



Institutional Drivers of Fourth Industrial Revolution (4IR) Entrepreneurship among Computer Engineering Technologists in Nigerian Polytechnics



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ABSTRACT

The spread of digital technologies linked to the Fourth Industrial Revolution (4IR) is reshaping how economies function, how innovation occurs, and how new ventures emerge. Tools such as artificial intelligence, robotics, cloud platforms, big data, and the Internet of Things are not only transforming production systems but also redefining the skills expected from graduates. As a result, higher education—particularly polytechnic education with its practical orientation—is under pressure to produce graduates who can combine technical expertise with entrepreneurial thinking. Despite this shift, there is still limited empirical evidence on how institutional conditions within polytechnics influence entrepreneurship among computer engineering technologists, especially in developing countries like Nigeria. This study examines how three key institutional factors—awareness of 4IR technologies, availability of facilities, and institutional support—shape entrepreneurship opportunities in Nigerian polytechnics. A survey of 125 respondents, including students, lecturers, and technologists, was conducted. The data were analyzed using descriptive statistics, correlation, reliability tests, and multiple regression. The results show that respondents generally understand 4IR technologies and recognize their business potential. The regression model indicates that the three institutional factors jointly account for 68.7% of the variation in entrepreneurship outcomes ($R^2 = 0.687$). Among them, institutional support has the strongest influence, followed by facilities and awareness. The study extends existing knowledge on digital entrepreneurship by demonstrating that awareness alone is insufficient; supportive institutional environments are essential. It further suggests that improving infrastructure, strengthening support systems, and deepening industry linkages are critical for advancing technology-driven entrepreneurship in Nigerian polytechnics.

Keywords:

Fourth Industrial Revolution;
Digital Entrepreneurship;
Institutional support;
Technical education;
Polytechnic innovation.

INTRODUCTION

Technological progress has increasingly become a defining force in shaping modern economies, influencing how industries operate, how services are delivered, and how societies respond to emerging challenges. Over the past few decades, rapid developments in computing systems, communication networks, and digital platforms have accelerated innovation and enabled new forms of enterprise across different sectors of the global economy (Xu, David, & Kim, 2018). This ongoing transformation is widely described as the Fourth Industrial Revolution (4IR).

The Fourth Industrial Revolution represents a new phase of technological advancement characterized by the convergence of digital, physical, and biological systems.

According to Schwab (2016), what distinguishes this revolution is not only the diversity of technologies involved but also the unprecedented speed at which they are diffusing globally across societies. Technologies such as artificial intelligence, robotics, cloud computing, blockchain, big data analytics, and the Internet of Things (IoT) are already reshaping production systems, service delivery models, and economic activities globally (Li, Hou, Yu, Lu, & Yang, 2017). These developments are fostering interconnected digital ecosystems that support innovation and broaden participation in economic activities.

Beyond transforming industries, these technologies are also redefining how value is created within modern economies.

Organizations increasingly rely on automation, intelligent systems, and data-driven processes to improve efficiency and competitiveness. For instance, artificial intelligence is being applied across sectors such as healthcare, finance, manufacturing, and transportation, while IoT technologies are enabling smart systems and automated processes (Bughin et al., 2018). As a result, new pathways for entrepreneurship are emerging, allowing individuals and organizations to develop innovative digital solutions and technology-based ventures.

Entrepreneurship plays a critical role in translating technological advancements into economic value. It involves identifying opportunities within evolving technological environments and transforming them into viable business ventures (Acs, Szerb, & Lloyd, 2018). In the 4IR era, entrepreneurship is increasingly technology-driven, with many ventures built on digital platforms that allow scalability and global reach with relatively low entry barriers (Nambisan, Wright, & Feldman, 2019).

These developments have important implications for higher education institutions. There is growing pressure on universities and technical institutions to produce graduates who are not only technically competent but also capable of innovation and entrepreneurial thinking (Etzkowitz & Zhou, 2018). In response, many institutions are revising their curricula and learning systems to incorporate digital skills, innovation practices, and entrepreneurship education (Salmon, 2019).

Polytechnic institutions occupy a unique position within this evolving landscape. Unlike traditional universities, they emphasize practical and application-oriented training, making them particularly relevant for technology-driven economies (Oketch, McCowan, & Schendel, 2014). Their focus on hands-on skills positions them as key contributors to innovation and entrepreneurship, especially in developing countries.

In Nigeria, polytechnics play a vital role in producing the technical workforce required for industrial development. Programmes in computer engineering technology, information technology, and related fields equip students with practical skills in programming, networking, embedded systems, and digital electronics (Aina, 2022). These competencies are directly aligned with technologies associated with the Fourth Industrial Revolution. However, despite this strategic role, many polytechnics face persistent challenges, including inadequate infrastructure, outdated laboratory facilities, limited research funding, and weak industry linkages (Oke & Fernandes, 2020; Oyedemi & Mogaji, 2022). These constraints can limit students' exposure to innovation and reduce their ability to engage in technology-driven entrepreneurship. One effective way to get ready for the wave of Industry 4.0 is by making strong investments in science, technology, engineering, and mathematics (STEM) education. In addition, the government needs to take a leading role in shaping and

developing the next generation's technological skills and digital awareness (Ajah & Chigozie-Okwum, 2019).

In this context, institutional readiness becomes a critical issue. Institutional readiness refers to the extent to which organizations are equipped to adopt emerging technologies, implement innovation-oriented policies, and create environments that support experimentation and entrepreneurial activity (Alalwan, Dwivedi, & Rana, 2017). Within higher education, readiness for Industry 4.0 involves factors such as technological infrastructure, curriculum relevance, faculty competence, and collaboration with industry (Adu-Gyamfi & Korneliusson, 2022).

The entrepreneurial ecosystem perspective provides a useful lens for understanding how these factors interact. It emphasizes that entrepreneurship is shaped by a network of institutions, policies, and resources that collectively support innovation (Guerrero, Urbano, & Fayolle, 2016). Similarly, the Triple Helix model highlights the importance of collaboration among universities, industry, and government in fostering innovation-driven development (Etzkowitz & Zhou, 2018).

