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Insights into Saudi Arabia's Research and Innovation Ecosystem

Executive Summary

Innovation Ecosystem in Focus

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INTRODUCTION

The Kingdom of Saudi Arabia is undergoing a significant transformation aimed at creating a knowledge-based economy closely aligned with its Vision 2030. Central to this transformation is a focused national effort to enhance the Kingdom's research, development, and innovation (RDI) landscape, positioning Saudi Arabia as a global leader in science, technology, and innovation. To achieve this, the Kingdom has undertaken a systematic and comprehensive approach to foster an ecosystem that advances RDI efforts in alignment with national priorities.

In 2021, the Research, Development, and Innovation Authority (RDIA) was established as the principal body responsible for steering and enabling RDI initiatives across the Kingdom. RDIA plays a pivotal role in shaping and executing the Kingdom's RDI strategies, ensuring that efforts are directed toward priority areas that will have a substantial impact on the nation's economy and societal well-being. These national priority areas include Health and Wellness, focusing on medical innovations that enhance life expectancy and combat diseases; Sustainability and Essential Needs, aimed at addressing global challenges like water security, food production and environmental sustainability; Energy and Industrials, which leverages Saudi Arabia's vast natural resources to

advance alternative energy and technological innovations; and Economies of the Future, targeting the development of smart cities, advanced technologies and high-value industries such as space exploration, quantum computing and artificial intelligence (AI). These four pillars, intertwined with the Kingdom's industrial and technological base, are designed to propel Saudi Arabia into a leading position in the global RDI landscape.

To establish a strong foundation for the Kingdom's RDI ecosystem, RDIA has spearheaded numerous capacity-building activities aimed at equipping Saudi leaders and practitioners with relevant skills that are key to a successful career.

Additionally, through the development of specialized strategies, RDIA has not only focused on these four key priority areas but has also meticulously outlined tens of research topics within each priority. The RDIA's strategic initiatives aim to nurture local talent, foster collaborations with global research institutions, and build an RDI infrastructure that supports both public and private sector innovation. RDIA is also instrumental in fostering partnerships across universities, industries, and international institutions to ensure that the Kingdom's research outputs align with global scientific trends while addressing local and regional challenges.



His Royal Highness, the Crown Prince, underscored these efforts by emphasizing Saudi Arabia's aspiration to become a global leader in innovation, with targets of annual spending in this sector of 2.5% of the country's Gross Domestic Product (GDP) by 2040. These concerted efforts by the RDIA are pivotal in ensuring that Saudi Arabia remains at the forefront of global innovation while contributing to the Kingdom's economic diversification and sustainable development goals.

In summary, aligning the Kingdom's research output with the national priority areas and their respective subcategories will ensure an optimal

return on investment (ROI) by directing resources towards high-impact fields that are both strategically significant and globally competitive. By focusing on areas with the greatest potential for economic growth and societal benefit, Saudi Arabia can ensure that its RDI investments yield substantial, long-term returns, contributing to national prosperity and global leadership in innovation.

In this context, this study aims to provide an overview of the current research output performance of Saudi Arabia overall and in the national priority areas and, accordingly, identify potential improvement areas that

could further enhance the productivity and quality of Saudi Arabian research performance (as indicated by its research publications). Many studies show the importance of basic research for technology, innovation, and economic growth, for example, Veugelers, 2014 and references within. As such, conducting a study that highlights areas where research output could be enhanced will support formulating strategies for driving innovation growth.

To identify potential improvement areas - the research output of Saudi Arabia overall and in the national priority areas - over the last 10 years (2014-2023) was analyzed using a range of relevant metrics such as research volume and impact, funding and collaboration dynamics. The performance is then benchmarked with a series of comparator countries and regions.

Additionally, a SWOT analysis of research areas is performed. Development opportunities are identified through benchmarking against other countries and regions combined with the SWOT analysis.

Another important aspect that could enhance the research output is increasing women's participation in research. Accordingly, the percentage of women among active researchers and inventors (identified from patents)

is analyzed and compared to other countries and regions.

16%

average yearly growth rate of Saudi Arabian research output in the period 2014-2023.

OVERVIEW

In this study, we have investigated Saudi Arabia's overall research performance, including performance in the national priority areas. From this analysis, we have identified performance strengths and areas for potential improvement.

Among the main strengths identified:

- A dramatic increase in the overall research output, including across the national priority areas, along with a high citation impact footprint.
- Most research topics constituting the national priority areas can be classified as strength or opportunity areas. The SWOT analysis indicates that Saudi Arabia has a solid research performance in the national priority areas that could support enhancing innovations.
- When considering Saudi Arabia's top funding organizations, we observe several international entities. This reflects the ability of Saudi-affiliated researchers to attract international funding.
- An increase in the percentage of women in research and inventions.

Among the main areas for potential improvement identified:

- Saudi Arabia has a high percentage of international collaboration in research. While valuable, by enhancing domestic research collaborations alongside international collaborations, Saudi

Arabian researchers can further strengthen their contributions to scientific advancements, achieving a balance between international collaboration and locally driven research output.

- Historically, there was no central Saudi Arabian research funding body acknowledged. With the establishment of RDIA in 2021, with central research funding within its remit, RDIA has launched several funding initiatives and allocated several grants focusing on national missions and priority areas. This will further enhance Saudi Arabia's research output within the national strategic RDI priorities.
- In Health and Wellness, we observe an increase in the number of research publications with the potential to improve citation impact performance.
- The percentage of women working in research and inventions could be further increased to reach levels within the proportional representation zone. Saudi Arabia's Vision 2030 focuses on increasing women's participation in all sectors, including research and innovations. The growth observed in the last years is expected to continue, which would support reaching such levels.



Overall, the above findings indicate that Saudi Arabia has a strong basis to achieve its research, development, and innovation aspirations by 2040.

First, Saudi Arabia has already demonstrated strong research performance in its national priority areas, reflecting a firm foundation capable of further enhancing research and innovation in those areas.

Second, Saudi Arabia's already relatively high overall research performance and further enhancing and preserving this performance should reflect positively in several GII metrics such as scientific articles and citation index. This will support Saudi Arabia's aspiration of achieving a position among the top 26 globally in this index.

Third, the dramatic increase in research output and, accordingly, in active Saudi-affiliated researchers form a strong basis for reaching higher levels in the number of researchers employed in Saudi Arabia.

Additionally, the focus on the national

priority areas and underlying research topics will eventually lead to topics in which Saudi Arabia demonstrates global excellence. Saudi Arabia is building the advanced infrastructure necessary to perform cutting-edge research at scale.

For example, RDIA has launched the 'Reactivation and Rebuilding of Existing Labs Initiative' to enhance existing research infrastructure. These efforts, supported by the aim of increasing R&D expenditure, will attract researchers from around the globe to perform research in Saudi Arabia in general and those specific excellence areas.

Finally, national research performance combined with a focus on development and innovation forms a strong basis for enhancing innovation commercialization, ultimately increasing GDP contributions and creating more job opportunities.



KEY FINDINGS

We have analyzed Saudi Arabia's research output and performance over the last 10 years (2014-2023). This study aims to derive comprehensive recommendations to enhance the productivity and quality of research performance. We have used a comprehensive set of metrics to identify strength areas and areas for further development.

The study assesses the research output in terms of volume, growth, citation impact and open-access documents, and also analyzes funding and collaboration dynamics. It further benchmarks Saudi Arabia's research performance against selected countries and regions.

