

# Patterns and trends of university-industry research collaboration in Ghana between 2011 and 2020

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## Abstract

**Purpose** – The ranking of universities and other research-intensive institutions in global ranking systems is based on numerous indicators, including number of articles with external collaboration, number of articles with international collaboration, number of articles with industry collaboration as well as co-patents with industry. The purpose of this paper is to examine university–industry research collaboration in Ghana, with the aim of exploring the relationship between the research output collaborations in the top four universities in Ghana and industry across different geographical scales.

**Design/methodology/approach** – This study's data was obtained from the SciVal database, which drawn its data from the Scopus bibliographic and citation database. The bibliographic and citation data were extracted using a search of the publications affiliated to the University of Ghana, for the period 2011–2020.

**Findings** – Key findings demonstrate a constant rise in the number of research publications by the selected universities over time. Research collaboration intensity in the selected universities in terms of co-authored publications was higher as compared to single-authored publications. University–industry research co-authorships were, however, lower when compared to university–university research co-authorships. The university–industry research co-authorships occurred mostly with Europe, Asia-Pacific and North American-based institutions as opposed to African-based institutions. In Ghana, four industry-based institutions were engaged in intensive research with the selected universities.

**Originality/value** – This study demonstrates that, for each selected university, it is possible to measure the performance of individual universities in both intra-regional and international collaboration. Such results may be useful in informing policy as well as merit-based public funding of universities in Ghana.

**Keywords** Ghana, Scopus, Innovation, Universities, Research trends, University–industry research collaboration, SciVal

**Paper type** Research paper

## Introduction

In recent times, most universities are getting involved in research as an innovative source to generate knowledge that has diffused to the industry (Mafu, 2023). The importance of research collaboration is clearly illustrated by Hausmann *et al.* (2011). According to Hausmann *et al.* (2011), the quantum of knowledge inherent in society is not dependent on the amount of knowledge held by an individual, but on the level of diversity of knowledge across individuals and the ability to put together and make use of such knowledge through a complex web of

interactions. Indeed, recognizing the vital contribution of research to national development, nations across the globe have made conscious efforts to determine the new horizon of scientific knowledge and methods to enrich their intellectual properties (Wani *et al.*, 2023). Assuredly, through joint efforts, individuals and organisations can compete and perform better

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in today's dynamic complex and interactive world, and universities are no exception. [Onyancha and Ocholla \(2007, p. 239\)](#) noted that research collaboration enables researchers to exchange knowledge, skills and techniques; affords researchers intellectual companionship by expanding their professional network in the scientific community; improves the visibility of the study; and reduces the cost of conducting research. According to [Mafu \(2023\)](#), university–industry collaboration (UIC) stimulates relevant research projects, encourages universities to find ways to amend their curriculum, and serves as a marketing tool to attract students, faculty and additional industrial research support. Collaborative knowledge production based on partnerships with industries has become a central theme in institutions of higher learning ([Kim et al., 2014](#)). UIC is, in fact, about facilitating innovation and maintaining a competitive edge through novel knowledge and resource exchanges according to numerous scholars (e.g. [Chedid and Teixeira, 2021a](#); [Chedid and Teixeira, 2021b](#)).

Consequently, the concept of UIC has increasingly become a topical subject among researchers worldwide ([Bastos et al., 2021](#)), and has motivated lengthy discussions on the implications of collaboration in general, and particularly for co-authorships in the scientific research environs ([Murashova and Loginova, 2017](#)). More specifically, the significance of UIC is becoming more recognised, as expected, especially on UIC and research publications. It is not surprising to note that collaboration between university and industry has taken centre stage in the ranking of universities and other research-intensive institutions. [Vernon et al. \(2018\)](#) have enumerated several indicators that different global ranking systems use in their pursuit to rank universities, and among the indicators are the number of articles with external collaboration, the number of articles with international collaboration, the number of articles with industry collaboration, as well as co-patents with industry. The importance of UIC cannot, therefore, be overemphasised. The UIC in research has become more pervasive in the current research-intensive university environment, especially in the quest of universities to obtain a world-class university status ([Kim et al., 2014](#)). Whilst collaboration with universities is perceived by industries as an important avenue to access students and technologies and to update their knowledge to boost the performance of firms as far as innovations are concerned, the essential aim of universities' collaboration with industry is predominately that of academic research ([Tagliazucchi et al., 2021](#)). Certainly, for academics within a university, one of the major requirements is to publish research and maintain high levels of research productivity to sustain their careers and build on their reputations ([Zhang and Wang, 2017](#)).

Because of its recognition as an imperative conduit to expedite the attainment of innovation-driven economic growth and development, most advanced economies perceive research collaboration between universities and industry as a principal research policy ([Bastos et al., 2021](#); [Skute et al., 2019](#)). Indeed, studies have echoed the importance of research collaborations and have advocated for national research policies to focus on promoting collaboration ([Onyancha and Maluleka, 2011](#); [Abramo et al., 2009a](#)). [Sjöö and Hellström \(2019\)](#) showed that research collaborations (especially cross-sectoral) lead to greater scientific impact as such publications tend to be cited more and tend to generate more intellectual property (IP).

[Mafu \(2023\)](#), however, advised that, to ensure that both parties contribute significantly to the interactions and to avoid conducting research that cannot be applied to the industry, universities must strive to work collaboratively with the industry right from the project's onset.

UIC is a multi-faceted concept, with different terms in the literature that refer to the same phenomenon ([Confraria and Vargas, 2019](#)). Examples of such terms include university–enterprise cooperation ([Du et al., 2022](#)), university–business collaboration ([Hewitt-Dundas et al., 2019](#)) and university–business cooperation ([Galan-Muros and Davey, 2019](#)), among others. Essentially, given that UIC generally refers to any form of interaction between higher education and industry for mutual benefits, the inconsistency among terminologies, such as “university” or “academia” on one side and “business”, “industry” or “firm” on the other makes it difficult to come up with a one-size-fits-all definition, especially as these terms are often used interchangeably ([Mahdad et al., 2020](#)). Overall, definitions found in the literature have been tied to the nature and type of collaboration concerned and are labelled differently in the literature. Like its definitions, the scope of UIC varies with an indication that collaborations can have various shapes and can be studied from several different perspectives ([Roncancio-Marin et al., 2022](#)).

The concept of UIC has predominantly been defined as any form of interaction between the university and industry that aims at encouraging the exchange of knowledge, research and technology to enable the initiative of innovations that serve as solutions to societal problems (e.g. [Ankrah and Al-Tabbaa, 2015](#)). Given the wide scope of UIC, its vagueness has led to some level of difficulty in measuring UIC. However, though attempts have been made to use co-authorship as a measure of UIC, some scholars (e.g. [Saad et al., 2021](#)) have argued that not all co-authored publications are products or outcomes of collaborative research. Nevertheless, there have been counterarguments on co-authorships as a direct indication of the research collaborations, given that publications are predominately accepted as part of the research process ([Roncancio-Marin et al., 2022](#)). The wide-ranging manifestations of UIC can, however, be classified under four broad categories: information and training (e.g. conferences and seminars), IP (e.g. patenting and spin-off creation), human resources (e.g. student internships and practitioner teaching) and research and development (R&D) activities (e.g. contract research and joint R&D projects) ([Bastos et al., 2021:179](#); [De Fuentes and Dutrénit, 2012: 1671](#); [Ramos-Vielba and Fernández-Esquinas, 2012: 250](#)). However, the focus of this paper is UIC on R&D activities. As such, for this study, “university–industry research collaboration” refers to a collaboration between a university and an industry-based institution that has resulted in a co-authored scientific publication.

Despite the interest placed in collaboration and its benefits, as well as the UIC's support for development of the research capacity of universities ([Bloch et al., 2019](#)), the literature on UIC in Ghana is rare. Undeniably, the extant literature has reported on UIC in both the developed and the developing world ([Bornmann, 2021](#)), but studies, especially on collaborations between universities and industry towards the production of research publications in developing countries, and more particularly in Ghana, seem unclear, as most studies on UIC have been skewed mainly towards the challenges of

UIC (e.g. Muparadzi and Caesar, 2021), and its influencing factors (e.g. He *et al.*, 2021; Li and Zhu, 2021). This has led to a general paucity of literature on collaborations between universities and industry that result in academic research publications, especially in Ghana. To help address the void identified, this study aims to examine university–industry research collaboration in Ghana, through an examination of co-authored research publications.

## University–industry research collaboration in Ghana: brief overview

Ghana’s aspiration to pursue innovation-led economic and social development has led to growing interest in UIC. For instance, Ghana’s development policy (Akufo-Addo, 2017); industrial policy (Tetteh, 2011); and Science, Technology and Innovation (STI) policy (Frimpong-Boateng, 2017) all encourage collaboration between universities and non-academic stakeholders, such as industry partners, working to realise the innovative capabilities of the country and its economic development. However, Mensah and Gordon (2020) asserted that research from most universities in Ghana does not seem to align with national development priorities because of outdated policies and institutional systems for STI, ineffective collaborations between universities and industry and inadequate incentives to encourage such collaborations and interactions. In fact, Abdulai *et al.* (2020) stated that, despite Ghana’s continued investment in higher education, infrastructure development and increase in book and research allowance in universities, there is very little evidence of sustained innovation performance in Ghanaian industries compared to Ghana’s contemporaries, such as Malaysia, Singapore and South Korea, who – although they gained independence at around the same time and had roughly the same GDP per capita as Ghana at the time – now have significantly higher and better innovation and economic indices than Ghana. Muparadzi and Caesar (2021) also add that, although UICs are beneficial to Ghana for developing evidence-based management practices, there is little evidence pointing to such benefits. This is because, comparatively, collaborations between universities and industry in Ghana are limited, not well-planned and lack investments from policymakers. This shows that the “nature and extent of (UIC) in Ghana are not strategic” (Muparadzi and Caesar, 2021). These sentiments re-echo what is captured in the current development policy of Ghana which states:

Meanwhile, little collaboration exists between public research institutions and businesses on product, service and process innovation, an area which holds a lot of prospects for product and industrial development, as well as job creation, if adequate mechanisms are in place to turn research outputs into viable commercial ventures”. (Akufo-Addo, 2017, p. 46)

Again, although some studies have explored UIC and technology transfer in general in Ghana (Abdulai *et al.*, 2020; Mensah and Gordon, 2020; Muparadzi and Caesar, 2021; Owusu-Agyeman and Fourie-Malherbe, 2019; Addy and Adabor, 2021), there seems to be a paucity of studies into the patterns, trends and extent of UIC as regards research in that country. While these issues may have been explored to some extent in certain studies conducted in the global north (Abramo *et al.*, 2009b; Lebeau *et al.*, 2008; Tijssen *et al.*, 2009), Mensah and Gordon (2020:246) stated that there is a need to gain a

better understanding of the nature and extent of UIC as it concerns research in developing countries such as Ghana. According to them, this is important as a way of understanding how universities can make a meaningful contribution to the economic development and competitiveness of the country, to develop more effective strategies and programmes toward sustainable development. The studies cited above reveal a number of important issues: first, there are various methodological approaches to assessing the nature and extent of UIC on research; second, co-authorship between universities and industry partners continues to grow; third, university–industry co-authored articles tend to have more impact (more cited), compared with university-authored articles; fourth, university–industry co-authored articles tend to be published in less prestigious sources compared to university-authored articles; fifth, academic researchers involved in UIC research tend to have superior research performance than those who are not; and, finally, such mappings and trend analyses of UIC provide useful comparative data for rankings and benchmarking objectives, as well as a simplistic reflection of the attractiveness of universities as providers of scientific knowledge and services to industry. Given the above disparities and voids, a deeper understanding of how Ghanaian universities and industries collaborate in the production and sharing of knowledge for innovation is critical (Abdulai *et al.*, 2020).

## Purpose and objectives of the study

The purpose of the study was to investigate the patterns, trends and extent of university–industry research collaboration in Ghana between 2011 and 2020, using the top four universities as cases for study. The specific objectives included:

- examine the trends of research and the number of publications produced by each of the selected public universities in Ghana;
- determine the number of papers with multiple institutional authorship versus those with single-institutional authorship;
- identify the industry collaborators with each of the universities; and
- examine the areas of university–industry research collaboration.

