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ICTs Utilization and Its Influence on Operational Performance of Manufacturing Enterprises

Festa Okrigwe[1], Olabamiji J. Onifade[1]*
[1]National Centre for Technology Management, Nigeria

Abstract The adoption and utilization of information and communication technologies (ICTs) have reshaped the economic landscape of different economic sectors in many nations; thus, assessing the extent to which ICTs have been adopted and used in the Nigerian manufacturing sector is imperative for stakeholders in the sector. Based on the survey data that was gathered among 454 manufacturing firms in different industries, the study offers an empirical insight into the actual situation of ICTs implementation in the Nigerian manufacturing industry. The results demonstrated that there were different levels of ICTs adoption, with the bigger firms showing more levels of technology integration relative to the smaller firms. Additionally, the findings determine the effect of the implementation of various ICTs solutions, such as enterprise resource planning (ERP) systems, automation technologies, and data analytics tools, on major operational measures such as production efficiency, supply chain management, and workforce productivity. The study offers implications to both manufacturers and policymakers in the sense that it is necessary to promote more ICTs innovations to improve the competitiveness and development of the industrial sector in Nigeria.

Keywords: *ICTs, Manufacturing, Firms, Technologies, Innovations*

1. Introduction

The landscape of the manufacturing sector has, in recent years, experienced a rapid transformation due to the advancement of information and communication technologies (ICTs). The use of ICTs in the sector has given the firms the opportunity to upgrade their operations and improve the quality of their products. This has enabled the firms in the sector to meet the increasing demands of locally developed products (Etim et al., 2023; Shamim et al., 2020). Hence, adopting ICTs in manufacturing firms is now a basic requirement to provide digital solutions such as online technologies/services, e-marketing tools, advanced ICT tools, and advanced manufacturing technologies. This, no doubt, can lead to tangible improvements in areas such as inventory management, quality control, supply chain coordination, and overall operational performance (Etim et al., 2023; Oláh et al., 2020; Zheng et al., 2018, 2019). This became imperative as the manufacturing sector, especially in developing countries like Nigeria, has significantly

***Corresponding Author:**
Olabamiji J. Onifade
banjionifade@gmail.com

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contributed to the country's economic growth (Ibitoye et al., 2022). According to the National Bureau of Statistics (2023), the manufacturing sector in 2022 contributed approximately 8.6% of the gross domestic product (GDP). Meanwhile, about 11% of the country's total workforce is employed in the sector.

A global report from the World Bank highlighted that the manufacturing sector grew rapidly with the advancement of the adoption and use of ICTs (World Bank Group, n.d.). The adoption and use of ICTs for innovation purposes in the manufacturing sector is seen as the successful implementation of ICT tools within the manufacturing firms to develop new goods and services or significantly improve on already existing goods and services (OECD/Eurostat, 2018). Unfortunately, manufacturing firms in Nigeria are sceptical about adopting and using these ICT tools. According to Babalola et al. (2021), most of the Nigerian manufacturing firms still lack innovative ICTs that could be adopted and used to develop new products and differentiate products/services. Also, the extent to which manufacturing firms have adopted and used ICTs is not well understood, and the operational activities of these ICT tools to increase performance remain largely unexplored (Iyer et al., 2019). This lack has kept the quality of products and services low and still expensive.

Theoretically, the study adopted the Technology Acceptance Model (TAM, Davis, 1989) and the Diffusion of Innovation (DoI) theory (Rogers, 2003). From the TAM's theory, the study determined the individual firms' intention to use ICT. This is determined by the firms' perception of the usefulness of the ICT and their perceived ease of using it. Conversely, the RoI explains the extent to which ICT innovations are communicated and adopted over time within a social system. The theory communicates the rate of diffusion of ICT innovations into the manufacturing landscape and its relative advantage to add value and improve the performance of manufacturing firms. Hence, from these theories, the TAM and the DoI, the study ascertains the extent to which the manufacturing firms in Nigeria have adopted and are using online technological tools and services, e-marketing tools, advanced information technologies, and the value addition of the ICTs to support innovations in the firms. However, the theory further established that the criterion of ICT innovation diffusion includes the knowledge or awareness of the firms about these ICT infrastructure and their suitability for use in their firms' different operational activities or processes in the manufacturing sector, the perceived usefulness of the ICTs, the extent to which they are being implemented, and the value addition. On the other hand, the financial performance of the firms indicates that the firms gained more financial gains as a result of their adoption and use of ICTs.