This benchmarking enables the identification of strengths and performance gap areas as well as the quantification of those gaps. The analysis is performed on the overall level of Saudi Arabia's research output and national priorities. Please refer to the full study for information on the dataset used to conduct this study and the metrics.

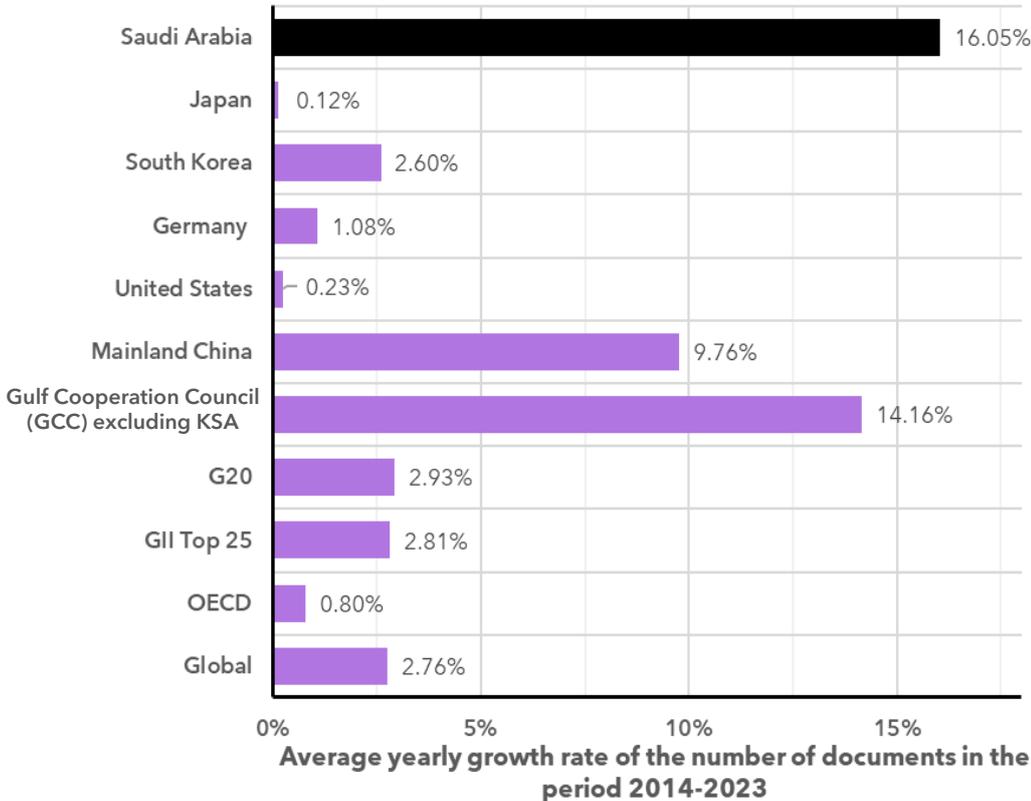


Figure 1: Average yearly growth of the number of documents from the overall research output from 2014-2023.

Research volume

Over the last 10 years, Saudi Arabia’s research output has increased rapidly from around 15,000 to around 56,000 publications, which is an average annual growth rate of around 16% (Figure 1). In parallel, the number of active Saudi Arabian researchers increased by 3.5x from approximately 18,000 in 2014 to approximately 66,000 in 2023 (Figure 2). This is excellent progress towards the RDIA aspiration of 140,000 researchers by 2040. The increase is observed across all national priority areas, with an average annual growth rate higher than the one observed when considering the overall research output.

The highest average annual growth rate is observed in Economies of the Future at 28%, followed by Sustainability and Essential Needs at 25%, Energy and Industrials at 23%, and Health and Wellness at 20%. In parallel, the number of active Saudi Arabian-affiliated researchers in each of the priority areas increased by 9.7x between 2014 and 2023 in Economies of the Future, 8.1x in Sustainability and Essential Needs, 7.2x in Energy and Industrials and 6.5x in Health and Wellness. All of the above reflects not only a significant increase in Saudi Arabia’s research output in general but also the specific focus on the national priority areas.

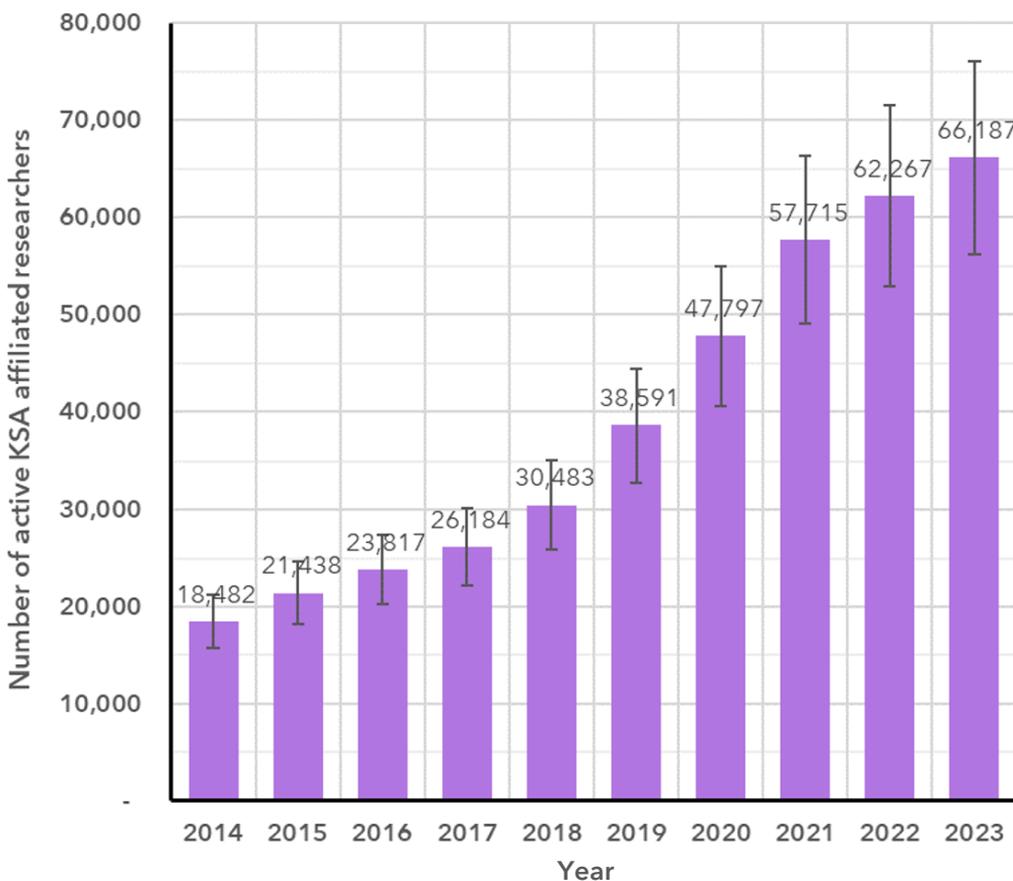


Figure 2: Number of active Saudi Arabian-affiliated researchers.

Citation impact

The citation impact footprint of Saudi Arabia's overall research output in the last 10 years, measured by the category normalized citation impact (CNCI), was 30% higher than the global average (CNCI of 1.3, as shown in Figure 3). This is slightly lower but very close to that of United States and the Gulf Cooperation Council (GCC), excluding Saudi Arabia, and higher than all other considered countries/regions.

30%

higher citation impact footprint of Saudi Arabia than the global average as measured by the CNCI in the period 2014-2023.

