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Saudi Arabia's Leap in Research and Development Excellence

Leading Research and Development
Transformation in the Kingdom's National
Priorities

1445-2023

A portrait of a man with a beard and mustache, wearing a traditional Saudi headdress (ghutra and agal) with a red and white checkered pattern. He is looking slightly to the right of the camera. The background is dark, and the image is set against a light blue gradient.

“Our ambition for Saudi Arabia is to become a global leader in research, development and innovation with an annual investment equivalent to 2.5% of GDP in 2040. This will diversify and add 60 Billion Saudi Riyals (\$16 billion) to the economy in 2040 while creating high value jobs in science and technology”



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Executive Summary

The report provides a comprehensive overview of the substantial progress achieved by Saudi Arabia in research, development, and innovation (RDI), highlighting the remarkable, positive advancements, aligned with its ambitious Vision 2030. It portrays the Kingdom's journey towards becoming a global RDI hub, focusing on the four national priority areas: Health and Wellness, Sustainable Environment, Energy and Industrial Leadership, and Economies of the Future. The report shows the Kingdom has made its largest historical contribution in the field of scientific publishing with a 146% increase in publications, reaching a total of 59,016 in 2022 compared to 2018. It showcases the impressive growth in research output, with an 18% annual increase in the number of active researchers, and the substantial annual growth rate of 25% in research publication across all subjects from 2018 to 2022. The report highlights the Kingdom's impactful research that is 71% more frequently cited compared to similar publications worldwide, exceeding global and regional averages and showcasing the Kingdom's commitment to sustainable development and technological innovation while emphasizing its role in shaping a better future and contributing significantly to the world's RDI landscape.

**146%**

increase in scientific
publications

**59,016**

total publications
in 2022

**18%**

increase in the number
of active researchers

**25%**

annual growth rate in
research publication
across all subjects from
2018 to 2022.

**71%**

of research is more
frequently cited compared
to similar publications
worldwide

**51%**

of research papers
are published in high-
quality journals Q1

Introduction and Background

In alignment with its transformative Vision 2030, the Kingdom of Saudi Arabia has placed a significant emphasis on research, development, and innovation (RDI). Launched in 2016, Vision 2030 encompasses the Saudi government's strategic framework for the future, focusing on a vibrant society, a thriving economy, and an ambitious nation. Under the guidance of His Royal Highness Prince Mohammed bin Salman bin Abdulaziz Al Saud, Crown Prince, Vision 2030 sets numerous goals and reform strategies to ensure the long-term economic success of the Kingdom.

Recognizing the vital role of research, development, and innovation as a catalyst for economic growth in leading nations, the Kingdom has actively prioritized RDI within Vision 2030. To spearhead these efforts, the Supreme Committee for Research, Development, and Innovation (RDI) was established in March 2021 and is chaired by His Royal Highness Prince Mohammed bin Salman bin Abdulaziz Al Saud, Crown Prince. This committee is responsible for devising a comprehensive roadmap for RDI in the Kingdom.

To foster growth and prosperity, the governance of research, development, and innovation in the Kingdom has undergone restructuring. The Crown Prince heads a supreme committee dedicated to overseeing RDI initiatives, while the establishment of the RDI Authority (RDIA) in June 2021 serves as an enabler, legislator, and regulator, with the responsibility of developing moonshots, flagship programs, projects, budget distribution, and performance monitoring.

In June 2022, the Supreme Committee for RDI announced the National Aspirations and Priorities for the next two decades. The aspirations and priorities encompass Health and Wellness, Sustainable Environment and Supply of Essential Needs, Energy

and Industrial Leadership, and Economies of the Future. These pursuits aim to enhance the Kingdom's global competitiveness and leadership in accordance with Saudi Vision 2030, reinforcing its position as the region's largest economy. Emphasizing the National Aspirations and Priorities, the Crown Prince expressed his determination for Saudi Arabia to become a global leader in research, development, and innovation. He further stated that by 2040, the Kingdom aims to invest an annual equivalent of 2.5% of GDP, diversify the economy by investing an additional 60 billion Saudi Riyals (\$16 billion), and generate high-value jobs in science and technology.

NATIONAL ASPIRATIONS AND PRIORITIES

In line with Vision 2030, the Kingdom of Saudi Arabia has identified four national priority areas to focus on in research, development, and innovation (RDI) activities. As mentioned before, these priority areas are Health and Wellness, Sustainable Environment and Affordable Supply of Essential Needs, Energy and Industrial Leadership, and Economies of the Future. These priorities are crucial for tackling the most critical challenges of our time and ensuring a sustainable future for the generations to come. They will serve as a guiding compass for future RDI projects and initiatives.

HEALTH and WELLNESS stands as the foremost national priority, given the Kingdom's advanced infrastructure for medical research, its leading medical system in the region, and its expanded genetic database, among other competitive advantages. Through this priority, the Kingdom aims to enhance people's health and well-being by addressing prevailing medical challenges, ensuring health equity through digital healthcare, and providing biotech solutions to the world.

The priority of SUSTAINABLE ENVIRONMENT and AFFORDABLE SUPPLY OF ESSENTIAL NEEDS seeks to establish the Kingdom as a global model for preserving the planet and meeting the basic needs of water, food, and sustainable energy. The development of environmentally friendly water provision and desalination technologies, modern and sustainable food production methods, increased green spaces, carbon capture and storage technologies, and low-cost electricity generation through sustainable means are key focuses of this priority.

ENERGY and INDUSTRIAL LEADERSHIP is another crucial priority, given the Kingdom's natural wealth and competitive advantages in energy and the industrial sectors. The Kingdom aims to develop technologies for alternative energy production, such as green hydrogen, solar, and wind power. Additionally, it seeks to advance technologically sophisticated and high-value industries, promote sustainable and competitive development of the mining sector, and secure a leadership position in the global energy and industrial landscape.

ECONOMIES OF THE FUTURE has also been identified as a priority area, leveraging the Kingdom's competitive advantages and leadership position. Through investments in futuristic cities like NEOM and the Red Sea Project, and with the capabilities of a talented pool of young Saudi innovators and a world-class digital infrastructure, this priority aims to foster innovation in digital technologies, shape the future of urban living, build human-friendly and carbon-free cognitive cities, explore the depths of the sea, and establish a global presence in the field of space exploration.

These national priorities underscore the Kingdom's commitment to sustainable development, technological advancement, and addressing global challenges. Through strategic focus and continuous investment in RDI, the Kingdom of Saudi Arabia aims to create a better future for its citizens and contribute to the well-being of humanity as a whole.

THE ROLE OF THE RDIA

The RDIA plays a pivotal role in addressing the challenges of today's complex landscape. In order to overcome these obstacles, it is essential to bring together various stakeholders, both nationally and internationally, and align their priorities. To achieve this, the governing structure managing

these priorities and projects has been reshaped, empowering the RDIA to set objectives, choose flagship projects, and develop strategic plans.

A key aspect of the RDIA's approach is the integration of academia with the private sector, start-ups, and small and medium-sized enterprises (SMEs). By fostering collaboration and knowledge exchange between these entities, the RDIA aims to unlock a wealth of innovative potential, drive economic growth, and secure a sustainable future.

To ensure the success and viability of the national RDI ecosystem, the RDIA has curated a distinctive portfolio of research grants and funding. These grants are meticulously designed and prioritized to nurture a vibrant innovative ecosystem, cultivate a highly skilled pool of innovators, and support cutting-edge research endeavors capable of transforming entire industries. The ultimate objective is to generate value for society at large and position the nation as a world-class hub for RDI.

In this way, the RDIA is committed to creating a robust and forward-thinking RDI landscape, enabling groundbreaking discoveries, fostering entrepreneurship, and driving a culture of innovation across diverse sectors.

THE STRUCTURE OF THE REPORT

In order to facilitate decision-making among leaders in RDI, this report aims to provide an overview of the current research performance within the four priority areas. For that purpose, the priority areas have been mapped to research publication output as one of the most relevant dissemination channels for research and innovation. This output has then been evaluated by some key indicators.

The report aims to be succinct, offering an overview of the current research landscape in the Kingdom of Saudi Arabia in Chapter 1, followed by a detailed analysis of research performance within the priority areas in Chapter 2.

01

Analysis of the Research and Development Performance of the Kingdom of Saudi Arabia

Achieving New Heights: Saudi Research and Authorship - Unmatched Growth, Pioneering Collaborations, and Global Citation Dominance

The Kingdom of Saudi Arabia showed a remarkable growth in the number of authors and research output in the most recent years, surpassing any comparator region. Its share of international collaborations is the highest amongst all comparators, and its citation impact is well above the global average.

According to the OECD, research and experimental development (R&D) encompasses systematic creative work aimed at expanding knowledge and devising new applications using this knowledge (OECD and Eurostat, 2018). However, tracking research, development, and innovation activities is a complex task, requiring a distinction between input and output indicators.

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Analysis of the Research and Development Performance of the Kingdom of Saudi Arabia

Inputs, such as skilled researchers and funding, are crucial components in fostering excellent research and development. Developing and maintaining national research capabilities is vital for a country's economic growth. Expenditure on R&D supports research by providing the necessary infrastructure, skilled researchers, and generating supply and demand for various industries.

On the other hand, measuring the output of R&D or science and technology (S&T) is more complex. Innovation surveys and patent utilization have been used to measure the effects of the innovation process in which R&D plays a significant role. Bibliometric methods, utilizing research outputs as indicators, have also been employed to assess research, development, and innovation activities (OECD, 2009; Gléinzel et al., 2019; Moed et al., 2004).

