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Industry 4.0 Technology Adoption and Market Scalability of Small and Medium Enterprises in Southwest, Nigeria

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ABSTRACT: *The study examined the relationship between i4.0 technology adoption and market scalability of small and medium enterprises in Southwest, Nigeria. The objectives of the study are to; examine the level of awareness of small and medium entrepreneurs of i4.0 technology in Southwest, Nigeria, evaluate the challenges of adoption of i4.0 technology by small and medium entrepreneurs in Southwest, Nigeria, determine the facilities required for the adoption of i4.0 technology by small and medium entrepreneurs in Southwest, Nigeria. The study adopted the descriptive research design of the survey type. Multistage sampling techniques was used to select the samples of one thousand two hundred (1,200) respondents from the owners of MSMEs in Southwest, Nigeria. Structure questionnaire was used to collect data from the respondents. Data collected were analyzed using descriptive statistics, while regression analysis was used to test the hypotheses. Findings of the study revealed that, majority of the small and medium entrepreneurs do not awareness about i4.0 technology in Southwest, Nigeria, the challenges identified as the problem confronting the adoption of i4.0 technology in Southwest Nigeria, which are lack of expertise about i4.0 technology, financial challenges, unstable power supply. The study concluded that, there is significant relationship between i4.0 technology adoption and number of markets covered by small and medium enterprises in Southwest, Nigeria; Based on the findings of this study, it therefore recommended that, owners of MSMEs in Southwest, Nigeria should embrace the adoption of i4.0 technology to increase their profitability.*

KEYWORDS: Industry 4.0, scalability, technology, small and medium enterprises, profitability

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INTRODUCTION

The fourth industrial revolution otherwise known as i4.0 was a development on the first three revolutions. It is a form of internet technology that enables industries to explore the online space to foster collaborations, synergy and methodology that enhances business performance. I4.0 got its quick and wide acceptance not just from its direct impacts on business performance but usability in other spaces like politics and academia. Market scaling is a type of scaling in which a business achieves a larger proportional output from its increase in input. It entails moving a product from its domicile market into new market and customer segments. This may also involve increase in the sales volume, geographical coverage, output and others. Small and medium size enterprises have been identified as one of the key engines of Nigerian economy due to its contribution to GDP and job creation (Adeeko, 2019). The formal sector is unable to meet the employment demands of the growing young population, as a result; millions of young Africans create jobs for themselves and others (Adeeko and Osunade, 2022).

There were 1,557,438 SMEs in Southwest, Nigeria, according to SMEDAN report 2022. The activities of these SMEs cut across the various forms of businesses such as trading, hairdressing, makeup artistry, catering, fashion designing, bead making, photography, and phone repairs among others. Probably, the alarming rate of i4.0 technology's adoption among the various business not leaving out the SMEs in Southwest, Nigeria, is what have led to the rate of new markets and products entrants and consequently, market scaling being experienced in the industry. However, this is the question this study seeks to answer. It is against this backdrop that this study is set to examine the relationship between industry 4.0 (i4.0) technology adoption and market scalability of small and medium enterprises in Southwest, Nigeria.

Research Objectives

The purpose of the study was to investigate the relationship between industry 4.0 (i4.0) technology adoption and market scalability of small and medium enterprises in Southwest, Nigeria. Specifically, the study:

1. What is the level of awareness of small and medium entrepreneurs of i4.0 technology in Southwest, Nigeria?
2. What are the challenges of adoption of i4.0 technology by small and medium entrepreneurs in Southwest, Nigeria?
3. What are the facilities required for the adoption of i4.0 technology by small and medium entrepreneurs in Southwest, Nigeria?
4. There is no significant relationship between i4.0 technology adoption and number of markets covered by small and medium enterprises in Southwest, Nigeria;
5. There is no significant relationship between i4.0 technology adoption and sales volume of small and medium enterprises in Southwest, Nigeria;

6. There is no significant relationship between i4.0 technology adoption and profitability of small and medium enterprises in Southwest, Nigeria.