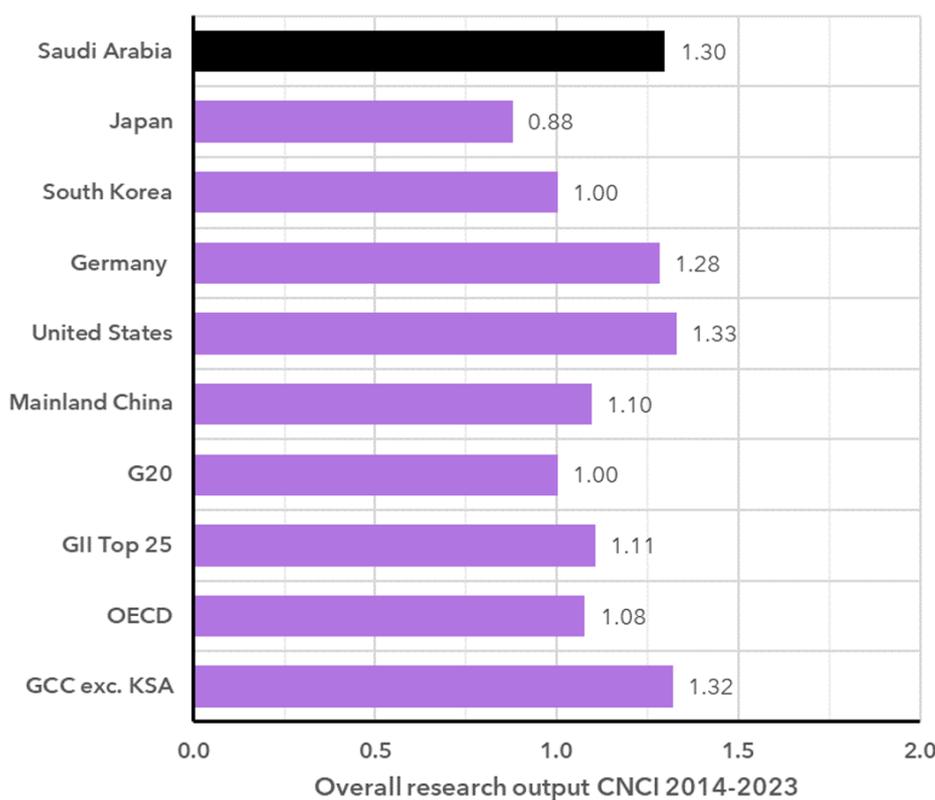


Figure 3: Research output CNCI in the period 2014-2023.

In Health and Wellness, Saudi Arabia's citation impact was 19% higher than the global average, but lower than several comparator countries/regions. This indicates that although Saudi Arabia has a relatively good citation impact performance in this area, it

could be further improved as this is a national priority area. In the areas of Sustainability and Essential Needs, and Energy and Industrials, Saudi Arabia has a citation impact of 57% and 64% (respectively) higher than the global average and higher than all other considered countries/regions. This indicates relatively high citation impact performance in these areas. In the area of Economies of the Future, Saudi Arabia has a citation impact that is 57% higher than the global average, lower than that of the United States and GCC countries, excluding Saudi Arabia, but higher than all other considered countries and regions. Nevertheless, this indicates the strength of Saudi Arabia in this area.

Research excellence

In terms of research excellence measured by the percentage of top 1% and top 10% documents from the overall research output, Saudi Arabia had a high performance with an average percentage of top 1% documents (Figure 4) and an average percentage of top 10% documents (Figure 5), higher than that of all the considered countries/regions. In the areas of Sustainability and Essential Needs, Energy and Industrials and Economies of the Future, Saudi Arabia's research output had a percentage of top 1% and top 10% higher than the global average and all considered countries/regions.

Only in Energy and Industrials was the percentage of top 1% and top 10% slightly lower but very close to that of the United States and GCC countries excluding Saudi Arabia. This demonstrates the research excellence of Saudi Arabia in those areas, as measured by the percentage of top 1% and top 10% documents.

In the area of Health and Wellness, Saudi Arabia has a percentage of top 1% and top 10% documents higher than that of the global average but lower than several of the considered countries/regions.

Accordingly, and in alignment with the citation impact analysis, the research excellence performance in Health and Wellness is relatively good but could be further improved.

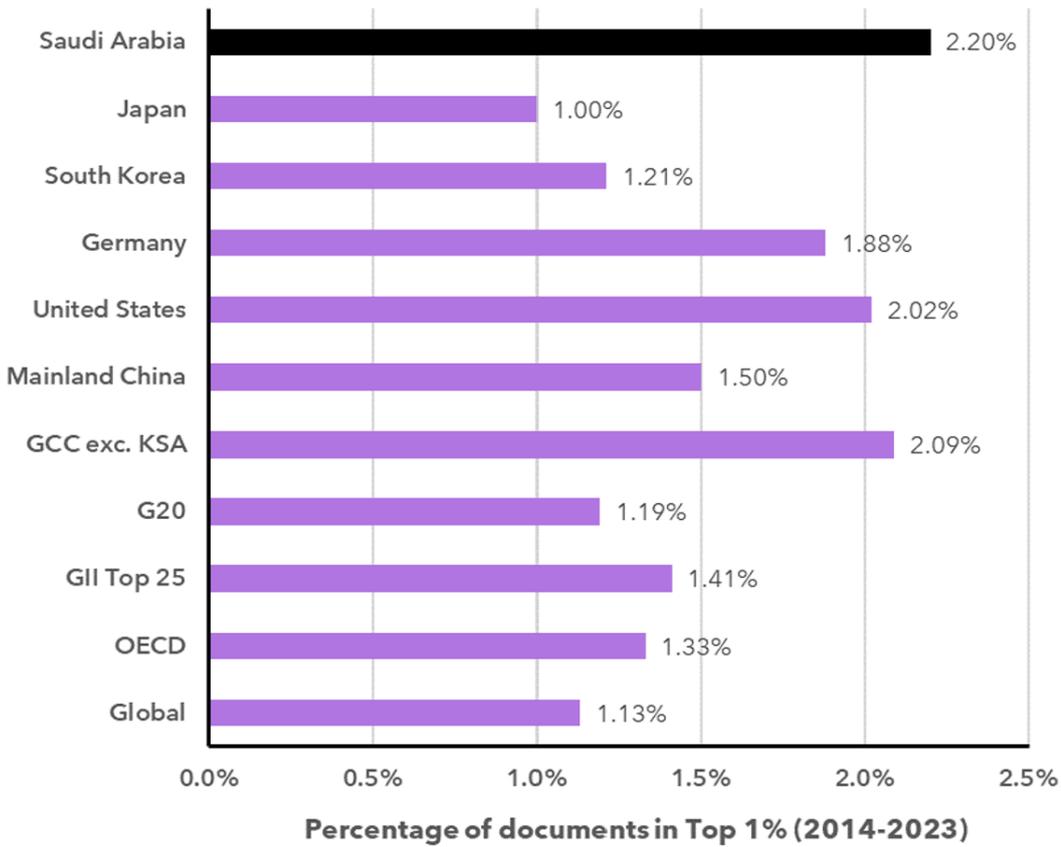


Figure 4:
Percentage of top 1% documents from overall research output in the period 2014-2023.

