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A CONCEPTUAL REVIEW OF DIGITAL TWIN-BASED BUSINESS ECOSYSTEMS IN SUPPLY CHAIN PLANNING

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Review

A B S T R A C T

In Today's fickle environment, supply chain management has become increasingly delicate and complex. In this context, a well-performed supply chain requires incorporating digitalization into supply chain networks. To fill this gap, the proposed paper aims to provide a better comprehension of prerequisites required when developing a digital twin in manufacturing supply chains, as well as the benefits and service business growth opportunities that are created for different companies by participating in a digital twin business ecosystem, and further the expected benefits for the entire ecosystem. Findings revealed that digital twins in the manufacturing supply chains are changing the way they do business. They offer a range of opportunities to facilitate collaborative environments, data-driven decisions and make business processes more robust. Finally, the paper aims to help academicians and practitioners to have good insight and overview of digital twins into supply chain planning activities and also it can provide insights for businesses regarding the use of digital twins in supply chain planning, helping them to improve their operations and gain a competitive advantage.

1. INTRODUCTION

Computerized twins give a few modern openings for item and benefit advancements for fabricating companies, and hence, this innovation is anticipated to alter the product-service offerings of fabricating companies (Tao et al., 2019). Besides, computerized twins are gathered to form modern commerce opportunities for a few companies inside the whole fabricating environment (Cai et al., 2017; Oubrahim et al., 2023). In expansion to the expanded product-service offerings of fabricating companies, modern databased benefit businesses are assumed to seem in, for illustration, arranging, extend administration, re-enactment modeling, visualization, control frameworks, robotization, and information analytics administrations (Singh et al., 2022). However, the application ranges and benefit trade concepts related to advanced twins are still within the investigation stage (Ivanov & Dolgui, 2021; Oubrahim et al., 2022a). The later writing surveys on advanced trade biological systems within the fabricating industry, (Huikkola et al., 2022) have examined that there exists a require for more empirical-level understanding around the operations of advanced commerce biological systems such that they can dodge both the benefit and digitalization catch 22s. In expansion to advanced commerce biological systems, the benefit trade and servitization among the fabricating organizations have been investigated as of late. Indeed, in spite of the fact that there exists an understanding on both advanced trade biological systems and benefit commerce in a computerized trade environment, (Jovanovic et al., 2022) have stated that the inquire

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about on industrial digital stages is still early. Since all the understanding from B2C setting isn't transferrable to B2B setting and to mechanical advanced stages. (Park et al., 2019) have argued that, for this reason, scholars should pay more consideration to exploring the early stages of the advancement of stage biological systems, for illustration, to get it how stage administration components advance. Concurring to Huikkola et al. (2022), there's, for occasion, a got to get it how the parts of administrators alter when a conventional advanced arrangement utilizer needs to gotten to be a framework supplier and bad habit versa.

2. BACKGROUND

2.1 Digital twin

An advanced twin may be a virtual show and comprehensive portrayal of the framework utilized to get it the execution parameters, improve forms, and viably improve value-added activities (Park et al., 2019).

An advanced twin may be a computerized partner of the physical frameworks based on a reenactment that bargains with plan frameworks and optimizes them for moved forward productivity (Guo, Zhao, Sun, & Zhang, 2019). Computerized twin improvement has significant potential in feasible fabricating operations since of its data-rich environment that encourage real-time checking, recreation, and forecast of fabricating forms (Cheng et al., 2020; Oubrahim et al., 2022b). Numerous fabricating organizations have mechanized their generation lines utilizing mechanical frameworks and IoT-based innovations, producing advanced data.

The computerized twin mimics the fabricating environment based on the collected data and makes a difference the proprietor choose between the accessible activities for expanded productivity, superior precision, and economies of scale (Alam & El Saddik, 2017). Cyber physical frameworks have played a basic part in numerous up and coming advances with the improvement of real-time detecting, progressed control, counterfeit insights, and service-oriented fabricating. Savvy fabricating, combined with cyber physical framework improvement, has cleared the street for advanced twin innovation to supply sufficient determination to arrange between the physical world and the virtual world (Alam & El Saddik, 2017; Oubrahim et al., 2022b). The interoperability between these developing advances comes about in critical potential for the improvement of compelling stages and applications to screen and control the fabricating frameworks, changing them into maintainable fabricating frameworks (Ahidar et al., 2017).