Overall, the objectives of this study are to investigate the extent to which manufacturing firms in Nigeria have adopted and used ICTs to innovate, especially for the development of new or significantly improved products; and to assess the impact of these ICT-driven innovations on the operational activities of the manufacturing firms and their overall performance. The results of this study offer useful information that would inform the strategic decisions of manufacturing companies in the country. It would also facilitate the development of evidence-based policies that would inform the government to increase technological integration and invention in the manufacturing sector in Nigeria.

2. Theoretical Framework

The role of the manufacturing sector in the growth of the Nigerian economy cannot be denied, as the sector has contributed immensely to the GDP of the country and increased employment opportunities (Okorie et al., 2020) for its booming population. The authors added that the sector has encountered several operational challenges that have led to low productivity, inefficient supply chain, and low utilization of the workforce, thereby hindering the competitiveness in both local and global markets. These challenges have affected the innovation capability of the sector, especially in adopting modern and advanced ICTs to boost production (Eze et al., 2020).

It has been generally accepted that firms that adopt and use ICTs are innovative and have the capacity to compete favourably at the global stage. Even countries such as Europe, America, Japan, Ghana, South Africa, and Kenya are striving to import ICTs to advance innovations in their manufacturing sectors. These countries are leading the world's manufacturing products and raising innovative trends. Thus, it is important for the firms in the Nigerian manufacturing sector to catch up with other nations to speedily adopt and use advanced ICTs for the production of goods and services and improve their operations, productivity, and competitiveness. Hence, the adoption and use of ICT tools such as online technologies/

services, e-marketing platforms, advanced ICTs, and advanced manufacturing technologies would provide the firms in the Nigerian manufacturing sector the opportunity to add value in their production and develop and improve products. Thus, the ICT tools are as follows:

1. *Online Technologies/Services:* The adoption and use of online technologies and services would be an added advantage in the manufacturing sector, as this would enable firms to streamline their operations and create an effective platform to relate with customers. It has been revealed from studies that the use of e-commerce platforms, enterprise resource planning (ERP), and procurement systems is a capable ICT tool that manufacturing firms can adopt to improve their inventory control systems, supply chain coordination, and engage with customers effectively (Etim et al., 2023; Oláh et al., 2020). With the adoption and use of these ICT tools, it is possible for the manufacturing firms to also enhance their visibility, respond quickly to customers' demands, and optimize other logistics.

2. *E-marketing Tools:* e-marketing tools are now being used widely to make developed products accessible and available to a wide range of customers (Obeidat, 2021). The authors added that business owners are now exploring the use of different social media handles to advertise their products online, create marketing content for their brand awareness, generate new sales requests, and interact with customers. Also, manufacturers are able to gather data from these sites to determine customers' perceptions and preferences and then make adjustments where necessary (Mukhtar et al., 2022).

3. *Advance ICT Tools:* ICT tools such as big data analytics, artificial intelligence (AI), and Internet of Things (IoT) are some of the advanced ICT tools manufacturing firms are adopting in their business venture (Paramesha et al., 2024). With these technologies, manufacturing firms have the potential to transform their operational processes and make data-informed decisions to gain strategic insights into the world of business.

4. *Advanced Manufacturing Technologies:* Manufacturing firms are adopting and using advanced manufacturing technologies (such as 3D printing, robotics, and automated systems) to improve the quality of their products, reduce waste, and increase the production rate. For instance, 3D printing technologies are used to elevate the customization of products, drive efficiency, and produce sustainable product design (Kantaros et al., 2025). Yet, robotics is used to execute repetitive tasks and work with other humans as operators in the firm (Adebayo et al., 2024). Thus, with the adoption of these advanced manufacturing technologies, it is certain that the responsiveness of the firms will be enhanced, and the firms are most likely to reduce their lead times and gain a competitive advantage within their ecosystem.

