publications

MDPI

Article

The Transformative Patent Landscape in Saudi Arabia Since the Saudi Vision 2030 Announcement

Mohammed Abdulfasi

Innovation & Technology Transfer Unit, Research Administrative Operations Department, King Faisal Specialist Hospital & Research Centre, Riyadh 11211, Saudi Arabia; mabdul1@kfshrc.edu.sa

Abstract: This study analyzes the patent landscape of Saudi Arabia from the announcement of Saudi Vision 2030 in late April 2016 to September 2024, utilizing the Patsnap database to evaluate patent grants across various organizations. The findings reveal a gradual increase in patent registrations, with Saudi Aramco leading in patent grants, followed by King Faisal University (KFU), King Fahd University of Petroleum and Minerals (KFUPM), King Abdullah University of Science and Technology (KAUST), and King Abdulaziz University (KAU). SABIC, a prominent industry player in Saudi Arabia, has registered most of its patents using its European Head Office address and holds extensive collaborations with international partners, generating numerous patents. The analysis identifies the top patent offices where KSA organizations seek protection, including the United States Patent and Trademark Office (USPTO), Saudi Authority for Intellectual Property (SAIP), European Patent Office (EPO), the China National Intellectual Property Administration (CNIPA), and the German Patent and Trade Mark Office. However, the limited number of registrations at the SAIP highlights a need for improvement. The primary application domains encompass borehole/well accessories, measurement devices, organic chemistry, computing, and chemical/physical processes. The landscape reveals that Saudi Aramco and KFUPM focus predominantly on upstream and downstream technologies, while KAU, KFU, and KAUST concentrate on life sciences. Key findings indicate a significant increase in patent activity since the vision announcement, suggesting a growing focus on innovation within Saudi Arabia. However, the concentration of patents among a few major players (Saudi Aramco and SABIC) and the underrepresentation of patents filed with the Saudi Authority of Intellectual Property (SAIP) highlight areas for improvement. This study emphasizes the necessity to support small and medium enterprises (SMEs) and healthcare research institutions to foster broader participation in innovation and protect novel technologies. This research contributes valuable insights into the current state of patenting activities in Saudi Arabia and outlines opportunities for enhancing the country's innovation ecosystem.

Keywords: patent landscape; Saudi Arabia; Saudi Vision 2030; patents; innovation; technology domains; intellectual property; knowledge based; research institutions

Citation: Abdulfasi, M. The Transformative Patent Landscape in Saudi Arabia Since the Saudi Vision 2030 Announcement. *Publications* **2024**, *12*, 47. https://doi.org/10.3390/publications12040047

Academic Editor: Andrew Kirby

Received: 7 October 2024
Revised: 28 November 2024
Accepted: 3 December 2024
Published: 6 December 2024

1. Introduction

Patent data serve as a key indicator of technological advancement and innovation within a nation or organization. They provide a tangible metric for measuring the output of research and development (R&D) activities, allowing insight into the invention process and its outcomes [1]. For nations like Saudi Arabia, especially after the announcement of Saudi Vision 2030, patent data hold significant importance in tracking progress toward becoming a knowledge-based economy, reducing dependence on oil, and encouraging innovation across multiple sectors [2]. By studying patent data for organizations based in the Kingdom of Saudi Arabia (KSA), we can assess the effectiveness of policies aimed at fostering innovation, identify emerging technologies, and measure the country's competitiveness on the global stage. Saudi Vision 2030, a strategic framework launched in 2016, outlines the Kingdom's ambition to diversify its economy and reduce its reliance on oil revenue

by fostering growth in other sectors such as renewable energy, biotechnology, healthcare, and information technology [3]. The vision emphasizes the role of innovation in achieving these goals, with patents being a key metric to gauge innovation activities [4]. Patents represent a bridge between scientific research and commercial applications, showcasing the transformation of novel ideas into protected intellectual property that can lead to economic growth and competitive advantages [5]. Patent data are a comprehensive resource for understanding innovation from both a national and organizational perspective [6]. By analyzing patent filings, it becomes possible to identify which sectors are experiencing technological growth, where R&D investments are concentrated, and which organizations are leading in innovation [7]. Patents are particularly valuable as they provide a legal framework for protecting inventions, encouraging inventors and organizations to invest in developing new technologies with the assurance of exclusive rights over their inventions for a specified period [8]. There are several reasons why patent data are essential for analyzing innovation:

- Patents provide insights into emerging technologies and areas of technological growth. Each patent represents a unique solution to a problem, signifying progress in scientific knowledge and industrial applications [9]. By examining patent trends, it is possible to gauge which industries or sectors are experiencing rapid innovation;
- Patents have a direct relationship with economic performance. They serve as an asset to organizations by granting them the exclusive right to commercialize inventions [10]. This not only encourages further investment in R&D, but also has the potential to create new markets, generate revenue, and boost national competitiveness [11]. For KSA, focusing on innovation-driven sectors is central to achieving its Vision 2030 goals;
- Patent data can highlight the areas in which organizations are investing their resources [12]. For example, the number of patents filed in a particular technology or industry can reflect the strategic priorities of companies or national research institutes [13]. In the KSA, an analysis of patent data since the Vision 2030 announcement can reveal which industries are being prioritized and how these investments align with the broader economic diversification strategy.

Patents are global assets, with inventions often filed in multiple jurisdictions to maximize protection [14]. By examining patent filings from organizations in the KSA at international patent offices, it becomes possible to measure the country's competitiveness on a global scale. A rising number of patents filed abroad, especially in regions with robust innovation ecosystems such as the United States, Europe, and Asia, indicates that KSA-based entities are playing an increasingly important role in global technological advancement. Saudi Vision 2030 is a transformative initiative aimed at diversifying the Kingdom of Saudi Arabia's economy and reducing its dependency on oil [15]. A central component of this ambitious plan is fostering innovation and research-driven growth across various sectors [16]. The vision outlines a strategic framework to build a knowledge-based economy, in which research, development (R&D), and innovation are prioritized. The goal is not only to create sustainable economic growth, but also to position Saudi Arabia as a global leader in technology and science [17]. One of the key pillars of Saudi Vision 2030 is the promotion of R&D activities across sectors such as healthcare, energy, and digital technologies [18]. Historically, Saudi Arabia's economy has been predominantly reliant on the oil and gas sector, which has significantly contributed to the country's gross domestic product (GDP). While these resources remain a critical part of the nation's wealth, the Vision 2030 strategy seeks to leverage human capital and technological advancements to drive long-term economic diversification [19]. This shift has led to increased investments in emerging sectors such as renewable energy, biotechnology, artificial intelligence (AI), nanotechnology, and information and communication technology [20]. Universities and research institutions have been integral to this process, with increased funding for research and greater collaboration with private-sector companies. The focus on research and innovation aligns with the broader global trend of using intellectual property to enhance competitiveness and create economic value [21]. National innovation performance is driven by combinations of

factors, particularly R&D investment and human capital, with globalization and country affluence also being critical [22]. Globalization is known to significantly accelerate digital technology adoption through technology transfers and spillovers, supporting nations in achieving technological convergence and fostering innovation [23].

