

International Publication Trends and Collaboration Impact on the Scientific Research of Saudi Arabia

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ABSTRACT

International collaborations are assumed to have a positive effect on scientific research advancement, which ultimately affects the economic growth of developing countries. To examine this effect, international collaborations in Saudi Arabia during the last two decades are investigated. Bibliometric and statistical analyses were applied to identify the characteristics of research collaboration using data extracted from Microsoft Academic Graph (MAG) between 2001 and 2020. After removing records with incomplete information, 158,860 publications were considered in the statistical analysis. The study showed that 64.74% of Saudi Arabia's scientific output involved international collaborations. Among the different collaboration countries, the United States and Egypt accounted for the highest numbers of collaborations. Over time, the ratio of international collaborations to domestic collaborations continued to increase, indicating the general interest of researchers in Saudi Arabia in international collaborations. The average growth rate of Saudi Arabia's scientific publications was 17.16% annually, and this growth was attributed more to international collaborations than domestic collaborations. Notably, co-authored publications with international first authors achieve a higher rate of citations than publications with domestic first authors. The analyzed dataset revealed that most scientific publications from Saudi Arabia were owed to international collaborations which have had a constructive effect on the quality of research and perceptibility of Saudi Arabia in the scientific community.

Keywords: Bibliometrics, Citation rate, Co-authorship, Collaboration Coefficient, Growth Rate.

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INTRODUCTION

The economic growth of countries in the 21st century depends on their advancement in technology and their contribution to science.^[1] The advancement in scientific research and technological innovation are considered as enablers for developing countries to attain a higher level of economic growth that is equivalent to that of developed countries. Although most scientific and technological advances occur over long periods and develop at a slow rate which might be imperceptible to the public, the accumulative results of these advances have visible effects on the country's economy. The economic growth of South Korea, which has been achieved in a relatively short time compared to that of Western countries, is mainly attributed to its advancement in science and technology. In Australia, the advances in science was estimated to account for 20% to 30% of the nation's overall economic growth, including activities such as employment, and exports.^[2]

Scientific research activity is regarded as the catalyst of evolution and progression in developing countries. The quality of goods and services provided by countries to the public depends on technological innovations, which are mainly driven by scientific research and the new information and knowledge produced by the scientific community. A major constructive effect on the economic complexity of countries had been observed with the scientific output of fundamental sciences and engineering.^[3] In addition, the diversity of the research output from scientific areas such as material science, medicine, chemistry, technology, and computer science constructively and substantially influences economic growth.^[4]

Recently, international collaborations in scientific research have gained much attention from many countries around the world. Co-authorship with international colleagues produces a positive impact on individual productivity.^[5] The increasing interest in university rankings and the research indicators involved in these rankings are two of the main reasons for the general trend of collaboration around the world.^[6] A study has shown that the percentage of internationally co-authored publications between 1986 and 1999 doubled.^[7] This percentage has increased in some countries to around 50%.^[8] Research collaboration is becoming the standard in

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the current research community of developing countries. Due to their lack of experience and availability of supporting infrastructure, developing countries resolve to collaborate with other countries that have more mature scientific research experience as a standard and effective way to strengthen their technical capabilities and to share resources.^[9] For instance, three-quarters of the growth in the scientific output of Vietnam between 2001 and 2015 was associated with international collaborations instead of depending solely on domestic collaborations.^[10] In China, international collaborations accounted for almost 50% of all published papers in healthcare science between 2001 and 2010.^[11] In the clinical medicine research of Malaysia, articles with international collaborations were published in higher impact factor journals and cited more frequently than articles without international collaborations, indicating that internationally co-authored papers are more valued.^[12]

Over the past twenty years, the number of peer-reviewed publications has increased as a result of scientific research activities.^[10,13] Publishing in peer-reviewed journals is one of the signs of the quality of scientific research. Peer-reviewed scientific publications have a positive and strong effect on the economic advancement of countries, which is mainly driven by knowledge.^[14] However, investigating the effect and magnitude of international collaborations on the scientific activities of a country and determining how the rate of collaboration has changed over time is an interesting topic that should be studied within the context of each country.

