Empirical Pathway of the Influence of Technological Factors on Acceptance to Adopt Industry 4.0 Technology Among Some Selected SMES Within Bauchi State

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Abstract
The general objective of this research works was to assess and validate a Pathway of the Influence of Technological Factors on Acceptance to adopt Industry 4.0 Technology among some selected SMEs within Bauchi State. The increasing use of technology by firms for innovative manufacturing has necessitated the need to further understand the factors that influence the rate of technology adoption by Small and Medium Enterprises SMEs in Nigeria, specifically amongst SMEs in Bauchi State. Unified theory of Acceptance and Use of Technology (UTAUT) was used as the underpinning theory in this research work. Related literatures by various authors on Industry 4.0 Technology were reviewed, survey research method was adopted. Three formulated research questions were developed into three research hypotheses which guided the study. A structured questionnaire was the instrument used for data gathering and the population for the study was 627 registered SMEs in Bauchi South Senatorial districts while the sample size used was 35 selected SMEs. The Data collected was analyzed using Smart PLS SEM 4.0 and SPSS 20. The findings of the study revealed that, Perceived Relative Advantage (PRA), Perceived Compatibility (PCT) and Perceived Complexity (PCX) were found to be positively and significantly associated with SMEs intention to adopt industry 4.0 technologies. It was concluded that in order to remain competitive, it is important for SMEs to stay up to date with the latest trends in technology and techniques. Among the recommendation was that SMEs should endeavour to adopt the use of industry 4.0 technology facilities so as to maintain high standards of quality production to effectively satisfy the need of their customers.

Keywords: *Pathway, Industry 4.0 Technology, SMEs, Intention to adopt, Influence.*

1. Background of the Study

The increasing integration of technology in business operations has heightened the need to understand the factors influencing technology adoption among Small and Medium Enterprises (SMEs) in Nigeria, particularly in the context of SMEs in Bauchi State. Technological advancements have led to widespread of its adoption across various sectors, including SMEs, which are globally recognized as pivotal drivers of economic growth, job creation, and income redistribution within economies. Information and Communication Technology (ICT) has emerged as a crucial tool for disseminating valuable information and supporting decision-making

processes, thereby becoming integral to business development and economic progress. As technological innovation continues to accelerate, SMEs must be prepared to adapt to these emerging trends, particularly within an uncertain economic landscape (Muhamad, Syed-Mohamad &Nor, 2021).

Industry 4.0 encompasses the adoption of modern production methodologies, including Just-In-Time (JIT), Lean Technology, and Agile Technology. However, the adoption of these advanced systems within the Nigerian context remains at a nascent stage, as a substantial number of SME operators continue to rely on traditional methods that are ill-suited to meet contemporary operational challenges (Akintayo, Akinlabi, Okokpujie, Ishola, & Akinlabi, 2021).

One critical strategy for enhancing the manufacturing capacity of Nigerian SMEs lies in the adoption of advanced manufacturing technologies. Unfortunately, these technologies have not been effectively utilized within the country's industrial sector as a tool for competitive advantage. Although SMEs contribute significantly to the broader economic landscape by fostering strong connections with various economic activities, their overall impact on industrial development has been limited. Many small enterprises in Nigeria face high failure rates within the first few years of operation, largely due to constraints such as excessive taxation and reliance on obsolete technologies advancements (Akintayo et al, 2021).

According to Igwe, Ebenuwa, Idenedo, (2020), the importance of technology adoption has been acknowledged, it remains largely underdeveloped in many developing nations, including Nigeria; consequently, it is essential for Nigerian SMEs, particularly in the manufacturing sector, to fully embrace and implement advanced technologies to position themselves as key contributors to the national economy. Researchers studying technology adoption among SMEs emphasize that firms must critically assess and evaluate their current technological conditions to identify gaps and better align with future technological requirements.

The increasing competition in product design, innovation, and supply compels manufacturers to adopt a more responsive and flexible approach. For SMEs to remain competitive, effective integration and use of cutting-edge technology is imperative to enhance their overall performance. However, achieving this in an environment constrained by financial and operational challenges presents significant hurdles (Xuan and Quang, (2020).

