# Roles of digital twins on material performances and resource utilization on upstream industry (the case of textile industry)

**BY**

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## ABSTRACT

Supply chain processes are receiving considerable attention as a cutting-edge technology that will transform raw materials from material suppliers to the manufacturing and processing industries to fulfill customer requirements. However, the textile and apparel manufacturer industry faces many challenges on raw material and resource utilization scenario. To cope with those challenges, digital twin (DT) strategies have been a useful tool to visualize, realize, analyze, and utilize materials and integrate raw material accessibility, product quality, and delivery service systems into the production line or entire supply chain process. Nevertheless, the development and adoption of DTs is still infant and immature in most manufacturing industries. Mainly textile and apparel industries have weak practices in importance and roles of DT. This study aims to explore the role of DT technology impacts on raw material, design, production, lines in the textile and apparel industry and the entire their supply chain performance. Digital supply chain twins' roles in material utilization, the production performance and the overall supply chain capabilities were investigated and studied in this paper. The investigations shows that digital supply chain twin have a positive and direct impacts on supply chain performance in supply chain visibility, raw material accessibility, real time decision making, process optimization, value chain optimization, resource utilization and visibility in a supply chain process of textile and apparel industries. Both the primary and secondary data have been analyzed and studied using descriptive analysis, and Fuzzy TOPSIS tools. The relation between digital twins with resilience of digital enablers on supply chain process for sustainable supply chain process needs further study and investigations.

**Keywords:** Digital Twin; Material Utilization, Cloud Computing, Textile and Apparel Industry; Physical
Entities, Supply Chain; Performance

## INTRODUCTION AND BACKGROUND

An integrated and optimized supply chain and logistic process requires modern, resource and information simulation driven visualized approaches. Those simulated and digitalized strategies accelerate resources, information and many rapidly in the supply chain process. Digital technology also changes the existing business process and creates new business opportunities. Furthermore, this strategy tackles the problem in related to demand and supply uncertainty, logistics constraints, delivery delay, higher complexity of new products, unstable world and technological change needs for emphasis for single companies moving the competition in supply chain networks (Zamboni,

2011). The biggest benefits that supply chains can take from digitizing their processes are speed and cost(Intensity, 2020). As a result, manufacturing firm are stresses companies to find new innovative methods to gain competitive advantages and increasing their performances (Westphal, 2016). Innovative and digital strategies provide to improve supply chain delivery process of products and services to their customers. According to (Intensity, 2020), (A.Addae-Korankye, 2013) shows that digital twin is a digital replica of a living or non-living physical entity. Digital twin refers to a digital replica of potential and actual physical assets, processes, people, places, systems and devices that can be used for various purposes. Many digital enterprise suites have to offer an integrated portfolio of software-based systems and automation technologies for industries to seamlessly integrate and digitalize the entire value chain, including suppliers(Kuehn, 2018). Through a digital twin concept, digital representation and a virtual copy of the supply chain can be crated(Marmolejo & Hurtado, 2020). As a result, today, the engineering, manufacturing, energy, and automotive industries are leading the way in leveraging digital twins to manage their most critical assets, followed by healthcare, the public sector, and even consumer retail. Whereas digitalization and innovation practice of developing countries are infant and non-integrated technological capability and digitalization practices(Damtew, Borena, & Yilma, 2021),(Dametew & Ebinger, 2017). Also, the development of digital twin DTs is still hampered by a number of factors, such as a lack of full understanding of the concept of DTs and problems with DT strategies in the automobile and related manufacturing industries. The previous study (Forum, 2013-14) shows that low income countries including Ethiopia, companies and business process are considered as low performance and lower competitiveness. Innovation and technological advancement that leverages distinctive competencies in the firm. Firms develop their capabilities to use innovative supply chains to knock innovations that sustain their competitive environments. Moreover nowadays, digital supply chain integration, and digital twin's strategies has become the most important source of economic growth and firm performance(Marmolejo & Hurtado, 2020).

However Ethiopian manufacturing industry performances are characterized by lowest level of industrialization and digital capability(Dametew & Ebinger, 2017). Mainly the core manufacturing sectors, such as textile and apparel industries ,steel, automotive and metal industries, are least developed in many aspects such as, resource optimization, logistics process, technology adoption, production volume, product quality, supply chain visibility(Dametew & Ebinger, 2017),(Dametewa*, Ebingerb, & Abebec, 2017), (Muzeyin, 2014). Due to poor digital technology the national textile and apparel industries non in electronic design automation (EDA), product lifecycle management (PLM), product data management (PDM), real time operation data and non-integrated physical asset management practices(Wube, Ketaw, & Ebinger, 2019). Outstanding to this Ethiopia textile and apparel industries are weak performance in supply chain process, economic contribution and poor competitive advantages. So far, few articles have discussed roles of digital twins on developed nation companies participate in supply chain management, and the literature on supply chain performances mostly focus on its structure and overall effects. Hence, we have null understanding of digital twin's role and practice in the supply chain process in

developing countries. To tackle the above problems this research was designed.

