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Research Paper

The Impact Of Blockchain Technology And The Internet Of Things On The Agile And Sustainable Supply Chain

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ABSTRACT

In addition to being a revolutionary technology for all industries, the Internet of Things; has also shown its potential in processes such as supply chain. With the advancement of technology and the emergence of the new era, the challenges of the traditional supply chain that follows a path from top to bottom (suppliers of raw materials to final consumers) are revealed. Also, due to environmental issues and the increasing speed of the changes in the needs of customers in various industries, including the retail industry, which has undergone many changes with the emergence of innovation, the entire path of the supply chain requires the implementation of strategies such as agile and green supply chains and achieving smartness. Therefore, emerging technologies such as The Internet of Things play a significant role in the agility and greenness of the entire retail supply chain. The presence of blockchain technology with decentralized data archiving in supply chain processes based on the Internet of Things guarantees the security of big data and helps in optimal data performance. This helps the agility of supply chain processes. In this chapter, dimensions, components, and key indicators effective in the implementation of an agile smart supply chain based on transformative technologies are examined.

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1. Introduction

The Internet of Things is a keyword to cover various aspects of extending the Internet and the Web to the physical realm, through the widespread use of distributed devices that have detection, measurement, or activation capabilities. In the Internet of Things, the items of our daily life join the framework of communication (Ghahremani-Nahr et al., 2021). Therefore, in the world of communication and information technologies, we are moving from communication at any time and place for everyone to communication at any time and place for everyone and everything (Aliahmadi et al., 2013). Undoubtedly, the effects of Internet of Things in various fields are growing and developing. In addition to being a revolutionary technology for all industries, the Internet of Things; It has also shown its potential in processes such as supply chain (Nozari et al., 2016). Management, forecasting and monitoring applications help managers improve their company's distribution operational efficiency and increase transparency in their decisions. Therefore, more than ever, the benefits of using the Internet of Things in the supply chain have been revealed. Because a wide range of IoT applications is used in supply chain management. This facilitates the tracking and monitoring of goods and creates more transparency in the process of communication and planning. All areas of the complex supply chain process can be improved with the Internet of Things (Nozari et al., 2022a).

By connecting items with information technology through embedded smart devices or through the use of unique identifiers and carrier data that can establish intelligent communication with the support of network infrastructure and information systems, the whole Production processes can be optimized and the entire product life cycle can be controlled from production to consumption (Aliahmadi et al., 2022a). By tagging items and contents, more information about the status of the workshop, the location of the status of the production machinery can be obtained. The useful information of tags as input data can serve to generate refined program and improve logistics. Self-organization and smart manufacturing solutions can be identified alongside design items. The information connected to an object and micro-processing from production to the end of the life cycle may be inseparable, the production date of an object and its current status can be continuously monitored and either stored on the label or placed inside the information system. Information indicating the history of use of a product, which includes valuable information for product design, marketing and service design related to the product, and also makes the final decision to recycle, reproduce or dispose of the product safely and environmentally friendly (Aliahmadi et al., 2022b).

Achieving customer satisfaction requires seamless collaboration and coordination across the value chain of suppliers, manufacturers, banks, regulators, logistics service providers and retailers. At the same time, disruption in the supply chain causes increased cost and more importantly, lost revenue. Worse, these disruptions are exacerbated by inefficient processes built on ineffective data (data that is not reliable and transparent). Organizations are looking for transparency, flexibility and agility in their supply chains to control these disruptions (Nozari et al., 2022a). Blockchain, as a part of efficient technologies in supply chains of organizations; It builds trust, transparency and consensus among all stakeholders, creating benefits for every actor and ensuring flexible business outcomes. The ability to establish instant trust in recorded transactions can lead to improved efficiency in many functions related to supply chain operations, including monetary exchanges, operational transactions, contracting, sourcing, etc., without the exclusive need for a centralized system (Nozari et al., 2022b). Blockchain technology provides the possibility of documentation and presentation of documents and documents, and as a result, facilities such as full tracking and tracing of the places where goods are placed, how to prepare, buy, allocate and use them are also provided (Aliahmadi et al., 2022c). It is obvious that the use of this technology improves transparency and accountability and facilitates the authentication process of goods and materials received. In addition to this acceleration of the flow of goods, timely delivery of products and greater transparency in logistics activities are the benefits that will accrue to all stakeholders of the supply chain through the adoption of this technology. Also, in such a

situation, the vertical integration of industries is considered more because the costs related to the movement of products between intermediaries are reduced by increasing transparency (Ghahremani-Nahr et al., 2022).