Patent data play a crucial role in tracking the progress of Saudi Vision 2030's innovation objectives. As a key performance indicator (KPI), they provide a measurable gauge of technological advancements and highlight the sectors leading R&D efforts in Saudi Arabia. By examining patent filings, researchers and policymakers can assess the country's transition toward a knowledge-based economy and identify the technologies emerging as top priorities. The volume of patents reflects the pace of innovation, while the nature and scope of these patents offer insights into where Saudi organizations are seeking to establish competitive advantages. For example, increases in patents related to AI, renewable energy, and biotechnology suggest alignment with global trends, and international patent filings indicate a growing focus on global competitiveness. Furthermore, patent data reveal insights into collaboration within the Kingdom's innovation ecosystem. Co-filed patents between academia, research institutions, and private companies demonstrate the flow of knowledge transfer contributing to market-driven technologies, which is central to Vision 2030. This research highlights the sectors gaining momentum and underscores Saudi Arabia's expanding role in the global knowledge economy. Additionally, the Kingdom is increasingly collaborating with international organizations, research institutions, and technology companies to exchange expertise and jointly develop new technologies. These collaborations, often formalized through joint patents and co-authored papers, reflect the growing interconnectedness of Saudi Arabia's innovation ecosystem with global R&D networks. Such partnerships not only enhance the capabilities of Saudi organizations, but also position the Kingdom as a significant player on the global innovation stage.

2. Research Methodology

This research analyzes the patent data of organizations based in the Kingdom of Saudi Arabia (KSA) following the announcement of Saudi Vision 2030 on 25 April 2016. The data span from 1 May 2016 until the end of September 2024, focusing on patent filings by KSA-based organizations. Patent data were be sourced from Patsnap, a comprehensive patent database that provides in-depth patent landscape analysis and insights into the technological advancements being protected by patents in specific domains. The analysis was based on the query: "APD: [20160501 TO 20240930] AND ANC_COUNTRY:(SA)", which generated the patent families assigned to organizations based in Saudi Arabia from the patent application filing date starting on 1 May 2016, to 30 September 2024. The chosen timeframe captures the full range of innovation activities post-Saudi Vision 2030, offering comprehensive insights into the Kingdom's technological advancements.

This study used a simple patent family approach to analyze inventions. This means that all related patents stemming from the same original invention are grouped together into a 'family', and only one representative patent from each family is counted. We used simple patent families, rather than extended families, to avoid counting the same invention multiple times. This provided a more accurate picture of true technological developments within the Kingdom. Patsnap's patent landscape visualization tool was leveraged to explore how KSA organizations are protecting their technologies in specific fields. This included identifying key technology domains where patents are filed and understanding the strategic directions taken by organizations in their R&D efforts. This study also examined the growth in patent filings since May 2016, providing insights into the progress of the Kingdom's innovation ecosystem in line with the goals of Saudi Vision 2030. Additionally, the research investigated the geographical distribution of patent filings, highlighting the top patent offices where KSA-based organizations are registering their patents, thereby shedding light on the global ambitions of Saudi innovators and potential commercialization markets. This study also assessed the extent of collaboration between Saudi organizations and international counterparts by analyzing co-filed patents and joint applications. This aspect

captured the broader network of innovation and knowledge exchange, showcasing Saudi Vision 2030's ambition to position the Kingdom as a global leader in technology and innovation. The results of this analysis provide a comprehensive understanding of how KSA-based organizations are contributing to the country's technological progress and long-term economic diversification.

In summary, this study analyzed patent data of KSA-based organizations from the announcement of Saudi Vision 2030 until the end of September 2024, using Patsnap. We employed a simple patent family approach to identify and analyze distinct inventions. The analysis utilized Patsnap's patent landscape visualization tool to explore technology domains, growth trends, the geographical distribution of patent filings, and international collaborations.

3. Results and Discussion

The search results identified a total of 16,318 simple patent families. These families are composed of various types of intellectual property, including 6361 granted patents, 5958 patent applications that have been published but are still under examination, 3736 industrial designs, and 263 utility models. However, since the focus of this research is on analyzing patent activity, particularly granted patents, we narrowed down the data to only those patents that have been granted and remain active and enforceable. This ensured that the analysis reflected ongoing innovation efforts and excluded patents that have expired or are no longer in force. From the total dataset, 5574 patent families contain granted patents that are both active and enforceable. These patents represent a total of 11,803 granted patents across different patent offices worldwide. To maintain simplicity and avoid duplication, this research focused on just one patent from each simple patent family, instead of analyzing all patents within a single family. This method provided a clearer understanding of the distinct innovations that Saudi organizations are protecting, rather than inflating the data with multiple related patents filed in different regions. By focusing on a single representative patent per family, the analysis can better capture the core technological advancements and areas of R&D where Saudi organizations are actively seeking protection for their innovations. This approach ensured a streamlined analysis of patent activity in Saudi Arabia since the launch of Vision 2030, providing insight into the country's growing focus on fostering a knowledge-based economy. It highlights the technological domains in which Saudi organizations are concentrating their efforts and demonstrates how they are leveraging intellectual property to secure a competitive edge in the global innovation landscape.

The patent grants to organizations based in Saudi Arabia, represented by one granted patent per patent family, have shown a remarkable upward trend since the announcement of Saudi Vision 2030 in 2016. In that year, there was only 1 patent grant, marking the beginning of this transformative phase. The numbers steadily increased in the following years, with 22 grants in 2017 and 48 in 2018, indicating a growing engagement in research and development activities. A more significant rise can be observed in 2019 with 134 patents granted, followed by a notable surge in 2020 with 193 patents. This upward trajectory accelerated in 2021 with 434 granted patents, and then doubled in 2022 with 1038 patent grants. The momentum continued into 2023 with 1652 patents, and as of the end of September 2024, the number had already reached 1994. This steady growth illustrates KSA-based organizations' increasing focus on innovation and intellectual property protection as part of the Kingdom's Vision 2030 strategy. The data clearly show an exponential rise in patent activity, which is indicative of Saudi Arabia's commitment to diversifying its economy and investing in new technology sectors. The trend is visually represented in Figure 1, which further emphasizes this upward shift in patent grants.

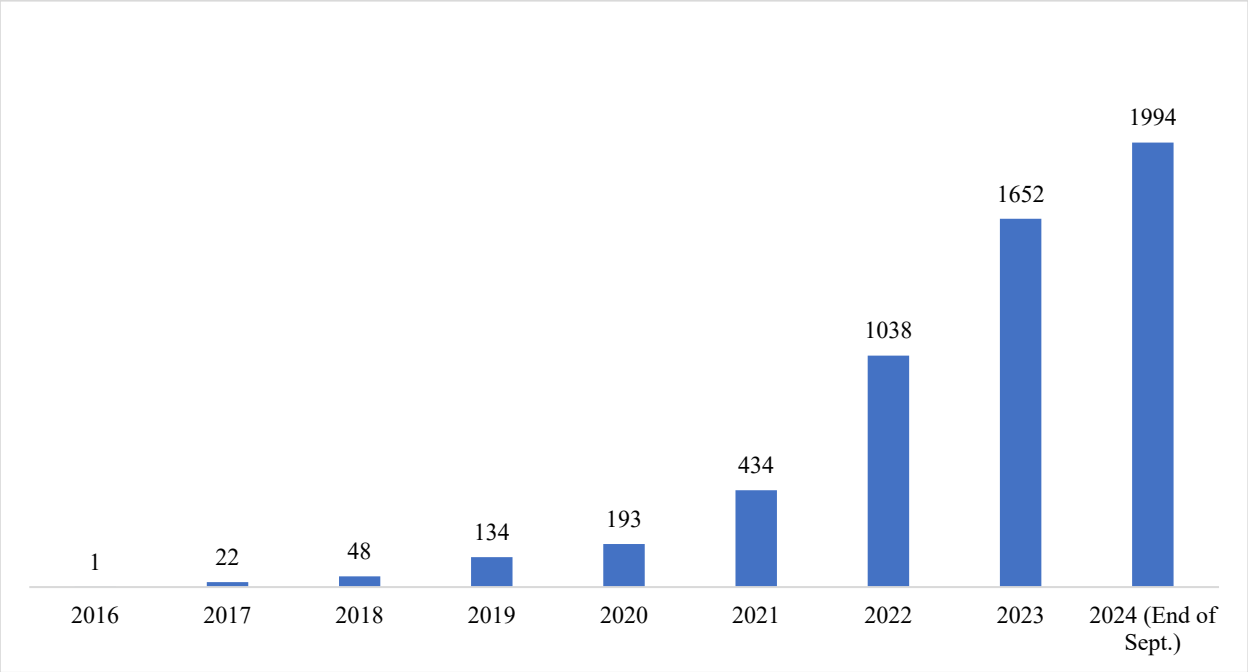

Figure 1. Annual patent grants to Saudi Arabia-based organizations (2016–September 2024).