Despite increasing scholarly attention to digital entrepreneurship and Industry 4.0 readiness, empirical evidence remains limited regarding how institutional environments influence entrepreneurship opportunities within polytechnic education systems, particularly in developing countries such as Nigeria. Most existing studies have focused on universities in developed contexts, leaving a gap in understanding the polytechnic sector.

Computer Engineering Technologists represent a particularly important group within this context because their training aligns closely with key 4IR technologies. Their expertise in computing systems, networking, and embedded technologies places them in a strong position to drive innovation (Nambisan et al., 2019). However, their ability to translate technical knowledge into entrepreneurial outcomes depends largely on the institutional environment in which they are trained.

To address this gap, this study adopts a conceptual framework grounded in the entrepreneurial ecosystem perspective and institutional readiness theory. It proposes that entrepreneurship opportunities among Computer Engineering Technologists are influenced by three key factors: awareness of 4IR technologies, availability of institutional facilities, and institutional support mechanisms. By examining these relationships, the study aims to provide empirical insights into how Nigerian polytechnics can better support technology-driven entrepreneurship in the Fourth Industrial Revolution era. The ongoing expansion of digital technologies associated with the Fourth Industrial Revolution (4IR) is changing how economies operate, how innovation is generated, and how jobs are structured. Technologies such as artificial

intelligence, robotics, cloud computing, big data, and the Internet of Things are opening new pathways for technology-based entrepreneurship (Schwab, 2016; Xu, David, & Kim, 2018). In response to these changes, higher education institutions are now expected to go beyond traditional teaching by preparing graduates who possess both technical expertise and the ability to create and sustain innovative ventures.

Polytechnic institutions, due to their emphasis on hands-on and applied learning, are strategically positioned to support this transition. They are expected to produce graduates with practical skills that align with industry needs and technological advancement. However, in many developing countries, including Nigeria, polytechnics continue to face structural limitations. Issues such as inadequate infrastructure, outdated laboratories, weak links with industry, and limited institutional support for innovation have been widely reported (Oke & Fernandes, 2020; Oyedemi & Mogaji, 2022).

Despite these challenges, there is still insufficient empirical understanding of how these institutional conditions influence entrepreneurship opportunities for computer engineering technologists within Nigerian polytechnics. This gap makes it difficult to design effective strategies for strengthening technology-driven entrepreneurship in this context.

Research Hypotheses

Based on the conceptual framework of the study, entrepreneurship opportunities are treated as the dependent variable, while awareness of Fourth Industrial Revolution (4IR) technologies, institutional facilities, and institutional support are treated as independent variables representing institutional readiness factors. The study therefore tests the following hypotheses:

H1: Awareness of Fourth Industrial Revolution (4IR) technologies has a significant positive influence on entrepreneurship opportunities among computer engineering technologists.

H2: Institutional facilities have a significant positive influence on entrepreneurship opportunities among computer engineering technologists.

H3: Institutional support has a significant positive influence on entrepreneurship opportunities among computer engineering technologists.

The Fourth Industrial Revolution and Global Technological Transformation

The global economy is currently undergoing a major technological shift commonly described as the Fourth Industrial Revolution (4IR). This phase is marked by the deep integration of digital technologies into everyday economic and social activities. According to Schwab (2016), the 4IR is driven by emerging technologies such as artificial intelligence, robotics, big data analytics, blockchain, automation systems, and the Internet of

Things (IoT). What makes this era distinct is not just the technologies themselves, but how interconnected and rapidly deployable they have become across sectors.

Unlike earlier industrial revolutions that were based on mechanization, electricity, or basic computing, the 4IR is defined by convergence—where multiple technologies interact simultaneously to reshape production and service systems (Xu, David, & Kim, 2018). Today, digital systems are embedded in almost every layer of economic activity, enabling smarter operations, faster decision-making, and entirely new business models.

Beyond productivity gains, these transformations are changing the nature of work. There is increasing demand for skills such as digital competence, critical thinking, adaptability, and innovation capacity. The World Economic Forum (2023) emphasizes that future jobs will require a blend of technical expertise and entrepreneurial thinking.

For countries like Nigeria, the 4IR presents a mixed reality. On one hand, it offers an opportunity to leapfrog developmental stages through digital adoption. On the other hand, persistent challenges—such as weak infrastructure, limited funding, and skill gaps—can slow down this transition (Adeniyi, 2022). This makes the role of educational institutions especially critical in preparing individuals to function effectively in this evolving landscape.

Entrepreneurship in the Fourth Industrial Revolution

Entrepreneurship remains a central mechanism for translating innovation into economic value. As noted by Acs, Szerb, and Lloyd (2018), entrepreneurs act as catalysts who convert ideas into viable products and services. In the 4IR context, this role has expanded significantly due to the rise of digital technologies.

Digital entrepreneurship refers to ventures that are built primarily on digital platforms and technological infrastructure (Nambisan, Wright, & Feldman, 2019). These ventures often scale faster and operate across borders with fewer entry barriers compared to traditional businesses. Examples include fintech startups, AI-driven services, and software-based enterprises.

The strength of entrepreneurship in any country is often tied to the quality of its ecosystem. Audretsch, Belitski, and Desai (2023) highlight that well-developed ecosystem—comprising institutions, policies, funding, and networks—are essential for sustained innovation and competitiveness.

In Nigeria, entrepreneurship has become increasingly important, especially as a response to unemployment and economic diversification challenges. This has led to the inclusion of entrepreneurship education in many tertiary programmes (Okoye & Eze, 2022). However, the effectiveness of such initiatives largely depends on the institutional environment, including access to technology,

exposure to innovation, and availability of support systems.

Awareness of 4IR Technologies and Entrepreneurship

Awareness of emerging technologies is a foundational factor in entrepreneurial development. Individuals who understand current technological trends are better positioned to identify opportunities and develop innovative solutions.

Nambisan et al. (2019) argue that technological awareness enhances opportunity recognition by helping individuals connect real-world problems with digital solutions. Within educational settings, exposure to technologies such as AI, IoT, and data analytics can stimulate creativity and encourage experimentation.

