# The Effect of Digitalization on the Performance of Manufacturing Firms in South-West Nigeria

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## Abstract

Adopting digitalization by manufacturing firms will increase and improve output and generate additional employment for downstream skilled labour in the production process. However, there is the possibility of job loss, affecting unskilled workers the most. The Nigerian manufacturing sector must undergo critical structural changes (dynamic shifts caused by technological innovation) required to drive economic growth and development. This study examines the effect of digitalization on the performance of manufacturing firms in South-West Nigeria using a sample of 45 randomly selected medium- and large-sized manufacturing firms across Oyo, Ogun, and Lagos states. The study employed the Ordinary Least Square and descriptive analytical techniques to analyze the data collected. The results revealed that 74.3% of firms upgrade their digital machines as needed, while over 50% have only minimally digitalized their work structures, operations, and production processes. This limited digitalization affects their competitiveness and revenue generation, impacting overall economic growth. Digitalization efforts focus on digital communication equipment for work structures and operations, with less emphasis on production processes that drive productivity. The regression results showed that digitalization had no significant effect on the performance of manufacturing firms, likely due to the low level of digitalization in their processes and operations. The study recommends upgrading employees' skills, especially digital skills, as labour significantly affects manufacturing output. Skills upgrades will help the sector adapt to new technologies, enhancing revenue and competitiveness.

**Keywords:** Digitalization, Manufacturing, Firm, Performance, Production, Operation

## Introduction

The manufacturing sector plays a crucial role in driving economic growth, particularly in newly industrialized countries (NICs)[1] that have sustained an increase in their per capita income over the years. The manufacturing sector's growth, share of total output, and employment have long been viewed as significant drivers of economic development because of the sector's potential to modernize economies, create skilled jobs, and generate positive spillover effects (Tybout, 2000).

Digitalization in the manufacturing sector offers the potential to increase and improve output while generating additional employment opportunities for skilled labour in the production process. However, there is a risk of job losses, primarily affecting unskilled workers. The digitalization of manufacturing is transforming how products are designed, fabricated, and used. It implies a substantive change in the origin of work, work tasks, the occupational structure of the workforce, and skill requirements (ILO, 2021). It is changing how production is designed, how customer needs are met through a broader digitalized value chain, and the introduction of sensors in the production process. For today's industry, the digitalization of manufacturing methods is critical, especially for firms transitioning from mass production to customized production, as the use of digital information can help lower production costs, optimize business results, create new revenue streams, and enhance customer experiences (Savic *et al*., 2019).

Digitalization is the process of applying and adopting digitization to economic processes (Brennen & Kreiss, 2014). It involves using technologies and obtaining value in new ways, enabling companies to increase their performance and competitiveness (Gobble, 2018). Manufacturing has been identified as one of the sectors where digital innovation is likely to profoundly impact the nature, volume, and relationships of work (Fernandez-Macias *et al*., 2021). The primary aims for the adoption of Digitalization by industries include enhancing performance (Markovitch & Willmott, 2014), improving smart production processes (Gerlitz, 2015), managing competition and stimulating demand (Sabbagh *et al*., 2012), promoting internal efficiency (Parviainen *et al*., 2017), reducing costs (Manyika *et al*., 2017), adapting to new changes (Henriette *et al*., 2015), and creating new products or services (Degryse, 2016).
Since the first industrial revolution, manufacturing firms have evolved their processes, operations, and functions. The fourth industrial revolution (Industry 4.0), often used as an

umbrella term for digital technologies capable of being implemented in the manufacturing sector, has the potential to increase the performance of manufacturing companies in the future (Kaufmann, 2016). In the context of the workforce, digitalization means organizations working in different ways using digital tools like mobile devices or technologies that enable a mobile environment, improve social collaboration, and provide a unified communication platform for better performance. The pathway to digital business transformation requires changes (Gartner *et al*., 2024). Digitalization extends beyond this, involving the implementation of digital technologies across all possible human and societal activities.

Manufacturing assumes a distinctive role in an economy because of its solid linkages with other segments of the economy and is the vital basis for the nation's economic growth. Over the past few decades, the Nigerian manufacturing sector has unsuccessfully undergone critical structural changes (dynamic shifts caused by technological innovation and new economic development) that are required to assume the main part in economic growth and development through digitalization. Additionally, the government has implemented various development plans and policies over the years to enhance the productivity of the manufacturing sector and boost capacity utilization. Despite these efforts, the sector's contribution to trade flows, exports, and GDP has remained low compared to other emerging economies that have leveraged digitalization to improve manufacturing firms' output. The share of the manufacturing sector in Nigeria's GDP has remained less than 4%, with minimal contributions to foreign exchange earnings and low shares of employment and government revenue generation. Although the industrial sector recorded a growth rate of 3.86% in Q4 2023, higher than in the previous quarters of the year, the sector only grew by a paltry 0.72% in 2023, contributing only 18.65% to aggregate GDP, behind agriculture (25.18%) and services (56.18%) (NISER, 2024). The results highlight the challenges facing Nigeria's industrial sector, including its limited economic impact, need for diversification, and potential for growth and transformation.

Skills development driven by digital manufacturing is crucial for unlocking a nation's employment potential and promoting economic diversification. With the advent of these new technologies and innovations, research and development in Nigeria should focus on developing technical skills that will drive production processes and operations for maximum productivity. Skill upgrading to meet the needs of the fourth industrial revolution should encompass a holistic knowledge of several disciplines. Despite past leaders' commitment to encourage and boost the manufacturing sector, especially small and medium enterprises (SMEs), through various programs, leveraging digital transformation is yet to reach its full potential in

manufacturing firms' output in Nigeria. Although the opportunities offered by digital technologies differ among countries, industries, and firm sizes, their adoption and impact vary (OECD, 2017). Against this backdrop, this study aims to examine the effect of digitalization on the performance of manufacturing firms in South-West Nigeria.

**Literature Review**

The evolution of digital manufacturing can be traced back to the 1960s when the idea of integrated manufacturing systems gained traction due to advancements in computing capabilities. This concept has garnered significant attention from researchers, leading to diverse perspectives and empirical findings (Banga & te Velde, 2018). The advancements in digitalization within manufacturing systems have necessitated organizations to grapple with materials, machines, and integrated issues within manufacturing firms. Computer-integrated manufacturing systems (CIMS) have been widely adopted by companies to address these integrated challenges. Digitalization, often referred to as the digital economy, encompasses the digital transformation of social and economic activities enabled by digital technologies. It involves significant innovations such as developing smart machines, smart platforms/ applications, and digital products Banga & te Velde, (2018) studied the prospect of manufacturing in the framework of digitalization for developing countries, with a specific emphasis on African countries. The study used different outputs and inputs measure in the digitalized economy to compare levels of digitalization across countries. The results show a fast-growing global digital economy but a persistent digital divide between developing and developed countries. African countries were found to be lagging behind Asian countries in digitalization due to high costs of capital and low digital willingness. The study further attempted to examine the potential of African countries in leveraging digitization for industrial growth by examining the impact of digitalization on labour productivity in a cross-country panel analysis over the period 1990 to 2013. The findings showed that digitalization and technological progress can enhance labour productivity. As the economy becomes more digitized, the impact on labour productivity increases, but the increase is less for low-income countries, implying that low-income countries have a lower ability to absorb and utilize digitalization.