The standardized assignee data offer valuable insights into the organizations driving innovation and technological advancement in Saudi Arabia, as illustrated in Figure 2. These data highlight the top patent assignees within the Kingdom, reflecting their commitment to research and development (R&D) and their strategic focus on intellectual property. The Saudi Arabian Oil Company (Saudi Aramco, Dhahran, KSA) leads significantly with 3039 patent grants, positioning itself at the forefront of technological advancements in energy production. Aramco's innovation strategy is bolstered by collaborations with local partners such as King Fahd University of Petroleum and Minerals (KFUPM, Dhahran, KSA) King Abdullah University of Science and Technology (KAUST, Thuwal, KSA), and Alfaisal University (Riyadh, KSA), as well as international partners like Korea Advanced Institute of Science and Technology (KAIST, Daejeon city, Yuseong-gu, Republic of Korea), the University of Durham (Durham, UK), and Schlumberger Technology Corp (Houston, TX, USA). These partnerships facilitate knowledge transfer and foster advancements across various technological fields. Following Saudi Aramco, King Faisal University (Al-Ahsa, KSA) ranks second with 525 patents, focusing on applied research across multiple disciplines, while interestingly, all its patents are solely assigned, indicating no partnerships with either local or international entities for patent registration. King Fahd University of Petroleum and Minerals, with 493 patents, is known for its specialized programs and emphasizes partnerships that drive real-world research initiatives. Its local partners include Saudi Aramco, the King Abdulaziz City for Science and Technology (KACST, Riyadh, KSA), and KAUST, while international collaborations involve prestigious institutions such as MIT, Yokogawa, and S-Oil Corporation. King Abdullah University of Science and Technology (KAUST) holds 367 patents and is recognized for its interdisciplinary research, often partnering with various local and global entities to enhance its research capabilities. King Abdulaziz University (KAU, Jeddah, KSA) has 273 patents, contributing broadly to various fields, while King Saud University (KSU, Riyadh, KSA), with 176 patents, focuses on health and environmental sciences. Imam Abdulrahman Bin Faisal University (IAU, Dammam, KSA) showcases its commitment to innovation with 129 patents, while King Abdulaziz City for Science and Technology plays a critical role in fostering scientific research with 94 patents. Additionally, Prince Mohammad Bin Fahd University (PMU, AlKhobar, KSA) and King Saud Bin Abdulaziz University for Health Sciences (Riyadh, KSA) have registered 40 and

35 patents, respectively. Together, these organizations exemplify Saudi Arabia's growing emphasis on R&D and innovation, aligning with the strategic goals of Saudi Vision 2030 and contributing to a more sustainable, technologically advanced future for the Kingdom.

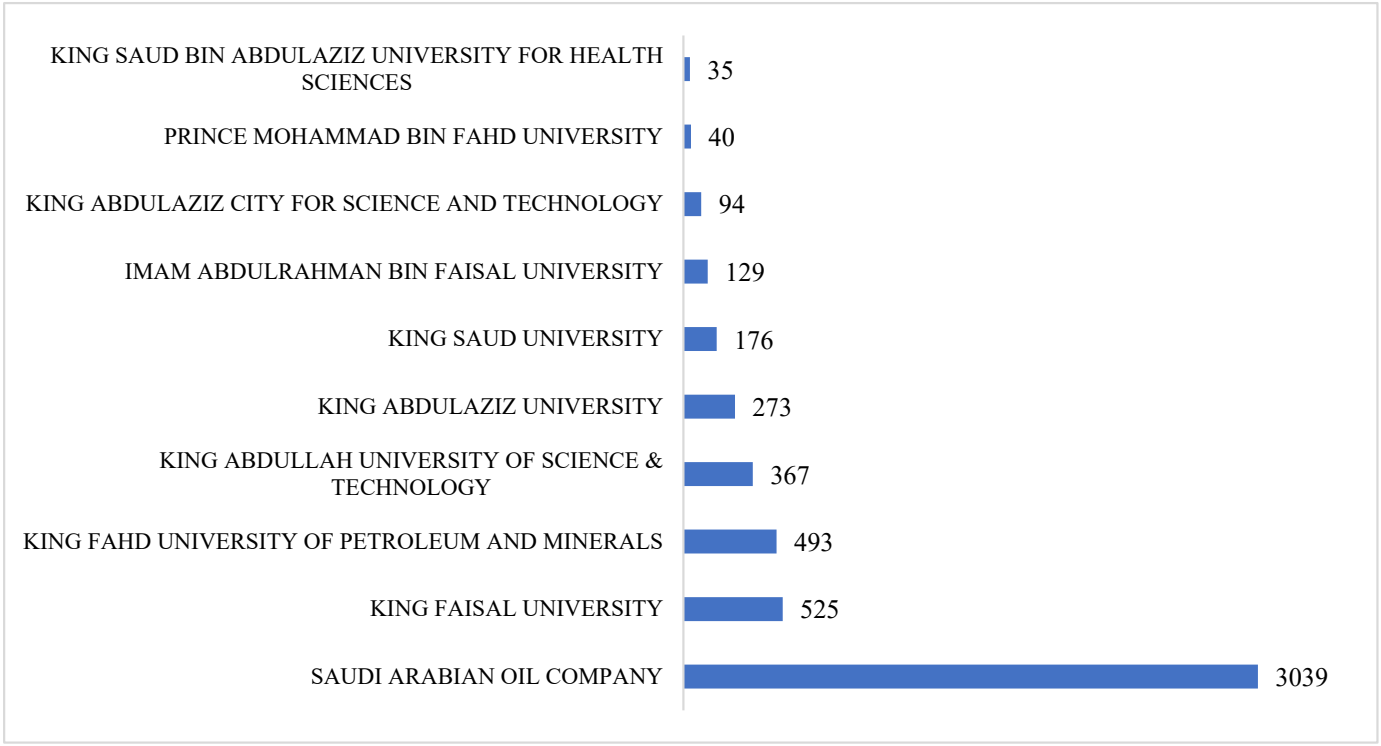

Figure 2. Top KSA-based organizations listed as assignees.

