Abstract

Achieving competitive advantage in business operations remains a focal concentration of companies the world around. Present business scenarios and disruptions have changed the business orientation from traditional to technology-oriented operations. Implementing new technologies in business operations started a new horizon known as the Industry 4.0 revolution. Hence, there exists a basic requirement for academicians, practitioners, and companies to understand, assist, and promote the implementation of Industry 4.0 technologies and guide them to implement these technologies to improve their business strengths according to their objectives and goals. This chapter addresses the Industry 4.0 technologies and their basic concepts. The incorporation of these technologies has provided certain benefits to businesses across the globe; therefore, certain drivers that compel and encourage companies to implement these technologies are also discussed in this chapter. Industry 4.0 is in its transition phase, especially in developing and emerging economies; hence, the barriers that inhibit the implementation of these technologies are also part of this chapter. Sustainable performance has been widely discussed in literature and companies are also compelled by different national and international organizations to address sustainable performance by improving their operations. Recently, technological incorporation has widely helped organizations to achieve this goal; therefore, how organizations have achieved these goals and how other companies can achieve these goals through the incorporation and combination of these technologies are discussed. Lastly, the potential of these technologies to achieve performance and future recommendations are also included.

Keywords: Industry 4.0; technological advancement; competitive advantage; sustainable performance

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Industry 4.0 on the Way to Companies' Performance

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6.1 Introduction

Traditionally, companies gain their competitive advantage through cost leadership, differentiation, and focus strategies (Michael, 1985). In the recent era, the principal driver of competition is technological change. Technological change not only alters the industrial structure but also creates and encourages new industries. Therefore, to handle the technological change and chase it as a competitive and value-added strategy, companies need deep knowledge, skills, capabilities, and understanding of new and emerging technologies. Despite the importance and need for these technologies, there exists misconception and misunderstanding regarding these new and emerging technological innovations and inventions. Further, the nexus between these technologies and the competitive and improved performance of companies is still ambiguous and underestimated. More importantly, the technological revolution and its acceptance, adoption, and treating it as a competitive weapon is highly recognized in higher technologically oriented countries, whereas there are several hidden and potential threats, barriers, and steps among the developing and emerging economies (e.g., Akhtar et al., 2022; Ghouri et al., 2022). As mentioned previously, companies using the Industrial 4.0 revolution as a competitive tool for their sustainable performance globally, however, there exists a gap in the literature about how these companies perceive Industry 4.0 and whether they are capable of incorporating these technologies for their sustainable performance.

Additionally, technological change is important because it alters the structure of companies and affects their operations to a certain extent. Literature has suggested that not all technologies are beneficial and are suitable for all companies to get a competitive advantage. Most of the companies operating in a higher technological environment have recorded a worsening performance; however, some of the companies working in low technology zones have reported higher and competitive change. This is because the adoption of technology depends on the company's structure and internal adoption environment. Despite these pros and cons, to get a competitive advantage, and sustainable performance, companies are motivated, attracted, and compelled by certain factors to incorporate and implement these technologies. Previous literature indicated that Industry 4.0 technologies, especially blockchain and artificial intelligence, have a strong and positive impact on corporate governance (Grove et al., 2018; Zhu, 2019; Ivaninskiy & Ivashkovskaya, 2022). Further, the Industry 4.0 revolution has brought a bunch of technologies and got more attention recently after the outbreak of the COVID-19 disruption. These technologies include but are not limited to blockchain technology, artificial intelligence, the internet of things (IoT), radio frequency identification system, robotics, machine learning, big data predictive analytics, and drone technology.

This chapter has focused on the types of Industry 4.0 technologies, the benefits of these technological adoptions, and the barriers and drivers in implementing these technologies. Majorly this chapter has discussed how these technological innovations and inventions help firms globally to gain competitive and sustainable performance. Before moving further, this chapter is interesting to address and discuss the following main headings.

- Industry 4.0 technologies and its basics concepts
- Benefits of Industry 4.0 technologies
- Drivers of Industry 4.0 adoption
- Barriers to implementing these Industry 4.0 technologies
- Role of Industry 4.0 technologies in achieving sustainable performance
- Conclusion

6.2 Industry 4.0 and Its Basic Concepts and Applications

Rapid dynamism has changed the way of competition among business concerns. Traditional methods and strategies of competition have been transformed into new emerging technology strategies and methods. Technological innovation and its implementation due to competition, disruptions, and other orientations have provided the companies to think in different ways, and this technological orientation has provided companies with several advantages. Therefore, "the incorporation of new and emerging technologies like blockchain technologies, artificial intelligence, internet of things, machine learning, robotics, etc., into business operations to gain sustainable and competitive advantage and performance is called the Industry 4.0 revolutions" (e.g., Ghouri et al., 2019, 2021). The industrial 4.0 revolution has gained immense attention and importance in recent times (Kin et al., 2020). Incorporation and implementation of computerized systems in business activities through smart systems and technologies have replaced human interference and hence promote business performance (e.g., Ameer & Khan, 2022).