No doubt, the adoption and utilization of these ICTs have added huge value to the manufacturing sector globally. The operational capacity of firms in the manufacturing sector has improved greatly with the adoption and use of the aforementioned ICTs, thus yielding more innovative outcomes in terms of products and customer satisfaction. According to the study of Dadzie et al. (2025), ICTs adopted and used in manufacturing firms help in the supply chain management, especially for inventory management to enhance and improve the sharing of information, reduce wastage, enable the demand routine of products, and optimise the process of making orders. The study posited that ICT adoption has significantly improved the inventory management system of the manufacturing firms, reduced their inventory holding, facilitated a 'Just-in-time' approach, and released capital stock, leading to increased production and competitiveness of the firms, aiding the firms to balance their stocks easily and meet the high demands of their customers. Interestingly, some manufacturing firms in Nigeria are championing the sector with the extent to which they have adopted and are using ICTs; thus, this study seeks to ascertain the performance of the firms that have adopted and are using ICTs and the value ICTs have added to their firms.

3. Methodology

3.1. Participants

The target participants for this study are manufacturing firms in Nigeria. The National Bureau of Statistics (NBS) provided a sampling frame, yet with two important limitations: 1. the frame was

compiled at the establishment level and therefore overestimated the population of firms, and 2. it was outdated. Consequently, a sampling frame was constructed from directories of firms obtained from the Manufacturers' Association of Nigeria (MAN), Lagos Chamber of Commerce and Industry (LCCI), Nigerian Association of Chambers of Commerce, Industry, Mines and Agriculture (NACCIMA), and National Association of Small-Scale Industries (NASSI). The resulting sampling frame included 2774 firms across all 75 International Standard Industrial Classification (ISIC) Revision 4 sectors. This frame is admittedly not perfect, but it has three key advantages: 1. It is up to date, particularly because it is based on membership directories; 2. It captures a significant proportion of the Nigerian formal private sector, and 3. It allows a stratified random sampling based on the ISIC sector and geographical spread.

Approximately 2300 firms were sampled with a 55.8% response rate. Of the 1382 returned questionnaires, 98 were discarded because they were not well completed, and out of the 1284 firms that responded appropriately to this survey, 454 (35.4%) were in the manufacturing sector, while 830 (64.6%) were in the service sector. Thus, this study considered the respondents from the manufacturing sector only.

3.2. Instruments

For the purpose of this study, a questionnaire was developed. The questionnaire was designed based on the guidelines and definitions provided in the latest edition of the Oslo Manual (OECD/Eurostat, 2018). This makes the questionnaires and the resulting data internationally comparable, for instance, with the findings from the Community Innovation Surveys implemented in European countries. The reliability and validity of the questionnaire were also confirmed.

3.3. Procedure

Data was collected using a questionnaire that was distributed among manufacturing firms. The data was analysed using descriptive and inferential statistics (logistic regression).

4. Results

Considering the extent to which manufacturing firms in Nigeria adopted and utilized ICTs, the following outcomes were obtained. Figure 1 shows how frequently Nigerian manufacturing companies use web technology for a range of business purposes. The most popular technologies, which show a strong integration into operational workflows, are online sourcing for innovation and e-banking services. While online ordering from suppliers and online sales to customers demonstrates a fairly balanced use, they also point to the need for more widespread use to optimize the advantages of e-commerce. The comparatively poor uptake of online payments and payment service receipts could be a sign of obstacles like cost, infrastructure, or trust.