Interestingly, Saudi Basic Industries Corporation (SABIC, Riyadh, KSA), one of the largest petrochemical companies globally, is not present in the list of the top KSA-based patent assignees. This absence prompted a further investigation using the Patsnap database to identify patent grants assigned to SABIC within the same timeframe. The results indicated that the SABIC European Head Office was predominantly listed as the assignee for many of the patents, primarily due to its operations and filings being conducted through its European branches. Consequently, this led to the search results not capturing the patents associated with SABIC directly in the context of KSA-based organizations. Upon closer examination, it was found that SABIC holds a total of 910 patent families within the specified range, resulting in 3211 extended individual patents protected across various patent offices. Notably, the Netherlands address was used in 793 patent families, indicating a strong European presence in its patenting strategy. Additionally, SABIC's registered patents during this period include significant collaborations with various co-assignees, such as the Scientific Design Company (Bergen County, NJ, USA), Dalian Institute of Chemical Physics (Dalian city, Liaoning, China), Ecolab (Saint Paul city, MN, USA), Exatec (Chaska city, MI, USA), BASF (Ludwigshafen city, Rhineland-Palatinate, Germany), TRUCAPSOL (Bethlehem, PA, USA), and BOREALIS (Vienna, Austria). Notably, SABIC has a strong and fruitful partnership with Scientific Design, resulting in numerous patents related to Ethylene Oxide-based technologies. This collaboration has yielded significant advancements in the processes for the production of Ethylene Oxide (EO), Ethylene Glycol (EO/EG), Bio-Ethylene, Bio-EO, Bio-EG, EO derivatives, Polyols, and Maleic Anhydride. Surprisingly, local partnerships for SABIC with KSA universities and institutions were quite few, reflecting a limited engagement in collaborative R&D initiatives within the Kingdom. This lack of collaboration underscores SABIC's emphasis on international partnerships, suggesting that there is significant potential for growth in forming local

academic collaborations. By engaging more with universities and research institutions within Saudi Arabia, SABIC could enhance its innovation and technology development efforts in the Kingdom, ultimately contributing to the national goals outlined in Saudi Vision 2030.

Analyzing the International Patent Classification (IPC) codes of top Saudi Arabian organizations offers valuable insights into their research and innovation priorities. The IPC provides a hierarchical system for classifying patents and utility models according to the different areas of technology to which they pertain. Essentially, it is a standardized way of categorizing inventions, making it easier to identify trends and compare technological focuses across different entities. In the industrial sector, SABIC's dominance in polymer chemistry and macromolecular compounds is immediately apparent. Their patent activity centers around IPC codes like C08L (compositions of macromolecular compounds), C07C (acyclic or carbocyclic compounds), and C08G (macromolecular compounds obtained through diverse polymerization techniques). This focus aligns with their global leadership in petrochemicals and their drive to develop innovative polymer materials. Meanwhile, Saudi Aramco's portfolio reflects both their core business in oil and gas (E21B, earth or rock drilling) and a diversification strategy that encompasses materials science (C09K) and geophysics (G01V).

Turning to academia, we see a different set of priorities. King Faisal University demonstrates a clear focus on medical and pharmaceutical research, with prominent IPC codes including A61P (therapeutic activity of chemical compounds), C07D (heterocyclic compounds), and A61K (preparations for medical or dental purposes). Interestingly, this focus on A61K is mirrored in KAU's top IPC code, suggesting a shared interest in pharmaceutical formulations and drug delivery systems. KFUPM, on the other hand, displays a more diverse research portfolio, with strengths in materials science (C09K), chemical processes (B01J), and energy technologies (E21B). This echoes Saudi Aramco's interests in materials science and energy, highlighting a potential area for collaboration and knowledge transfer between industry and academia. Finally, KAUST carves its own niche with a leading IPC code of B01D (separation), indicating a focus on chemical engineering and separation technologies, a field with potential applications across various industries. These variations in IPC code prominence underscore the diverse research and innovation landscape within leading KSA organizations, showcasing a nation striving for progress across a multitude of technological frontiers.

3.1. Patent Protection Across Key Global Markets

The analysis of patent registrations sheds light on the leading patent offices where KSA-based organizations are securing protection for their innovations. The dataset for this examination includes 5574 simple patent families, translating into 11,803 ungrouped patents. Ungrouped patents refer to multiple filings for the same invention across different jurisdictions to ensure comprehensive intellectual property protection. This approach is essential for companies and inventors who want to prevent the unauthorized use or replication of their technologies across various markets. By filing patents in multiple regions, organizations not only safeguard their innovations, but also gain access to broader commercialization opportunities. The United States Patent and Trademark Office (USPTO) emerges as the most favored destination for patent registrations, with a significant 7756 granted patents. This reflects the importance of the U.S. market, recognized for its strong innovation landscape, business opportunities, and strategic value. The high number of patent filings in the U.S. indicates that KSA-based organizations are focused on protecting their technologies in one of the world's most competitive and lucrative markets. Next, the Saudi Authority of Intellectual Property (SAIP) Office recorded 1929 patents, illustrating a clear focus on bolstering local innovation within the Kingdom as part of Saudi Vision 2030's goals to foster homegrown R&D and technology development. The European Patent Office (EPO) follows with 554 patent filings, signaling that KSA-based organizations are also targeting European markets, which provide access to a wide range of commercial and legal

advantages within the EU. Furthermore, China and Germany also feature prominently in the dataset, with 297 and 293 patents, respectively. Filing in China reflects a strategic effort to tap into the world's second-largest economy, while Germany's position highlights its role as a major technological hub in Europe. Figure 3 provides a clear visual breakdown of this distribution, showcasing the global spread of KSA-based patents and highlighting the key jurisdictions where protection is sought.

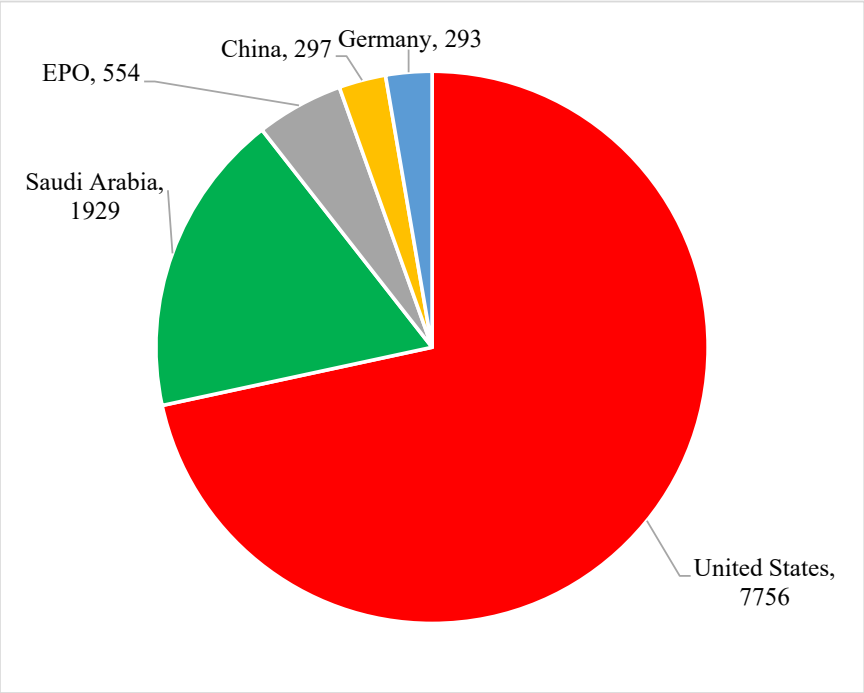

Figure 3. Distribution of patent registrations by top patent offices for KSA-based organizations.

To expand on the analysis of patent registrations, we can explore deeper into the strategies employed by key KSA-based organizations, illustrating their use of various global patent offices to protect their technologies across multiple jurisdictions. This approach highlights the significance of safeguarding intellectual property not just locally, but on a global scale, especially for organizations that seek to commercialize their innovations in diverse markets. For Saudi Aramco, the dominant presence in the United States Patent and Trademark Office (USPTO) is evident, with 4784 patents registered. This overwhelming preference for U.S. protection demonstrates the company's focus on securing its energy-related technologies in one of the world's most competitive and economically rewarding markets. The SAIP follows with 1452 patent registrations, emphasizing Saudi Aramco's commitment to protecting its innovations within the Kingdom, aligning with national priorities under Saudi Vision 2030. Additionally, 466 patents are registered with the European Patent Office (EPO), signaling Saudi Aramco's strategy to protect its technologies across the European market.