**Digitalization and Digital Supply Chain Twins**

According to (Damtew et al., 2021) study shows that digitalization is a tool for renewal, simplification and improvement that must be incorporated into our approach to principle, strategies and development policy. While innovation capitalists create market-ready concepts by building on and transforming raw ideas that are sold to customer companies in order to be industrialized and commercialized. An effective relationship, client companies should provide innovation capitalists with direction and guidance about their product gaps, innovation priorities, and business goals by sharing information based on a trusted and long-term relationship. According to (Sidek, 2013) argue that innovation is one of the most important competitive weapons and generally it seen as a firm's core value capability. (Rhey, 2008) also explore that innovation within supply chains pertains to how firms leverage suppliers to develop more effective ways to serve either existing or new markets, whether by harnessing existing knowledge or by creating new knowledge. Thus the application and adaptation of digital technologies including internet of things (IoT), cloud computing, big data analytics (BDA),digital twins, automation and robotics are the main technologies and solutions which have accelerated digital transformation in a business environments (Damtew et al., 2021),(Kuehn, 2018). Besides, digital supply chain twins, in different study (Marmolejo & Hurtado, 2020) defined as a digital twin could be a digital representation of a real-world entity or system. Digital twins are virtual replicas of physical assets and, although there are many applications for the technology, twins share a typical implementation pattern (Intensity, 2020). Twins are built using software package (CAD), bill of materials, simulation models, IoT sensors, timeseries data, maintenance records, and the other data a manufacturer wishes to bring together(Gerlach, Zarnitz, Nitsche, & Straube, 2021). The information is then managed, unified, and modeled to make a high-fidelity digital representation of the physical reality. In line with (Gerlach et al., 2021),(X. Zhang & Aramyan, 2009) shows that the digital supply chain twin could be a digital representation of the physical (often multi enterprise) supply chain. It's a dynamic, real-time and time-phased representation of the varied associations between the info objects that ultimately form up how the physical supply chain operates. It's the idea for local and end-to-end deciding for the provision chain that ensures that this higher cognitive process is aligned horizontally and vertically throughout the provision chain. The digital supply chain twin comes from all the relevant data across the availability chain and its operating environment. Furthermore (Framework, 2019) shows that a digital twin is that the combination of a computational model and a real-world system, designed to observe, control and optimize its functionality. The revised relevant studies, we find that most of them discuss the definition and progress of digitalization on the current business process (Gerlach et al., 2021), (Damtew et al., 2021),(Kuehn, 2018). However, few scholars (Gerlach et al., 2021),(X. Zhang & Aramyan, 2009) have conducted detailed researches on the roles of digital twins in a supply chain process., in the studies especially concentrating on the supply chain integration performances from the perspective of real-time and time-phased representation and visual representation physical assist of the supply chain process.

Although supply chain integrations share some common features with traditional firms, they differ significantly in their objectives, governance and composition and these make co-operatives' participation(Chen & Huang, 2020) in supply chain become a gap in the literature. The supply chain digital twins have been highly impact and control on supply chain optimization focuses on the improvement of the operative production and logistic control, such as scheduling and routing of orders, and technical control strategies(Kuehn, 2018). But these optimization levels on the supply chain process are not properly quantified and studied in the previous literatures. Some studies(Kuehn, 2018), concentrated a particular issue digital twins as a potential solution, digital twins are expected to promote this development by integrating them with dynamic information(Chen & Huang, 2020) and supply chain optimization process. However, the digital twin impacts on supply chain performance interims of resource utilization, real-time data processing, flexibility, supply chain decision and risk issue in a supply chain process are needs further investigation and studies. As well, the latest textile industries digital twin supply chain integration and co-operations have just entered the promotion stage in developing nation including Ethiopia; the empirical research on them is still null. Thus, this study attempts to bridge the gap by analyzing the roles of digital twin on supply chain performance to integrate textile and apparel industries in a supply chain process and proposing a general collaboration framework that involves of all. The supply chain segments including the supplier, manufacturer, distributor, retailor and the customer's related partners Integration and collaboration have been studied and investigated. The digital twin impacts on supply chain performances in resource utilization, supply chain visibility, risk, financial performance, decision making, real-time data processing, and supply chain flexibility have been studied and quantified.

**Research Objectives**

The main objective of this study is to investigate the impacts of digital twin's on supply chain performance in general textile and apparel industries in particular. Mainly the study investigate their roles of digital twins for supply chain performances in visibility and visualization, innovation in supply chain process, real-time data processing, supply chain optimization, digital skill and digital market performance in global manufacturing industries in general developing nation textile and apparel industries in particular. Risk management performance in digital twin supply chain process also studied and investigated.

## MATERIALS AND METHODS

To analyze with the key research objectives, this research use both qualitative and quantitative i.e. mixed methods and combination of primary and secondary sources. The qualitative data was supported the quantitative data analysis and results. The expected result was triangulated, while the researcher utilizes the qualitative and quantitative data types in the data analysis. Fuzzy TOPSIS Analysis: Due to the recognition and ease within the concept of the standard TOPSIS, it's often criticized for its inability to adequately handle the inherent uncertainty and imprecision related to the mapping of the choice maker's perception of crisp values.

However, initially, the Fuzzy TOPSIS method was developed by Hwang and Yoon and widely used for an estimate as far could even be a selected alternative near the foremost effective solution (Moayeri, Shahvarani, Behzadi, & Hosseinzadeh-Lotf, 2015). It provides to figure

on selected the choice should have the shortest distance from the positive ideal solution and thus the farthest distance from a negative ideal solution (Fuat Alarcin, 2014). In these methods the Fuzzy Positive Ideal Solution (FPIS), which represents a mission benefit and thus the Fuzzy Negative Ideal Solution (FNIS), lowering the mission of the business process? Mathematically Fuzzy TOPSIS concept follows the subsequent concepts (Moayeri, Shahvarani, Behzadi, & Hosseinzadeh-Lotf, 2015; Rajendra, Garg, & Ashish, 2014).

Step 1: Determination of Linguistic Terms, Membership Functions and also the weighting of evaluation criteria investigate the linguistic variables for all criteria. Each linguistic variable is assigned a bunch of membership functions; determine weights of evaluation criteria and also the ratings of alternatives are considered as linguistic terms. Suppose there are J possible alternatives called D=, which are to be evaluated against M criteria, C =. Is the factors weights are denoted by wi (i =1, 2 …m). The performance ratings of every chief Dk (k =1, 2, …, K) for every alternative Dj (j =1, 2, …, n) with relevance criteria Ci (i =1, 2, …, m) are denoted by Rk = xijk (i =1, 2, …, m; j =1, 2, …, n; k =1, 2, …, K) with membership function μRk

(x).s.