The government of Saudi Arabia has recognized the value of advancement in education and science in accomplishing a bright future for Saudi Arabia. Since its establishment in 1932, along with its growing economy, Saudi Arabia has continued to increase the assigned budget for science and technology (S&T). As a developing country, Saudi Arabia, which has a historic practice of higher education and science, offers an attractive case study that demonstrates the benefit of international scientific collaborations.

This study aims to conduct a comprehensive exploration of the scientific activities in Saudi Arabia using bibliometric and statistical analysis. The objectives are as follows: (1) to identify the characteristics of Saudi Arabia scientific output; (2) to quantify domestic and international collaborations in Saudi Arabia; (3) to find out whether international collaborations have driven the growth in scientific activities during the past two decades; and (4) to determine if international research collaboration helps in producing higher quality and more impactful research compared with that of domestic collaborations.

DATA AND METHODOLOGY

Data Source and collection

The dataset of publications used in this study was obtained from the Microsoft Academic Graph (MAG) database, which is “a heterogeneous graph containing scientific publication records, citation relationships between publications, authors, institutions, journals, conferences, and fields of study”.^[15] MAG is used by government agencies as a tool for in-depth analyses of scientific and technological trends, and the development of statistical indicators on science, technology, and innovation (STI). It has been selected because of its large coverage scope which encompasses more than 244,000,000 publications, covering all fields of scientific research.^[16]

To retrieve the related set of publications, all publications in MAG, which contain Saudi Arabia as one of the affiliated countries during 2001 and 2020, were downloaded. Only the publications written in the English language were included. The involved publication types are conferences, books, journals, and patents. The extracted dataset contained a list of variables which included authors, affiliations, research area, and the number of citations. In publications, institutional affiliations are listed for each author. Affiliation countries for each author in each of the publications were extracted. According to the authors and extracted countries of affiliation, the articles were classified into one of the following two main categories: (a) single-author publications, for publications with only a single author; and (b) multiple-author publications for those with more than one author. Furthermore, the multiple-authored publications were classified into domestic or international collaborations.

The collected publications were classified according to their research areas into 19 broad groups: material science, medicine, chemistry, computer science, biology, mathematics, engineering, physics, environmental science, geology, psychology, business, geography, economics, sociology, political science, history, art, and philosophy.

Analysis Methods

To analyze the collected publication dataset, mostly descriptive statistical analysis was used. All analyses were conducted using Python 3.7 and Excel Workspace on the Windows platform. For studying the publication trend in the dataset over time, the study period was divided into four 5-year subperiods: 2001–2005, 2006–2010, 2011–2015, and 2016–2020. The rate of growth was estimated by the Compound Annual Growth Rate (CAGR).^[17] Given that n is the number of years in the dataset, X is number of publications in the ending year, and Y is number of publications in the beginning year, CAGR can be calculated as:

$$CAGR = \left(\frac{X}{Y}\right)^{\frac{1}{n-1}} - 1$$

In addition, the ratio of collaborative papers for each scientific research area was quantified using the collaboration coefficient (CC), where R_j is the number of publications that have j authors in the research area, MAX is the greatest number of authors in the research area, and P is the total number of publications in the research area.^[18] It can be defined as:

$$CC = 1 - \frac{\sum_{j=1}^{MAX} \left(\frac{1}{j}\right) R_j}{P}$$

The CC value is a ratio between 0 and 1, where 0 means no collaboration, and single-author publications dominated the publication records of this research area, and 1 means that all the publications in this research area were collaborative.

To quantify the domestic and international collaboration in Saudi Arabia, multiple author publications were categorized into two main categories based on the collaboration type. The categories are domestic collaboration (DOM), which includes publications that had multiple authors where the affiliation countries of all authors were Saudi Arabia, and international collaboration (IC) for publications that had multiple authors where at least one of them had an overseas affiliation.

To evaluate the quality of publications, citation analysis was used. In this analysis, the IC category was further classified based on the first authors into two sub-categories: IC.SA for internationally co-authored publications with Saudi Arabia being the affiliation country of the first author; and IC. IA for internationally co-authored publications with an international (overseas) first author. In addition, a set of boxplots was created to show the distribution of citations for the publication type for each study area.

To visualize the collaborative relationships between Saudi Arabia and other countries, a global map was generated to show the research collaborations of Saudi Arabia with the countries around the world. In addition, a graph analysis method was used to build a visual star-like graph of nodes and links. The countries are represented in this Figure as nodes, while the links represent the collaborations. Saudi Arabia forms the center of the graph where other collaboration countries are connected to the center. The weight of the connection between Saudi Arabia and any other country was defined as the total number of collaborated publications between these countries.