For King Fahd University of Petroleum and Minerals (KFUPM), the USPTO leads with 780 patent registrations, signifying the institution's goal of securing its technological advancements, particularly in energy and engineering, in the U.S. market. In contrast, patent registrations in the SAIP (26) and China (12) are relatively few, but it shows their cautious and selective approach in expanding protection to other strategic regions. The 10 filings in the EPO reflect KFUPM's interest in European markets. At King Abdullah University of Science and Technology (KAUST), their focus is similarly global, with 434 patents registered in the USPTO, followed by 92 in the EPO and 75 in SAIP. This demonstrates KAUST's balanced strategy to protect its wide-ranging innovations, spanning fields such as biotechnology, environmental sciences, and materials engineering, across both international and local markets. King Faisal University (KFU) stands out with a strong focus on the U.S.

market, where it has 633 patents, yet remarkably, it has only one patent registered within the SAIP. This indicates a significant focus on international markets, particularly the U.S., over local protections, which could suggest an emphasis on global commercial potential or collaborations. Similarly, King Abdulaziz University (KAU) follows a similar pattern, with 451 patents registered in the USPTO and a single patent in Great Britain. This signals a strong priority toward U.S. protection, perhaps indicative of the institution's goal to ensure their innovations are safeguarded in one of the world's most lucrative intellectual property environments.

SABIC, a global leader in the chemicals industry, has strategically protected its intellectual property across a wide range of international markets. The data from Patsnap reveal that SABIC has 1784 active patents in the United States, making it the top jurisdiction for its patent registrations. This highlights the importance SABIC places on the U.S. market, known for its advanced innovation ecosystem and commercial potential in chemicals and petrochemicals. Following closely is the European Patent Office (EPO), where SABIC has secured 1343 active patents, ensuring robust protection across Europe, one of the largest markets for advanced materials and industrial innovation. In China, SABIC has registered 1273 active patents, signaling its commitment to safeguarding its innovations in one of the fastest-growing and highly competitive chemical markets in the world. Germany, a global leader in industrial technology, follows with 1217 active patents, further emphasizing SABIC's focus on key European markets for its technology portfolio. In South Korea, SABIC has 482 active patents, reflecting its interest in a region known for high-tech industries and innovation. Additionally, 440 active patents are registered with the Gulf Cooperation Council (GCC), reflecting SABIC's focus on protecting its intellectual property within its home region. SABIC also holds 382 active patents in India, further demonstrating its global reach and commitment to securing intellectual property in fast-growing economies with significant industrial demand. This broad geographic spread of SABIC's patent portfolio underscores the company's global strategy to protect its technologies across diverse markets, ensuring both commercial opportunities and protection from unauthorized use of its innovations. However, the relatively lower number of patent registrations within Saudi Arabia, which is 129 patents, signals a potential area for further strengthening local intellectual property protection efforts.

The data reveal that KSA-based organizations are not only focused on protecting their intellectual property in local markets, but are also keen to secure their innovations in global innovation hubs such as the U.S., Europe, and China. The significance of protecting patents in multiple jurisdictions cannot be overstated, as it allows these organizations to leverage broader commercialization opportunities, mitigate the risk of unauthorized use, and establish a foothold in competitive international markets. However, despite the promising global presence, the relatively low number of patent registrations in the local market, particularly with the Saudi Authority for Intellectual Property (SAIP), raises concerns. For example, while Saudi Aramco and several universities like KAUST and KFUPM have filed a substantial number of patents internationally, their local filings are far fewer in comparison. This trend points to possible hurdles or barriers within the local intellectual property system that may be discouraging or complicating patent protection efforts in Saudi Arabia. These challenges could include administrative complexities, higher costs, or longer processing times, among other potential obstacles. Given the Kingdom's focus on fostering innovation as part of Saudi Vision 2030, it is crucial to address these issues to encourage more local patent filings. Creating a more accessible, streamlined patenting process within SAIP would not only bolster the protection of homegrown innovations but also strengthen the overall innovation ecosystem within the country. As KSA-based organizations continue to make strategic decisions to protect their technologies globally, greater attention must be given to overcoming barriers in the local market. This will ensure that the Kingdom's intellectual property system is aligned with its broader ambitions for leadership in science, technology, and innovation.

3.2. Top Application Domains for Patent Protection by KSA-Based Organizations

The analysis of patent filings reveals the key application domains in which KSA-based organizations are protecting their technological innovations. The classification of these technologies is based on the International Patent Classification (IPC) codes, which are assigned to patent documents to indicate the specific technological domains they pertain to. Each patent family in this analysis, totaling 5574 families, is associated with one or more application domains, as identified through these IPC codes. Since many technologies are multifaceted, it is not uncommon for a single patent family to be classified under multiple application domains, reflecting the diverse uses and innovations embedded in the patents. Among the leading application domains, borehole and well accessories, which fall under the broader category of Earth Drilling and Mining, lead the list with 1458 patent documents. This indicates the strategic importance of the oil and gas industry to the Kingdom's innovation landscape, with key stakeholders such as Saudi Aramco and the local university KFUPM playing pivotal roles in driving innovation and protecting technologies in this sector. These organizations have been at the forefront of advancing technologies related to drilling and mining, aligning with the Kingdom's resource-driven economy and its focus on sustainable development in the energy sector.

Other significant application domains include Organic Chemistry, with 646 patent documents falling under the broader domain of Chemistry Apparatus and Processes. The computing sector, which is also classified under Instruments, accounts for 505 patents, reflecting the growing importance of digital technologies in the KSA's innovation ecosystem. Additionally, specialized chemistry fields such as drilling compositions (492 patents), chemical and physical processes (425 patents), and separation processes (360 patents) underscore the heavy focus on both industrial and research chemistry in Saudi Arabia. In the medical sciences, drug compositions account for 383 patents, showing considerable innovation in pharmaceutical development and healthcare technology. Further, drilling accessories and inorganic chemistry, with 348 and 329 patents, respectively, emphasize the ongoing developments in earth sciences and industrial chemistry. Figure 4 visually presents these top application domains, offering a clearer understanding of the technological areas in which KSA-based organizations are actively protecting their innovations.

