IJARST

International Journal of Advanced Research in Science and Technology

https://doi.org/10.62226/ijarst2024132537

ISSN 2319 – 1783 (Print)
ISSN 2320 – 1126 (Online)

The Adoption Of 4th Industrial Technologies For Economic Development In Developing Countries – The Opportunity And Challenges. The case of United Republic of Tanzania

Adum Joseph [1], Godfrey Ochwoto Orwaru [2], Seth Mwego [3], Mitaki Areba Evans [4]
Faculty of Computing Management and Social Sciences, Kampala International University in Tanzania (KIUT)

ARTICLEINFO

Article history:
Received 27 Feb 2025
Accepted 07 Mar 2025
Available online 13 Apr 2025

Keywords:
Fourth industrial revolution, fourth industrial technologies, industry 4.0, Automation.

ABSTRACT

The major purpose of this research was to carry out assessment on challenges and opportunities of integrating fourth (4^{th}) industrial technologies on economic development in developing countries. The case study research design was used because a case study is a comprehensive description and analysis of a single situation or a number of specific situations. A self-designed structured questionnaire was used to collect data from 150 respondents selected randomly from academicians, government officials, company directors, and Information Communication Technology (ICT) directors. The researchers collected 150 completed questionnaires from the respondents. Data were analysed using percentage, frequency and statistics. The findings of this research indicate that cybersecurity, and cloud computing technologies and mostly adopted for integration in economic development. General technical challenges, and lack of technical infrastructures such as affordable electricity and internet access are found out to be critical challenges in adopting fourth industrial technologies in developing countries. Facilitating the access to multilevel platforms that offer digital transformation programs for businesses, and connecting people to digital networks and intensely improving the efficiency of organizations was found to be a very good opportunity of integrating 4^{th} industrial technologies for economic development in developing countries. It is therefore recommended by the researchers that the infrastructures with standard security measures should be built to minimize cyber insecurity. The researchers also recommend that specialized training for technical staff and employees on how to operate and manage 4^{th} industrial technologies be conducted and the use of secure supported technological policies be implemented as a mechanism to prevent internal and external data loss.

1. Introduction

At the beginning of the 20th century, the main forces impacting the world economy and trade were the oil, metallurgy, and engineering industries. Today, the world is rapidly transforming into a digital economy, as evidenced by the prominence of tech giants such as Amazon, Google, Apple, Netflix, and Microsoft, which have become the highest-ranking companies in the world in terms of market capitalization in recent years (Modgil, S et al, 2020)

The 4th industrial revolution has brought about rapid technological changes such as artificial intelligence, robotics, big data, augmented reality, genetic engineering, additive manufacturing, the internet of things, cloud computing, and 3-d printing. These technologies have the potential to increase the speed, efficiency, and sustainability of the production of goods and services including in Africa (Signé, 2022).

The emergence of new and novel digital technologies has imposed individuals and organizations within all sectors to embrace the fourth industrial revolution (Industry 4.0). In the manufacturing sector, digital transformation has a strong focus on integrating technologies such as artificial intelligence, the Internet of Things and cloud computing to make the industry and businesses smart. The transformative process of digitalization has had a dynamic impact on working practices and employees, and the access to new technologies have reshaped the conditions for how employees work, learn and interact and in turn also how the organization needs to be managed. Digital transformation and innovation management are multifaceted interconnected, which continuously opens up new possibilities and challenges to management practices; hence, this field calls for further investigation (Lopes JM et al, 2024).

The explosive developments of information and communication technologies, and their subsequent integration into business processes, are the essence of the fourth Industrial Revolution, known as Industry 4.0. Industry 4.0 consists of several innovative technologies that have dramatically revolutionized the field of business

by enabling disruptive responses to the challenges stemming from issues such as environmental uncertainty. Technological innovations fostered by Industry 4.0 provide an opportunity to move economic processes to qualitatively new levels of management (Chen J et al, 2018).

In China, the "Made in China 2025" strategy was introduced by the Chinese government in 2015 as part of a decade long strategic plan. This 4th industrial revolution initiative involves the transformation of the Chinese industrial sector to become more competitive and increase the local production of core components. The initiative is focused on several high technology industries such as aerospace, biotechnology and automotive industry. Presently, the government is aggressively investing in information and telecommunication infrastructure to fast track the transition to industry 4.0 and improve their technology readiness level.

The French government launched the "La Nouvelle France Industrially" in 2013 to support revolutionising their industrial production base in 4th industrial revolution by identifying 34 sector-based priorities aimed at supporting businesses. Subsequently, the „industry of the future" project was launched, the initiative has five (5) key goals. These are: developing cutting edge technology, assisting businesses to adapt to new paradigms, capacity building, promoting the industry of the future, and strengthening European and international cooperation (Conseil, 2013).

The Japanese government launched the "revitalization and robot strategy" with the goal of increasing productivity and robotization of the manufacturing and service industry by 2020. The „Industrial Value Chain Initiative" was launched by Japanese companies to develop an industry 4.0 communications and software standard to facilitate a seamless connection for companies over the Internet and support collaboration among value chain partners. Other similar 4th industrial revolution initiatives by the Mexican, Indian government are „Crafting the Future" and „Made in India" respectively (Mittal. S, 2018).