Further details, definitions, and concepts of these emerging technologies are introduced in the following sections. These Industry 4.0 technologies included as follows:

[Insert 15032-6112-006-Figure-001 here]

Figure 6.1 Representative technologies in a firm value chain

Source: Michael E Porter (1998)

6.2.1 Big Data Analytics

Big data refers to the large, complex, and diverse datasets that are available in raw form with firms and used to analyze, interpret, and implement competitive and value-added business strategies to optimize business decision-making and achieve competitive and sustainable performance. Hence, it is evident from the literature that the implementation and adoption of decisions based on big data analytics brought enhanced technological capabilities and promote sustainable performance by enhancing innovation, productivity, and competitiveness among

firms (Mikalef et al., 2019; Khan et al., 2022; Sun et al., 2022). Further, organizational decision-making is made based on big data analytics by monitoring, evaluating, and managing organizational problems in better and more advanced mechanisms. At the organizational level, big data analytics might be treated at three major levels: data as a tool (dealing with firms existing issues with traditional capabilities), data as an industry (formation of new ventures and new computerized systems to handle new technologies), and data as a strategy (formation of new business models through the technology). Dealing with big data is a challenging job for industries worldwide because data produced through machines, cloud technologies, and business operations have increased by approximately 1,000 exabytes per year. Considering this discussion vital, big data analytics has taken a deep-rooted role in the Industrial 4.0 revolution (Yin & Kaynak, 2015).

6.2.2 Blockchain Technology

The origin of blockchain was initially started with the concept of "cryptocurrency" in 1991. Since then the blockchain was considered to be the most primitive Industry 4.0 technology in business operations. Treiblmaier (2018) defined blockchain as the digital, decentralized, and distributed ledger to record the business transactions in chronological order to create a permanent and tamper-proof transactions record. Three types of blockchains are widely used in the business community and these are public, private, and hybrid blockchains. Blockchain technology has widely been implemented by firms worldwide to actualize competitive and sustainable business performance (Marbouh et al., 2020; Nandi et al., 2021; Treiblmaier, 2018; Wang et al., 2019).

6.2.3 Autonomous Robots

The use of man-made machines to carry out the daily manufacturing activities and other heavy technical work that might not be efficiently performed by the human resource is called "robotics." To carry out the just-in-time inventory and JIT manufacturing activities, the inclusion of robotics is as important as other autonomous systems. Therefore, to enhance the organizational output, performance, and efficiency, the incorporation of robotics made task performance easier and more optimized. In the operationalization of robotics, the role of human–

machine interaction is quite important because of the control and command mechanism. Therefore, the role of close collaboration between these two is crucial and for the organizations, the adoption of robotics technology is cumbersome along with its benefits (Hedelind & Jackson, 2011).

The implementation of robotics in manufacturing industries is widely recognized in previous literature, and it enhances organizational sustainability and competitive performance (Tankova & da Silva, 2020; Xiao et al., 2020); however, the use of robotics in services industries has been recently recognized in the recent era after the outbreak of COVID-19 (Javaid et al., 2020; Sarker et al., 2021). The implementation of robotics has proved, enhanced, and optimized business performance in all industries. Similarly, robotics has also been implemented in other industries like production, logistics, and distribution and is merely controlled by human interaction. The majority of the famous and multinational companies like Pepsi Co, automotive companies, and electronic industries have incorporated robotic technology and achieved sustainable and competitive performance.

6.2.4 Simulation

Simulation is the use of computerized programs that express and represent the dynamism of actual system behavior and outlook. The simulation uses models and mathematical descriptions instead of a real system which is the same as a real system. The use of simulation tools and instruments played a supportive role in manufacturing, production, and distribution activities which help in achieving sustainable and competitive performance. In today's dynamic and fragile business environment, the use of simulation provides adjustment against complex systems by planning the business operations by providing real-time knowledge and information regarding the actual system through engineering capabilities (Weyer et al., 2016). Therefore, based on simulation models and mathematical descriptions, competitive business strategy and tactical approach can be done through real-time information and knowledge hence providing optimized, competitive, and sustainable business operations (Uhlemann et al., 2017; Khan et al., 2021).