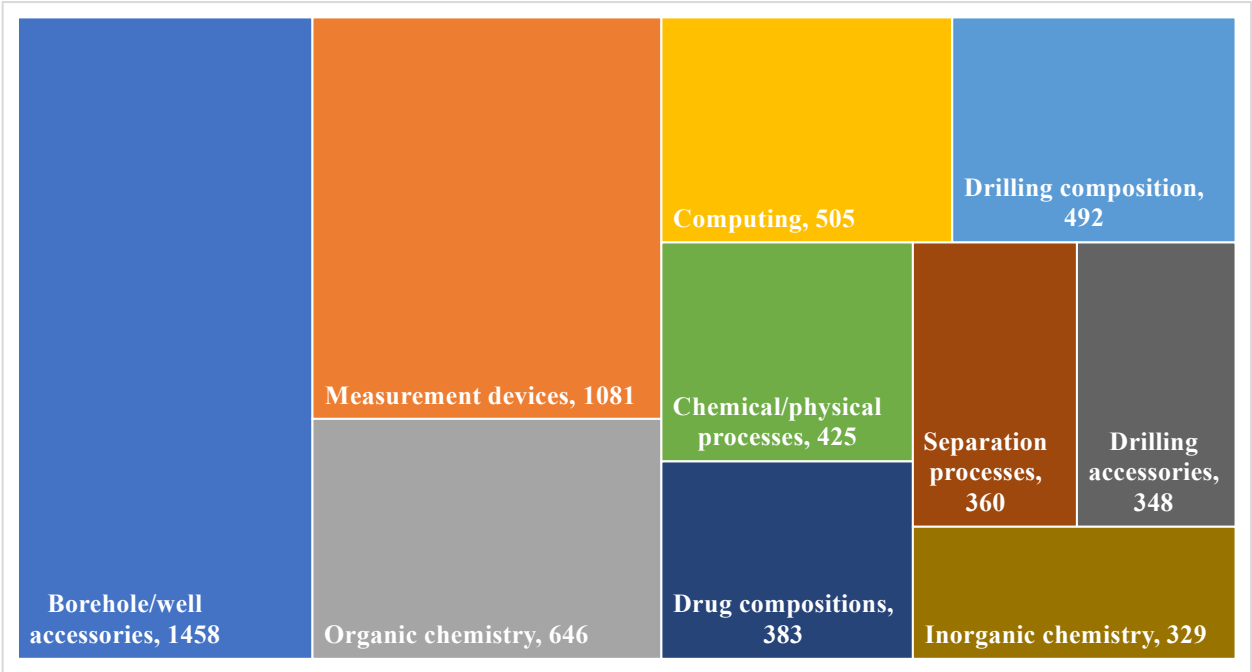

Figure 4. Top application domains for patents filed by KSA-based organizations.

3.3. Patent Landscape Analysis of KSA-Based Organizations: Focus Areas and Technological Expertise

The landscape analysis of the 5574 patent families offers a detailed overview of the technological innovation landscape for KSA-based organizations. Utilizing Patsnap's patent mapping software, this analysis visually represents the focus areas of these organizations through various color-coded dots, with each dot corresponding to a specific organization working in a particular technological domain. The landscape, illustrated in Figure 5, provides a layer-by-layer breakdown of similar patent documents grouped into broader technological categories, offering a clear understanding of the key sectors where these entities are concentrating their research and development efforts. Saudi Aramco and King Fahd University of Petroleum and Minerals (KFUPM) are clearly the most prominent players in this landscape, particularly within the oil and gas sector. The landscape reveals their substantial expertise and focus on both upstream and downstream technologies, highlighting their contributions to Saudi Arabia's energy sector. Key areas of innovation for these organizations include the following:

- Measure and Testing: This layer covers technologies related to monitoring and measuring key parameters in oil exploration and production. Both Saudi Aramco and KFUPM have a strong presence in developing cutting-edge measurement tools and techniques to optimize resource extraction and operational efficiency;
- Downhole End: Technologies under this layer are focused on downhole operations, including the development of tools and methods used deep within oil wells. These innovations are critical for maintaining well integrity, enhancing oil recovery, and reducing operational risks in challenging environments;
- Treatment Fluid: This category highlights innovations in the development of treatment fluids used in hydraulic fracturing, drilling, and well stimulation processes. Both Saudi Aramco and KFUPM are leading efforts in designing advanced fluid compositions that improve extraction efficiency and minimize environmental impact;
- Hole Assembly: This layer reflects advancements in technologies related to well drilling and completion tools. Patents in this domain demonstrate Aramco and KFUPM's expertise in designing equipment that ensures precise and safe drilling operations.
- Steam Cracking and Pyrolysis: These patents focus on chemical processes used in refining crude oil and producing valuable petrochemical products. Saudi Aramco's innovations in this field are central to refining operations and petrochemical production;
- Aromatic Derivatives: Saudi Aramco and KFUPM have also contributed significantly to the development of aromatic hydrocarbons, a key component in the production of plastics, synthetic fibers, and other petrochemical products;
- Earth Working and Wells: this category includes innovations in the exploration and development of oil fields, focusing on techniques to increase oil recovery and well productivity;
- Seismic Dataset: Saudi Aramco's strength in this domain reflects its extensive research in seismic data acquisition and analysis, used for subsurface exploration and identifying oil and gas reservoirs.

Together, these focused areas underscore Saudi Aramco and KFUPM's leadership in oil and gas technology development, with their expertise spanning across the entire value chain—from exploration and drilling to refining and petrochemicals. Their research in these critical fields aligns with Saudi Arabia's strategic emphasis on maintaining its global leadership in energy production and technology.

King Faisal University and King Abdulaziz University, in contrast, have a distinct focus on medical and chemical technologies, as revealed by their patent portfolios. Key areas of innovation for these institutions include the following:

- Drugs and Organic Compounds: Both universities are actively engaged in pharmaceutical research, with their patents covering the development of novel drug compositions, including CK2 inhibitors and antimicrobial agents. This reflects their commitment to

advancing healthcare and therapeutic solutions, particularly in combating diseases prevalent in the region;

- Antimicrobial Agents: King Faisal University and King Abdulaziz University have also made significant strides in the development of compounds aimed at addressing microbial resistance, a growing concern in global healthcare.

Their patenting activities in these domains highlight their research strengths in the life sciences, showcasing their contributions to the development of new drugs and treatments.

King Abdullah University of Science and Technology (KAUST), while diversely spread across both the chemical and oil-related sectors, also has a significant presence in medical research. In addition to its contributions to oil and gas technologies, KAUST is actively engaged in the following:

- CK2 Inhibitor and Drugs: KAUST has patented innovations in CK2 inhibitors and other drug compositions, underscoring its capabilities in biomedical research and pharmaceutical development. These compounds are critical in developing therapeutic agents for treating diseases, including cancer;
- Organic Compounds: KAUST's research in organic chemistry also aligns with the development of pharmaceutical compounds and chemical processes, adding depth to the Kingdom's broader scientific expertise in the life sciences.

