment using blockchain, all data and information can be shared decentrally so that the parties can see the same data. In such a situation, and when sharing information, it is no longer necessary for each supply chain player to act as an intermediary between adjacent partners. More precisely, each node must be able to view transactions in order to approve or reject them, but this approval or rejection depends on the nature of the supply chain program (Kamble et al., 2021).

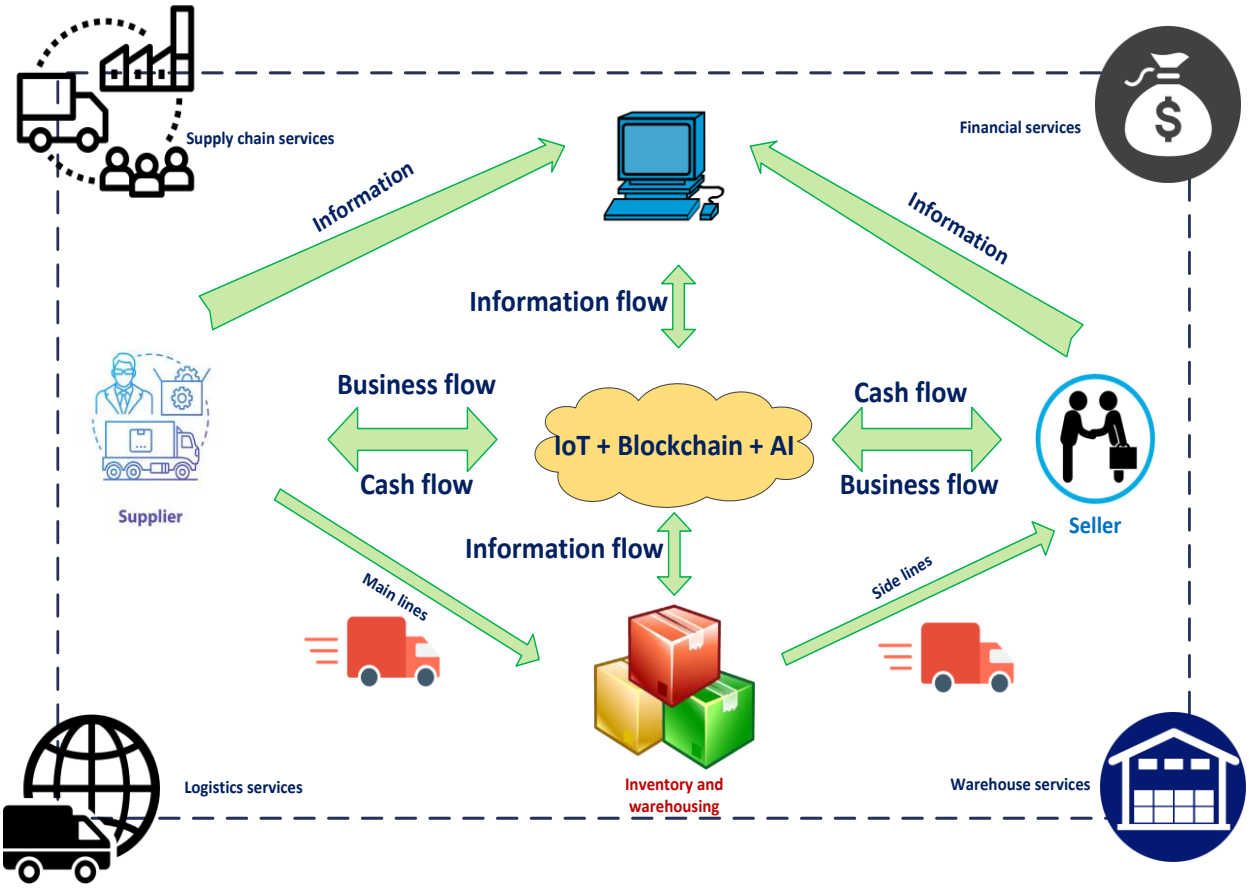

Fig. 2. The framework for the presence of transformational technologies in the supply chain

Because blockchain is a combination of protocols and technology to create a consensus-based distributed database, this database allows transactions between parties to be validated without the use of a central reference or intermediary. Yet other forms of intermediation, such as software or the cloud network, continue to be used in supply chains based on this intelligent technology (Nahr et al., 2021).