Digital Transformation affects individuals, companies and societies as a whole. In particular, a rapid spread of digital technologies establishes a huge change of movement. It is essential that economies continually invest in developing digital infrastructures to meet existing and future demand. They use the foundation for many new services, applications, and business models (Norberto et al, 2020).

In the history of mankind, the introduction of new general-purpose technologies has spread like a wave, even if a large-scale introduction of technology sometimes takes time. Productivity growth comes from the useful uses of this technology spreading across different sectors of the economy. The economy has drastically evolved in that Technical progress, which opens up new economic prospects, gives rise to new products, services and working methods (Carlsson C, 2019).

Recent research recognizes the importance of social aspects of digital transformation and the value for managers to look beyond digital technologies, to formalize a shared understanding and to transcend organizational structures. Customers of today expect targeted messages that can be advanced through a data driven marketing strategic technology. Using digital channels to implement search engine marketing and email marketing and email. Only about 25% of businesses are very confident in their ability to execute, whether integrating all sources into a comprehensive digital business strategy, managing the entire application lifecycle, mapping the customer journey or the ability to pull initiatives together into a cohesive digital transformation strategy (Carlsson C, 2019).

The influence of Industry 4.0 extends far beyond factory floors and production lines. It redefines the very essence of work altering job roles, skills requirements, and training paradigms. The implications are substantial, with approximately 375 million workers—equivalent to 14% of the global workforce— anticipated to transition to new occupational categories and acquire novel skills due to automation, according to McKinsey & Company. As a response, labor unions and numerous companies advocate for the retraining of displaced workers, potentially elevating their skill levels in the process. It is crucial to provide proper education and training to the current and future workforce to ensure they are comfortable and proficient in using these technologies, ultimately maximizing their productivity (Beier et al., 2020).

In Europe, as in the rest of the world, digital innovation and transformation foreshadow the coming of what has been called the Fourth Industrial Revolution. The concept of Industry 4.0 has emerged to describe this digital transformation in industry in all sectors. Integrating digital innovations technologies in their business strategies is an essential means of creating value and digital integration and connection of systems may create seamless digitalised value chains.

In Bangladesh, the 4IR presents both opportunities and challenges in the manufacturing sector. Despite limited research on 4IR adoption and readiness in the country, advancements in digital technologies such as the IoT, cloud computing, and CPSs are gradually being adopted by forward-thinking firms. However, this transition is hindered by infrastructural limitations, insufficient technical expertise, and inadequate GS. Despite these challenges, the government's Smart Bangladesh vision is expected to boost 4th industrial revolution capabilities, positioning the manufacturing sector for enhanced efficiency, flexibility, and competitiveness in the global market. This integration of 4th industrial technologies is vital for Bangladesh to stay competitive, improve productivity, and transform into a smart economy (Rumi, 2020).

Africa presents a sea of economic opportunities in virtually every sector, and the continent's youthful population structure is an enormous opportunity in this digital era and hence the need for Africa to make digitally enabled socio-economic development a high priority. Africa has fewer legacy challenges to deal with and is therefore adopting digitized solutions faster out of necessity. For Africa, the

current moment offers a leapfrogging opportunity. Today's technologies indicate the scale and speed at which technology is transforming traditional socioeconomic sectors (African Union, 2020).

The level of utilization of 4th industrial technologies is not currently widespread in Nigeria. But there could be potential applications to various sectors of the economy, causing disruptions in industries across the country. (Lou et al. 2019). IoT and drone technologies are expected to be central to the future of agriculture. 3D printing is transforming manufacturing. Automation of jobs due to artificial intelligence and robotics will also cause tectonic transformations in the Nigerian labour market. Blockchains are increasingly finding applications in the financial markets and even international trade. Digital platforms are also transforming both trade and transportation industries as well as other markets.

Tanzania has also started laying the foundations for the realising the opportunities presented by the unfolding 4th industrial revolution by investing in digital infrastructure. We have seen initiatives such as the establishment of the National ICT Broadband Backbone, Universities' Innovation and Technology Hubs, Tanzania Artificial Intelligence Lab, and Blockchain Tanzania Community reflect a growing demand to increase the national digital eco-system. These initiatives are already recording positive impacts in terms of launching new innovations and start-ups. Tanzania has the great potential to leapfrog in terms of technology and unlock the opportunities of the 4IR. The country is already in an era of digital transformation with 25% of its population now connected to the internet. Some 83% of the population has a mobile connection, thereby creating a strong network landscape. This facilitates growing internet penetration with opportunities for mobile money, social media, and e-learning and other digital opportunities being adopted (Ndung'u, N., & Signé, L., 2020).

1.1 Purpose of the study

The main purpose of the study was to assess the challenges and opportunities of integrating 4th industrial revolution technologies in economic development in developing countries. The following research questions guided the research.

1. What are the 4th industrial technologies mostly adopted, and technological challenges of integrating 4th industrial revolution technologies in economic development in developing countries?
2. What are the opportunities of integrating 4th industrial technologies in economic development in developing countries?

2. Literature review

2.1 Adoption of 4th industrial revolution technologies

McKinsey (2016) in his report underlines that the key for the successful adoption to the new technological conditions is the ability of governments to adopt the right policies. Governments that will not be able to follow the appropriate long-term policies will set their economies at risk. He suggested that major technological achievements may imply significant public policy issues.