Figure 1
Using Online Technologies, Tools, and Services to Support Innovation

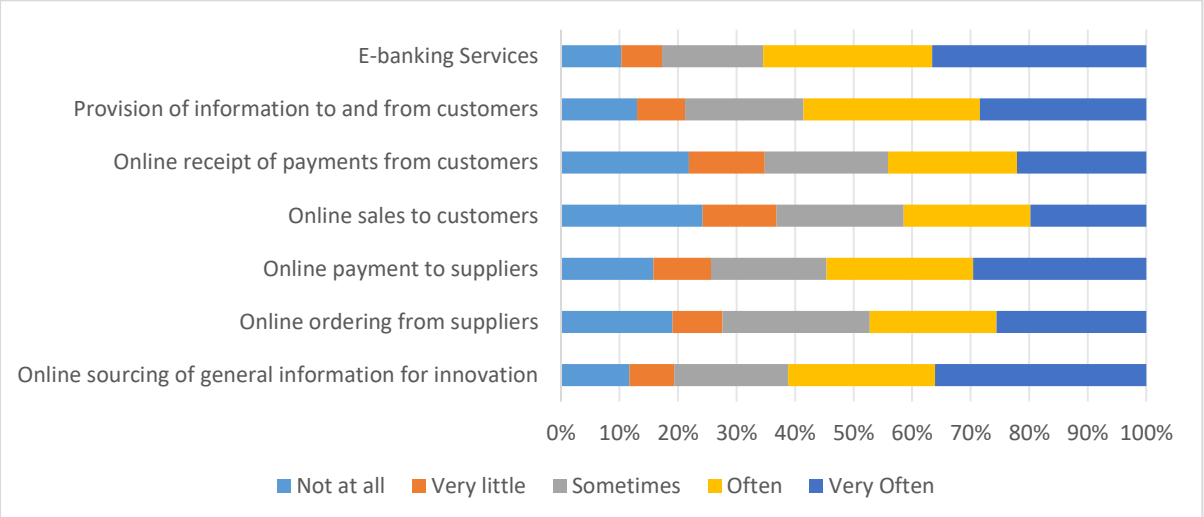


Figure 2 shows how firms adopt e-marketing tools to support innovation. Email marketing leads at 32.3%, followed by banner ads (23.8%) and social media marketing (23.3%). Statistics show a typically low adoption rate of e-marketing techniques. The low adoption rate (about 6%) of sophisticated technologies like pop-ups and 3-D visualization suggests a large gap in digital marketing. Nigerian manufacturing firms are at the initial stages of adopting digital marketing, necessitating strategic interventions for progress.

Figure 2

Using E-Marketing Tools to Support Innovation

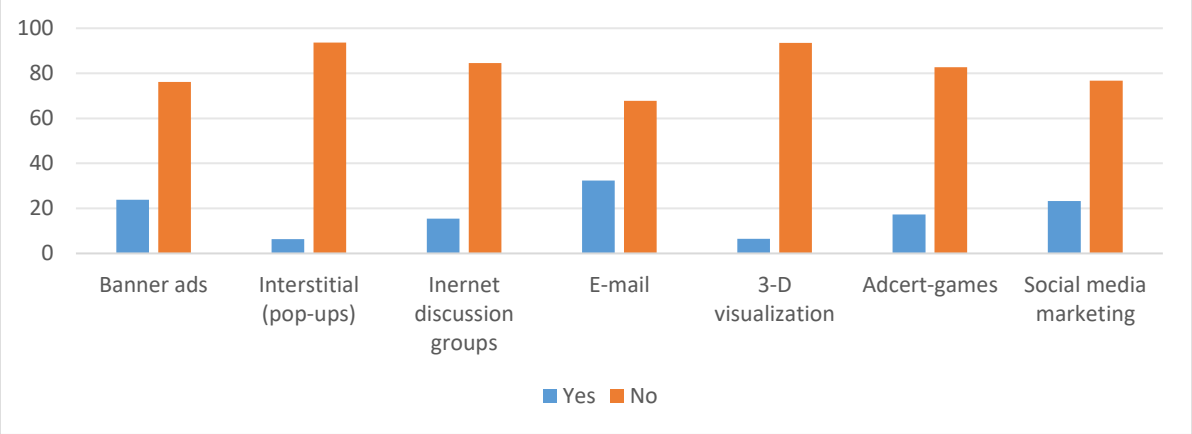


Figure 3 reports the usage of advanced information technologies for innovation in manufacturing firms in Nigeria. ERP solutions are the most widely adopted (33.4%), followed by computer-aided design/ manufacturing (CAD/CAM) (30.7%), and cloud-based manufacturing and radio frequency identification (RFID) are the least adopted (about 12%). Almost 50% of businesses believe that cutting-edge technologies are "Not Applicable" to their operations. The data shows that Nigerian manufacturing firms are in the initial phase of technological transformation, concentrating mainly on fundamental operational technologies and demonstrating minimal preparedness for advanced manufacturing solutions.