4. Sustainable IoT and Blockchain supply chain

Supply chains are at the heart of the process of delivering products to customers at the right time and at the right cost. No matter what kind of products an organization produces or sells, keeping customers satisfied and achieving financial goals depends on building an efficient and reliable supply chain network (Aliahmadi et al., 2016). Achieving customer satisfaction requires integrated collaboration and coordination across the value chain of suppliers, manufacturers, banks, regulators, logistics service providers, and retailers. At the same time, supply chain disruptions increase costs and, more importantly, loss of revenue. Worst of all, these disruptions are exacerbated by inefficient processes based on ineffective data (data that is not reliable and clear). Organizations seek transparency, flexibility, and agility in their supply chains to control these disruptions. IoT and blockchain, as part of efficient technologies in corporate supply chains; In addition to generating huge amounts of data, it build trust, transparency, and consensus among all stakeholders, creates benefits for each actor, and ensure flexible business results (Khanfar et al., 2021).

In today's world, sustainability has become one of the most important concerns of any organization in various industries. Today, companies with high ratings have lower debt costs for impact on environmental, social and governance factors and perform better than the market in the medium and long term (Venkatesh et al., 2020). Supply chains have a huge and direct impact on society, the environment and financial performance. With the right use of the latest technologies, supply chains have more potential to create and encourage a sustainable world. Using a combination of technologies such as the Internet of Things, artificial intelligence and blockchain, companies can reduce greenhouse gas emissions, optimize routes, reduce waste, ensure efficient transactions with suppliers, improve worker safety, and Reduce risks. Some of the IoT applications that enable a sustainable supply chain are (Sunmola, 2021):

- Using the integrated IoT solution and other technologies, we can find better driving directions. Therefore, it is possible to reduce the fuel consumption of diesel and gasoline used by freight vehicles, which are one of the largest consumers of energy and contributors to greenhouse gas emissions.
- Another benefit of IoT is the sustainability of waste reduction and disposal. With an IoT technology connected, we can track all goods from origin to destination and view them in real time. So we can reduce all kinds of damages, thefts and damages.
- IoT technology can also be used to improve safe working practices, which is one of the main concerns of any manufacturing and logistics company. Internet-connected sensors can be placed around a factory or warehouse and used by workers. Activity and movement data can be analyzed to quickly detect any dangerous or hazardous behavior.

Artificial intelligence and the combination of its analytical capabilities can increase the strength and capability of the supply chain and create a reliable path in the direction of supply chain. Some applications of artificial intelligence for supply chain stability are:

- Artificial intelligence algorithms can assist in backhauling activities. These are the movements of the trucks returning from their destination to the origin. Artificial intelligence can instantly analyze vehicles, volumes, routes and stops to identify optimal opportunities to share transportation with other organizations. Transport sharing not only helps reduce shipping costs, it also reduces environmental impact.

- Artificial intelligence can also have a huge impact on an organization's sourcing activities.
- Producing products that people will not want to buy is another issue that can affect not only a company's financial performance but also the environment. Therefore, artificial intelligence can be a very useful tool in accurately predicting customer demand. And therefore, companies only produce and ship what customers want to buy.

Blockchain is considered to be the next disruption in the world of technology that can overcome many trade barriers. In addition to economic and environmental benefits, blockchain has many other benefits in terms of social sustainability. Ways that blockchain can encourage supply chain sustainability include (Parung, 2019):

- Blockchain enables a healthy relationship with supplier and customer by creating transparency and trust between supply chain stakeholders.
- Blockchain can also be useful for humanitarian supply chains. This technology enables easy and fast financial transactions in times of crisis or disaster.
- By using blockchain, we can guarantee healthy, safe and quality food. Which certainly reduces the prevalence of foodborne illness and also increases customer confidence in the food industry.

Figure 3 shows an analytical framework for implementing a sustainable supply chain based on artificial intelligence, the Internet of Things, and blockchain technology. Using this framework, we can identify the key elements of a sustainable supply chain based on transformational technologies. The goal of sustainable supply chains is to interact with direct and subsidiary suppliers and maximize the overall social, environmental and ethical impact. Technologies such as artificial intelligence, the Internet of Things, and the Chinese blockchain can play an important role in achieving this goal and much more. Understanding technology and sustainability as a competitive advantage and focusing on system change, along with individual programs, to ensure The secret to success is the long-term and lasting impact.