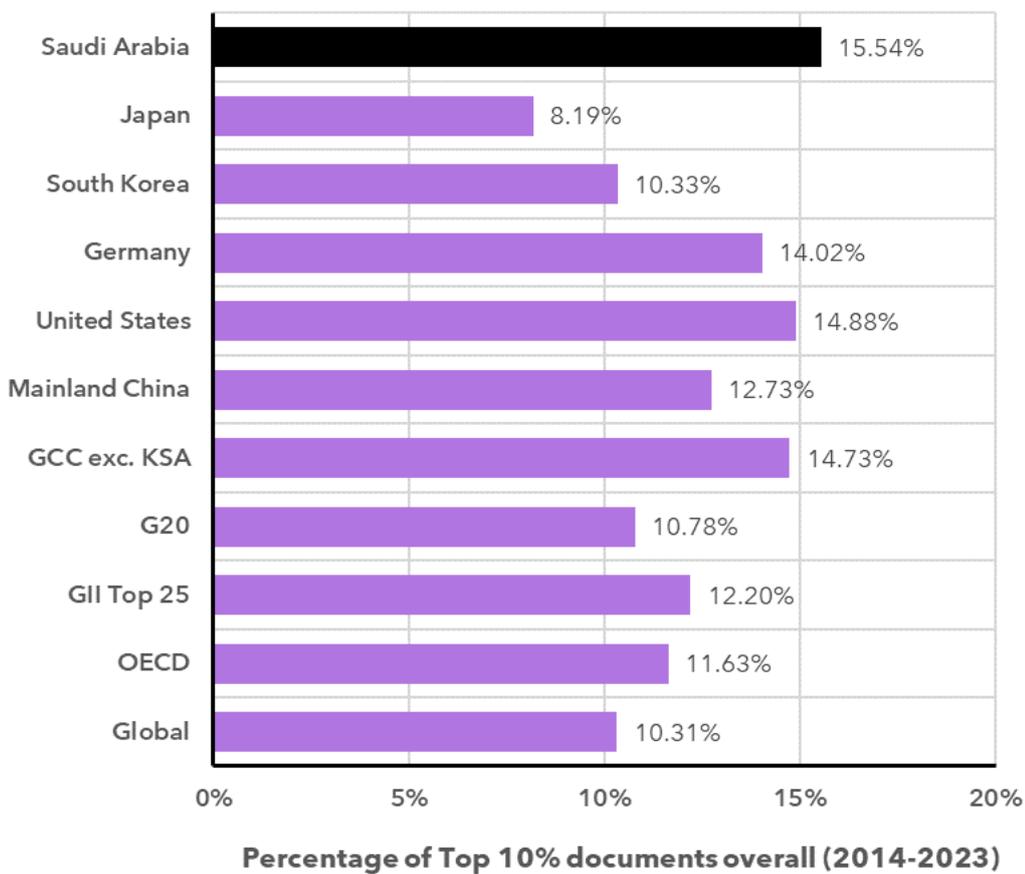


Figure 5:
Percentage of top 10% documents from overall research output in the period 2014-2023.

Research funding

When considering the top 20 funding organizations of Saudi Arabia’s overall research (Figure 6) and in the national priority areas there are several international funding agencies. This reflects the ability of Saudi Arabian-affiliated researchers to attract international funding. On the other hand, no central Saudi Arabian funder is historically found in funding acknowledgments, the main Saudi Arabian funding organizations are academic institutes.

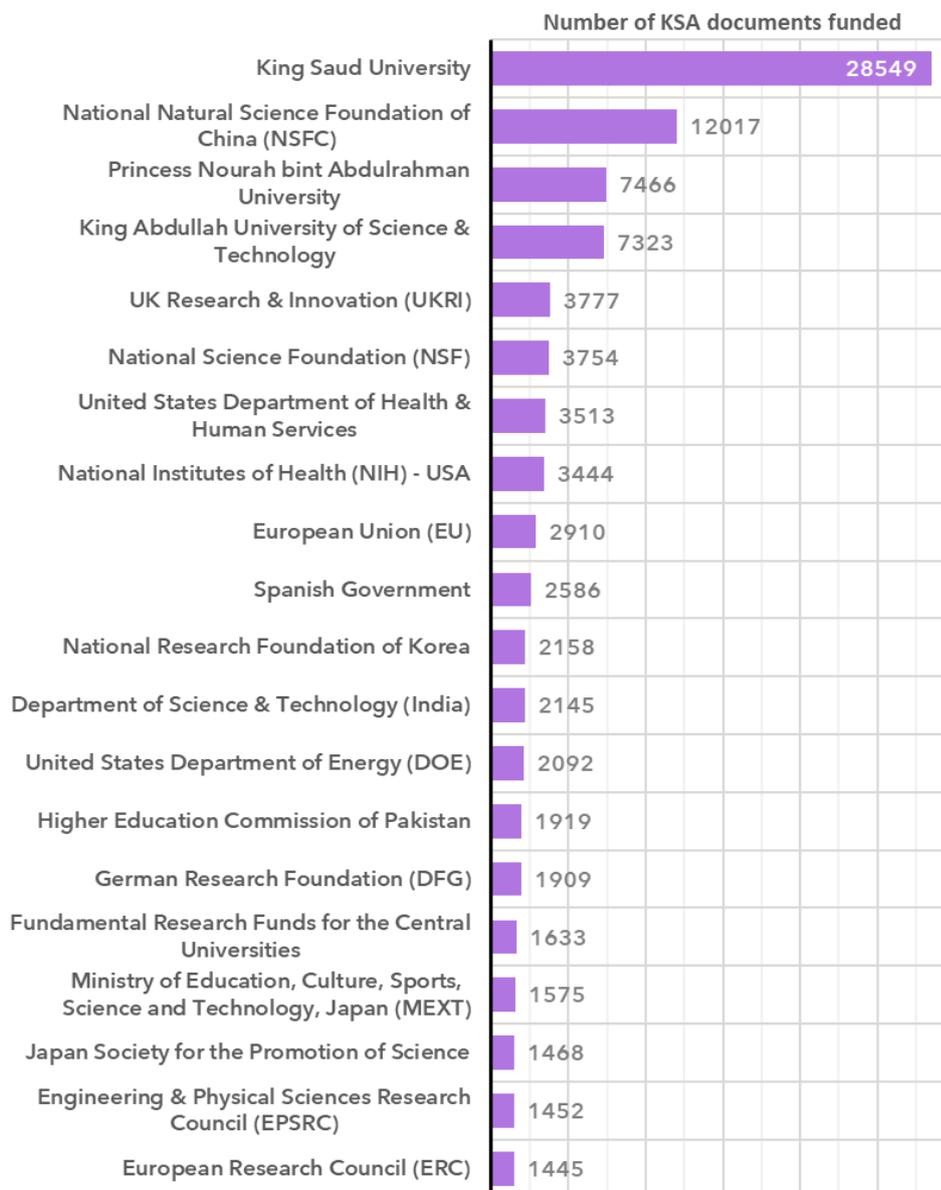


Figure 6: Top 20 funding organizations of Saudi Arabia publications in terms of number of documents in the period 2014-2023.



With the establishment of RDIA in 2021, including responsibilities as a central funding entity, fund distribution can now be aligned with national criteria such as missions, performance and priority areas across all research institutions. For example, RDIA has recently allocated 120m SAR for 100 research groups in the area of Health and Wellness, 135m SAR for 36 research lab infrastructures in the same area, and 120m SAR for research grants within the Sustainability and Essential Needs national priority area. Such funding focused on the national priority areas will further enhance the research output of Saudi Arabia in those areas.