Scholars have also stressed the need for curriculum reform. Salmon (2019) suggests that institutions must redesign teaching approaches to reflect digital realities, while Xu et al. (2018) emphasize strengthening technological literacy among students.

In practical terms, when technologists lack awareness of emerging technologies, they may struggle to see business opportunities embedded within them. Therefore, increasing awareness is not just an academic goal—it is a necessary step toward fostering entrepreneurship.

Institutional Facilities and Technological Innovation

Facilities within educational institutions play a direct role in shaping innovation outcomes. Access to functional laboratories, reliable internet, and modern equipment provides the environment needed for hands-on learning and experimentation.

Oke and Fernandes (2020) identify technological infrastructure as a key indicator of Industry 4.0 readiness. Similarly, Guerrero, Urbano, and Fayolle (2016) note that institutions with better facilities tend to produce more innovative and entrepreneurial graduates.

In the Nigerian context, however, infrastructural challenges remain a major concern. Many polytechnics struggle with outdated laboratories, inconsistent power supply, and limited access to modern tools (Oyedemi & Mogaji, 2022). These constraints can limit students' ability to translate theoretical knowledge into practical innovations.

Improving institutional facilities is therefore essential—not only for academic purposes but also for enabling real-world problem-solving and venture creation.

Institutional Support and Entrepreneurship Development

Beyond physical infrastructure, institutional support systems are critical in nurturing entrepreneurship. These include policies, mentorship programmes, funding opportunities, and industry linkages.

The entrepreneurial ecosystem perspective highlights that supportive institutional environments significantly influence innovation outcomes (Guerrero et al., 2016). Likewise, the Triple Helix model (Etzkowitz & Zhou, 2018) underscores the importance of collaboration between academia, industry, and government.

In practice, institutions that actively support entrepreneurship—through incubation centres, innovation hubs, and partnerships—are more likely to produce graduates who engage in business creation. These platforms provide not just resources, but also guidance and exposure.

However, many institutions in developing countries, including Nigeria, still lack structured support systems. Strengthening these mechanisms is therefore crucial for promoting technology-based entrepreneurship among students and technologists.

Empirical Studies on 4IR Readiness in Higher Education

Empirical research on 4IR readiness shows a consistent pattern: awareness is increasing, but institutional capacity often lags behind. Oke and Fernandes (2020) found that while African universities are becoming more aware of emerging technologies, many lack the infrastructure needed for full implementation.

Similarly, Adeniyi (2022) reported that Nigerian universities face significant barriers, including funding limitations and inadequate facilities. Adu-Gyamfi and Korneliusen (2022) further emphasize the role of leadership and institutional policies in driving digital transformation.

More recent studies, such as Audretsch et al. (2023), link digital transformation directly to entrepreneurial outcomes, showing that institutions that integrate technology into their programmes tend to produce more innovative graduates.

Despite these insights, there is still limited research focusing specifically on polytechnics—particularly in Nigeria—and how their institutional environments influence entrepreneurship among technologists. This gap is important given the practical and industry-oriented nature of polytechnic education.

Conceptual Framework

This study is guided by the assumption that institutional conditions shape entrepreneurship outcomes among computer engineering technologists. Drawing from the entrepreneurial ecosystem perspective and institutional readiness theory, three key factors are identified:

- Awareness of 4IR technologies
- Institutional facilities
- Institutional support

Awareness enables opportunity recognition, facilities provide the means for experimentation, and institutional support creates an enabling environment for innovation.

Together, these factors determine the extent to which technologists can engage in entrepreneurship within the 4IR context.

Therefore, the conceptual framework proposes that these institutional readiness factors collectively influence entrepreneurship opportunities among computer engineering technologists.

Independent Variables

- Awareness of Fourth Industrial Revolution technologies

- Institutional Facilities
- Institutional Support

Dependent Variable

- Entrepreneurship Opportunities

Figure 1 illustrates the conceptual framework of the study, which proposes that awareness of Fourth Industrial Revolution technologies, institutional facilities, and institutional support influence entrepreneurship opportunities among computer engineering technologists.

Conceptual Framework: Institutional Determinants of 4IR-Driven Entrepreneurship

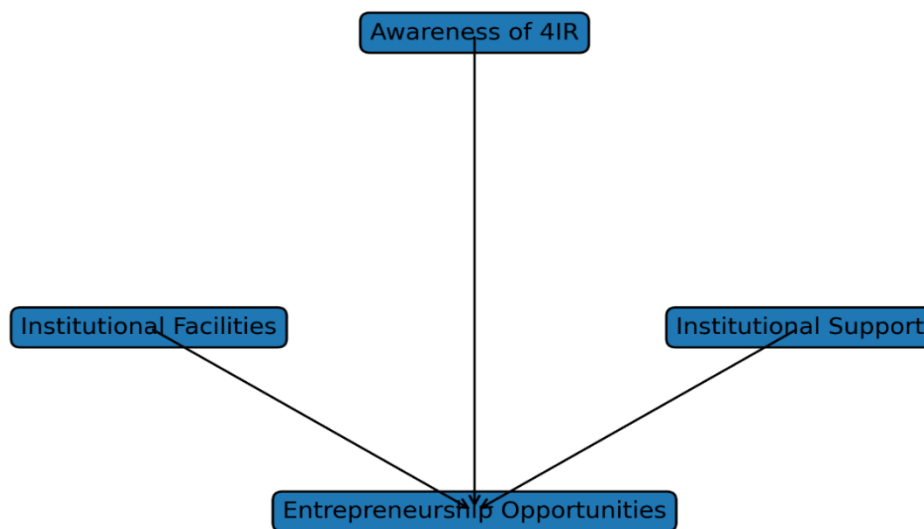


Figure 1: Conceptual Framework of Institutional Drivers of Fourth Industrial Revolution (4IR) Entrepreneurship while enabling statistical analysis of variable relationships.

