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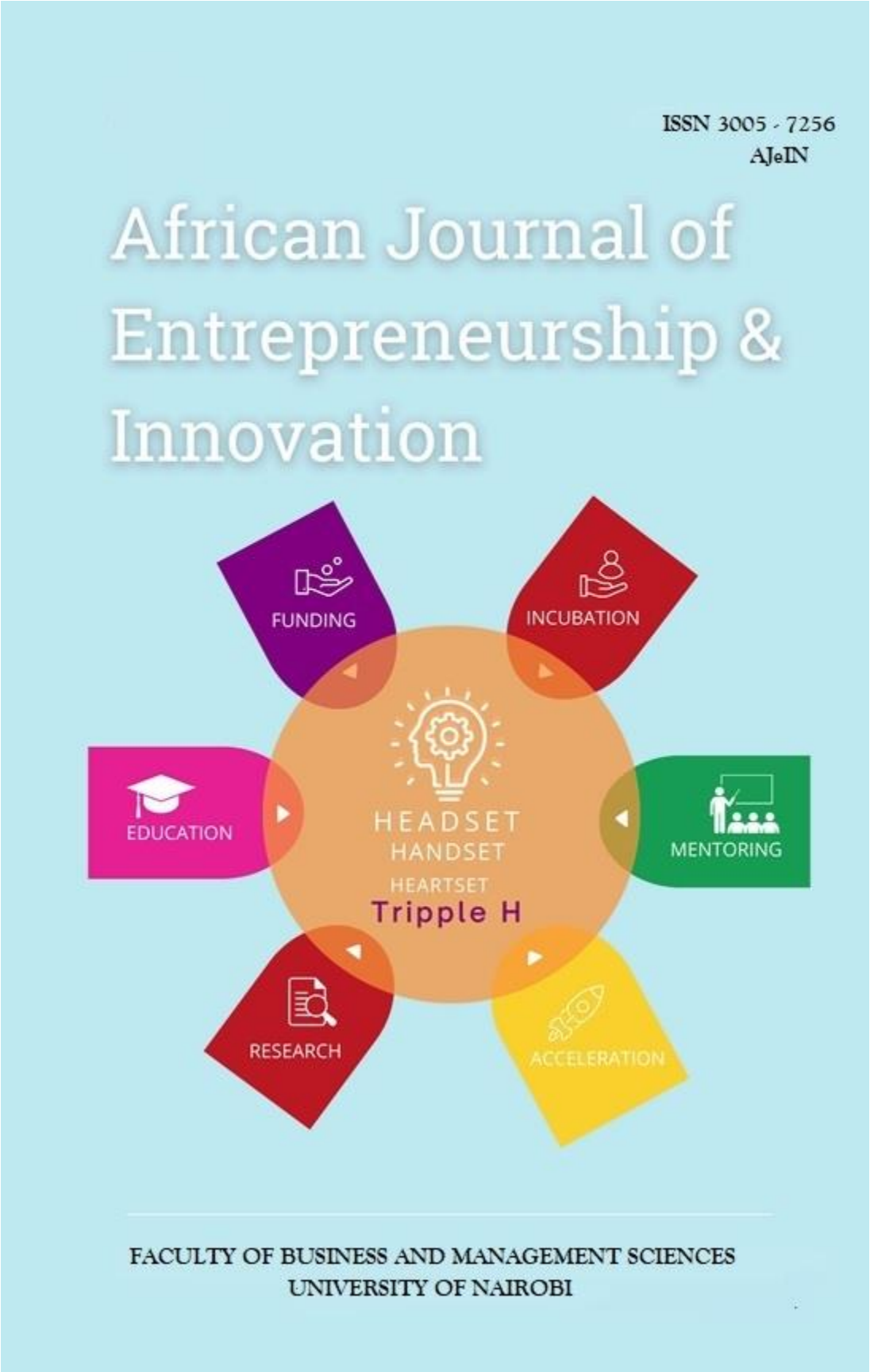

Development of a categorization framework for research collaborations: A typology for assessing innovation potential in Nigerian universities

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Abstract

This study categorizes research collaborations in Nigerian universities into eight groups (C1 to C8) using data from academic journals. The framework assesses innovation capacity, assuming interdisciplinary collaboration leads to more impactful outcomes. From 274 universities, a sample of 139 was obtained. Results show Nigerian scholars are most active in C2 collaborations (43.30%), involving authors from the same department, followed by C3 (15.67%) between different departments within the same faculty. Single authorship (C1) accounted for 10.62%, interdisciplinary (C4) for 12.20%, cross-university (C5) for 10.45%, university-industry (C6) for 3.87%, university-government (C7) for 2.59%, and international (C8) for 1.30%. The study recommends more interdisciplinary research collaborations to enhance innovative and commercially viable outputs.