A number of developed countries such as Germany, the UK and USA have put in place public policies that focus on implementing 4th industrial revolution in their respective countries. It is critical that developing countries also take steps to adopt 4th industrial revolution in order to take advantage of it as well as not be adversely affected by these technologies if not adopted. There are a number of reasons why developing countries are not able to fully implement 4th industrial revolution technologies such as lack of commitment, infrastructure and lack of skilled workers (Sohail A et al, 2020)

Sohail .A et al (2020) suggested in their research that Countries especially in developing countries which fail to adopt the new manufacturing paradigm would most likely lag behind in terms of economic growth and prosperity. They found out that many developing countries rely on outsourcing and offshoring of jobs, due to reduced labor cost. However, this may change as many developing countries would bring back manufacturing to their own shores as products would be manufactured more cheaply and efficiently in the smart factories of the 4th industrial revolution.

In the history of mankind, the introduction of new general-purpose technologies has spread like a wave, even if a large-scale introduction of technology sometimes takes time. Productivity growth comes from the useful uses of this technology spreading across different sectors of the economy (Carlsson 2019).

According to Lund et al. (2019), the adoption of 4th industrial revolution technologies have bolstered trade, where they stated that, rapid adoption of these technologies has provided the comparative advantage from specialisation and mechanisation which has promoted global growth, engendering international trade. They further stated that as a result, global supply chains have also increased with the rise of the internet technologies. They concluded that the current episode of technological change will impact trade via blockchains, digital platforms, IoT among several other drivers of these technological transformations.

The need to adopt to technology in developing countries is also supported by statistics that estimate that in future new professional roles will emerge, and many of them are related to the use of technology, for instance: AI and machine learning specialists, big data specialists, digital transformation specialists, new technology specialists, software and applications developers and analysts, information technology services specialists, etc. (World Economic Forum, 2018).

A similar study conducted by Bayode A et al. (2019) to discover the readiness of South-African executives to adopt the 4th industrial revolution revealed that a clear majority (96%) of the executives surveyed were not confident of their organizations‟ preparedness to fully exploit the possibilities associated with Industry 4.0. They

conducted a survey to assess the 4th industrial revolution readiness level of South-African companies.

According to a report presented by Douglas L. (2022), he emphasized that if governments do not act strategically to seize the opportunities created with this new wave of technological change, the increasing technological gap could reduce the ability of developing countries to catch up, which would increase income inequality across countries. Ultimately, what we should be aiming for is not Industry 4.0 as final goal, but strategic ways to use it to grow economies faster.

2.2 Technologies of 4th industrial revolution

Madakam et al. (2015) elaborated that the fourth industrial revolution is made possible by all the technologies being used in it, but it is what connects the physical and digital systems to one another. Thus, making it possible for different people, sensors and devices to communicate with one another intelligently.

The fourth industrial revolution is characterized by a fusion of disruptive technologies that facilitate the complete automation of manufacturing facilities and the integration of a company‟s supply chain partners. These technologies encompass both software and hardware components. Some of the major Industry 4.0 technology and concepts are discussed below.

Figure 1: 4th industrial revolution enabling technologies ((Domino, 2017)

Domino. P (2017) stated that the 4th industrial revolution has the potential for greatly re-shaping the global economy. Keeping pace with this technological wave requires innovation and drastic restructuring of the manufacturing sector. Many developed countries are trying to achieve the vision of 4th industrial revolution due to its many advantages such as improved efficiency, use of fewer natural resources and increased productivity.

1. Augmented Reality/Virtual Reality (AR/VR): are two different concepts that enhance human-machine interactions (HCIs) Billinghurst. M et al. (2002). Augmented Reality (AR) is an interactive technology that digitally inserts an object into the operator‟s physical environment, while virtual reality (VR) effectively shuts out the user from the physical world. These technologies have several potential applications in different industries. For example, Data generated with VR technology can be used to develop training, communication, and interaction methods for different applications,

.

2. The Industrial Internet of Things (IoT): is an extension or a next developmental phase of the Internet which was invented over 2 decades ago. IoT is a computing concept that describes the integration of different physical objects attached with sensors or actuators through the internet to remotely monitor and control specific equipment or activities. These connected objects can collect and exchange large amounts of data in real time. The number of IoT connected devices is growing rapidly, over 23 billion devices are presently connected and that number is expected to rise to approximately 75 billion devices by 2025. IoT connected objects have vast capabilities and varied applications

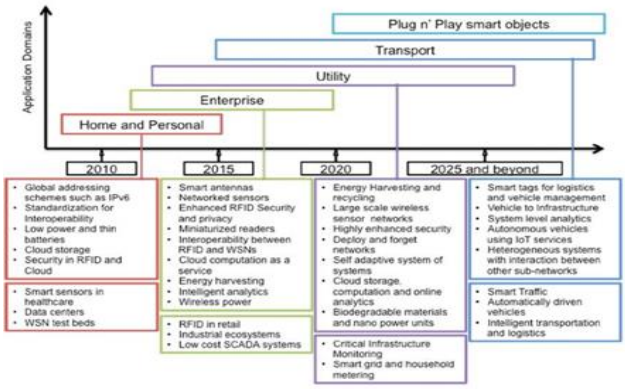

Figure 2: Technological advancements in IoT Applications (Gubbi & Jayavardhana., 2013)

3. Additive Manufacturing (AM): Gibson et al (2010) in their definition of additive Manufacturing, refered to as an umbrella of technologies or processes capable of manufacturing an object from a three-dimensional computer model or design, where they also stated that the additive manufacturing process involves depositing layers of an appropriate feedstock sequentially until the final part is made. They discovered that Additive manufacturing or 3D printing technology offers several benefits such as a shorter product development cycle, facilitation of mass customization, and waste reduction. Although AM still lags behind traditional manufacturing processes in terms of built speed, product accuracy and scalability, there has been a rapid increase in the rate of adoption of the technology by manufacturers.