Research Question

The following research questions were raised to guide the study:

1. What is the level of awareness of small and medium entrepreneurs of i4.0 technology in Southwest, Nigeria?
2. What are the challenges of adoption of i4.0 technology by small and medium entrepreneurs in Southwest, Nigeria?
3. What are the facilities required for the adoption of i4.0 technology by small and medium entrepreneurs in Southwest, Nigeria?

Hypotheses

The hypotheses formulated and tested at 0.05 level of significance were:

1. There is no significant relationship between i4.0 technology adoption and number of markets covered by small and medium enterprises in Southwest, Nigeria;
2. There is no significant relationship between i4.0 technology adoption and sales volume of small and medium enterprises in Southwest, Nigeria;
3. There is no significant relationship between i4.0 technology adoption and profitability of small and medium enterprises in Southwest, Nigeria.

LITERATURE REVIEW

The origin of Industry 4.0 (i4.0) could be traced to a German federal government program that encompassed private businesses and universities in 2011. Kagermann and Helbig (2013) reported that the purpose of the program was to boost German's local industry through improved productivity and efficiency by developing the best production system. The Founder and Executive Chairman of the World Economic Forum, Klaus Schwab while airing his view in 2015, noted that the Fourth Industrial Revolution is a development on the digital revolution that has been evolving since few years back known as third digital revolution. In this technology, physical, biological and digital spheres interface. Scope, velocity and systems impact are the hallmark and the reasons for the distinguished fourth revolution. The diffusion rate of i4.0 is not what can be compared to any of the previous ones as it is moving at an exponential rate. Its disruptive impact on largest percentage of industry globally and the deepness of its moves have birthed transformation of the management, governance and production systems. The Internet of Things and Internet of Services are the bedrocks of i4.0. The implication of this is that every component, product and machine are embedded and interacted with the digital technology. Pozdnyakova, Golikov, Peters, &Morozova(2019), while buttressing this, believed that all German enterprises should run on internet industrial technology by 2023 because as of date, half of the industrial enterprises in Germany are internet inclined.

Industry 4.0 has some technological components. According to Romanova and Kuzmin (2021), the Internet of Things, 3D printing, cyber-physical systems and networks are the main bedrock of industry 4.0 while advanced materials, digital technologies, new energy and biotechnologies and environmental protection focused technologies are the main technological systems. The Fourth Industrial Revolution basically encourages organizations that adopts interfaced framework for education, science, commerce and network incorporating individual producer or manufacturer. Fedushko, Ustyianovych, Syerov&Peracek (2020) aired their opinion on this and stated that with the incorporation of digital networks, ICT and on-line technologies, dynamism with flexibility in the structure of internal networks gets introduced into the economic systems. Romanova and Kuzmin (2021) agreed that new technological system allows for quick and easy adaptation to environmental and market situation changes and disruption. Sukhodolov (2019) also concurred that the birth of industry 4.0 came after discovering new technologies such as the internet and digital networks; without the interface of human effort, these technologies process automatically.

Moreover, acquisition of modern and efficient IT infrastructure and facilities would make easy transition for industries to industry 4.0; the opportunities accrued to the transition would be seen against the threat. Facilitation of production process through the use of internet technologies births greater efficiency as the intelligent machines would interact with one another easily. Sima, Wu, Tian, Xie, Foo, Li & Liu (2020)noted that one of the challenges prone to organizations is to identify and sought for the workforce to facilitate the implementation of the production process. The challenge for organizations is to find a knowledgeable workforce that has the skill and potential needed to implement such a production flow. They also noted that the whole value chain will change as the relationships between suppliers, organizations, customers, and other stakeholders will be affected. Flexibility will be brought to the production process as customers' needs will be the vocal point. Also, Carvalho and Cazarini (2020) submitted that every industry across the globe is gradually adopting industry 4.0 is a model of advanced production. Cugno, Castagnoli, Büchi&Pini (2022) believed that acquisition of new skills, potential and competencies coupled with the deliberate efforts to modify the activities, practices and workplaces of the organization are germane to the full adoption of Industry 4.0 technologies.