Kroll *et al*. (2018) examined the effects of digitalization and automatization on the innovation performance and production efficiency of manufacturing firms in Germany. Utilizing survey data from the 2012 German Manufacturing Survey conducted by the Fraunhofer Institute for Systems and Innovation Research, covering firms with at least 20

employees, they employed OLS and logistic regression techniques for analysis. Their study found that adopted digital technologies increase innovative performance and boost production efficiency within their respective domains, exerting a positive effect. Additionally, the results revealed several other valid determinants of innovative performance and production efficiency, further strengthening the explanatory power of the digitalization models.

In the Nigerian context, Agboola *et al*. (2019) investigated the effects of digitalization on the performance of commercial banks. Employing purposive and simple random sampling procedures, the study surveyed 370 non-managerial employees from a commercial bank. The data were analyzed using descriptive statistics and Pearson correlation tests. The study found a slightly significant and positive relationship between digitalization and the performance of commercial banks and a strong positive relationship between commercial banks' performance and product innovation in Nigeria.

Martín-Peña *et al*. (2019) explored a framework incorporating evolving trends in servitization and digitalization to analyze their relationship with manufacturing performance. Based on cross-sectional data from 828 manufacturing firms in Spain between 2014 and 2017, they employed ordinary least square regression (OLS) techniques for analysis. The findings revealed that while servitization and digitalization improved manufacturing performance, digitization played a positive mediating role in the servitization-industrial performance nexus, helping to differentiate between the indirect and direct impacts of servitization on manufacturing performance.

Michael *et al*. (2019) examined digitalization and its influence on business model innovation using qualitative techniques based on data generated from the automation and media industries in Austria and Hungary. The results demonstrated the influence of digitalization on the two firms and highlighted the challenges and opportunities companies perceived when altering their business models. The study revealed how the two industries handled the impact of digitization by comparing the similarities and differences in their approaches to business model innovation. Moreover, employee competencies and organizational capacities were identified as impending challenges that industries will face.

Savastano *et al*. (2019) conducted a systematic literature review to establish the existence and extent of research evidence on the contextual impacts of industrial processes brought about by the digital transformation of manufacturing. Their results showed that the applicability of digital manufacturing technologies differs substantially across diverse industries within the manufacturing sector, granting a growing number of technical tools, industrial and managerial strategies, and end-user applications. In some industry segments,

digital manufacturing was found to be technologically feasible but not economically viable. Overall, the examined literature indicated that the dispersal of digital manufacturing in industries is frequently linked with an expansion toward shorter and more dispersed global value chains.

Marcon *et al*. (2019) examined the barriers to the digitalization of servitization among researchers, managers, and consultants using a qualitative approach. The results showed that consultants perceived more strategic barriers, whereas managers perceived more operational barriers. The study also revealed that financial and data security issues were among the most critical barriers to digitalization. The dynamic capabilities of a firm contribute to managing its resources and skills to exploit opportunities and mitigate risks, such as high employee resistance and adapting to a rapidly changing environment.

Areti (2018) investigated the role of dynamic capability in the digital transformation of seven different apparel manufacturing firms in Greece, employing qualitative methods to examine the influence of each aspect of dynamic capability. The results showed that Greek apparel manufacturers needed more awareness of digital technologies and mechanisms to identify how the new digital era could impact their performance and transform their structures to gain a competitive advantage. Nevertheless, the pace of this transformation was slow due to the financial situation in Greece. At the same time, other large international firms had already undergone a digital transformation in their manufacturing processes, gaining advantages from it.

Chen (2017) critically analyzed the perspectives of integrated and intelligent manufacturing enablers. The results showed that opportunities were increased by opening the Internet of Things (IoT) and Cyber-Physical Systems (CPS) technologies, allowing for more open and broader integration comprising three levels: vertical integration, horizontal integration, and end-to-end integration. Their findings also revealed that intelligent manufacturing technologies were enablers for implementing intelligent manufacturing.

Olamade *et al*. (2014) examined the strategic use and deployment of ICT and the strength of its deployment by manufacturing firms in South/West Nigeria. The study employed primary data and descriptive analysis, using a 5-point Likert scale and Lorenz curve computation to analyze information generated from structured questionnaires administered to 84 manufacturing companies in Nigeria. The results supported the tactical use of ICT by the companies and concluded that ICT would be used more tactically if the competition was motivated by the competitive advantages that are more ICT-intensive.

Gbadegeshin (2019) examined how digitalization influences the commercialization of high technologies in the life sciences industry, using pharmaceutical, medical device, and e-health companies in Finland as a case study. The results showed the need to distinguish between digitalization and digitization, as both terms were used interchangeably or misused. The results also indicated that commercial activities positively influenced digitalization, particularly in sourcing information and managing big data, creating various assessments, official activities, and routinization.

Adeoti (2012) investigated technology investments by firms in South-West Nigeria and how investment-related technology factors affected firms' export potential. The results revealed that imported technologies drove investment in technology. Firm size had a strong positive relationship with export potential and was the most important factor affecting firms' export potential. The results also showed that investment in skills upgrading, skill intensity, and quality management were investment-related technological factors that positively impacted export potentials.

Mefuna and Abe (2015) examined the impact of the technological environment on manufacturing industries in Enugu State, Nigeria. The study employed primary data and Pearson moment correlation analysis to analyze the generated data. The results revealed that the technological environment significantly added value to the performance and growth of manufacturing industries because most manufacturers needed to measure the acquired/imported and local technology in terms of affordability, maintenance, adaptability, and the waste of learning for maximum application.

## Methodology

### Data Source

This study used primary and secondary data. The primary data was sourced using firm-level structured questionnaires, while the secondary data was collected mainly from the National Bureau of Statistics (NBS) and the Manufacturers Association of Nigeria (MAN).

A purposive sampling technique was adopted to select three manufacturing subsectors from thirteen (13) subsector categories based on NBS' classification. The selected subsectors are Food, Beverages and Tobacco; Chemicals and Pharmaceuticals and Plastic and Rubber Products. The total sample size for this research study was 45 manufacturing firms, which were selected from the MAN frame using a snowball sampling technique (see Table 1).