Research output can take various forms, and assessing research excellence requires tracking citation traces to measure the influence of different outputs. The number of publications by researchers, institutions, and countries is considered a fundamental indicator in these evaluations. In the Kingdom of Saudi Arabia, there has been a substantial increase in both the number of publications and authors over the past five years.

Research outputs surged from 24,057 publications in 2018 to 59,016 publications in 2022. During the same four-year period, the number of authors rose from 23,766 to 45,862. This amounts to an impressive annual growth rate of 25% for publications and 18% for authors—much higher than any global or regional average (FIGURE 1-1).

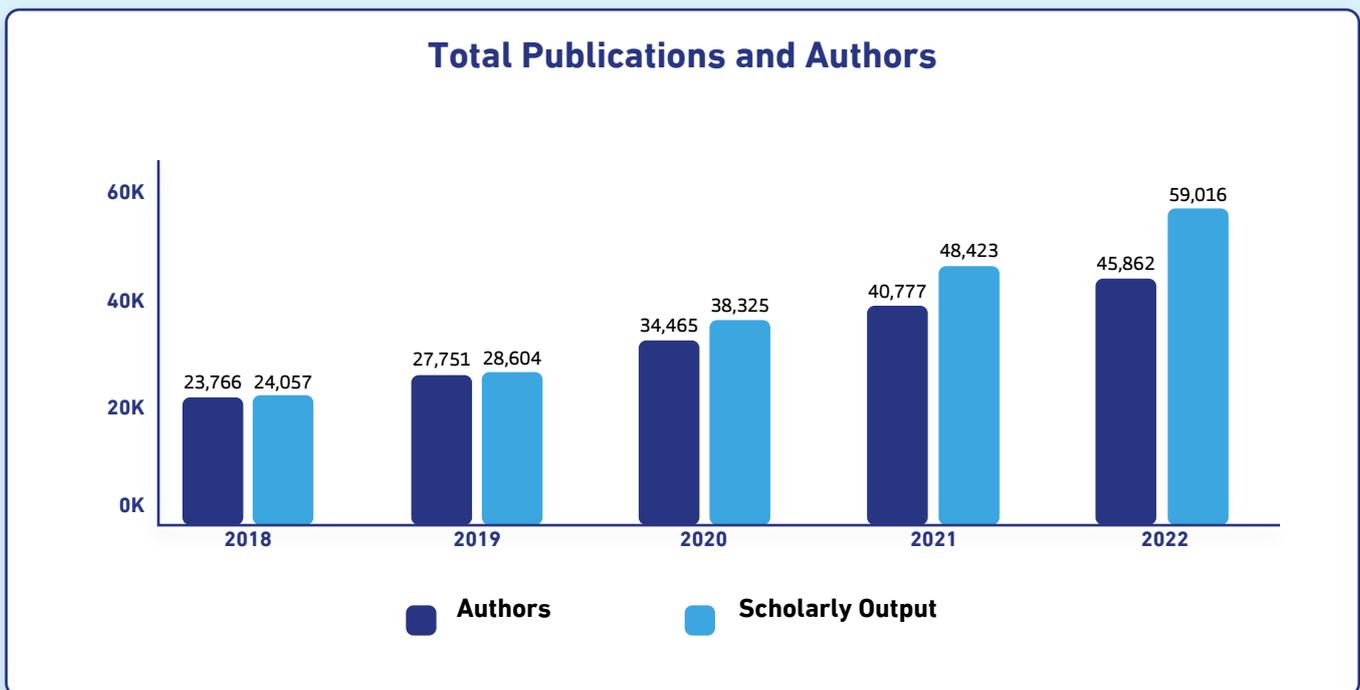


FIGURE 1-1

KSA's number of authors (dark blue) and research output (light blue) by year, 2018–2022.

Source: Scopus

This growth in research output spans across all research sectors, with the academic sector predominantly contributing 95% of the publications. However, the private, governmental, and health sectors also play vital roles, accounting for 4% of

publications from the governmental and health sectors and 2% from the private sector (FIGURE 1-2). A detailed examination of the top players within each sector will be provided further in the report.

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Analysis of the Research and Development Performance of the Kingdom of Saudi Arabia

Scholarly Output per Sector 2018-2022

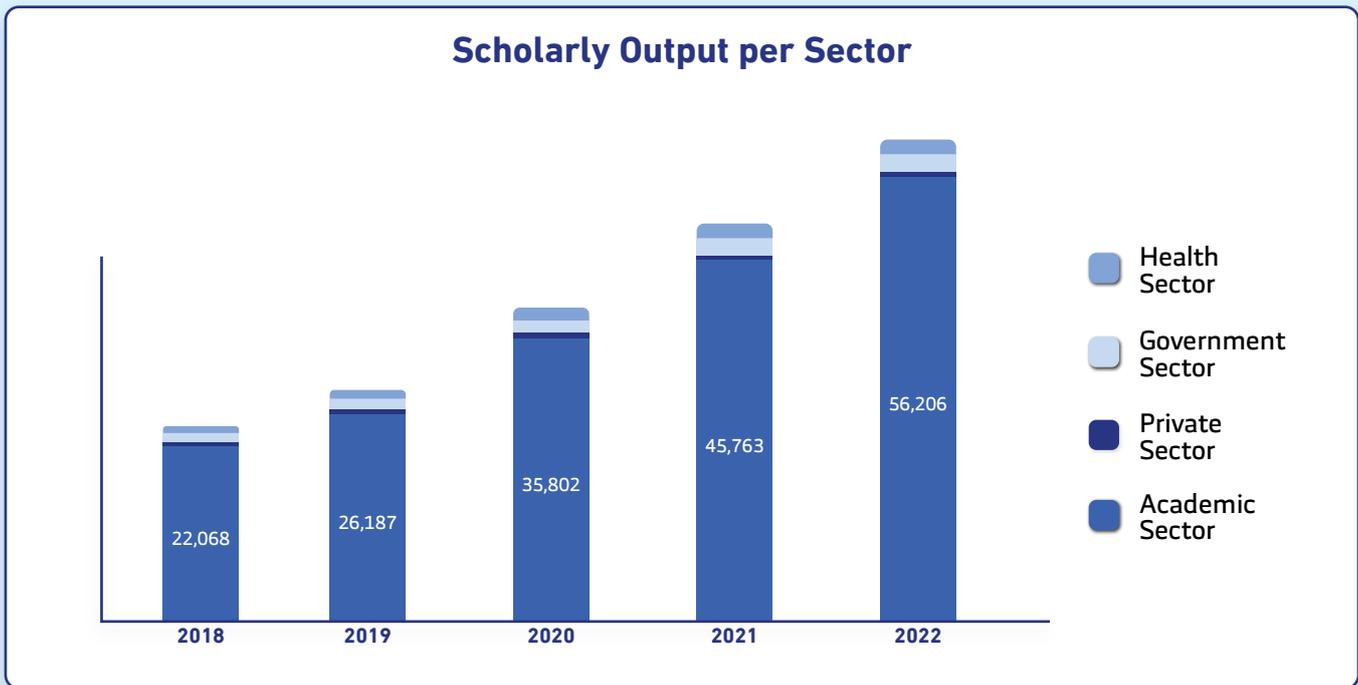


FIGURE 1-2

Research output per sector for Kingdom of Saudi Arabia, 2018–2022.

Source: Scopus

Although corporate players like Aramco and Sabc may have lower publication numbers compared to other sectors, they typically prioritize research outputs in the form of patents or products (FIGURE 1-3).

Overall, the research performance of the Kingdom of Saudi Arabia, evidenced by a significant increase in publications and authors, highlights its dedication to expanding knowledge both nationally and globally.

FIGURE 1-3 displays the Field-Weighted Citation Impact (FWCI), which provides insight into the impact of citations on research publications. It is important to recognize that citation distributions

can be influenced by factors such as publication year, subject area, and publication type. Due to their recent publication, newer works may not have had adequate time to accumulate citations compared to older publications. Additionally, publications in the field of medicine tend to have a higher citation rate due to distinctive publication and citation patterns. Furthermore, it is observed that review articles tend to attract more citations compared to other types of publications. To account for these variations, normalization is necessary, and the FWCI serves as an indicator for this purpose. An FWCI value above 1 indicates a citation impact higher than the global average, while a value below 1 suggests a lower citation impact.