MATERIALS AND METHODS

Research Design

This study employed a quantitative cross-sectional survey approach to investigate how institutional factors shape entrepreneurship opportunities for Computer Engineering Technologists within Nigerian polytechnics in the era of the Fourth Industrial Revolution (4IR). The choice of this design was informed by its suitability for collecting measurable data and examining relationships among variables such as awareness of 4IR technologies, institutional facilities, institutional support, and entrepreneurship outcomes.

Cross-sectional surveys are commonly used in education and entrepreneurship research because they allow data to be gathered from respondents at a specific point in time

Population, Sample, and Sampling Technique

The study population consisted of individuals involved in Computer Engineering Technology programmes in Nigerian polytechnics, including students, lecturers, laboratory technologists, and technical instructors.

The accessible population was drawn from the Computer Engineering departments of Federal Polytechnic Daura and Hussaini Adamu Federal Polytechnic, Kazaure, with an estimated total of 210 individuals. These participants were considered relevant due to their exposure to technologies such as artificial intelligence, networking systems, embedded systems, and digital electronics.

The sampling frame was developed from official departmental staff records and student enrollment lists obtained from the selected institutions.

To ensure fair representation, a stratified random sampling technique was adopted. The population was grouped into three categories:

- Students
- Lecturers
- Technologists

Sample size was determined using Yamane’s (1967) formula:

$$n = \frac{N}{1+N(e)^2} \tag{1}$$

Where:

n = sample size

N = population size

e = margin of error (0.05)

The calculation produced a minimum sample size of 138 respondents. However, due to practical constraints during data collection, 125 valid responses were obtained. This number remains statistically adequate for correlation and regression analysis in social science studies.

Instrumentation

Data were collected using a structured questionnaire designed to capture the major variables in the study.

The instrument was divided into five sections:

- Section A: Demographic information (institution, category, level, experience)
- Section B: Awareness of 4IR technologies (5 items)
- Section C: Institutional facilities (5 items)
- Section D: Entrepreneurship opportunities/readiness (5 items)
- Section E: Institutional support (6 items)

Altogether, the instrument contained 21 items measuring the four key constructs.

Responses were rated on a five-point Likert scale ranging from Strongly Disagree (1) to Strongly Agree (5). This format is widely accepted for measuring perceptions and attitudes in educational research.

Validity and Reliability of the Instrument

To ensure content validity, the questionnaire was reviewed by experts in engineering technology, entrepreneurship education, and research methods. Their input helped refine the clarity and relevance of the items. Construct validity was assessed using Exploratory Factor Analysis (EFA), where factor loadings of 0.50 and above were considered acceptable.

Reliability was tested using Cronbach’s Alpha, with results indicating satisfactory internal consistency:

Table 1: Alpha across all constructs

Construct	Cronbach Alpha
Awareness of 4IR	0.786
Institutional Facilities	0.725

Entrepreneurship Opportunities	0.767
Institutional Support	0.853

All values exceeded the acceptable threshold of 0.70, confirming the reliability of the instrument.

Data Collection Procedure

Data collection was carried out through an online survey. The questionnaire link was shared via departmental communication channels, WhatsApp groups, and academic mailing lists within the selected polytechnics. Respondents were informed about the purpose of the study before participation, and completion of the questionnaire was entirely voluntary. The online method made it easier to reach participants across both institutions within a limited timeframe.

Data Analysis

The data were analyzed using SPSS software. Descriptive statistics such as frequencies, percentages, means, and standard deviations were used to summarize the data. Reliability was confirmed using Cronbach’s Alpha.

Pearson correlation analysis was used to examine relationships among the variables, while multiple regression analysis was applied to determine the predictive effects of awareness, facilities, and institutional support on entrepreneurship.

The regression model is expressed as:

$$Entrepreneurship = \beta_0 + \beta_1(Awareness) + \beta_2(Facilities) + \beta_3(Institutional\ support) + \epsilon \tag{2}$$

Before running the regression, diagnostic tests were conducted to confirm that key statistical assumptions were satisfied. These included:

- Normality (skewness and kurtosis)
- Multicollinearity (Variance Inflation Factor)
- Homoscedasticity (residual analysis)

The results confirmed that the data met the requirements for regression analysis.

Ethical Considerations

Ethical standards were strictly followed throughout the study. Participation was voluntary, and respondents were adequately informed about the purpose of the research. Confidentiality was maintained by ensuring that no personal identifiers were included in the dataset or reported findings. All data were used strictly for academic purposes.

In addition, approval was obtained from the relevant departments of the participating polytechnics before the commencement of data collection.

RESULTS AND DISCUSSION

This chapter presents the outcome of the data analysis carried out for this study. The analysis was performed

using the Statistical Package for the Social Sciences (SPSS). It covers respondents' background information, reliability and validity checks, descriptive statistics, correlation analysis, and multiple regression results.

The main objective here is to show, using empirical data, how awareness of Fourth Industrial Revolution (4IR) technologies, availability of institutional facilities, and institutional support systems influence entrepreneurship opportunities among Computer Engineering Technologists. A total of 125 responses were collected, while 121 valid cases were used for most inferential analyses after excluding incomplete entries.

Response Rate and Data Quality

Out of the 125 questionnaires administered, all were returned and entered into the dataset. However, for scale-based analysis, 121 responses (96.8%) were usable, while 4 responses (3.2%) were removed due to missing values using listwise deletion.

This high usable response rate indicates that respondents understood the questionnaire reasonably well. It also suggests that the dataset is reliable enough for further statistical testing and interpretation.

Construct Validity Assessment

To confirm that the questionnaire measured what it was intended to measure, Exploratory Factor Analysis (EFA) was conducted.

The results showed that all items loaded appropriately on their respective constructs, with factor loadings above the acceptable threshold of 0.50. In addition, the Kaiser-Meyer-Olkin (KMO) value and Bartlett's Test of Sphericity indicated that the dataset was suitable for factor analysis.

These outcomes confirm that the instrument has acceptable construct validity and that the variables—awareness, facilities, institutional support, and entrepreneurship—are well represented by the items used.