6.2.5 The Industrial Internet of Things (IoT)

Connecting physical objects called "things" with the internet for the purpose of exchanging information and data is called the internet of things. Things or objects are based on the nature of the business or application involved. For example, sensors are used to monitor temperature and moisture within a building or in a container. Similarly, radio frequencies are used to locate physical objects and shipments (Sarkis & Dou, 2017). Through this data collection, systems run their analysis and are further refined by human interaction to make real-time business operations (Rahman & Rahmani, 2018). Through this real-time decision-making, origination achieves competitive and sustainable performance, especially in supply chains and inventory management. Presently, the internet of things played a vital role in the manufacturing, production, and distribution of materials especially during the period of COVID-19 pandemic.

6.2.6 Cloud Computing

Cloud computing is internet-based computing in which shared information and sources are available and handed over to computers and other technology devices for storage and analysis. Cloud computing has numerous benefits to the information and communication technologies which are helpful to supply chains to go for automation by providing the integration and facilitation to the management. Cloud computing includes the information technology resources which are used to store and process the data in a virtual network and serve many clients simultaneously. Cloud computing consists of three models: software as a service (SaaS) in which the access to the system depends on the purchasing of the system like ERP, second is Platform as a server (PaaS) in this type the clients are allowed to access the application like software developers, and third is Infrastructure as a Server (IaaS) that provides the clients the fundamental programming like storing the data, etc.; one of the major examples of cloud computing is Google Drive that provided limited access and storage of the client data.

Companies in today's era majorly depend on the data and use it to analyze the data to forecast and actualize the future demands of their products. Traditionally, cloud computing is used by firms to store data and to perform automation functions in their organizations like ERP systems, etc. (Garrison et al., 2015; Khayer et al., 2020); however, cloud computing has been recently highly recognized during the outbreak of the COVID-19 pandemic and serve the

enterprises to gain survival, competitive, and sustainable performance (Narayanamurthy & Tortorella, 2021; Prihatiningtias & Wardhani, 2021).

6.2.7 Additive Manufacturing

Three-dimensional (3D) technology used to customize the goods and products for customers comes under additive manufacturing. The common types include 3D and prototype printing which are used to produce small quantities to have the required stock in their inventory. It is the quality of additive manufacturing that lightweight but long-lasting material can be used to manufacture the products. In this regard, aerospace firms implement these technologies to construct aircraft and their parts through titanium to avoid weight (Rüßmann et al., 2015). Further, well-known multinationals like Google, Motorola, and Apple accelerate their smartphone applications and their speed through additive manufacturing. Additive manufacturing has provided companies advantages of reduced lead time, mass customization, agility, and increased volume production (Conner et al., 2014).

Traditionally, additive manufacturing has played a critical but less capable role in firms' sustainable performance due to lower penetration and adoption. These technologies are used to manufacture parts from 3D models, and this process is done in several layer-by-layer stages which reduces the raw material consumption. Further, these technologies make the companies capable of enabling the JIT function in their production by promoting speed, adaptability, and versatility (Frazier, 2014; Haq et al., 2016). However, the actual strength and application of these technologies were implemented during the COVID-19 pandemic outbreak. The majority of the companies survive and gain competitive and sustainable performance due to the implementation of this technology (Khan & Manzoor, 2021; Larrañeta et al., 2020).

6.2.8 Augmented Reality

It is an emerging technology that creates harmony and interaction between the virtual world and its surroundings. With this technology, Google has created the Google glasses which are also known as Magic Leap and converts the light angle and depths by adjusting the human eyes (He et al., 2017). The technological outbreak and its adoption have made things different for human

beings to handle but this technology has provided them with interaction with the human and technology. Firms are using this technology in combination with computer systems, graphics, and physical elements. It is also used to control different tasks through sensor technology.

6.3 Industry 4.0 for Managerial Decision-Making

The managerial decisions define the future of companies, and these decisions are based on the dynamic internal and external organizational environment. Today's working environment and market situations are different and more complicated compared to the previous business environment. Therefore, the managerial decision regarding the adoption of Industry 4.0 is a crucial segment in organizational philosophy. Traditional decision-making in the business sector was based on the adequate way or best way "the philosophies of Max Webber" but today's dynamic, fragile, and complicated business needs more accurate, well-defined, and reliable decisions to compete in the dynamic and fragile business environment. Therefore, Industry 4.0 played an adequate role in managerial decisions and provides more accurate, reliable, and automated systems and data to forecast future requirements and make future decisions. The decisions made based on Industry 4.0 technology information were considered more adequate to gain competitive and sustainable firm performance. The Industry 4.0 features are outlined in Figure 6.2.