The existing writing demonstrated that organizations are considered fruitful on the off chance that they can deliver high-quality items assembly client needs and desires with moo fabricating and supply chain costs (Leng et al., 2020). An advanced twin can control generation forms in reaction to the changing showcase needs with tall precision and nimbleness. Computerized twin systems have considered one or more fabricating offices with the center of creating free customized applications, but they need a center on creating a advanced twin as a center mechanical component of the whole framework (Leng et al., 2020). The computerized change plan of numerous organizations requires overhauls in existing fabricating frameworks to shrewd and brilliantly maintainable fabricating frameworks. A digital supply chain twin is utilized for progressed supply chain modeling based on prescriptive analytics that works in real-time and can decide the correct remedial activity supporting supply chain optimization. The potential of the advanced twin within the supply chains and later advancements in rising advances, such as added substance fabricating, BDA, and IoT, request a survey of existing writing to get it computerized twin components, applications, and challenges.

The advanced twin, combined with the control of huge information analytics, fake insights, and interconnected IoT frameworks, has the potential to open covered up esteem for organizational decision-making (Lu & Xu, 2019). Computerized twin proprietors can foresee operational disappointments, make strides item quality, and diminish downtime (Tao et al., 2019). The innovation effectively employments nonstop optimization frameworks, which bolsters consolidating the framework and handle parameters amid the generation cycle.

Advanced twin innovation offers three noteworthy points of interest. To begin with, it permits existing generation frameworks, forms, and components to be coordinates and made congruous utilizing little gadgets like sensors and application program. Moment, it makes a difference increment efficiency by diminishing blunders and applying predictive maintenance to diminish breaking down. At long last, the generation information of computerized twins is put away within the framework and are utilized for handle optimizations. Simchenko et al. (2020) recommended utilizing computerized twins to map exercises over the whole supply chain. As before long as client orders are entered into the framework, the arrange points of interest and related exchanges can be captured by the advanced supply chain twin, empowering real-time simulation and decision-making. For case, in case any delays happen within the supply chain due to machine breakdown or supply delays, this data can be sent to the advanced supply chain twin utilizing developing advances such as mechanical IoT gadgets, cloud computing, and enormous information analytics. In this manner, it is fundamental to survey how distinctive Industry 4.0 advances can meet supply chain needs when considering the arrangement of advanced supply chain twin (Kamble et al. 2022).

The literature uncovered the utilize of different Industry 4.0 advances that are utilized within the computerized supply chain twin design. We recognized IoT, recreation modeling, cyber physical frameworks, machine learning, and fake insights as up-and-coming

innovations that can play a noteworthy part in creating advanced supply chain twins.

2.2 Digital twin business ecosystems in manufacturing

In later ponders, the part of advanced twins in shrewdly fabricating and related stages has produced a extraordinary bargain of intrigued. Mihai et al. (2022) propose a nitty gritty system for computerized twin-driven feasible fabricating. They highlight the preferences of advanced twins for expanding insights and maintainability at diverse layers of the generation stage, such as fabricating gear, frameworks, and administrations (Mihai et al, 2022) contend that advanced twins can successfully interface the gadget layer and arrange layer in fabricating frameworks, hence they play a more successful part in all esteem joins. By coordination divided advanced data, companies can be given with a comprehensive see on, for illustration, items, fabricating, supply chain, client encounter, and productivity. Be that as it may, fair utilizing computerized twins to upgrade trade victory in fabricating stages isn't sufficient. It is similarly vital to coordinate these empowering advances with the real needs of clients and clients (Hannola et al. 2021. Li et al. 2020) have also recommended that companies ought to change from company-centered to user-centered substances to move forward their productivity and adequacy and client involvement. This change is as of now on its way in numerous fabricating companies, which are moving center from a product-centric approach to combined item and benefit offerings, called servitization. Adjusting between the benefit needs of clients and income goals has ended up a central source of competitiveness within the fabricating division. (Cenamor, Rönnberg, Sjödin & Parida, 2017) have recommended that a stage approach may encourage both customization and operational proficiency by leveraging the esteem of advanced advances to overcome the so-called benefit conundrum. One striking contention in their think about is that a stage approach requests that companies distinguish and characterize modern parts. They too contend that the engineering and stage parts of servitized manufacturers to reinforce understanding of how to form fruitful environments within the fabricating division; all performing artists included ought to know their part and have a unflinching commitment to work collaboratively to use the esteem of shared data (Tao et al., 2019). The selection of modern sorts of parts and endeavors for esteem cocreation and shared interface are among the key prerequisites for an ecosystem-based trade (Oubrahim et al., 2022a). Meierhofer et al. (2020) have come to comparable con collusions after analyzing shrewdly mechanical administrations from the angle of their esteem recommendation. They state that producers got to forsake the part of esteem maker and instep adopt the considering demonstrate of esteem co-creation through client interaction. As famous, advanced twins are a momentous enabler for the development of a benefit trade within the fabricating sector. However, each participating on-screen character will have different jobs and encounter distinctive torments and picks up, each of which is subordinate on the circumstance in address. The so-called commerce system, that's, the requirements of the performing artists within the biological system and the esteem in utilize, ought to be modeled to begin with. As it were at that point will applying an advanced twin arrangement to supply the esteem in utilize be considered as a way of coordinating with 'the actor's problem'. This cultivates co-creation of esteem between distinctive on-screen characters, such as suppliers and clients (Meierhofer et al., 2020). Be that as it may, since ecosystem-based considering is still or maybe a modern marvel in companies, they regularly battle with embracing the prerequisites of an ecosystem-based commerce. A ponder by (Kokkonen et al., 2022) on DBEs found that companies regularly recognize the potential of unused shapes of esteem co-creation, but they as a rule endure from finding ways to arrange participation, and hence, they battle at adapting with interconnectivity, interoperability, and competing interface. In this paper, it is contended that the complementarity of distinctive companies' offerings isn't a prerequisite but or maybe ought to be developed in a shared advancement handle between environment members.