Key Words: *Research collaborations, research categorization innovation capacity, Nigerian academic journals*

1. Introduction

In today's knowledge-driven economy, innovation is the "science of progress" as it has become a critical driver of economic growth, competitiveness, and societal progress (The Economist, 2019). Nigerian universities, as key players in the national innovation system, are expected to play a pivotal role in fostering innovation and entrepreneurship. One effective strategy for achieving this goal is through research collaborations. According to Cummings and Kiesler (2008), research collaborations involve the coming together of researchers from diverse backgrounds, institutions, and disciplines to share knowledge, expertise, and resources. Such collaborations have been shown to enhance innovation capacity by facilitating the exchange of ideas, accelerating knowledge creation, and promoting the development of new technologies and products. Rosenberg (1990) also submitted that research collaborations can enhance innovation capacity and national development in the following ways (1) Access to diverse expertise and knowledge, (2) Sharing of resources, (3) Accelerated knowledge creation, (4) Enhanced research quality and impact, (5) production of commercialisable products and services, (6) contribution to national gross domestic product (GDP), and increases a nation's ranking on the Global Innovation Index (GII).

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According to the Stern, Porter and Furman (2000), national innovation potential is the ability of a country to produce and commercialise a flow of innovative products (especially technological products), over the long term. They also noted that countries that produce standard products using standard or regular methods may not sustain a competitive advantage. Instead, competitive advantage must come from creating and commercialising new products and processes, thereby shifting the technology frontier as fast as their rivals can catch up. Rua (2023) and Cypris (2025) submitted that a country's innovation capacity is measured by the following key indicators: (1) exports of technology products. (2) knowledge services (3) sales of innovative products, (4) number of patents filed/granted per year, (5) revenue growth rate from innovative products, and (6) the level of research and development (R&D).

From the foregoing, this study aimed to identify and categorise research collaborations in Nigerian universities to provide answers to the following research questions and achieve the stated objectives:

1.1. Research Questions

a) What forms of research collaboration are employed by academics in Nigerian universities?
b) Is there a significant difference in the types of research collaboration predominantly adopted by academics in Nigerian universities?
c) Do research collaborations utilised by academics in Nigerian universities have high innovation potential?

1.2. Objectives of the Study

a) To identify and categorise the forms of research collaboration that are employed by academics in Nigerian universities.
b) To ascertain the most frequent research collaboration type adopted by academics in Nigerian universities.
c) To determine if the most prevalent forms of research collaborations utilised by academics in Nigerian universities have high innovation potential.

1.3. Research Hypotheses

To ascertain if the results are meaningful, relevant to the research questions and replicable, the following two null hypotheses were tested:

a) There is no significant difference in the types of research collaboration predominantly adopted by academics in Nigerian universities.
b) The research collaborations commonly used by academics in Nigerian universities do not lack innovation potential.

2.0. Literature Review

2.1. Nigerian Universities

As of June 2024, there are 274 universities in Nigeria (Statista, 2024). With a plethora of faculties and disciplines and the establishment of entrepreneurship development centres and departments of Entrepreneurship in most of the universities, entrepreneurial ecosystems with emphasis on interdisciplinary, cross-university, and cross-institutional research collaborations are expected to be created to promote scholarly and professional research and development, innovations, commercialisable products, business startups, and employment opportunities. Unfortunately, this seems not to be the case as most Nigerian universities seem to place less emphasis on inter-disciplinary and professional cross-institutional research collaborations, resulting in a very low number of innovative products and technology-driven startups (Uwubanwen & Obeki, 2019). Instead, most of these universities seem to place more emphasis on scholarly research for publication in peer-reviewed journals for promotional purposes.