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Figure 6.2 Author's contribution

6.4 Challenges of Industry 4.0 Adoption

Despite the advantages and benefits of Industry 4.0, literature has indicated numerous challenges and barriers to its implementation. However, the challenges and barriers differ according to culture and economy. Followings are the major challenges identified and discussed in previous literature in various industries

6.4.1 Cost of Implementation

One of the basic requirements for any change is capital and resources. Therefore, the adoption of Industry 4.0 technologies brought capital change and exerts pressure on the organizational resources. However, for the achievement of sustainable performance and competitive advantage, change adoption is a crucial element but it is on one hand a cumbersome issue for the companies due to ambiguous benefits. Literature has indicated that the adoption of new technological changes primarily brings a cost burden on the firm's operations (Alaloul et al., 2020). Alongside initial setup costs, hidden and associated costs like workforce training, infrastructure costs, and maintenance costs are also the major implementation barriers in Industry 4.0 technologies. More importantly, the long-term ambiguous return is also a potential challenge for its implementation. These hidden and ambiguous costs associated with direct and indirect adoption of Industry 4.0 technologies have been proven especially in the literature on the construction industry (Oesterreich and Teuteberg, 2016). Therefore, addressing these challenges is the most exponential and initial step to achieving a sustainable and competitive edge in a similar industry and likewise.

6.4.2 Resistance to Change

Organizational structure is an important factor in the response and adoption of change. Technological change is the most influential and critical change firms have to address. The majority of the organizations in developing and emerging economies are fragmented and conservative in their business operations and based on rigid or centralized organizational structures. This type of structure and business activities leads to a lack of interest and willingness among the management that cause resistance to the adoption of innovative and emerging technologies like Industry 4.0 technologies.

The adoption of any type of innovative technology and its successful implementation is truly based on the motivation and commitment of the firm's employees. Especially at the managerial level employees are true representatives of the organizational decisions. Therefore, to address the resistance barrier, the motivation, commitment, and training of the employees are very important. Previous literature has indicated that these barriers can be a potential threat to the

adoption and implementation of technological change among organizations (Chan et al., 2019; Sarkis & Dou, 2017).

6.4.3 Lack of Labor Force

Companies gain a competitive advantage in their workforce. Geographical location and availability of skilled, cheap, and trained workforce is a dire requirement of companies across the world. Further, the retained, loyal, and committed workforce is also required to gain competitive and sustainable performance for the firms. Literature indicated that companies are ambiguous about the capabilities of their workforce regarding the adoption of change especially technological change (Ghouri et al., 2021; Hewage et al., 2008). Their findings also suggested that a lack of skilled workforce leads to poor reduced firm performance.

6.4.4 Unclear Benefits and Gains

Most firms tend to achieve short-term benefits and primarily focus on these benefits; however, benefits from Industry 4.0 adoption are based on long-term conditions. The firms feel hesitation regarding the adoption and selection of Industry 4.0 due to unclear return and long-term benefits which are ambiguous and unclear. Further, the unclear and ambiguous benefits make the decisions of adopting these emerging technologies more difficult and hectic for the companies operating in developing and emerging economies. From this perspective, these and other companies need to deeply analyze and thoroughly evaluate the gains and losses by cost and benefit analysis regarding the adoption of Industry 4.0 technologies because the literature has indicated that not all technology adoption is favorable for every company. Further, it is also evident that some highly mature and competitive firms sometimes failed to gain the desired gains from highly saturated and developed technologies in even the most developed culture (Michael, 1985). Hence, the decision to adopt and implement these technologies needs careful and experienced analysis.

6.4.5 Lack of Investment in Research and Development

Resource allocation in organizations for different activities is based on their goals and objectives. The majority of the firms remain in the transition phase because of this globalized and sophisticated business environment. Therefore, firms primarily focus on their core activities and mostly neglect the research and development activities. The training, research, and development in the business sector are majorly considered cost burdens instead of benefits. Hence, the allocation of resources and funds is critical and minimum in those organizations, and it is especially observed in developing and emerging economies. The technological change and its adoption are purely based on firms' attitudes toward research and development activities and funds allocation for these activities. This is a potential barrier to the implementation of Industry 4.0 technologies in organizations. Again, the companies are reluctant to allocate investment in research and development activities because of ambiguous and lower chances of research and development projects.

6.4.6 Lack of Standardization

The business sector always pursues those potentials and targets for which there exist standardized permissions and protocols. As discussed earlier, emerging technologies are unstandardized due to their emerging dimension; hence, organizations are hesitant to approach them without prescribed standards.