**Table 1: Total Sample Size**

| States | Food & Beverages | Chemical & Pharmaceuticals | Plastic & Rubber Products | Total |
|---|---|---|---|---|
| **Lagos** | 5 | 5 | 5 | **15** |
| **Ogun** | 5 | 5 | 5 | **15** |
| **Oyo** | 5 | 5 | 5 | **15** |
| **Total** | **15** | **15** | **15** | **45** |

Source: Authors' Computation

The study's scope is South-West Nigeria, specifically Lagos, Ogun, and Oyo. These states were chosen because of the clusters of manufacturing firms around them. Also, this study limits the manufacturing firms to medium—and large-scale enterprises. Hence, six medium-scale and nine large-scale firms were selected per state from the MAN frame.

**Model Specification**

One of the simple production functions that provides a reasonable description of the actual reality of an economy is the Cobb-Douglass production function, which is relevant in addressing the issue of production, employment and capital stock of manufacturing. This study adapts the Cobb-Douglass production function with slight modifications. According to the proposition of economic theory on the production function, labour and capital are germane, although the proportion in which they are combined has implications for the nature of the technology adopted by the firm. Economic theory frequently applies aggregate production functions of the following form:

$$Y = f(K, L) \quad (1)$$

Where:

Y is aggregate output, K is aggregate capital, and L denotes aggregate Labour. The equation implied that output could directly be mapped with the input feed into the production process. However, other factors can indirectly or directly impact output. Thus, equation (1) can be modified to include other control variables (such as digitalization) using the work of Albert (2006); we treat digitalization as a third input which enters the production function directly:

$$Y = f(K, L, T) \quad (2)$$

T is a vector of variables for digitalization (digital skills, Hardware, Software, communication equipment, emailing). It is a factor that influences multifactor productivity through its positive impact on the productivity of capital and labour:

$$Y_i = A(T_i)\, f(K_i, L_i, T_i) \quad (3)$$

We assume a generalised Cobb-Douglass production form of technology, which yields a more specific relationship between input and output.

$$Y_i = Af(L_i^{\beta}, K_i^{\gamma}, T_i^{\alpha}, e^{\mu}) \quad (4)$$

Since Cobb-Douglass is linear in the logarithms of variables, equation 4 can be rewritten in a log-linear form as:

$$\ln Y_i = \lambda + \beta \ln L_i + \gamma \ln K_i + \alpha \ln T_i + \mu_i \quad (5)$$

Where: λ = (ln A), Y = Value of firm's turnover, L = Number of people employed by firms, **K** = firm's fixed asset or net capital stock, T is the digitalization variable comprising digital skills, hardware, software, communication equipment. A is an efficiency parameter, and μ stands for the error term. For $i = 1, \ldots, n$, where n is the number of firms, and for the parameters β, ϒ, α, are the regression coefficients to be estimated and are expected to be positive. Equation (5) is the baseline model for the study and was estimated using the Ordinary Least Square (OLS) technique.

## Results and Discussion

### Descriptive Analysis – Manufacturing Firm's Characteristics

Table 2 shows the results of the field exercise on manufacturing firms in sampled states. The characteristics of the firms show that food, beverage, and tobacco manufacturing firms constituted 48.6 per cent, chemical and pharmaceutical companies made up 31.4 per cent, and rubber and plastic products accounted for 20 per cent, respectively. 54.3 percent of the study sample are from Oyo State, 14.3 percent and 31.4 percent are from Ogun and Lagos, respectively, with medium-scale firms constituting the larger percentage at 74.3 percent. Because of the technicality of the questions, the qualifications and positions of the respondents were asked; the results show that the majority of the respondents are in managerial positions with at least a bachelor's degree certificate.

**Table 2: Manufacturing Firm's Characteristics**

| **States** | **Percentage** | **Manufacturing Sub-sector** | **Percentage** |
|---|---|---|---|
| Oyo | 54.3 | Food, Beverages &Tobacco | 48.6 |
| Ogun | 14.3 | Chemical and Pharmaceutical | 31.4 |
| Lagos | 31.4 | Plastic and Rubber Products | 20.0 |
| **Types of Establishment** | **Percentage** | **Educational Qualifications of Respondent** | **Percentage** |
| Medium scale | 74.3 | Higher National Diploma | 11.8 |
| Large scale | 25.7 | NCE Holder | 2.9 |
| **Positions of Respondent** | **Percentage** | Bachelor's degree | 50.0 |
| Director | 12.5 | Master's degree | 29.4 |
| Manager | 59.4 | Others | 5.9 |
| Supervisor | 28.1 | | |

Source: Field Study 2020

**Extent to which firms digitalized their processes, operations and work structure**

Descriptive statistics were used to explain the extent to which the manufacturing firms in Nigeria have digitalized their processes, operations, and work structures. Table 3 shows the total number of employees by manufacturing subsector and state. It reveals that a significant percentage of the number of employees in the manufacturing subsector are in firms with 10 or fewer employees to 100 employees across all the samples states. The output also indicates that most of the firms that responded are medium-scale firms.

**Table 3: Total Number of Employees by Manufacturing Subsector and State**

| States | Total No. of employees | Manufacturing subsector | | | Total |
|---|---|---|---|---|---|
| | | **Food and Beverages** | **Chemical and Pharmaceuticals** | **Plastic and rubber products** | |
| **Oyo** | Less than/equal 10 | 1 | 2 | 0 | 3 |
| | 11 – 100 | 5 | 1 | 7 | 13 |
| | 101 – 200 | 0 | 1 | 0 | 1 |
| | 201 – 300 | 1 | 0 | 0 | 1 |
| | 701 – 800 | 1 | 0 | 0 | 1 |
| | **Total** | **8** | **4** | **7** | **19** |
| **Ogun** | 11 – 100 | 1 | 1 | - | 2 |
| | 101 – 200 | 1 | 0 | - | 1 |
| | 201 – 300 | 0 | 1 | - | 1 |
| | 401 – 500 | 0 | 1 | - | 1 |
| | **Total** | **2** | **3** | **-** | **5** |
| **Lagos** | 11 – 100 | 3 | 1 | - | 4 |
| | 101 – 200 | 0 | 2 | - | 2 |
| | 201 – 300 | 1 | 0 | - | 1 |
| | 501 – 600 | 1 | 0 | - | 1 |
| | Above 800 | 2 | 0 | - | 2 |
| | **Total** | **7** | **3** | **-** | **10** |

Source: Field Study 2020

Crosstabulation and Chi-square tests were employed to examine the categorical variables simultaneously. Comparing the chi-square statistic against a critical value from the chi-square distribution helps to determine whether the observed cell counts are significantly dissimilar from expected cell counts. At a 95% confidence level (0.05), if the p-value (labelled Asymp sig) < (0.05), then we conclude that the variables are not independent for each other and that there is a statistical relationship between the categorical variables. Table 4 shows the crosstabulation and chi-square statistics of two variables - manufacturing subsectors and total number of employees, with null and alternative hypotheses stated:

**$H_0$**: There is no relationship between manufacturing subsector and total number of employees.

**$H_1$**: There is a relationship between manufacturing subsector and total number of employees.

Since the p-value 0.07 > 0.05, we conclude by rejecting $H_0$ and accept$_{ing\ H1,}$ which shows that the manufacturing subsector and total number of employees are not independent but are statistically related.