RESULTS

Publication Trends

From 2001 to 2020, Saudi Arabia published 181,130 publications in MAG. However, 22,270 publications were excluded because they had incomplete information. The remaining 158,860 publications were used in the analysis conducted in this study. The first analysis done is classifying the publications into the broad research area, which is shown in Figure 1. This analysis showed that almost 65% of the publications were focused on just 4 main areas: material science (18.17%), medicine (16.93%), chemistry (16.70%), and computer science (13.10%). Each of the remaining research areas accounted for less than 10% of the total scientific output for Saudi Arabia, especially sociology, political science, history, art, and philosophy which accounted for less than 0.5% of the total publications.

In 2020, Saudi Arabia published 21,449 publications compared to only 904 publications produced in 2001. During this period, two phases of growth can be observed. The first phase is between 2001 and 2010, with an annual growth rate of about 16.25% per annum. The second phase is between 2011 and 2020, in which the rate of growth was 13.47%. Table 1 presents the number of publications for each of the research areas based on the four 5-year subperiods and the growth rate between 2011 and 2020. Generally, the number of publications has grown for all the research areas, with a rate of growth of 17.16% per annum between 2001 and 2020. Among the different research areas, political science, sociology, psychology, material science, and computer science showed the highest growth of more than 20% per year, whereas engineering showed the lowest growth of 0.8% per year.

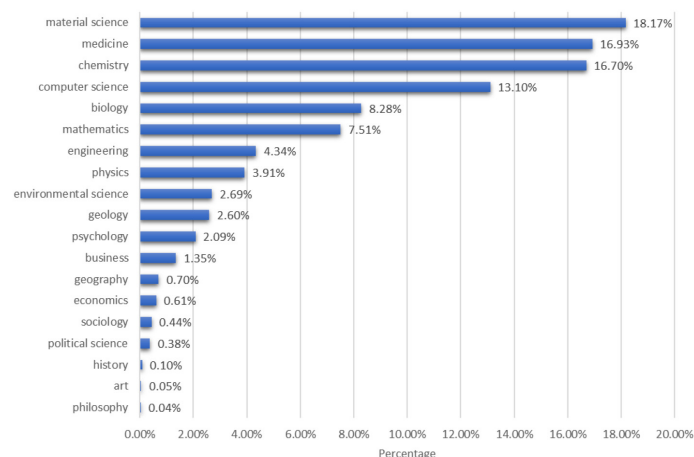


Figure 1: Broad scientific research areas of Saudi Arabia between 2001 and 2020 and their percentages.

Table 1: Distribution of the number of original articles from Saudi Arabia published in Microsoft Academic Graph (MAG) between 2001 and 2020 based on the four 5-year subperiods and the growth rate.

| Broad research areas | 2001-2005 | 2006-2010 | 2011-2015 | 2016-2020 | Growth rate (%/year) |
|-----------------------|-----------|-----------|-----------|-----------|----------------------|
| Material science | 544 | 1405 | 8668 | 18255 | 23.18% |
| Medicine | 1092 | 2291 | 8227 | 15282 | 15.63% |
| Chemistry | 828 | 1583 | 8970 | 15142 | 17.23% |
| Computer science | 441 | 1508 | 6235 | 12630 | 21.61% |
| Biology | 252 | 809 | 5118 | 6981 | 17.83% |
| Mathematics | 584 | 1237 | 4672 | 5434 | 13.21% |
| Engineering | 481 | 1035 | 3383 | 2003 | 0.80% |
| Physics | 231 | 367 | 2083 | 3536 | 15.82% |
| Environmental Science | 138 | 228 | 1061 | 2851 | 18.378% |
| Geology | 270 | 391 | 1292 | 2172 | 10.14% |
| Psychology | 50 | 137 | 888 | 2246 | 23.92% |
| Business | 88 | 189 | 599 | 1275 | 17.99% |
| Geography | 25 | 71 | 359 | 651 | 19.83% |
| Economics | 57 | 126 | 335 | 449 | 9.50% |
| Sociology | 13 | 29 | 254 | 406 | 24.57% |
| Political science | 14 | 39 | 169 | 379 | 25.70% |
| History | 7 | 6 | 33 | 105 | 13.90% |
| Art | 3 | 7 | 35 | 40 | 10.96% |
| Philosophy | 2 | 4 | 26 | 34 | 10.22% |
| All areas | 5120 | 11,462 | 52,407 | 89,871 | 17.16% |