Demographic Characteristics of Respondents

Distribution by Institution

The respondents were mainly drawn from Federal Polytechnic Daura and Hussaini Adamu Federal Polytechnic Kazaure. A large majority, 113 respondents (90.4%), were from Federal Polytechnic Daura, while 8 respondents (6.4%) were from Kazaure. The remaining 4 responses (3.2%) did not indicate any institution.

This imbalance suggests that the findings largely reflect the realities within Federal Polytechnic Daura, which should be considered when interpreting the results.

Distribution by Respondent Category

Participants included students, lecturers, and technologists. Students formed the largest group with 72 respondents (57.6%), followed by lecturers with 39

respondents (31.2%), and technologists with 10 respondents (8.0%). Four responses (3.2%) were not classified.

This composition shows that the study captures more of the student perspective, though staff input adds valuable practical and institutional insights.

Distribution by Level of Study

Among students, ND II respondents were the majority (36.0%), followed by HND I (14.4%) and HND II (9.6%). ND I students accounted for only 2.4%. A significant portion (37.6%) was recorded as missing, which is expected since this variable does not apply to staff.

This indicates that responses were mainly from students with some level of academic exposure and experience.

Distribution by Years of Experience

Most staff respondents were relatively early in their careers. About 55.2% had less than 5 years of experience, while 31.2% had between 5–10 years. Only a small proportion had over 15 years of experience.

This may explain the relatively high openness to new technologies and innovation observed in later findings.

Reliability Analysis

Reliability analysis was conducted using Cronbach's alpha to determine the internal consistency of the multi-item scales used in the study. Four distinct constructs were assessed: awareness of 4IR, institutional facilities, entrepreneurship opportunities/readiness, and institutional support. In each case, 121 valid responses were used, while 4 incomplete cases were excluded through listwise deletion.

- Awareness of 4IR: 0.786 (Good)
- Institutional Facilities: 0.725 (Acceptable)
- Entrepreneurship: 0.767 (Good)
- Institutional Support: 0.853 (Very Good)

All values exceed the 0.70 benchmark, confirming that the instrument is reliable and suitable for academic analysis.

Table 2: Reliability Statistics for Study Constructs

Construct	Number of Items	Cronbach's Alpha	Interpretation
Awareness of 4IR	5	0.786	Good
Institutional Facilities	4	0.725	Acceptable
Entrepreneurship Opportunities/Readiness	4	0.767	Good
Institutional Support	6	0.853	Very Good

Source: SPSS output from field survey, 2026.

Descriptive Statistics

Awareness of 4IR

Respondents generally showed a good level of awareness of 4IR concepts. Mean scores ranged between 3.50 and 4.29.

While many respondents agreed that 4IR skills are important (mean = 4.29), fewer indicated strong familiarity with the concept itself (mean = 3.50). This suggests that although students and staff recognize the importance of 4IR, deeper understanding may still be developing.

Institutional Facilities

Responses indicate that facilities are moderately available. Internet access and power supply scored relatively high (mean = 4.04), which reflects improvements in digital access in Nigerian institutions. However, variation in responses suggests uneven distribution of resources across departments or institutions—something common in Nigerian polytechnics.

Entrepreneurship Opportunities

Entrepreneurship-related responses were strongly positive. Many respondents agreed that 4IR creates new business opportunities (mean = 4.27) and expressed interest in starting technology-based ventures (mean = 4.29).

This shows a strong entrepreneurial mindset among respondents, especially among students.

Institutional Support

Institutional support was rated fairly high overall, particularly in areas like encouragement for innovation. However, availability of innovation hubs recorded the lowest mean (3.64), highlighting a gap in structured support systems.

This reflects a common issue in Nigeria where ideas exist, but institutional structures to support startups are still limited.

Table 3: Descriptive Statistics of Study Variables

S/N	Item	Mean	Std. Dev.	Decision
1	Familiar with the concept of 4IR	3.50	1.385	Agree
2	Understands basic 4IR technologies	3.83	1.174	Agree
3	4IR-related topics are taught in programme	3.66	1.339	Agree
4	Practical exposure to emerging digital technologies	3.78	1.281	Agree
5	4IR skills are important for the future of Computer Engineering Technologists	4.29	1.172	Agree
6	Department has adequate computer laboratories	3.78	1.235	Agree
7	Internet access and power supply support digital learning	4.04	1.344	Agree
8	Students are encouraged to carry out hands-on technology projects	3.98	1.099	Agree
9	Available facilities support innovation and experimentation	4.02	1.028	Agree
10	4IR technologies create entrepreneurship opportunities	4.27	0.922	Agree
11	Can identify business ideas based on technical skills	4.09	0.949	Agree
12	Ability to develop simple technical solutions or prototypes	3.98	1.110	Agree
13	Interested in starting a technology-based business	4.29	0.978	Agree
14	Department encourages innovation and creativity	4.24	0.958	Agree
15	Curriculum is relevant to current 4IR industry needs	3.78	1.037	Agree
16	Lecturers have adequate knowledge of emerging technologies	3.84	1.133	Agree
17	Institution collaborates with industries for training or internships	3.90	1.227	Agree
18	Entrepreneurship training is supported through workshops or seminars	4.03	1.040	Agree
19	Innovation hubs or incubation centres are available to students	3.64	1.252	Agree

Source: SPSS output from field survey, 2026.

Using a five-point Likert scale, these means indicate a broad positive disposition toward the relevance of 4IR, entrepreneurial potential, and the role of institutional support. The fact that all mean scores exceeded 3.50 indicates that respondents leaned toward agreement across all major dimensions measured. Particularly noteworthy is the combination of high ratings for the importance of 4IR skills, perceived entrepreneurship opportunities, and interest in technology-based business

start-up. This pattern suggests that the respondents do not view 4IR merely as a technological trend but as a practical and economic opportunity space.

Composite Variable Analysis

To facilitate inferential testing, the study computed four composite indices representing awareness of 4IR, institutional facilities, entrepreneurship, and institutional support using mean scores across their respective items. The resulting descriptive statistics showed that:

- Entrepreneurship: 4.1591 (highest)
- Facilities: 3.9545
- Institutional Support: 3.9050
- Awareness: 3.8116

This shows that respondents are highly inclined toward entrepreneurship, even slightly more than their perceived institutional readiness.