4. Cloud computing: according to Mell. P & Grance. T (2011), cloud computing is a computing concept suitably defined by the National Institute of Standards and Technology (NIST) as “a model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction”. The explored that “cloud‟ is a global network of remote servers that are interconnected via the internet and operate as a single ecosystem. These servers are designed to offer various services such as processing, data storage, management, etc. Such services are very cost effective and highly scalable because it is provided over the internet. They stated that there are five (5) essential characteristics of cloud services, namely, on-demand self-service, broad network access, resource pooling, rapid elasticity, and measured service.

Google drive, Microsoft one drive and Amazon web services (AWS) are common examples of cloud service offerings

2.3 Opportunities of adopting technologies of 4th industrial revolution in economic development

Besides the challenges that may arise or get bigger during the 4th Industrial revolution, there are also significant economic and social opportunities that may contribute to a sustainable socioeconomic growth in developing countries.

According to digital transformation (2017), concerning entrepreneurship, new technologies must not be treated as a threat for human work but as a valuable tool/assistant for employees to increase their productivity and facilitate their decision-making and for entrepreneurs to boost their business competitiveness and productivity.

While 4th Industrial revolution offers opportunities for enhanced productivity and efficiency, it concurrently raises concerns about the displacement of traditional roles and the compelling need for reskilling and upskilling

The 4th industrial revolution has created many opportunities in economic development especially in manufacturing industries. Brynjolfsson and McAfee (2014) mentioned that 4th industrial technologies offer opportunities for enhanced productivity and efficiency in economic development. Automation, data analytics, and AI-powered systems provide routine cognitive functions which are evolving, and necessitating a new set of skills centered around adaptability, digital literacy, and problem-solving. Its further discovered that the application of 4th industrial technologies can achieve several benefits such as real-time monitoring and control of important production parameters such as production status, energy consumption, material flows, customer orders and supplier data.

Benkarouba & Benbouzian (2022), attributed that the integration of 4th industrial technologies offers opportunities to disseminate knowledge, and it allows companies to be more connected with customers and ensure the sustainability of production and good performance, in addition, digital solutions enable circular business models through automated monitoring, control and optimizations of resources and material flows. They also found out that several studies show that digital technologies, especially those related to the concept of 4th Industrial technologies, have been identified as important enablers of circular economy business models as they allow companies to share data within their supply chains and identify and track products and materials, improving their ability to retain value.

Kavitdesai (2018) in his research mentioned that 4th industrial technologies provide the world with a great opportunity and the potential to regenerate the natural environment, connect billions more people to digital networks and dramatically improve the efficiency of organizations. He further stated that 4th industrial revolution is being driven by emerging technology breakthroughs in fields such as artificial intelligence, robotics, the Internet of Things, autonomous vehicles, 3-D printing, nanotechnology, biotechnology, quantum computing, Neuro-technological brain enhancements and genetic editing. Similarly, Lund et al. (2019) stated that international trade has been faster using blockchains since it provides enough flexibility in making payments than the traditional letter of credit. These technologies could reduce shipping and customs processing times by 16-28%, boosting global trade by 6-11%.

Lund et al. (2019) noted that 4th industrial technologies in Nigeria has provided a great opportunity of economic development especially in the trade sector, that accounted for about 14% of her GDP in 2018. They further stated that this trend is expected to increase with greater application of these technologies. They mentioned that digital platforms like Jumia, Konga, Alibaba, Amazon, and freelancing sites like Upwork and Fiverr are becoming more popular since they lower transaction costs involved in the search process, and connect buyers and sellers directly. They also estimated that, with increased automation, trade in goods may reduce while trade in services is expected to increase in the future. Since the services sector is outperforming the manufacturing sector, this growth in trade of services is expected to contribute largely to Nigeria's economic growth.

Douglas L. (2022) presented in his report on 4th industrial revolution and noted that 4th industrial revolution presents an opportunity of a new playing field for developing countries which might have missed the early transformations of industrialization, and therefore the developing countries cannot afford to miss this new shift of technological change. 4th industrial technologies improve and increases production, as supported by Douglas. L in his report where he emphasized that using 4th industrial technologies in manufacturing industry improves productivity and reduces environmental damage from industrialization and creates new jobs rather than bringing job losses although Africa has a history of slow industrialization.

2.4 Technological challenges of 4th industrial revolution

In the study conducted by Simbnegavi et al. (2018), they noted that High Skilled Man Power is a major technological challenge of 4th industrial technologies. They also observed that many developing countries still lags behind in terms of highly trained people that would be a vital part of an economy relying on smart manufacturing. Governments in Africa as well as both public and private sector, educational institutions have to improve the quality of their education and focus on Science and Technology education (Simbanegavi et al., 2018).

