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Opportunities and Challenges in the Operations Management for Industry 4.0

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Abstract

This study investigates the opportunities and challenges in the operations of composite manufacturing industry for the adoption of Industry 4.0. As known from the literature that industry-4.0 is referred as the fourth industrial revolution which majorly focuses on cyber-physical systems. It is suggested that the instantaneous integration of digital and physical systems, in conjunction with new transformative technologies that facilitate work, will revolutionise the ways of work and, as a result, there is process of work management. This customary trade-offs in operations between the aspiring objectives of quality, speed, flexibility, and cost have potential to be disrupted or, at the very least, altered by this technology, which has the capacity to disrupt them. The purpose of this article is to present an overview of the key transformative technologies of Industry-4.0 to find the opportunities and challenges in the operations of composite manufacturing industry for the adoption of Industry 4.0. Mainly composite manufacturing industries have been considered to execute this study. In this study, the opportunities and challenges have been explored while implementing Indutry-4.0 technologies via advanced robotics (AR), artificial intelligence (AI), blockchain technology (BCT), internet of things (IoT), additive manufacturing (AM) in operations of composite manufacturing industry.

Keywords: Composite, manufacturing, industry 4.0, additive manufacturing, information technology, blockchain, robots, artificial-intelligence

INTRODUCTION

Computerizing, Automation and electrifying the system have the great impact on manufacturing of commodities and services. Industry-4.0 is the integration of physical and digital system like additive manufacturing (AM), the internet of things (IoT), blockchain technologies (BCT), advanced robotics (AR), artificial intelligence (AI), and other associated technologies. These transformative technologies have a big impact on supply and operations. The technologies associated with Industry-4.0 have a potential effect on both individually and collectively, to decrease the costs, increase flexibility, boost speed, and enhance the quality. Furthermore, Industry-4.0 presents the opportunity to alleviate the inherent conflicts between these crucial operational priorities. Engaging with Industry-4.0 is crucial for the academic community in operations management (OM). This study aims to investigate the extent opportunities and challenges in the operations of composite manufacturing industry for the adoption of Industry 4.0. Furthermore, it seeks to identify the new and significant operational issues that will arise because of the progress and implementation of these technologies [1-4]. This paper examines how the

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different fundamental technologies of Industry-4.0 impact the operations management processes in composite manufacturing industry. The main objectives of this study are (i) to enhance the comprehensive knowledge of Industry 4.0 within the operations management community (ii) to explore research areas in operations management by highlighting potential opportunities and challenges. With these objectives, we will concentrate our attention on the operational consequences of these fundamental technologies in the context of operations management. The focus in this study is to explore these technologies in the manufacturing industries rather than the service industry. For this study we have considered only agricultural and manufacturing industry. Industry-4.0 is not only a term encompassing a wide range of different transformative technologies but also, the potential of Industry 4.0 lies in the possible interactions and synergies among different components of these technologies. For instance, the progress made in artificial intelligence (AI) and sensor-based technologies has facilitated the creation of concerted robots which will function in conjunction with humans. Keeping in view these synergies, the present study presents a comprehensive summary with the research consequences in the operations management, this study is compiled as Section 2 describes about the additive manufacturing (AM), Section 3 represents the consequences of IO Timple mentation in the desired area. Section 4 depicts the consequences of the implementation of blockchain technologies. Advanced robotics (AR) and artificial intelligence (AI) is described in Section 5 and Section 6. However, section 7 covers the other important technologies including in Industry-4.0. Finally, Section 8, provides conclusion regarding the influence of Industry 4.0 on operations strategy [5-20].