**Table 4: Manufacturing Subsector by total number of employees**

| **Manufacturing subsector** | **Total number of employees** | | | | | | **Total** | **Chi-square** |
|---|---|---|---|---|---|---|---|---|
| | **Less than/equal 10** | **11-100** | **101-200** | **201-300** | **401-500** | **Above 500** | | |
| **Food and beverage** | 1 | 9 | 1 | 2 | 0 | 4 | 17 | **Reject Ho** |
| **Chem and Pharm** | 2 | 3 | 3 | 1 | 1 | 0 | 10 | **0.07 > 0.05** |
| **Plastic and rubber products** | 0 | 7 | 0 | 0 | 0 | 0 | 7 | |
| **Total** | **3** | **19** | **4** | **3** | **1** | **4** | **34** | |

**Chi-Square Tests**

| | Value | Df | Asymp. Sig. (2-sided) |
|---|---|---|---|
| Pearson Chi-Square | 17.213[a] | 10 | 0.070 |
| Likelihood Ratio | 19.528 | 10 | 0.034 |
| Linear-by-Linear Association | 3.252 | 1 | 0.071 |
| N of Valid Cases | 34 | | |

a. 16 cells (88.9%) have an expected count of less than 5. The minimum expected count is .21.

**Source: Field Study 2020**

Table 5 also shows the crosstabulation and chi-square statistics of manufacturing subsectors with the below null and alternative hypotheses:

**$H_0$**: There is no relationship between manufacturing subsector and digital skills experts.

**$H_1$**: There is a relationship between manufacturing subsector and digital skills experts.

Since the p-value is 0.805 > 0.05, we conclude by rejecting $H_0$ and accept$_{ing\ H1,}$ which shows that the manufacturing subsector and digital skills experts are not independent but statistically related.

**Table 5: Manufacturing Subsector by Digital Skills Experts in the Firm**

| | | | | | | |
|---|---|---|---|---|---|---|
| | **Total number of digital skills experts in the firm** | | | | **Total** | |
| **Manufacturing subsector** | **Less than/equal 10** | **11 – 100** | **101 – 200** | **401 – 500** | | **Chi-square** |
| **Food and beverage** | 8 | 6 | 1 | 1 | 16 | |
| **Chem and Pharm** | 4 | 4 | 0 | 0 | 8 | **Reject Ho** |
| **Plastic and rubber products** | 4 | 1 | 0 | 0 | 5 | **0.805 > 0.05** |
| **Total** | **16** | **11** | **1** | **1** | **29** | |

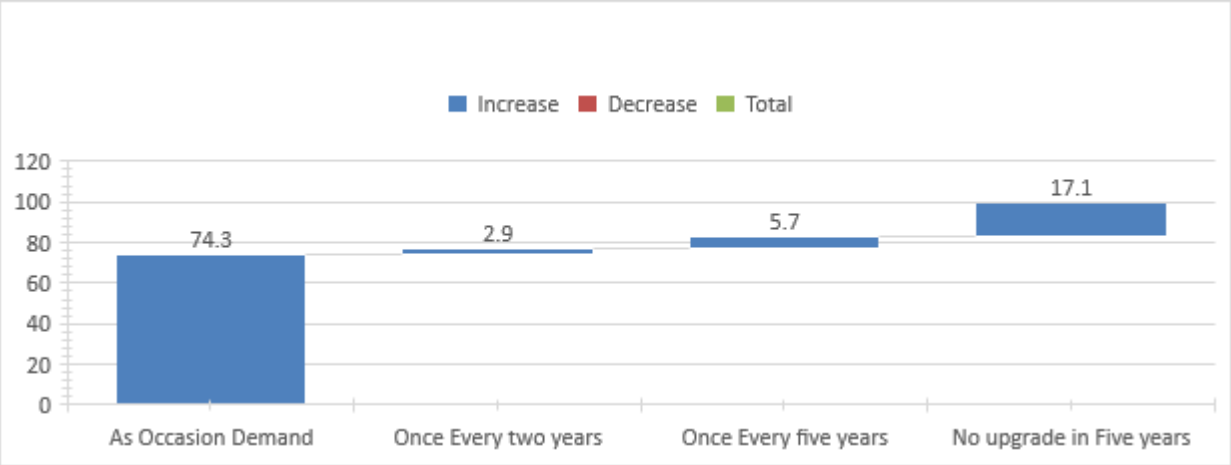
**Chi-Square Tests**

| | Value | Df | Asymp. Sig. (2-sided) |
|---|---|---|---|
| Pearson Chi-Square | 3.032[a] | 6 | 0.805 |
| Likelihood Ratio | 3.782 | 6 | 0.706 |
| Linear-by-Linear Association | 1.544 | 1 | 0.214 |
| N of Valid Cases | 29 | | |

a. ten cells (83.3%) have an expected count of less than 5. The minimum expected count is .17.

**Source: Field Survey 2020**

**Figure 1: How often do Manufacturing Firms Upgrade/Change to Modern/Hi-Tech Equipment**

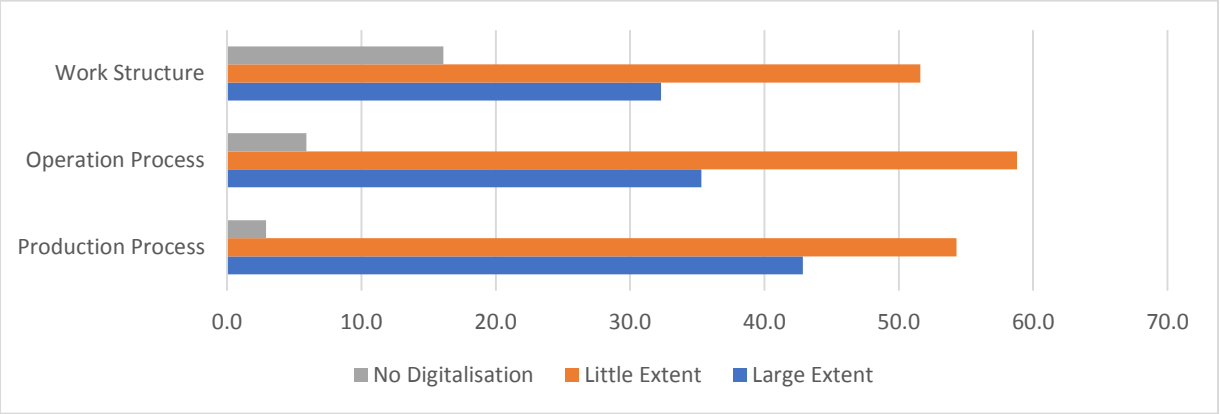



**Source:** Field Survey 2020

Technological adoption and digitalization of manufacturing processes are both essential for small-and large-scale manufacturing companies to retain competitive in this rapidly changing environment. Organizations that aim to keep up with industry advancements and maintain a competitive edge will need to support their manufacturing base in transitioning to the digital/manufacturing smart era possible. Figure 1 shows how often manufacturing firms upgrade/change to modern technical equipment for their operation and production processes. The result shows that 74.3% upgraded as occasion demand, 17.1% did not upgrade their equipment in the last five years, 5.7% upgraded once every five years, and 2.9% upgraded every two years. The implication is that Nigeria's manufacturing space will be limited in competing effectively with real-time intelligence about their production processes, which will help them make better operation and production decisions for better performance.