3. FINDINGS AND DISCUSSIONS

3.1 Supply chain digital twin

Conventional supply chains may now not be sufficient within the computerized age. Cutting edge markets advantage not as it were from supply chain productivity, but too from its nimbleness and adaptability. Nowadays, the supply chain is advancing from a conventional show of straight, person, and no concurrent connections to a more associated and facilitated organize of commerce accomplices. The supply chain is expected to be restored, computerized and able to supply the desired administrations. Subsequently, it must advance through interconnected advanced gadgets and complex systems. This computerized supply chain interfaces distinctive partners (counting clients) more successfully and empowers them to reply speedier and adjust to a quickly changing advertise. Counseling clarifies the five measurements of alter as takes after (Ageron et al., 2020; Oubrahim & Sefiani, 2022).

1) Computerized supply chain methodology: The objective is to coordinated computerized developments within the in general supply chain methodology.
2) Supply Chain Administration and Operational Show: A particular computerized working demonstrate in which information now not depends on location. Large enterprises working

all-inclusive will consider inside coordination committees in more detail.

3) Coordinates execution: Executing diverse supply chain capacities is exceptionally imperative. The most objective is to supply forms that give all the data required by representatives.
4) Coordinates supply chain execution estimation: This highlight makes it conceivable to track any arrange or exchange through a computerized working demonstrate. When utilizing barcodes or RFID labels, the utilize of labeling advances opens the way to getting real-time data on physical relocation. A digital twin can be characterized as an energetic virtual representation of a protest or physical framework, utilizing real-time data to get it, learn, and reason. In spite of the fact that its definition changes from source to source, the most thought is to supply an advanced representation of a resource (unmistakable [presence] or intangible [framework]), which employments the Web of Things to get significant information in genuine time. And based on the created demonstrate, how it worked within the past and how it works presently, comes to the conclusion.

3.2 The importance of digital twin in supply chain planning

The advanced twin was created with three fundamental components counting physical item (PP), virtual item (VP) and information trade. Advanced Twin has three vital highlights: synchronization between physical item and virtual item, comprehensive and energetic information collection, and high-quality virtual modeling. These three characteristics play a critical part in managing with arranging challenges. By synchronizing between the physical item and the virtual item, the computerized twin makes strides the speed of operation and responsiveness to decrease obtainment time. Arranging is based on data recovered from chronicled things and each unit within the supply chain. As a rule, there's a noteworthy time slack between target distinguishing proof, information collection, information trade, and execution. Synchronization between the physical item and the virtual item permits data to be shared between each unit and each design within the supply chain in genuine time, which essentially diminishes obtainment time. In expansion, synchronization between the physical item and the virtual item upgrades the human-machine interaction between the supply chain and engineers. So, engineers can rapidly oversee the supply chain by changing virtual items. By powerfully and comprehensively collecting information, Computerized Twin altogether makes strides estimate exactness. As a rule, information collected from authentic cases are frequently not comprehensive sufficient to completely portray the situations they incorporate and the status of supply chain units or products. In differentiate, Advanced Twin powerfully collects information from different sources. Within the physical product, the advanced twin records real-time information of physical items, situations, comparable items, and administrators. Within the virtual item, the computerized twin extricates information from virtual models and reenactments. Chronicled case information is additionally put away. In expansion, distinctive advanced twins can have connected and trade information with each other, permitting the advanced twin to recover information from other frameworks. Subsequently, this tremendous information makes determining and arranging more exact over a longer period. With tall quality modeling, Computerized Twin improves arranging approval. A key approach to confirming arranging is simulation. Conventional computer program and instruments frequently incorporate insufficient natural components, rules, instruments, and behaviors. In differentiate, the computerized twin models all of this within the virtual item. Hence, the reenactment quality will be made strides, and the arranging confirmation will have less deviations.