Private Sector

Top 5 Entitles of Private Sector 2018-2022	Scholarly Output	FWCI
Saudi Aramco	2,841	1.43
SABIC	367	1.20
Saudi Electricity Company	81	1.52
Integrated Gulf Biosystems	6	9.24

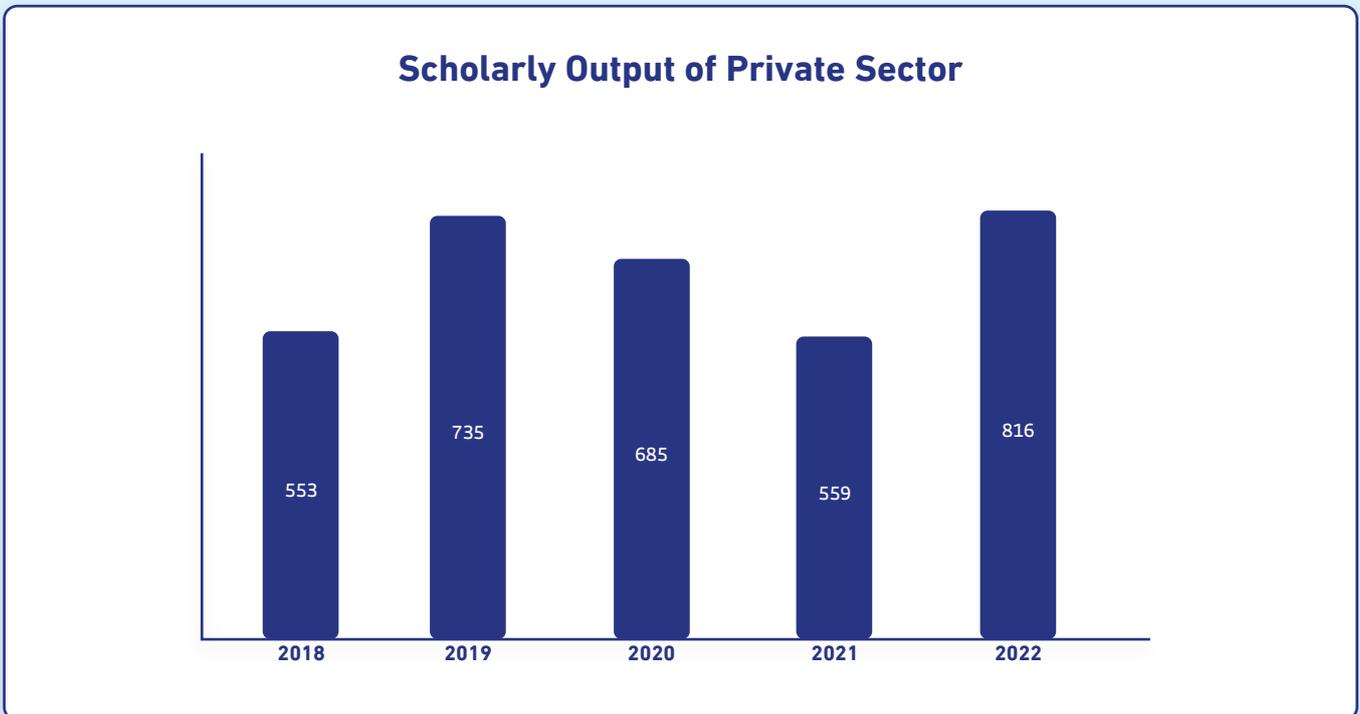


FIGURE 1-3

Annual research output for KSA's private sector, top private actor's output and impact, 2018–2022.

Source: Scopus

In terms of research output, private actors in Saudi Arabia may have a comparatively lower overall contribution. Nevertheless, their involvement significantly contributes to the nation's high citation impact within the research landscape. Notably, the King Faisal Specialist Hospital and Research Centre and King Fahd Medical City emerged as major contributors in the health sector, with other actors publishing fewer than 1,000 publications during the

specified period (refer to Figure 1-4). Remarkably, publications from Johns Hopkins Aramco Healthcare exhibit an exceptionally high impact, exceeding global averages. One possible explanation for this elevated impact could be the mutually beneficial collaboration between Johns Hopkins Aramco Healthcare and the renowned research institution, Johns Hopkins University.

1

Analysis of the Research and Development Performance of the Kingdom of Saudi Arabia



Health Sector

Top 10 Entitles of Health Sector 2018-2022	Scholarly Output	FWCI
King Faisal Specialist Hospital and Research Centre	3,515	1.17
King Fahad Medical City	1,541	1.27
King Fahad Specialist Hospital, Dammam	738	0.86
King Saud Medical City	737	1.66
King Khaled Eye Specialist Hospital	479	0.65
Johns Hopkins Aramco Healthcare	459	2.17
Security Forces Hospital Program Riyadh	396	0.91
King Fahd Armed Forces Hospital	266	1.22
King Fahd General Hospital	193	1.48
Asir Central Hospital	139	1.06

Scholarly Output of Health Sector

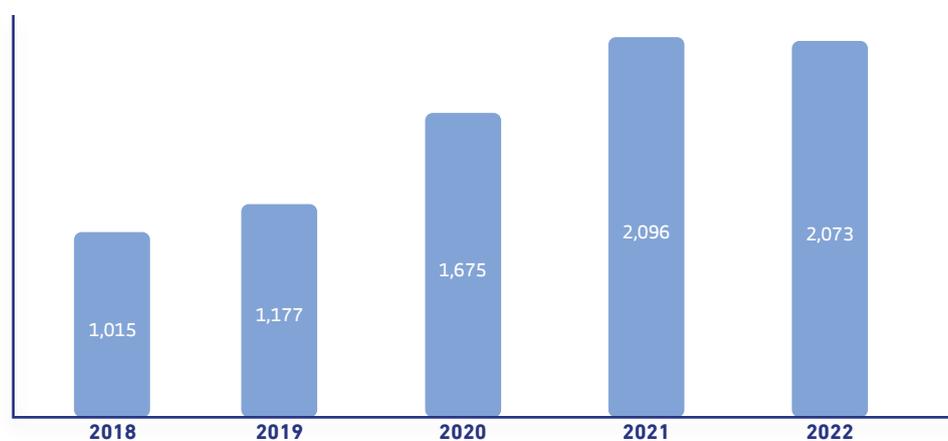


FIGURE 1-4

Annual research output for KSA's private sector, top private actor's output and impact, 2018–2022.

Source: Scopus

Considering the higher outputs and greater number of academic institutions, TABLE 1-1 presents data only for institutions with more than 5,000 publications between 2018 and 2022, along with their respective FWCI (Field-Weighted Citation Impact) during the same period.

Among these institutions, King Saud University and King Abdulaziz University stand out as the most

prolific, with an exceptionally high citation impact. It is noteworthy that none of these active institutions have a citation impact below the global average, which demonstrates the highly significant research conducted by these institutions. King Abdullah University of Science and Technology boasts the highest FWCI among these institutions.



Academic Sector

Top Entitles of Academic Sector 2018-2022	Scholarly Output	FWCI
King Saud University	35,290	1.68
King Abdulaziz University	30,365	1.89
King Abdullah University of Science and Technology	13,087	2.05
King Khalid University	13,073	1.52
King Fahd University of Petroleum and Minerals	11,517	1.76
Taif University	10,984	1.80
Prince Sattam Bin Abdulaziz University	10,661	1.68
Imam Abdulrahman Bin Faisal University	8,383	1.65
Princess Nourah Bint Abdulrahman University	7,628	1.49
Umm Al-Qura University	7,601	1.61
Qassim University	7,328	1.22
Taibah University	6,328	1.40
Al Jouf University	5,668	1.42
King Faisal University	5,611	1.57

TABLE 1-1

Research output and impact for KSA's top academic sector actors, 2018–2022.

Source: Scopus

As mentioned earlier, the citation impact also increased over this period (FIGURE 1-5). The FWCI for research from KSA researchers grew from 1.51 in 2018 to 1.71 in 2022. This means that, on average, research from KSA received 71% more citations compared to similar publications worldwide. This is the highest FWCI when compared to other benchmarks such as OECD and G20. Since the global level serves as the benchmark for normalization, the FWCI remains consistent at one.

In terms of GCC countries, their performance closely resembles that of KSA, which is expected considering Saudi Arabia's significant contribution to the output and impact of this region. Interestingly, while OECD and G20 countries experienced a slight decline during this period, the overall performance of KSA remains impressive.

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Analysis of the Research and Development Performance of the Kingdom of Saudi Arabia

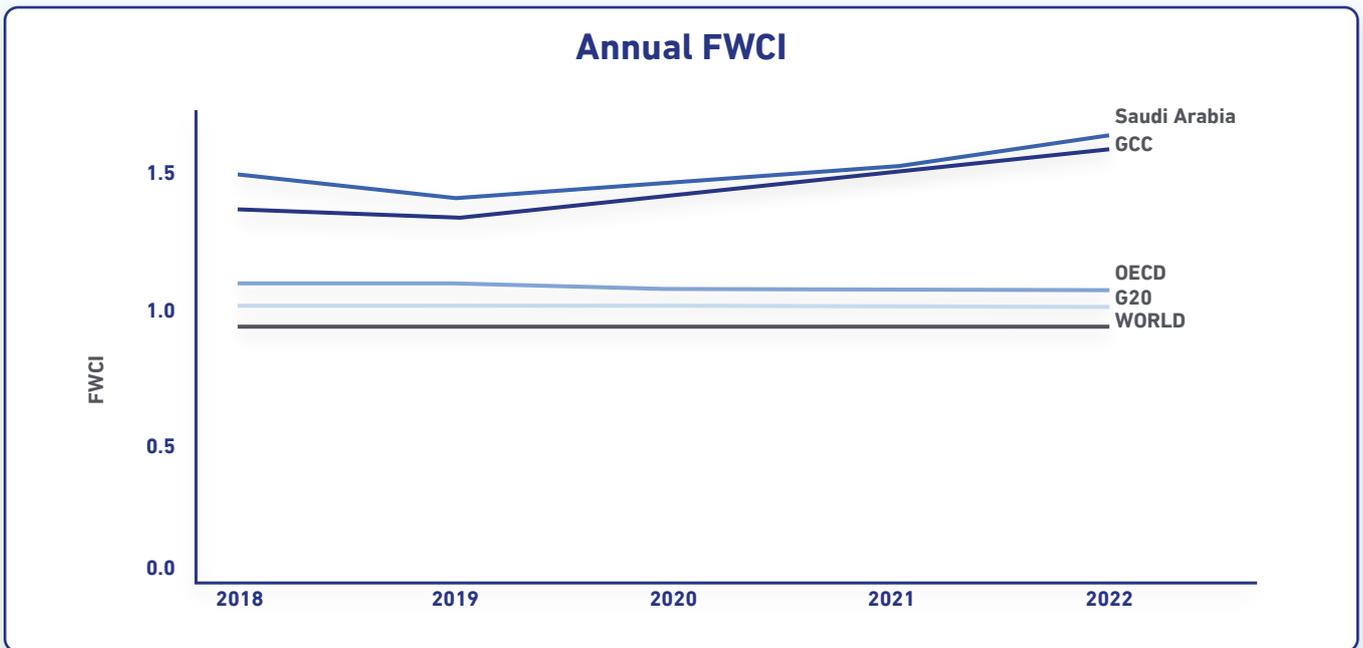


FIGURE 1-5

Annual field-weighted citation impact (FWCI) for KSA and comparators, 2018–2022.