In a traditional hierarchical supply chain network, the flow of data across the network often mimics the flow of goods. In a distributed ledger environment using blockchain, all data and information can be shared in a decentralized manner so that parties can view the same data. In such a situation and when sharing information, there is no longer a need for each supply chain actor to act as an intermediary between nearby 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.

In the following, the effects of using Internet of Things and Blockchain technologies in the smart supply chain are presented.

2. Internet of Things and Agile Supply Chain

Traditional supply chains face various challenges such as uncertainty, cost, complexity and vulnerability problems. To overcome these problems, supply chains must be smarter. By making goods intelligent, Internet of Things provides the possibility for customers to have the complete information of the goods from raw materials to production through the Internet and use them to make purchasing decisions. This information can include ingredient information, production process information, information related to the manufacturing company, distributor information, product warranty, or other information required by the customer (Aliahmadi et al., 2022d).

The Internet of Things has covered this field of e-commerce by coding each order and embedding the required information in it. The information embedded in the orders is read and sent to the centralized data collection system at any point from the production process to delivery using radio wave identification technology. Therefore, customers are able to track their orders in real time, and know the fate of their order (Nozari et al., 2021a). One of the most important parts of e-commerce is transportation and moving goods. This section can be managed in such a way that the movements are fully and accurately visible. By making goods intelligent and equipping vehicles with global positioning systems, Internet of Things technology will be able to determine the amount of goods being transported as well as the origin and destination of the order. By implementing the Internet of Things technology, companies are able to monitor all their products online and gather complete information about the processes that the goods go through (Fallah et al., 2022). Despite a strong and integrated database, they are not only good at returning information in business processes and sharing information between transaction parties, but are also able to analyze this business data accurately and in real time. In this way, companies can also analyze their competitive markets and predict their future business trends to capture the market share of their products in the best way. In fact, this can improve the ability of companies to respond to the market (Najafi et al., 2022).

One of the most important applications of Internet of Things technology in the production sector is the activation of the automation system in which the identification and tracking of materials and products become possible. As a result, the cost of manpower mistakes will be significantly reduced. With the intelligentization of goods in the production sector, in addition to the accurate identification and tracking of raw materials and spare parts during the production process, the amount of waste and breakdowns can also be accurately measured. This feature allows managers to identify bottlenecks and weak points in e-commerce (Nozari et al., 2022b).

Hence, emerging technologies such as the Internet of Things play a significant role in making the entire retail supply chain path agile and green. The Internet of Things and the supply chain have joined hands today, and in fact, logistics tracking is one of the most common applications of the Internet of Things. Supply chain management is complex and risky – when something goes wrong, it often has cascading effects that affect entire industries. The supply chain based on the Internet of Things can help managers from production to

transportation and delivery to monitor logistics and ultimately prevent bottlenecks in critical supply chain networks. This can increase the agility of supply chain processes (Nozari et al., 2021b).

The use of IoT in supply chain management allows logistics partners to collect and use data for better inventory management, transportation and incident response. These capabilities pave the way for the use of machine learning models to create advanced and responsive supply management solutions that predict bottlenecks, save time and money, and accelerate incident response. Visibility in the supply chain using IoT technology is shown in Figure 1.