Table 2: Collaboration coefficient of Saudi Arabia broad research areas between 2001 and 2020.

| Broad research areas | 2001-2005 | 2006-2010 | 2011-2015 | 2016-2020 |
|-----------------------|-----------|-----------|-----------|-----------|
| Material science | 0.44 | 0.53 | 0.67 | 0.71 |
| Medicine | 0.29 | 0.40 | 0.58 | 0.66 |
| Chemistry | 0.50 | 0.57 | 0.70 | 0.73 |
| Computer science | 0.38 | 0.48 | 0.58 | 0.65 |
| Biology | 0.32 | 0.41 | 0.56 | 0.62 |
| Mathematics | 0.32 | 0.41 | 0.56 | 0.62 |
| Engineering | 0.36 | 0.45 | 0.53 | 0.60 |
| Physics | 0.41 | 0.50 | 0.66 | 0.68 |
| Environmental science | 0.46 | 0.52 | 0.62 | 0.66 |
| Geology | 0.51 | 0.55 | 0.60 | 0.64 |
| Psychology | 0.35 | 0.41 | 0.44 | 0.49 |
| Business | 0.35 | 0.32 | 0.44 | 0.49 |
| Geography | 0.28 | 0.42 | 0.51 | 0.63 |
| Economics | 0.39 | 0.31 | 0.44 | 0.50 |
| Sociology | 0.18 | 0.20 | 0.22 | 0.30 |
| Political science | 0.15 | 0.29 | 0.34 | 0.42 |
| History | 0.18 | 0.24 | 0.16 | 0.29 |
| Art | 0.25 | 0.30 | 0.25 | 0.27 |
| Philosophy | 0.33 | 0.20 | 0.19 | 0.16 |
| All areas | 0.34 | 0.40 | 0.48 | 0.53 |

Research collaborations

Most of the analyzed publications had multiple authors. Table 2 shows the collaboration coefficients (CCs), which are computed based on the number of authors for each of the defined research areas over the four 5-year subperiods. The CCs value showed a continuous increase through the study periods for nearly all broad research areas, especially for the last two periods, with the highest increase being observed in chemistry and material science. However, a decrease in collaborations can be observed in the research area of philosophy through the whole study periods.

Based on the categorization of publications according to the co-authorship status, Table 3 shows the percentages of single-authored scientific publications, in addition to domestic and international collaborative scientific publications for all the research areas. Overall, single-authored publications accounted for approximately 12.69% of the total publications between 2001 and 2020. Nevertheless, the percentages of publications with a single author varied among the different areas of research, with philosophy, art, and history publications having the highest percentages of 74.24%, 62.35%, and 60.93%, respectively.

Domestic publications contributed to approximately 22.57% of the publications with engineering and environmental science publications having the highest percentages of 36.48% and 34.76%, respectively. In addition, international collaboration publications, which had at least one international affiliation, reported the highest percentage of 64.74% among the other collaboration type categories. Biology had the highest percentage of international collaboration, with about 80.83% of publications, followed by physics (77.37%) and chemistry (74.27%). All research areas had an international collaboration rate of around 25% or more except for philosophy.

Furthermore, the identified collaborative publications were categorized into three categories based on the first authorship and the conditions as defined in the 'Data Collection and Analysis Methods' Section. The categories and their percentages are as follows. The domestic authors' category (DOM) for publications with all domestic authors accounted for 22.57% of the total collaborative publications. The second category for internationally collaborated publications with domestic first authors (IC.SA) formed about 20.84% of the total collaborative publications. The third category of internationally collaborated publications with overseas first authors (IC.IA) comprised about 43.91% of the total collaborated publications.