INTERNET OF THINGS (IOT)

According to Holdowsky et al. (2015) [21], a sensor is a device which converts one type of energy signals in to the electrical signal. As per their study that the average cost of a sensor decreased by more than ninety percent during the period of 1992 to 2014 (from $22.00 to $1.40), at the same time speeds of microprocessor climbed by a factor of 991 (from 29 million to 28,751 million Hz) same period. Completeness refers to the ability to construct system-wide state information by integrating sensor data of specific local characteristics. Significantly, the incorporation of synchronized communication in the Internet of Things (IoT) would improve the promptness linked to the quality and comprehensiveness of information. Undoubtedly, the strategic importance of the Internet of Things (IoT) arises from its always improving capacity to overcome the limitation of darkness and generate information without human detection, in various previously imperceptible situations. Although RFID technology contributes to the Internet of Things, sensors allow for the collection of far more comprehensive data. Moreover, the real-time connectivity linked to the Internet of Things (IoT) enables the translation of this abundant local information into comprehensive system-level information [22-31]. Accurate determination of inventory buffer sizes, while a prominent area of emphasis in the field of operations management research, is not the exclusive responsibility of an operations manager. Although the on-time implementation, ongoing enhancement, and front-end building of the effective operating system are likewise decisive, and the comprehensiveness, excellence, and promptness of information envisaged by the Internet of Things have the capacity to significantly influence these elements. For instance, General Motors use sensors to track humidity levels to enhance the painting process. If the conditions are not ideal, the work item is sent to a different section of the facility (McKinsey 2015) [32].

ADVANCED ROBOTICS (AR)

Artificial intelligence in manufacturing systems is already highly developed, and manufacturing automation is not a new concept. More than 15 years ago, robots at a 40,000-square-meter facility near Mount Fuji, operated by Fanuc, were manufacturing approximately 50 robots per 24-hour shift without any supervision for a period of 10 years. Nevertheless, the technology is progressing swiftly and has the potential to greatly influence industry, agricultural production, service management, and distribution. Conventional robots in the workplace are fitted in protective metal enclosures that ensure physical segregation from workers during regular operations. This is not due to the inherent hazards associated with the activities carried out by robots, such as welding. The reason behind this is that we have not yet equipped robots with adequate cognitive abilities to adapt and make necessary changes in unexpected and fast evolving surroundings. The robot must maintain strict control and isolation over the workspace due to the inherent unpredictability of human workers' movements. New generations of robots can now work alongside humans thanks to developments in artificial intelligence and robotics. Such collaborative robots, commonly known as "cobots," are now being implemented in actual manufacturing settings. For instance, BMW already employs robots in conjunction with humans on their manufacturing line in Spartanburg, South Carolina, therefore increasing the risk of incurring more severe accidents. Notably, contemporary robots can perform this task with greater speed (Knight 2014) [28]. However, they pose challenges in terms of programming and installation, and their integration into human production lines is hindered by the associated hazards. Furthermore, exoskeletons are being used to further obfuscate the difference between robotic and human labourers. Without a doubt, computer science and engineering researchers are currently studying the continued development and evolution of cooperative or interactive robots. Examining the adoption, acceptability, and use of robots in manufacturing (and service) environments appears to be the focus of research in the field of Operations Management (OM), particularly for those interested in behaviour management. The prospect of humans and robots collaborating (which is now to some extent a reality) prompts enquiries on the construction and administration of mechanical systems. To address these issues, it is necessary to understand how employees perceive and engage with robots in repetitive work environments. While somewhat less captivating from a fresh perspective in operations management research, the progress in robotics is also altering the economic advantages of investing in factory automation. Procuring and implementing robots is a highly laborious process. Contemporary home office robots necessitate a team of professionals endowed with the expertise to install (including robots equipped with security systems), calibrate, and ensure their optimal functionality [33-40].