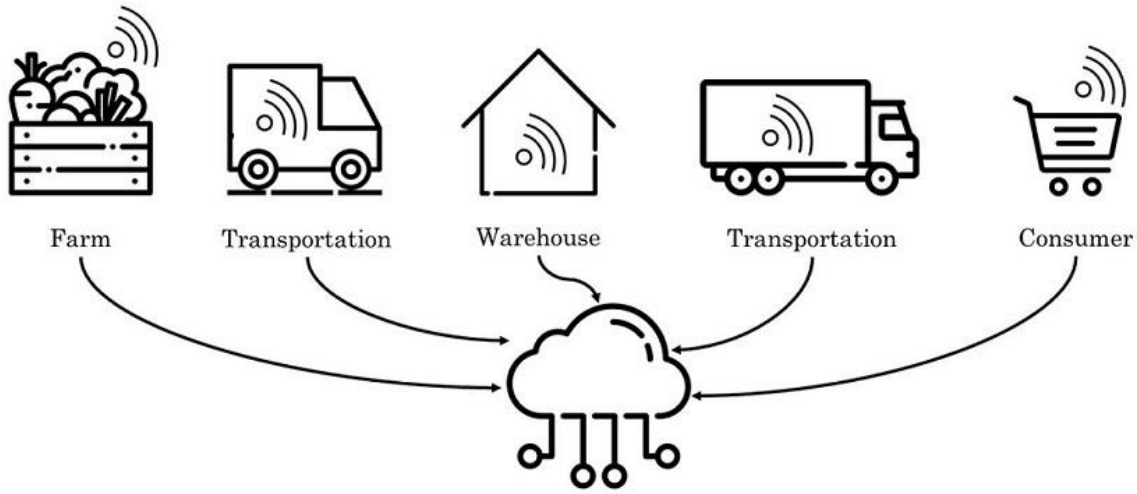

Fig. 1. Visibility in the supply chain using IoT technology (Correa et al., 2020)

The conducted studies show the effect of information technology on improving responsiveness, distribution and transmission of information, efficiency of the chain and promotion of cooperation in both internal and external dimensions, preventing the emergence of the leather whip effect and developing sales channels. Also, information technology applications in supply chain management with two technological approaches and information systems are very important. At the same time, studies have shown that factors such as the size of the organization, success rate, uncertainty and pressure from other chain partners, etc. play a significant role in the adoption of information technology (Nahr et al., 2021).

Future intelligent objects have the ability to analyze human behavior using artificial intelligence, machine learning and with the help of data collected by RFID tags, and with the help of predictive models, make detailed analyzes for providing supply chain assistance. Such objects will have the ability to manage the supply chain with the help of analyzing the market situation, the situation of competitors, the interests of customers, etc (Nahr et al., 2021).

Automation in the supply chain increases the speed of processes significantly. With the development of the Internet of Things and the formation of smart cities, the need to implement a smart supply chain in future cities is strongly felt. In a smart city, all procedures need to be done intelligently. The Internet of Things plays a very prominent role in the supply chain. With the advancement of the Internet of Things, supply chains are also becoming more modern and capable (Nozari et al., 2021a).

Of course, the existence of various challenges in providing basic goods in a smart city shows that chain services still need to evolve and improve. Anticipating needs in advance will improve urban services. Information technology, Internet of things and data processing are among the topics that make the processes of goods supply and logistics improve. Some other benefits of the Internet of Things in the supply chain include:

- *Intelligent route planning tools and IoT tracking technologies are exponentially increasing the overall speed of the supply chain.*
- *All parties involved in the supply chain cycle have access to relevant data and can resolve issues quickly and accurately.*
- *The Internet of Things provides managers with detailed insight into the flow of goods.*
- *Combining the Internet of Things and supply chain management is a good way for retailers to learn more about their products, customers and demand, and build strategies accordingly.*
- *The Internet of Things in the supply chain creates greater awareness in resource and labor management.*

3. Blockchain and Agile Supply Chain

Due to the expansion of the supply chain of today's organizations at various national and international levels, its importance has increased in such a way that it is said that competition between organizations has been replaced by competition between their supply chains. Therefore, improving the performance of the supply chain is one of the most important challenges facing managers and puts them in constant struggle to identify ways to improve the performance of their supply chain. Focusing on emerging technologies and identifying their dimensions and characteristics, from the perspective of how these technologies help to improve performance, is one of the solutions that can help solve the challenge of improving the performance of supply chains. Usually, the performance of supply chains is measured with diverse and key characteristics desired by customers, such as cost, quality, speed, etc (Nozari et al., 2022c).

Blockchain, as a part of efficient technologies in supply chains of organizations; builds trust, transparency and consensus among all stakeholders, creating benefits for every actor and ensuring flexible business outcomes. Blockchain's potential extends far beyond cryptocurrency applications and is now recognized as a fundamental mechanism that can improve supply chain efficiency and effectiveness. The global supply chain is worth more than $40 trillion annually. Logistics requires complex international regulations to oversee the movement of goods around the world. Due to the existence of information asymmetry in the large volume of information flows, such a system is prone to error or corruption among the intermediaries involved (Nozari et al., 2021b).

It is obvious that the use of this technology improves transparency and accountability and facilitates the authentication process of goods and materials received. In addition to this acceleration of the flow of goods, timely delivery of products and greater transparency in logistics activities are the benefits that will accrue to all stakeholders of the supply chain through the adoption of this technology. Also, in such a situation, the vertical integration of industries is considered more because the costs related to the movement of products between intermediaries are reduced by increasing transparency.