Table 3: Saudi Arabia's scientific publications are categorized by research area and collaboration type.

| Broad research areas | Total number of publications | Publications with a single author (%) | Domestic collaborative publications (%) | International collaborative publications (%) |
|-----------------------|------------------------------|---------------------------------------|---|--|
| Material science | 28872 | 7.32% | 22.70% | 69.98% |
| Medicine | 26892 | 18.84% | 28.38% | 52.78% |
| Chemistry | 26523 | 6.35% | 19.38% | 74.27% |
| Computer science | 20814 | 11.74% | 27.27% | 60.99% |
| Biology | 13160 | 5.93% | 13.24% | 80.83% |
| Mathematics | 11927 | 15.82% | 15.13% | 69.05% |
| Engineering | 6902 | 21.01% | 36.48% | 42.51% |
| Physics | 6217 | 9.44% | 13.19% | 77.37% |
| Environmental Science | 4278 | 11.31% | 26.09% | 62.60% |
| Geology | 4125 | 13.28% | 34.76% | 51.95% |
| Psychology | 3321 | 31.74% | 16.65% | 51.61% |
| Business | 2151 | 31.29% | 17.11% | 51.60% |
| Geography | 1106 | 20.98% | 17.72% | 61.30% |
| Economics | 967 | 30.61% | 10.65% | 58.74% |
| Sociology | 702 | 58.26% | 10.97% | 30.77% |
| Political science | 601 | 42.10% | 12.81% | 45.09% |
| History | 151 | 60.93% | 14.57% | 24.50% |
| Art | 85 | 62.35% | 11.76% | 25.88% |
| Philosophy | 66 | 74.24% | 9.09% | 16.67% |
| All areas | 158,860 | 12.69% | 22.57% | 64.74% |

Singled authored publications had only Saudi Arabia affiliation.

Between the two periods of 2001 to 2005 and 2016 to 2020, the total number of publications increased from 5120 to 89,871. During this period, there was an increase in the proportion of international collaborative publications, where such publications aided in approximately 71% of this increase. Table 4 shows the number of international publications in the four 5-year periods. As seen from 2001 to 2005, almost 26% of the whole Saudi Arabian scientific output had an international co-author(s). This percentage increased to 41% from 2006 to 2010, 64% from 2011 to 2015, and 71% from 2016 to 2020. However, a reduction of 100% in international publications was observed in history for the period from 2006 to 2010, as well as a reduction of 24.8% in engineering, and 33.3% in philosophy for the period from 2016 to 2020.

At the same time, the percentage of the international publications in some study areas remained very low on the four 5-year periods. This was clearly observed in sociology, political science, history, art, and philosophy, where their international publications did not exceed 0.5% of the total number of the international publications in the whole study periods.

Table 4: Distribution of the number of international collaborative publications from Saudi Arabia published in Microsoft Academic Graph (MAG) between 2001 and 2020 based on the four 5-year subperiods.

| Broad research areas | 2001-2005 | 2006-2010 | 2011-2015 | 2016-2020 |
|-----------------------|-----------|-----------|-----------|-----------|
| Material Science | 150 | 588 | 5770 | 13697 |
| Medicine | 137 | 581 | 4214 | 9261 |
| Chemistry | 216 | 763 | 6701 | 12019 |
| Computer Science | 111 | 561 | 3439 | 8584 |
| Biology | 113 | 544 | 4149 | 5831 |
| Mathematics | 184 | 590 | 3316 | 4145 |
| Engineering | 84 | 319 | 1445 | 1086 |
| Physics | 90 | 199 | 1609 | 2912 |
| Environmental Science | 30 | 82 | 648 | 1918 |
| Geology | 87 | 186 | 698 | 1172 |
| Psychology | 16 | 72 | 453 | 1173 |
| Business | 38 | 59 | 291 | 722 |
| Geography | 5 | 26 | 192 | 455 |
| Economics | 32 | 46 | 198 | 292 |
| Sociology | 3 | 7 | 70 | 136 |
| Political Science | 3 | 12 | 71 | 185 |
| History | 1 | 0 | 6 | 30 |
| Art | 1 | 2 | 7 | 12 |
| Philosophy | 0 | 1 | 6 | 4 |
| All areas | 1301 | 4638 | 33,283 | 63,634 |

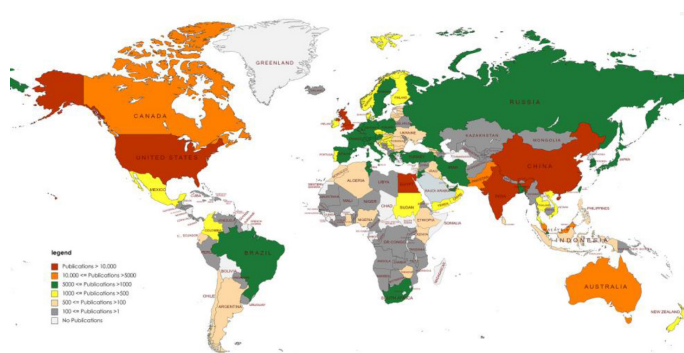


Figure 2: Geographical distribution of publications of Saudi Arabia.