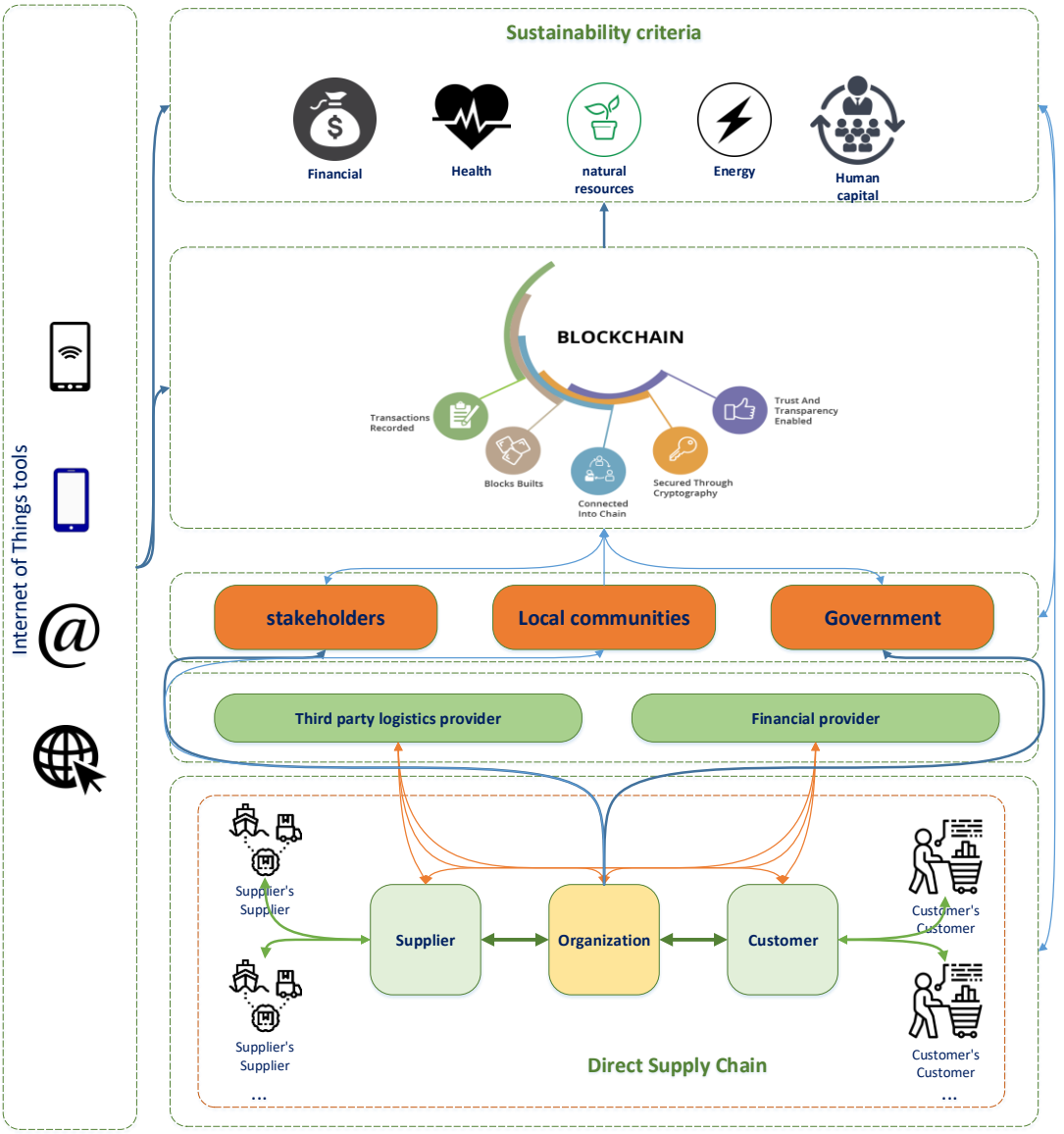

Fig. 3. IoT – blockchain based sustainable supply chain conceptual framework

5. Conclusion

In today's world, smart technologies add powerful capabilities to business processes and can also impact sustainable supply chain networks. Tracking potential environmental and social conditions that may impose environmental, health, and safety concerns is an important practical focus for using these technologies. An Internet of Things-based supply chain provides a better guarantee of human rights and fair labor by receiving accurate information from a variety of factors. Smart contracts may, in particular, be able to legislate to track and control sustainable conditions and regulatory policies automatically and to strengthen or manage appropriate reforms. The environmental and social dimensions have produced a more generalizable perspective on the supply chain.

In this research, the potentials of IoT technologies, artificial intelligence and blockchain in sustainable supply chain management were discussed. Studies show that issues such as increasing greenhouse gas emissions due to improper design of supply chain structure in the production and transportation of products, increasing risk and costs in supply chain management, lead organizations and companies to the direction that these

technologies Apply. In this study, the potential impact of IoT technology and its infrastructure, due to the transparency created at different levels of the supply chain, accurate product tracking, quality improvement, carbon sequestration, recycling improvement, carbon emission exchange schemes, financial arrangements and thus social sustainability, Economic and environmental issues in the supply chain were discussed. Finally, a conceptual framework for a sustainable supply chain based on evolving technologies such as the Internet of Things and Blochin was proposed. Examining and understanding this framework can clarify the dimensions and main components of the sustainable supply chain based on these technologies. By understanding these dimensions, the degree of emphasis on different sectors can be calculated and evaluated according to the approaches of societies towards sustainability.

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