Scholars such as Wang, Huang, Gao, Zhang, & Liang (2021) argued that recently, the development of i4.0 has been assisted by the manufacturing innovation technologies with digital and technological transformations which are seen as key to the implementation and adoption of the Industry 4.0 paradigm. On this, Ceipek, Hautz, De Massis, Matzler&Ardito (2021)opined that inculcating technological based innovations which is a key feature of i4.0 can breed improved production and efficiency with a subsequent result of wealth and economic improvement. According to Caruso (2018), the characteristics of Industry 4.0 among others are production of mass goods on short runs, production capacities networking, fragmentation of value chain globally, enhancement of collaborations among producers, sellers, customers with the industry and services sectors. Additionally, Caruso observed that industry 4.0 has the characteristic that enables the use of information and communications technologies (ICTs) that promotes cordial relationship

between the players of value chain by breaking down relationship barriers. Klingenberg, Júnior& Müller-Seitz (2022) added that i4.0 leverages on the usage of artificial intelligence (AI), modelling and simulation, nano-engineering of materials, advanced robotics, massive digitization, adaptive automation, additive and precision manufacturing and big data analytics.

However, small and medium enterprises (SMEs) is one of the major sectors that need to key into i4.0 technologies for enhanced productivity and competitive advantages in the highly competitive industry. Meanwhile, Faller and Feldmúller (2015) reported that it may be difficult for small or medium-sized enterprises (SMEs) to adopt i4.0 technologies due to the fund involvement and other related issues unlike the large companies who have enough resources and fund to implement trends that relate to technology. Hermann, Bücker, Pentek& Otto (2016). identified this as a national concern as a result of their contribution to the national economy and believed that SMEs should receive support from the society for them to experience evolution in the businesses. Zhong, Xu, Klotz& Newman (2017) noted due to envisage that i4.0 will be disruptive like the first three industrial revolutions in the industry, SMEs must be ready and intentional of its adoption. Meanwhile, it is noteworthy that the evolution of I4.0 has not come without some challenges that has been hampering its adoption in the industry. Gorecky, Zamfirescu, Pirvu&Chakravarthy (2014) believed that the main challenge to i4.0 adoption is demanding research and development from the academic industry. According to Li, Hou, & Wu (2017), there is an agreement in literature confirming the quest for directive on the implementation and management of operations of the technologies as they change in complexities. Wan, Tang, Shu, Li, Wang, Imran&Vasilakos (2016) agreed that the biggest challenge to an industry that wants to interconnect and blend all its factors of production is networking its heterogeneous systems. They noted the unavailability of standard solution that enhances the networking of vendor specific interfaces and communication protocols. However, Thoben, Wiesner&Wuest (2017) had a contrary view by stating that there is need for preservation of privacy and restriction of access to illegible users to having access to networking capabilities. Other scholars such as Müller, Kiel& Voigt (2018) argued that some industries resist transparency while others see sharing of data and information as a means of enhancing performance in the operations. Oesterreich and Teuteberg (2016) noted lack of protective infrastructure and vulnerability to cyber-attacks in some SMEs had led to their consistence resistance.

In another development, the value or worth of SMEs' performance can be measured by their ability to grow their profit while minimizing cost over time. Jorgenson (2001) submitted that propensity or ability of IT firms to achieve growth impressively at a minimized cost which is termed as 'scaling' is the measure of their prosperity. Coutu (2014) stated that the term scalability was inspired by Silicon Valley firms' success stories. Autio, Mudambi&Yoo(2021) and Shepherd &Patzelt (2020) also noted that the term scaling had a fast adoption in the entire business environment, academic literature and the political cycle. Autio et al. (2021)argued of recent that there has been no consistency in the application of the term scaling due to its lack of specific definition. Mader&Wincent (2023) defined scaling as an addition to the input that yields a larger

proportional output. Specifically they said "scaling as an *increase in the size of a focal subject that is accompanied by a larger-than-proportional increase in the performance resulting from the said subject*'. Here, subject refers to what is being scaled such as size and number of market served, number of customers, geographical coverage and number of product sold, among others.