6.4.7 Data Protection and Cybersecurity

The majority of the Industry 4.0 technologies are based on data collection, analysis, and storage. The major threat associated with emerging technology is data protection and its security. As previously discussed, the companies are reluctant to allocate funds for research and development to formulate and discover innovative and inventive business technologies but the data storage

and its security again required an investment. Again, the fund's allocation and protection of these data is a cumbersome task for the firms operating with minimum capital.

6.4.8 Legal and Contractual Issues

The business operations are protected and supported by legal and contractual agreements. However, the outbreak of technological innovation, especially Industry 4.0, is recent and so far, there are no adequate and authenticated legal frameworks and contractual agreements, especially in the developing and emerging economies. This is another potential threat that causes hindrances in the adoption and implementation of Industry 4.0 technologies. For example, blockchain technology like the Bitcoin exchange has not been protected and permitted in the majority of the countries which causes hesitation and risk among business organizations and owners.

6.5 Drivers of Industry 4.0 Adoption

The chasing and adoption of any market change are mostly driven by some potential factors. Similarly, some of the major drivers of Industry 4.0 are discussed later and also described in Table 6.1 with the sources.

6.5.1 Changing Market Demands

Business operations have changed dramatically nowadays and especially after the globalization and outbreak of certain disruptions. To meet the market demands and accelerate the business operations to meet the customers' demands, firms need to be more proactive and efficient. To cater to these factors firms need to adopt the dynamic technology market changes which are the dire need of time to accelerate the production and distribution process. Further, the uncertain and differentiated futuristic demands compel the firms to adopt the Industry 4.0 technologies to forecast the futuristic demands more precisely and accurately.

6.5.2 Competition

Today's business operations are more competitive as compared to traditional ones due to more easily available business information. Further, it is getting more and more difficult for business concerns to meet the differentiated customer requirement. The firms capable of fostering and chasing the technological market changes are more successful in fulfilling the customer's requirements; however, others failed to do so. Therefore, it is a dire requirement of time for the survival of firms to adopt emerging market innovations and technologies like blockchain, artificial intelligence, and Internet of Things.

6.5.3 Uncertain Disruption Outbreak

History has revealed that the outbreak of disruption does not remain rare but its outbreak may be often. These disruptions include the outbreak of communicable diseases, natural disasters, and other man-made disasters. Recently, the outbreak of the COVID-19 pandemic has approximately changed the business operations of almost every business concern and also created a majority of new business models and business entities. All these business models and business concerns are majorly based on technological innovations, especially Industry 4.0 technologies. Industry 4.0 technologies like blockchain, artificial intelligence, Internet of Things, robotics, drone technology, and big data have helped firms to remain sustained and competitive in the market and also helped others to create new business entities. Therefore, these disruptions compel the firms to adopt emerging Industry 4.0 technologies to provide sustainable business performance.

6.5.4 Top-Level Management Motivation/Interest

Success and failure of the business decisions are majorly depending on the managerial motivation and interest. Literature has indicated that managerial interest and motivation lead the firm's performance to an optimized and competitive edge and their failure causes vice versa (Sarkis & Dou, 2017). The decision to adoption and implementation of Industry 4.0 technologies is purely based on the employer, top- and mid-level managerial interests, and motivation.

Therefore, managerial motivation and initiative act as an exponential driver in the adoption of Industry 4.0 technologies.

6.5.5 Resource Capabilities

Adopting a change is not an easy decision to be considered immediately; however, certain factors need to be analyzed and considered earlier. Among these, the firm's resources played a major role, and these resources include the financial capabilities, trained workforce, and organizational infrastructure. The successful chasing and adoption of any market change especially the technological change mainly depends on firms' resources. Adoption of technological change not only required initial capital but also required training of the workforce and maintenance of the infrastructure. Therefore, the firm's resource capabilities are essential drivers for the adoption of Industry 4.0 technologies.

Some of the other drivers are covered in table one through their sources. These are additional but potential drivers in the incorporation of Industry 4.0 technologies.