Using a desk research methodology (Kiely, 2024), this study sought to empirically ascertain the type and frequency of research collaborations that academics in Nigerian universities engage in and their potential for producing innovative outcomes.

2.2. Research

The Oxford English Dictionary (2020) defines research as "the systematic investigation into the study of materials and sources to establish facts and reach new conclusions". Research can be classified into basic academic research and professional research. According to Al Masud (2024), academic research, or scholarly research, aims to contribute to the larger body of knowledge within a specific field of study. Scholarly research is carried out by students and academic staff in tertiary institutions, especially in universities, follows formal scientific procedures, focuses on existing concepts and theories, and seeks to add new insights or dispel old positions. Results of scholarly research are made public through academic writings, dissertations, conferences, peer-reviewed, and published in relevant academic

journals (Al Masud, 2024). Academic research is usually the basic criteria for the promotion of academic staff; hence most of such research is theoretical, small-scaled, with little or no collaboration among the research scientists. Findings are peer-reviewed and published based on academic discipline standards.

On the other hand, professional research addresses more complex and practical problems affecting the university, government, organisation, or industry (Al Masud, 2024). Professional research usually requires the knowledge base of the academic institution to address business or societal needs. It usually requires collaboration between academia and industry or government and does not always follow formal scientific procedures. Professional research findings are often kept private or shared internally among the funding agencies for the purpose for which the research was conducted or funded.

Academic research seeks to expand knowledge, while professional research aims to address real-world challenges. Both play crucial roles in advancing our understanding and improving practices, and both types of research are carried out within an entrepreneurial ecosystem. However, this study sought to ascertain the most relevant type of research that will enhance the functionality of an entrepreneurial ecosystem, and which should attract the most collaboration and funding.

2.3. Research Collaborations

Al Masud (2024) defined collaborative research as a partnership between two or more parties who work together to achieve common goals. The COVID-19 pandemic, HIV/AIDS and other previous pandemics have made research collaborations more critical and imperative, especially in solving complex problems that evolve every day globally (Hays, 2005; Envuladu, Miner & Agho, 2022). Collaboration enables researchers from different backgrounds, such as industry and academia, to come together to address a problem, usually of multidimensional significance (Wuchty, et al., 2007).

According to Al Masud (2024), while research is the foundation for forming knowledge, collaboration is a strategy to deal with situations that seem challenging to solve individually and for developing solutions that can have a significant impact on society. For example, a business or government might partner with a university to conduct research on nuclear power, or cancer treatment. In this case, the business organization or government can provide the finances and resources for research while the

university can provide the academic knowledge, theories, and expertise needed to analyse the data and draw meaningful conclusions that will enable an innovative solution to be obtained.

Therefore, this study aims to identify, categorise and discuss the different types of research in Nigerian universities to ascertain their innovation potential.

2.3.1. Types of Research Collaborations

Different scholars have identified different types of research collaborations. However, understanding the different types of collaborative research and how they can contribute to advancing knowledge in various fields will help to appreciate the value of collaborative research and its potential for creating positive, innovative changes in the world (Al Masud, 2024).

Al Masud (2024) identified two broad types of collaborative research, namely homogenous and heterogenous collaborations. Homogeneous research involves individuals or groups that share similar backgrounds or perspectives, while heterogeneous research involves individuals or groups with diverse backgrounds and perspectives. A collaborative research team is considered homogenous when the research team members are similar in terms of their backgrounds, expertise, and research interests. This type of collaborative research can be beneficial because team members may share similar perspectives and approaches to research, which can lead to more efficient and effective collaboration (Al Masud, 2024).

On the other hand, heterogeneous collaboration involves team members with diverse backgrounds, expertise, and research interests. While this type of collaboration can be more challenging, it can also lead to more innovative and creative research outcomes. Heterogeneous teams can bring different perspectives and ideas to the table, which can lead to new insights and approaches that might not have been possible with a more homogeneous team (Al Masud, 2024).