The scaling definition offered by Mader&Wincent (2023) implies that scaling in firms can be promoted by synergies among firms, economies of scope and scale. That is, performance can be improved by economies of scope and synergies when combined output grows more than the combined input. Secondly, in support of an earlier submission by Keupp, Palmié&Gassmann (2012), from the management perspective, performance connotes financial returns, i.e economic returns and performance. Thirdly, scaling is not restricted to startups/new ventures. Some businesses may still be able to increase their focal products, markets, services and other input related performance indices even when established businesses may not achieve any improvement in their turnover or other performance indicating factors. Lastly, the definition makes room for multiple relative scaling measurement by its transformation to quantitative measures of scaling. This is done by measuring scaling across organizations or by measuring scaling of an organization across a specific time otherwise known as absolute scaling. There are different types of scaling. According to Mader&Wincent (2023) scaling are of four types, these are: market scaling, financial scaling, volume scaling and organizational scaling. Meanwhile, this study will focus on market scaling, as bothers on number of markets, profitability and sales volume.

Studying market scaling of small and medium-sized enterprises (SMEs) could be very attractive because of their incapacitation in realizing economies of scale and inability to compete especially on price basis. While buttressing this, Belyaeva, Rudawska&Lopatkova (2020) stated that SMEs must adopt competitive methods different from those of large firms since it is often very difficult for them to enjoy economies of scale and price competitiveness. Market scaling entails get products out of their production domain to an entirely new market segment, geographical region and customer segments. Lu & Beamish (2001) agreed with this view by stating that scale and scope economies are the most identified gains. These are gains from increased turnover and output which are achieved by increase in revenue in the markets geographical extension. Also, Adeniyi and Adeeko (2023) agreed that digital technology enhances small business performance. However, several related studies have been credited to this subject matter but have been discredited because none was found to have used the specific variables of the study such as number of market coverage, sales volume and profitability to investigate the relationship between industry 4.0 (i4.0) technology adoption and market scalability of small and medium enterprises in Southwest, Nigeria. This therefore represents the gap this present study has filled.

METHODOLOGY

The study adopted the descriptive research design of the survey type. The population of the study consisted of all the owners of MSMEs in Southwest, Nigeria which were one million, five hundred

and fifty five thousand, four hundred and thirty eight (1,557,438), (national survey of SMEDAN, 2022). The sample of the study consisted of one thousand two hundred (1,200) respondents which was achieved through multi stage sampling techniques. The first stage involved the use of simple random sampling technique to select four (4) out of the six (6) states in the region. The selected states were Ondo, Ekiti, Oyo and Osun States. The second stage involved the use of proportional stratified random sampling technique to select respondents from each of the sampled states. Three hundred and eight five (385) respondents were selected from Ondo State, two hundred and thirty five (235) from Ekiti State, three hundred and ten (310) from Oyo State and two hundred and seventy (270) from Osun State. The study adopted an instrument tagged 'I4.0 Technology Adoption and Market Scalability of Small and Medium Enterprises in Southwest, Nigeria (I4.0MS). The questionnaire was structured on a five-point Likert scale as follows: Strongly Agreed (SA), Agreed (A), Strongly Disagreed (SD) Disagreed (DA) and Neutral (N). The instrument was subjected to face and content validity by some experts in entrepreneurial studies department. The reliability of the instrument was estimated at 0.84 using Chronbach's Alpha reliability method. The data collected for this study was analyzed using both descriptive and inferential statistics. All hypotheses was tested at 0.05 level of significance.

RESULTS AND DISCUSSION

Data generated for this study are presented in the tables below.

Table 1. Schedule of Questionnaire distribution

S/N	Questionnaire	No returned	Percentage (%)
1.	Completed and returned	1,116	93.0
2.	Not returned	60	5.0
3.	Discarded	24	2.0
	TOTAL	**1,200**	**100**

Source: Field work (2023)

Total samples of one thousand and two hundred (1,200) questionnaire were distributed to the respondents, one thousand one hundred and sixteen (1,116), which represent (93.%) were dully filled and returned, upon which the analysis is based.