## Literature review

### University–industry research collaboration and academic research publications

Generally, the literature depicts viewpoints for and against the impact of UIC on academic research output. Whilst some researchers perceive a positive relationship between UIC and research publications, where UIC is seen to improve academic research performance (e.g. Aldieri *et al.*, 2019), others have argued that collaborations between universities and industry could rather do more harm to academic research publications than good, considering the conditions laid out mostly from the beginning of the collaboration to maintain the confidentiality of the output from such collaborations (e.g. Bemke-Š witiłnik *et al.*, 2020). Bemke-Š witiłnik *et al.* (2020) emphasised that collaborations between industry and university researchers often pose some difficulties due to varied views from the collaborators in relation to motivation to publish, choice of

publication channel and interpretation of findings. [Kim et al. \(2014\)](#), however, reported that applying UIC as a novel approach to measuring research performance among 46 Korean universities showed significant improvement in the performance of several previously low-ranked universities, irrespective of the rigid hierarchical structure of the Korean higher education system.

That said, prior literature has confirmed and disproved (e.g. [Zhang and Wang, 2017](#); [Tijssen et al., 2009](#) and [Lundberg et al., 2006](#)) the notion that UIC can improve academic research performance and output. The latter have argued that there is no relationship between UIC and the research performance of universities, as UIC may or may not result in academic research publications. For instance, in China, [Zhang and Wang \(2017\)](#) used a data set of 804 engineering academics with the aim of extending the research on UIC to reconcile the mixed findings on the influence of research performance on UIC. The study reported a negative correlation between the intensity of UIC and academic research performance, and hence advised universities to enact policies that will encourage researchers to seek collaborations with industry without due consideration of research performance. Equally, a study using a total of 436 Swedish companies reported that one-third of the companies that had provided funding and collaborated with the university had not co-authored any publications with the university ([Lundberg et al., 2006](#)). In addition, more than a decade ago, a statistical analysis of the 350 largest research universities showed that, although UIC enables meaningful comparisons for rankings and benchmarking objectives and are helpful sources of evidence-based quantitative information, such data do not provide conclusive evidence about the magnitude or nature of university–industry research outcomes ([Tijssen et al., 2009](#)). Indeed, considering the adverse consequences that may come with UIC, [Tagliuzucchi et al. \(2021\)](#) described the relationship between UIC and academic research publications or performance as being an inverted U-shape, rather than linear, where UIC positively influences academic research performance to only a certain level after which scientific outputs decrease marginally.

That notwithstanding, on the contrary, quite a number of studies have also established positive relationships between UIC and academic research publications (e.g. [Aldieri et al., 2019](#) and [Bikard et al., 2019](#)) and have stressed that one of the most efficient methods to investigate research collaborations is the co-authorship of publications using a bibliometric approach based on publication and citation statistics (e.g. [Bemke-Ś witolnik et al., 2020](#)). For instance, the findings in [Aldieri et al. \(2019\)](#) show publications as outputs from collaborations between universities and industry in Italy and as being of relevance to the academic performance of Italian academic institutions.

[Bikard et al. \(2019\)](#) also insisted that although some prior research suggest that UIC may generate lower publication rates especially for the academic scientists due to the insistence of industry on IP through patency and secrecy, UIC has a high potential of fostering specialization and boosting academic contributions to open science. Indeed, [Bikard et al. \(2019\)](#) revealed that academic scientist who collaborate with industry produces more follow-on publications and fewer on patents than did academic scientist without industry collaboration. The

findings of [Bikard et al. \(2019\)](#) is echoed in a study by [Garcia et al. \(2020\)](#) from Brazil who in their longitudinal and comprehensive data set of UIC revealed a positive relationship between UIC and research productivity where research groups that collaborate with industry especially over a long term have increased academic productivity. Similarly, [Bemke-Ś witolnik et al. \(2020\)](#) emphasised that collaborations between universities and industries lead to higher research quality and publications, given that researchers can advance more while collaborating than they can while working individually.

Furthermore, collaborations between universities and industry come in various forms. In other words, there are different levels of collaboration. The literature, however, notes intra-university collaborations, inter-university and international collaborations as the main forms of collaborations. [Ebel et al. \(2018\)](#), however, noted that whether intra, inter or international, collaborations generally have positive effects on a research activity. Nevertheless, given that some authors indicate that international collaborations are the focus of funding agencies (e.g. [Belussi et al., 2010](#)), others seem to show more of intra, and inter-university collaborations instead of international collaboration. For instance, in 2020, Zhigang and colleagues in their analysis of co-authorships in Web of Science (WoS)-indexed publications reported some level of growth among individuals (2.2 authors per publication in 1980 to 7 in 2019), inter-university (1.59 in 1980 to 2.66 in 2019), with a much lower growth for international collaborations (1.4 authors in 1980 to 1.48 in 2019). This implies an increase in intra-institutional collaboration, as opposed to inter-institutional and international collaborations. Similarly, to identify the degree and types of research collaborations in Malaysia, [Cheng et al. \(2013\)](#) analysed 22,244 journal articles published between 2008 and 2011, using data from Scopus database. [Cheng et al.'s \(2013\)](#) findings revealed a more intra-institutional collaboration than there is for international collaborations. [Cheng et al. \(2013\)](#) outlined Iran, India, the UK, Japan and the USA as the top five international collaborators with physics and astronomy, agriculture and biological sciences, engineering, health protection and computer science as the top disciplines with significant international collaborations. On the contrary, [Balogun's \(2023\)](#) report from a bibliometric analysis of 83 bibliometric publications in Nigeria discovered an overwhelming increase in inter-institutional and international collaborations with 60% increase in domestic and international collaborations and 40% collaborations with foreign nationals and Nigerians in diaspora as collaborators. The top collaborating countries [Balogun \(2023\)](#) established were USA, the UK, Brazil, China, Portugal, Malaysia, India, Pakistan and South Africa.

Besides, UIC is paramount in open research and development (R&D) ([Schultz et al., 2021](#)). Indeed, open research initiatives are beginning to produce results as evidenced by the growing popularity of open access ([Chisita and Chiparasha, 2019](#)). Thus, although relatively nascent, collaboration in R&D is increasingly becoming a fixture in contemporary research performance evaluations frameworks. This is in response to the transmutation in knowledge production and the increasing emphasis on dynamic knowledge production ([Kim et al., 2014](#), p. 98).

Furthermore, in another breadth, given that a number of barriers plague collaboration between industry and university,



quite a number of studies have devoted considerable efforts to investigating the factors that could drive or inhibit the operations of UIC (e.g. [Rossoni et al., 2023](#); [O'Dwyer et al., 2022](#)) and have suggested possible ways by which these obstacles can be attenuated to ensure a successful UIC. These challenges, the literature suggests, if correctly managed, will have a positive effect on the perceived success of UIC, and if neglected, will tend to have a negative impact on making UIC a reality. In their systematic review aimed at identifying the barriers and facilitators of UIC, [Rossoni et al. \(2023\)](#), for instance, acknowledged that even though UIC for the purpose of research, development and innovation remains a challenging process, undertaking small projects with a gradual increase in complexity, social capital and social tax incentives are key players for every successful UIC. Likewise, [Tseng et al. \(2020\)](#) emphasised that UIC, often supported by state interventions, is critical and hence stressed the need for financial support from the government coupled with the implementation of a variety of policies and programs to enhance UIC to bridge the gap between academic research and industry application. Similarly, drawing on a large-scale survey and public records, [Bruneel et al.'s \(2010\)](#) research findings identified prior experience of collaborate research, breadth of intervention by government and inter-organizational trust as ways of reducing the barriers to UIC. Equally, to explore the factors leading to a successful UIC, as well its perceived barriers, [O'Dwyer et al. \(2022\)](#) identified barriers such as trust and reluctance to share, whilst outlining appropriate mechanisms, and public funding as enablers of collaborations between university and industry. That notwithstanding, [Rybnicek and Königsgruber \(2019\)](#), in their extensive analysis of research publications as outcomes of UIC, distilled four factors identified as influencers for the successful implementation of such partnerships. These include institutional factors, which refer to the participating institutions; relationship factors, which refer to the linking between those partners; output factors, which refer to the desired results of the collaboration; and framework factors, which refer to environmental aspects.

Given that UIC in developed countries are supported by a sophisticated research infrastructure and vast resources for R&D ([Roncancio-Marin et al., 2022](#)), Africa's contribution to global research productivity has consistently remained significantly low despite the benefits associated with collaborative knowledge production ([Mwelwa et al., 2020](#); [Onyanacha and Ocholla, 2007](#)). As such, UIC activities in Africa are relatively low, making its scientific study challenging ([Fischer et al., 2020](#)). Likewise, although collaborative research is increasing in Africa ([Bornmann, 2021](#)), the pattern shows minimal continental collaboration on research ([Onyanacha and Maluleka, 2011](#)). Furthermore, while studies show that UIC on research can improve research productivity and impact ([Abramo et al., 2009a](#)), there is little evidence on the nature and extent of UIC in research in Africa and how it maps onto the global research output. For instance, sub-Saharan Africa (SSA) accounts for less than 1% of global research output and global citation impact, despite representing 14% of the global population ([Blom et al., 2016](#); [Fonn et al., 2018](#)). The situation is even direr for Ghana, considering that the bulk of the scientific production in the sub-region emanates from South Africa, Nigeria and Kenya ([Duermeijer et al., 2018](#)). Consequently, although minimal

empirical evidence on some scientific studies on UIC through which Ghanaian universities actively collaborate with industry exists (e.g. [Abdul-Abdulai et al., 2020](#)), UIC in Ghana is still a work in progress ([Muparadzi and Caesar, 2021](#)).

## Research methodology

This study adopted informetrics as a research design. Informetrics is a quantitative research design that examines “patterns that show up not only in publications but also in many aspects of life, as long as the patterns deal with information” ([Diodato, 1994](#), p. ix). The design encompasses bibliometrics, scientometrics, librametrics, cybermetrics, webometrics and altmetrics ([Onyanacha, 2020](#)). The design comprises several methods, which some scholars have termed as techniques. The methods can be grouped into two broad categories, namely, descriptive informetrics (relies on publication counts) and evaluative informetrics (relies on citation and altmetric counts). The most popular informetric methods are citation analysis, social network analysis, network analysis, co-citation analysis, content analysis, cluster analysis, co-word and word co-occurrence analysis, information and knowledge visualization and mapping, bibliographic coupling and science mapping, among others ([Onyanacha, 2020](#)). Infometrics has generally gained increased attention among scholars from a variety of disciplines as a common scientific research design in education, research and trend analysis ([Qiu et al., 2017](#); 4). Its uptake in the recent past has propelled informetrics to rank among the top-ranking topics in library and information science (LIS) research (see [Chang et al., 2015](#); [Onyanacha and Majanja, 2017](#); [Onyanacha, 2018](#); [White, 2010](#)). Apart from its use to resolve some methodological issues in the research process and improve the scientific accuracy of quantitative analysis of information from a theoretical point of view ([Qiu et al., 2017](#)), informetrics informs policies and decisions across a broad range of fields, from economy to politics and to social issues that influence the flow and use patterns of information ([Maluleka and Onyanacha, 2016](#)). [Onyanacha \(2020\)](#) has outlined 361 areas of informetrics research focus, including evaluating research performance of researchers, institutions and countries, developing and/or improving research indicators, evaluating scientific production, journals, scholarly communication, scientific collaboration, authorship patterns, measuring societal academic and societal impact of research and mapping knowledge. The assessment of research collaboration through the analysis of patterns of co-authorship of publications has also taken centre stage in informetric research ([Doyeon and Kim, 2021](#); [Xiuqian et al., 2011](#)).