However, Springer Nature (2023), identified five types of research collaboration, which are (1) Collaboration within an academic institution: This type involves various configurations of faculty, staff, administrators, and students working together on research projects within the same institution. This setup allows for easy communication and face-to-face meetings, facilitating progress and adjustments. (2) Collaboration with other academic institutions: This type involves researchers from

different institutions working together on a project, often with a primary investigator inviting junior researchers to collaborate. This collaboration promotes mutual benefits, such as sharing resources and expertise. (3) Collaboration with a government entity: This type involves policymakers and researchers working together to address common concerns or questions. Government agencies may provide funding or resources, while researchers offer expertise to inform policy decisions. (4) Collaboration with private industry: This type involves researchers partnering with private companies to develop new products, technologies, or services. This collaboration promotes innovation and can lead to groundbreaking discoveries. (5) Collaboration with international researchers: This type involves researchers from different countries working together on a project, often facilitated by global conferences, study abroad programs, or online platforms. International collaboration broadens cultural perspectives, increases the pool of research data, and fosters global solutions.

Springer Nature (2023) elaborated on interdisciplinary, multi-disciplinary, and cross-cultural collaborations: (1). Interdisciplinary collaborative research involves researchers from various disciplines working together on a project. Such collaboration integrates different perspectives and expertise, leading to a deeper understanding of the research topic. (2). Multi-institutional collaborative research features researchers from different universities or organisations collaborating on a project. It offers opportunities for networking and resource sharing, while also creating a larger pool of research data and resources, while (3) Cross-Cultural Collaborative Research involves researchers from diverse cultures coming together to work on a project. This collaboration helps bridge cultural differences and enhances understanding of the research topic

Elsevier (2024) further identified research collaborations to include (1) co-authorship, (2) research network building, (3) joint research, and (4) research partnerships. Al Masud (2024) further submitted that collaborative research is a powerful tool that can drive innovation and change as it allows for the creation of new ideas, technologies, and solutions that benefit society.

2.3.2. Interdisciplinary Collaboration

Interdisciplinary research collaborations have been shown to possess a greater potential for innovation than intradisciplinary collaborations. Klein (1990) earlier observed that interdisciplinary collaboration involves the integration of multiple disciplines, such as natural sciences, social sciences, engineering, and humanities, to tackle complex research questions and problems, and facilitates the exchange of

ideas, methods, and theories across disciplinary boundaries, fostering a more comprehensive understanding of the research topic with a high innovation potential. Klein (1990) also discovered that interdisciplinary collaboration brings together and exposes researchers to diverse methodologies and tools, allowing them to approach research problems from different perspectives with greater possibilities for innovative outcomes. Wuchty et al (2007), and Uzzi et al (2013), reveal that interdisciplinary collaboration leads to more innovative and impactful outcomes than disciplinary or multidisciplinary collaborations. Cummings and Kiesler (2005) discovered that interdisciplinary collaboration brings about the integration of different knowledge areas with the potential to create a new and innovative knowledge base for innovative outcomes, while Hong and Page (2004) had earlier discovered that interdisciplinary collaboration enables individuals with different cognitive potentials to come together to generate creative ideas and solve an identified problem.

2.4. Theoretical Framework

The concept of collaborative research and innovation potential is underpinned by several key theoretical frameworks, each offering unique insights into the dynamics of cooperation among various institutional sectors. Among these, Social Capital Theory explores the value of social networks and relationships in fostering collaboration and knowledge sharing (Coleman, 1988); Knowledge Spillover Theory emphasises the unintentional sharing of knowledge between individuals and organisations, leading to innovation (Audretsch & Feldman, 1996); the Triple Helix Model underscores the critical role of collaboration among three key sectors: academia, industry, and government (Etzkowitz & Leydesdorff 2000); Innovation Systems Theory examines the interconnected systems that enable innovation (Lundvall,1992); while Collaborative Advantage Theory focuses on the benefits that organisations can derive from working together (Huxham & Vangen, 2005).

However, this study adopts the Triple Helix Model as its theoretical framework. The model was developed by Etzkowitz and Leydesdorff (2000), to underscore the critical role of collaboration among three key sectors: academia, industry, and government. The model posits that interaction and synergy among these entities can significantly enhance innovation potential and drive economic development. By fostering an environment where knowledge is shared and combined across these sectors, the Triple Helix Model promotes a holistic approach to innovation, creating a conducive atmosphere for research breakthroughs and technological advancements.