Research collaboration

Saudi Arabia has very high levels of international collaborations when considering its overall research output and in all the national priority areas, with percentages exceeding all of the other considered countries and regions (Figure 7). At the same time, this means that Saudi Arabia has the lowest number of papers with only national affiliations. Having high percentages of international collaborations has several advantages. For example, research with international collaborations enhances research quality and academic reputation, broadens research horizons and resources, addresses global challenges through united efforts and builds international networks.

International collaborations provide global opportunities for two-way knowledge sharing by Saudi Arabia's academia. By enhancing domestic research capacity alongside global partnerships, Saudi Arabian researchers can further amplify their contributions to scientific advancements, achieving a balance between international cooperation and locally driven research output.

The top 3 collaborating countries with Saudi Arabia (Figure 8) in terms of the number of papers when considering the overall research output and the research output in Sustainability and Essential Needs and Economies of the Future are Egypt, India, and Pakistan. In the area of Energy and Industrials, Egypt, Mainland China, and India are the top 3 collaborating countries. In the area of Health and Wellness, Egypt, India and the United States are the top 3 collaborating countries.

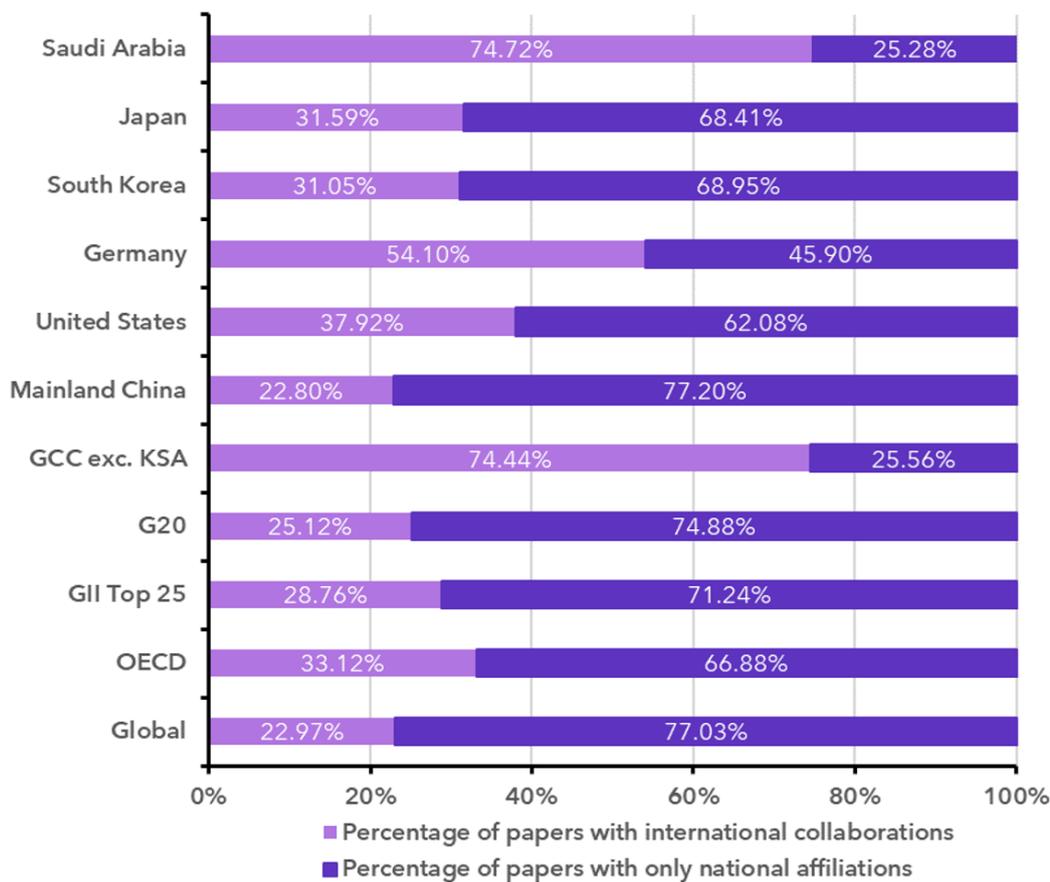


Figure 7: Percentage of papers with an international collaboration or only national affiliations in the period 2014-2023.

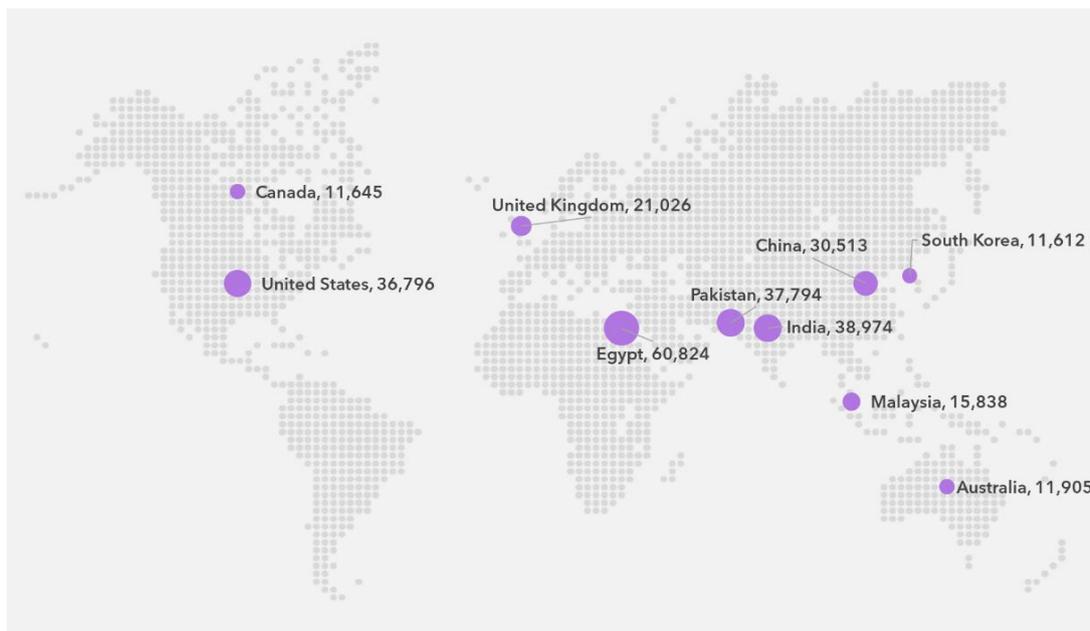


Figure 8: Top 10 countries in terms of number of documents in collaboration with Saudi Arabia in the period 2014-2023.

Open access

The number and percentage of Saudi Arabian open-access documents from the overall research output increased continuously in the period 2014-2023. When considering the overall research output in the period 2014-2023, Saudi Arabia had a higher percentage of open-access documents than those of all considered countries/regions, except for Germany (Figure 9). This high percentage of open-access documents could lead to higher research output visibility, knowledge dissemination, and possibly citations. Similarly, we notice in the priority areas an almost continuous increase in the number and percentage of open-access documents.

While we observe in the areas of Health and Wellness and Economies of the Future a percentage of 73.8% and 63.7% in 2023, respectively, we observe lower percentages in the areas of Sustainability and Essential Needs and Energy and Industrials national priorities of 57.8% and 48.7% respectively. In different disciplines, there could be different dynamics regarding publishing open-access documents, and this could be the reason behind the different percentages observed across the national priority areas.