The firms were also asked about the extent to which they have digitalized their production and operation processes and work structure. Figure 2 shows that over 50% of the firms have digitalized their work structure, operations, and production processes to a small extent, while over 30% have digitalized to a large extent.

**Figure 2: Digitalization of Manufacturing Processes and Work Structure**




**Source: Field Survey 2020**

Table 6 reveals the aspect of manufacturing processes that digitalization has improved over the last five years. The results show that digitalization in manufacturing firms has improved the production process, final product/output, completion time, design and production cost with the following percentages: 69, 54, 46 and 43, respectively. However, for the operation process, digitalization improved completion time by 63%, the final output/product by 50%, the work task on the production floor by 40% and the production cost by 34% in that order, respectively.

**Table 6: Aspect of manufacturing processes that digitalization improved**

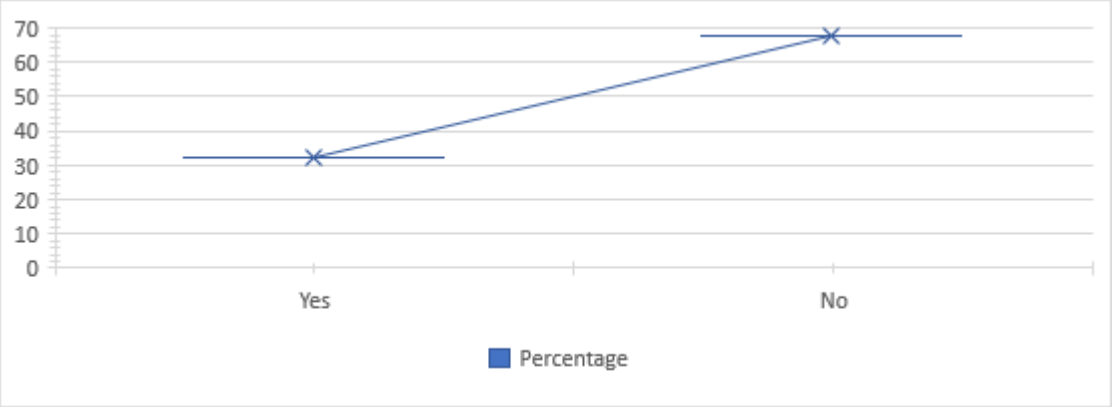
| | **Production Process** | | **Operation Process** | |
|---|---|---|---|---|
| | Yes | No | Yes | No |
| Design | 46 | 54 | 26 | 74 |
| Fabrication | 23 | 77 | 11 | 89 |
| Input | 29 | 71 | 31 | 69 |
| Final Product/Output | 69 | 31 | 54 | 46 |
| Work tasks in the production floor | 34 | 66 | 40 | 60 |
| Production Cost | 43 | 57 | 34 | 66 |
| Completion time | 54 | 46 | 63 | 37 |

**Source:** NISER Field study 2020

The operation of digital machines in manufacturing firms is critical to the production and operation processes. Figure 3 reveals the percentage of firms that engaged consultants for

operating digital machines. Approximately 32% of firms do not engage consultants in operating the digital machines, while 68% of the manufacturing firms engaged consultants in operating the machines, likely due to the technical complexity of the digital machines.

**Figure 3: Engagement of consultants in operating digital machines**



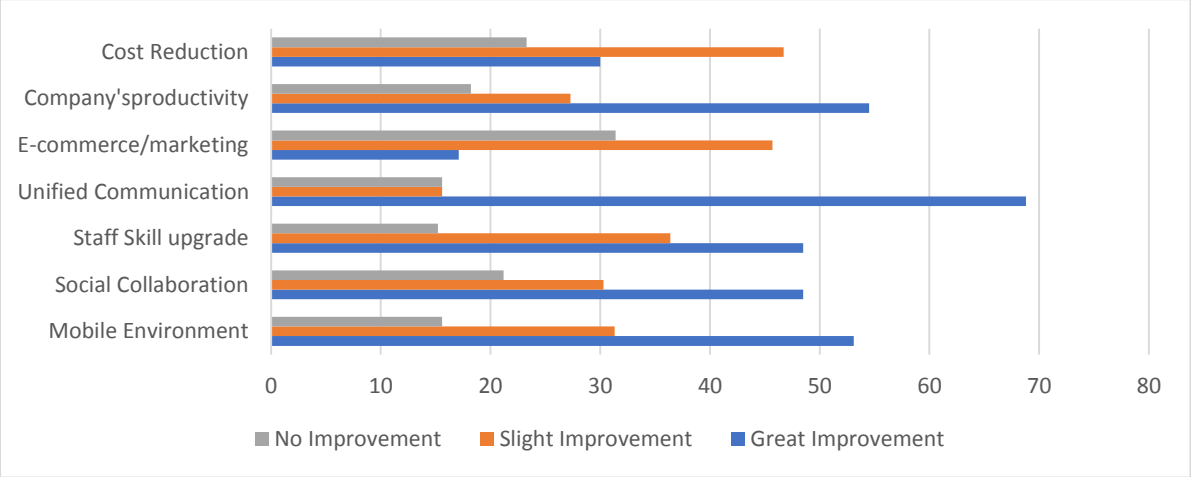

**Source: Field Study 2020**

In the last five years, manufacturing firms have shown significant improvement in varios aspects of work structure components due to digitalization, as shown in Figure 4. Nearly 70% of firm agreed that Unified Communication (UC) improved significantly due to digitalization. UC is the most effective digital communication tool that firms use to improve their performance. It is a marketing and business concept used to increase users' productivity and optimize business processes; it describes the incorporation of enterprise communication services. Examples of Unified Communication that firms use are mobility features, presence information, call control and speech recognition, instant messaging, fixed mobile convergence (FMC), audio, web and video conferencing, desktop sharing, voice (including IP telephony) and data sharing.