Adopting Industry 4.0 requires businesses to find ways to rebuild, modify, and customize their machines to meet the new demands of modern technology. However, it is concerning to see that many businesses do not fully understand the critical factors in adopting Industry 4.0, even though they acknowledge that they understand its potential (Narula, Prakash, Dwivedy, Talwar & Tiwari, 2020). As a result, the adoption factors identified are crucial to take into account for the successful implementation of this megatrend technology, which aims to increase overall efficiency and effectiveness to have transparency and more accuracy (Narula et al., 2020).

2. Statement of the Problem

Industry 4.0 technology, characterized by the integration of digital and physical systems in manufacturing, has introduced a disruptive shift across various industries. Manufacturing firms, particularly small and medium-sized enterprises (SMEs), face numerous challenges and must continuously innovate to remain competitive. In developing countries, many SMEs struggle to transition swiftly to fully integrated production and management systems. As a result, it is critical to formulate a strategic approach for adopting industrial advancements in their businesses.

Innovation is widely recognized as a crucial asset, yet the Nigerian manufacturing sector remains underdeveloped (Igwe et. al., 2020). A significant number of SME operators continue to rely on

traditional methods rather than adopting modern technologies. These outdated technologies are insufficient to address contemporary manufacturing and management challenges; while large corporations and smaller technology-driven firms are actively investing in the opportunities presented by Industry 4.0, many SMEs lack the necessary resources, technology and expertise to participate in this technological shift. The capacity to adopt Industry 4.0 technologies varied significantly amongst larger enterprises and SMEs due to disparities in financial resources, technical expertise, and experience in managing new technologies (Akintayo et. al., 2021).The disparity in resources has profound effect on the industry, evidenced by the decline in small-scale firms that are unable to compete with larger companies capable of producing higher-quality products more efficiently and cost-effectively (Muhamad et al., 2021).

Although adopting Industry 4.0 and the utilization of information and communication technologies are expected to greatly enhance SME development and competitiveness, the technology has not yet garnered sufficient trust among SME management. This hesitancy stems from the gap between financial limitations and the creative capabilities required for successful adoption (Mirwan, Titis, Fitri, & Tsuyoshi, 2021).

Additionally, SMEs often lack both the human and financial resources necessary to thoroughly assess the potential advantages and disadvantages of adopting Industry 4.0 technologies; many SMEs, rather than experiencing growth, are merely struggling to survive due to financial constraints (Dominik, Vladimír, & Helmut, 2020).

While numerous studies like Dominik, et al., (2020), Muhamad et al., (2021), Mirwan et al., (2021), Xuan and Quang, (2020), Narula et al., (2020) have explored the adoption of Industry 4.0 technologies amongst SMEs, there is a scarcity of research specifically addressing the intention of Nigerian SMEs—particularly those in Bauchi State to adopt these technologies. Therefore, this study seeks to fill this gap by assessing and validating the Influence of Technological Factors on SME Intention to Adopt Industry 4.0 Technology in Bauchi State.

3. Research Objectives of the Study

The study specifically seeks to:

1. Assess the relationship between perceived relative advantage and SMEs intention to adopt Industry 4.0 technology in Bauchi State.
2. Ascertain the relationship between perceived compatibility and SMEs intention to adopt industry 4.0 technology in Bauchi State.
3. Identify the relationship between perceived complexity and SMEs intention to adopt Industry 4.0 technology in Bauchi State.

4. Research Hypotheses

H_a1: Perceived relative advantage is positively associated with SMEs intention to adopt industry 4.0 technologies in Bauchi State.

H_a2: Perceived compatibility is positively associated with SMEs intention to adopt industry 4.0 technologies in Bauchi State.

H_a3: Perceived complexity is positively associated with SMEs intention to adopt industry 4.0 technologies in Bauchi State.