Table 4: Descriptive Statistics for Composite Variables

Variable	Mean	Std. Deviation	N
Entrepreneurship	4.1591	0.76171	121
Awareness of 4IR	3.8116	0.93427	121
Facilities	3.9545	0.87560	121
Institutional Support	3.9050	0.84515	121

Source: SPSS output from field survey, 2026.

Correlation Analysis

All variables were positively and significantly related ($p < 0.01$).

Key observations:

- Facilities → Entrepreneurship ($r = 0.750$)
- Institutional Support → Entrepreneurship ($r = 0.748$)
- Awareness → Entrepreneurship ($r = 0.630$)

These results indicate that improvements in awareness, facilities, and institutional support are associated with increased entrepreneurship orientation and perceived entrepreneurship opportunities among respondents. The strongest bivariate associations with entrepreneurship were facilities ($r = 0.750$) and institutional support ($r =$

0.748), followed by awareness of 4IR ($r = 0.630$). This suggests that while awareness is important, the practical and institutional environment may play an even more decisive role in translating technological consciousness into entrepreneurial readiness.

Table 5: Correlation Matrix of Study Variables

Variables	Awareness of 4IR	Facilities	Entrepreneurship	Institutional Support
Awareness of 4IR	1.000	0.549**	0.630**	0.530*
Facilities	0.549*	1.000	0.750**	0.736*
Entrepreneurship	0.630*	0.750**	1.000	0.748*
Institutional Support	0.530*	0.736**	0.748**	1.000

Correlation is significant at the 0.01 level (2-tailed).

Source: SPSS output from field survey, 2026.

This indicates that while awareness matters, practical support and infrastructure have stronger influence.

Figure 2, correlation heatmap of awareness of 4IR, while figure 3 provides a visual representation of the correlation structure among the study variables, showing that awareness of 4IR, institutional facilities, and institutional support are all positively associated with entrepreneurship opportunities

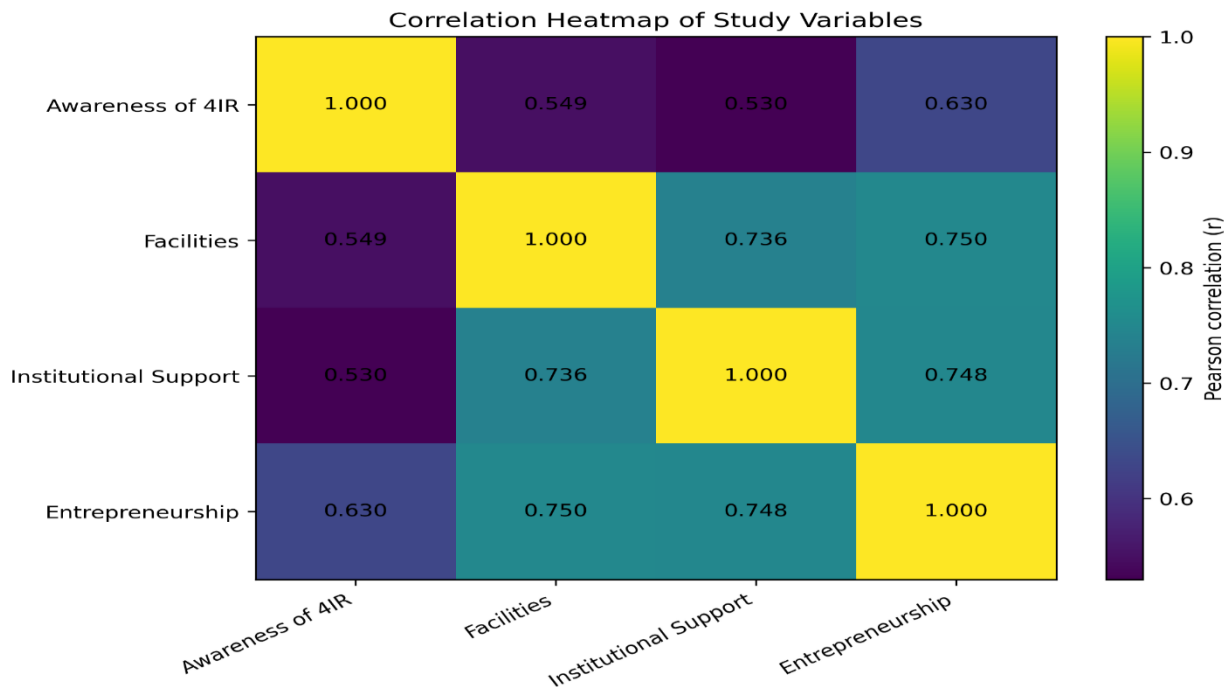


Figure 2: Correlation Heatmap of Awareness of 4IR, Institutional Facilities, Institutional Support, and Entrepreneurship Opportunities

Multiple Regression Analysis

Multiple regression analysis was conducted to determine the joint and individual effects of awareness of 4IR, facilities, and institutional support on entrepreneurship. Entrepreneurship served as the dependent variable, while awareness of 4IR, facilities, and institutional support were entered as predictors.

Model Summary

The regression model produced a multiple correlation coefficient of $R = 0.829$, indicating a very strong relationship between the combined predictors and entrepreneurship. The coefficient of determination was $R^2 = 0.687$, while the adjusted R^2 was 0.679 . This means that approximately 68.7% of the variance in entrepreneurship was explained by awareness of 4IR, facilities, and institutional support taken together. This is a substantial explanatory power for a social science model and suggests that the selected predictors are highly relevant to understanding entrepreneurship opportunities in the study context. The standard error of estimate was 0.43125 .

Table 6: Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of Estimate
1	0.829	0.687	0.679	0.43125

Predictors: Awareness of 4IR, Facilities, Institutional Support.

Source: SPSS output from field survey, 2026.