The study focused on four public universities in Ghana, namely, the University of Ghana (UG), Kwame Nkrumah University of Science and Technology (KNUST), the University of Cape Coast (UCC) and the University for Development Studies (UDS). The universities were selected based on their research outputs indexed in SciVal, which surpassed 100 publications. Raw data were retrieved from the SciVal database. SciVal is a research performance assessment tool that allows one to analyse Scopus data. Indeed, most of the bibliometric analyses on research performance, including collaborations between universities and industry, have used

Scopus and WoS, among other databases. Scopus and SciVal are two databases of controlled quality. Scopus is one of the largest databases of bibliographic and citation data and is less biased in its coverage of publications originating from the global south than the WoS. For its part, SciVal provides access to the research performance of over 21,000 research institutions and their associated researchers, from 234 nations worldwide. To extract relevant data from SciVal, a search using the name of the institution as a search query was conducted within the institution field. The data was retrieved and saved in Microsoft Excel format. Data was analysed to examine single and co-authored publications, number of collaborating institutions by type, and geographic region, industrial organisations or institutions collaborating with the selected universities and distribution of number of collaborating institutions by geographic region.

## Results and discussion

Both the findings and discussions of the study are detailed in this section. The section mainly answers the study's research objectives and is divided into subsections as follows: yearly publication output in the selected universities; single vs

co-authored publications in the selected universities; number of collaborating institutions by type and geographic region; non-academic (industry-based) institutions collaborating with the selected universities; and UIC across the Scopus fields of research.

### Yearly publication output of the selected universities

Research output in the four universities surveyed in this study quadrupled between 2011 and 2020, increasing from 368 to 1,428 at UG, 227 to 1,005 at KNUST, 80 to 485 at UCC and 44 to 336 at UDS (Table 1). In terms of total research productivity, UG leads the pack, producing nearly half (8,150, 48.12%) of the total publication output between the four universities during the period 2011 and 2020. This is followed by KNUST (5,062, 29.90%), UCC (2,124, 12.54%) and UDS (1,599, 9.44%). While the annual publication output continues to grow across all four universities, the annual growth rate (AGR) of the number of publications has been fluctuating, particularly for UG and UDS, since 2011. AGR is the year-on-year growth in research productivity by each of the four universities. It is calculated using the formula:

$$AGR = \frac{(\text{Current year's research output} - \text{Previous year's research output})}{\text{Previous year's research output}} \times 100$$

UDS recorded the highest AGR (52.27%) between 2011 and 2012 while UCC's 0.64% decline in publication output between 2014 and 2015 is the lowest (negative) AGR during the period under review.

These results indicate a significant increase in the research productivity of the four universities since 2011 and are consistent with the results of a previous study by Owusu-Nimo

and Boshoff (2017) who reported impressive growth in Ghana's research output over a 24-year period (1990–2013) at an average annual growth rate of 9.3%. There are several plausible drivers for this significant growth, including external research funding, government strategies to bolster STI in Ghana (Al Marzouqi et al., 2019) and the need for academics to maintain high research performance to sustain their careers and

**Table 1** Yearly publication output in the selected universities

University	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
<b>UG (N = 8,150)</b>										
<i>n</i>	368	493	513	607	691	853	907	1,117	1,173	1,428
% of <i>N</i>	4.52	6.05	6.29	7.45	8.48	10.47	11.13	13.71	14.39	17.52
AGR (%)		33.97	4.06	18.32	13.84	23.44	6.33	23.15	5.01	21.74
<b>KNUST (N = 5,062)</b>										
<i>n</i>	227	215	243	307	441	554	578	686	806	1,005
% of <i>N</i>	4.48	4.25	4.80	6.06	8.71	10.94	11.42	13.55	15.92	19.85
AGR (%)		−5.29	13.02	26.34	43.65	25.62	4.33	18.69	17.49	24.69
<b>UCC (N = 2,124)</b>										
<i>n</i>	80	92	110	156	155	210	235	272	329	485
% of <i>N</i>	3.77	4.33	5.18	7.34	7.30	9.89	11.06	12.81	15.49	22.83
AGR (%)		15.00	19.57	41.82	−0.64	35.48	11.90	15.74	20.96	47.42
<b>UDS (N = 1,599)</b>										
<i>n</i>	44	67	82	103	130	155	174	216	292	336
% of <i>N</i>	2.75	4.19	5.13	6.44	8.13	9.69	10.88	13.51	18.26	21.01
AGR (%)		52.27	22.39	25.61	26.21	19.23	12.26	24.14	35.19	15.07

Source: Authors' own work

reputation (Zhang and Wang, 2017). However, recently, many of the top universities in Ghana are making efforts to improve their positioning on global university ranking tables because such rankings have implications for competitiveness, resource allocation and prestige. Because research performance is one of the key indicators for ranking universities (Kim *et al.*, 2014), many Ghanaian universities have invested in building research capacity by providing targeted training and small grants for research and conference travels for their researchers (Fosci *et al.*, 2019), establishing research support and administration systems and restructuring their doctoral programmes (Alabi and Mohammed, Alabi and Mohammed, 2018) to improve their research productivity and relevance. The combined effect of these efforts has led to the recent featuring of some Ghanaian universities among the top-ranked universities in Africa (e.g. Time Higher Education World University Rankings).

The growth in the research productivity, however, appears to be relatively steadier for UCC and KNUST in terms of the average growth per year. That notwithstanding, UG has produced far more research than the other universities during the period under study. Several reasons could account for this, including the number of academics with high level research training and institutional research support structures and research funding. The most recent Ghana Tertiary Education Commission (GTEC) (2020) report shows that UG (1,018) has more academic staff with doctoral degrees, as compared to KNUST (554), UDS (265) and UCC (194). The high number of academics with high-level research training at UG may have contributed to its ranking as the most productive of the four universities in terms of research output. Furthermore, although the lack of institutional research support structures and inadequate institutional funding for research (Bornmann, 2021) are major challenges for Ghanaian academics, Alabi and Mohammed (2018) singled out the UG as an exception, noting the establishment of the Office of Research, Innovation and Development and the allocation of a large internal research fund of \$200,000 to support research that aligns with national priorities. These factors have very likely contributed to the relatively large output of UG compared with the other universities.

### Single vs co-authored publications

Table 2 shows research collaboration intensity in the selected institutions between 2011 and 2020, with more than half of the annual publication outputs being co-authored publications. Only UCC in 2011 produced the same number of co-authored publications as single-authored papers. Of the 8,150 publications of UG between 2011 and 2020, 5,598 were co-authored publications, whereas 2,552 were single-authored publications. This translates to 68.69% co-authored publications and 31.31% single-authored articles. Similarly, 1,468 (29%) of KNUST publications over the same period were single-authored and 3,594 (71%) were co-authored publications. UCC's single-authored publications during the same period amounted to 745 (35.08%) of their total publication output, as compared to 1,379 (64.92%) of their publication output, which was co-authored over the same period. Furthermore, 440 (27.52%) of UDS publications over the same period were single-authored and 1,159 (72.48%) were co-authored publications.

These results in Ghana confirm the results of recent studies (Bornmann, 2021; Onyancha, 2021) regarding the growing

numbers of research collaborations in Africa. This finding is also consistent with Owusu-Nimo and Boshoff (2017) who reported that 89% of Ghana's total research output between 1990 and 2013 were co-authored publications. Given the growing emphasis on collaborative knowledge production (Binz-Scharf *et al.*, 2015; Onyancha and Maluleka, 2011; Kim *et al.*, 2014), it is unsurprising that co-authored research publications constitute a larger proportion of the total research output in the selected universities. More significantly, the amount of research collaboration per year has continuously increased since 2011 in all four universities. In terms of the performance of the individual universities, the proportion of UDS co-authorship proportion was higher than the other universities (UDS, 72.48%; KNUST, 71%; UG, 68.69%; and UCC, 64.92%), despite contributing the least to the total research production among the four universities during the 10-year period (UG 8,150, 48.12%; KNUST 5,062, 29.90%; UCC 2,124, 12.54%; and UDS 1,599, 9.44%). It is also likely that the sustained growth in research collaborations by the four universities has led to the remarkable increase in their research productivity over the past decade, as shown in Table 1 (Siddique *et al.*, 2023; Paraskevopoulos *et al.*, 2021; Kim *et al.*, 2014). Indeed, in their bibliometric analysis of LIS research from the Arab World with data spanning seven decades (1951–2021), Siddique *et al.* (2023) reported an upward trend in the publications with substantial growth in the past four years.

### Number of collaborating institutions by type and geographic region

Table 3 shows the different categories of collaborating institutions (academic, corporations, government institutions, medical institutions and others) across the different geographical regions. The data suggest that most of the research collaborations by the universities occur at the level of university–university collaboration (UUC) as opposed to UIC. For instance, out of the 2,859 collaborations with UG, 2,001 (69.99%) are with other academic institutions and 858 (30.01%) are with non-academic (industry-based) institutions. At KNUST, of the 2,608 collaborations, 1,796 (68.87%) are UUC and 812 (31.13%) are with non-academic (industry-based) institutions. At UCC, of the 1,552 total collaborations, 1,191 (76.74%) are UUC and 361 (23.26%) are with non-academic (industry-based) institutions and at UDS, out of the 954 collaborating institutions, 636 (66.67%) are UUC and 318 (33.33%) are non-academic (industry-based) institutions.

A further examination of the data in Table 3 reveals that, across the different categories of non-academic industry-based institutions (corporations, government institutions, medical institutions and others), the four universities have collaborated on research the least with corporations both in Africa and the global north. However, in Africa, UG, KNUST and UCC have collaborated mostly with government institutions, whereas only UDS has collaborated mostly with medical institutions on the continent. Similarly, in Europe and Asia-Pacific, UG, KNUST and UDS have collaborated mostly with medical institutions, whereas only UCC has collaborated mostly with government institutions. Finally, in North America, UG, UCC and UDS have collaborated mostly with government institutions, with only KNUST having collaborated mostly with medical institutions. Overall, most non-academic industry-based

Table 2 Single vs co-authored publications in selected universities in Ghana

University	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
<b>UG</b>										
<b>Single</b>										
<i>n</i>	118	179	209	205	230	284	272	332	359	364
%	32.07	36.31	40.74	33.77	33.29	33.29	29.99	29.72	30.61	25.49
<b>Co-authored</b>										
<i>n</i>	250	314	304	402	461	569	635	785	814	1,064
%	67.93	63.69	59.26	66.23	66.71	66.71	70.01	70.28	69.39	74.51
<b>TOTAL</b>										
<i>N</i>	368	493	513	607	691	853	907	1,117	1,173	1,428
<b>KNUST</b>										
<b>Single</b>										
<i>n</i>	100	67	81	95	107	156	167	188	232	275
%	44.05	31.16	33.33	30.94	24.26	28.16	28.89	27.41	28.78	27.36
<b>Co-authored</b>										
<i>n</i>	127	148	162	212	334	398	411	498	574	730
%	55.95	68.84	66.67	69.06	75.74	71.84	71.11	72.59	71.22	72.64
<b>TOTAL</b>										
<i>N</i>	227	215	243	307	441	554	578	686	806	1,005
<b>UCC</b>										
<b>Single</b>										
<i>n</i>	40	39	46	56	49	58	98	92	116	151
%	50.00	42.39	41.82	35.90	31.61	27.62	41.70	33.82	35.26	31.13
<b>Co-authored</b>										
<i>n</i>	40	53	64	100	106	152	137	180	213	334
%	50.00	57.61	58.18	64.10	68.39	72.38	58.30	66.18	64.74	68.87
<b>TOTAL</b>										
<i>N</i>	80	92	110	156	155	210	235	272	329	485
<b>UDS</b>										
<b>Single</b>										
<i>n</i>	23	17	22	31	34	43	54	70	63	83
%	52.27	25.37	26.83	30.10	26.15	27.74	31.03	32.41	21.58	24.70
<b>Co-authored</b>										
<i>n</i>	21	50	60	72	96	112	120	146	229	253
%	47.73	74.63	73.17	69.90	73.85	72.26	68.97	67.59	78.42	75.30
<b>TOTAL</b>										
<i>N</i>	44	67	82	103	130	155	174	216	292	336

Source: Authors' own work

research collaborations by UG (346, 12.10%) and UCC (170, 10.95%) have been with government institutions, whereas that of KNUST (378, 14.49%) and UDS (191, 20.02%) have been with medical institutions, globally.