5. Empirical Review

Muhammad and Imronudin (2023) examine the influence of relative advantage, compatibility, complexity, observability and trialability on the intention to use. The study population consisted

students in the Surakarta area who were users of the Dana e-wallet and had engaged in online transactions using the application. A total of 162 respondents participated in the study. Data collection was carried out through questionnaire distribution, and the data were analyzed using Structural Equation Modeling-Partial Least Squares (SEM-PLS). The findings revealed that relative advantage significantly influences the intention to use e-wallets, while compatibility has a significant effect on mobile payment adoption. Complexity, however, was found to have no significant impact on the intention to adopt e-wallets. Observability and trialability both exhibited significant effects on the intention to use e-wallet services. The study concluded that technology adoption and acceptance by the community were positively influenced by high values of relative advantage, compatibility, trialability and observability, as these characteristics enhance adoption. Conversely, low complexity is essential for adoption, as high complexity negatively impacts technology acceptance.

Saeedi, Juwaidah and Kelly, (2022) studied "intention to adopt industry 4.0 technologies among Malaysian dairy manufacturing SMEs". Their study explores small and medium enterprises (SMEs) who were the key economic growth engines that play vital roles in Malaysia's economy and were considered the backbone of industrial development. Presently, the dairy manufacturing industry was one with high potential. Technology is one of the enablers that assist companies to enhance their performances. Currently, SMEs were still hesitant to embrace and adopt new technology. The fundamental objective of their study was to identify the determinants of the intention to adopt Industry 4.0 technologies among SMEs in Malaysia. Data were collected from 114 managers of Small and Medium Enterprises (SMEs) and analyzed using SPSS. Their findings from multiple regression revealed that the intention of SMEs to adopt Industry 4.0 Technologies was positively influenced by perceived usefulness (PU), perceived ease of use (PEU), subjective norm (SN), perceived behaviour control (PBC) and attitude (Att). Attitude had partial mediation effects on both relationships between PU and intention. It also has relationships between PEU and intention in adopting Industry 4.0 Technologies. The study concludes and supports the assumptions of two theories - Theory of Planned Behaviour (TPB) and Technology Acceptance Model (TAM). Their study contributes to enhancing managers and higher authority of SMEs in deciding the future course of their manufacturing firms and policymakers in mapping out plans for Malaysian SMEs in the dairy manufacturing industry.

Grufman, Lyons, and Sneiders (2020) in "exploring readiness of SMEs for industry 4.0" examined the readiness of SMEs for the fourth industrial revolution characterized by interconnected and autonomous virtual and physical systems. Using literature review and grounded theory, the study identified organizational challenges, such as the need for company-specific strategies and skilled employees, as significant barriers. Opportunities include flexibility, cloud computing, and public investment. The study concludes that SMEs' readiness for Industry 4.0 remains relatively low, indicating a need for further development and support.

Muhamad et al., (2021) ditto "technological-organizational-environmental (TOE) framework in industry 4.0 adoption among SMEs in Malaysia" address the influence of industry 4.0 technology on Malaysian SMEs, which are vital to the national economy. The research explores how the TOE framework can analyze factors influencing Industry 4.0 adoption among these enterprises. The study highlights the challenges faced by SMEs in Malaysia, including technological, organizational, and environmental factors, and emphasizes the importance of adopting Industry 4.0 to maintain competitiveness and innovation.

In another study Muhamad et al., (2021) proposed a conceptual framework for SMEs' readiness for Industry 4.0 in "Navigating the Future of Industry 4.0 in Malaysia." The study asserts that

small and medium-sized enterprises (SMEs) must proactively adapt to rapidly evolving technologies for effective leverage of the opportunities presented by Industry 4.0. The proposed framework focuses on factors such as people, processes, and technology (PPT) to enhance SMEs' readiness and contribute to significant development within the Malaysian context.