This framework not only highlights the importance of each sector's contributions to innovation but also encourages the establishment of partnerships and collaborative networks. Consequently, the Triple Helix Model serves as a guiding principle in understanding how collaborative efforts can lead to sustained economic growth and innovation in various fields. Through this lens, the study explored the extent to which these intricate relationships among academia, industry, and government have been promoted in the articles published in Nigerian academic journals.

2.5. Empirical Evidence

Numerous studies have demonstrated the innovative potential of interdisciplinary collaboration. However, this study reviewed the following key studies on the impact of interdisciplinary research collaboration on the innovative capacities of institutions, entrepreneurial ecosystems and nations. Wuchty, Jones, and Uzzi (2007), conducted research on the topic, "The Increasing Dominance of Teams in Production of Knowledge." This study analysed over 19 million research papers and 2.1 million patents to investigate the trend of research collaborations. The authors found that teams, rather than solo authors, were increasingly dominating the production of knowledge. They also discovered that teams tend to produce more innovative and high-impact research.

Uzzi, Mukherjee, Stringer, and Jones (2013), conducted a study on "Atypical Combinations and Scientific Impact." This study examined the relationship between research collaboration and scientific impact. The authors found that research teams that combine diverse expertise and experience tend to produce more innovative and high-impact research. They also discovered that teams that collaborate across disciplinary boundaries tend to have a higher scientific impact.

In the same vein, Fleming, Mingo, and Chen (2007) worked on "Collaboration and Creativity: The Small World Problem", in which they investigated the relationship between research collaboration and creativity. The authors found that researchers who collaborate with others tend to produce more innovative and creative research. They also discovered that researchers who collaborate with others from diverse backgrounds and disciplines tend to have a higher creative and innovative output.

Since the unit of analysis for this study was articles published by Nigerian academics, we also reviewed several studies on research collaboration and innovation by Nigerian academics, out of which the following three studies were found very relevant to the objectives of this paper:

Ogunsola (2011) investigated the impact of research collaboration on academic productivity in Nigerian universities. Using a survey of 150 academics from five Nigerian universities, the results showed that research collaboration had a significant positive impact on academic productivity, measured by the number of publications, citations, and research grants. The study also found that the frequency and quality of research collaboration were significant predictors of academic productivity.

Oyelaran-Oyeyinka and Adebowale (2012) conducted a study on university-industry collaboration as a determinant of innovation in Nigeria. Using notable research institutes and selected universities in Nigeria, they examined the types, intensity, and impact of collaboration and learning between universities and research institutes. The findings, which were arrived at through descriptive statistics and Probit regression analysis, revealed that the size of the research institute, its available infrastructure and human capability through the availability of grants and knowledge base, influence the types and intensity of collaboration and the resulting level of innovation. The study encourages university-industry research collaboration.

Adelowo, Ilevbare, and Morufu (2022) studied the level of collaboration, networking and research productivity in Nigeria's research institutes. The study utilised a cross-sectional survey with data collected from a total of 1611 senior researchers, scientists and engineers in seventeen research agencies/institutes in Nigeria. The results showed that internal collaborations among researchers and scientists were high, and the purpose of collaboration included research engagement, grantsmanship writing and journal publications. The findings also revealed that most researchers engaged in external collaboration, particularly with other research institutes, Universities and Polytechnics, with a significantly positive effect of collaboration on research productivity.

The empirical evidence above supports the notion that interdisciplinary research collaboration can significantly enhance innovation. However, while some of the studies, especially the ones conducted by Nigerian academics, have taxonomized and categorized research collaborations between public institutions/institutes and the universities, none seems to have specifically focused on identifying and categorizing types of research collaborations in Nigerian universities with the intent of determining their innovation potential. This is a significant gap between research and innovation, which this study aims to fill.

3.0. Methodology

3.1. Population

The population of the study comprised of all academic publications in Nigerian universities, which runs into millions.

The study utilised secondary research methods to collect, collate, analyse, and interpret data from published academic journals. This was done to draw conclusions and predict current trends in research collaborations within Nigerian universities.