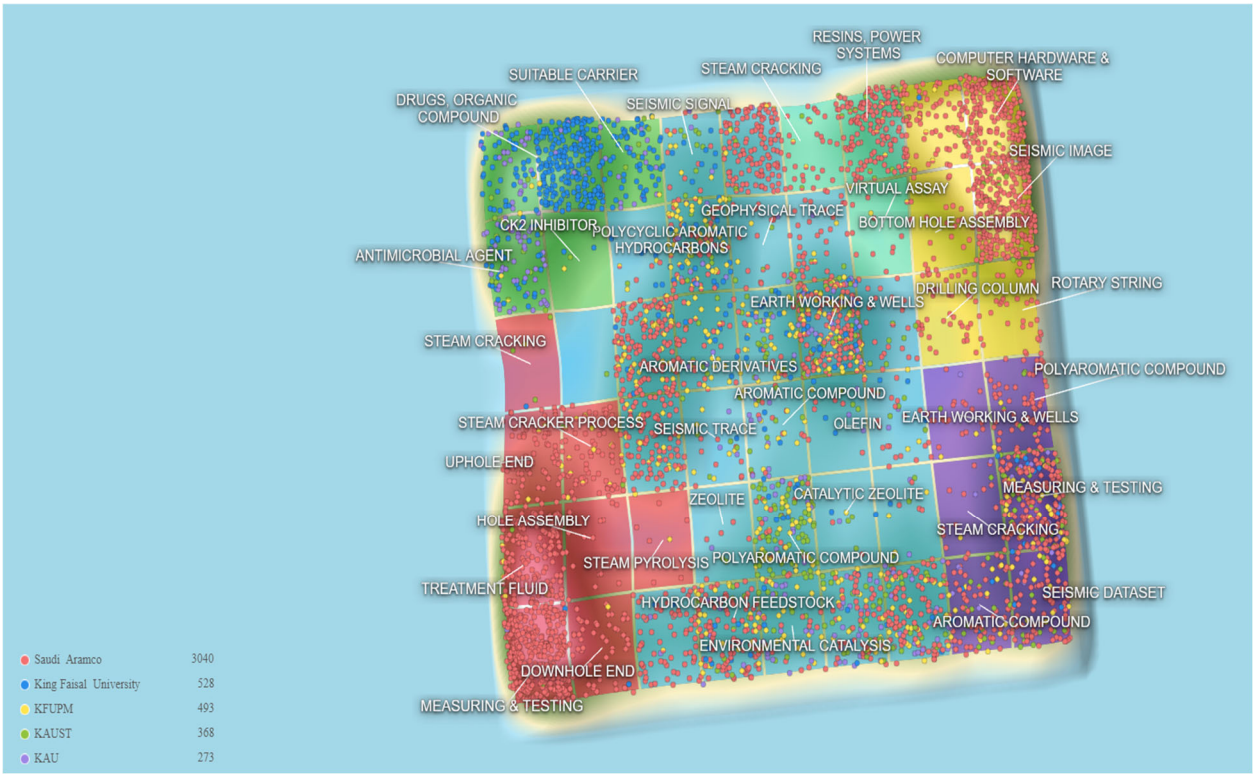

Figure 5. Patent landscape analysis of KSA-based organizations: visual representation of key technological domains and organizational expertise.

Alongside these life science innovations, KAUST's focus on oil and gas remains robust as follows:

- Earth Working and Wells: similar to Saudi Aramco, KAUST's research in this area highlights its contributions to oil exploration and drilling technologies, supporting the Kingdom's energy sector;
- Aromatic Compounds: KAUST's innovations in chemical processes, particularly related to petrochemicals, reflect its expertise in catalysis and materials science, areas where the university has achieved global recognition;

- Seismic Dataset: KAUST is also contributing to advancements in seismic data analysis, a critical tool for understanding subsurface formations and identifying energy resources.

This comprehensive landscape analysis provides invaluable insights into the strategic research directions of these leading KSA organizations. Saudi Aramco and KFUPM's dominance in oil and gas technologies reflects their central role in Saudi Arabia's economy, while the contributions of King Faisal University, King Abdulaziz University, and KAUST highlight the diversity of innovation within the Kingdom, extending into fields like medical sciences and petrochemical research. The visualization in Figure 5 encapsulates this ecosystem, offering a detailed look at the key technology areas being protected and developed by KSA-based institutions. This analysis is not only significant for understanding current trends in Saudi innovation but also serves as a guidepost for future technological developments and collaborations.

Figure 6 presents a comprehensive patent landscape analysis of SABIC, offering a visual representation of the key technological domains in which the company is actively securing its intellectual property. The landscape reveals that SABIC's patenting efforts span a wide range of advanced industrial and chemical technologies, including hydrocracking units, waste plastic recycling, fertilizers, polymerization processes, and olefin production—areas critical to the global chemicals and petrochemicals industries. Additionally, SABIC is safeguarding innovations in fibers, propylene copolymers, building materials, thermoplastics, catalyst compositions, pellets, quench water systems, and urea production. These patents reflect SABIC's deep expertise and leadership in research and innovation within these domains, aligning with its strategic focus on sustainability, circular economy initiatives, and the development of advanced materials. SABIC's diversified patent portfolio not only highlights its role in pioneering technologies that are shaping the future of the chemical industry, but also underscores its commitment to addressing key global challenges such as plastic waste, sustainable materials, and energy-efficient industrial processes. By focusing on these broad technological areas, SABIC continues to reinforce its position as a global innovator, driving industrial progress and contributing to economic growth both locally and internationally.

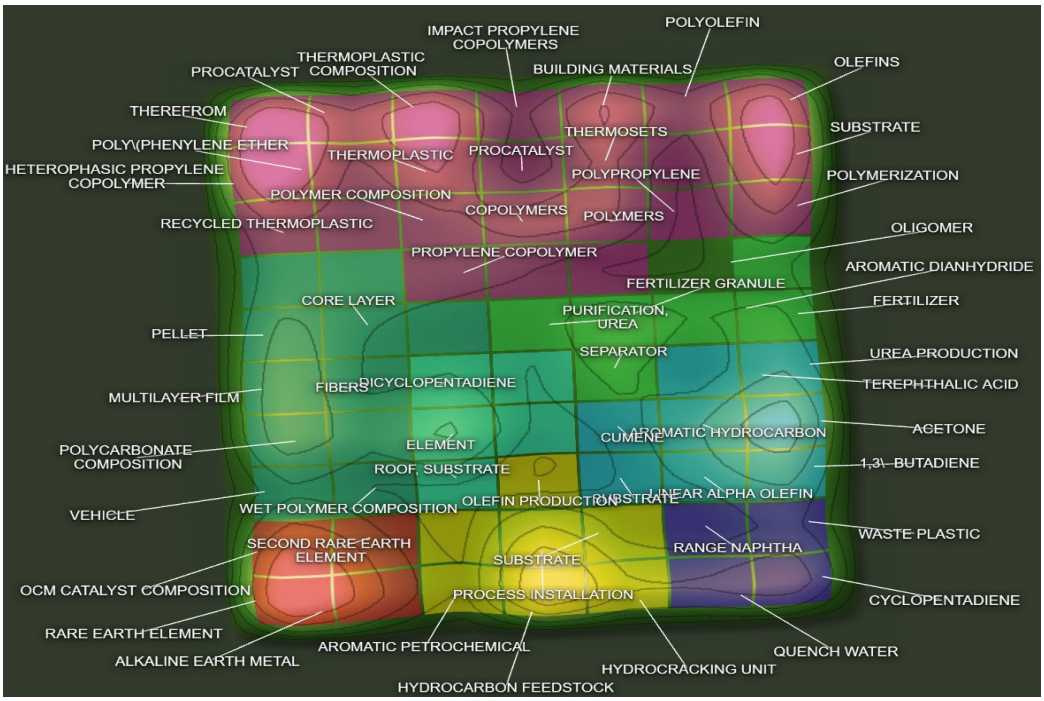

Figure 6. Patent landscape analysis of SABIC: visual representation of key technological domains and innovations.

4. Conclusions

The analysis of patent data is pivotal in understanding the innovation landscape, especially in the context of Saudi Arabia's strategic objectives as outlined in Saudi Vision 2030. Since the announcement of this vision in late April 2016, the steady increase in patent registrations from KSA-based organizations underscores a growing commitment to fostering innovation and intellectual property protection. Utilizing Patsnap's comprehensive database, this study highlights the leadership of Saudi Aramco in patent grants, affirming its role as a major player in advancing technological innovations. Following closely are prominent educational institutions like King Faisal University, KFUPM, KAUST, and KAU, which indicate a collaborative ecosystem aimed at harnessing research and development capabilities. Notably, SABIC's patent portfolio, heavily concentrated in Europe, exemplifies the company's global approach to innovation. Its partnership with international co-assignees such as the Scientific Design Company and BASF signals a strategic alignment with leading research entities to enhance its technological advancements. However, the limited collaboration with local institutions suggests an area for growth; fostering more robust partnerships within the Kingdom could significantly bolster KSA's innovation ecosystem and align with the goals of Vision 2030.

A critical observation from this analysis is the concentration of patent registrations among a few major players. Primarily, Saudi Aramco and SABIC dominate the patent landscape, while other contributors are primarily academic and research institutions. This limited participation highlights the need for concerted efforts to support small and medium enterprises (SMEs) and healthcare research institutions in their innovation endeavors. Increased funding and resources for these sectors can pave the way for the development of novel technologies that warrant patent protection. Encouraging diverse players in the patenting arena will enrich the innovation landscape and create a more competitive environment.