Ayentimi et al. (2019) observed that the economy of many developing countries especially countries like Ghana, Zimbabwe, Sierra Leone, Tanzania and many other countries relies on small businesses and trading on a small scale. These small businesses have low growth rates and lack the culture of innovation, which is essential for 4th industrial revolution.

Kazmi et al., (2019) noted that one of the biggest challenges would be developing the infrastructure which is required to adopt this new manufacturing paradigm. Some

developing countries lack even basic infrastructure; hence they have a long way to go before they can be prepared for 4th industrial revolution. Electricity which is taken for granted in developed countries can also be an issue for developing countries. They stated that Pakistan, for example, has a supply demand gap of 7 gigawatts. Similarly, Phadke et al. (2019) are in support of this where they stated that 46 million rural households lack electricity in India (Phadke et al., 2019). They argued that many countries in Africa don't have access to electricity. This lack of access to electricity or shortage in electricity is one of the first hurdles that need to be overcome.

3. Methodology:

In this research, use case study research design was applied because a case study is a comprehensive description and analysis of a single situation or a number of specific situations. A self-designed structured questionnaire was used to collect data from 150 respondents selected randomly from Information Communication Technology (ICT) directors, government officials, company directors, and Academicians.

Table 1: Distribution of the sample population of the study

Respondents	Number	Percentages (%)
Academicians	40	26.7
Government Officials	30	20
Company Directors	50	33.3
ICT Directors	30	20
Total	**150**	**100%**

Source: Primary field data (2025)

Closed ended questionnaire was designed to collect data from the selected respondents, it was used to collect data from a wide range of individuals because it provided direct answers and it comprised of written questions that were filled by the respondents.

The face validity of questionnaire was established by giving the questionnaire to research experts for scrutiny on its validity. The questionnaires were administered to 150 respondents as indicated in table 1 above.

4. Analysis of the findings

Table 2: Most important 4th industrial technologies in different settings

	Cloud Computing		**Internet of Things**		**Robotics**		**Cybersecurity**	
	Freq	Percent (%)	Freq	Percent (%)	Freq	Per (%)	Freq	Per (%)
Most preferable	80	53.3	75	50	59	39.3	115	76.7
Preferable	21	14	52	34.7	47	31.3	24	16
Least Preferable	26	17.3	10	6.7	24	16	11	7.3
Not Preferable	23	15.3	13	8.7	20	13.3	01	0.7
Total	**150**	**100%**	**150**	**100%**	**150**	**100%**	**150**	**100%**

Source: Primary field data (2025)

The above table 4.3 shows the respondents' perspectives about the 4th industrial technologies which are most preferable for their various economic activities in general. The findings indicate that more than half of the respondents (55.8%) prefer cybersecurity. This implies that Since there is increased connectivity in 4th industrial revolution, there is high demands for new, secure, reliable methods of communications and sophisticated identity and access management. While 43.3% of the respondents believed that the use of robotic technology is much preferable to them, because it can be used to develop infrastructure such as drones which can be used in transport system and many other ways. Drones are now emerging as a relatively cheap mode of transportation that can help in the delivery of critical supplies to inaccessible areas in a timely manner. For example, in Rwanda, the government has partnered with Zipline – a California-based start-up, United Parcel Service (UPS) and the Global Vaccine Alliance (Gavi) to deliver blood to hospitals in remote parts of the country. This can solve some issues of infrastructural issues. This finding supports the related literature for example in the study conducted by L.T Chamba & F Chari (2023) found out that proliferation of robotics such as drones may be applied to circumvent the country's constraints in poor infrastructure.

4.1 Opportunities of 4th industrial technologies

In this part, the findings showed that there are several explorable opportunities 4th industrial technology in economic development. The report is made based on self ratings of the respondents on the opportunities of e-learning pedagogy at Kampala International University.

The table belows show the results with the descriptive statistics on respondents' ratings on ffacilitating the access to multilevel platforms that offer digital transformation programs for businesses

Table 3: 4th industrial technologies disseminate knowledge, and it lets companies to be more connected with customers

Category	Frequency	Percentage (%)
Strongly disagree	20	13.3
Disagree	5	3.3
Undecided	5	3.3
Agree	50	33.3
Strongly agree	70	46.7

Total	**150**	**100%**

Source: Primary field data (2025)

Many companies and organization in developing countries has high demand to connect with customers at their convenient. In the 4th industrial revolution, it is a norm and culture for convenience. The results from the respondents indicate that 46.7% of the respondents are in total agreement to this. This seems to suggest that convenience connection with customers increases productivity and customers' relations with their companies. This finding is contentious to current literature which is consistent about dissemination of knowledge, and it lets companies to be more connected with their customers. Benkarouba & Benbouzian (2022), attributed that the integration of 4th industrial technologies offers opportunities to disseminate knowledge, and it allows companies to be more connected with customers and ensure the sustainability of production and good performance, in addition, digital solutions enable circular business models through automated monitoring, control and optimizations of resources and material flows. The finding further reveals that 13.3% of the respondents are total disagreement. They seem to believe that getting about companies and convenience connection isn't just through 4th industrial technology platforms, rather physically, which is another option. This might be true but there is no convenience in physical connection.