With a finite population of 274 universities in Nigeria in the following proportions (Statista, 2024): Federal Universities = 62, State universities = 63, and Private universities = 149, we used the Cochran formula to calculate the sample size for the study as follows:

Cochran's Formula for Finite Populations:

$n = (Z^2 * P * (1-P)) / (e^2 + (Z^2 * P * (1-P)) / N)$

Where:

n = sample size

Z = Z-score corresponding to the desired confidence level (Typically 1.96)

P = estimated proportion of the population (0.5 for maximum variability)

e = desired margin of error (0.05)

N = population size (274 universities)

Substituting the values, we get:

$n \approx 139$

For this study, a sample size of 139 Nigerian universities, including federal, state, and private institutions, was proportionally selected at a 95% confidence level and a 5% margin of error.

3.2 Number of Academic Publications per University

To determine the minimum number of academic publications per each category of university, we used the proportionate stratified sampling method:

First, we calculated the proportion of each type of university:

- Federal universities: $63/274 \approx 0.23$ (or 23%)
- State universities: $64/274 \approx 0.23$ (or 23%)
- Private universities: $149/274 \approx 0.54$ (or 54%)

Now, we allocated the sample size of 139 to each category using these proportions:

- Federal universities: $139 \times 0.23 \approx 32$

- State universities: 139 x 0.23 ≈ 32
- Private universities: 139 x 0.54 ≈ 75

From the above results, we randomly selected 32 academic journals published by Federal Universities, 32 academic journals published by State universities, and 75 academic journals published by Private universities for the study. This allocation ensures that the sample is representative of the population and that each category of university is adequately represented. This distribution also assumes a relatively similar level of academic research activities among the three categories of universities.

In this study, the academic journals are the units of observation while the types of research collaborations in the articles published in the journals are the units of analysis. Therefore, we reviewed all the articles published in the 139 academic journals to assess (1) the types of collaboration, and (2) the frequency of each type of collaboration.

4. Results

4.1. Types of Collaborations

A total of 1946 articles were published in 139 journals, and 8 categories of research collaborations, labelled C1 to C8 were identified as shown below:

C1 Collaboration (Single Authorship, No Collaboration): Research conducted independently by a single author within a department.

C2 Collaboration (Intra-Departmental Collaboration): Collaborative research involving two or more authors from the same department.

C3 Collaboration (Inter-Departmental Collaboration): Research collaboration between two or more authors belonging to different departments within the same faculty.

C4 Collaboration (Interdisciplinary/Inter-Faculty Collaboration): Collaborative research involving two or more authors from different faculties or disciplines, such as between the fields of Law and Medicine.

C5 Collaboration (Inter-University/Cross-University Collaboration): Collaborative research between authors from different universities or tertiary institutions.

C6 Collaboration (University-Industry/Organisation Collaboration): A partnership for research between university academics or research teams and private organisations.

C7 Collaboration (University-Government Collaboration): Research carried out collaboratively between university academics or research teams and government agencies or institutions.

C8 Collaboration (International Collaboration): Research collaborations involving academics, research groups, universities and organisations from different countries.

4.2 Underlying Assumptions

The findings from this study were based on the following assumptions that emanated from the works of Klein (1990), Cummings and Kiesler (2005), Wuchty, Jones and Uzzi (2007), Fleming, Mingo, and Chen (2007), Uzzi, Mukherjee, Stringer, and Jones (2013) and Al Masud (2024) on research collaborations:

1. A higher frequency of C1 and C2 collaborations often results in more localised research outcomes, limiting the prospects for obtaining resources necessary for innovation and impactful advancements.
2. Increased interdisciplinary (C4) collaborations lead to greater access to cross-disciplinary knowledge and resources, fostering impactful results and driving innovation.
3. Collaborations at the inter-university (C5), university-industry (C6), university-government (C7), and international levels (C8) enhance the potential for securing resources, gaining interdisciplinary insights, and achieving economic, technological, and innovative growth for the involved institutions and nations.
4. Greater engagement in C4 through C8 collaborations leads to more impactful research outputs, higher publication rates in renowned journals, and improved university rankings in research, development, and innovation.