Jayashree et al. (2021) conducted an empirical study on Malaysian SMEs" investigating the relationship between Industry 4.0 technology implementation and sustainability goals. The study employs structural equation modeling to demonstrate whether technological innovation exerts a positive influence on both the implementation of Industry 4.0 and sustainability outcomes. The studied discovered effective implementation of Industry 4.0 serves as a mediating factor in the relationship between innovation attributes and the achievement of sustainability objectives. Chonsawat and Sopadang (2021) in "Smart SMEs 4.0 Maturity Model to Evaluate the Readiness of SMEs Implementing Industry 4.0" proposed a maturity model for assessing SMEs' readiness for smart manufacturing. The model, consisting of five dimensions and 43 sub-dimensions, was tested in Thailand, showing its effectiveness in evaluating and guiding SMEs' transition to Industry 4.0.



***Figure 1*:** Research framework

6. Methodology

In conducting this research, a survey design was employed and the study was tested and analyzed in Bauchi State. The study population comprises 627 registered SMEs in Bauchi south senatorial district comprising seven (7) Local Governments Areas. The source for this population was MSMEs Development Agency of Nigeria survey report of 2021. The study sample size was 35 selected SMEs where census sampling technique was employed to determine the sample size and ensure each unit within the population had an equal probability of being included in the sample. The unit of analysis was Owner/Manager within SMEs in Bauchi State. The instrument used for data collection was a structured questionnaire which was subjected to face and content validation by experts in the field of Management Science. Reliability analysis was conducted to assess internal consistency of the study variables. Cronbach's Alpha coefficient was computed on all components of the questionnaire and their assessment given; Alpha of 0.7 and above was used in this study as a threshold. Primary method of data collection was used. Questionnaire was administered to the respondents and retrieved personally by the researcher and a research assistant for analysis. The data collected from the respondents based on the questionnaire distributed to them was analyzed using Smart PLS SEM 4.0 and Statistical Package for Social

Science (SPSS V.20). The original copy was the composite and founding evidence.

7. Hypotheses Testing

Significance Effects of Direct (Path Coefficient)

Hypothesis	Relationships	Standard Beta	t-Value Stat	p-Value	Decision
H_1	PRA -> IA	0.334	1.784	0.000	Supported
H_2	PCT -> IA	0.390	1.762	0.000	Supported
H_3	PCX -> IA	0.236	1.653	0.000	Supported

Source: Field Survey, 2026

H_1: Perceived relative advantage is positively associated with SMEs intention to adopt industry 4.0 technologies.

The first alternate hypothesis of the study postulates that "Perceived relative advantage is positively associated with SMEs intention to adopt industry 4.0 technologies." (H_1). As indicated in the result of table 4.7, this relationship was supported, as the path coefficient for this relationship shows a statistically positive and significant result with **(**β =0.334, t-value =1.784, and p<0.000**)**. This very finding of (H_1) was also empirically complemented by prior studies. Several scholars like Muhammad & Imronudin, (2023), Riccardo et al., (2020), Jayashree et al. (2021), Bai C., Dallasega P., Orzes G. and Sarkis J., (2020) and Vytautas et al. (2020) statistically agree that Industry 4.0 technology provides beyond economic advantages, numerous opportunities for environmental and social sustainability. Theoretically, this finding can also be supported by the Unified Theory of Acceptance and Use of Technology (UTAUT) by Venkatesh et al. (2003).

H_2: Perceived compatibility is positively associated with SMEs intention to adopt industry 4.0 technologies.

Similarly, the second alternate hypothesis (H_2), which postulates that "Perceived compatibility is positively associated with SMEs intention to adopt industry 4.0 technologies" was also supported. This is so because the path coefficient for this relationship, as shown in Table 4.7, turns out to be statistically positive and significant with **(**β =0.390, t-value =1.762 and p<0.000**)**. Empirically, this finding is consistent with existing literature, including the study by Usman et al. (2019), Xuan and Quang (2020). Muhammad and Imronudin (2023), Martin (2019) and Jayashree et al. (2021). Theoretically, this finding can also be supported by the Unified Theory of Acceptance and Use of Technology (UTAUT) by Venkatesh et al. (2003).