The following are examples that demonstrate the potential of blockchain in reducing supply chain costs and improving service levels.

- ***Find resources***

Sourcing is considered as one of the most important application areas of blockchain. Buying companies can assess the supplier's value and risk based on detailed information about how they are procured, produced and transported. Because transactions between a vendor and its partners can be visible to others in the chain, buying companies can monitor a supplier's performance and gain the knowledge they need to negotiate better prices. Such information can also represent how cost is distributed throughout the supply chain. Providing economic visibility enables better participation of smaller companies in the supply chain value network. In addition, information may be shared with insurers to negotiate transportation coverage with logistics providers and manufacturers (Aliahmadi et al., 2022a).

- ***Tracking and interception***

Information asymmetries and inconsistencies among supply chain participants are always present, creating barriers to tracking specific transactions and commodities. Downstream participants in the supply chain often need information about a product, including the assembly process, material lists, and cautionary warnings. The integrity of a product's transaction records requires extensive processes and controls that are not easily achieved (Nozari et al., 2022b).

- ***Payment process***

Blockchain can also be used to improve payment processing in the supply chain, especially where buyers use a supply chain finance (SCF) platform to pay their suppliers' invoices (Nozari et al., 2021a).

- ***Logistics and transportation***

The ability to track a container shipment along its journey from origin to destination has historically been a major supply chain challenge and has not changed much in the past 50 years. The process is complex and involves nearly 30 entities including importers, exporters, shipping fleets, clearing agents, shipping lines, shipping companies, surveyors, banks, tax authorities, health organizations and insurance brokers. The shipping tracking process is a manual and paper-based process that involves hundreds of communication events (Nahr et al., 2021).

These benefits can reduce losses, especially in the case of spoilage of perishable goods. It can also ensure the completeness and accuracy of documents and reduce manipulation, fraud in documents. This is because transactions recorded on the blockchain are immutable so that no party can alter the records. The transparency provided by the distributed ledger can effectively influence the processes of resource allocation, transportation planning, and dynamic adjustment of prices based on supply and demand. Because information such as capacity, cost, and delivery time, estimates for different transportation routes are provided to the beneficiaries. Overall, the use of blockchain to enhance global logistics transactions can improve free trade between companies and countries by reducing the costs of intermediaries such as freight brokers. This cost reduction can reduce the costs of transporters and ultimately the consumer price (Nozari et al., 2022c).

- ***Ensuring compliance with ethical and safety principles***

Every year, about 10% of people in the world get sick or die from contaminated food. The issue of ensuring the authenticity of supply sources is very important in the food industry. Additionally, counterfeit food products cost consumers millions of dollars. However, this is not limited to food but includes a wide range of goods, including clothing, diamonds, auto parts, and electronics, among others. The complexity of today's supply chains makes it difficult for retailers, manufacturers, and consumers to verify the authenticity of raw materials and product components and to detect any mistakes regarding ethical issues, child labor, fraud, or other unethical practices that may have occurred in the creation of a product.

While the food industry seems to be the main application in this regard, similar cases can be considered for other types of products. For example, there are similar precautions in the process of manufacturing and distributing drugs. Non-consumable goods such as cloth and diamonds can also benefit from blockchain. Diamonds and minerals require proof of authenticity. This includes knowing where these goods are sourced, ownership assets, authenticity, certifications and safety features (Aliahmadi et al., 2022c).

- ***Smart palettes***

Blockchain-connected smart pallets can make it easier to locate and optimize pallet usage. Blockchain can reduce costs associated with unused, lost, or stolen pallets and lead to new or improved business models for

processes such as vendor-managed inventory, automated customs clearance, and pay-per-use. It can also improve the scalability and flexibility of production (Nozari et al., 2022a).

Figure 2 shows the relationship between blockchain and supply chain schematically.