Historically, the automation of machining operations has focused on optimising variable costs (in situations when labour is costly), enhancing quality (when robots can outperform people in job repetition), or guaranteeing safety (in cases when the machining centre poses hazards or the activity requires hard physical effort). Robots are ideal for high-volume, repetitive tasks because of their high setup costs and times. However, because robots are prone to repairing or reworking defects and are difficult to complete, they are not appropriate for demanding or low-volume tasks. Recent iterations of robots, created by firms like ABB, iRobot, Motomon, and others, have gotten more affordable and, notably, more customisable to carry out various duties, hence decreasing their frequent redundancy. As inexpensive, customisable, and collaborative robots grow more prevalent, the factories of the future will undergo significant technological transformations. Agricultural robotics is also progressing swiftly. Based on Jordan's (2018) [25] findings, almost 60% of the lettuce and 50% of the kale and celery using automated technologies. Not only do advanced robotics harvest delicate fruits like berries, but they are also used to pack, pull weeds, and determine when the fruit is ripe. Marketing collaborations including such technology can have resemblance to cooperation within the manufacturing sector. The repercussions of robotics technological progress extend beyond agricultural and industrial sectors. Significant progress has been achieved in machine automation and the utilisation of unmanned aerial vehicles (UAVs). For decades, automated guided vehicles have been employed in industrial settings. Yet, sensors and associated technology have already advanced to the stage where such vehicles may independently and autonomously follow a predetermined course. For example, a lot of George Mason University students will have another option when it comes to eating: having their food delivered on demand by automated, mobile robots (Holley 2019) [22]. It is projected that autonomous cars will have a significant impact on supply chains and transportation systems (e.g. Parker and Olsen 2019) [37]. Drones, or unmanned aerial vehicles, are a rapidly becoming commonplace robotic tool. Robotic systems have the capability to monitor distant areas, transport small objects like medicine, monitor assets, and apply chemical sprays to crops. Significantly large drones designed for transporting passengers are also imminent (Associated Press 2016). Drones are employed for the purposes of inventory reconciliation and pipeline inspection, among other applications. They have the potential to facilitate the advancement of novel automobiles (Agatz et al. 2018) [2]. Similar opportunities to those for autonomous ground vehicles appear to exist in the field of operational management research. To summarise, several technologies have made advancements in terms of cost, adaptability, speed, and/or quality; robotic collaboration plays a crucial role in this regard. Furthermore, the supply chain's functioning can be significantly impacted by the choice of automated transportation.

ARTIFICIAL INTELLIGENCE (AI)

The term AI is not well defined, much like Industry 4.0. Traditionally, AI was characterised as the application of computers to imitate human intelligence. Indeed, it is commonly employed to propose that computers, as opposed to humans, are the ones that solve issues, a perspective that aligns seamlessly with Oblivious Machine theory. Expanding upon the analytics framework, we can categorise corporate intelligence systems as descriptive, predictive, or programmed. Personnel responsible for inspecting, selecting, or defining items must accurately identify and categorise various products. Such can result in cognitive exhaustion, and mistakes can result in flaws or erroneous choice or positioning of objects. Artificial intelligence capable of identifying images or objects might enhance the classification abilities of workers or empower robots to efficiently carry out such jobs. As detailed in Section 3, operations enabled by sensors will produce substantial volumes of data that can be analysed using artificial intelligence to reveal past connections between operations and results. This information can then be utilised to enhance design and management procedures. Facial technology has been created in agriculture to facilitate the comprehension of individual cow behaviour by large-stock farmers and small-stock farmers, thereby enhancing milk production (Owen 2018) [38]. These applications are elucidated by the fact that artificial intelligence (AI) analyses the present condition (of products or social processes) and does not inherently forecast future results or performance. Conclusions can be drawn by forecasting future results and grounding these forecasts on present activities. The significance of predictive AI has grown for firms engaged in fixed assets, such as General Electric and Siemens, since their monitoring processes depend on the accurate prediction of future outages. This necessitates sensors to consistently provide data to the computer, supported by advanced algorithms to calculate the remaining lifespan by considering both present and previous measurements [41-43]. Artificial intelligence (AI), in which software produces behaviours (or at least instructions), is not a recent development. The existence of manufacturing and decision-making systems (DSS) dates back several decades. Now the changes in this are the increasing application of machine learning in the development of these therapeutics. Technological progress in this technique is also facilitating the growing application of descriptive and predictive intelligence. Generally, operational management models would undertake methodical measures to define targets. When addressing decision-making difficulties, computers employ data learning and statistical approaches to acquire the ability to make sound decisions independently, without depending on an underlying model. Furthermore, there exist hybrid variations of this methodology, in which the algorithm receives some direction but not the complete model (for instance, refer to Gijsbrechts et al. 2018 for a dual-source implementation) [18]. Roose (2019) asserts that a significant number of top-level executives remain hesitant, even in public, to confront the adverse effects that artificial intelligence (AI) and technology can have on human employees [40]. Within a unique setting, these managers present a distinctive narrative: they engage in competition to maintain their own employees' competitive edge, but they exert less influence on their employees. Future full automation is what the founder of the Chinese e-commerce company JD.com aspired to for his company. As previously stated, human labour has traditionally been more efficient but still slower than robots. However, the emergence of sophisticated robotics and artificial intelligence is poised to alter this equilibrium. Artificial intelligence offers abundant possibilities for creating techniques for both broad and specialised applications across organisational management study. The intricate nature and magnitude of the challenge, together with the rapidity of its resolution, will be the distinguishing features of forthcoming efforts. From a behavioural standpoint, AI pertains to the dynamic process of human-technology interaction, akin to that of a robot. The growing dependence of employees on recommendations provided by artificial intelligence raises intriguing concerns regarding the management of the human-machine interaction. An expanding body of research in behavioural science (Dietvorst et al. 2015, 2016) [12,13] and organisational management (OM) investigates algorithmic avoidance and the interplay between human agents and decision support systems (DSS). The study of