The data further suggest that the four universities conducted collaborative research mostly with European, Asia-Pacific and North American-based institutions. For instance, 917 (32.07%) of the collaborating institutions with UG were from Europe, followed by 640 (22.39%) from Asia-Pacific and 587 (20.53%) from North America, compared to 400 (13.99%) from Africa. Similarly, 932 (35.74%) of the collaborating institutions with KNUST were from Europe, followed by 554 (21.24%) from Asia-Pacific and 485 (18.60%) from North America, compared to 329 (12.62%) from Africa. In UCC, 464 (29.90%) of the collaborating institutions were from Europe, followed by 400 (25.77%) from Asia-Pacific and 289 (18.62%) from North America,

compared to 204 (13.14%) from Africa. In UDS, however, 379 (39.73%) of the collaborating institutions were from Europe, followed by 185 (19.39%) from Africa, compared to 172 (18.03%) from Asia-Pacific and 162 (16.98%) from North America.

The trend is similar for UIC. Of the 858 non-academic institutions that collaborated with UG between 2011 and 2020, 348 (40.56%) are from Europe, 182 (21.21%) are from North America, 159 (18.53%) are from Asia-Pacific and 144 (16.78%) are from Africa. In KNUST, out of the 812 non-academic institutions, 380 (46.80%) are from Europe, 150 (18.47%) are from North America, 145 (17.86%) are from Asia-Pacific and 79 (9.73%) are from Africa. For UCC, out of the 361 non-academic collaborating institutions, 131 (36.29%) are Europe-based, 76 (21.05%) are North American, 83 (22.99%) are from Asia-Pacific and 43 (11.91%) are African-based, and out of the 318 non-academic institutions that



Table 3 Number of collaborating institutions by type and geographic region

Institution	North America	Africa	South America	Middle East	Europe	Asia-Pacific	Worldwide
<b>UG</b>							
Acad.	405	286	103	157	569	481	2001
Corp.	40	3	0	2	30	6	81
Govt.	59	53	9	13	142	70	346
Med.	52	34	11	15	143	73	328
Other	31	24	1	4	33	10	103
Total	587	400	124	191	917	640	2,859
<b>KNUST</b>							
Acad.	335	250	96	154	552	409	1,796
Corp.	17	2	0	1	20	8	48
Govt.	49	35	11	16	133	63	307
Med.	58	32	13	13	194	68	378
Other	26	10	0	4	33	6	79
Total	485	329	120	188	932	554	2,608
<b>UCC</b>							
Acad.	213	161	56	111	333	317	1,191
Corp.	8	1	0	1	7	3	20
Govt.	27	21	6	7	64	45	170
Med.	26	10	6	6	50	32	130
Other	15	11	0	2	10	3	41
Total	289	204	68	127	464	400	1,552
<b>UDS</b>							
Acad.	117	141	9	27	205	137	636
Corp.	4	3	1	0	2	1	11
Govt.	21	16	5	3	38	15	98
Med.	13	19	5	6	129	19	191
Other	7	6	0	0	5	0	18
Total	162	185	20	36	379	172	954

Source: Authors' own work

collaborated with UDS, 174 (54.72%) are Europe-based, 45 (14.15%) are North American, 35 (11.01%) are from Asia-Pacific and 44 (13.84%) are African-based (Table 3).

In terms of the different categories of non-academic, industry-based institutions that conduct collaborative research with the four universities, these trends are also palpable. In UG, for instance, of the 81 corporations that collaborated with the university during the period under review, fewer were African-based (3, 3.70%), as compared to foreign-based (Europe: 30, 37.04%; Asia-Pacific: 6, 7.41%; North America: 40, 49.38%); of the 346 government institutions that collaborated with the university, fewer were African-based (53, 15.32%), as compared to foreign-based (Europe: 142, 41.04%; Asia-Pacific: 70, 20.23%; North America: 59, 17.05%); and of the 328 medical institutions that collaborated with the university, fewer were African-based (34, 10.37%), as compared to foreign-based (Europe: 143, 43.60%; Asia-Pacific: 73, 22.26%; North America: 52, 15.85%). In KNUST, fewer African-based corporations (2, 4.17%) collaborated with the university than foreign-based ones (Europe: 20, 41.67%; Asia-Pacific: 8, 16.67%; North America: 17, 35.42%); fewer African-based government institutions (35, 11.40%) collaborated with the university than foreign-based ones (Europe: 133, 43.32%; Asia-Pacific: 63, 20.52%; North America: 49, 15.96%); and fewer African-based medical

institutions (32, 8.47%) collaborated with the university than foreign-based ones (Europe: 194, 51.32%; Asia-Pacific: 68, 17.99%; North America: 58, 15.34%). The data on UCC shows that fewer African-based corporations (1, 5%) collaborated with the university than did foreign-based ones (Europe: 7, 35%; Asia-Pacific: 3, 15%; North America: 8, 40%); fewer African-based government institutions (21, 12.35%) collaborated with the university than did foreign-based ones (Europe: 64, 37.65%; Asia-Pacific: 45, 26.47%; North America: 27, 15.88%); and fewer African-based medical institutions (10, 7.69%) collaborated with the university than did foreign-based ones (Europe: 50, 38.46%; Asia-Pacific: 32, 24.62%; North America: 26, 20%). Finally, the data on UDS shows that, apart from North America (4, 36.36%), relatively more African-based corporations (3, 27.27%) collaborated with the university on research than did foreign-based ones (Europe: 2, 18.18%; Asia-Pacific: 1, 9.09%); except for Asia-Pacific (15, 15.31%), fewer African-based government institutions (16, 16.33%) collaborated with the university on research than did foreign-based ones (Europe: 38, 38.78%; North America: 21, 21.43%); and more African and Asia-Pacific-based medical institutions (19, 9.95%) collaborated on research with the university than did North American-based medical institutions (13, 6.81%), though fewer did so as compared to Europe (129, 67.54%).

These results mean that there is limited research collaboration between the selected universities and industry. A plausible explanation is that UIC in Ghana is limited, not well-planned and lacks investment from policymakers. These sentiments are emphasised in Ghana's development policy. Consequently, Muparadzi and Caesar (2021) characterised UIC in Ghana as non-strategic but, it is unfortunate, that Mensah and Gordon (2020) hinted at the lack of incentives to foster effective UIC in Ghana. It is also argued that UIC is constrained by contrasting cultures and norms between academia and industry (Muparadzi and Caesar, 2021; Bemke-Š witolnik *et al.*, 2020). Bemke-Š witolnik *et al.* (2020) asserted that varied motivations to publish, choice of publication channel and interpretation of findings are constricting for UIC. This is because academic culture promotes openness and sharing of knowledge through scientific publications, but corporate culture promotes secrecy and the monetisation of their innovation for competitiveness (Sjöo and Hellström, 2019). Furthermore, the perceived lack of trust regarding IP ownership decisions and the over-reliance on scientific rigour, as opposed to relevance between universities and industries, respectively, undermine UIC (Muparadzi and Caesar, Muparadzi and Caesar, 2021). Finally, Owusu-Nimo and Boshoff (2017, p. 1116) found that industry or the private sector provided very little to no funding for research support to Ghanaian universities. These are the factors that are likely responsible for the low UIC on research in the selected universities. This notwithstanding, the results conform to what persists on the continent, with the study by Fischer *et al.* (2020) showing that UIC activities in Africa are at a relatively low level.

While the common trend is that the four universities had fewer research collaborations with Corporations across all geographical settings, a very interesting UIC pattern was identified from the data. Overall, in Africa and North America, the universities collaborated more with government institutions, whereas in Europe and Asia-Pacific they collaborated more with medical institutions. Individually however, UG and UCC collaborated more with government institutions, whereas KNUST and UDS collaborated more with medical institutions. It is not immediately apparent what factors may account for this pattern, but these results reveal that government institutions and medical institutions are important partners for research co-authorship for academics in the selected universities – more so than corporations. It will be worth investigating why these patterns emerged.

Most of the institutions (all categories) that collaborated with the four universities under investigation are European-based, followed by Asia-Pacific and then institutions in North America. However, when it comes to non-academic institutions that engaged in UIC with these universities, the Asia-Pacific region drops from the second position to the third. Still, fewer African-based institutions engaged in research collaboration (including UIC) with the universities than those from Europe, North America and Asia-Pacific regions. These results are consistent with Onyancha (2021) and Onyancha and Maluleka (2011) who reported that there is minimal research collaboration among African researchers in terms of co-authorships, as compared to researchers from other continents. The results further confirm the findings of Bornmann (2021), who, based on analysis of SCImago

Institutions Ranking data, reported that the USA, France and the UK are the three countries that collaborate most frequently with African countries. It is very likely that the relatively high collaboration from the West and the global North is driven by the international research funding and academic mobility (e.g. attaining PhD abroad) (Confraria *et al.*, 2020). The fact that external funding (particularly from Europe and North America) is among the leading sources of research funding for Ghanaian researchers (Owusu-Nimo and Boshoff, 2017), and the fact that many academics in Ghana acquired their PhDs in Europe and North America are likely the reasons why these Ghanaian institutions collaborated most with institutions from these countries. Meanwhile, Owusu-Nimo and Boshoff (2017) argued that collaborating more with international (non-African) partners is good for Ghana in strengthening the country's regional and continental integration. Such collaborations are achieved in two principal ways: first, Northern countries operate as “nodes” in global research networks and could therefore link Southern countries on the fringes of those networks; and second, North–South research collaborations contribute more to local knowledge production for the South than is the case for South–South research collaborations. This second point is reinforced by Onyancha (2021, p. 590) who found that “the North largely performed better than the other [...] geo-economic regions in terms of the number of papers, citations, citations per paper and citations per country”.

#### Non-academic (industry-based) institutions collaborating with the selected universities

The top ten non-academic (industry-based) institutions collaborating with the selected academic institutions are shown in Table 4. The data shows that over the period under consideration, four institutions [Ghana Health Service (GHS), Ghana Atomic Energy Commission (GAEC), Korle Bu Teaching Hospital (KBTH) and Kumasi Centre for Collaborative Research in Tropical Medicine (KCCR)] have had collaborations with the four universities, co-authoring more than 200 publications across the four universities. The Ghana AIDS Commission and Youth Harvest Foundation Ghana (YHFG) have collaborated the least on research with the four institutions, producing four and one co-authored publications, respectively. The trend is similar in terms of which non-academic (industry-based) institutions are collaborating with more researchers in the selected institutions. Practitioners in GHS have co-authored with 755 researchers across the four universities, practitioners at GAEC have collaborated with 350 researchers across the four universities, practitioners in KBTH have co-authored with 628 researchers across the four universities and practitioners at KCCR have collaborated with 248 researchers across the four universities. The rest have collaborated with fewer than 200 researchers, with the smallest number of collaborations coming from the Ghana AIDS Commission and YHFG, which have collaborated with nine and one researchers, respectively, from the four universities. The results also show that, overall, the top ten non-academic institutions collaborate more with co-authors at the selected universities than at other institutions, except in the case of UDS, where GHS, GAEC and KBTH have collaborated more with researchers from other

**Table 4** Non-academic (industry-based) institutions collaborating with the selected universities

No.	Institution	Sector	Univ.	Co-authored publications	Co-authors at univ.	Co-authors at other institutions
1	Ghana Health Service	Govt	UG	299	361	318
			KNUST	102	162	125
			UCC	102	162	125
			UDS	92	70	110
2	Ghana Atomic Energy Commission	Govt	UG	181	238	190
			KNUST	36	50	36
			UCC	36	50	36
			UDS	13	12	28
3	Ministry of Health, Ghana	Govt	UG	47	124	59
			KNUST	18	16	14
			UCC	18	16	14
			UDS	10	17	12
4	Ministry of Lands and Natural Resources, Ghana	Govt	UG	33	76	37
			KNUST	12	16	17
			UCC	12	16	17
			UDS	2	6	2
5	Bank of Ghana	Govt	UG	8	15	7
			KNUST	1	1	1
			UCC	1	1	1
			UDS	1	1	1
6	Korle Bu Teaching Hospital	Med	UG	367	488	374
			KNUST	47	66	65
			UCC	47	66	65
			UDS	6	8	19
7	Agogo Presby Hospital	Med	UG	1	1	1
			KNUST	36	57	28
			UCC	0	0	0
			UDS	0	0	0
8	Kumasi Center for Collaborative Research in Tropical Medicine	other	UG	36	40	31
			KNUST	206	215	121
			UCC	0	0	0
			UDS	6	5	3
9	Ghana AIDS Commission	Govt	UG	4	9	3
			KNUST	0	0	0
			UCC	0	0	0
			UDS	0	0	0
10	Youth Harvest Foundation Ghana	Other	UG	0	0	0
			KNUST	0	0	0
			UCC	0	0	0
			UDS	1	1	1

Source: Authors' own work

institutions, and in the cases of KNUST and UCC, where the Ministry of Lands and Natural Resources has collaborated more with researchers from other institutions.