Source: Scopus

In 2022, the research outcomes achieved by the Kingdom resulted in its largest publication record in history. These publications were primarily focused on high-quality journals, indicating that the Kingdom values not only quantity but also the quality of research. The figure above illustrates the average percentage distribution of research publication quality across Q1, Q2, Q3, and Q4 journals from 2018 to 2022. The data includes comparisons between the Kingdom, G20 countries,

and the global average. The Kingdom consistently published the majority of its research in high-quality journals, surpassing a 50% share. This demonstrates the Kingdom's commitment to maintaining research standards during this period. Moreover, it highlights the Kingdom's prioritization of high-quality publications and their limited presence in lower-ranked journals. These efforts collectively contribute to the Kingdom's ability to produce exceptional research outputs.

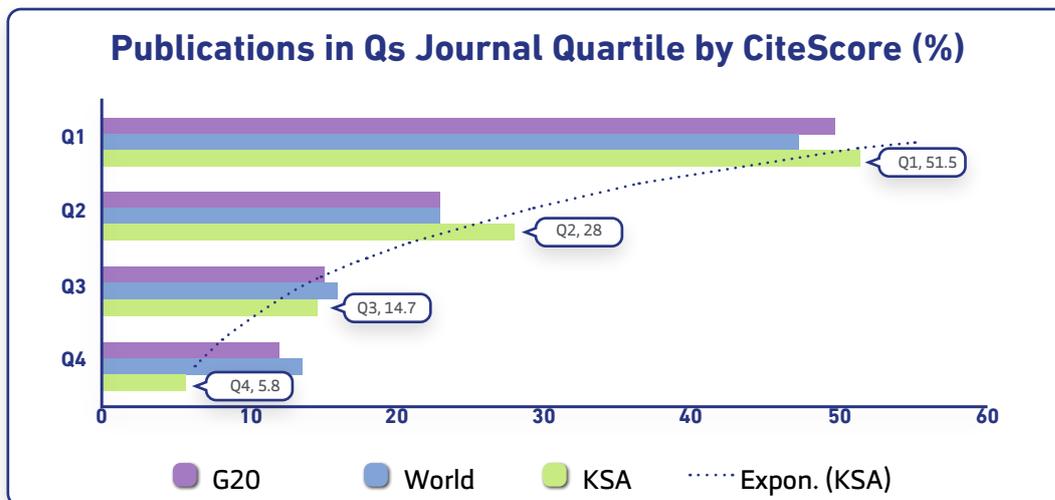


FIGURE 1-6

Publications in Qs Journal Quartile by CiteScore (%)

Source: Scopus

International collaboration may be one factor driving this remarkable performance. Numerous studies have demonstrated the positive impact of international collaboration on research and citation performance. KSA's international research collaboration increase from 73% in 2018 to 78% in 2022, indicating the extensive global reach of KSA research (FIGURE 1-7).

played a major role in fostering this international collaboration. The private sector had the lowest level of international collaboration, which is expected considering the nature of research conducted in corporations. The health sector, although relatively low in terms of international collaboration, may focus more on addressing local issues in these specialized institutions.

Similar to the output figures, academic institutions

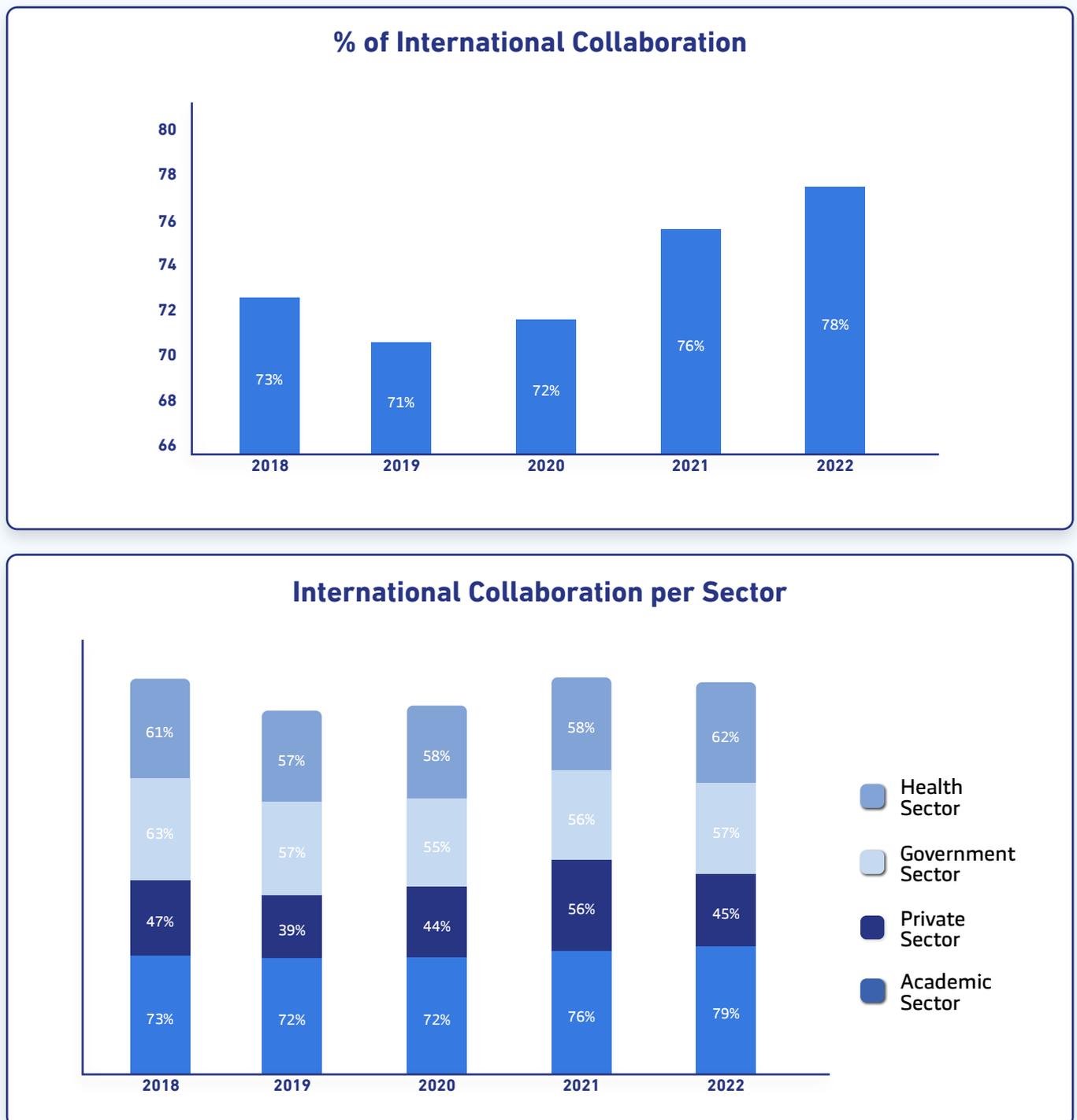


FIGURE 1-7

KSA's annual share of international collaboration across all sectors (left panel) and per sector (right panel), 2018–2022. Source: Scopus

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Analysis of the Research and Development Performance of the Kingdom of Saudi Arabia

Top Collaborator Countries, 2018-2022		
EGY		38,126
IND		25,758
PAK		23,435
USA		22,613
CHN		18,372
GRB		12,867
MYS		10,204
AUS		7,545
TUN		7,363
CAN		6,782
KOR		6,549
TUR		5,810
DEU		5,523
FRA		5,337
ARE		5,043
ITA		5,030
ESP		4,108
JOR		4,085
TWN		3,677
RUS		3,369

FIGURE 1-8

Top international partner countries for KSA, 2018–2022.

Source: Scopus

The top countries for research collaboration were Egypt, India, and Pakistan, with the United States and China as additional significant contributors globally.

This should come as no surprise, given that India has emerged as a prominent driver of global research output in recent years, and Egypt is geographically close to the Kingdom.

A possible explanation for this extensive international collaboration is the substantial mobility of researchers from Saudi Arabia (see FIGURE 1-9). Among OECD countries, only Switzerland, Iceland, and Luxembourg have a lower proportion of sedentary researchers (those who do not engage in international mobility) while Saudi Arabia has a notably higher percentage of long-term or permanent-staying researchers.