ANOVA Result

The ANOVA table showed that the regression model was statistically significant, $F(3,117) = 85.794$, $p = 0.000$. This indicates that the combined influence of the three predictors on entrepreneurship is significant and that the model provides a much better fit than a null model with no predictors. In practical terms, awareness, facilities, and institutional support jointly make a meaningful contribution to explaining entrepreneurship outcomes among the respondents.

Table 7: ANOVA for Regression Model

Source	Sum of Squares	df	Mean Square	F	Sig.
Regression	47.866	3	15.955	85.794	0.000
Residual	21.759	117	0.186		

Total	69.625	120			
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Dependent Variable: Entrepreneurship.

Source: SPSS output from field survey, 2026.

Coefficients and Relative Contributions

The coefficient table showed that all three predictors made significant positive contributions to entrepreneurship. Awareness of 4IR had an unstandardized coefficient of $B = 0.202$, a standardized beta of 0.248 , $t = 3.903$, and $p = 0.000$. Facilities recorded $B = 0.305$, $\beta = 0.350$, $t = 4.409$, and $p = 0.000$. Institutional support produced $B = 0.324$, $\beta = 0.359$, $t = 4.585$, and $p = 0.000$.

Based on the standardized beta values, institutional support emerged as the strongest predictor of entrepreneurship, followed closely by facilities, while awareness of 4IR, though still significant, had the smallest relative effect among the three. This means that while awareness is necessary, institutional structures and enabling support systems are more influential in shaping entrepreneurship outcomes. In other words, respondents may appreciate 4IR and understand its significance, but entrepreneurship flourishes more strongly where there is institutional encouragement, accessible facilities, and practical support mechanisms.

Table 8: Regression Coefficients

Predictor	B	Std. Error	Beta	t	Sig.
Constant	0.921	0.206	—	4.471	0.000
Awareness of 4IR	0.202	0.052	0.248	3.903	0.000
Facilities	0.305	0.069	0.350	4.409	0.000
Institutional Support	0.324	0.071	0.359	4.585	0.000

Dependent Variable: Entrepreneurship.

Source: SPSS output from field survey, 2026.

Regression Equation

Based on the unstandardized coefficients, the regression equation for the model can be expressed as:

$$Entrepreneurship = 0.921 + 0.202(Awareness) + 0.305(Facilities) + 0.324(Institutional Support)$$

Figure 3 below illustrates the regression model showing the relative influence of awareness of Fourth Industrial Revolution technologies, institutional facilities, and institutional support on entrepreneurship opportunities among Computer Engineering Technologists.

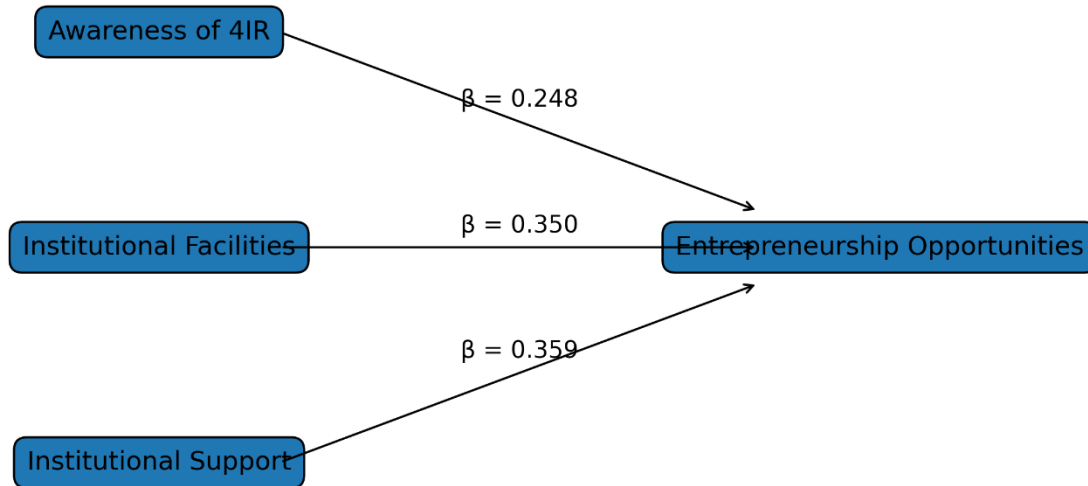


Figure 3: Regression Model Showing the Influence of Awareness of 4IR, Institutional Facilities, and Institutional Support on Entrepreneurship Opportunities

This equation indicates that, holding other factors constant, a one-unit increase in awareness of 4IR increases entrepreneurship by 0.202 units, a one-unit increase in facilities increases entrepreneurship by 0.305 units, and a one-unit increase in institutional support increases entrepreneurship by 0.324 units. The coefficients reinforce the conclusion that institutional support and facilities are particularly critical for strengthening entrepreneurship outcomes in the 4IR context.

Collinearity Diagnostics

The collinearity statistics showed tolerance values of 0.664 for awareness of 4IR, 0.423 for facilities, and 0.436 for institutional support. The corresponding VIF values were 1.507, 2.363, and 2.295 respectively. These values are within commonly accepted limits and do not suggest problematic multicollinearity. Therefore, the predictors are sufficiently distinct to remain in the model without seriously distorting the regression estimates.

The collinearity diagnostics further showed condition indices up to 18.142. While this suggests some shared variance among predictors, the overall diagnostic pattern does not indicate severe collinearity. Thus, the model can be considered statistically stable and interpretable.

Hypothesis Testing

The hypotheses of the study were tested using the regression coefficients and significance values from the

multiple regression analysis. A hypothesis was accepted when the predictor variable had a positive coefficient and a significance value less than 0.05.

Table 9: Summary of Hypothesis Testing

Hypothesis	Path	Beta	Sig.	Decision
H1	Awareness of 4IR → Entrepreneurship Opportunities	0.248	0.000	Accepted
H2	Institutional Facilities → Entrepreneurship Opportunities	0.350	0.000	Accepted
H3	Institutional Support → Entrepreneurship Opportunities	0.359	0.000	Accepted

The results show that all three hypotheses were supported. Awareness of 4IR technologies, institutional facilities, and institutional support each exerted a positive and statistically significant influence on entrepreneurship opportunities among Computer Engineering Technologists.