Figure 3

Using Advanced Information Technologies for Innovation

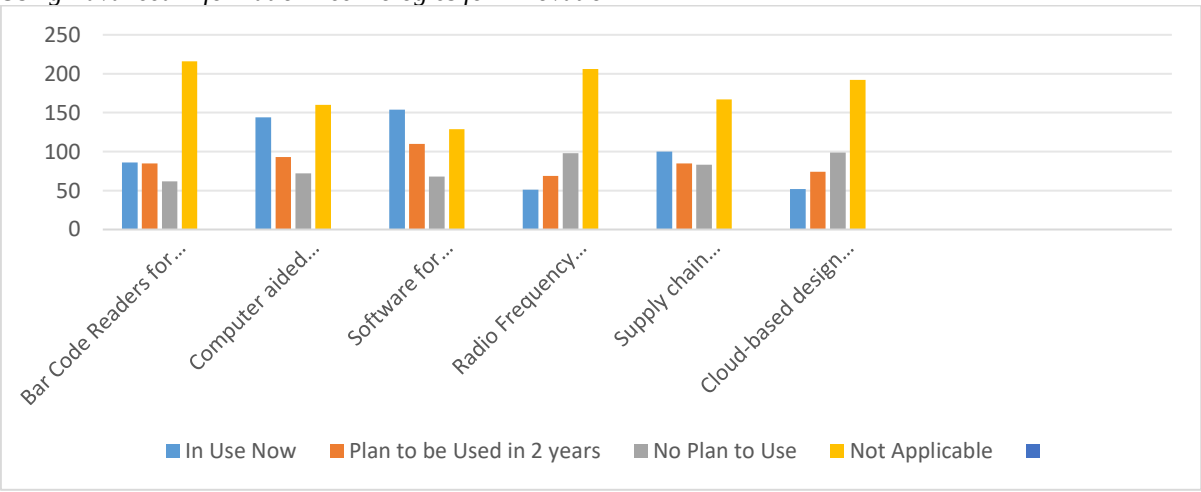


Figure 4 displays the plans for the present and future use of different industrial production methods. It demonstrates the widespread use of computer-integrated manufacturing (CIM), the most popular technology at the moment, with a sizable portion of users aiming to implement it soon. Other

technologies that exhibit differing degrees of present and future use are also covered, including robots, sensors, vision technologies, fast prototyping, and D-printed manufacturing. Interestingly, some respondents said they had no plans to adopt specific technologies, particularly advanced materials and CIM.