Company's productivity and mobile environment improved significantly with the use of digital tools in all the manufacturing firms. Over 50% of the firms agreed with this assertion, with the mobile environment focusing more on the hardware and software of the digital tools they are using for better performance. The hard wares are computers, PCs or mobile devices. Network infrastructure and maker, GPS, camera, compass, accelerometer, tracking/sensing system, Monitor or display screen, Software includes an application or programming, web service and a content server. Almost 48% of manufacturing firms responded that digitalization improved staff skills upgrade and social collaboration significantly. At the same time, over 40

per cent said there was a slight improvement in some work structure components, especially cost reduction and e-commerce/marketing.

**Figure 4: Aspect of manufacturing firms' work structure that digitalization improved in the last five years.**

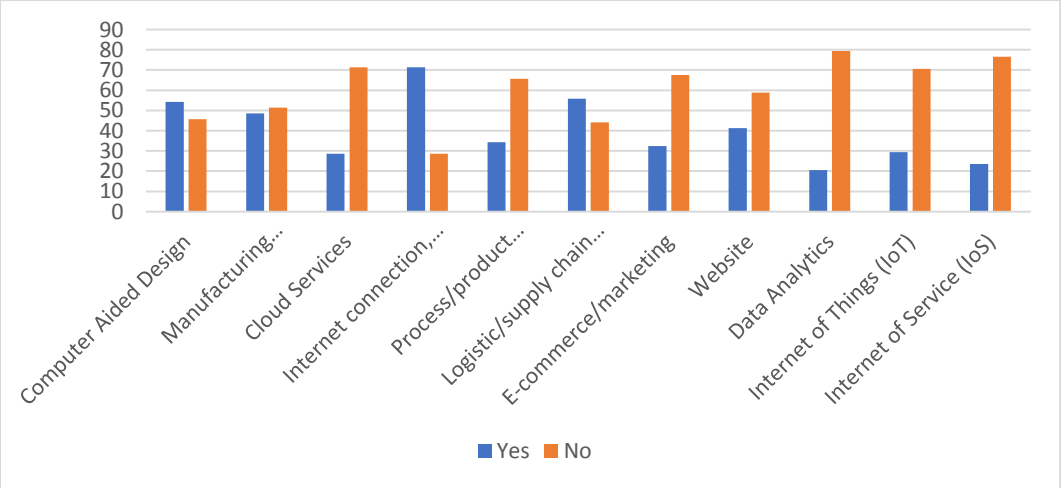



**Source:** Field Survey 2020

**Role of Digitalization on Manufacturing Firms' Productivity**

All organisations/ businesses can now leverage digitalization or digital innovations such as mobility, digital skills, the Internet of Things, and data analytics to drive productivity and customer satisfaction. The key is not just identifying and implementing these digital tools in isolation but applying them in new combinations to address specific organizational challenges and drive transformation and productivity. This study explores various components of digitalization that contribute performance improvements in manufacturing firms.

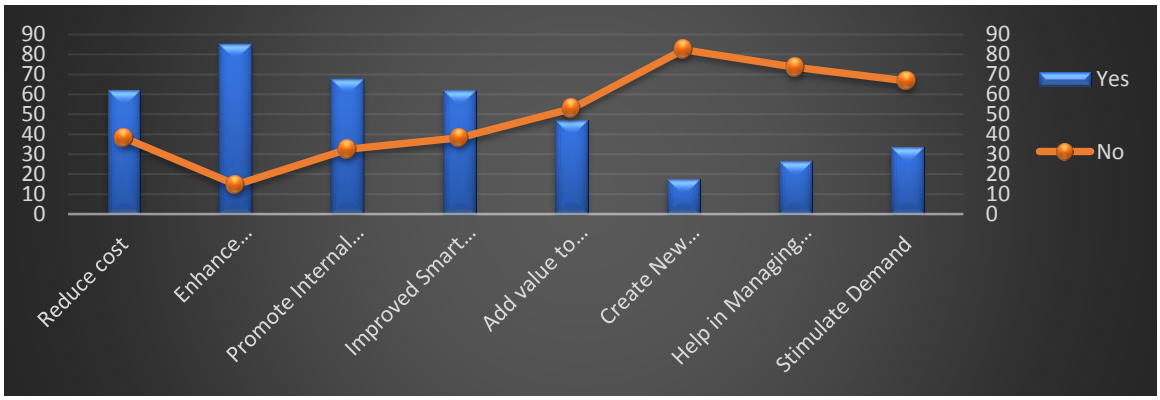
**Figure 5: Component of Digitalization that Drives Firms Performance**




**Source: Fieldwork 2020**

Figure 5 reveals that internet connection, usage and access, computer-aided design, logistics and supply chain management, manufacturing resources planning, and websites were the major components of digitalization driving the performance of manufacturing firms over the last five years. 70% of respondents from the manufacturing firms explained that internet connection, access and usage helped in driving performance in their organization; this is followed by logistics and supply chain management and computer-aided design with 55.9% and 54.3%, respectively. From these results, it can be deduced that manufacturing firms in Nigeria need to leverage themselves on the importance of digitalization to drive productivity/performance, especially with the use of cloud services, data analytics, and IoS—IoT and automated machines, which are the focus of industry 4.0 and industrial revolution across the globe.

**Figure 6: Ways in which Component of Digitalization Impact Manufacturing Firms Productivity**




**Source: Fieldwork 2020**

The digitalization of manufacturing firms is not merely a one-time change but an ongoing journey; it is a collection of decisive actions using digital instruments/tools that jointly move the firm forward to achieve its vision and improve performance/productivity. There are different ways digitalization have impacted organizations over time; this study examines ways in which some components of digitalization have impacted the productivity of manufacturing firms in Nigeria. The results, as shown in Figure 6, indicated that over 60 per cent of manufacturing firm respondents agreed that digitalization has reduced the cost of production, enhanced performance, promoted internal efficiency, and improved smart production processes. Conversely, over 65% of respondents reported that digitalization did not create new products or services, nor help in managing competition and did not create demand for their product/ services; this finding agrees with the work of Marcus Hoffmann (2019).

**Performance Level of the Manufacturing Firms**

This sub-section presents and discusses the empirical result of the effect of digitalization on the performance of manufacturing firms in Nigeria using the Ordinary Least Square (OLS) technique shown in Table 7.

**Table 7: Regression Results of the effect of Digitalization on the Manufacturing firms' Performance**

| Model | R | R Square | Adjusted R Square | Std. Error of the Estimate |
|---|---|---|---|---|
| 1 | 0.972[a] | 0.945 | 0.927 | 0.51911 |

| Dependent variable: Turnover | Coefficient | T | Prob. |
|---|---|---|---|
| (Constant) | 0.713 | 2.213 | 0.114 |
| Total number of employees of the firm | 0.014 | 7.209 | 0.006 |
| Digital machines | -0.082 | -0.294 | 0.797 |
| Fixed Asset of the Firm | 0.224 | 0.231 | 0.839 |
| Digital communication equipment | -0.473 | -0.483 | 0.677 |

**Source: Authors' computation**

Table 7 shows the regression analysis results on the effect of digitalization on manufacturing performance. Firms' turnover was used as a proxy for performance, the total number of employees as labour input, fixed assets as capital input, and digital machines and digital communication equipment as a proxy for digitalization.