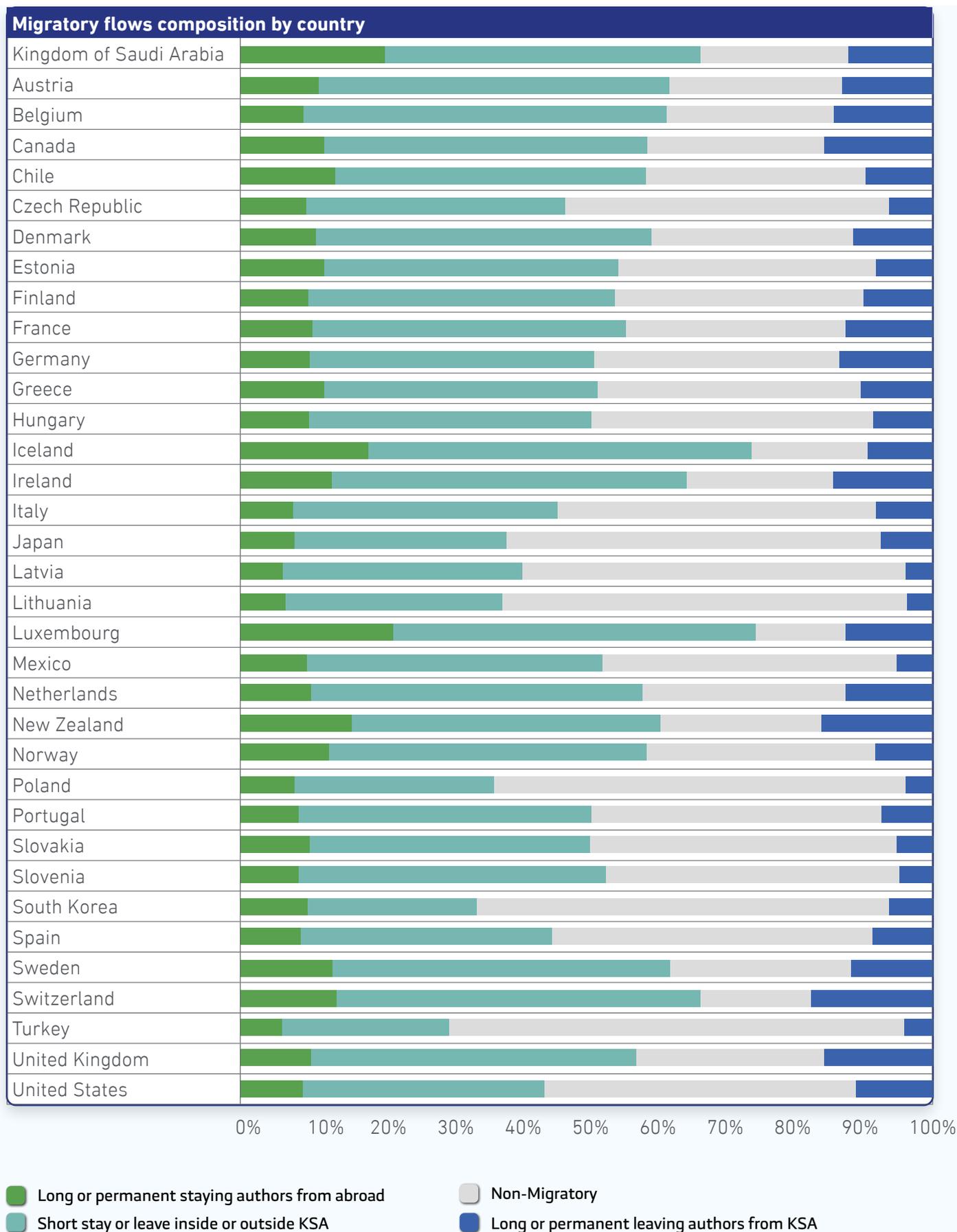


FIGURE 1-8 Share of authors per mobility category for KSA and OECD countries, active authors in the five years prior to March 2022. Source: Scopus

02

Research and Development Performance on National Priorities

This chapter delves into the progress of research and innovation in the Kingdom of Saudi Arabia across the four national priorities and analyzes growth rates, performance of top institutions, notable trends, collaboration challenges, and innovation potential. Additionally, a detailed bibliometric assessment of subfields within the priorities is proposed for future analysis. The chapter concludes by spotlighting the Kingdom's remarkable AI research performance across publication and impact which surpassed global averages.

The analyses in this chapter focus on the visible changes in some data points, recognizing that significant changes in output metrics typically take several years to become apparent due to publishing delays and the implementation of policy changes.

The number of active authors per year is represented by the blue bars in FIGURE 2-1, while the number of

publications per year is shown by the green bars. The percentage at the top displays the growth between 2021 and 2022. Health and Wellness has the largest number of authors and publications, but the other priorities have higher growth rates. Economies of the Future and Sustainable Development stand out with their growth rates, although it should be noted that they initially started from lower levels.

2 Research and Development Performance on National Priorities



FIGURE 2-1

KSA's number of authors (blue bars) and research output (green bars) per priority area, 2021 and 2022. Percentages indicate growth from 2021 to 2022.

Source: Scopus

To evaluate whether specific research questions have been addressed within the priority areas, this report utilizes Topics of Prominence. Topics of Prominence provide a detailed approach to grouping research publications and identifying high-performing or emerging research clusters. Topics are created by clustering articles with strong citation linkages and are aligned to the research-question level. Topic names are derived from the keywords used in the abstracts of the articles.

Unsurprisingly, Covid-related research has been the most prominent topic within Health and Wellness in recent years (TABLE 2-2.1). Other relevant topics cover a wide range of research questions, including Dentistry, Diabetology, and Personalized Medicine.

Within Sustainable Environment, one recurring topic focuses on renewable energies, such as Electric Power Transmission Networks, Wind Power, Electric Power, Solar Energy, Photovoltaic Cells, and Solar Radiation.

Health & Wellness	Sustainable Environment
COVID-19; SARS-CoV-2; Coronavirus	Electric Power Transmission Networks; Wind Power, Electric Power
Tooth; Bone And Bones; Dentin	Reservoirs (Water); Oil Well Flooding; Hydraulic Fracturing
Pharmaceutical Preparations; Nanoparticles; Tablets	Secondary Batteries; Electric Batteries; Lithium Alloys
Oral Health; Periodontitis; Dental Caries	Solar Energy, Photovoltaic Cells; Solar Radiation
Anti-Bacterial Agents; Infection; Methicillin-Resistant Staphylococcus	Adsorption; Adsorbents; Activated Carbon
Synthesis (Chemical); Derivatives; Pyridines	Seismic Waves; Seismology; Seismic Data
Students; Medical Students; Education	Electricity; Energy; Economics
Obesity; Motor Activity; Child	Biodiesel; Diesel Engines; Engine Cylinders
Volatile Oils; Antioxidants; Oils	Corrosion; Carbon Steel; Corrosion Inhibitors
Rotavirus; Norovirus; Coronavirus	Climate Models; Model; Rainfall
Plasmons; Metamaterials; Surface Plasmon Resonance	Electric Potential; Electric Inverters; DC-DC Converters
Insulin; Type 2 Diabetes Mellitus; Glucose	Heavy Metals; Soils; Cadmium
Orthodontics; Malocclusion; Temporomandibular Joint	Soil; Biochar, Soil Organic Carbon
Eye; Glaucoma; Cataract	Combustion; Combustors; Ignition
Pharmacists; Pharmaceutical Preparations; Pharmacy	Microbial Fuel Cells; Anaerobic Digestion; Bioreactors
MicroRNAs; Long Untranslated RNA; Neoplasms	Photocatalysis; Photocatalysts; Solar Cells
T-Lymphocytes; Neoplasms; Immunotherapy	Membranes; Desalination; Ultrafiltration
Alzheimer Disease; Dementia; Amyloid	Gasification; Pyrolysis; Coal
Antioxidants; Rats; Silymarin	Exergy; Heat Pump Systems; Rankine Cycle
Spine; Patients; Low Back Pain	Ozonization; Degradation; Wastewater Treatment

TABLE 2-2.1

Top topic clusters for HEALTH AND WELLNESS and SUSTAINABLE ENVIRONMENT for KSA, 2018–2022.

Source: Scopus

Energy and Industrial Leadership primarily focuses on renewable energy and material sciences for developing new efficient materials. On the other hand, Economies of the Future appears biased towards digital technologies (TABLE 2-2.2).

Energy	Economies of the Future
Heat Transfer; Nusselt Number; Natural Convection	Algorithms; Computer Vision; Models
Photocatalysis; Photocatalysts; Solar Cells	Wireless Sensor Networks; Sensor Nodes; Routing Protocols
Graphene; Carbon Nanotubes; Nanotubes	Cryptography; Authentication; Data Privacy
Secondary Batteries; Electric Batteries; Lithium Alloys	Cognitive Radio; MIMO Systems; Orthogonal Frequency Division Multiplexing
Plasmons; Metamaterials; Surface Plasmon Resonance	Computer Crime; Network Security; Intrusion Detection
Adsorption; Adsorbents; Activated Carbon	Semantics; Models; Recommender Systems
Concretes; Compressive Strength; Cements	Fractional; Fractional Order; Derivatives
Catalysts; Zeolites; Hydrogenation	Cloud Computing; Clouds; Distributed Computer Systems
Organic Light Emitting Diodes (OLED); Solar Cells; Conjugated polyisobutene	Electric Potential; Electric Inverters; DC-DC Converters
Membranes; Desalination; Ultrafiltration	Random Variables; Order Statistics; Distribution
Ligands; Crystal Structure; Organometallics	Antennas; Slot Antennas; Microwave Antennas
Synthesis (Chemical); Derivatives; Pyridines	Decision Making; Fuzzy Sets; Models
X Rays; Fluorescence; Shielding	Software Engineering; Models; Software Design
Ferrites; Saturation Magnetization; Magnetic Properties	Classification (Of Information); Learning Systems; Algorithms
Nanocrystals; Semiconductor Quantum Dots; Zinc Sulfide	Solitons; Waves; Nonlinear Equations
Catalysis; Synthesis (Chemical); Catalysts	Optimization; Algorithms; Evolutionary Algorithms
Biosensors; Electrodes; Voltammetry	COVID-19; SARS-CoV-2; Coronavirus
Control; Controllers; Linear Matrix Inequalities	Fixed Point; Fixed Point Theorem; Metric Space
Thermoelasticity; Wave Propagation; Heat Conduction	Estimator; Models; Variable Selection
Imines; Crystal Structure; Metal Complexes	Synchronization; Chaotic Systems; Chaos Theory

TABLE 2-2.2

Top topic clusters for ENERGY AND INDUSTRIALS and ECONOMIES OF THE FUTURE for KSA, 2018–2022.