Collaboration Countries

In total, Saudi Arabia collaborated with 163 countries worldwide, as shown on the map presented in Figure 2. As seen in the Figure, Saudi Arabia collaborated with about 84% of the countries around the world. Table 5 shows the top 20 collaborative countries with Saudi Arabia. Of the top 20 countries, 10 are considered developed or scientifically advanced countries. The percent of the total in this Table is

Table 6: Average citation for publications that had been published from 2011 to 2015 classified by research area and collaboration status.

| Broad research areas | Domestic collaborative publications (DOM) | International collaborative publications (IC) | Relative citation index |
|-----------------------|---|---|-------------------------|
| Material Science | 23.45 | 67.29 | 2.87 |
| Medicine | 26.51 | 54.6 | 2.06 |
| Chemistry | 17.71 | 71.89 | 4.06 |
| Computer Science | 28.87 | 53.73 | 1.86 |
| Biology | 12.09 | 81.4 | 6.73 |
| Mathematics | 13.23 | 72.46 | 5.48 |
| Engineering | 37.43 | 45.08 | 1.2 |
| Physics | 11.8 | 71.77 | 6.08 |
| Environmental Science | 21.88 | 64.99 | 2.97 |
| Geology | 28.56 | 56.48 | 1.98 |
| Psychology | 14.78 | 69.91 | 4.73 |
| Business | 19.27 | 53.66 | 2.78 |
| Geography | 20.54 | 60.47 | 2.94 |
| Economics | 8.81 | 73.57 | 8.35 |
| Sociology | 12.9 | 51.61 | 4 |
| Political science | 13.54 | 45.83 | 3.38 |
| History | 11.11 | 33.33 | 3 |
| Art | 33.33 | 50 | 1.5 |
| Philosophy | 0 | 42.86 | NA |

DISCUSSION

The value of scientific collaboration is acknowledged by the contemporary research community in both developing and developed countries. Developing countries utilize scientific collaborations with developed countries as a successful approach to develop their own research capability and to enhance their economies. Investigating the progress of scientific collaborations over time could provide useful insights into the advancement and economic status of developing countries. Considering the current country of study, it has been found that a large percentage of the scientific output of Saudi Arabia during the last 20 years has resulted from international collaborations. As Saudi Arabia's international collaborations with developed or developing countries have increased, the percentage of domestic collaborations has decreased marginally, indicating that the research experience of Saudi Arabia has advanced over time.

Regarding the nature and motives of international collaborations, it has been observed that collaboration with international countries was more frequently utilized in experimental research fields such as medicine, life sciences, and earth science as a method for resource sharing. More specifically, research in life and earth sciences involves large investments, expensive devices, and equipment required for conducting experiments, which may be the main reasons for the high percentage of publications with international collaborations. Additionally, in the clinical medicine research field, international collaborations might be attributed to the vital need for professional skills, the availability of data sources, and the ease of data collection.

Based on the results of the current study, four main findings could be highlighted. However, these findings should be inferred within the context of this study, including its strengths and limitations. The chief strength of this study is its inclusion of the different types of publications; this enables the obtaining of the full material regarding the characteristics of research collaboration in Saudi Arabia. According to Wang, the selection of 20 years as the study time window is considered sufficient for a reliable analysis of the publications' growth rate and identifying the citation patterns.^[19] However, a biased analysis of the citation could result from the variation of the citation patterns based on the different scientific areas considered in this study.