4.3. Frequency of Collaborations

Table 1: Frequency of Collaborations

Type of Research Collaboration	Frequency	Percentage
C1(Single authorship)	207	10.62
C2 (Intra-Departmental)	843	43.30
C3 (Inter-departmental)	305	15.67
C4 (Interdisciplinary/faculty)	237	12.20
C5 (Inter-University)	203	10.45
C6 (University-Industry)	75	3.87
C7 (University-Government)	51	2.59
C8 (International)	25	1.30
TOTAL	**1946**	**100 %**

From Table 1 above, the results show that Nigerian scholars were highest in C2 collaborations (43.30%), which is the collaboration between two or more authors within the same department, followed by C3 collaborations (15.67%), which is the collaboration between two or more authors from different departments but within the same faculty or institute. C1 collaboration scored 10.62 % while C4, C5, C6, C7 and C8 scored 12.20%, 10.45%, 3.87%, 2.59% and 1.30% respectively.

4.4. Discussion

Table 1 presents a comprehensive overview of various types of research collaborations, highlighting a total of 1,946 collaborations categorized into eight distinct types. The distribution of collaborations reveals interesting trends in research dynamics within a given academic ecosystem.

a) Dominance of Intra-Departmental Collaborations: The most prominent type of collaboration is intra-departmental (C2), which accounts for 843 collaborations, making up 43.30% of the total. This significant share suggests that researchers prioritise collaboration within their departments, potentially due to shared interests, resources, and familiarity among colleagues.
b) Inter-Departmental and Interdisciplinary Collaborations: The second most common category is inter-departmental collaborations (C3) with 305 occurrences (15.67%), indicating a healthy level of interaction between different academic departments. Additionally, interdisciplinary collaborations (C4) represent 12.20% (237 collaborations), indicating that while most collaborative efforts are centralised within departments, there is still a notable push towards integrating diverse perspectives and expertise.
c) Lower Representation of Broader Collaborations: The remaining categories (C5 to C8) show a marked decline in collaboration frequency:
   - Inter-university collaborations (C5) account for 203 (10.45%),
   - University-Industry collaborations (C6) are at 75 (3.87%),
   - University-Government collaborations (C7) total 51 (2.59%),
   - International collaborations (C8) are the least frequent, with only 25 (1.30%).

This trend may suggest barriers to collaboration outside immediate academic environments, such as institutional limitations, resource allocation challenges, or the complexity of establishing partnerships across different entities.

1. Single Authorship: Interestingly, single authorship (C1) is notable with 207 collaborations (10.62%). This may reflect a scholarly inclination towards individual contributions in addition

to collaborative efforts, possibly highlighting the importance of personal research endeavours even within a collaborative framework.

Table 2: Institutional Based collaboration types & ANOVA Result

	Federal Univ	State Univ	Private Univ	Total (%)
C1(Single authorship)	104 (50.2%)	58 (28.0%)	45 (21.74%)	2017 (100%)
C2 (Intra-departmental)	325 (38.6%)	301 (35.7%)	217 (25.74%)	843 (100%)
C3 (Inter-departmental)	96 (31.5%)	121 (39.7%)	88 (28.9%)	305 (100%)
C4(Inter-disciplinary/faculty)	101 (42.6%)	66 (27.85%)	70 (29.54%)	237 (100%)
C5 (Inter-University)	52 (25.62%)	47 (23.2%)	104 (51.2%)	203 (100%)
C6 (University-Industry)	28 (37.3%)	15 (20%)	32 (42.7%)	75 (100%)
C7 (University-Government)	16(31.4%)	21 (41.2%)	14 (27.5%)	51 (100%)
C8 (International)	9 (36.0%)	12 (48.0%)	4 (16.0%)	25 (100%)

Differences in collaboration types between universities were not significant $p>0.05$, $d = 0.96$ using ANOVA statistics at 0.05 level of confidence

4.5. Test of Hypothesis One

P-value: The p-value measures the probability that the observed differences in collaboration types occurred by chance. In this case, a p-value greater than 0.05 suggests that there is no statistically significant difference in the collaboration between the different types of universities (Federal, State, and Private). This means that the variations in collaboration types are likely due to random variation rather than any systematic difference between the universities.

Effect Size ($d = 0.96$): The effect size (Cohen's d) measures the magnitude of the difference between groups. An effect size of 0.96 is considered large, indicating that while the differences are not statistically significant, they are practically meaningful. This suggests noticeable differences in collaboration types between the universities, even though these differences are not statistically significant.