Source: Scopus

The following section highlights the top players within each priority area, outlining their growth in output and citation impact in the most recent year.

In the previous chapter, it was noted that King Saud University is the leading contributor to the priority area of Health and Wellness (TABLE 2-3). It is worth mentioning that due to its already high research output, it may be more challenging for the university

to further increase these numbers. The growth rate of 5% from 2021 to 2022 is relatively modest compared to other institutions that experienced approximately 50% growth rate or higher in research outputs during the same period. In terms of citation impact, almost all institutions exceeded the global average by a significant margin.

Top Institutions by Scholarly Output 2021 and 2022, Health & Wellness

University	2021	2022	Growth	FWCI 2022
King Saud University	3,345	3,515	5%	1.37
King Abdulaziz University	2,041	2,322	14%	1.44
King Saud bin Abdulaziz University for Health Sciences	1,124	1,167	4%	0.99
Taif University	836	1,118	34%	1.64
Imam Abdulrahman Bin Faisal University	930	1,017	9%	1.52
King Khalid University	793	1,141	44%	1.26
Umm Al-Qura University	699	1,080	55%	1.40
Prince Sattam Bin Abdulaziz University	720	1,019	42%	1.09
Qassim University	735	978	33%	1.18
Princess Nourah Bint Abdulrahman University	628	1,034	65%	1.44
Jazan University	648	939	45%	1.39
Ministry of National Guard - Health Affairs	760	781	3%	0.93
King Faisal Specialist Hospital and Research Centre	773	758	-2%	1.15
Al Jouf University	536	801	49%	1.37
Ministry of Health, Saudi Arabia	563	636	13%	1.55
King Faisal University	471	568	21%	1.45
Taibah University	470	564	20%	1.23
University of Hail	364	517	42%	1.47
Alfaisal University	406	462	14%	1.71
King Fahad Medical City	374	360	-4%	1.06

TABLE 2-3

Top institutions by output for HEALTH AND WELLNESS with research output in 2021 and 2022, growth between both years and FWCI 2022.

Source: Scopus

A similar trend can be observed in the priority area of Sustainable Environment (TABLE 2-4). Notably, the growth rates from 2021 to 2022 for most institutions in this field are higher compared to Health and Wellness, and the Field-Weighted Citation Impact (FWCI) is also higher. This emphasizes the importance of the Sustainable Environment sector for the Kingdom of Saudi Arabia.



Top Institutions by scholarly output 2021 and 2022, Sustainable Environment

University	2021	2022	Growth	FWCI 2022
King Saud University	1,342	1,608	20%	1.83
King Abdulaziz University	835	1,049	26%	2.44
King Fahd University of Petroleum and Minerals	766	907	18%	1.99
Taif University	682	786	15%	2.40
King Abdullah University of Science and Technology	663	711	7%	2.04
King Khalid University	410	731	78%	2.13
Prince Sattam Bin Abdulaziz University	289	599	107%	2.92
Saudi Aramco	310	463	49%	1.36
Princess Nourah Bint Abdulrahman University	155	369	138%	1.71
Qassim University	187	264	41%	1.91
Umm Al-Qura University	141	296	110%	1.66
King Faisal University	178	244	37%	1.39
Al Jouf University	134	252	88%	1.72
Imam Abdulrahman Bin Faisal University	140	217	55%	2.39
University of Hail	111	164	48%	1.77
University of Jeddah	88	158	80%	1.28
University of Tabuk	90	151	68%	1.69
Jazan University	75	136	81%	1.81
Najran University	46	144	213%	2.06
Prince Sultan University (PSU)	71	119	68%	1.87

TABLE 2-4

Top institutions by output for SUSTAINABLE ENVIRONMENT with research output in 2021 and 2022, growth between both years and FWCI 2022.

Source: Scopus

In the Energy and Industrial Leadership priority area (TABLE 2-5), there is a wide range of growth rates from 2021 to 2022. Some institutions, such as Princess Nourah Bint Abdulrahman University, doubled their research output, while others experienced lower growth rates or even a slight decline. King Khalid University surpassed King Abdulaziz University in terms of growth by achieving a 55% increase in output in 2022.



Top Institutions by scholarly output 2021 and 2022, Energy

University	2021	2022	Growth	FWCI 2022
King Saud University	1,960	2,060	5%	1.82
King Khalid University	1,444	2,241	55%	2.17
King Abdulaziz University	1,681	1,732	3%	2.30
Taif University	981	1,288	31%	2.47
Prince Sattam Bin Abdulaziz University	783	1,307	67%	2.45
King Fahd University of Petroleum and Minerals	891	1,067	20%	2.19
King Abdullah University of Science and Technology	945	945	0%	2.00
Princess Nourah Bint Abdulrahman University	488	983	101%	1.86
Umm Al-Qura University	420	717	71%	2.15
Imam Abdulrahman Bin Faisal University	481	450	-6%	1.92
Al Jouf University	294	566	93%	2.01
Qassim University	310	471	52%	1.34
Taibah University	342	371	8%	1.62
King Faisal University	272	426	57%	1.52
Majmaah University	261	302	16%	2.30
University of Tabuk	239	322	35%	2.28
University of Hail	218	304	39%	1.68
University of Jeddah	211	308	46%	1.97
Prince Sultan University (PSU)	144	241	67%	1.70
Saudi Electronic University	19	38	100%	2.67

TABLE 2-5

Top institutions by output for Energy and Industrial Leadership with research output in 2021 and 2022, growth between both years and FWCI 2022.

Source: Scopus

Although the overall output related to the Economies of the Future priority is lower compared to other priority areas, the top institutions still produce around 1,000 publications annually (TABLE 2-6). Impressive growth rates and citation impact can be seen, as is the case with Taif University, which experienced a 21% growth and displayed an FWCI of 2.52 in 2022.



Top Institutions by scholarly output 2021 and 2022, Economies of the Future

University	2021	2022	Growth	FWCI 2022
King Abdulaziz University	1,146	1,476	29%	2.06
King Saud University	884	988	12%	1.86
Taif University	829	1,000	21%	2.52
Prince Sattam Bin Abdulaziz University	516	998	93%	1.80
King Abdullah University of Science and Technology	636	608	-4%	1.62
King Khalid University	371	702	89%	1.79
Princess Nourah Bint Abdulrahman University	221	842	281%	1.80
Umm Al-Qura University	384	578	51%	2.08
Prince Sultan University (PSU)	390	529	36%	2.02
Qassim University	298	531	78%	1.77
Al Jouf University	240	421	75%	1.98
King Fahd University of Petroleum and Minerals	282	337	20%	1.43
University of Jeddah	244	334	37%	1.60
Taibah University	277	284	3%	1.71
University of Tabuk	165	298	81%	1.73
King Faisal University	158	281	78%	2.74
University of Hail	168	261	55%	3.24
Saudi Electronic University	170	251	48%	1.65
Imam Abdulrahman Bin Faisal University	163	257	58%	1.78
Majmaah University	157	239	52%	1.59

TABLE 2-6

Top institutions by output for ECONOMIES OF THE FUTURE with research output in 2021 and 2022, growth between both years and FWCI 2022.

Source: Scopus

Various studies have demonstrated that academic-corporate collaborations have a positive impact on citation rates. However, in the Kingdom of Saudi Arabia, the percentage of academic-corporate collaborations is lower compared to comparator countries, except for the field of Sustainable Environment (FIGURE 2-7). This may be attributed to the relatively lower presence or research output of the private sector in the country. It is important to address this issue in order to tap into the potential of innovation and development in this area.