Sun et al. (2019) [48] and Saez de Tehada (2018) [8] shown that observance to Decision Support Systems (DSS) may be somewhat lower, but can be enhanced by modifying their presentation or algorithmic procedures. In general, we anticipate that AI will exert a substantial influence on a range of operations and delivery functions.

ADDITIVE-MANUFACTURING (AM)

Additive manufacturing (AM), is a robotic technique that generates physical objects by sequentially adding tiny layers of material from a computer 3D model. This is also called as 3D printing. In this technique the original 3D digital model is transformed into a digital. stl file format and thereafter divided into a series of flat horizontal-layer models. The digitally sliced layers serve as the guiding instructions for the additive manufacturing "machine" to create the product layer by layer in a systematic way. Additive manufacturing (AM) has been widely acknowledged as a pioneering technology that has momentous implications for operations management. The researcher examines the mainstay operating objectives of quality, adaptability, efficiency, and cost. Additive manufacturing (AM) allows the creation of intricate forms and interior structures that cannot be achieved with conventional manufacturing techniques. Additive manufacturing (AM) also addresses the manufacturing limitations that the design engineers come across when developing objects whose performance quality is influenced by shape. GE successfully developed the new design utilising additive manufacturing (AM) technology. Subject to spatial limitations, certain additive manufacturing machines have the capability to concurrently manufacture many things. Inherently flexible, additive manufacturing (AM) technologies have the potential to eradicate industrial diseconomies of variation at their theoretical limit. Due to the time-consuming nature of prototype production using conventional manufacturing techniques, commercial production may necessitate the creation of specialised tooling and equipment tailored to the product. Due to its flexibility, additive manufacturing (AM) enables quick prototyping and eliminates the need for waiting for product-specific resources in commercial production. Consequently, the speed to market is significantly improved. Due to comparable factors, the initial production costs are also decreased as there is no need for investments in product-specific industrial processes. Holding all other factors constant, a lower initial cost decreases the sales volume needed to reach the breakeven point, therefore enabling the profitable manufacture of low volume products. Optimising product design to minimise the number of component parts can effectively decrease assembly-related variable costs. Within a separate additive manufacturing (AM) application, engineers at GE created a novel turboprop engine that was constructed using a mere twelve components, in contrast to the previous iteration which consisted of 855 components. Instead of mass manufacturing of a restricted range of items, the regionally dispersed low volume manufacture of highly tailored products is becoming more appealing. The need for service parts is characterised by significant unpredictability in terms of scheduling, venue, and necessary parts, resulting in costly inventory storage. The strategic placement of additive manufacturing (AM) machines near assets will facilitate the timely printing of the necessary service part that will lead to enhanced uptime and condensed inventory. The realisation of this ambition is now being achieved, as Siemens asserts its status as the pioneer in the commercial printing of replacement parts on request for big gas turbines (Müller 2016) [35]. However promising AM is, its current usefulness is limited by numerous notable drawbacks. Quality of a product is not only determined by its complex geometry. Key factors include strength, dimensions, composition, product consistency, and several other attributes. However, AM continues to encounter difficulties in these aspects. Variations in materials necessitate distinct additive manufacturing (AM) methodologies, therefore constraining the adaptability of AM machines and their capacity to manufacture objects using several materials. This study shows that the production cycle time of additive