Figure 4
Advanced Manufacturing Production Technologies and Innovation

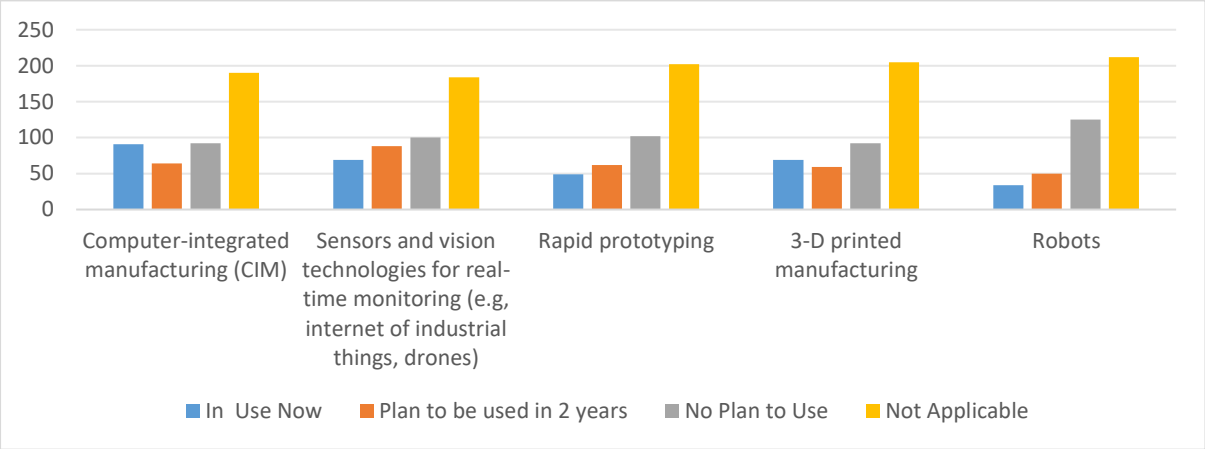
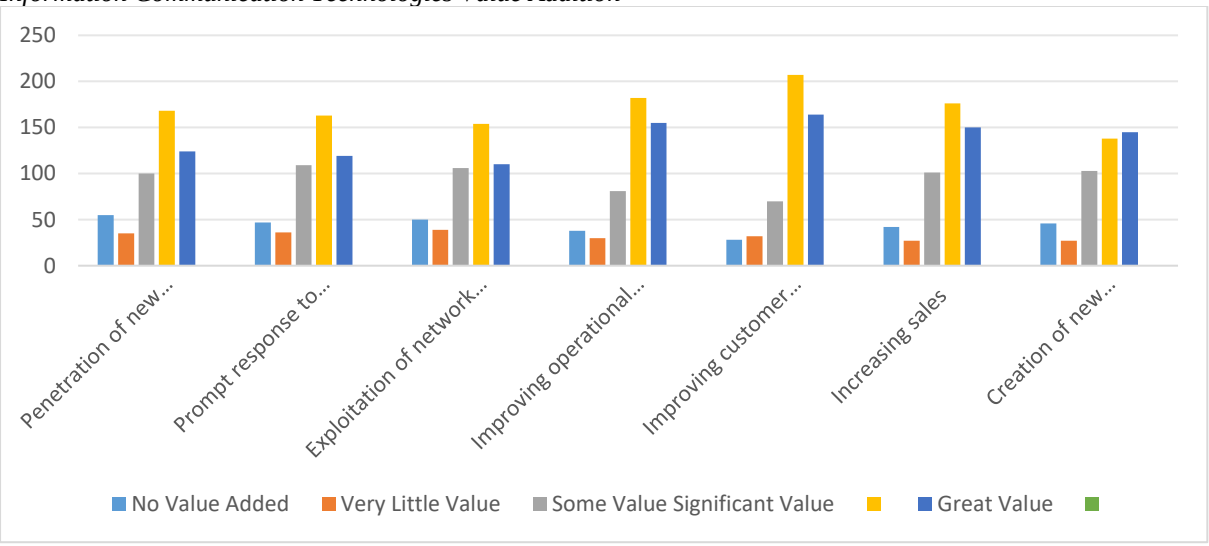


Figure 5 discusses the contribution of IT to the manufacturing firms in Nigeria. According to the study, ICTs are the most valuable for operational tasks (69.3%) and customer service (74% rating high value). At 65.7% and 61.7%, respectively, sales growth and the development of new products also demonstrate significant beneficial effects. However, with only 38.8% claiming strong value addition, market penetration seems to be the most difficult issue. ICTs generally have a greater impact on internal operations and customer relations than on efforts to expand the market. Simply put, market expansion is still a more difficult area for technology implementation, but internal processes and customer service are where Nigerian manufacturing companies are benefiting the most from ICTs.

Figure 5
Information Communication Technologies Value Addition



With respect to the impact of ICT innovations on the operational performance of manufacturing firms in Nigeria, binary logistic regression was used to test the two formulated hypotheses, and the results were presented as follows.

ICTs innovation does not significantly lead to new or significantly improved production methods: The outcome of Table 1 indicated that neither online technologies (B = -0.022, p = 0.830) nor advanced IT (B = -0.103, p = 0.493) is statistically significant. This shows that the use of online technologies and advanced IT does not really affect the adoption of new production methods. This observation contradicts the assumption that online platforms and digital tools should support the innovation of processes. This can be an indication of a misalignment of IT investments and improvements in the production processes. The finding also indicated that advanced manufacturing technologies (B = 0.267, p = 0.067) and ICTs value addition (B = 0.196, p = 0.080), though not significant, come near statistical significance. This indicates that technologies of advanced manufacturing and ICTs value addition can be positively influential on production innovation; however, the influence is not sufficiently strong to be convincing. The model is accurate in predicting 57.0% of the instances in which the innovation of ICTs results in new or improved production methods. The small pseudo R^2 values (Cox and Snell R^2 = 0.019; Nagelkerke R^2 = 0.025) further emphasize the fact that the variables included do not entirely explain the drivers of production innovation.