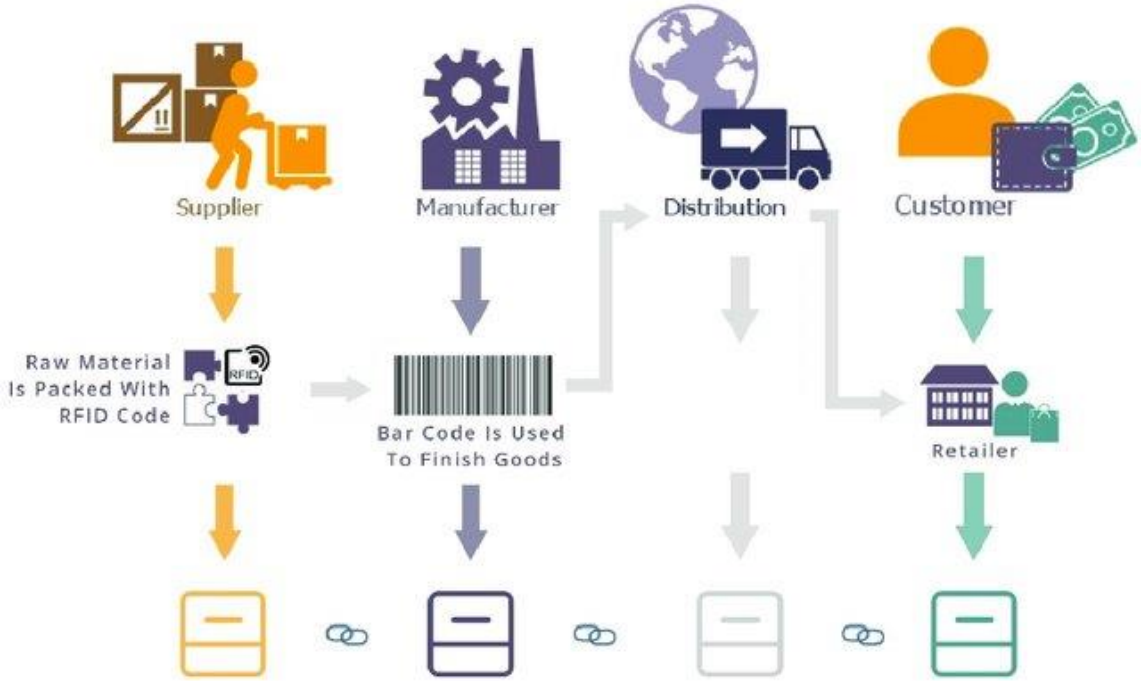

Fig. 2. Blockchain in a supply chain (Johar et al., 2021)

So blockchain greatly reduces, if not eliminates, the kind of enforcement, tracking, and coordination problems we've discussed. Since participants have separate versions of the blockchain, each party can check the status of a transaction, identify errors, and hold the other party accountable for their actions. No participant can overwrite past data, as doing so would require overwriting all subsequent blocks in all shared versions of the blockchain (Nozari et al., 2021a).

4. Conclution

The Internet of Things and blockchain technology are an inseparable part of the future of the supply chain. A future in which, in addition to the speeding up of information throughout the chain and the analysis of this huge data, the delivery of goods to the final customers has also changed, eliminating the basic intermediaries and reducing costs and time from production to delivery of the product. The Internet of Things and Blockchain technology, by affecting various parts of logistics management such as production, storage, transportation, information management and after-sales services, increases their efficiency and improves their performance in an organization. The Internet of Things, relying on the intelligentization of materials, goods and processes, improves the level of logistics management of institutions to a dynamic and efficient level. Among the advantages of implementing these technologies in an organization is the reduction of service time to customers and the reduction of costs related to after-sales services. Moving organizations towards JIT is the biggest progress in the way of reducing the stopped capital of the organization, and in fact, it directs its capital towards circulating costs and creating production and performance infrastructures. The creation of a strong information base facilitates the forecasting and planning processes as well as the preparation and supply of resources.

With the services and information provided through these technologies, customers get product information, production information, and supply chain information. Therefore, the information related to the distribution route plan, distribution schedule and native distribution, sales records, order changes, production status and sales status will be available for customers through the Internet. Also, the information related to logistics, including the transportation route, delivery time, customer information, and the location of the goods are specified. Manufacturers will also get product information, production process information, logistics information, inventory information. Among other information available in this field, it includes knowledge of marketing strategies, knowledge of new products, control of production and products, and knowledge of customer buying patterns. The use of various Internet of Things and Blockchain solutions during the supply chain makes the information sharing between related departments reach the maximum. As a result, the production rate is close to its optimal point in accordance with supply and demand.