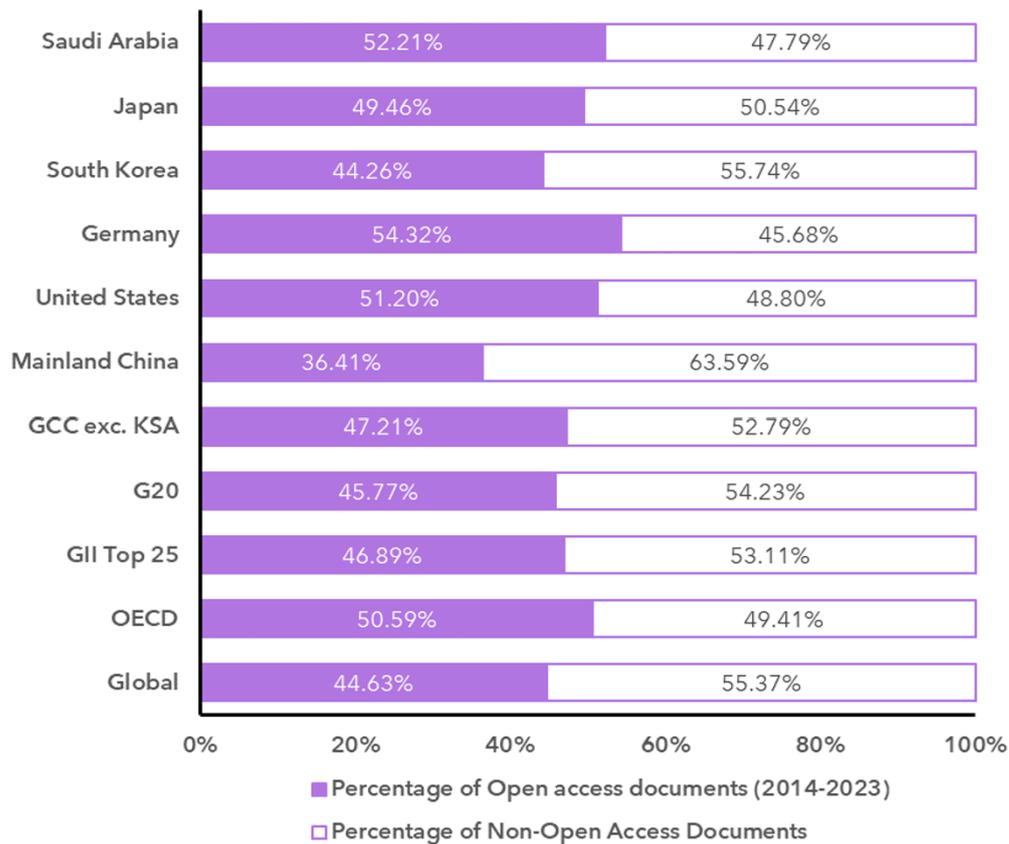


Figure 9: Percentage of open access documents from overall research output in the period 2014-2023.

“All national priority areas are classified as strength areas and most of the research topics constituting those areas are classified as strength or opportunity areas”

SWOT Analysis

The performed SWOT analysis (Figure 10) is based on two main metrics: productivity relative to the global productivity and impact measured by the CNCI. A value above 1 in the first metric, indicates that the country has a share from the world research in this topic higher than the share of the country from the global research in the same period.

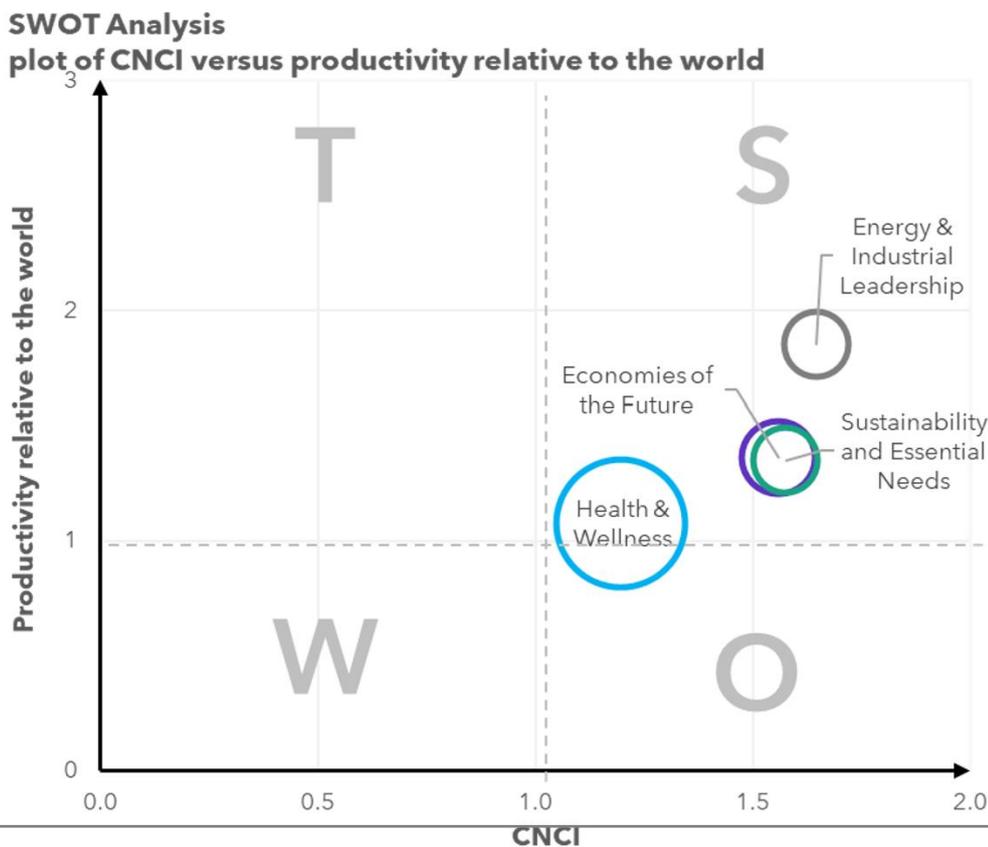


Figure 10: SWOT analysis of Saudi Arabia in the national priority areas. The y-axis shows the productivity relative to the global productivity (share of Saudi Arabia from the global productivity in the national priority area normalized by Saudi Arabia's share of global productivity when considering overall research). The x-axis shows the impact relative to the global average.

A CNCI above 1 indicates a research impact footprint in the research topic higher than that of the global average. A strength area has values above one in both metrics, reflecting a relatively high productivity and citation impact footprint.