Socio-Demographic Characteristics of the respondents

Table 2: Socio-Demographic Characteristics of the respondents

Gender of respondents	**Frequency**	**Percent %**
Male	706	63.3
Female	410	36.7
Total	**1116**	**100.0**
Age		
18-29 years	148	13.3
30-39 years	298	26.7
40-49 years	439	39.3
50 years and above	231	20.7
Total	**1116**	**100.0**
Marital Status		
Married	684	61.3
Single	432	38.7
Total	**1116**	**100.0**
Educational Qualification		
Primary	82	7.4
Secondary	416	37.3
Tertiary	617	55.3
Total	**1116**	**100.0**

Source: Fieldwork (2023)

The table 2 revealed the demographic data of the respondents 706 (63.3%) of the respondents were male, while 410(36.7%) of the respondents were female, 439 (39.3%) of the respondents' age lies between (40 – 49 years. 684 (61.3%), of the respondents were married, while, 617(55.3%) of the respondents have tertiary education.

What is the level of awareness of small and medium entrepreneurs of i4.0 technology in Southwest, Nigeria?

Table 3: Level of awareness of small and medium entrepreneurs of i4.0 technology in Southwest, Nigeria

Items	SA	A	D	SD
My organization uses E-Commerce	8(.7%)	104(9.3%)	580(52.0%)	424(38.0%)
Using Social Media for marketing	670(60.0%)	167(10.0%)	335(30.0%)	0(0%)
Financial Technology Application	134(12.0%)	116(10.0%)	335(30.0%)	535(48.0%)
Digital Payment System	0(0%)	0(0%)	580(51.3%)	536(48.7%)
Internet Banking	781(70.0%)	167(10.0%)	167(10.0%)	167(10.0%)

Source: Fieldwork (2023)

Table 3 revealed that, 580(52.0%) of the respondents disagreed that, their organization use E-Commerce, 670(60.0%) of the respondents strongly agreed of Using Social Media for marketing, 535(48.0%) of the respondents strongly disagreed using Financial Technology Application for their business, 580(51.3%) of the respondents disagreed about awareness of Digital Payment System, while 781(70.0%) of the respondents strongly sagreed about the awareness of internet banking.

What are the challenges of adoption of i4.0 technology by small and medium entrepreneurs in Southwest, Nigeria?

Table 4: Challenges of adoption of i4.0 technology by small and medium entrepreneurs in Southwest, Nigeria

Items	SA	A	D	SD
Lack of expertise about i4.0 technology	583(55.0%)	281(26.6%)	142(13.4%)	53(5.0%)
Financial challenges	212(20.0%)	487(46.0%)	219(20.7%)	141(13.3%)
Unstable power supply	283(26.7%)	565(53.3%)	141(13.3%)	71(6.7%)
Lack of sensitization about the benefit of i4.0 technology	246(23.3%)	707(66.7%)	71(6.7%)	34(3.3%)
Poor managerial kills	671(63.3%)	283(26.7%)	34(3.3%)	71(6.7%)

Source: Field Survey (2023)

Table 4 revealed that 583(55.0%) of the respondents strongly agreed that the challenge is lack of expertise about i4.0 technology, 487(46.0%) of the respondents agreed that, it is financial challenges, 565(53.3%) of the respondents agreed that it unstable power supply. Also, 707(66.7%) of the respondents agreed that, Lack of sensitization about the benefit of i4.0 technology, while, 671(63.3%) of the respondents strongly agreed that Poor managerial skills.

Table 5: What are the facilities required for the adoption of i4.0 technology by small and medium entrepreneurs in Southwest, Nigeria?