Table 4: Facilitating the access to multilevel platforms that offer digital transformation programs for business

Category	Frequency	Percentage (%)
Strongly disagree	5	3.3
Disagree	17	11.3
Undecided	10	6.7
Agree	42	28
Strongly agree	76	50.7
Total	**150**	**100%**

Source: Primary field data (2025)

Table 4. reveals the respondents' results about facilitating the access to multilevel platforms that offer digital transformation programs for businesses in developing countries. It shows that 50% of the respondents are in total agreement and this may imply that definitely there is a wider span of accessing electronic resources online anywhere at any time anyone would like. The results further reveal that 28% of them agreed and concur with this as one of the opportunities of 4th industrial technologies, while 11.3% of the respondents where not in agreement about this. It has also been found out that 6.7% of the respondents could neither agree nor disagree about this matter. This suggest that they are not sure about the possibility 4th industrial technologies to facilitate the access to multilevel platforms that can offer digital transformation programs for business. However, 3.3% of the respondents strongly disagreed that this is not an opportunity of of 4th industrial technologies. This could imply that access to resources on multiple platform is not only through these technologies but also through other means.

Table 5: Connect people to digital networks and intensely improve the efficiency of organizations

Category	Frequency	Percentage (%)
Strongly disagree	12	8
Disagree	5	3.3
Undecided	8	5.3
Agree	55	36.7
Strongly agree	70	46.7
Total	**150**	**100%**

Source: Primary field data (2025)

The table 2. Shows the results from respondents which reveals that 46.7% of the respondents strongly agree that 4th industrial technologies provide easy connection to people and improve the efficiency of organizations. This proves that the whole world is now a global village since people can connect to communicate and do business globally without any much complication. In this 4th industrial revolution, most businesses are conducted online because many people are connected. As a result, there is improved efficiency in many organizations in developing countries. The result also reveals that 8% of the respondents totally disagree with this matter. This finding seems to suggest that global connection can still be possible and organizations can still be efficient in the absence of 4th industrial technologies.

4.2 Challenges of 4th industrial technologies towards economic development

Table 4: Shows the challenges of 4th industrial technologies on economic development in developing countries

Variable	Category	Frequency	Percentage (%)

Luck of highly trained personnel that would be a vital part of an economy relying on smart manufacturing (4th industrial manufacturing technologies)	Agree	20	13.3
Most of the rural areas in developing countries lack the infrastructure to protect digital data from cyber criminals that is essential for economic development in 4th industrial revolution	Agree	45	30
Luck of technology-based policies implementation	Strongly agree	10	6.7
General technical challenges	Strongly agree	70	46.7
Total		**150**	**100%**

Source: Primary field data (2025)

General technical challenges of 4th industrial technologies

The table 4 shows the results of respondents on challenges of 4th industrial technologies towards economic development in developing countries. The results revealed that more than half of the respondents presented by 46.7% strongly agreed that ttechnical challenges have made adoption of 4th industrial technologies a very complex thing. *Some of the respondents when contacted directly seems to suggest that these technical challenges ranges from managing big multimedia data, cyber related issues, among others*. This implies that the complex nature of 4th industrial technologies require high technical literacy of participants engaged in them. This suggests that the technological requirement is challenging due to lack of familiarity with those technologies. This could explain why most companies fails to implement smart factories in their organizations. The adoption of such technologies can be meaningless as most of the companies fail to employee the technical requirements, so to overcome this particular challenge it is recommended that companies must heavily invest to provide the technical solutions and support for the successful adoption and implementation of 4th industrial technologies.

Most of the rural areas in developing countries lack the infrastructure to protect digital data from cyber criminals that is essential for economic development in 4th industrial revolution

The table 4 also show respondents' results about technical infrastructure to protect digital data from cyber criminals. The result reveals that lack of well-built infrastructural facilities in developing countries is also one of the biggest challenges of adopting 4th industrial technologies for economic development as it is indicated by 30% of the respondents who agreed that one of the biggest challenges in of 4th industrial revolution is lack of technical infrastructure. This finding could suggest why there is an incline in cyber-attacks on most sectors in developing countries. Most of the developing countries lack the infrastructure that is essential before their economies can rely on the 4th industrial technologies. It is strongly suggested that most developing countries must improve its infrastructure, including the availability of electricity, high speed internet connections and even roads.

This finding is in contentious to current literature which seemed to be consistent with luck of technical infrastructure. Bruhl (2015) pointed out from his findings that Communication networks and internet protocols are among the many information technology infrastructures that need to be built and implemented. Bruhl also suggested that, to facilitate cooperative work on different platforms, standardized interfaces and open architectures should be created as part of this infrastructure. This implies that keeping large amounts of data on not technically approved external server infrastructure raises the issue of cyber security since unauthorized access to the data must be prevented. It is therefore suggested that further training is needed for technical staff and entire employees to adapt to the increased use of virtual work and other 4th industrial technologies.

Luck of highly trained personnel that would be a vital part of an economy relying on smart manufacturing (4th industrial manufacturing technologies)

The table 4 also shows the result on how respondents rated on lack of highly trained personnel that would be a vital part of an economy relying on smart manufacturing. The findings presented that lack of highly trained personnel is also a very big challenge of 4th industrial technologies in developing countries as it is indicated by 13.3% of the respondents. This is also a clear indication that it is one of the biggest challenges. Since 4th industrial technologies offer diverse technologies, this requires highly trained technical personnel to manage and operate them for different purposes. Its strongly suggested that in developing countries, specialized technical personnel be trained by governments, private sectors, academic institutions among others.