3.3 Digital Twin-benefits in manufacturing

Manufacturing is becoming smart at all levels from the physical device, through factory management, to production networks, gaining abilities to learn, configure and execute with cognitive intelligence. Smart manufacturing is coined by several agencies, such as the Department of Energy (DoE) and the National Institute of Standards and Technology (NIST) in the United States. According to Davis et al. (2012) smart manufacturing is the dramatically intensified application of manufacturing intelligence' throughout the manufacturing and supply chain enterprise (Davis et al., 2012; Iqbal et al., 2021). It comprises the real-time understanding, reasoning, planning and management of all aspects of manufacturing processes, facilitated by the pervasive use of advanced sensor-based data analytics, modeling, and simulation. NIST defines smart manufacturing systems as "fully-integrated, collaborative manufacturing systems that respond in real time to meet changing demands and conditions in the factory, in the supply network, and customer needs" In smart manufacturing, a physical 'thing' in a factory is connected to the Industrial Internet via standard cyber gateways and abstracted as a Digital Twin in the cyberspace. Each Digital Twin in the cyberspace is an abstraction of its counterpart in the physical world by reflecting its physical status. The cyberspace stores and processes the streamed data from connected physical objects. These data are used to model, simulate and predict the status of each physical thing under dynamic working conditions. The pervasive use of smart technologies, such as Big Data Processing and Artificial Intelligence enables the extraction of manufacturing intelligence at every single moment of manufacturing

activities. The collective intelligence in locally connected factories and the cyberspace paves the way for some dramatic changes from the aspects of intra-business operation, inter-business collaboration and production model,

- Smart Production: Manufacturing systems augmented with cognitive intelligence (Amjad et al., 2021; Oubrahim et al., 2023) can take over more and more production jobs. Connected and self-organizing manufacturing systems will tackle new manufacturing tasks with high efficiency and flexibility. The relationship between humans and machines will also change; one direction is a factory will become fully-immersed human-machine collaboration space (Oubrahim et al., 2022a).
- Smart Production Network: Connected cyber-physical production systems will form a global production network that can respond in almost real-time to dynamic changes in local production systems and external supply chain (Bauer et al., 2008). A production network of adaptive and self-optimizing production systems can enable autonomous configuration and planning of production activities for production jobs at changing scales to achieve sound economic, environmental and social impacts.
- Mass Personalization: Production model will move from a push type mass production model to pull-type mass personalization (Alfaro-Saiz et al., 2020; Li & Mathiyazhagan, 2018).

Smart factories that are fully responsive to changes and demands from the factory, supply chain, and customer side can achieve batchsize-of-1 production with high efficiency and flexibility. The ubiquitous manufacturing intelligence in distributed factories and production systems can sense, configure and collaborate by themselves based on near real-time production status and demands, which therefore provides the required agility for producing highly personalized products.

4. CONCLUSION

In conclusion, the paper emphasizes the importance of digitalization in the context of supply chain management and highlights the benefits of incorporating digital twins in manufacturing supply chains. The study identifies key prerequisites required for the successful development of digital twins, including data quality, system integration, and effective communication among stakeholders. By enabling companies to monitor and analyze their operations in real-time, digital twins can facilitate data-driven decision-making, improve efficiency, reduce costs, and enhance supply chain resilience. Moreover, the study shows that digital twins can create significant growth opportunities for companies through increased collaboration and the development of new service business models. The paper also emphasizes the importance of building a digital twin ecosystem to maximize the benefits of this technology. A digital twin ecosystem involves a network of companies and stakeholders that work together to develop and implement digital twins in their operations. This approach allows companies to share data and collaborate more effectively, leading to improved supply chain visibility, better decision-making, and increased efficiency. Furthermore, the study identifies several benefits of a digital twin ecosystem, including reduced risk, improved innovation, and the development of new business opportunities.

Overall, the paper provides valuable insights for academicians, practitioners, and businesses seeking to improve their supply chain operations through the use of digital twins. By highlighting the prerequisites for successful digital twin development, the study helps companies to better understand the challenges and opportunities associated with this technology. Additionally, the paper emphasizes the benefits of a digital twin ecosystem and provides guidance on how to develop such an ecosystem. Ultimately, the study demonstrates that digital twins are a powerful tool for improving supply chain efficiency, reducing costs, and enhancing competitiveness, and that companies that embrace this technology can gain a significant advantage in today's fickle and complex business environment.

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