Items	**SA**	**A**	**D**	**SD**
Acquisition of technical and technological skills	580(52.0%)	424(38.0%)	8(.7%)	104(9.3%)
Availability of modern equipment	335(30.0%)	670(60.0%)	0(0%)	167(10.0%)
Constant and regular power supply	335(30.0%)	535(48.0%)	134(12.0%)	116(10.0%)
Sensitization about the benefit of adoption of i4.0 technology	580(51.3%)	536(48.7%)	0(0%)	0(0%)
Good managerial kills	781(70.0%)	167(10.0%)	167(10.0%)	167(10.0%)

Source: Fieldwork (2023)

Table 3 revealed that, 580(52.0%) of the respondents strongly agreed that, acquisition of technical and technological skills is a must for the adoption of adoption of i4.0 technology by small and medium entrepreneurs in Southwest, Nigeria. , 670(60.0%) of the respondents agreed that availability of modern equipment, 535(48.0%) of the respondents agreed that constant and regular power supply, 580(51.3%) of the respondents strongly agreed that sensitization about the benefit of adoption of i4.0 technology, while 781(70.0%) of the respondents strongly agreed that it is good managerial skills.

$H_0$1: There is no significant relationship between i4.0 technology adoption and number of markets covered by small and medium enterprises in Southwest, Nigeria

Table 6: relationship between i4.0 technology adoption and number of markets covered by small and medium enterprises in Southwest, Nigeria Model Summary

Model	R	R square	Adjusted R .Square	Std error of Square the estimate	df	Sig.
1	.783 [a]	.969	.963	2.391	1115	000

Source: Fieldwork (2023)

Decision: The significant level is .000 which is less than 0.05, there is a significant relationship between i4.0 technology adoption and number of markets covered by small and medium enterprises in Southwest, Nigeria**.** The regression helps us to conclude with the R (coefficient of correlation) that there is 78.3% direct relationship between 4.0 technology adoption and number of markets covered by small and medium enterprises in Southwest, Nigeria**.**

$H_0$2: There is no significant relationship between i4.0 technology adoption and sales volume of small and medium enterprises in Southwest, Nigeria

Table 7: Relationship between i4.0 technology adoption and sales volume of small and medium enterprises in Southwest, Nigeria

Model	R	R square	Adjusted R .Square	Std error of Square the estimate	df	Sig.
1	.813 [a]	.659	.963	5.214	1115	001

Source: Fieldwork (2023)

Decision: The significant level is .001 which is less than 0.05, there is significant relationship between i4.0 technology adoption and sales volume of small and medium enterprises in Southwest, Nigeria**.** The regression helps us to conclude with the R (coefficient of correlation) that there is 81.3% direct relationship between i4.0 technology adoption and sales volume of small and medium enterprises in Southwest, Nigeria.

$H_0$3: 3. There is no significant relationship between i4.0 technology adoption and profitability of small and medium enterprises in Southwest, Nigeria

Table 7: relationship between i4.0 technology adoption and profitability of small and medium enterprises in Southwest, Nigeria

Model	R	R square	Adjusted R .Square	Std error of Square the estimate	df	Sig.
1	.776 [a]		.603	.553	1115	002

Source: Fieldwork (2023)

Decision: The significant level is .002 which is less than 0.05, there is significant relationship between i4.0 technology adoption and profitability of small and medium enterprises in Southwest, Nigeria**.** The regression helps us to conclude with the R (coefficient of correlation) that there is 77.6% direct relationship between i4.0 technology adoption and profitability of small and medium enterprises in Southwest, Nigeria.

DISCUSSION OF FINDINGS

The findings of this study revealed that, majority of the small and medium entrepreneurs do not awareness about i4.0 technology in Southwest, Nigeria, while relative number of them aware about it. The following challenges were identified as the problem confronting the adoption of i4.0 technology in Southwest Nigeria, which are lack of expertise about i4.0 technology, financial challenges, unstable power supply, lack of sensitization about the benefit of i4.0 technology, poor managerial skills. The study also revealed that, there is significant relationship between i4.0 technology adoption and number of markets covered by small and medium enterprises in Southwest, Nigeria; there is significant relationship between i4.0 technology adoption and sales volume of small and medium enterprises in Southwest, Nigeria; there is significant relationship between i4.0 technology adoption and profitability of small and medium enterprises in Southwest, Nigeria. Based on the findings of this study, it can therefore be concluded that, the adoption of i4.0 technology is a must for any small and medium enterprises who want remain competitive in the global trend. Based on the findings of this study, it therefore recommended that, owners of MSMEs in Southwest, Nigeria should embrace the adoption of i4.0 technology to increase their profitability.

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