Step 2: Construct the fuzzy decision matrix. This matrix is directly related to linguistic variables and therefore the criteria alternatives. Assumed that the number of criteria is n and therefore the count of projects is m, fuzzy decision matrix is obtained with m rows and n columns as within the following matrix:

$$D = \begin{matrix} c1 & c2 & \dots & \dots & \dots & cn \end{matrix}$$

$$\begin{bmatrix} \tilde{x}_{11} & \tilde{x}_{12} & \dots & \tilde{x}_{1n} \\ \tilde{x}_{21} & \tilde{x}_{22} & \dots & \tilde{x}_{2} \\ \tilde{x}_{m1} & \tilde{x}_{m2} & & \tilde{x}_{mn} \end{bmatrix}$$ Where $\tilde{x}_{ij} = (a_{ij}, b_{ij}, c_{ij})$ and

$a_{ij} = \min\{a_{ijk}\}$, $b_{ij} = \frac{1}{}\sum_{k\ k=1} b_{ijk}$, $c_{ij} = \max\{c_{ij}^{k}\}$ Where $A_1$, $A_2$, … $A_m$ alternatives, the parameters of the process which must be ranked according to established criteria or indicators C1, C2, Cn, $x_{ij}$ is the rating of alternative, Ai with regard to criterion Cj.

Step 3: Normalize the fuzzy decision matrix. The normalization of fuzzy decision matrix is accomplished using linear scale transformation. If the normalizing positive and maximum value, the factors are highly contributing at positive way and therefore the reverse is true.

$R = [r_{ij}]$, $i = 1,2, \dots, m$; $j = 1,2, \dots, n$ ; Where $r_{ij}$ is the normalized value of xij=($a_{ij}$, $b_{ij}$, $c_{ij}$) and then,

$$r_{ij} = \{\frac{a_{ij}}{c_{j+}}, \frac{b_{ij}}{c_{j+}}, \frac{c_{ij}}{c_{j+}}\ and\ c_{j+}$$

$$= \max c_{ij}\ (benefit), and\ r_{ij}$$

$$= \{\frac{a_{j-}}{a_{ij}}, \frac{a_{j-}}{b_{ij}}, \frac{a_{j-}}{c_{ij}}\ and\ a_j -$$

$$= \min a_{ij}\ (cost)$$ *Step 4:* Calculate the weighted normalized fuzzy decision matrix

$$V = [\tilde{v}_{ij}], i = 1,2, \dots n; j$$

$$= 1,2, \dots J\ where\ \tilde{v}_{ij} = \tilde{x}_{ij} X w_i$$

*Step 5:* Determine the fuzzy positive-ideal solution (FPIS A+) and fuzzy negative-ideal solution (FNIS A-). Value of ranges belongs to the closed interval [0, 1]. FPIS and FNIS are defined as triplet (1, 1, and 1) or (0, 0, 0).

Else, the values determined by using the following formula: $A^* = (\tilde{v}_1^*, \tilde{v}_2^*, \dots \tilde{v}_n^*, and$ $A^- =$

$(\tilde{v}_1^-, \tilde{v}_2^-, \dots, \tilde{v}_n^-$

$$Where\ \tilde{v}_j^{+} = (1,1,1) and\ \tilde{v}_j^{-} = (0,0,0), j = 1,2,\dots n.$$

*Step 6:* Calculate the distance of each alternative from FPIS and FNIS.

$d_{i+} = \sum_{i=1}^{n} d_v(\tilde{v}_{ij}, \tilde{v}_{j*} and\ d\ d_{i-} = \sum_{j=1}^{n} d_v(\tilde{v}_{ij}, \tilde{v}_j^{-}, i = 1,2, \dots, m$, But the distance between two fuzzy numbers $\tilde{\alpha} = (a_1, a_2, a3)$ and, $\tilde{b} = (b_1, b2, b_3)$, can be calculated as:

$$d(\tilde{a}, \tilde{b}) = \sqrt{\frac{1}{3}[(a_1 - b_1)^2 + (a_2 - b_2)^2 + (a_3 - b_3)^2]}$$

Step 7.Calculate the closeness coefficient to the best solution. The closeness coefficient CCi is defined to work out the ranking order of all alternatives. The index CCi indicates that the choice is near the FPIS( dj + ) and much from the FNIS( dj − ). The closeness coefficient to the best solution is calculated as:

$$CC_i = \frac{d_{i+}}{d_{i+} + d_{i-}}$$

8. Ranking the Alternatives: The ranking order of all alternatives, the ranking of alternatives is dole out supported the calculated closeness coefficients. The choice with the very best coefficient represents the simplest alternative is near FPIS and farthest from the FNIS. Thus, this positive ideal solution may be a solution that maximizes the benefit criteria and minimizes cost criteria, while the negative ideal solution maximizes the price criteria and minimizes the benefit criteria.

**Table.1**. Verbal scales for evaluation of supply chain performance indicators and variables

| Verbal Scale | Strongly negative impact | Medium Negative impact | Low negative Impact | No Impact | Lower Positive Impact | Medium positive Impacts | Strongly positive Impact |
|---|---|---|---|---|---|---|---|
| Intensity of Influence | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| Corresponding Triangular Fuzzy Numbers | (3,4,5) | (2,2,3) | (1,2,3) | (1,1,1) | (4, 5,6) | (5, 5, 7) | (5, 6, 7) |

**RESULT AND DISCUSSIONS**

A Digital Twin helps the customer remotely perform their twin properties' regular activities, maximizing and reducing service costs. Main DT provides enhanced visualization of process optimization, resource utilization, real-time management and data processing, operation and service optimization, and real-time decisionmaking ability. Furthermore, DT has an impact on risk issues in a supply chain process. For our empirical investigations, supply chain visibility and visualization (SCVV), supply chain innovation (SCI), real-time data processing (RDP), supply chain optimization (SCO), digital market performance (DMP), risk issues in a supply chain process (RSC), and resource utilization and improved efficiency (RUE) were used as performance indicators in digital supply chain processes investigation.