The ANOVA results suggest that the collaboration patterns among Federal, State, and Private universities in Nigeria are similar, with no significant differences. However, the large size indicates that there are practical differences worth noting. For instance, Federal universities have a higher percentage of single authorship (C1) and intra-departmental collaborations (C2), while Private

universities have a higher percentage of inter-university (C5) and university-industry (C6) collaborations1.

These findings imply that while the overall collaboration patterns are similar, specific collaborations may be more prevalent in certain universities. This could be due to differences in resources, institutional policies, or research priorities. Understanding these patterns can help universities develop targeted strategies to promote more effective and impactful research collaborations.

4.6. Test of Hypothesis Two

Based on the assumptions for this study, the higher innovation potential is associated with C4 (Inter-disciplinary/faculty), C5 (Inter-University), C6 (University-Industry), C7 (University-Government), and C8 (International) collaborations. However, the most prevalent forms of research collaborations among Nigerian academics are C2 (Intra-departmental) and C3 (Inter-departmental) collaborations. These types of collaborations do not meet the assumption of high innovation potential.

Using the ANOVA statistics presented in Table 2, the research collaboration types commonly used by academics in Nigerian universities do indeed lack significant innovation potential. The ANOVA results indicate that the differences in collaboration types between Federal, State, and Private Universities were not statistically significant ($p > 0.05$), but the effect size ($d = 0.96$) was large, suggesting practical differences. Federal universities have a higher percentage of C4 collaborations, Private universities lead in C5 and C6 collaborations, and State universities excel in C7 and C8 collaborations. Despite these variations, the overall collaboration patterns are similar, and the most common types of collaborations (C2 and C3) do not align with the higher innovation potential.

Therefore, we are unable to accept hypothesis 2 which states that the research collaborations commonly adopted by academics in Nigerian universities do not lack innovation potential. To enhance innovation potential, academics in Nigerian universities are encouraged to engage more in C4 to C8 collaborations.

However, while no single type of university dominates all collaboration types, the highest types of research collaboration among all Nigerian universities, which is C2 and C3 collaborations, do not meet the assumption for high innovation potential. Therefore, academics in Nigerian universities are

encouraged to engage more in C4 – C8 collaborations to enhance their ability to produce innovative and impactful research outcomes.

5.0. Conclusion and Recommendations

5.1. Conclusion

The cumulative data illustrate a preference for local and intra-disciplinary collaboration over broader engagements. This preference may point toward an academic culture that favours established connections and closer working relationships, which can facilitate faster communication and stronger teamwork. Overall, the findings underscore the significance of department-centric collaborations while also indicating areas such as university-industry and international partnerships that could benefit from further development to enhance research impact and interdisciplinary innovation. The distribution of collaborations not only helps to understand existing research dynamics but also provides insights into potential areas for growth and greater collaboration in academic research.

5.2. Recommendations

In the rapidly evolving landscape of the 21st century, it has become increasingly clear that interdisciplinary and cross-institutional research collaborations are vital for fostering innovation. These collaborations - designated as C4, C5, C6, C7, and C8 - represent the foundational elements of creating groundbreaking products and services that can drive economic growth and social development. Each university in Nigeria should actively embrace and vigorously promote these collaborative efforts.

By forming strong partnerships across various disciplines, institutions can leverage each other's strengths, expertise, and resources. This approach not only enhances the quality and impact of research but also encourages the exchange of diverse ideas and perspectives, leading to more creative solutions to complex challenges.

Moreover, engaging in collaborative research initiatives can significantly boost a university's visibility and reputation on both national and international levels. It will attract funding opportunities, skilled researchers, and students eager to be part of innovative projects.

To foster such collaborations, Nigerian universities should create supportive policies and structures that encourage cross-disciplinary dialogue and partnerships. This can include facilitating joint research grants, hosting interdisciplinary workshops, and establishing networks that connect researchers across different institutions.

In summary, embracing and promoting interdisciplinary and cross-institutional research collaborations is essential for the innovation ecosystem within Nigerian universities. By prioritising these collaborative endeavours, institutions can contribute significantly to advancing knowledge and developing innovative solutions that address the pressing needs of society in the 21st century.

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