Although the regression shows a very high $R^2$, which explains how closely the model fits the regression line, most independent variables do not align with a-priori expectation. For instance, the total number of employees of the firm had a significant positive relationship with the firm's turnover, implying that an increase in the number of employees of the firm will lead to an increase in the firm's turnover (productivity), suggesting that manufacturing activities in Nigeria remain largely labor-intensive. This means that the Nigerian manufacturing sector has yet to fully leverage the importance of digitalization, especially the use of artificial intelligence (AI), intelligent machines, and automated systems to streamline production processes. Although the firm's fixed assets meet the a-priori expectations regarding sign (positive) and

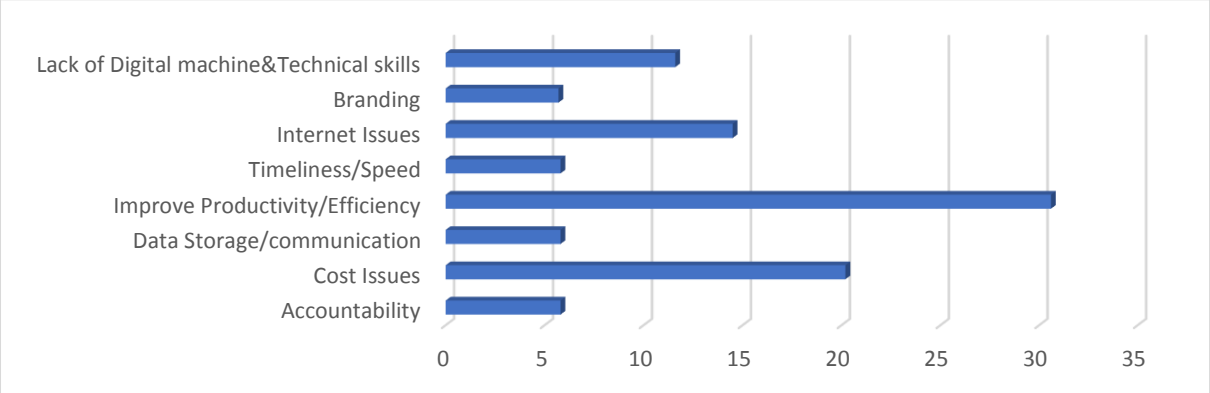
magnitude, the variable is not statistically significant. This means that firms' fixed assets are not a significant determinant of productivity.

The main independent variable of interest is digitalization, proxied by two variables: digital machines and digital communication equipment. Both variables have negative but statistically insignificant coefficients, indicating a potential adverse effect of digitalization on the performance of manufacturing firms in Nigeria. However, these negative effects are not statistically significant, suggesting that the observed relationship may be due to random variation rather than a real underlying effect. This implies that the study did not find strong evidence that digitalization, as measured by these proxies, has a meaningful impact on the outcome. The results may indicate that the lack of significant impact is due to the limited adoption of digital technologies within these firms, as evidenced by the minimal extent of digitalization reported in their manufacturing processes and work structures (see Figure 2).

**Factors Driving the Use of Digital Tools by Manufacturing Firms**

There are several reasons why companies use digital tools or adopt digital machines in their production process and work structure.

**Figure 1: Selected Factor Driving the Use of Digital tools/Equipment by Manufacturing firms in Nigeria.**

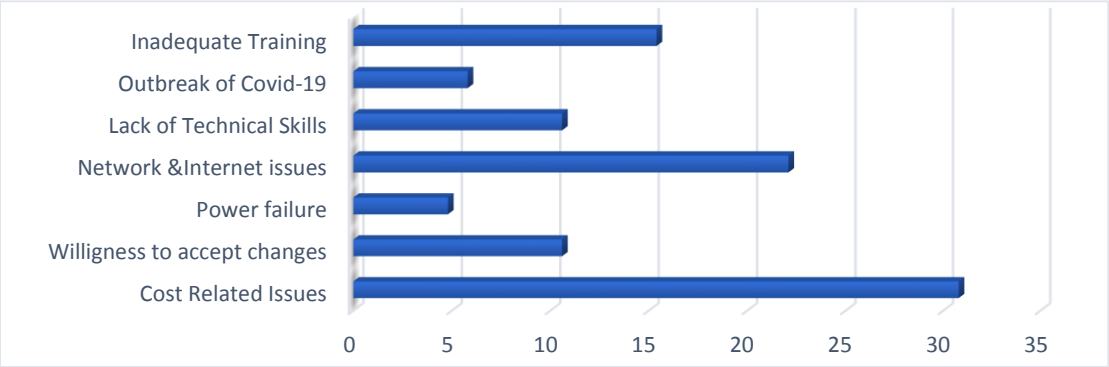



**Source: Field Study 2020**

The reasons range from the issues of cost, internet, productivity/efficiency, digital machines/technical skills and timeliness. Figure 7 shows that 30 percent of respondents indicated improved productivity/efficiency as the main reason for using digital tools in their production and operation processes as well as in their work structures. This is followed by cost issues (20 percent), internet issues (15 percent) and lack of digital machines/technical skills (11 percent). Additionally, 5 percent of respondents alluded to other reasons such as branding, timeliness/speed, data storage/communication, and accountability.

**Challenges faced by Manufacturing Firms in Adapting Digital Tools/Equipment**

**Figure 2: Challenges faced by manufacturing firms in Adapting/Accessing Digital Equipment**




**Source: Field Work 2020**

Several challenges were identified by the manufacturing firms as hinderances to their adapting/accessing digital equipment in their production and operation process. The most critical challenges, as shown in Figure 8 reveal that 30 percent of respondents identified cost-related issues as the major challenge. This is followed by network and internet issues (22 percent), inadequate training, resistance to change and lack of technical skills among others.

## Conclusion and Recommendations

This study examined the effect of digitalization on the performance of manufacturing firms using a sample of selected manufacturing firms in South-West Nigeria. The study revealed that the majority of firms (74.3%) are medium-sized. A significant portion of these firms (74.3%) upgrade their digital machines as needed, while over 50% have only minimally digitalized their work structures, operations, and production processes. This low level of digitalization affects their competitiveness and revenue generation, impacting overall economic growth. The regression analyses revealed a significant positive relationship between the total number of employees and firm turnover, suggesting that labour-intensive firms experience higher productivity with increased staffing. However, the presence of digital machines and communication equipment showed a non-significant negative effect on turnover, indicating that the effects of adopting these machines on productivity is yet to significantly manifest, which may be attributed to low level of adoption and diffusion across firms.

Digitalization efforts are primarily focused on digital communication equipment for work structures and operations, with less emphasis on production processes. While digital machines and communication tools have the potential to improve productivity, their current

impact is negative and insignificant, indicating that the firms' commitment to these investments could unlock greater potential.