Academic-corporate share of scholarly output

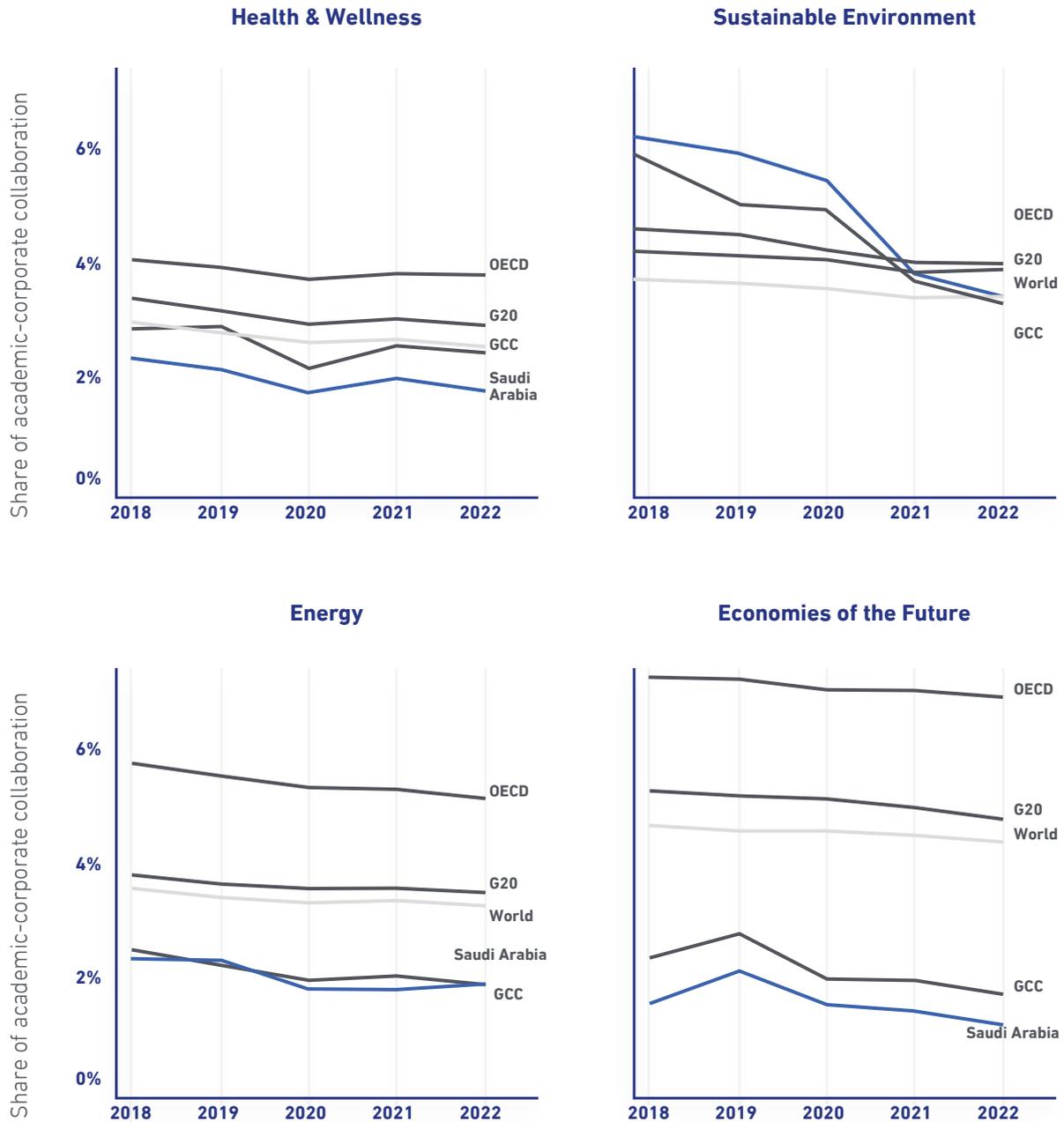


FIGURE 2-3

Share of academic-corporate collaboration for KSA and comparators per sector, 2018–2022.

Source: Scopus

On the other hand, when it comes to international collaboration, the situation changes. As mentioned in the previous chapter, the Kingdom of Saudi Arabia has a remarkable share of international collaborations, (FIGURE 2-8). Interestingly, regarding Health and Wellness, the GCC countries exhibit an even higher level of international collaboration, unlike in other priority areas.

International collaboration share of scholarly output

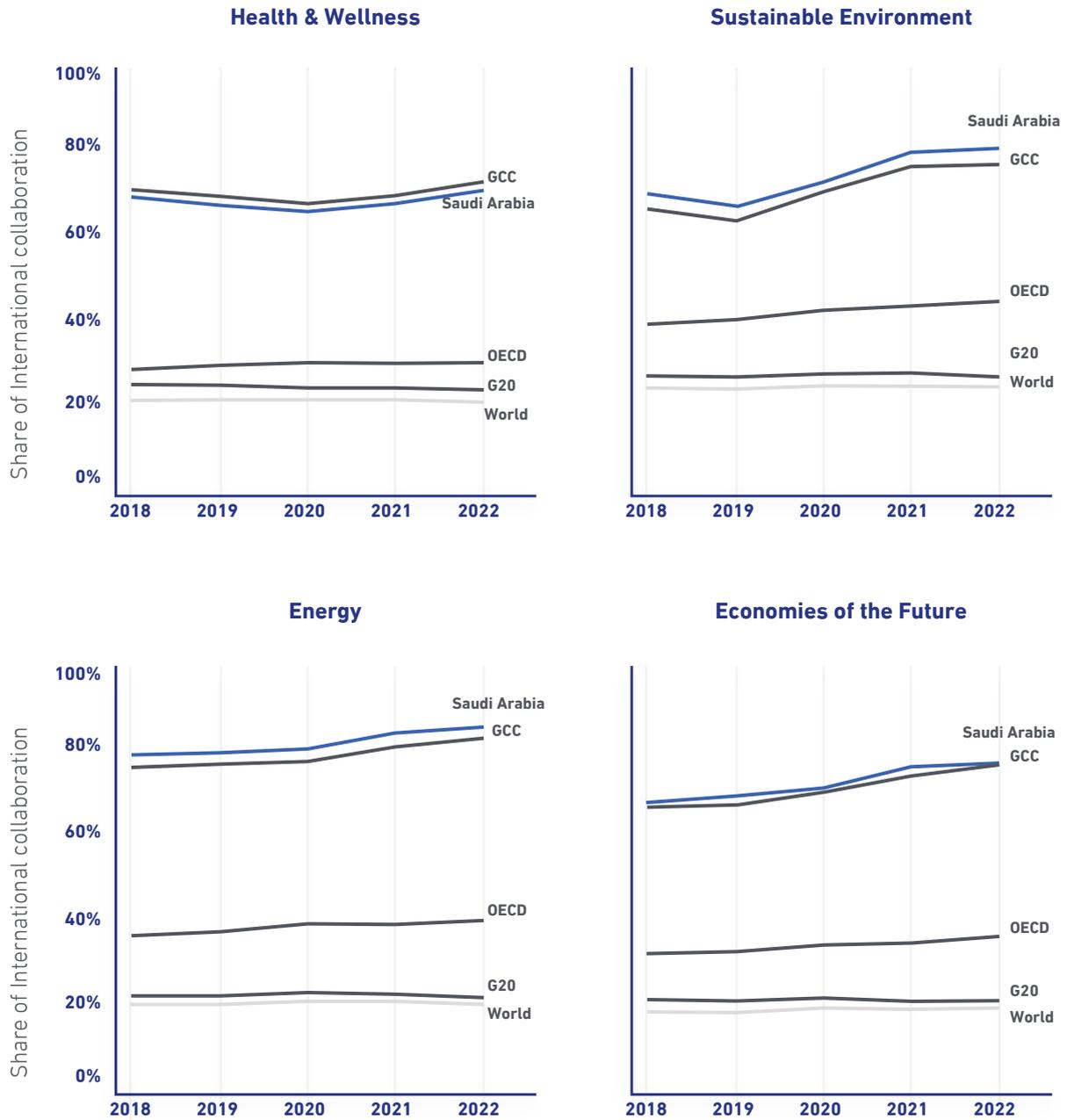


FIGURE 2-7

Share of international collaboration for KSA and comparators per sector, 2018–2022.

Source: Scopus

Outlook into Subfields – The Case of Artificial Intelligence

As mentioned in the introduction, the four priority areas can be further categorized into subfields. For instance, the subfields of Economies of the Future can include Future Urban Mobility and Infrastructure, Big Data Analytics and AI, and others. The subfields of Energy and Industrial Leadership can be divided into Renewable Energies or Batteries.

To conduct a bibliometric assessment of these subfields, it is necessary to have a clear, comprehensive definition of all publications related to these research areas. Typically, this is achieved through mapping of journal or article classifications, or through search queries using keywords. However, these specific methodologies are beyond the scope of this report. While we performed a basic mapping for the four priority areas earlier, determining the exact delineation of the subfields would require additional effort, including multiple workshops and feedback rounds to ensure the quality of the resulting publication sets.

Additionally, the prominent topics highlighted in the previous section can also be utilized. However, due to the nature of citation clusters, they alone are insufficient to define publication sets for several reasons. These clusters are based on citation links,

which means that publication sets would ultimately miss relevant new publications that have not yet been cited, or groups of publications that are closely related to the field of study.

Hence, it is necessary to defer the assessment of these subfields to conduct a more detailed analysis at a later stage. Nevertheless, it remains highly pertinent to evaluate the research performance of the Kingdom of Saudi Arabia in these subfields to identify potential areas of focus and strength.

Elsevier has already established publication sets for various reports, such as those concerning the United Nations Sustainable Development Goals (SDGs) or Artificial Intelligence. For instance, we utilized one of these sets to evaluate the research performance of the Kingdom of Saudi Arabia in the field of AI.

Globally, AI research has generated over half a million publications between 2018 and 2022, with a Field Weighted Citation Impact (FWCI) of 1.8. In the same period, researchers from the Kingdom of Saudi Arabia published 8,380 publications (TABLE 2-9), surpassing the global FWCI in this field with an impressive value of 2.58.

Kingdom of Saudi Arabia	
Research output	8,380
FWCI	2.58
Share of academic-corporate collaboration	2.1%
Share of international collaboration	75%

TABLE 2-8

Output, FWCI and share of international collaborations for KSA's AI-related publications.