H_3: Perceived complexity is positively associated with SMEs intention to adopt industry 4.0 technologies.

The third alternate hypothesis (H_3), which postulates that "Perceived complexity is positively associated with SMEs intention to adopt industry 4.0 technologies" was also supported as the path coefficient that specified this relationship was statistically positive and insignificant with β =0.236, t-value =1.653 and p<0.000**).** Empirically, the finding of this hypothesis three (H_3) was in line with Hashimy, et al. (2023), Wischmann, et. al., (2019), Lai-Wan, Lai-Ying, Jun-Jie, Garry, & Keng-Boon, (2019) and Jayashree et al. (2021). Theoretically, this finding can complementarily be supported by the Unified Theory of Acceptance and Use of Technology (UTAUT) by Venkatesh et al. (2003).

8. Conclusion

The SMEs industry in Nigeria was experiencing significant growth and increasingly contributing to the national economy. This sector delivers essential services to both businesses and individuals and facilitating the production of diverse materials. It encompasses various modalities, including digital production which are employed to produce an array of products and services. As competition intensifies within the industry due to rising demand for the use of smart manufacturing technology, it is crucial for small and medium-sized enterprises (SMEs) in the sector to remain abreast of the latest advancements in manufacturing technology and methodologies. Furthermore, maintaining high standards of quality is essential for SMEs to ensure customer satisfaction and uphold their competitive edge.

9. Recommendations

Based on the results of the study, the researcher proposes the following recommendations:
SMEs should strive to integrate Industry 4.0 technologies to uphold high quality standards and effectively meet customer demands.
SMEs should develop strategies to educate their members/stakeholders about emerging smart technologies, which can facilitate the transition from traditional mechanical production methods to a fully digitalized production system.
Given the growing significance of the SMEs sector in Nigeria's economy, government should work towards providing these SMEs with access to smart technologies at subsidized rates.
As a sector crucial to both businesses and individuals, academic institutions in Bauchi State should consider establishment of skills acquisition programs within their educational offerings.

10. Limitation and Suggestions for Further Studies

This research acknowledges numerous limitations that suggest avenues for further study. Given that the focus was on manufacturing SMEs, a relatively novel area, there were constraints due to the limited availability of prior studies and academic literature specifically addressing Nigerian SMEs and their adoption of Industry 4.0 technologies. The research was confined to SMEs within Bauchi State, which may restrict the applicability of the findings to other manufacturing SMEs in other State of the Nation. Therefore, it is recommended that future research be conducted to assess the generalizability of these findings across different SMEs sectors in other States of the nation. Additionally, future studies should consider incorporating moderating or mediating effect to better understand their impact.
Finally, this study is also suggesting that future research should explore the service industry to broaden the scope of this inquiry.

11. Research Implication

This research carries significant implications for Small and Medium Enterprises (SMEs) confronting the advancements associated with Industry 4.0 and related technologies. The findings emphasize the importance of SMEs' intention toward these technologies in adapting to external changes and comprehending their potential advantages. Specifically, managers within SMEs must train their production personnel and product engineers in these advanced methods, enabling employees to evaluate and discern the viability of emerging technologies. Absent such intentional efforts, companies may be inclined to dismiss new technologies due to a lack of understanding regarding their potential and benefits.
Furthermore, these insights are relevant for policymakers seeking to accelerate the adoption of

Industry 4.0 technologies. The policymakers need to facilitate knowledge transfer between entities well-versed in Industry 4.0, such as technology producers or academic institutions, and SMEs. Invariably, the adoption of new technologies extends beyond the technology itself; regulatory complexities can present obstacles for SMEs. Therefore, a well-defined framework guiding companies through the adoption process would be highly beneficial.
Theoretically, this study integrates perceived relative advantage, perceived compatibility, and perceived complexity within a single framework as per the study's IVs and introduces intention to adopt industry 4.0 as the study's DV. This approach provides a comprehensive examination of the factors influencing SMEs intention to adopt Industry 4.0 technology.

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