**Empirical Result and Discussion**

**Table. 2**. Fuzzy AHP pairwise comparison matrix of the given variables to digital twins with respect to Supply chain Performances.

According the fuzzy TOPSIS principles shows that if on variables have lower closeness coefficient value have the highest impact on the performance and firms, the highest closeness

coefficient values have the lowest impact on the performance and competitiveness. Hence the analysis and discussion of our empirical investigations were done based on these contexts. The fuzzy TOPSIS ranking of the impacting levels of digital twins on various indicators were investigated. Based on our findings as shown in the table (SCI)> (SCVV) > (RDP) > (RUE) > (SCO) > (RSC) > (DMP) the digital twins have direct and positive impacts on supply chain performances from the highest to the lowest respectively. Rendering to these empirical investigations the adoption and implementation of digital twins have highly impacts on supply chain visibility and visualization (SCVV), supply chain innovation (SCI), real-time data processing (RDP), supply chain optimization (SCO), digital market performance (DMP), risk issue in a supply chain process (RSC) and resource utilization and improve efficiency (RUE).On the other hand the deficiency of a digital twin technology have negative impacts on various supply chain levels of textile and apparel manufacturer industry

| | SCVV | SCO | RUE | RSC | DMP | RDP | SCI |
|---|---|---|---|---|---|---|---|
| SCVV | (1,1,1) | (1, 1, 3) | ( 1/3 , 1 /2 ,1) | ( 1/3 , 1/3 ,1) | (1, 1, 1) | (1, 2, 3) | ( 1/3 , 1/3 ,1)) |
| SCO | ( 1/3 , 1, 1) | (1,1,1) | (1, 1, 3) | ( 1/3 , 1/3 ,1) | ( 1/3 , 1 /2 ,1) | (1, 1, 3) | ( 1/3 , 1/3 ,1) |
| RUE | (1, 2, 3) | (1, 2, 3) | 1,1,1 | (1, 2, 3) | ( 1/3 , 1, 1) | (1, 3, 5) | (1, 1, 1) |
| RSC | (5, 7, 9) | (1, 1/3, 5) | (1, 1, 3) | 1,1,1 | ( 1/3 , 1/5, 1) | (1, 2, 3) | ( 1/3 , 1, 1) |
| DMP | (1, 1, 1) | (1, 2, 3) | ( 1/3 , 1/2, 1) | (1, 1, 3) | 1,1,1 | (1, 2, 3) | (1/2, 1, 1) |
| RDP | ( 1/3 , 1/2, 1) | ( 1/3 ,1 /2 ,1/2) | ( 1/5 ,1/3 ,1) | ( 1/3 , 1, 1) | ( 1/3 , 1/2, 1) | 1,1,1 | ( 1/5 ,1/3 ,1) |
| SCI | (1, 3, 3) | (3, 4, 5) | (1, 1, 1) | (1, 3, 3) | (1, 2, 3) | (1, 3, 5) | 1,1,1 |

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Table.3. The Impacts of Internal Supply chain Integration on Performance

| TABLE I. THE IMPACTING LEVELS OF DT IN VARIOUS INDICATORS | TABLE III. LOADING VALUES OF VARIABLES | |
|---|---|---|
| TABLE II. | TABLE IV. CUMULATIVE FUZZY WEIGHTING VALUE | TABLE V. C CJ |
| TABLE VI. RESOURCE UTILIZATION AND IMPROVE EFFICIENCY (RUE) | TABLE VII. 0.710952 | TABLE VIII. 0 .520 |
| TABLE IX. SUPPLY CHAIN INNOVATION (SCI) | TABLE X. 0.888675 | TABLE XI. 0 .516 |
| TABLE XII. REAL-TIME DATA PROCESSING (RDP) | TABLE XIII. 0.743691 | TABLE XIV. 0 .519 |
| TABLE XV. DIGITAL MARKET PERFORMANCE (DMP) | TABLE XVI. 0.551937 | TABLE XVII. 0 .526 |
| TABLE XVIII. INTEGRATING NETWORK NODE CAPABILITY (INC) | TABLE XIX. 0.651937 | TABLE XX. 0 .524 |

| | | |
|---|---|---|
| TABLE XXI. SUPPLY CHAIN OPTIMIZATION (SCO) | TABLE XXII. 0.750152 | TABLE XXIII. 0 .521 |
| TABLE XXIV. RISK ISSUE IN A SUPPLY CHAIN PROCESS (RSC) | TABLE XXV. 0.650152 | TABLE XXVI. 0 .522 |
| TABLE XXVII. SUPPLY CHAIN VISIBILITY AND VISUALIZATION (SCVV) | TABLE XXVIII. 0.885783 | TABLE XXIX. 0 .517 |