manufacturing (AM) process is very slow as compared to conventional manufacturing processes. However, the post process finishing can function as the blockage in this regard. Moreover, while the initial production cost is minimal, the variable cost per part of additive manufacturing (AM) is frequently elevated due to the expenses associated with input materials. Nevertheless, it is important to acknowledge that additive manufacturing (AM) exhibits appeal in terms of sustainability due to its capacity to significantly reduce the amount of material lost during production. The speed and cost constraints are significant factors in large-scale manufacturing, thereby making additive manufacturing (AM) more appealing than traditional methods only for small production numbers. As an example, HP introduced a new additive manufacturing (AM) technology designed for large-scale manufacturing and formed a collaboration with automotive component maker GKN in 2018. The purpose of this collaboration was to use HP Metal Jet in their facilities to manufacture operational metal components for major automobile industries, such as Volkswagen (HP 2018). Nevertheless, Volkswagen asserts that the optimal application of 3D printing technology lies not in mass production of automobiles, but rather in the development of specialised components (SC Digest 2018). Indeed, the HP printers are presently designed exclusively for manufacturing cosmetic items, such as customisable automobile key rings and name plates (SC Digest 2018). Given that maintenance and repair operations (MRO) are considered a logical early implementation of additive manufacturing (AM). it has also been a subject of contemporary operations management (OM) study [44-50]. In their study, Song and Zhang (2018) propose a hybrid multipart MRO system that allows for the stocking or 3D printing of spare parts on demand [47]. Their findings indicate that now a days 3D printing technology is in vague. Setting aside the concept of AM, the MRO industry has experienced substantial transformation in the last two decades. The manufacturing industries of original equipments, such as Siemens and GE, have shown a strong desire to assume a growing responsibility in the lucrative after-sale service sector. The potential consequences of additive manufacturing (AM) on maintenance, repair, and overhaul (MRO) contracting and supply chain architecture are significant and hence, warrant further investigation. The flexibility advantages of additive manufacturing regarding preliminary product line design have been the major focus of recent study, beyond the MRO context. In their study, Dong et al. (2016) investigates the influence of flexibility economics on assortment planning, specifically on the selection of product variants to offer [16]. Their findings indicate that, when compared to conventional flexible production technologies that incur variable capacity costs due to product variety growth, the implementation of additive manufacturing (AM), which has variable capacity costs that remain constant regardless of variety, results in the firm offering a greater variety of products. Sethuraman et al. (2018) [43] investigate the capacity of additive manufacturing (AM) to offer personal fabrication capabilities inside the framework of a monopolistic company for marketing or making the product design available to consumers, and they may thereafter use by using additive manufacturing technique to produce the product according to their desired quality. D'Aveni, a renowned strategic scholar with considerable research and writing on additive manufacturing (AM), asserts that we are approaching a future without assembly, where supply chains are eliminated as all components are produced simultaneously in a single mechanism of building a product. There is no second opinion that the future of this technology is not devoid of any obstacles. Primarily, firms will encounter challenges in adapting to the novel mechanized paradigm, in which the procurement of machinery and secondary-assembly becomes obsolete, and the research and development department will have absolute authority. (Blanding 2018) Regardless of the imminent realisation of such a future, this vision offers both prospects and obstacles for the academic community to the field of Operations Management.