Table 1
The Effect of ICTs Innovation on Improved Production Methods

Variables	B	S.E.	Wald	Sig.	Exp(B)
Online Tech	-0.022	0.104	0.046	0.83	0.978
Advanced IT	-0.103	0.15	0.469	0.493	0.902
Advanced Manufacturing Technologies	0.267	0.146	3.363	0.067	1.306
ICTs Value Addition	0.196	0.112	3.058	0.08	1.216
Constant	-0.633	0.323	3.83	0.05	0.531
Model Indices:					
Chi-square=10.351	Cox &Snell R^2 = 0.019		-2 log Likelihood = 578.331		
% cases correctly predicted = 57%	Nagelkerke R^2 = 0.025				

ICTs innovation does not significantly lead to new or significantly improved products: Table 2 shows that the coefficients for online technologies (B = 0.120, p = 0.259), advanced IT (B = 0.131, p = 0.389), and advanced manufacturing technologies (B = -0.044, p = 0.766) are not significant. This indicates that employing these technologies does not make much difference in the formation of new or much better products. Conversely, the finding indicates that ICTs value addition (B = 0.267, p = 0.022) has a significant contribution to product innovation. This denotes that the more organizations exploit ICTs to create value, the higher the chances are that organizations will produce new or significantly better products. The model hits the nail on the head and forecasts 62.4% of instances where innovation in ICTs results in new products or products that are much improved. These low pseudo-R-values (Cox and Snell R^2 = 0.030; Nagelkerke R^2 = 0.040), nonetheless, highlight that the predictors applied are not sufficient to explain innovation in products.

Table 2
The Effect of ICTs Innovation on Improved Products

Variables	B	S.E.	Wald	Sig.	Exp(B)
Online Technology	0.12	0.106	1.274	0.259	1.127
Advanced IT	0.131	0.152	0.742	0.389	1.14
Advanced Manufacturing Technologies	-0.044	0.147	0.089	0.766	0.957
ICTs Value Addition	0.267	0.117	5.222	0.022	1.306
Constant	-1.453	0.347	17.494	0	0.234
Model Indices:					
Chi-square=17.847	Cox &Snell R^2 = 0.030		-2 log Likelihood = 562.900		
% cases correctly predicted = 62.4%	Nagelkerke R^2 = 0.040				

5. Discussion

The research sets out to know the level of adoption and use of ICTs by manufacturing companies in Nigeria, on the one hand, and the effects of ICT innovations on the operation of companies, on the other hand. Nigeria has made significant strides in the adoption and use of ICTs by the manufacturing companies. This is not new, as Lefophane and Kalaba (2020) found that in certain aspects, such as e-banking and online sourcing, they are deeply integrated in their workflows. Online ordering and sales are also applied, but they are not as popular, which means that they can be further expanded to take the full advantage of e-commerce. Nevertheless, there is a lower adoption rate in the use of online payment and payment receipts, probably because of the hurdle of cost, infrastructure constraints, or lack of trust. Likewise, even though email marketing is the most widely used e-marketing tool, sophisticated digital marketing solutions such as pop-up and 3-D visualization are not widely used, which shows that there is a great gap in digital marketing opportunities.

ERP solutions and CAD/CAM systems are the most used in terms of advanced information technologies, which are associated with an orientation towards basic operational technologies. Nevertheless, the level of adoption of sophisticated technologies, such as cloud-based manufacturing or RFID, remains quite low, with nearly half of the companies regarding those technologies as something that does not apply to their operations. This means that Nigerian manufacturing companies are yet to reach the mature levels of technological changes, and are not quite prepared to adopt high-technology manufacturing solutions. Also, although the most popular production technology is CIM, the implementation of other high-tech methods, such as robotics, sensors, and 3D printing, differs greatly, with some companies not planning to implement some methods at all.

Improvement in ICTs has been most noted in internal processes and customer services, where most firms indicated that they gained much in terms of improved benefits. ICTs also play an important role in terms of sales growth and the development of new products. Nevertheless, it is not easy to penetrate the market, and the number of firms that show good value addition in this domain is very small. This implies that even though ICTs improve operational efficiency and customer relations, their effects on increasing the market reach remain weak. This is in contrast to the findings of Cuevas-Vargas et al. (2021), indicating that the adoption of ICTs by manufacturing companies in Nigeria has a high level of market integration, but there is a significant gap in adoption in other areas, especially concerning advanced technology and online marketing. To combat these gaps and maximize the use of ICTs to foster innovation, competitiveness, and market expansion, strategic interventions are necessary.