**The Roles of DT on Supply Chain Visibility and Visualization**

Our empirical investigations on the impacts of digital twin technology in supply chain process performance with respect to supply chain visibility and visualization also supported by (Moshood, Nawanir, & Sorooshian, 2021). In a supply chain process its core, the supply chain visibility depends on ensuring that the organization provides access to reliable and current knowledge concerning the supply chains in terms of internal and external processes (Moshood, Nawanir, & Sorooshian, 2021). Furthermore, the empirical result in the above shown that the impacts of digital twins on supply chain performance with various indicators described as supply chain visibility and visualization (SCVV) with (0.517) closeness coefficient, supply chain innovation and digitalization (SCI) with closeness coefficient(0.516), Integrating network node capability (INC) with(0.524) closeness coefficient values positively impacted the supply chain process performances. From the given alternatives digital twins have the second highest impacting factors of supply chain visibility and visualization next to supply chain innovation and digitalization. These implies that any firms have well-organized digital twin strategies, that are highly performance and have better supply chain visibility and visualization capability than traditional supply chain process. Supply chain visibility necessitates a cross-divisional platform that helps in proactively managing end-to-end supply chains in real-time. Using The Digital Twins can help visualize and analyses of supply chain process for the physical object or process and by use of machine learning, further optimizations and predictions can be made.TD similarly provides to visualize the supply chain components including product development and production planning, logistics systems that one could build it in the same central manner for a supply network seems logical. Moreover, TD provides to control drive visibility of supply chain systems into individual shipments and enables detailed operation-level alerts, requiring more thorough integration and a robust connectivity structure. In a supply chain process visibilities have great power in order to improve internal decision making and operating performance. Digital twins have highly influenced the supply chain systems in the core visibility processes including (visibility for sensing, learning, coordinating and integrating. These enable to allow an organization to reconfigure their supply chain in accordance with both internal needs and outside demands of the customers.

**DT Used As Supply Chain Innovation Strategies**

In the current environment the advancement of innovation and digitalization including with the rise of industry 4.0, novel technologies open new opportunities for business transformation. Mainly innovation and digitalisations provide to have agile, reliable, and flexible business process in the supply chain segments. The previous study (Arenkov Igor et.al, 2019) also shows that innovation and digital technologies development have an impact on the transformation of supply chains, including the emergence of closed loop chains as the basis for a circular economy and business performances. The result in the figure below shows that digital twin have highly impacted on supply chain innovation (SCI), supply chain visibility and visualization (SCVV),real-time data processing (RDP), supply chain optimization (SCO), digital market performance (DMP), risk issue in a supply chain process (RSC) and resource utilization and improve efficiency on a supply chain process. These results the highest, digitalized supply chin process have highest and positive impact on the performance and competitiveness firms at various scenario.

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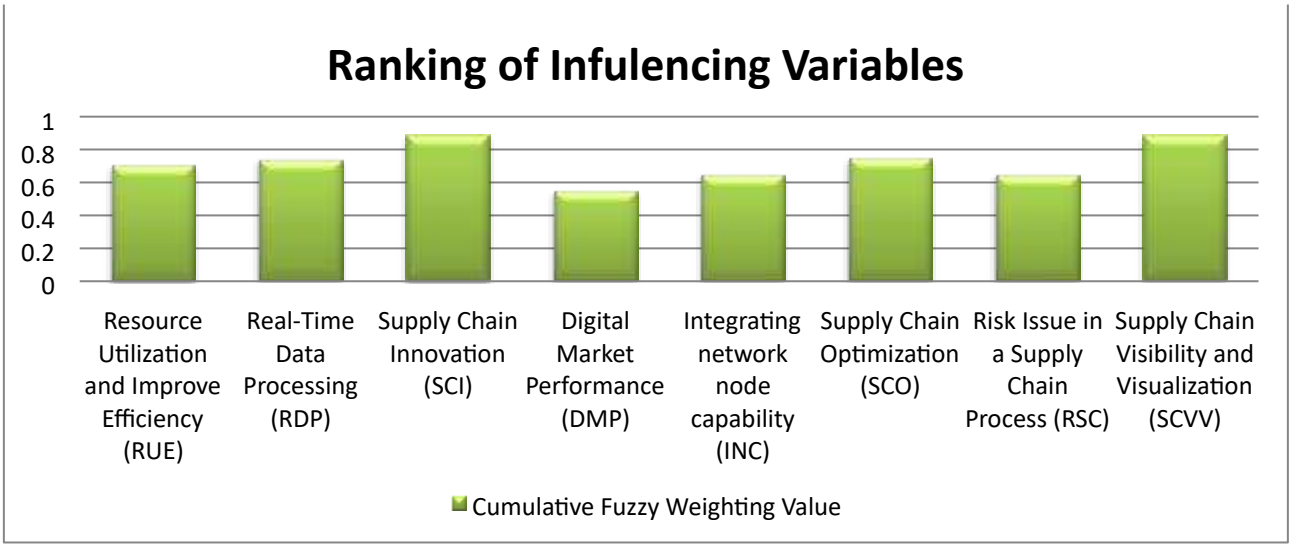


FIGURE.1. The roles of dt on supply chain performance with various indicators integrated and Regardless of the challenges innovation and digital networks, many industry leaders, supply chain providers agree that, in the forthcoming, business organizations will share data, resources and many across a supply chain and logistics sector, and work together to continuously improve the supporting technology and analytical engines to ensure efficient, reliable, resilient and sustainable supply chains.Therefore innovation and digitalization's have provides to adding agility and flexibility of the supply chain process increasing the performance and interactions capability of suppliers, customer, retailor, manufacture and logistic providers in the efficient and effective manner. These leads to improve the overall performance and competitiveness of supply chain process and entire manufacture industries as whole. Also, with the help of innovation on various supply chin system and strategies Digital twin provide to gain popularity, agility and advancements of the firm.