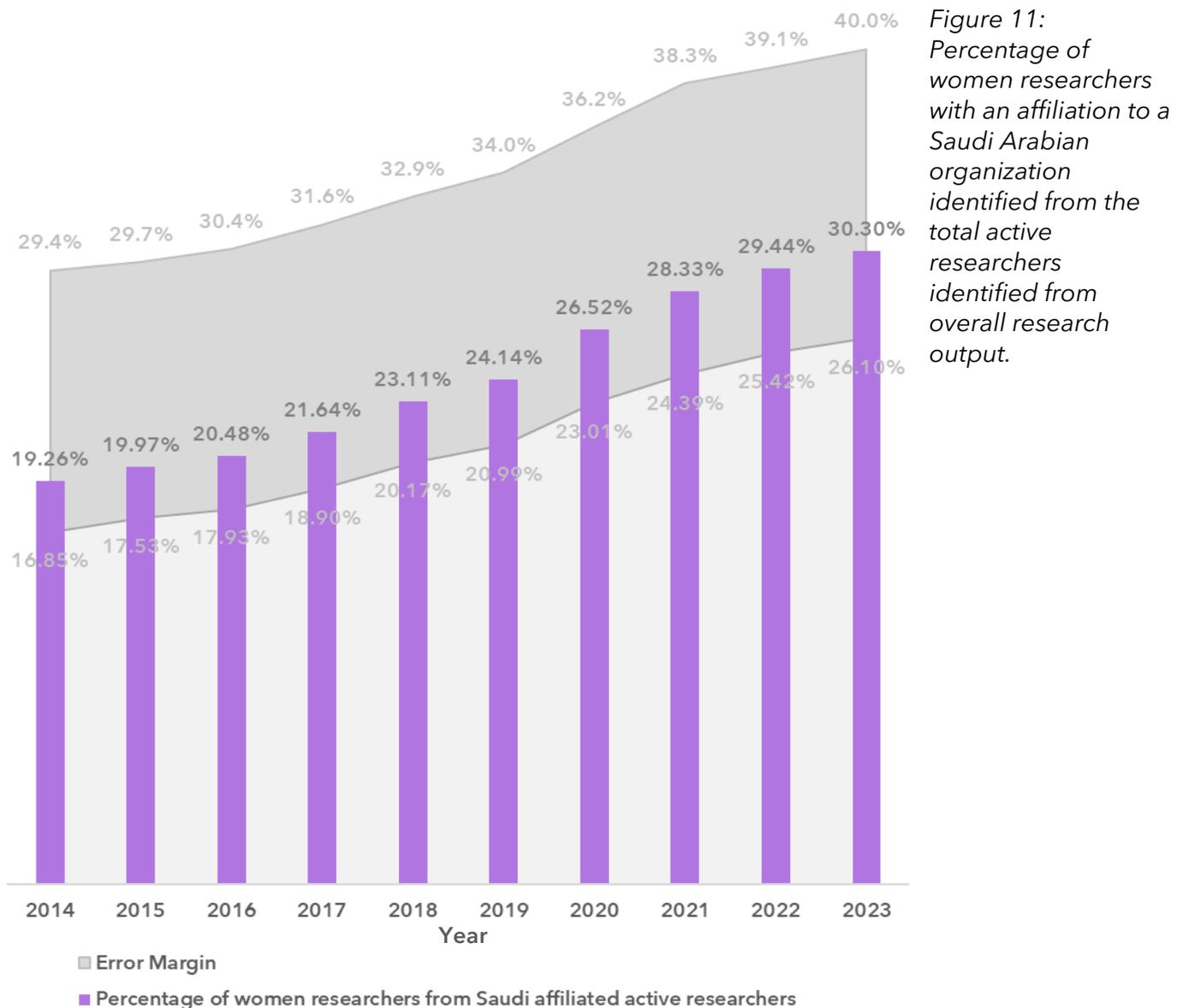
On the other hand, a weakness area would have a value below 1 in both metrics, reflecting a relatively low productivity and citation impact. A threat area would have a relatively high productivity but a relatively low citation impact. An opportunity area would have a high citation impact but low relative productivity.

When considering the national priority areas, all can be classified as strength areas. However, increasing the output of papers in Health and Wellness will be important to preserve the strength status. When investigating the underlying research topics of the national priority areas, we observe that most of them are either strengths or opportunities, and very few are weaknesses or threats. Depending on the priority of a certain research topic, one should consider improving research output and/or impact for those that are currently not classified as strength areas.

Overall, the SWOT Analysis indicates that Saudi Arabia has strong research performance in the national priority areas, which could support enhancing innovations in them.

The percentage of women in research and inventions in Saudi Arabia

The percentage of women researchers in Saudi Arabia has increased continuously in the last 10 years, from 19.3% in 2014 to 30.3% in 2023 (Figure 11). This indicates a huge increase and reflects the efforts made in Saudi Arabia to support women's participation in research.





This also shows that the growth in female active researchers was higher than that of male active researchers in this period. When comparing the compound annual growth rate¹ (CAGR) of the share of active women researchers in Saudi Arabia from 2018-2022 to that of considered G20 countries (Figures 13), we observe that it was more than double than that of the highest value achieved among these countries.

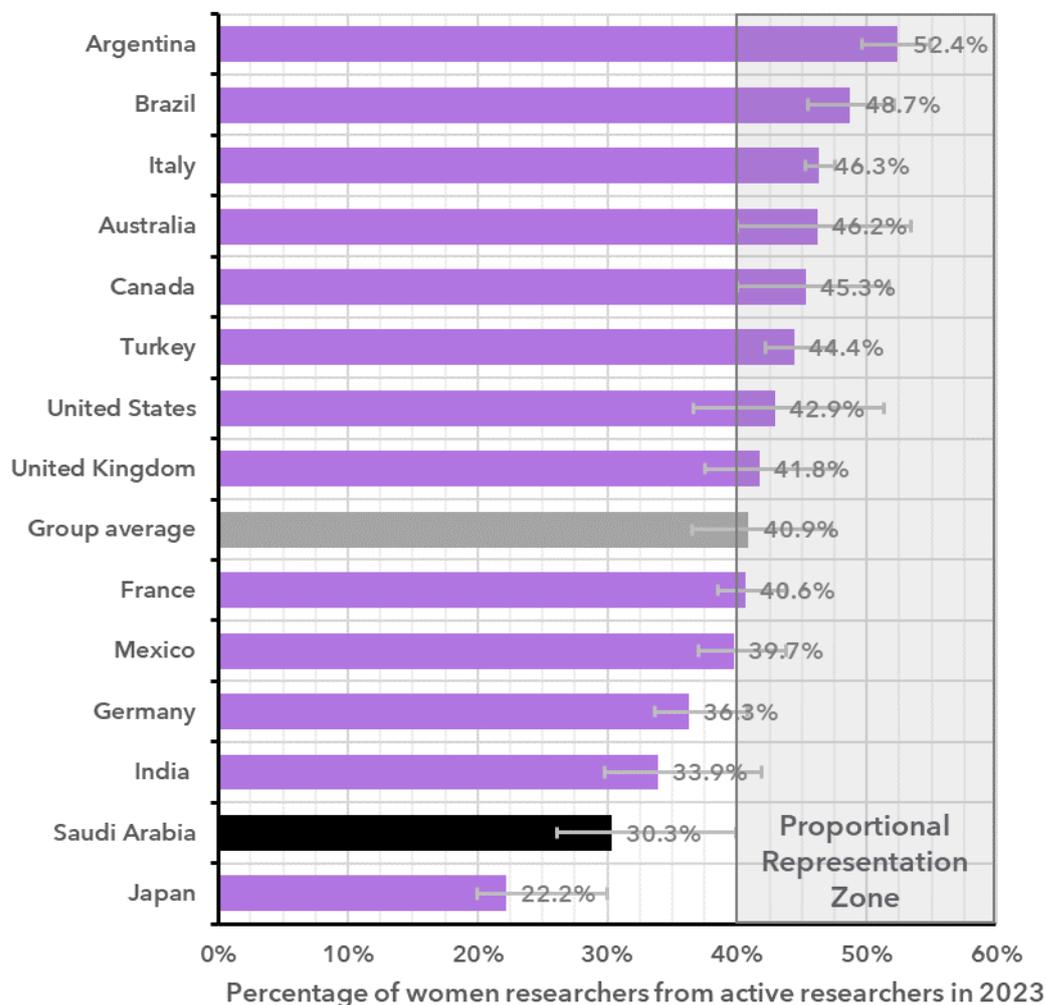
This further confirms the efforts made in Saudi Arabia to increase the participation of women in research.