The first point is related to the stage of growth of the Saudi Arabian scientific research capability. Currently, most of the scientific output from Saudi Arabia (87%) is produced by either domestic or international collaborations, demonstrating that collaborations play a crucial role in the scientific research and knowledge establishment in Saudi Arabia. Moreover, the publications of Saudi Arabia are characterized by the high

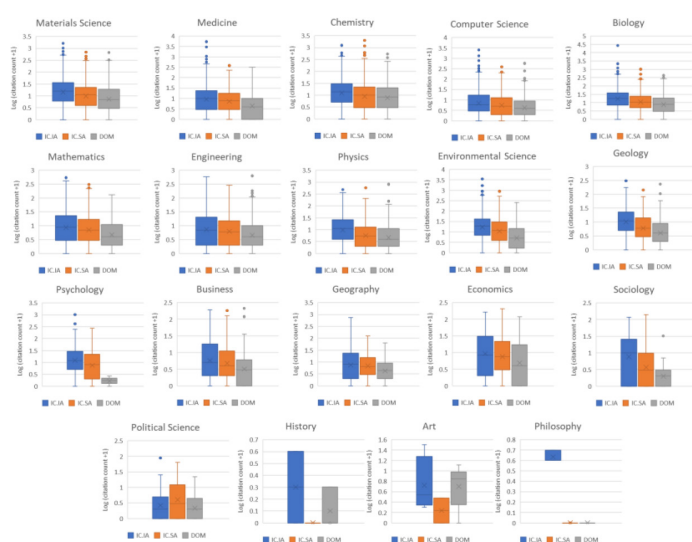


Figure 4: Distribution of citations classified by broad research areas and first authors' affiliation. "Dom" domestic co-authored publications; IC,SA internationally co-authored publications with Saudi Arabia based first author's affiliation; IC,IA internationally co-authored publications with overseas first author's affiliation.

and growing percentage of international collaborations. The collaboration coefficient has increased over the years, showing the general trend of the increment in international collaborations, with a sacrifice of the decrement in domestic collaboration. While 64.74% of Saudi Arabia's total scientific publications are produced by international collaboration, only 22.57% of this total is produced by domestic collaboration. This indicates that, like many developing countries which depend on other developed or developing countries to build their research capabilities, Saudi Arabia is still at an early stage of research capacity building. In contrast, other developed countries such as China, Taiwan, South Korea, Turkey which had a lower rate of international collaboration,^[20,21] a substantial proportion (71%) of the growth in Saudi Arabia's scientific output throughout the past 20 years resulted from collaboration with other countries.

Second, Saudi Arabia has mostly collaborated with the United States, where between 2001–2005 and 2016–2020, the number of co-authored publications with authors from the US has largely increased. Increased collaboration with the United States implies the maturing scientific experience of Saudi Arabia and the cooperation of both countries in addressing the common areas of concern. In addition, Saudi Arabia has also collaborated with other scientifically advanced and developed countries such as China and the United Kingdom.

Third, the results provide enough evidence to show that Saudi Arabia has profited from international collaborations with other countries in research projects. As anticipated, publications resulting from international collaborations accumulated more citations than domestic collaborative publications. This observation is consistent with findings from previous studies which suggest that international collaborative publications are more visible to the research community than domestic collaborative publications.^[22]

Fourth, more significantly, an interesting finding from the results is that the affiliation country of first authors of international collaborative publications has a considerable effect on the number of citations received. Internationally collaborative publications with overseas first authors acquired more citations than those with domestic first authors. This finding is consistent with the result of a previous study that reported that higher levels of international collaboration have a positive and considerable impact on citations.^[23]

CONCLUSION

This study has shown that during the last 20 years from 2001 to 2020, Saudi Arabia's scientific publications have grown yearly with an average of 17.16% per year. The growth

was mainly attributed to international collaborations, which accounted for about 71% of the growth. The United States and Egypt are the most collaborative countries with Saudi Arabia, as they are the main partners with Saudi Arabia in many scientific research projects. The results analysis in this study provides evidence that international collaborations aided in enhancing the visibility and the research impact of Saudi Arabia's scientific output, which led to augment the country's research capabilities.

Even though international collaboration has increased in most of the research areas, some areas still need to increase their international collaborative works. This can come through looking for opportunities for international collaborations by the researchers. In addition to the government role in encouraging and supporting the researchers in terms of providing funds, incentives and opportunities can be further raised for domestic researchers to have more and easier contact with foreign researchers by supporting international mobility of domestic researchers, hosting international researchers in all research areas especially the research areas that need to enhance their international collaborations such as sociology, political science, history, art, and philosophy.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

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