**DT Used As Real-Time Data Processing**

For the supply chain process DT have significant impacts on manufacturing industries process optimization, safe, stabile, sustainable and effective flow of product and services with the supply chain segments. The digital twin enabled by sensing technologies and IoT, can monitor its products and services in the supply chain environments in physical and virtual worlds. During digital virtualization this process, data can be collected in real-time. This data provides to support the analysis of complexity supply chain process in manufacturing systems. Besides in in the supply chain segments the real-time digital twins will enable us to rethink paradigms for operation of industrial assets in the context of the digitalization and cloud ecosystems. According to (Thomas H.-J. Uhlemanna.et.al, 2017)shows that acquisition of data and the development of different options in production system and factory planning require up to 2/3rds of the total needed time resources. But digital twin strategy and digitization offers the possibility of automated data acquisition to the manufacturing process. Thus digital twins provides to effective and efficient data process, acquisition of data and optimization in the supply chin and manufacturing industries. Therefor regional and national textile and apparel industries critical to consider digital twin strategies for the acquisition, data warehousing and real data process of their supply chain systems.

**DT Used As Supply Chain Optimization**

Drive agile and efficient alignment of supply of premium products as closely as possible to market demand with sufficient resilience or operational flexibility to readily adjust production. Study (F. Ferranti.et.al, 2021) shows that in the optimization, the electricity and steam generation were introduced to obtain a global energy balance of the production site. Likewise

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the digital twin technologies provide to improve and optimize the supply chain process in the current business environments. Particularly, it optimizes information shearing, resource utilization, supply chain segment virtualizations in the supply chain process. The digital twin strategy optimize on supply chain process through integration of supply chain segments (supplier, manufacturer and customer) in various level and with different area of integrations. Digital twin integration mainly optimized for the functional area integration including in financial, quality, flexibility, technological capability, warehouse, transportation, and production and manufacturing process. The digital twin impacts on supply chain optimization and other various performances investigated in figure below

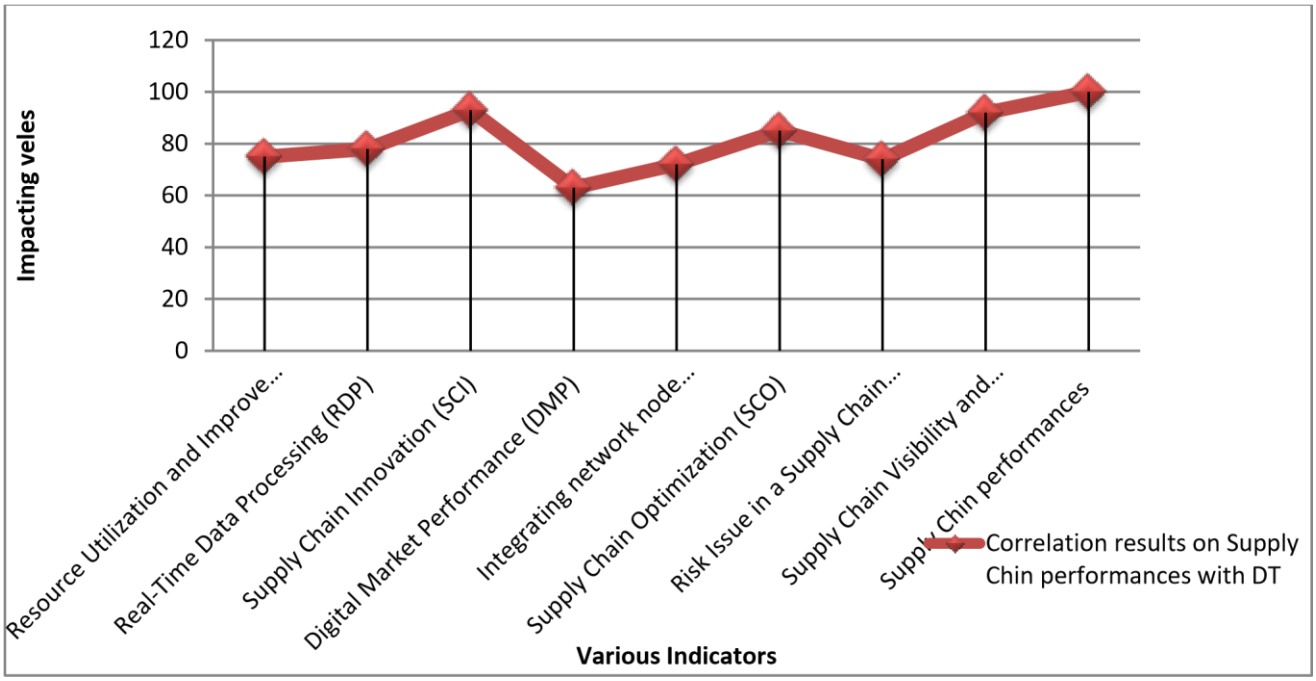


FIGURE.2. Correlation results on supply chin performances with dt strategies with various indictors

According to the empirical investigation shown in the above figure, the percentage capability of the supply chain process in , supply chain optimization , supply chain visibility and visualization , supply chain innovation , real-time data processing , digital market performance , risk issue in a supply chain process and resource utilization and improve efficiency investigated from digital twin point of views. Adoption and implementation of effective and efficient digital twin strategies have highly accelerated the performance of automotive supply chain process. According to the result due to digital twin technology firms highly integrated and optimized their business process at higher extents. On the contradictory traditional, nonintegrated and fragmental strategies negatively impact on the supply chain process of internal company, supplier and customer performances. Besides the digital transformations optimize to exploit market opportunities through supply chain planning, scheduling and supply chain accounting. Besides, sensors on a production line of supply chain process can be used to create a digital twin of the process and analyze important performance indicators. Adjustments to the digital twin can identify new ways to optimize production, reduce variances, and help with root-cause analysis.