Unified communication, company productivity, and mobile environments have significantly improved due to digitalization. Unified communication, in particular, optimizes business processes and user productivity. Encouraging the use of these digital tools, along with policies from the Nigerian Industrial Revolution Plan (NIRP), is crucial for the sector's global competitiveness. The Manufacturers Association of Nigeria (MAN) should lead in policy implementation.

Given the significant positive impact of labour on manufacturing firms' output, upgrading employee skills, especially digital skills, is crucial. This will enable the sector adapt to new technologies, thereby enhancing revenue and competitiveness. Competitiveness is essential for the Nigerian manufacturing sector to diversify its output and revenue base. The National Competitiveness Council of Nigeria should support these initiatives. Firms must invest in upgrading their digital technology. Small-scale firms should aim to grow into large-scale operations to enhance competitiveness.

**References**

Adeoti, J. O. (2012). Technology-related factors as determinants of export potential of Nigerian manufacturing firms. *Structural Change and Economic Dynamics*, *23*(4), 487-503.

Agboola, M. G., Awobajo, K. A., Oluwatobi, S. O., Akinbode, M. O., Fagbohun, M. O., Esse, U. C., ... & Betek, C. M. (2019, September). Effect of Digitalization on the performance of commercial banks in Nigeria. In *IOP conference series: Earth and environmental science*,*331*(1), 012-014.

Banga, K., & te Velde, D. W. (2018). *Digitalization and the Future of Manufacturing in Africa*. London: ODI.

Brennen, S., & Kreiss, D. (2014). Digitalization and digitization. *Culture digitally*, *8*(2), 10-19.

Chen, Y. (2017). Integrated and intelligent manufacturing: Perspectives and enablers. *Engineering*, *3*(5), 588-595.

Degryse, C. (2016). Digitalization of the economy and its impact on labour markets. ETUI Working Paper 2016.02. Brussels: European Trade Union Institute (ETUI).

Fernandez-Macias, E., Klenert, D., & Anton, J. I. (2021). Still needs to be more disruptive? Characteristics, distribution and determinants of robots in Europe. *Structural Change and Economic Dynamics*, *58*, 76-89.

Gartner, J., Maresch, D., & Tierney, R. (2024). The key to scaling in the digital era: Simultaneous automation, individualisation and interdisciplinarity. *Journal of Small Business Management*, *62*(2), 628–655.

Gbadegeshin, S. A. (2019). The effect of Digitalization on the commercialisation process of high-technology companies in the life sciences industry. *Technology Innovation Management Review*, *9*(1).

Gerlitz, L. (2015). Design for product and service innovation in industry 4.0 and emerging smart society. *Journal of Security & Sustainability Issues*, *5*(2), 181–198.

Gobble, M. M. (2018). Digitalization, digitization, and innovation. *Research-Technology Management*, *61*(4), 56–59.

Henriette, E., Feki, M., & Boughzala, I. (2015). The shape of digital transformation: A systematic literature review. In S. Kokolakis, M. Karyda, E. N. Loukis, & Y. Charalabidis. (Eds.), Proceedings from Ninth Mediterranean Conference on Information Systems (MCIS), Samos, Greece: 431–443.

International Labour Organization (2021). *Shaping skills and lifelong learning for the future of work.* International Labour Conference 109th Session, 2021. ILC. 109/VI

Kaplanidou, A. (2018). *Digitalization in the apparel manufacturing process*. Master's thesis, Utrecht University.

Kaufmann, S. (2016). Security through technology? Logic, ambivalence and paradoxes of technologised security. *European Journal for Security Research*, *1*(1), 77–95.

Kroll, H., Horvat, D., & Jäger, A. (2018). *Effects of automatisation and digitalization on manufacturing companies' production efficiency and innovation performance* (No. 58). Fraunhofer ISI Discussion Papers-Innovation Systems and Policy Analysis.

Manyika, J., Remes, J., Mischke, J., & Krishnan, M. (2017). The Productivity Puzzle, A Closer Look at the United States. *McKinsey Global Institute, Discussion Paper*.

Marcon, É., Marcon, A., Le Dain, M. A., Ayala, N. F., Frank, A. G., & Matthieu, J. (2019). Barriers for the Digitalization of servitisation. *Procedia CIRP*, *83*, 254-259.

Markovitch, S., & Willmott, P. (2014). Accelerating the digitization of business processes. *McKinsey-Corporate Finance Business Practise*, pp. 1–4.

Martín-Peña, M. L., Sánchez-López, J. M., & Díaz-Garrido, E. (2019). Servitisation and Digitalization in manufacturing: the influence on firm performance. *Journal of Business & Industrial Marketing*, *35*(3), 564-574.

Mefuna, I., & Abe, A. (2015). Technological environment and some selected manufacturing industries in Enugu State, Nigeria. *Journal of Global Economics*, *3*(2), 1–5.

Michael, C. J., Dennis, S. M., Maryan, C., Irving, S., & Palmsten, M. L. (2019). A general framework for human-machine digitization of geographic regions from remotely sensed imagery. In *Proceedings of the 27th ACM SIGSPATIAL International Conference on Advances in Geographic Information Systems*.

Nigerian Institute of Social and Economic Research (2024). Social and Economic Watch – March 2024. Available at https://niser.gov.ng/v2/niser-social-economic-watch-march-2024/

OECD (2017). Critical issues for Digital transformation in the G20. Available at https://www.de.digital/DIGITAL/Redaktion/EN/Publikation/key-issues-for-digital-transformation-g20.pdf?__blob=publicationFile&v=1

Olamade, O. O., Oyebisi, T. O., & Olabode, S. O. (2014). Strategic ICT-use intensity of manufacturing companies in Nigeria. *Journal of Asian Business Strategy*, *4*(1), 1.

Parviainen, P., Tihinen, M., Kääriäinen, J., & Teppola, S. (2017). Tackling the digitalization challenge: how to benefit from Digitalization in practice. *International journal of information systems and project management*, *5*(1), 63-77.

Sabbagh, K., Friedrich, R., El-Darwiche, B., Singh, M., Ganediwalla, S., & Katz, R. (2012). Maximising the impact of digitization. *The Global Information Technology Report, 2012*, pp. 121–133.

Savastano, M., Amendola, C., Bellini, F., & D'Ascenzo, F. (2019). Contextual impacts on industrial processes brought by the digital transformation of manufacturing: A systematic review. *Sustainability*, *11*(3), 891.

Savić, N., Lazarević, J., Kukić, Z., & Marinković, E. (2019). Digital transformation: Challenges for companies in Serbia. *Ekonomika preduzeća*, *67*(1-2), 101-114.

Tybout, J. R. (2000). Manufacturing firms in developing countries: How well do they do, and why? *Journal of Economic Literature*, *38*(1), 11–44.