Table 6.1 Drivers of Industry 4.0 adoption

Driver	Category	Source
Legislative standards	Countries' legal and regulatory frameworks and changes in legislation and regulations	Malyshev (2008)
Strategies	Differentiation and conscious strategies regarding Industry 4.0 implementation	Kane et al. (2015); Pagani (2013)
	Customer orientation and requirements	Geissbauer et al. (2016)
	Reduction in cost	Colotla et al. (2016); Dujin et al. (2014); Moeuf et al. (2018)
	Just-in-time inventory and lean manufacturing To cope with competitors as competitors have adopted Industry 4.0 technologies	Lasi et al. (2014); Moeuf et al. (2018)

Workforce	A qualified workforce can compel the firms to adopt Industry 4.0 technologies	Geissbauer et al. (2016)
Public adviser systems	Adoption of Industry 4.0 technologies due to public pressure	Malyshev (2008)

6.6 Role of Industry 4.0 Technologies in Achieving the Sustainable Performance

Technological change is the major driver and motivator of competition. Technological innovation has changed industrial structures and helped in creating new business ventures. Due to this technological emergence, the majority of the well-known firms that failed to adopt them have been eroded and some of the others have gained their places. The major example of this is Nokia which refuses to adopt the technological shift and has been easily replaced by other companies small in size and capital. Therefore, competition is the initial phase in getting a competitive advantage and sustainable performance. Hence, technological innovation has initiated a healthy competition among the firms of developed, developing, and emerging economies. Technological innovation is considered crucial for firms if they create healthy competition or lead to competitive advantage and industrial structural change.

6.6.1 Digitalized Technology in Value Creation

The basic shift in gaining a competitive advantage and sustainable performance is value creation through technological innovations. In the recent era, the business activities performed in organizations are a bunch of technologies, and these technologies help to produce value creation in production and other activities. The majority of the value creation activities are carried out through the combination of technological innovation, inputs in the shape of information or material, and the human resources to produce the output. Similarly, the material handling in logistics may be carried out through the combination of traditional techniques and Industry 4.0 technologies like RFIDs, bar codes, sensors, etc. In simple words, technological innovation has

not been used only in primary activities but is also used for supportive business operations. Therefore, all the inbound activities, outbound activities, operations activities and services, and marketing activities are carried out through the combination of computer-aided designs and human interaction. Hence, it is pervasive that value creation needs information that can be generated from the use of technology and involves all the categories as shown in Figure 6.2. Technological innovations are used to schedule, plan, control, and accomplish business activities.

Case 1: The Walmart and IBM Collaboration to Trace Product Through Blockchain

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Spinach, lettuce, and leafy green vegetables are about to get the blockchain treatment from Walmart, as the world's largest food retailer has announced that 100 of its vegetable suppliers will be asked to enter details about their products into a blockchain.

The scheme enables the retailer to pinpoint the origin of every head of lettuce and bag of spinach it sells, boosting transparency in the supply chain. Queries have nonetheless been raised as to whether the move is a gimmick, or a positive step toward embedding the technology into the economy.

The move was prompted following numerous cases of vegetable-associated food contamination. Earlier this year, dozens of people fell sick after eating Romaine lettuce, and in 2006, an E.coli outbreak from infected spinach killed three people and affected 199.

Food Contamination Fuels Call for Technology

The challenge with food-borne outbreaks is to identify the batch of vegetables responsible and then isolate the source to a specific location and supplier. Walmart believes that a blockchain database will allow it to track every item of leafy green vegetables back to the field where it was grown, thereby increasing transparency and saving costs, as the need to remove all spinach from sale across multiple stores in the event of a contamination scare would be eliminated.

Walmart is working with IBM to create the blockchain through its IBM Food Trust system. All the data will be hosted on IBM's cloud computers.

The blockchain ledger of transactions could be the ideal system for the food supply chain, as produce can pass through multiple suppliers before it ends up on the supermarket shelf. Every time a supplier passes produce on to a new supplier, a fresh entry will be made into the blockchain, creating a record for every vegetable transaction, right back to its origin.

The spinach behind the 2006 E.coli outbreak was not traced back to its contaminated source (a Californian farm) for 15 days. Blockchain entries would ensure the source to be instantly trackable, and tainted items removed from shelves without delay. The traceability would also eliminate the need to remove all items in the offending category, as only the batch traced to the source need to be removed.

System Complexity and IBM Involvement Raise Questions

Blockchain is usually associated with decentralized transaction currencies like Bitcoin and Ether, where its very nature means that those participating in the currency do not need a central bank to police the system, as the software and the users create and impose the rules.

The need for Walmart to employ such a system for its supply chain, especially one run by IBM, has raised questions: A blockchain database is self-policing—and so doesn't need a middleman—yet IBM is setting itself up as a blockchain middleman.

Of course, conventional databases can be altered, transactions may not always be logged and systems are far from tamper-proof. The attraction of blockchain for supply chain management is its immutability, but if someone in the supply chain inputs incorrect information, it can never be altered, and will infect the transparency of the chain. And if a batch of vegetables is tampered with, it can only be identified with physical checks

The credibility of the blockchain depends on only correct information being uploaded.