Concerning the hypothesis that ICTs innovation is not an important cause of new or significantly improved production methods, the analysis showed that there is a complex interaction between ICTs innovation and the development of new goods and services. There are other variables, such as online technologies and advanced IT, but they are not statistically significant. On the other hand, the negative correlation that existed between ICTs value addition and the development of new goods and services is interesting. The predictive capability of the model is not high because the R^2 values are low and the model fails to accurately predict cases of the production of new goods and services; therefore, the null hypothesis is accepted, and the model indicates that ICTs innovation is not a big determinant of the new methods of production. This means that even though investment in ICTs is said to be a major driver of development, its impact is context-specific. The studies show that the use of ICTs can significantly change the methods of production and the economic outcomes. This intensification of the ICTs capital increases productivity in the manufacturing industry, more than half of which comes out of the upstream sectors (Liu & Saam, 2021).

The use of ICT professionals, cloud and big data, and digital technologies boosted labour productivity by 23% and total factor productivity by 17% in French manufacturing enterprises (Cette et al., 2022). Equally, more preferable ICTs intensity increases on growth in South African agro-processing firms, particularly in more ICT-intensive sectors (Lefophane & Kalaba, 2022). The use of ICTs also helps to achieve the sustainable development goals. A case in point is Spanish olive oil cooperatives, where market orientation, staff training, and cooperative integration favour technological innovation (Mozas-

Moral et al., 2020). In some cases, however, increased use of ICTs can have a negative impact on labour share (Cette et al., 2022).

With regards to the hypothesis that ICTs innovation does not significantly result in new or significantly improved products, results show that ICTs value addition significantly impacts positively, whereas other ICTs-related variables (e.g., online technologies, advanced IT, and advanced manufacturing technologies) do not show significant results. Such results indicate that investing in ICTs capabilities might not be adequate to facilitate product innovation. Hence, the hypothesis is rejected, meaning that ICTs strategies should be aligned with product development objectives to inculcate an innovative culture and to make sure that ICTs investments are incorporated into the product development process successfully. Conversely, research has shown a positive impact of the use of ICTs on the creation of new products and services in the manufacturing sector. Li et al. (2022) state that 1% change in ICTs investment results in an increase in the total factor productivity of approximately 1.8% in manufacturing businesses. Moreover, the utilization of ICTs significantly influences marketing innovation, which, in turn, affects the commercial outcomes (Cuevas-Vargas et al., 2022). But the effect can vary between developed and developing economies, where ICTs patents have been found to have a positive impact on advanced economies and a negative impact on developing ones (Nguyen et al., 2021). Our results do, however, indicate that this relationship is context-specific, implying that not all ICTs, in fact, result in the creation of new goods and services.

The research concludes that the Nigerian manufacturing companies are at the initial stages of digitalization, and the various fields of technology are not uniformly adopted. Although the internal processes of the manufacturing firms, as well as the relationships between the firms and their customers, can be enhanced by the adoption and usage of ICTs, the manufacturing method is not enhanced. It is hence confirmed that ICTs themselves do not bring about new or much better products or processes in the manufacturing industry, and it takes a conglomeration of factors. To ensure that the ICTs are maximized in the manufacturing sector, the organizational structure and culture must be supportive, with a pragmatic approach adopted.

The research suggests that the manufacturing firms should be given incentives/tax holiday for them to upgrade their technologies and also partner with knowledge institutions to foster innovation. Firms should also develop a good and practical digital strategy and invest in ICTs to stay competitive. Further, companies should invest more in research and development (R&D) and increase their ability to implement advanced digital marketing tools and strategies to use ICTs in developing new products and expanding their market. As a way of enhancing productivity further, the next round of research must centre on establishing the factors that enable ICT adoption in the manufacturing industry of Nigeria. Although the study has found that ICTs can improve internal processes and not production methods, additional research might be able to identify whether the impact is constrained by infrastructure, financial, or human resources shortcomings. Comparative studies on different manufacturing subsectors (food processing and automotive) could be used to elucidate the reasons why some sectors benefit more from digital technologies than others. Moreover, exploring the role of innovative technologies, such as AI and IoT, and government policies, such as tax breaks or broadband development, could provide viable information to accelerate the major digital change.

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