BLOCKCHAIN TECHNOLOGY

Given the vast amount of data presently accessible via the Internet of Things (IoT), It calls for need to hoardthis it in a manner that is both easily accessible and secure. A potential resolution to this storage issue is the implementation of blockchain technology. Babich and Hilary (2019) [5] said that blockchain technology has indeed robust operational applications and there is a considerable hype in block-chain technology. Block chain is a decentralized, extremely safe method of storing records. The data on the system is stored on a decentralized network, making it distributed in the sense that it can be viewed and written to from any endpoint. The security of the system is ensured after a block has been appended to the chain, as it becomes immutable and cannot be modified independently. As a ledger, it serves as a repository for information. Digitised currencies, like bitcoin, that leverage blockchain technology are well-known to many individuals. Nevertheless, it is the other applications of blockchain that are expected to be more beneficial for operations managers. When a product moves through the supply chain, a blockchain makes it possible to store detailed information about its exact history. While it is possible to achieve this using a centralised database, such as those offered by corporate software solutions like SAP and Oracle, the distributed nature of this approach offers more flexibility. Employing a blockchain eliminates the necessity of granting third-party entry to business susceptible systems. Moreover, each participant could contribute information to the chain without requiring a direct affiliation with a centralised "owner." Once information is a part of the chain, it becomes secure, but there is no guarantee that it will be posted exclusively. Like any information system, the blockchain infrastructure is vulnerable to the "garbage-in-garbage-out" problem. Blockchain technology makes it possible to have fully digitalized data. Stated differently, data from IoT sensors can be automatically uploaded. The accuracy of the sensors directly determines the accuracy of the information stored on the blockchain. To help put this into reality, one way to look at this is the potential for the New Zealand to China kiwifruit supply chain. During the picking process, assume that each fruit is automatically tagged with a micro-RFID. Each instance in which the tag interfaces with a reader, data regarding its location and timestamp is recorded in the blockchain. Furthermore, suppose that, before being packaged, a temperature monitor is affixed to the tray in which the kiwifruit is placed. The full documentation of the temperatures that each fruit in the tray has experienced is then recorded and posted to the appropriate chains of each fruit whenever a reader comes across it. A Chinese buyer would be able to access a website that translates the blockchain data into useful information by scanning the tag. Which place did they grow the kiwifruit? What is its age? To which temperature extremes has it been subjected? How probable is it go to its ideal edible temperature? Indeed, all the necessary technology to actualise this scenario now exists. The correct positioning of the micro-RFID during hand picking and the Chinese consumer's accurate interpretation of the chip would be the main obstacles. Fruits are currently labelled individually during packaging, and RFID tags are attached to kiwifruit pallets. Consequently, the transition to personalised RFID tags is not a significant leap. Additionally, Chinese consumers are used to using rapid response (QR) codes to access additional information about a product, even though scanning tags may require an upgrade in phone technology. Timely implementation of trace-level QR codes connected to a blockchain is feasible. Described above is an unparalleled degree of knowledge. It would enable much effective management of product recalls. Moreover, it would enhance product safety, especially in the food and pharmaceutical sectors, and reduce instances of fraud. Development of efficient techniques for entering the information has the potential to greatly enhance the accountability of the supply chain. Specifically, it should enable the assessment of whether ethical norms have been followed during the manufacturing and distribution of the product. An additional significant use of blockchain technology, apart from its role in storing information, is the provision of "smart contracts." These contracts are activated automatically in response to externally validated events. As an illustration, payment may be approved immediately upon the container's arrival at customs. Of more relevance is the integration of smart contracts with comprehensive supply chain data. For instance, the remuneration allocated to the kiwifruit transporter may be contingent upon the highest and lowest temperatures encountered by the fruit throughout its transportation. While efficient contracting is a well-established field in operations management, smart contracts appear to provide a myriad of coordination mechanisms that were not before explored.

One more significant advantage of blockchain technology is the eradication of intermediaries. A significant portion of the present function of distributors and goods forwarders is centred around information delivery. Blockchain technology has the potential to virtually eradicate many of those positions. Moreover, should nations adopt the technology, it is possible that customs procedures may be greatly streamlined. Nevertheless, the achievement of these efficiency improvements depends on a certain degree of standardisation throughout the sector. The emergence of several rival blockchains, which is highly probable, and their subsequent proprietaryization, which is a plausible outcome, may result in the loss of numerous efficiencies. Our analysis reveals multiple research prospects arising from the probable influence of blockchain technology on the operations and protocols related to the supply chain. If this technology drastically alters the structure or power dynamics inside supply chains, it becomes necessary to thoroughly examine these novel configurations. Furthermore, as previously said, smart contracts appear to offer a substantial potential for more efficient and advanced coordinating contracts.