Luck of technology-based policies implementation

The Table 4 also reveals the respondents' rating about luck of technology-based policies implementation where it was found out that 6.7% of the respondents agreed that there is serious lack of technology-based policies implementation. This implies that most companies stop at policy documentation level other than implementation. This could suggest why many developing countries prepare funding proposal for supporting technologies implementation but don't allocate funds to facilitate such implementation instead, the fund is diverted to something else such as political activities. This affects the adoption of 4th industrial technologies for economic development in developing countries. This study is supported by Zaman, R. (2022)

who found out that developing countries like Bangladesh has always been slow to implement state-of-the-art modern technologies policies. This attitude of lagging may contribute to the downfall of Bangladesh's economy. He further stated that the upcoming industrial revolution will focus on technology, and those who can leverage the technology, as well as have the capability to advance the technology further, will come out as winners.

5. Recommendations and Further studies

5.1 Recommendations

Developing countries must continue to invest in both physical and digital infrastructure such as reliable and affordable electricity and internet access with an emphasis on digital inclusion. They should partner with private sector in order to accelerate infrastructural development and thus enable 4th industrial technologies adoption.

It is also recommended that developing countries should prioritize the implementation of 4th industrial technologies at the highest level, with personal commitments from country leaderships.

Developing countries must invest on improving their human capital and closing digital skill gaps. Further training is needed for technical personnel and other employees to adapt to the increased use of virtual work

5.2 Further study

Basing on the findings of the research, the researcher identified the areas that still need to be studied and provided some recommendations which will be of great help for future ressearchers.

During the research as well as the analysis process, several other ideas came up that could be of interest and worthwhile to be investigated more thoroughly. Feature researchers need to investigate and identify relationship gaps between academic institutions and industries towards shaping learners in adopting and integrating 5th industrial technologies in economic development.

6. References

1. African Union (2020). The Digital Transformation Strategy for Africa (2020-2030)

2. Ayentimi, D.T. and J. Burgess (2019). Is the fourth industrial revolution relevant to sub-Sahara Africa. *Technology Analysis & Strategic Management*, 31(6), pp.641-652.

3. Bayode A, J.A van der Poll and R.R Ramphal (2019). 4th Industrial Revolution: Challenges and Opportunities in the South African Context A. *7th JOHANNESBURG Int'l Conference on Science, Engineering, Technology & Waste Management (SETWM-19)* Nov. 18-19, 2019 Johannesburg (SA).

4. Beier Grischa, André Ullrich, Silke Niehoff, Malte Reißig, Matthias Habich (2020). Industry 4.0: How it is defined from a sociotechnical perspective and how much sustainability it includes – A literature review, *Journal of Cleaner Production*, Volume 259, 2020, 120856, ISSN 0959-6526, https://doi.org/10.1016/j.jclepro.2020.120856

5. Benkarouba, F. Z., & Benbouzian, M. (2022). The Role of Digital Technologies from Industry 4.0 in Implementing the Circular Economy and Achieving Sustainability. *Industrial Economics Review*, 12, 88-110.

6. Billinghurst. M, "Augmented reality in education," *New Horizons for Learning*, vol. 12, (5), pp. 1-5, 2002

7. Brynjolfsson, Erik, and Andrew McAfee. *The second machine age: Work, progress, and prosperity in a time of brilliant technologies*. WW Norton & company, 2014.

8. Brühl, V. (2015). Wirtschaft des 21. Jahrhunderts – Herausforderungen in der Hightech-Ökonomie, 1st Edn. Wiesbaden: Springer Fachmedien

9. Carlsson, C. (2019). Combining ANFIS and Digital Coaching for Good Decisions in Industrial Processes. Adv. Intell. Syst. Comput. 1000, 190–200. https://doi.org/10.1007/978-3-030-21920-8_18

10. Chen, J.; Yin, X.; Mei, L (2018). Holistic innovation: An emerging innovation paradigm. *Int. J. Innov. Stud*. 2018, 2, 1–13. [Google Scholar] [CrossRef]

11. Conseil national de l"industrie. (2013). The New Face of Industry in France.

12. Dana Matoušková. Digitalization and Its Impact on Business. *Review of Business & Management*' TMP Vol.18., Nr. 2., pp. 51-67. 2022

13. Digital Transformation Scoreboard 2017: Evidence of Positive Outcomes and Current Opportunities for EU Businesses [Internet]. 2017. Available at: http://ec.europa.eu/DocsRoom/documents/21501/attachments/1/translations/en/renditoni

14. Domino (2017). Printing Sciences 'ready for the Industry 4.0 challenge' | Interpack 2017

15. Douglas Letsholathebe (2022). Industry 4.0 for inclusive development. *United Nations Commission on Science and Technology for Development (CSTD)*, twenty-fifth session Geneva, 28 March - 1 April 2022

16. Gibson. I, D. Rosen and B. Stucker, "Additive manufacturing technologies: *Rapid prototyping to direct digital manufacturing*," 2010. https://doi.org/10.1007/978-1-4419-1120-9

17. Gubbi and Jayavardhana, (2013). "Internet of Things (IoT): A vision, architectural elements, and future directions." *Future generation computer systems* 29.7 (2013): 1645-1660.