The complexity of the system, no doubt difficult to navigate for those without expertise or specific instruction, is a potential red flag. Cryptocurrencies are the domain of IT specialists who can quickly grasp the technology, spurred on by the prospect of making a profit.

But mundane operations like sourcing vegetables lack this motivation. IBM's system has been developed for large food businesses such as Unilever, and likely requires specially trained personnel.

Blockchain is being touted as an almost magical solution to multiple challenges. The UK finance minister has even suggested that blockchain could help Britain achieve frictionless trade after Brexit. Governments around the world are looking at introducing regulation to blockchain to unleash its power for financial services.

Until now, blockchain has been used to create self-governing, decentralized systems such as cryptocurrencies. The big question is whether it can become an immutable mechanism for policing everyday transactions across society.

That really would be a transformative technology.

6.6.2 Industry 4.0 in Competitive and Sustainable Advantage

The digitalized technologies that are adopted and helpful for firms to gain competitive advantage and sustainable performance are discussed earlier. These technologies are incorporated by different firms to gain these advantages and are discussed in brief later.

Big data predictive analytics is a collection of large amounts of data required by companies for obtaining new and valid information. In today's world, the availability of real-time data provides dream opportunities to firms which can be obtained through the application of new and advanced statistical tools to forecast sustainable opportunities, hence reducing the risk and increasing the feedback (Bakshi, 2012; Bartosik-Purgat & Ratajczak-Mrożek, 2018; Warner & Wäger, 2019).

Similarly, blockchain technology which is also known as digital ledger technology is a decentralized database used to record transactions for partners. Further, these blockchains can be public, private, or hybrid depending on the nature of record keeping. Firms are adopting these technologies to enhance transparency and reliable and fast transactions in their business operations. Various firms of different sectors globally implement this technology to gain faster, reliable, accurate, trusted, and authentic transaction records among business operations. These

industries include financial and insurance agencies, energy and oil sectors, environmental protection agencies, advertising, health, and public administration sectors (Narayanan et al., 2016).

Case 2: Google Uses AI to Design Next-Generation Chips in Just Six Hours

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Gordon Moore, the founder of Fairchild Semiconductor and Intel, in 1975 predicted that the number of transistors on an integrated circuit would double every 2 years. This observation, now known as Moore's Law, has continued to hold true, but may very well be on the verge of being rendered obsolete.

As modern-day silicon is overhauled to accommodate the intricacies of running artificial intelligence (AI) models, Google has gone the other way and is now designing chips using AI. The company explained this cyclic clockwork, research for which has been going on for well over a year, in the science publication Nature.com last week.

Designing a chip, called floorplanning in technical circles, is an arduous months-long process that has so far remained one of the few areas that haven't been receptive to automation. It seems that will change soon. "In under six hours, our method automatically generates chip floorplans that are superior or comparable to those produced by humans in all key metrics, including power consumption (Tufail et al., 2021), performance, and chip area," explained Google in a paper authored by 20 researchers.

Google itself isn't a chip manufacturer per se but the Mountain View, CA-based company has developed several chips, and its tensor processing unit (TPU) hardware specifically to support the processing of AI workloads for internal research. Google said it is already banking on the procedure to design its next iteration of TPUs for its AI-processing data centers, and possibly other commercial use cases.

Essentially, AI is being leveraged to help in the development of future-ready AI applications

Some of the other Industry 4.0 technologies include augmented reality (AR), Artificial intelligence (AI), and the Internet of things (IoT), which have been widely incorporated by many firms across the world to actualize their sustainable and competitive performance. AR has been widely recognized by many firms to achieve their extraordinary objective as AR is used to convert digital information into an image that can be viewed and interpreted through different

devices to produce valuable and understandable knowledge (Loureiro et al., 2020). A most recent breakthrough in the field of AR is the invention of the modern telescope "James Webb Space Telescope" which is used to identify the secrets of Galaxy clusters in space. The data and images collected through this telescope are interpreted and converted into meaningful information and facts to further understand the reality and secrets of the universe.

Case 3: Artificial Intelligence and Samsung Firm Performance

AI technology based on machine learning to upscale images Samsung Electronics was the first to unveil 8K AI tech for television. The technology can analyze content and can automatically upscale low-resolution images to 8K picture quality. This innovation solves the current problem with the availability of high-resolution content to use on super-high resolutions screens. Now, all pictures can be transformed to 8K, which is currently the highest resolution capable in digital television.