EMERGING TECHNOLOGIES

Many other emerging technologies are having a significant impact on Industry 4.0, even though our focus is primarily on foundational technologies like blockchain technology (BCT), advanced robotics (AR), artificial intelligence (AI), additive manufacturing (AM), and the Internet of things (IoT). The integration of digitally generated visual or other sensory data into the real world is known as augmented reality, or AR. This technology has broad applications, extending beyond entertainment to include economic sectors. General Electric (GE) is utilising augmented reality (AR) to enhance production and efficiency by transmitting work instructions to facilities and employing sensors to oversee assembly and ensure workers are well-informed. Upon encountering an issue, the system promptly alerts the operator or guides them to the subsequent action (Kelner, 2018) [27]. Furthermore, while Google Glass is not now accessible for consumer usage, wearable augmented reality glasses are already being used in production. A worker can remotely scan Google Glass to gain insight into its functionality. The user will be presented with a map, image, or video of their preference. Additional applications for electronic devices encompass gadgets specifically engineered to mitigate physical and mobility injuries, as well as devices specifically developed to monitor and record worker exposure to explosives. The progress of technology and artificial intelligence has led to the emergence of novel advancements in material science. These include thin, robust, transparent, and very efficient graphene materials, as well as a smart material capable of regulating its qualities in reaction to external feedback. Furthermore, apart from the progress made in wearable technology, it has the potential to facilitate the development of intelligent goods tailored for use in production and industrial processes (Lake et al., 2018). Furthermore, Agriculture 4.0 encompasses specialised agricultural machinery and the production of high-quality food. For instance, vertical farming and genetics these are the significant technologies in this domain. Furthermore, there is a growing favourability for experimental and bio printed animal and plant proteins. Venture capital funding totalling $25 billion was directed towards the agricultural technology sector in 2015, which includes seed, crop, protein, and food technology. By 2020, the China Agricultural Development Bank intends to have invested at least 3 trillion yuan, or $435 billion, in modernizing China's agricultural sector.

CONCLUSION

The relationship established between the business and the equipment entails competitive benefits like price, flexibility, speed, and quality. Although all these factors are significant, the company must prioritise its top four focus and decide among them. All business strategies, such as those focused on customers and their values, facilitate the business in making this decision. The prioritisation order directs the development and construction of the physical operational architecture, including factors such as the level of vertical integration, design capacity, transportation and MRO system assets, and the distribution zones for different types of products. An operational and supply chain architecture is a framework in which intangible processes and procedures govern the movement of products and commodities. As previously illustrated, the technologies that underpin Industry 4.0 have the potential to enhance one or more of the four fundamental domains, either independently or in conjunction. Significantly, Business 4.0 has the potential to alleviate some of the pressure on crucial and lucrative clients. Industry 4.0 fundamentally establishes a novel framework for strategic business architecture and associated operations. Advancements in technology, such as the Internet of Things, will have a direct influence on the management of operations and supply chains, and will also indirectly affect the selection of real estate. Others may have a direct influence on architecture, but their effect on the process is merely indirect. The advent of Industry 4.0 is expected to significantly influence the field of architecture and the methodology of ideation. Cost-effective additive manufacturing and easily configurable robots decrease the minimum scale needed for commercial production and enhance the efficiency and speed of initiating production. Integrated robotics, artificial intelligence, gadgets, and augmented reality can augment (or obviate) the function of human resources. The integration of the Internet of Things, blockchain technology, and digitisation could facilitate the instantaneous remote monitoring, control, and optimisation of assets in both industrial and field settings. A global, decentralised, agile network of manufacturing assets capable of rapidly and flexibly adapting and modifying operations is feasible. Many people think that operations and supply chain management will be greatly impacted by Industry 4.0's integration of the physical and digital system. To understand the implications and limitations of Industry 4.0 and to help develop the technologies and strategies that will enable its potential and implementation, the operations management community should embrace this vision. We anticipate that this publication will prove valuable to organisational management researchers who are investigating the potential and obstacles within this domain.

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