In terms of which of the four universities are participating more in these UIC, UG researchers have co-authored more publications with practitioners (i.e. seven out of the ten non-academic institutions) than any of the other universities. For instance, 361 researchers at UG have co-authored 299 publications with practitioners at the GHS. Both KNUST and UCC have co-authored 102 publications each with GHS and have each had 162 of their researchers collaborating with the same institution. UDS has had 70 of their researchers co-authoring 92 publications with practitioners at the GHS. Similarly, more KNUST researchers have co-authored more

publications with practitioners at two of the ten non-academic (industry-based) institutions than any of the other universities. For instance, 215 researchers at KNUST have co-authored 206 publications with practitioners at the KCCR. Forty UG researchers have co-authored 36 publications and five UDS researchers have co-authored six publications at the KCCR. No researchers from UCC have collaborated with the KCCR staff. Only one researcher from UDS has co-authored a single publication with a practitioner from YHFG. None of the other universities has engaged in UIC on research with YHFG.

Based on the data, all but a very few of the non-academic institutions collaborated more with co-authors at the selected universities than at other institutions. Particularly for the top four non-academic institutions that had the most research-

intensive UIC with the four universities, only UDS has had fewer collaborations from three of them (GHS, GAEC and KBTH) compared with other institutions. Combining these results with the fact that UG and KNUST have, comparatively, collaborated more with the four non-academic institutions than UCC and UDS, some possible explanations can be deduced. First, proximity to the universities influences the extent to which the non-academic institutions collaborate with the different universities. For instance, UG collaborated more with institutions within the Greater Accra region (e.g. GHS, GAEC and KBTH), whereas KNUST collaborated more with institutions within the Ashanti region (e.g. KCCR). In the same vein, UDS was the only university to have collaborated with YHFG, an institution in the Upper East region of Ghana. These trends confirm the notion that “geographical proximity fosters interaction and knowledge exchange collaboration between firms and universities” (Atta-Owusu *et al.*, 2021, p. 2). In other words, industries are more likely to collaborate with local universities. It has, however, been shown that the influence of geographical proximity on collaboration decisions (including UIC) decreases over time (Atta-Owusu *et al.*, 2021).

A second possible explanation is the fact that some institutions have shared facilities and resources. For instance, both GAEC and KBTH have shared campuses and teaching and research facilities with UG. Students offering most of the health science programmes at UG are mostly trained at the KBTH facilities

(Owusu-Nimo and Boshoff, 2017). Similarly, the School of Nuclear and Allied Sciences was jointly established by UG and GAEC to offer graduate-level programmes in atomic energy-related fields. Also, KCCR was developed as a platform for biomedical, agricultural and ecological research, with collaboration between the KNUST’s School of Medical Sciences and the Bernhard-Nocht Institute for Tropical Medicine in Hamburg, Germany. It is the vision of the Centre to “attract the most talented and innovative KNUST scientists who carry innovative concepts and technologies back to their departments, faculties and beyond” (KCCR, 2022). The Committee for Human Research and Publication of the KNUST also conducts ethical evaluations and approve prospective research projects with the centre. These relationships based on shared facilities and resources are likely the reasons why some of the non-academic institutions collaborated more with the selected universities than did others.

### University–industry collaboration across the Scopus fields of research

Tables 5 and 6 should be read side-by-side as they detail the number and ratio of institutions collaborating with the four universities across the different subject fields, according to SciVal classification. The percentages in Table 5 are based on the data in Table 6. Across all subject fields, most of the institutions that collaborated with the four universities were

**Table 5** Percentage share of the number of academic and industry institutions collaborating with Ghanaian universities across the fields of research

Field of research	UG		KNUST		UCC		UDS	
	Acad.	Ind.	Acad.	Ind.	Acad.	Ind.	Acad.	Ind.
Agricultural and biological sciences	76.62	23.38	80.93	19.07	82.05	17.95	84.18	15.82
Arts and humanities	89.02	10.98	95.89	4.11	98.11	1.89	88.46	11.54
Biochemistry, genetics and molecular biology	72.61	27.39	78.83	21.17	81.82	18.18	78.63	21.37
Business, management and accounting	95.60	4.40	94.08	5.92	97.14	2.86	94.74	5.26
Chemical engineering	88.29	11.71	88.66	11.34	86.67	13.33	87.50	12.50
Chemistry	79.51	20.49	83.61	16.39	86.27	13.73	75.47	24.53
Computer science	89.40	10.60	83.42	16.58	90.57	9.43	85.71	14.29
Decision sciences	85.42	14.58	80.15	19.85	100.00	0.00	92.31	7.69
Dentistry	61.54	38.46	90.91	9.09	0.00	0.00	0.00	0.00
Earth and planetary sciences	80.08	19.92	80.98	19.02	74.16	25.84	88.14	11.86
Economics, econometrics and finance	91.63	8.37	95.33	4.67	95.56	4.44	87.23	12.77
Energy	84.70	15.30	86.34	13.66	81.13	18.87	84.62	15.38
Engineering	81.86	18.14	93.90	6.10	83.58	16.42	88.46	11.54
Environmental science	82.40	17.60	83.33	16.67	81.59	18.41	86.44	13.56
Health professions	82.64	17.36	90.91	9.09	84.62	15.38	81.25	18.75
Immunology and microbiology	75.49	24.51	73.54	26.46	77.81	22.19	76.47	23.53
Materials science	82.83	17.17	93.28	6.72	86.96	13.04	85.71	14.29
Mathematics	80.46	19.54	82.47	17.53	93.10	6.90	93.10	6.90
Medicine	69.20	30.80	67.36	32.64	75.97	24.03	57.14	42.86
Multidisciplinary	77.40	22.60	76.55	23.45	81.66	18.34	77.12	22.88
Neuroscience	83.73	16.27	78.92	21.08	78.26	21.74	84.29	15.71
Nursing	80.99	19.01	80.13	19.87	89.29	10.71	78.46	21.54
Pharmacology, toxicology and pharmaceuticals	76.49	23.51	79.61	20.39	90.16	9.84	83.78	16.22
Physics and astronomy	76.16	23.84	84.65	15.35	82.22	17.78	76.92	23.08
Psychology	92.54	7.46	84.21	15.79	92.86	7.14	77.78	22.22
Social sciences	86.46	13.54	84.30	15.70	92.12	7.88	87.18	12.82
Veterinary	71.53	28.47	75.38	24.62	82.35	17.65	84.31	15.69

Source: Authors’ own work



**Table 6** Number of academic and industry institutions collaborating with Ghanaian universities across the fields of research

Research fields	UG		KNUST		UCC		UDS	
	Acad.	Ind.	Acad.	Ind.	Acad.	Ind.	Acad.	Ind.
Agricultural and biological sciences	485	148	573	135	192	42	165	31
Arts and humanities	219	27	70	3	52	1	23	3
Biochemistry, genetics and molecular biology	997	376	838	225	585	130	184	50
Business, management and accounting	174	8	143	9	68	2	36	2
Chemical engineering	98	13	86	11	39	6	14	2
Chemistry	260	67	199	39	44	7	80	26
Computer science	135	16	166	33	48	5	24	4
Decision sciences	41	7	105	26	13	0	12	1
Dentistry	8	5	50	5	0	0	0	0
Earth and planetary sciences	213	53	166	39	66	23	52	7
Economics, econometrics and finance	186	17	102	5	43	2	41	6
Energy	155	28	139	22	43	10	22	4
Engineering	176	39	231	15	56	11	46	6
Environmental science	529	113	565	113	164	37	153	24
Health professions	100	21	30	3	22	4	13	3
Immunology and microbiology	622	202	553	199	305	87	143	44
Materials science	82	17	111	8	40	6	12	2
Mathematics	70	17	127	27	27	2	27	2
Medicine	1,402	624	1319	639	955	302	340	255
Multidisciplinary	565	165	581	178	383	86	182	54
Neuroscience	247	48	292	78	18	5	59	11
Nursing	196	46	125	31	25	3	51	14
Pharmacology, toxicology and pharmaceuticals	205	63	121	31	55	6	31	6
Physics and astronomy	214	67	182	33	37	8	80	24
Psychology	360	29	64	12	26	2	21	6
Social sciences	645	101	376	70	222	19	170	25
Veterinary	98	39	49	16	14	3	43	8

Source: Authors' own work

academic institutions (UUC). For example, out of the total of 633 institutions that collaborated with UG in the areas of agricultural and biological sciences, 485(76.62%) were academic, whereas 148 (23.38%) belonged to the “industry” category. Meanwhile, in the field of Decision Sciences, all 13 (100%) institutions that collaborated with UCC are academic institutions.

The data in Table 6 further reveals that the majority of the non-academic (industry-based) institutions, expressed as a percentage of the total number of non-academic (industry-based) institutions that collaborated with the four universities, collaborated in the field of *Medicine* (UG = 624, 26.49%; KNUST = 639, 31.87%; UCC = 302, 37.33%; and UDS = 255, 41.13%). The smallest number of non-academic (industry-based) institutions collaborated in the fields of *Arts and Humanities* (UCC = 1, 0.12%), *Dentistry* (UG = 5, 0.21%), *Decision Sciences* (UDS = 1, 0.16%) and *Health Professions* (KNUST = 3, 0.15%). The top five subject fields, where most of the non-academic (industry-based) institutions collaborated with the four universities are (in alphabetical order), *Agricultural and Biological Sciences* (UG = 148, 6.28%; KNUST = 135, 6.73%; UCC = 42, 5.19%; UDS = 31, 5.00%); *Biochemistry, Genetics and Molecular Biology* (UG = 376, 15.96%; KNUST = 225, 11.22%; UCC = 130, 16.07%; UDS = 50, 8.06%); *Immunology and Microbiology* (UG = 202, 8.57%; KNUST = 199, 9.93%; UCC = 87, 10.75%; UDS =

44, 7.10%); *Medicine* (UG = 624, 26.49%; KNUST = 639, 31.87%; UCC = 302, 37.33%; UDS = 255, 41.13%); and *Multidisciplinary* (UG = 165, 7.00%; KNUST = 178, 8.88%; UCC = 86, 10.63%; UDS = 54, 8.71%). None of the industry-based institutions collaborated with UCC in the fields of *Decision Sciences* and *Dentistry* or UDS in the field of *Dentistry*.

Similarly, in terms of the number of co-authored publications across the different subject fields, the data in Tables 7 and 8 show that the number of co-authored publications was lower for UIC as opposed to UUC in most of the fields except for instances where the field yielded no publications. The highest number of UIC co-authored publications, expressed as a percentage of the total number of co-authored publications per subject field was witnessed in *Neuroscience* (UG = 51.30%; UDS = 50.00%) and *Immunology and Microbiology* (KNUST = 50.98). Almost all the industry co-authorships accounted for less than 50% of the total number of co-authored publications in each field and university as shown in Tables 7 and 8.