Internet of things (IoT) refers to the network of physical things "Objects" with the internet for the sake of data and information exchange between the source and objects. These objects might be household appliances, lighting and heating equipment, buses and trucks, and even wearables (Atzori et al., 2010; Wortmann & Flüchter, 2015). Globally, the majority of the firms are using this technology in their warehouses, shipment, and tracing other information from remote areas through the sensors and RFIDs to actualize competitive and sustainable performance (Garrido-Hidalgo et al., 2020; Kukard & Wood, 2017; Khan et al., 2017; Tian, 2016; Yerpude & Singhal, 2020). Similarly, AI is the artificial data generated by machines through their intelligence and improvises human intelligence in decision-making. It is realized from the previous experience of AI that the decisions made through AI are more efficient, rational, and reliable in achieving specific and difficult organizational goals. AI has been highly recognized in industries to gain competitive and sustainable performance (Gupta et al., 2020; Kumar et al., 2020; Toorajipour et al., 2021). Machine learning is another sub-aspect of AI that is used to elaborate that the computerized systems independently and automatically acquire, learn, and adopt new information and data. The ML also has been adopted by the firms to gain

and cash the emerging business opportunities that lead to their sustainable and competitive advantage in the industry (Acemoglu & Restrepo, 2018; Hirata et al., 2020).

Previously discussed technologies have changed the functioning and sustainable outlook of the firms that brought prosperity and shaped the social, economic, and environmental aspects of the communities (Nisar et al., 2021). These technologies not only improve these elements but also improve and create new business attitudes, behaviors, and information and communication patterns among stakeholders. One of the important stakeholders, the customers have been empowered and enriched with the information and knowledge and hence connected with business operations more precisely and closely (Alamäki & Korpela, 2021). Through the information, customers can much more precisely exchange their ideas and opinions with the firms and hence influence their business operations and decisions. Therefore, with the incorporation of these digitalized technologies, firms are more accurately and intensely exchanging their relations with their stakeholders and achieving efficiency, effectiveness, and competitive and sustainable business operations. In short, Industry 4.0 technologies change the existing traditional business models into more precise and comprehensive ones (Caputo et al., 2021; Luz Martín-Peña et al., 2018; Rachinger et al., 2018).

The business models created through these technologies are more diversified and therefore reduce the reliance on the physical factors and hence provide a comprehensive broad spectrum of digitized business solutions like helping in creating digital and sustainable products, enhancing the digitalized sales channels, or the use of robotics in manufacturing. Besides benefits, handling Industry 4.0 technologies is a cumbersome deal for firms but if they are handled and chased through proper and planned activities, they can generate optimized business operations and sustainable business performance (Ribeiro-Navarrete et al., 2021). The adoption and utilization of these emerging technologies have been widely implemented by the banking sector in the shape of FinTech, insurance companies and financial investment funds, supply chain operations, and the marketing sector in the shape of digital marketing.

6.7 Benefits of Industry 4.0 Technologies

1. Industry 4.0 technologies provide companies with the ability to surpass the boundaries of space allowing them to access larger and diversified global markets and help them to chase competitive and sustainable growth.
2. Industry 4.0 technologies deeply affect the firm's internal and external strategies and put significant influence on the resources and business processes that cause them to think differently and chase the market opportunities through new business models and strategies by reducing the risk and threats.
3. Industry 4.0 technologies empower the customers by providing them information and easy access to business news; hence, they are in a much stronger position to influence the business operations to behave in a sustainable and eco-friendly manner.
4. Industry 4.0 has deeply affected the labor market by introducing new methods and techniques of business solutions, hence replacing the workforce with robotics and other digitized solutions. These and other digitized factors put additional pressure on firms to operate and behave more sustainably and competitively in markets.
5. In financial markets, Industry 4.0 brought new methods of transactions, payments, and settlements that enhance business operations not even domestically but also internationally. Therefore, compel the firms to adopt these emerging technologies to be more competitive and sustainable.
6. Industry 4.0 adoption and dissemination not only impact the micro-level strategies but also influence the macro-level business operation and therefore compelling the international economies to consider these technologies to achieve sustainable performance.

6.8 Conclusion

This chapter has focused on the basics of Industry 4.0 technologies in business operations. This chapter covers the mostly applied and well-known Industry 4.0 technologies, defines them, and provides their little contribution to sustainable firm performance. These technologies include blockchain technology (BCT), artificial intelligence (AI), Internet of Things (IoT), robotics,

machine learning (ML), simulation, AR, and additive manufacturing. Further, this chapter covers the barriers to the implementation of Industry 4.0 technologies, drivers of Industry 4.0, and the benefits of their application in achieving sustainable performance. Additionally, this chapter covers the role of Industry 4.0 technologies in achieving sustainable and competitive firm performance through case studies.

6.9 References

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