Continuing this growth in the following years would lead to an increase in the total number of active researchers, and the Kingdom would reach the proportional representation zone (40%-60%). Knowing that Saudi Arabia's CAGR for 2018-2023 is 4.67%, indicating a consistent growth in this metric in 2023.

In the period 2014-2023, the percentage of women researchers from active researchers affiliated with a Saudi Arabian organization was highest in the area of Health and Wellness (32.4%), which was also slightly higher than the one identified from overall research output (31.2%), followed by the percentage in the area of Economies of the Future (26.5%), Sustainability and Essential Needs (19.7%) and Energy and Industrials (17.8%).

¹ The CAGR represents the mean annualized growth rate for compounding values over a given time period. The formula for CAGR is $\left(\frac{V_f}{V_i}\right)^{\frac{1}{T}} - 1$, where V_i is the initial value, V_f is the final value and T is the time period.

Figure 12: Percentage of women researchers affiliated with an organization in the respective G20 country identified from the total active researchers identified from overall research output in 2023. The group average represents the average considering all countries in the figure.



However, in the areas with the lowest percentages, we also observe the highest average growth in the last 10 years. The average yearly growth rate between 2014 and 2023 in Health Wellness was approximately 5%, in Economies of the Future approximately 8.7%, in Sustainability and Essential Needs approximately 9.7%, and in Energy and Industrials approximately 11%.

Continuing with similar growth rates in the following years will lead to a higher percentage. Maintaining a CAGR of approximately 5% in the next five years will lead to approximately 38% of women among active researchers in Saudi Arabia.

Compound Annual Growth Rate of share of women among active researchers (2018-2022)

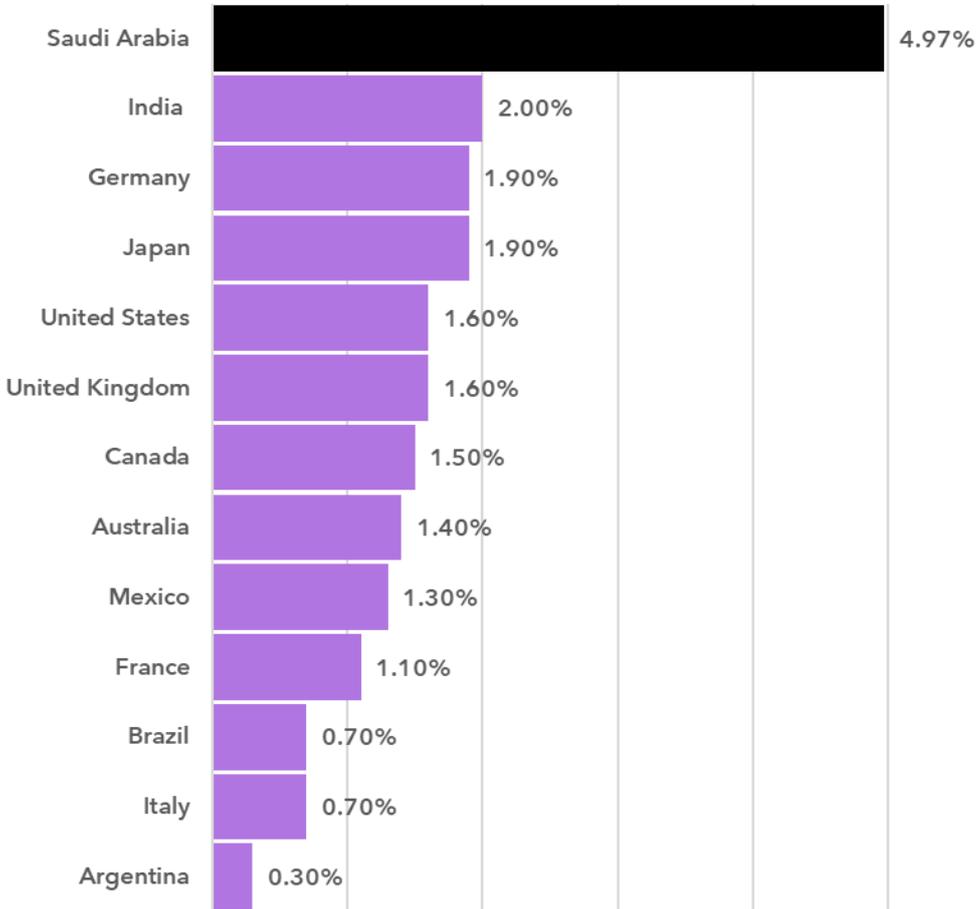


Figure 13: The CAGR of the percentage of women from active researchers in the period 2018-2022. The data for Saudi Arabia is from the current analysis. The data for other countries is from Elsevier's Gender Equality in Research & Innovation Report. The validity of comparing values from different analyses is discussed below.

The percentage of PCT² Applications with one woman inventor increased from 10.1% in 2014 to 23% in 2023, with fluctuations from one year to another but an overall positive trend (Figure 14).

This reflects Saudi Arabia's efforts to increase women's participation in inventions. However, the percentage observed in 2023 could be further improved to the levels exhibited in published research.

² A PCT application is an international patent application filed through the Patent Cooperation Treaty (PCT).



Figure 14: Share of PCT applications with one woman inventor in Saudi Arabia.



KEY OPPORTUNITIES

From the above-identified potential development areas and global practices in the context of research development, the following opportunities could further enhance the research performance in Saudi Arabia:

Enhancing local expertise: Establishing dedicated national research institutes focused on the national priority areas. Such institutes could have the necessary research infrastructure – such as state-of-the-art laboratories and innovation hubs – providing the necessary resources for researchers to conduct cutting-edge studies locally. Local collaboration facilitated by RDIA through initiatives such as the National Semiconductor Hub and the Innovation Districts Alliance ensures the building of local expertise and focus on the national priorities.

Offering further competitive scholarships and research grants specifically targeted at enhancing local expertise within the national priority areas, such as the Young Scholars Grant and the Research Consortium Grant already launched by RDIA within the Saudi Basic Science Initiative and establishing mentorship programs that pair seasoned researchers with early-career academics can also foster a supportive environment for producing high-quality local publications and building local expertise.

Increase the impact of funding: This study underscores the importance of a centralized funding body, a function currently within RDIA's remit. Distributing resources based on national focus areas would help ensure alignment between research activities and the Kingdom's strategic goals. RDIA has already launched several funding initiatives with a focus on the national priority areas. For example, the Saudi Basic Initiative focuses on enhancing basic and fundamental scientific research in the Kingdom, the Saudi Applied Research and Technology Initiative focuses on technology development and commercialization of research output, and the Reactivation and Rebuilding of Existing Labs Initiative aims to enhance existing research facilities in the Kingdom that will lead to increased research output and quality.

Recognizing research excellence in national priorities: Creating national research awards or recognition programs for outstanding contributions in national priority areas can incentivize researchers to focus on topics of national importance and raise awareness in the research community about the importance of those research topics.

Increasing participation of women in research and inventions: To further increase the participation of women in research and innovation, short-term and long-term strategies will ensure consistent progress. In the short term,

integrating gender considerations within the processes and mechanisms used to allocate funding to research and innovation could be a powerful tool to drive change. In the long term, mandating gender equality plans (GEPs) would go one step further by requiring individual institutions to reflect on the status of gender equality within their own organizations and take action where this is needed.



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