The majority of UIC co-authored publications, expressed as a percentage of the total number of UIC co-authored publications for each university, was witnessed in *Medicine* (UG = 1,738, 40.18%; KNUST = 999, 42.72%; UCC = 288, 43.64%; UDS = 224, 36.54%). The smallest number of co-authored publications per each university were witnessed in *Decision Sciences* (UG = 5, 0.12%; UDS = 1, 0.16%) and *Arts*

Table 7 Percentage share of co-authored publications across the fields of research

Research fields	UG		KNUST		UCC		UDS	
	Acad.	Ind.	Acad.	Ind.	Acad.	Ind.	Acad.	Ind.
Agricultural and biological sciences	74.58	25.42	77.89	22.11	82.85	17.15	85.17	14.83
Arts and humanities	81.31	18.69	94.12	5.88	97.83	2.17	85.00	15.00
Biochemistry, genetics and molecular biology	57.26	42.74	62.57	37.43	75.69	24.31	68.72	31.28
Business, management and accounting	95.44	4.56	95.96	4.04	97.78	2.22	95.74	4.26
Chemical engineering	87.36	12.64	89.09	10.91	85.37	14.63	89.47	10.53
Chemistry	67.87	32.13	77.63	22.37	83.02	16.98	63.89	36.11
Computer science	87.21	12.79	89.71	10.29	76.19	23.81	87.18	12.82
Decision sciences	87.18	12.82	82.61	17.39	100.00	0.00	90.00	10.00
Dentistry	57.14	42.86	64.29	35.71	0.00	0.00	0.00	0.00
Earth and planetary sciences	62.78	37.22	81.78	18.22	70.69	29.31	86.11	13.89
Economics, econometrics and finance	92.47	7.53	95.97	4.03	96.49	3.51	89.83	10.17
Energy	63.80	36.20	89.86	10.14	82.14	17.86	87.10	12.90
Engineering	76.25	23.75	93.40	6.60	84.52	15.48	88.41	11.59
Environmental science	73.94	26.06	83.25	16.75	79.38	20.62	85.55	14.45
Health professions	61.90	38.10	83.33	16.67	82.35	17.65	80.00	20.00
Immunology and microbiology	57.57	42.43	49.02	50.98	72.18	27.82	65.50	34.50
Materials science	76.36	23.64	87.32	12.68	84.78	15.22	84.62	15.38
Mathematics	87.69	12.31	87.14	12.86	78.95	21.05	90.00	10.00
Medicine	55.70	44.30	56.30	43.70	61.80	38.20	63.75	36.25
Multidisciplinary	61.39	38.61	57.02	42.98	70.87	29.13	63.78	36.22
Neuroscience	48.70	51.30	70.00	30.00	76.47	23.53	50.00	50.00
Nursing	69.84	30.16	68.87	31.13	93.33	6.67	70.00	30.00
Pharmacology, toxicology and pharmaceuticals	70.90	29.10	80.30	19.70	94.00	6.00	81.48	18.52
Physics and astronomy	58.43	41.57	76.74	23.26	70.42	29.58	65.71	34.29
Psychology	81.04	18.96	71.88	28.13	92.31	7.69	75.00	25.00
Social sciences	85.27	14.73	88.64	11.36	91.53	8.47	88.48	11.52
Veterinary	60.47	39.53	53.52	46.48	73.33	26.67	78.26	21.74

Source: Authors' own work

and Humanities (KNUST = 3, 0.13%; UCC = 1, 0.15%). No publications were co-authored in the fields of *Dentistry* for UCC and UDS, and *Decision Sciences* for UCC. The top seven subject fields where most UIC publications were co-authored across the four universities (in alphabetical order) are *Agricultural and Biological Sciences* (UG = 289, 6.68%; KNUST = 174, 7.45%; UCC = 41, 6.21%; UDS = 58, 9.46%); *Biochemistry, Genetics and Molecular Biology* (UG = 486, 11.23%; KNUST = 213, 9.11%; UCC = 62, 9.39%; UDS = 61, 9.95%); *Environmental Science* (UG = 202, 4.67%; KNUST = 106, 4.54%; UCC = 40, 6.06%; UDS = 25, 4.08%); *Immunology and Microbiology* (UG = 356, 8.23%; KNUST = 235, 10.06%; UCC = 37, 5.61%; UDS = 59, 9.62%); *Medicine* (UG = 1,738, 40.18%; KNUST = 999, 42.72%; UCC = 288, 43.64%; UDS = 224, 36.54%); *Multidisciplinary* (UG = 200, 4.67%; KNUST = 150, 6.42%; UCC = 37, 5.61%; UDS = 46, 7.50%); and *Social Sciences* (UG = 151, 3.49%; KNUST = 65, 2.78%; UCC = 25, 3.79%; UDS = 22, 3.59%).

Consistent with the data in Table 3, these results show that there were fewer UIC co-authored publications across the four universities in almost all fields. The only instances where relatively higher numbers of publications were co-authored through UIC were in the field of *Neuroscience*, in the case of UG and UDS, and *Immunology and Microbiology*, in the case of KNUST. Overall, across all fields and universities, the most

research-intensive area was *Medicine* (7,581, 28.59%), and the least research-intensive area was *Dentistry* (28, 0.11%), based on Table 8. When adjusted for only UIC co-authored publications, the trend remains the same, with *Medicine* (3,249, 40.96%) being the most intensive research area and *Dentistry* (11, 0.14%) being the least. This presents an interesting revelation, in that the proportion of the intensity of research in the field of *Medicine* appreciates significantly from 29% to 41% and marginally from 0.11% to 0.14% in the case of *Dentistry*, when we consider UIC co-authored publications only. This trend is also confirmed by the proportion of non-academic industry institutions that collaborated on research with the four universities, across all subject fields (see Table 6). Many of the collaborations by these industry-based institutions occurred in the field of *Medicine* (1,820, 31.43%) and the least is *Dentistry* (10, 0.17%). It can be deduced, therefore, that the four selected universities collaborated intensively in the field of *Medicine*, and collaborated the least in the field of *Dentistry*, during the period under review.

## Conclusion and recommendations

The purpose of the study was to investigate the patterns, trends and extent of university–industry research collaboration in Ghana between 2011 and 2020, using the top four universities as cases of study. It emerged that research collaborations contributed largely to the growth in the research output of the

Table 8 Number of co-authored publications across the fields of research

Research fields	UG		KNUST		UCC		UDS	
	Acad.	Ind.	Acad.	Ind.	Acad.	Ind.	Acad.	Ind.
Agricultural and biological sciences	848	289	613	174	198	41	333	58
Arts and humanities	161	37	48	3	45	1	17	3
Biochemistry, genetics and molecular biology	651	486	356	213	193	62	134	61
Business, management and accounting	293	14	190	8	88	2	45	2
Chemical engineering	76	11	98	12	35	6	17	2
Chemistry	150	71	118	34	44	9	23	13
Computer science	150	22	122	14	48	15	34	5
Decision sciences	34	5	38	8	16	0	9	1
Dentistry	8	6	9	5	0	0	0	0
Earth and planetary sciences	221	131	175	39	41	17	31	5
Economics, econometrics and finance	270	22	119	5	55	2	53	6
Energy	104	59	133	15	23	5	27	4
Engineering	199	62	354	25	71	13	61	8
Environmental science	573	202	527	106	154	40	148	25
Health professions	65	40	30	6	28	6	12	3
Immunology and microbiology	483	356	226	235	96	37	112	59
Materials science	84	26	124	18	39	7	11	2
Mathematics	57	8	61	9	30	8	18	2
Medicine	2,185	1,738	1,287	999	466	288	394	224
Multidisciplinary	318	200	199	150	90	37	81	46
Neuroscience	56	59	63	27	13	4	11	11
Nursing	220	95	104	47	28	2	49	21
Pharmacology, toxicology and pharmaceuticals	173	71	159	39	94	6	22	5
Physics and astronomy	104	74	99	30	50	21	23	12
Psychology	171	40	46	18	24	2	9	3
Social sciences	874	151	507	65	270	25	169	22
Veterinary	78	51	38	33	11	4	36	10

Source: Authors' own work

four universities, even though UIC on research still represents a relatively lesser component of the total research collaborations of the universities. Furthermore, it was noted that most of the UIC on research that the four universities have engaged in have been with European, Asia-Pacific and North American-based institutions and to a lesser extent with African-based institutions. Locally, four Ghanaian industry-based institutions (GHS, GAEC, KBTH and KCCR) were found to have the most research-intensive UIC with the four universities. What is more, it appears that the four universities tend to collaborate more with industry-based institutions in close proximity to them.

Regarding the performance of the four universities regarding collaboration intensity, different rankings emerged, depending on which indicators were used. For the proportion of co-authorships to total research output, and UIC by type, the ranking is UDS, KNUST, UG and UCC in that order. For UIC involving local industry-based institutions (in terms of the number of co-authored publications and the number of co-authors), the ranking is UG, KNUST, UCC and UDS, in that order. Finally, for UIC based on subject field, different rankings exist across the different fields. However, for the most research-intensive field for UIC, which is Medicine, the ranking is UCC, KNUST, UG and UDS. Regarding this study's limitations, the fact that the study was conducted on only one database, despite its quality, can be considered a limitation, as some productive and influential studies may have been left out. Again, provided that the measurement of research performance is usually assessed by the number of

publications, academic research performance should be measured by both quantity and impact of publication (Liao, 2011). As such, given that this study did not include the impact of collaborations between the universities and industry, this is another limitation of this study. With respect to areas for further studies, the study focused on four public universities, whereas further studies may extend to other public, and or private universities in Ghana. Again, this study presents descriptive analysis of the publication output because of UIC, whereas further studies may examine the difference in publication outputs across the universities. Furthermore, future research could consider more than one database with a triangulation of both the quantitative and qualitative approaches to gain an in-depth understanding of the descriptive analysis of this study. Finally, a collaborative study between universities across countries is also recommended.

### Implications of the study

The current study adds novelty in the knowledge generation on UIC in Ghana and helps to fill a gap in the literature on the patterns, trends and extent of UIC in research in Ghana. It provides useful data to inform knowledge generation and innovation policies across universities in Ghana and on the continent of Africa. The current study helps to identify areas that need more collaboration and comparative data on which universities in Ghana are the main providers of scientific knowledge and services for the industries in Ghana, as well as in

which areas such collaborations or technology transfers are taking place. Overall, the study contributes to the literature relating to UIC and offer insights on how to improve these collaborations. Again, the findings from the analysis presented in this study revealed an increase in studies relating to UIC in recent years and hence reinforces the relevance of the subject matter. Furthermore, the content of the current study can be implemented as the guidelines for UIC analysis in Ghana. Other studies could use the findings of this study as a benchmark to conduct other related analyses on UIC in Ghana and Africa. Indeed, knowledge on the UIC in Ghana is informative and insightful to the global community and could serve as useful references for future cross-country collaborations.