Interpretation

What this means in simple terms:

- Knowing about 4IR is good, but not enough
- Having access to labs, internet, and tools matters more
- Institutional backing (training, support, policies) matters most

This aligns strongly with the Nigerian reality—many students have ideas, but lack structured support to turn them into businesses.

Discussion of Major Findings

The results of this study point to a generally encouraging picture regarding the readiness of respondents to engage with Fourth Industrial Revolution (4IR) trends and technology-driven entrepreneurship. From the descriptive analysis, it is evident that many respondents not only acknowledge the relevance of 4IR skills but also see practical opportunities for applying such knowledge in real-life business situations. The high level of agreement on issues such as the importance of digital skills and interest in starting technology-based ventures suggests that respondents are not passive observers of technological change; rather, they are beginning to position themselves as active participants within this evolving digital economy. This is particularly important in the Nigerian context, where youth-driven innovation is increasingly becoming a pathway to economic survival and growth.

The reliability results further strengthen confidence in these findings. The consistency observed across all the measured constructs indicates that the questionnaire items were stable and dependable in capturing the intended variables. In practical terms, this means that the patterns observed in awareness, facilities, institutional support, and entrepreneurship are not random but reflect actual tendencies among the respondents.

Looking at the relationships among the variables, the correlation results show a clear pattern: all the major factors move in the same direction. In other words, higher awareness of 4IR, better access to facilities, and stronger institutional support are all associated with increased entrepreneurial inclination. This reinforces the idea that entrepreneurship in a technology-driven environment does not happen in isolation. Instead, it is shaped by a combination of knowledge, access to tools, and the level of encouragement provided by the institution. For instance, a student who has access to a functional lab and supportive lecturers is more likely to experiment with ideas than one who only has theoretical knowledge.

The regression analysis provides deeper insight into this relationship. With about 68.7% of the variation in entrepreneurship explained by the model, the results indicate a strong predictive capacity. More importantly, institutional support and facilities emerged as more

influential than awareness alone. This finding is very relevant within Nigerian polytechnics, where students are often exposed to theoretical concepts but may lack the practical environment needed to translate those ideas into viable solutions. It suggests that knowing about technologies like artificial intelligence or IoT is not sufficient; what matters more is whether students have access to working systems, mentorship, and platforms that allow them to test and refine their ideas.

From a practical standpoint, these findings highlight the need for a more coordinated approach to promoting entrepreneurship within technical institutions. Improving curriculum content alone will not be enough. There must also be deliberate investment in laboratories, reliable internet access, innovation spaces, and structured support systems such as incubation centres and industry partnerships. In addition, lecturers need continuous exposure to emerging technologies so they can guide students effectively.

Overall, the study shows that polytechnic institutions in Nigeria have the potential to go beyond their traditional teaching role and become centres for innovation and enterprise development. When the right combination of awareness, infrastructure, and institutional backing is in place, students and technologists are more likely to move from simply learning technology to actually using it to create businesses and solve real-world problems.

CONCLUSION

This study set out to examine how institutional conditions shape entrepreneurship opportunities for Computer Engineering Technologists in Nigerian polytechnics within the era of the Fourth Industrial Revolution (4IR). In particular, it focused on three major factors: awareness of 4IR technologies, availability of institutional facilities, and the level of institutional support for innovation and entrepreneurship. The findings clearly show that the ongoing digital transformation associated with 4IR is opening up new paths for technology-based entrepreneurship, especially for individuals with training in areas such as programming, networking, embedded systems, and digital electronics. However, having technical knowledge alone is not enough. What really determines whether such knowledge can be turned into viable business ventures is the kind of environment provided by the institution. Although most respondents demonstrated a fair level of awareness of emerging technologies, this awareness did not automatically translate into entrepreneurial action. Instead, factors such as access to functional laboratories, stable internet, hands-on learning opportunities, and structured institutional encouragement were found to play a more decisive role. In practical terms, students and technologists are more likely to explore business ideas when they are supported

by a system that makes experimentation and innovation possible.

The statistical analysis further confirmed this pattern. Awareness of 4IR, institutional facilities, and institutional support jointly explained a large portion of the variation in entrepreneurship outcomes. Among these, institutional support stood out as the most influential factor, followed by facilities, while awareness—though important—had a comparatively smaller effect. This indicates that beyond classroom teaching, institutions need to actively create platforms that enable students to apply what they learn.

The study also confirmed that all the stated hypotheses (H1, H2, and H3) were supported, as each of the three factors showed a significant positive relationship with entrepreneurship opportunities. This reinforces the idea that entrepreneurship development in technical fields is not driven by a single variable but by a combination of knowledge, infrastructure, and institutional backing. From a broader perspective, the study highlights the importance of building strong institutional ecosystems within Nigerian polytechnics. Schools that invest in modern equipment, promote innovation-based teaching, and maintain active links with industry are more likely to produce graduates who can create jobs rather than only seek them. This is particularly important in Nigeria, where youth unemployment remains a major challenge.

In terms of academic contribution, this research adds to existing discussions on digital entrepreneurship and institutional readiness by providing evidence from the polytechnic system, which is often less studied compared to universities. It also supports key theoretical ideas from the entrepreneurial ecosystem approach and the Triple Helix model by showing how collaboration, infrastructure, and institutional structures influence real outcomes in a developing country setting.

From a policy and management standpoint, the findings suggest that school administrators and government agencies should pay more attention to strengthening innovation support systems. This includes improving laboratory facilities, embedding entrepreneurship into technical programmes, and creating partnerships with industries that can expose students to real-world applications. That said, the study is not without its limitations. The data were collected from only two polytechnics, which means the findings may not fully represent all institutions across Nigeria. In addition, the use of self-reported responses means that some answers may reflect personal opinions rather than exact institutional realities.

Future studies can build on this work by covering more polytechnics across different regions of the country and by including additional variables such as funding access, startup support systems, and government policies that influence digital entrepreneurship.

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