Source: Scopus

Equally noteworthy is the annual growth of these publications. In 2018, KSA researchers published slightly above 500 outputs, while by 2022, this number had risen to nearly 3,000. This translates to a Compound Annual Growth Rate (CAGR) of 50% during this period.

In the same timeframe, the percentage of academic-corporate collaborations only accounted for 2.1%, which aligns with the KSA average but falls significantly below the global average of 4.8% for this subject.



03

Conclusion

This report aimed to showcase a basic bibliometric assessment of the four priority areas for research, development, and innovation activities for the Kingdom of Saudi Arabia. The report revealed steeply growing output and impact. Industrial and Energy Leadership, Economies of the Future, and Sustainable Environment and Affordable Supply of Essential Goods seem to be the drivers of this success, but given the short period of assessment and possible distortion of global research activities due to the pandemic, this would need to be refined and validated.

This report aimed to present a fundamental bibliometric evaluation of the four priority areas for research, development, and innovation activities in the Kingdom of Saudi Arabia. The findings of the report indicate a significant increase in output and impact. Industrial and Energy Leadership, Economies of the Future, and Sustainable Environment and

Affordable Supply of Essential Goods appear to be the key drivers of this success. However, given the limited assessment period and potential distortions caused by the global research landscape during the pandemic, further refinement and validation are necessary.

3

Conclusion

The Research, Development, and Innovation Authority (RDIA) was established in 2021 to support the Kingdom's transition towards an innovation-driven economy, in alignment with its Vision 2030. The authority assumes various responsibilities, including promoting and facilitating the research, development, and innovation (RDI) sector, coordinating the efforts of institutions and research centers, proposing policies, legislation, and regulations, and providing funding to the sector.

In order to facilitate decision-making for RDI-leaders, this report aims to present an overview of the current research performance within the four priority areas. To achieve this, the priority areas have been linked to scholarly publication output, which is one of the most significant channels for disseminating research and innovation. Subsequently, this output has been evaluated using key indicators.

The research outputs published by researchers from the Kingdom of Saudi Arabia have shown significant growth, with an impressive annual growth rate of 25% across all subjects from 2018 to 2022. This growth

rate is four times higher than the global average and even surpasses the average growth rate of the Gulf Cooperation Council (GCC) countries. The increase in research output is evident across all subjects, including each priority area. When compared to global activity levels, Industrial and Energy Leadership and Economies of the Future exhibited the highest activity during the specified period, while Sustainable Environment and Affordable Supply of Essential Goods and Health and Wellness are at or below the global average. However, it is important to note that this is perhaps influenced by the global focus on the UN Sustainable Development Goals and the ongoing global pandemic.

The citation impact of all priority areas is considerably higher than the global average, reflecting a rate of collaboration in research from the Kingdom of Saudi Arabia that is also above the global average. More detailed analysis will be necessary to validate these findings. Nonetheless, it appears that the Kingdom of Saudi Arabia is making substantial progress towards achieving its Vision 2030 goals.



04

Appendix

Mapping of the RDIA priority areas

The first task for this report was to define the priority areas to assess the RDI activities.

This is by no means an easy task, and extensive knowledge in the creation of thematic publications sets and defining specific research areas is required for this. This process involves either a highly specific search query to define the area or an extensive mapping of subjects of interest to available classification systems like the All Science Journal Classification (ASJC, utilized by Scopus) or the Science-Metrix Journal Classification. Both approaches require several validation steps and are time-consuming. As an alternative, it is possible to use an article-level classification, which is more accurate than journal-based classifications. Journal-based classifications assign subjects to publications based on the journals they have been published in, which may cause confusions with multidisciplinary journals and publications that are considered to be of interest to multiple subjects, while article-level classifications usually apply more sophisticated ways to map publications to subject areas.

The Science Metrix classification consists of three different levels, from a domain (e.g., Health Science or Natural Sciences) over field level (e.g., Biomedical Research or Clinical Medicine with the Health Sciences) to a subfield (e.g., Biophysics or Physiology within Biomedical Research). With that level of granularity, it was possible to map the priority areas comprehensively and yet sharply enough.

A possible mapping of RDIA pillars to the article-level Science Metrix classifications may be based on areas and subjects. For example, the RDIA pillar "Sustainability and Essential Needs" includes as subject area "Agriculture and Food," which is further stratified into "Precision Agriculture" and "Aquaculture Productivity." These subjects may be mapped to Science Metrix Field "Agriculture, Fisheries and Forestry" – "Agronomy and Agriculture" and "Fisheries."

It should be acknowledged that this mapping is preliminary and needs to be validated and further defined for more detailed assessments.

Mobility classes

Short-staying authors from abroad are those authors who first published for another country, then published for less than two years for the institution in the country (e.g., KSA), and after this short period published for another country and not anymore for the institution in the country.

Long-staying authors from abroad are returnees to other countries. A returnee to another country is an author that first published for another country, then published for the institution in the country (e.g., KSA) for at least two years and then published again for another country and not anymore for the institution in the country.

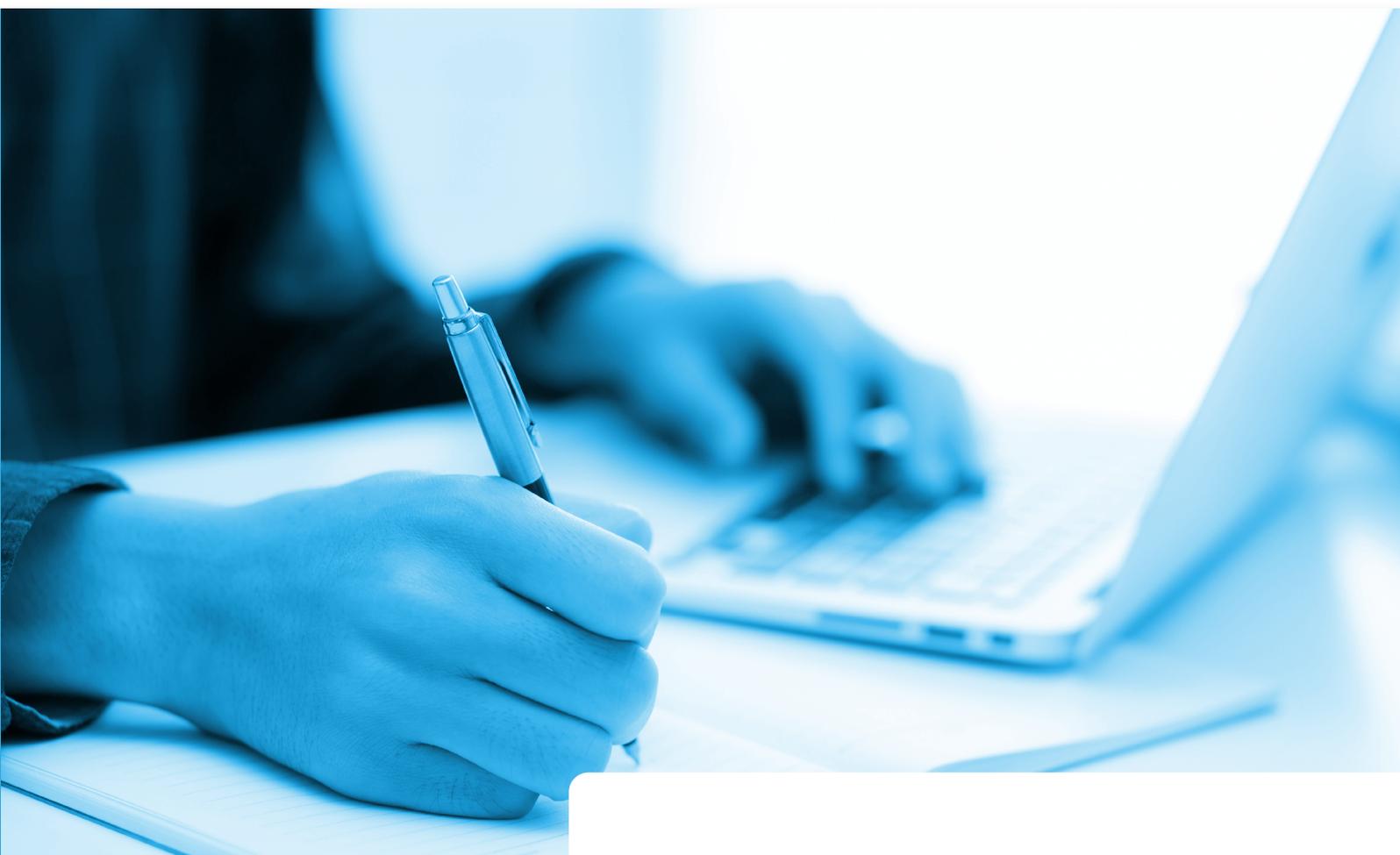
Permanently staying authors from abroad: authors that permanently publish for the institution in the country (e.g., KSA) after publishing first abroad.

Non-migratory authors are those authors who never published for another country but for the institution in the country (e.g., KSA), according to publications indexed in Scopus.

Short leaving authors from the country: are those authors who first published for the institution in the country (e.g., KSA), then published for less than two years for another country, and then published again for the institution in the country.

Long-leaving authors from the country are returnees to the institution in the country (e.g., KSA). A returnee to the institution in the country is an author who, after first publishing for the institution in the country, published in another country for at least two years but not anymore for the institution in the country and then published again for the institution in the country.

Permanently leaving authors from the country: are authors who permanently left the institution in the country (e.g., KSA). An author who permanently left the institution in the country is an author who first published for the institution in the country and then published in another country and did not publish anymore for the institution in the country.



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