## References

- Abdulai, A.-F., Murphy, L. and Thomas, B. (2020), “University knowledge transfer and innovation performance in firms: the Ghanaian experience”, *International Journal of Innovation Management*, Vol. 24 No. 3, p. 2050023, doi: [10.1142/S1363919620500231](https://doi.org/10.1142/S1363919620500231).
- Abramo, G., Andrea D’Angelo, C. and Di Costa, F. (2009a), “Research collaboration and productivity: is there correlation?”, *Higher Education*, Vol. 7 No. 2, pp. 155-171, doi: [10.1007/s10734-008-9139](https://doi.org/10.1007/s10734-008-9139).
- Abramo, G., D’Angelo, C.A., Di Costa, F. and Solazzi, M. (2009b), “University–industry collaboration in Italy: a bibliometric examination”, *Technovation*, Vol. 29 Nos 6/7, pp. 498-507, doi: [10.1016/j.technovation.2008.11.003](https://doi.org/10.1016/j.technovation.2008.11.003).
- Addy, E. and Adabor, E. (2021), “Leadership roles and sustainable public-private partnership between technical universities and industry in Ghana”, *Tertiary Education and Management*, Vol. 27 No. 1, pp. 73-89, doi: [10.1007/s11233-021-09066-4](https://doi.org/10.1007/s11233-021-09066-4).
- Akufo-Addo, N.A.D. (2017), *The Coordinated Programme of Economic and Social Development Policies (2017-2024): An Agenda for Jobs: Creating Prosperity and Equal Opportunity for All*, Government of Ghana, Accra.
- Al Marzouqi, A., Alameddine Hassan, M., Sharif, A. and Alsheikh-Ali, A.A. (2019), “Research productivity in the United Arab Emirates: a 20-year bibliometric analysis”, *Heliyon*, Vol. 5 No. 12, pp. 1-8.
- Alabi, G. and Mohammed, I. (2018), “Research and PhD capacities in sub-Saharan Africa: Ghana report”.
- Aldieri, L., Guida, G., Kotsemir, M. and Vinci, C.P. (2019), “An investigation of impact of research collaboration on academic performance in Italy”, *Quality & Quantity*, Vol. 53 No. 4, pp. 2003-2040, doi: [10.1007/s11135-019-00853-1](https://doi.org/10.1007/s11135-019-00853-1).
- Ankrah, S. and Al-Tabbaa, O. (2015), “Universities–industry collaboration: a systematic review”, *Scandinavian Journal of Management*, Vol. 31 No. 3, pp. 387-408, doi: [10.1016/j.scaman.2015.02.003](https://doi.org/10.1016/j.scaman.2015.02.003).
- Atta-Owusu, K., Fitjar, R.D. and Rodríguez-Pose, A. (2021), “What drives university–industry collaboration? Research excellence or firm collaboration strategy?”, *Technological Forecasting and Social Change*, Vol. 173, p. 121084, doi: [10.1016/j.techfore.2021.121084](https://doi.org/10.1016/j.techfore.2021.121084).
- Balogun, J.A. (2023), “Thematic evaluation of Nigeria’s bibliometric research publications”, *Health Research in Nigeria: A Bibliometric Analysis*, Springer Nature Singapore, Singapore, pp. 57-96.
- Bastos, E.C., Sengik, A.R. and Tello-Gamarra, J. (2021), “Fifty years of university–industry collaboration: a global bibliometrics overview”, *Science and Public Policy*, Vol. 48 No. 2, pp. 177-199, doi: [10.1093/scipol/scaa077](https://doi.org/10.1093/scipol/scaa077).
- Belussi, F., Sammarra, A. and Sedita, S.R. (2010), “Learning at the boundaries in an ‘open regional innovation system’: a focus on firms’ innovation strategies in the Emilia Romagna life science industry”, *Research Policy*, Vol. 39 No. 6, pp. 710-721, doi: [10.1016/j.respol.2010.01.014](https://doi.org/10.1016/j.respol.2010.01.014).
- Bemke-Ś witalnik, M., Drabek, A., Kamińska, A.M. and Smoliński, A. (2020), “Research collaboration patterns in sustainable mining—a co-authorship analysis of publications”, *Sustainability*, Vol. 12 No. 11, p. 4756, doi: [10.3390/su12114756](https://doi.org/10.3390/su12114756).
- Bikard, M., Vakili, K. and Teodoridis, F. (2019), “When collaboration bridges institutions: the impact of university–industry collaboration on academic productivity”, *Organization Science*, Vol. 30 No. 2, pp. 426-445, doi: [10.1287/orsc.2018.1235](https://doi.org/10.1287/orsc.2018.1235).
- Binz-Scharf, M.C., Kalish, Y. and Paik, L. (2015), “Making science: new generations of collaborative knowledge production”, *American Behavioral Scientist*, Vol. 59 No. 5, pp. 531-547, doi: [10.1177%2F0002764214556805](https://doi.org/10.1177%2F0002764214556805).
- Blom, A., Lan, G. and Adil, M. (2016), *Sub-Saharan African Science, Technology, Engineering, and Mathematics Research: A Decade of Development, International Bank for Reconstruction and Development/The World Bank, Washington, DC*.
- Bloch, C., Ryan, T. and Andersen, J.P. (2019), “Public-private collaboration and scientific impact: an analysis based on Danish publication data for 1995-2013”, *Journal of Informetrics*, Vol. 13 No. 2, pp. 593-604.
- Bornmann, L. (2021), “Research excellence in Africa: a bibliometric study (version 1)”, Figshare, doi: [10.6084/m9.figshare.14179538.v1](https://doi.org/10.6084/m9.figshare.14179538.v1)
- Bruneel, J., d’Este, P. and Salter, A. (2010), “Investigating the factors that diminish the barriers to university–industry collaboration”, *Research Policy*, Vol. 39 No. 7, pp. 858-868, doi: [10.1016/j.respol.2010.03.006](https://doi.org/10.1016/j.respol.2010.03.006).
- Chang, Y.-W., Huang, M.-H. and Lin, C.-W. (2015), “Evolution of research subjects in library and information science based on keyword, bibliographic coupling, and co-citation analyses”, *Scientometrics*, Vol. 105 No. 3, pp. 2071-2087, doi: [10.1007/11192-015-1762-8](https://doi.org/10.1007/11192-015-1762-8).
- Chedid, M. and Teixeira, L. (2021b), “The university challenge in the collaboration relationship with the industry”, *Handbook of Research on Modern Educational Technologies, Applications, and Management*, IGI Global, pp. 449-465, doi: [10.4018/978-1-7998-3476-2.ch027](https://doi.org/10.4018/978-1-7998-3476-2.ch027).
- Chedid, M. and Teixeira, L. (2021a), “Knowledge management in University-Software industry collaboration”, *Handbook of Research on Modern Educational Technologies, Applications, and Management*, pp. 114-130, doi: [10.4018/978-1-7998-3476-2.ch028](https://doi.org/10.4018/978-1-7998-3476-2.ch028).
- Cheng, M., Yu, K.W., Hen, I., Hoi Piew Tan, L. and Fok, K.F. (2013), “Patterns of co-authorship and research collaboration in Malaysia”, *In Aslib Proceedings: New Information Perspectives*, doi: [10.1108/AP-12-2012-0094](https://doi.org/10.1108/AP-12-2012-0094).



- Chisita, C.T. and Chiparasha, B. (2019), “Open access initiatives in Zimbabwe: case of academic libraries”, *The Journal of Academic Librarianship*, Vol. 45 No. 5, doi: [10.1016/j.acalib.2019.102047](https://doi.org/10.1016/j.acalib.2019.102047).
- Confraria, H. and Vargas, F. (2019), “Scientific systems in Latin America: performance, networks, and collaborations with industry”, *The Journal of Technology Transfer*, Vol. 44 No. 3, pp. 874–915, doi: [10.1007/s10961-017-9631-7](https://doi.org/10.1007/s10961-017-9631-7).
- Confraria, H., Blanckenberg, J. and Swart, C. (2020), “Which factors influence international research collaboration in Africa?”, in Ramutsindela M., Mickler, D. (Eds), *Africa and the Sustainable Development Goals*. *Sustainable Development Goals Series*, Springer, Cham, pp. 243–255, doi: [10.1007/978-3-030-14857-7\\_23](https://doi.org/10.1007/978-3-030-14857-7_23).
- De Fuentes, C. and Dutrénit, G. (2012), “Best channels of academia–industry interaction for long-term benefit”, *Research Policy*, Vol. 41 No. 9, pp. 1666–1682, doi: [10.1016/j.respol.2012.03.026](https://doi.org/10.1016/j.respol.2012.03.026).
- Diodato, V. (1994), *Dictionary of Bibliometrics*, The Haworth Press, New York, NY.
- Doyeon, L. and Kim, K. (2021), “Research and development investment and collaboration framework for the hydrogen economy in South Korea”, *Sustainability*, Vol. 13 No. 19, p. 10686, doi: [10.3390/su131910686](https://doi.org/10.3390/su131910686).
- Du, S., Bstieler, L. and Yalcinkaya, G. (2022), “Sustainability-focused innovation in the business-to-business context: antecedents and managerial implications”, *Journal of Business Research*, Vol. 138, pp. 117–129, doi: [10.1016/j.jbusres.2021.09.006](https://doi.org/10.1016/j.jbusres.2021.09.006).
- Duermeijer, C., Amir, M. and Schoombee, L. (2018), “Africa generates less than 1% of the world’s research; data analytics can change that”, available at: [www.elsevier.com/connect/africa-generates-less-than-1-of-the-worlds-research-data-analytics-can-change-that](http://www.elsevier.com/connect/africa-generates-less-than-1-of-the-worlds-research-data-analytics-can-change-that)
- Ebel, S., Beitel, C., Runnebaum, J., Alden, R. and Johnson, T. (2018), “The power of participation: challenges and opportunities for facilitating trust in cooperative fisheries research in the Maine lobster fishery”, *Marine Policy*, Vol. 90, pp. 47–54.
- Fischer, B., Guerrero, M., Guimón, J. and Schaeffer, P.R. (2020), “Knowledge transfer for frugal innovation: where do entrepreneurial universities stand?”, *Journal of Knowledge Management*, Vol. 25 No. 2.
- Fonn, S., Peter Ayiro, L., Cotton, P., Habib, A., Mbithi, P.M. F., Mtenje, A., Nawangwe, B., et al. (2018), “Repositioning Africa in global knowledge production”, *The Lancet*, Vol. 392 No. 10153, pp. 1163–1166, doi: [10.1016/S0140-6736\(18\)31068-7](https://doi.org/10.1016/S0140-6736(18)31068-7).
- Fosci, M., Loffreda, L., Chamberlain, A. and Naidoo, N. (2019), “Assessing the needs of the research system in Ghana. Report for the SRIA programme”, *Report Commissioned by: The UK Department for International Development*, Vol. 25 No. 2, doi: [10.1108/JKM-01-2020-0040](https://doi.org/10.1108/JKM-01-2020-0040).
- Frimpong-Boateng, K. (2017), *National Science, Technology and Innovation Policy*, Ministry of Environment, Science and Technology (MEST), Government of Ghana, Accra.
- Galan-Muros, V. and Davey, T. (2019), “The UBC ecosystem: putting together a comprehensive framework for university–business cooperation”, *The Journal of Technology Transfer*, Vol. 44 No. 4, pp. 1311–1346, doi: [10.1007/s10961-017-9562-3](https://doi.org/10.1007/s10961-017-9562-3).
- Garcia, R., Araújo, V., Mascarini, S., Santos, E.G. and Costa, A. R. (2020), “How long-term university–industry collaboration shapes the academic productivity of research groups”, *Innovation*, Vol. 22 No. 1, pp. 56–70, doi: [10.1080/14479338.2019.1632711](https://doi.org/10.1080/14479338.2019.1632711).
- GTEC (2020), *Tertiary Education Statistics: annual Statistics Report 2018/2019*, Ghana Tertiary Education Commission, Accra, Ghana.
- Hausmann, R., Hidalgo, C.A., Bustos, S., Coscia, M., Chung, S., Jimenez, J., Simoes, A. and Yildirim, M.A. (2011), *The Atlas of Mapping Paths to Prosperity*, Puritan Press, Hollis, NH.
- He, V.F., von Krogh, G., Sirén, C. and Gersdorf, T. (2021), “Asymmetries between partners and the success of university–industry research collaborations”, *Research Policy*, Vol. 50 No. 10, doi: [10.1016/j.respol.2021.104356](https://doi.org/10.1016/j.respol.2021.104356).
- Hewitt-Dundas, N., Gkypali, A. and Roper, S. (2019), “Does learning from prior collaboration help firms to overcome the ‘two-worlds’ paradox in university–business collaboration?”, *Research Policy*, Vol. 48 No. 5, pp. 1310–1322, doi: [10.1016/j.respol.2019.01.016](https://doi.org/10.1016/j.respol.2019.01.016).
- KCCR (2022), available at: <https://kccr-ghana.org/> (accessed 21 February 2022).
- Kim, Y., Lim, H.J. and Lee, S.J. (2014), “Applying research collaboration as a new way of measuring research performance in Korean universities”, *Scientometrics*, Vol. 99 No. 1, pp. 97–115, doi: [10.1007/s11192-013-1095-4](https://doi.org/10.1007/s11192-013-1095-4).
- Lebeau, L.-M., Laframboise, M.-C., Larivière, V. and Gingras, Y. (2008), “The effect of university–industry collaboration on the scientific impact of publications: the Canadian case, 1980–2005”, *Research Evaluation*, Vol. 17 No. 3, pp. 227–232, doi: [10.3152/095820208X331685](https://doi.org/10.3152/095820208X331685).
- Li, Z. and Zhu, G. (2021), “Knowledge transfer performance of industry–university–research institute collaboration in China: the moderating effect of partner difference”, *Sustainability*, Vol. 13 No. 23, p. 13202, doi: [10.3390/su132313202](https://doi.org/10.3390/su132313202).
- Liao, C.H. (2011), “How to improve research quality? Examining the impacts of collaboration intensity and member diversity in collaboration networks”, *Scientometrics*, Vol. 86 No. 3, pp. 747–761, doi: [10.1007/s11192-010-0309-2](https://doi.org/10.1007/s11192-010-0309-2).
- Lundberg, J.G., Tomson, I., Lundkvist, J., Sk, R. and Brommels, M. (2006), “Collaboration uncovered: exploring the adequacy of measuring university–industry collaboration through co-authorship and funding”, *Scientometrics*, Vol. 69 No. 3, pp. 575–589, doi: [10.1007/s11192-006-0170-5](https://doi.org/10.1007/s11192-006-0170-5).
- Mafu, M. (2023), “Technology transfer as a catalyst for effective university–industry collaboration in Botswana”, *African Journal of Science, Technology, Innovation and Development*, Vol. 15 No. 5, pp. 1–18, doi: [10.1080/20421338.2023.2173403](https://doi.org/10.1080/20421338.2023.2173403).
- Mahdad, M., Minh, T.T., Bogers, M.L. and Piccaluga, A. (2020), “Joint university–industry laboratories through the lens of proximity dimensions: moving beyond geographical proximity”, *International Journal of Innovation Science*, Vol. 12 No. 4, doi: [10.1108/IJIS-10-2019-0096](https://doi.org/10.1108/IJIS-10-2019-0096).
- Maluleka, J.R. and Onyancha, O.B. (2016), “Research collaboration among library and information science schools in South Africa (1991–2012): an informetrics study”,