**DT Provides to Digital Market Performance**

Adoption and Implementation of digital twins have great impact on the market performance of supply chain process. Mainly it provides to base on technologies, the global digital twin market is categorized as IoT, block chain, artificial intelligence & machine learning, big data analytics, and others. The artificial intelligence & machine learning segment is expected to hold a significant share of the market during the forecast period, due to the AI-enabled digital twin technology being capable of repeated use and improving functionality by enhancing productivity. The digital twin technology is straightforward to reuse, retrain, and adapt to the prevailing environment, which is anticipated to propel the segment within the near future. Also, the digital twin is one of leading technologies that enables companies to align themselves with competitive flow that exists in the market.

Table.4. Bivariate correlation results of integrated DT strategies impacts with various digital supply chain performance indictors

| **Correlations** | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | (DTS) | (SCV) | (INC) | (RDP) | (SCO) | (RSC) | (SCI) | (RUE) | (DMP) |
| Effective Digital Twin Strategies (DTS) | Pearson Correlation | 1 | | | | | | | | |
| supply Chain Visibility and Visualization (SCVV) | Pearson Correlation | .959** | 1 | | | | | | | |
| Integrating network node capability (INC) | Pearson Correlation | .470** | .448** | 1 | | | | | | |
| Real-Time Data Processing (RDP) | Pearson Correlation | .798** | .806** | .231 | 1 | | | | | |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Supply Chain Optimization (SCO) | Pearson Correlation | .696** | .751** | .595** | .669** | 1 | | | | |
| Risk Issue in a Supply Chain Process (RSC) | Pearson Correlation | .656** | .732** | .547** | .599** | .807** | 1 | | | |



| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Supply chain Innovation | Pearson Correlation | .877** | .925** | .445** | .905** | .862** | .819** | 1 | | |
| Resource Utilization and Improve Efficiency (RUE) | Pearson Correlation | .886** | .914** | .455** | .907** | .829** | .754** | .969** | 1 | . |
| Digital Market Performance (DMP) | Pearson Correlation | .468** | .447** | .997** | .229 | .593** | .546** | .443** | .453** | 1 |
| **. Correlation is significant at the 0.01 level (2-tailed). | | | | | | | | | | |

**DT Roles on the Issue of Risk in a Supply Chain Process.**

The above table shows the impacts and correlation results for the digital twin influencing variables on supply chain integration performances. According to the results, digital twins have a positive impact on reducing the risk in a supply chain process. In the supply chain process, the risks are associated with business processes, particularly supply and demand uncertainty. The bullwhip effect occurs when changes in demand and supply enhance the severity of inventory fluctuation as it travels up the supply chain. Typically, such risks influence operational characteristics like lead time and inventory on business performance. Due to daily or weekly stock-out/overage charges, current performance indicators may deteriorate. While digital twins have a significant impact on risk reduction, timeefficient coordination is essential to balance demand and supply in the textile and apparel supply chains. Also, improving the flow of information along the value chain, as well as enhancing customer and supplier communication, could be part of the prevention strategy for supply chain risk with digital twin technology. Before allocating resources to the actual supply chain and manufacturing process, digital twin enterprises can develop a virtual counterpart of a realworld product, test and validate it, and discover process issues. Also, digital twins can aid in the prevention of existing product faults in the supply chain process. In addition, digital twins are used in supply chains to eliminate bottlenecks and optimize processes. For example, they can provide context around complex scenarios, provide clues on where to investigate, and enable companies to assess the relationship between external factors such as market conditions or macroeconomics that will necessitate changes to processes and logistics management of automotive supply chain processes. Therefore, in the current automotive industry, dynamic simulation modelling and analytical optimization, as well as the use of digital twins, is the dominant technologies in supply chain risk management. By addressing disruption location, length, and recovery strategies using optimization and simulation methodologies, auto-suppliers and manufacturing companies can develop new knowledge regarding the impact of disruption propagation on network output performance. Also, the following figure shows on the impacts of DT for optimization of automotive supply chain process.