18. Kazmi, H., F. Mehmood, Z. Tao, Z. Riaz and J. Driesen (2019). Electricity load-shedding in Pakistan: Unintended consequences, opportunities and policy recommendations. *Energy policy*, 128, pp.411-417

19. Kevitdesai (2018) fourth industrial revolution and digital economy - *Destination Digital Africa: Preparing our youth for the future*

20. KPMG, "The Factory of the Future - Industry 4.0: *The challenges of tomorrow*." 2016

21. L.T Chamba & F. Chari (2023). challenges and opportunities for the adoption of the 4th industrial revolution (4ir) in the public sector of developing countries

22. Lopes JM, da Silva Filho LC (2024). Adoption of Fourth Industrial Revolution Technologies in the Construction Sector: *Evidence from a Questionnaire Survey. Buildings.* 2024;14(7):2132.

23. Lou, Karine, Stephan Kreutzer, Francie Sadeski, Matthieu Lecave, and Fiona Merki. (2019). "Country Case Study: Nigeria." Unlocking the Potential of the Fourth Industrial Revolution in Africa. Côte d'Ivoire: *African Development Bank Group. Study Report*.

24. Lund, Susan and Jacques Bughin. 2019. "Next-Generation Technologies and the Future of Trade." VOX CEPR Policy Portal. Accessed June 6, 2020. https://voxeu.org/article/next-generation-technologies-and-future-trade

25. M.T. Dewa, D.Q. Adams, T.G.Tendayi, L. Nyanga, M. Gxamza, and L. Ganduri, "Ndustry 4.0: A myth or a reality in south Africa?" in SAIIE29 Proceedings, Spier, Stellenbosch, South Africa, 2018, .

26. Madakam, S., R. Ramaswamy and S. Tripathi (2015). Internet of Things (IoT): A literature review. *Journal of Computer and Communications*, 3(05), p.164

27. McKinsey (2016). Industry 4.0 after the initial hype: Where manufacturers are finding value and how they can best capture it [Internet]. 2016. Available at: https://www.mckinsey.com/~/media/mckinsey/business%20functions/mckinsey%20dig

28. Mell. P and T. Grance, "The NIST definition of cloud computing," 2011. https://doi.org/10.6028/NIST.SP.800-145

29. Miorandi. D et al(2012). Miorandi D et al, "Internet of things: Vision, applications and research challenges," *Ad Hoc Networks*, vol. 10, (7), pp. 1497-1516, 2012. https://doi.org/10.1016/j.adhoc.2012.02.016

30. Mittal. S (2018). "A critical review of smart manufacturing & Industry 4.0 maturity models: Implications for small and medium-sized enterprises (SMEs)," *J. Manuf. Syst*., vol. 49, pp. 194-214, 2018. https://doi.org/10.1016/j.jmsy.2018.10.005

31. Modgil, S.; Gupta, S.; Bhushan, B (2020). Building a living economy through modern information decision support systems and UN sustainable development goals. *Prod. Plan. Control* 2020, 31, 967–987.

32. Norberto de Almeida Andrade1, Giuliano Carlo Rainatto2, Genésio Renovato da Silva Neto3, Jucilene Moreira de Barros Faria. Digital Transformation and the Fourth Industrial Revolution - *Theory of Disruptive Innovation 2020*.

33. Ndung'u, N., & Signé, L. (2020). Capturing the Fourth Industrial Revolution: A Regional and National Agenda. *Foresight Africa 2020 report*. Brookings Institution.

34. Phadke, A., W.Y. Park and N. Abhyankar (2019). Providing reliable and financially sustainable electricity access in India using super-efficient appliances. *Energy Policy*, 132, pp.1163-1175.

35. Rumi, M.H., Rashid, M.H., Makhdum, N., Nahid, N.U (2020).: Fourth industrial resolution in bangladesh: prospects and challenges. *Asian J. Soc. Sci. Legal Stud*. 2(5), 104–114 (2020)

36. Simbanegavi, W., A. Patel, L. W. Senbet, R.B.A. Mouelhi, J. Gatune, K.Y. Amaoko, S. Mutanga, T. Altenburg, B. Coulibaly and A. Prakash (2018). World of work in the 4th industrial revolution: inclusive and structural transformation for a better Africa. *G20 Insights Policy Briefs*.

37. Signé, L. and Ndung'u, N. (2020) Capturing the Fourth Industrial Revolution—A Regional and National Agenda. Brookings Foresight Africa. https://www.brookings.edu/wp-ontent/uploads/2020/01/ForesightAfrica2020_Chapter5_20200110.pdf

38. Sohail Asghar, Gulmina Rextina, Tanveer Ahmed & Manzoor Illahi Tamimy. The Fourth Industrial Revolution in the Developing Nations: Challenges and Road Map. *Commission on Science and Technology for Sustainable Development in the South (COMSATS)* issue 102

39. World Economic Forum. (2018). The future of jobs report 2018, available at: http://www3.weforum.org/docs/WEF_Future_of_Jobs_2018.pdf, accessed on 07 October 2019.

40. Zaman, R. (2022), "Innovation Diffusion as Progressive Waves", The Waves, 2021, Available at: https://www.the-waves.org/2021/12/05/innovation-diffusion-as-progressive-waves/ , (accessed: October 22, 2023).