References

- Aliahmadi, A., Jafari-Eskandari, M., Mozafari, A., & Nozari, H. (2016). Comparing linear regression and artificial neural networks to forecast total productivity growth in Iran. International Journal of Information, Business and Management, 8(1), 93.
- Aliahmadi, A., Jafari-Eskandari, M., Mozafari, M., & Nozari, H. (2013). Comparing artificial neural networks and regression methods for predicting crude oil exports. International Journal of Information, Business and Management, 5(2), 40-58.
- Aliahmadi, A., Nozari, H., & Ghahremani-Nahr, J. (2022a). A framework for IoT and Blockchain Based on Marketing Systems with an Emphasis on Big Data Analysis. International journal of Innovation in Marketing Elements, 2(1), 25-34.
- Aliahmadi, A., Nozari, H., & Ghahremani-Nahr, J. (2022b). AIoT-based Sustainable Smart Supply Chain Framework. International Journal of Innovation in Management, Economics and Social Sciences, 2(2), 28-38.
- Aliahmadi, A., Nozari, H., & Ghahremani-Nahr, J. (2022c). Big Data IoT-based Agile-Lean Logistic in Pharmaceutical Industries. International Journal of Innovation in Management, Economics and Social Sciences, 2(3), 70-81.
- Aliahmadi, A., Nozari, H., Ghahremani-Nahr, J., & Szmelter-Jarosz, A. (2022d). Evaluation of key impression of resilient supply chain based on artificial intelligence of things (AIoT). arXiv preprint arXiv:2207.13174.
- Correa, J. S., Sampaio, M., Barros, R. D. C., & Hilsdorf, W. D. C. (2020). IoT and BDA in the Brazilian future logistics 4.0 scenario. Production, 30.
- Fallah, M., & Sadeghi, M. E. (2022). Quantitative analysis of the applied parts of Internet of Things technology in Iran: an opportunity for economic leapfrogging through technological development. Journal of Science and Technology Policy Letters.
- Ghahremani-Nahr, J., & Nozari, H. (2021). A Survey for Investigating Key Performance Indicators in Digital Marketing. International journal of Innovation in Marketing Elements, 1(1), 1-6.
- Ghahremani-Nahr, J., Aliahmadi, A., & Nozari, H. (2022). An IoT-based sustainable supply chain framework and blockchain. International Journal of Innovation in Engineering, 2(1), 12-21.
- Johar, S., Ahmad, N., Asher, W., Cruickshank, H., & Durrani, A. (2021). Research and applied perspective to blockchain technology: A comprehensive survey. Applied Sciences, 11(14), 6252.
- Nahr, J. G., Nozari, H., & Sadeghi, M. E. (2021). Green supply chain based on artificial intelligence of things (AIoT). International Journal of Innovation in Management, Economics and Social Sciences, 1(2), 56-63.

- Najafi, S. E., Nozari, H., & Edalatpanah, S. A. (2022). Investigating the Key Parameters Affecting Sustainable IoT-Based Marketing. In Computational Intelligence Methodologies Applied to Sustainable Development Goals (pp. 51-61). Springer, Cham.
- Nozari, H., & Aliahmadi, A. (2022). Lean supply chain based on IoT and blockchain: Quantitative analysis of critical success factors (CSF). Journal of Industrial and Systems Engineering.
- Nozari, H., Fallah, M., Kazemipoor, H., & Najafi, S. E. (2021a). Big data analysis of IoT-based supply chain management considering FMCG industries. Бизнес-информатика, 15(1 (eng)), 78-96.
- Nozari, H., Fallah, M., Szmelter-Jarosz, A., & Krzemiński, M. (2021b). Analysis of security criteria for IoT-based supply chain: a case study of FMCG industries. Central European Management Journal, 29(4), 149-171.
- Nozari, H., Ghahremani-Nahr, J., Fallah, M., & Szmelter-Jarosz, A. (2022a). Assessment of cyber risks in an IoT-based supply chain using a fuzzy decision-making method. International Journal of Innovation in Management, Economics and Social Sciences, 2(1).
- Nozari, H., Najafi, S. E., Jafari-Eskandari, M., & Aliahmadi, A. (2016). Providing a model for virtual project management with an emphasis on IT projects. In Project Management: Concepts, Methodologies, Tools, and Applications (pp. 476-496). IGI Global.
- Nozari, H., Sadeghi, M. E., & Najafi, S. E. (2022b). Quantitative Analysis of Implementation Challenges of IoT-Based Digital Supply Chain (Supply Chain 0/4). arXiv preprint arXiv:2206.12277.
- Nozari, H., Szmelter-Jarosz, A., & Ghahremani-Nahr, J. (2022c). Analysis of the Challenges of Artificial Intelligence of Things (AIoT) for the Smart Supply Chain (Case Study: FMCG Industries). Sensors, 22(8), 2931.