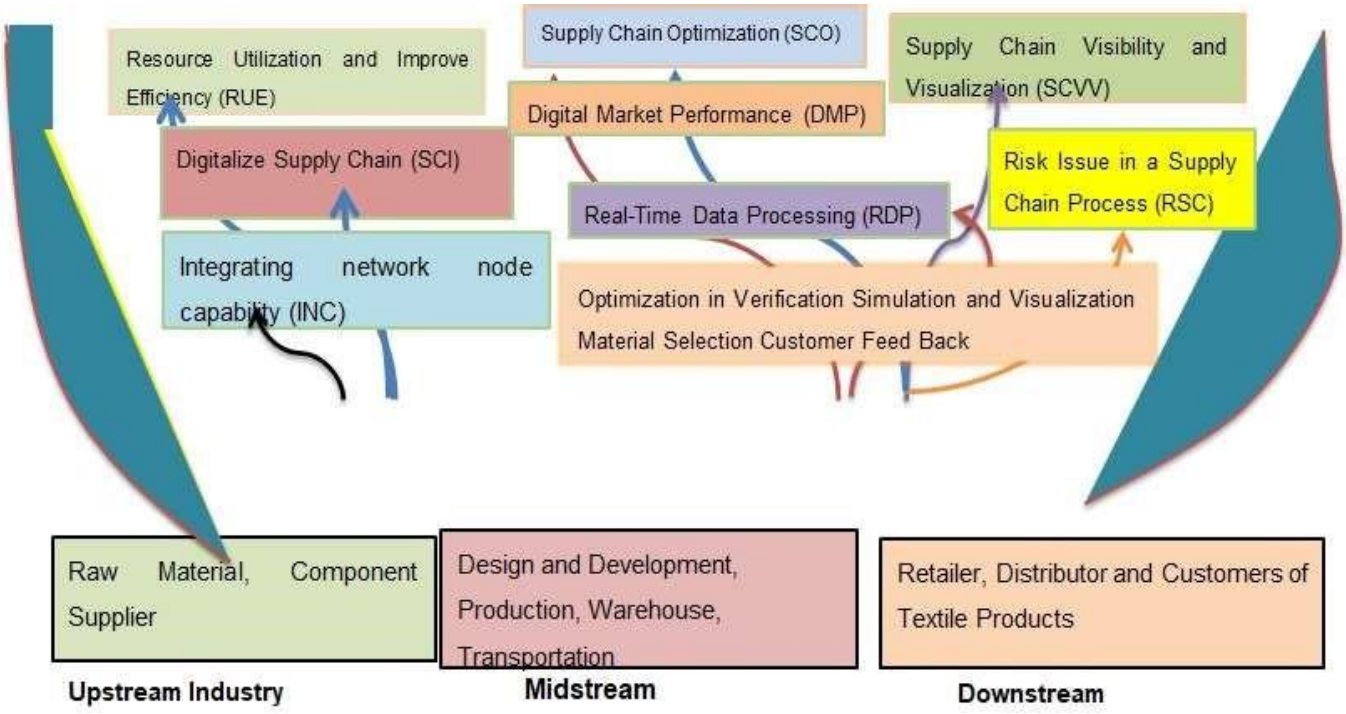


**Figure.3.** DT Enables Textile and Apparel Supply Chin Process form Raw Material Supplier to Sale

(Customer)DT As Drive


## CONCLUSION, IMPLICATIONAND RECOMMENDATION

### Conclusion

Supply chain processes are receiving considerable attention as a cutting-edge technology that can transfer raw materials from material suppliers to the manufacturing and processing industries to fulfill customer requirements. However, the textile and apparel industry face many challenges, including raw material shortages, quality, real-time delivery, material accessibility, flexibility of supply chain processes, and inefficient production systems. As the propagation of digital technologies continues to disrupt market segments and industries, adopting digital twin strategies can help organizations transform to meet changing business conditions and evolving customer needs. The bay digitalization and technological revolution are a glimpse into the future of several developments that have the potential to support long-term and improved productivity and performance in manufacturing industries. DT is a digital representation of physical entities, and integrating real-time and realworld data seems to be a promising approach for improving performance and competitiveness. The adoption and implementation of digital twins has had a great positive impact on the performance and competitiveness of manufacturing textile and apparel industry supply chains. The goal of this study was to investigate the effects of digital twins on supply chain performance in order to improve manufacturing industry performance in terms of market shares, competitiveness, and effective chains of global manufacturing industries in general and developing nation textile and apparel industry in particular. Study investigated the roles of digital twins for supply chain performance in visibility and visualization, innovation in supply chain processes, real-time data processing, supply chain optimization, digital skills, and digital market performance. As well, the impacts of DT on supply chain risk and risk management in the manufacturing process were studied and investigated. In particular, the challenges and potential roles of digital twin applications strategies in upstream supply chain integration for raw material utilization in the textile and apparel industry were also discussed. The biggest digital twin technologies, including digitalization, cloud computing, block chain technology, and internet of things (IoT) specific impacts on material utilization, production performance, quality, overall supply chain capabilities, and firm competitiveness, were investigated. Adoption and implementation of DT improve supply chain visibility and visualization (SCVV), supply chain innovation (SCI), realtime data processing (RDP), supply chain optimization (SCO), digital market performance (DMP), supply chain risk issues (RSC), and resource utilization and improved efficiency (RUE). Our empirical investigations show that the adoption and implementation of DT in the textile and apparel industry supply chain has the highest

positive impacts on various indicators, including (SCI) > (SCVV) > (RDP) > (RUE) > (SCO) > (RSC) > (DMP), from the highest to the lowest, respectively.

Our investigations conclude that, in the current environment, the advancement of innovation and digitalization, including with the rise of industry 4.0, novel technologies offer new opportunities for business transformation. Mainly, innovation and digitalisation provide the ability to have an agile, reliable, and flexible business process in the supply chain segments. Also, irrespective of the challenges of innovation and digital networks, many industry leaders and supply chain providers agree that, in the future, business organizations will share data, resources, and expertise across the supply chain and logistics sector and work together to continuously improve the supporting technology and analytical engines to ensure efficient, reliable, resilient, and sustainable supply chains. Hence, innovation and digitalization have provided an opportunity to add agility and flexibility to the supply chain process, increasing the performance and interaction capabilities of suppliers, customers, retailers, manufacturers, and logistic providers in an efficient and effective manner. This leads to improving the overall performance and competitiveness of the supply chain process and the entire manufacturing industry. For this study, both the primary data from 75 respondents and secondary data through a systematic literature review of 27 articles were analysed and studied using descriptive analysis and Fuzzy TOPSIS Analysis tools. Our investigation is not comprehensive. More research and investigation are needed into the relationship between digital twins and the resilience of digital enablers in the supply chain process, which is also considered. 4.2. Managerial Implications This research has definite theoretical and practical significance. First, our research contributes to the supply chain integration literature from the perspective of the digital twin integrations of manufacturing industries in terms of resource integration, supply chain optimization, agility, innovation in supply chain, and financial cooperation, finding them capable of completing internal and external integration. Second, this work is the first study to explicitly explore the general co-operative framework for digital twin roles and integration practices in the textile and apparel industry supply chain process and to improve the firm performance in market shares, competitiveness, and effective chains of global manufacturing industries in general and developing nation industries in particular. 4.3. Recommendations

These investigations into digital supply chain twin impacts on supply chain performance in terms of supply chain visibility, real-time decision making, process optimization, value chain optimization, resource utilization, and visibility in a supply chain process were studied and investigated. Further research and investigation are required into the relationship between digital twins and the resilience of digital enablers in the supply chain process. We recommend studying the relationship between specific challenges and the resilience of digital enablers in supply chain processes with digital supply chain twins for manufacturing industry performance in sustainable business environments.

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