- Mousaion*, Vol. 34 No. 3, pp. 36–59, available at: <https://hdl.handle.net/10520/EJC-63951aff6>
- Mensah, A.M. and Gordon, C. (2020), “Strategic partnerships between universities and non-academic institutions for sustainability and innovation: insights from the university of Ghana”, *Sustainability Challenges in Sub-Saharan Africa I*, Springer, Singapore, pp. 245–278, doi: [10.1007/978-981-15-5358-5\\_10](https://doi.org/10.1007/978-981-15-5358-5_10).
- Muparadzi, A. and Caesar, L.D. (2021), “Examining the dynamics of industry–university collaborations in Ghana”, *Journal of Applied Research in Higher Education*, Vol. 13 No. 2, pp. 591–608, doi: [10.1108/JARHE-03-2020-0064](https://doi.org/10.1108/JARHE-03-2020-0064).
- Murashova, E. and Loginova, V. (2017), “University–industry interaction trends in the Baltic sea region: a bibliometric analysis”, *Baltic Journal of European Studies*, Vol. 7 No. 2, pp. 28–58, doi: [10.1515/bjes-2017-0009](https://doi.org/10.1515/bjes-2017-0009).
- Mwelwa, P., Joseph, U., Boulton, G., Wafula, J., Muliario, Y. and Loucoubar, C. (2020), “Developing open science in Africa: barriers, solutions and opportunities”, *Data Science Journal*, Vol. 19 No. 1, pp. 1–17, doi: [10.5334/dsj-2020-031](https://doi.org/10.5334/dsj-2020-031).
- O’Dwyer, M., Filieri, R. and O’Malley, L. (2022), “Establishing successful university–industry collaborations: barriers and enablers deconstructed”, *The Journal of Technology Transfer*, Vol. 48 No. 3, p. 32, doi: [10.1007/s10961-022-09932-2](https://doi.org/10.1007/s10961-022-09932-2).
- Onyancha, O.B. (2018), “Forty-five years of LIS research evolution, 1971–2015: an informetrics study of author-supplied keywords”, *Publishing Research Quarterly*, Vol. 34 No. 3, pp. 456–470, doi: [10.1007/12109-018-9590-3](https://doi.org/10.1007/12109-018-9590-3).
- Onyancha, O.B. (2020), “Informetrics research methods outlined”, in P Ngulube (Ed.) *Handbook of Research on Connecting Research Methods for Information Science Research*, IGI Global, pp. 320–348.
- Onyancha, O.B. (2021), “Regional and international research collaboration and citation impact in selected sub-Saharan African countries in the period 2000 to 2019”, *Global Knowledge, Memory and Communication*, Vol. 70 Nos 6/7, pp. 577–594, doi: [10.1108/GKMC-04-2020-0039](https://doi.org/10.1108/GKMC-04-2020-0039).
- Onyancha, O.B. and Majanja, M.K. (2017), “LIS education”, in Abdullahi I. (Ed.), *Global Library and Information Science: A Textbook for Students and Educators*, De Gruyter, Berlin, pp. 113–140.
- Onyancha, O.B. and Maluleka, J.R. (2011), “Knowledge production through collaborative research in sub-Saharan Africa: how much do countries contribute to each other’s knowledge output and citation impact?”, *Scientometrics*, Vol. 87 No. 2, pp. 315–336, doi: [10.1007/s11192-010-0330-5](https://doi.org/10.1007/s11192-010-0330-5).
- Onyancha, O.B. and Ocholla, N.D. (2007), “Country-wise collaborations in HIV/AIDS research in Kenya and South Africa, 1980–2005”, *Libri*, Vol. 57 No. 4, pp. 239–254, doi: [10.1515/LIBR.2007.239](https://doi.org/10.1515/LIBR.2007.239).
- Owusu-Agyeman, Y. and Fourie-Malherbe, M. (2019), “Workforce development and higher education in Ghana: a symmetrical relationship between industry and higher education institutions”, *Industry and Higher Education*, Vol. 33 No. 6, pp. 425–438, doi: [10.1177%2F0950422219875000](https://doi.org/10.1177%2F0950422219875000).
- Owusu-Nimo, F. and Boshoff, N. (2017), “Research collaboration in Ghana: patterns, motives and roles”, *Scientometrics*, Vol. 110 No. 3, pp. 1099–1121, doi: [10.1007/s11192-016-2221-x](https://doi.org/10.1007/s11192-016-2221-x).
- Paraskevopoulos, P., Boldrini, C., Passarella, A. and Conti, M. (2021), “The academic wanderer: structure of collaboration network and relation with research performance”, *Applied Network Science*, Vol. 6 No. 1, p. 35, doi: [10.1007/s41109-021-00369-4](https://doi.org/10.1007/s41109-021-00369-4).
- Qiu, J., Zhao, R., Yang, S. and Dong, K. (2017), *Informetrics: theory, Methods and Applications*, Springer, Cham, 2017, pp. 4–14.
- Ramos-Vielba, I. and Fernández-Esquinas, M. (2012), “Beneath the tip of the iceberg: exploring the multiple forms of university–industry linkages”, *Higher Education*, Vol. 64 No. 2, pp. 237–265, doi: [10.1007/s10734-011-9491-2](https://doi.org/10.1007/s10734-011-9491-2).
- Roncancio-Marin, J., Dentchev, N., Guerrero, M., Díaz-González, A. and Crispeels, T. (2022), “University–industry joint undertakings with high societal impact: a micro-processes approach”, *Technological Forecasting and Social Change*, Vol. 174, p. 121223, doi: [10.1016/j.techfore.2021.121223](https://doi.org/10.1016/j.techfore.2021.121223).
- Rossoni, A.L., de Vasconcellos, E.P.G. and de Castilho Rossoni, R.L. (2023), “Barriers and facilitators of university–industry collaboration for research, development and innovation: a systematic review”, *Management Review Quarterly*, doi: [10.1007/s11301-023-00349-1](https://doi.org/10.1007/s11301-023-00349-1).
- Rybnicek, R. and Königsgruber, R. (2019), “What makes industry–university collaboration succeed? A systematic review of the literature”, *Journal of Business Economics*, Vol. 89 No. 2, pp. 221–250, doi: [10.1007/s11573-018-0916-6](https://doi.org/10.1007/s11573-018-0916-6).
- Saad, M., Guermat, C. and Boutifour, Z. (2021), “The interaction between academia and industry and its impact on national innovation capacity: the case of Algeria”, *Industry and Higher Education*, Vol. 35 No. 5, pp. 570–580, doi: [10.1177%2F0950422220931418](https://doi.org/10.1177%2F0950422220931418).
- Schultz, C., Gretschek, O. and Kock, A. (2021), “The influence of shared R&D-project innovativeness perceptions on university–industry collaboration performance”, *The Journal of Technology Transfer*, Vol. 46 No. 4, pp. 1144–1172, doi: [10.1007/s10961-020-09818-1](https://doi.org/10.1007/s10961-020-09818-1).
- Siddique, N., Ur Rehman, S., Ahmad, S., Abbas, A. and Khan, M.A. (2023), “Library and information science research in the Arab world: a bibliometric analysis 1951–2021”, *Global Knowledge, Memory and Communication*, Vol. 72 Nos 1/2, pp. 138–159, doi: [10.1108/GKMC-06-2021-0103/full/pdf](https://doi.org/10.1108/GKMC-06-2021-0103/full/pdf).
- Sjöö, K. and Hellström, T. (2019), “University–industry collaboration: a literature review and synthesis”, *Industry and Higher Education*, Vol. 33 No. 4, pp. 275–285, doi: [10.1177%2F0950422219829697](https://doi.org/10.1177%2F0950422219829697).
- Skute, I., Zalewska-Kurek, K., Hatak, I. and de Weerd-Nederhof, P. (2019), “Mapping the field: a bibliometric analysis of the literature on university–industry collaborations”, *The Journal of Technology Transfer*, Vol. 44 No. 3, pp. 916–947, doi: [10.1007/s10961-017-9637-1](https://doi.org/10.1007/s10961-017-9637-1).
- Tagliacuzzi, G., Marchi, G., Gherardini, F. and Leali, F. (2021), “The multiple roles of universities in UI collaborations: the case of Emilia–Romagna motor vehicle industry”, *Journal of Engineering and Technology Management*, Vol. 62, p. 101645, doi: [10.1016/j.jengtecman.2021.101645](https://doi.org/10.1016/j.jengtecman.2021.101645).
- Tetteh, H.S. (2011), *Ghana Industrial Policy*, Government of Ghana, Accra.

- Tijssen, R.J.W., Leeuwen, V.T.N. and Wijk, V.E. (2009), “Benchmarking university–industry research cooperation worldwide: performance measurements and indicators based on co-authorship data for the world’s largest universities”, *Research Evaluation*, Vol. 18 No. 1, pp. 13–24, doi: [10.3152/095820209X393145](https://doi.org/10.3152/095820209X393145).
- Tseng, F.-C., Huang, M.-H. and Chen, D.-Z. (2020), “Factors of university–industry collaboration affecting university innovation performance”, *The Journal of Technology Transfer*, Vol. 45 No. 2, pp. 560–577, doi: [10.1007/s10961-018-9656-6](https://doi.org/10.1007/s10961-018-9656-6).
- Vernon, M.M., Balas, E.A. and Momani, S. (2018), “Are university rankings useful to improve research? A systematic review”, *PloS One*, Vol. 13 No. 3, doi: [10.1371/journal.pone.0193762](https://doi.org/10.1371/journal.pone.0193762).
- Wani, J.A., Ganaie, S.A. and Rehman, I.U. (2023), “Mapping research output on library and information science research domain in South Africa: a bibliometric visualisation”, *Information Discovery and Delivery*, Vol. 51 No. 2, doi: [10.1108/IDD-10-2021-0115](https://doi.org/10.1108/IDD-10-2021-0115).
- Xiuqian, Z.G., Yang, C., Chen, P., Hu Yuanjia, O. and Yitao, W. (2011), “R&D collaboration networks of Chinese

- universities in medical field: an empirical analysis based on informetrics”, 2011 IEEE International Symposium on IT in Medicine and Education, *IEEE*, doi: [10.1109/ITiME.2011.6132119](https://doi.org/10.1109/ITiME.2011.6132119)
- Zhang, B. and Wang, X. (2017), “Empirical study on influence of university–industry collaboration on research performance and moderating effect of social capital: evidence from engineering academics in China”, *Scientometrics*, Vol. 113 No. 1, pp. 257–277, doi: [10.1007/s11192-017-2464-1](https://doi.org/10.1007/s11192-017-2464-1).

### Further reading

- Hu, Z., Tian, W., Guo, J. and Wang, X. (2020), “Mapping research collaborations in different countries and regions: 1980–2019”, *Scientometrics*, Vol. 124 No. 1, pp. 729–745, doi: [10.1007/s11192-020-03484-8](https://doi.org/10.1007/s11192-020-03484-8).

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