The analysis of patent offices reveals a preference for securing intellectual property through established global hubs such as the USPTO, EPO, and the Chinese patent office, indicating a strategic focus on markets with substantial commercial potential. The underrepresentation of patents filed with the Saudi Authority of Intellectual Property (SAIP) is concerning and deserves further investigation. Addressing potential barriers to local patent registrations could enhance domestic innovation and encourage local startups and research institutions to secure their inventions, ultimately contributing to the Kingdom's economic diversification efforts.

The top application domains identified in this analysis—borehole/well accessories, measurement devices, organic chemistry, computing, and chemical/physical processes—demonstrate the targeted areas of innovation that align with the Kingdom's resource-based economy and technological aspirations. The emphasis on upstream and downstream technologies by Saudi Aramco and KFUPM showcases their pivotal roles in the oil and gas sector, while King AbdulAziz University, King Faisal University, and KAUST's focus on life sciences reflects a broader commitment to health and environmental sustainability.

While this study provides valuable insights into the patent landscape in Saudi Arabia, it is not without limitations. The analysis primarily focuses on the number of patent registrations, which may not fully capture the commercialization status of these patents—a crucial factor in assessing the effectiveness and impact of innovation. Understanding whether these patents have been successfully commercialized or translated into marketable products is significant for evaluating the overall health of the innovation ecosystem. Future studies could benefit from exploring the commercialization trajectories of these patents, providing a more comprehensive understanding of the translation of intellectual property into economic and societal benefits. Additionally, the focus on patent data alone does not account for other forms of intellectual property protection, such as trade secrets or copyrights, which can also play significant roles in innovation strategies. Future work could involve a more granular examination of specific technological sectors, qualitative assessments of the factors influencing patenting behavior among local institutions, and

exploring the implications of collaboration patterns on innovation outcomes. Further studies may also assess the impact of policy changes on patent registrations in the Kingdom, providing a holistic view of the evolving innovation landscape.

In conclusion, the increasing number of patents filed by KSA-based organizations signifies a positive trend towards innovation and technological advancement, aligning with the strategic objectives of Saudi Vision 2030. To sustain this momentum, it is crucial for local organizations to enhance collaboration, particularly within the Kingdom, and to address the challenges associated with local patent registrations. Supporting SMEs and healthcare research institutions with funding and resources will be necessary for fostering innovation and protecting novel technologies through patents in the near future. This holistic approach will not only strengthen KSA's innovation ecosystem but will also contribute significantly to the Kingdom's economic and social development goals. As the landscape evolves, the continued monitoring and analysis of patent data will be essential in guiding policy decisions and fostering a vibrant culture of innovation.

Funding: This research did not receive any external funding, and the APC was funded by KFSHRC.

Data Availability Statement: The raw data supporting the conclusions of this article will be made available by the authors on request.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. Braguinsky, S.; Choi, J.; Ding, Y.; Jo, K.; Kim, S. Mega Firms and Recent Trends in the U.S. Innovation: Empirical Evidence from the U.S. Patent Data. *Natl. Bur. Econ. Res. (Work. Pap.)* **2023**, *31460*. [CrossRef]
2. Sarabdeen, J.; Ishak, M.M.M. Intellectual property law protection for energy-efficient innovation in Saudi Arabia. *Heliyon* **2024**, *10*, e29980. [CrossRef] [PubMed]
3. Naimi, S.M.A. Economic Diversification Trends in the Gulf: The Case of Saudi Arabia. *Circ. Econ. Sustain.* **2021**, *2*, 221–230. [CrossRef] [PubMed]
4. Fasi, M.A. Triple helix collaboration: Uncovering research opportunities among industry, academia, and researchers—A case study of Saudi Aramco's Patent Portfolio Analysis. *J. Knowl. Econ.* **2023**, *15*, 14486–14520. [CrossRef]
5. Khasawneh, M.A.; Thaher, N.H.; Shibli, R.A.; Elhaija, W.S.A.; Alwahadni, A.M. Bolstering Economic Growth in the Arab Region Through Commercialization of Research Outcomes. In *Higher Education in the Arab World: Research and Development*; Springer International Publishing: Cham, Switzerland, 2022; pp. 141–163.
6. Sousa, M.J.; Jamil, G.; Walter, C.E.; Au-Yong-Oliveira, M.; Moreira, F. Big data analytics on patents for innovation public policies. *Expert Syst.* **2023**, *40*, e12673. [CrossRef]
7. Yun, S.; Cho, W.; Kim, C.; Lee, S. Technological trend mining: Identifying new technology opportunities using patent semantic analysis. *Inf. Process. Manag.* **2022**, *59*, 102993. [CrossRef]
8. Thumm, N. 16: Regulation of patents and the impact on innovation. In *Handbook of Innovation and Regulation*; Edward Elgar Publishing: Cheltenham, UK, 2023; pp. 346–372.
9. Verma, C.; Suri, P.K. Big data' patentometrics for R&D decision-making. *Digit. Policy Regul. Gov.* **2021**, *23*, 317–336.
10. Blind, K.; Ramel, F.; Rochell, C. The influence of standards and patents on long-term economic growth. *J. Technol. Transf.* **2021**, *47*, 979–999. [CrossRef]
11. China's innovation capacity. In *The Dynamics of the Innovation Divide between China and Europe*; Routledge: London, UK, 2022; pp. 112–156.
12. Paula, F.D.O.; Silva, J.F.D. R&D spending and patents: Levers of national development. *Innov. Manag. Rev.* **2021**, *18*, 175–191.
13. Gassmann, O.; Bader, M.A.; Thompson, M.J. Evaluating and Valuing Patents. In *Patent Management-Protecting Intellectual Property and Innovation*; Springer: Berlin/Heidelberg, Germany, 2020; pp. 51–93.
14. Romualdas, G.; Eigirdas, Ž.; Karel, Š.; Schieg, M. Assessing the global competitiveness of European countries. *J. Compet.* **2023**, *15*, 36–52.
15. Amirat, A.; Zaidi, M. Estimating GDP Growth in Saudi Arabia Under the Government's Vision 2030: A Knowledge-based Economy Approach. *J. Knowl. Econ.* **2020**, *11*, 1145–1170. [CrossRef]
16. Kazim, S.M.; AlGhamdi, S.A.; Lytras, M.D.; Alsaywid, B.S. Nurturing Future Leaders: Cultivating Research and Innovation Skills in Saudi Scientific Community. In *Transformative Leadership and Sustainable Innovation in Education: Interdisciplinary Perspectives*; Emerald Publishing Limited: Bingley, UK, 2024; pp. 231–265.
17. Shahwan, R.; Zaman, T. Role of Universities as Knowledge Creators in a National Innovation System: An Open Innovation Paradigm. In *Industry Clusters and Innovation in the Arab World*; Emerald Publishing Limited: Bingley, UK, 2023; pp. 259–280.
18. Madkhali, A.; Sithole, S.T.M. Exploring the Role of Information Technology in Supporting Sustainability Efforts in Saudi Arabia. *Sustainability* **2023**, *15*, 12375. [CrossRef]

19. Alhamad, S.H.; Hani, S.I.B.; Dakhli, A.C.; Almahayreh, A. The effectiveness of applying the economic and technological dimensions of the kingdom of Saudi Arabia's vision 2030 to achieve the competitive advantage of the Hail Region. *Front. Energy Res.* **2024**, *12*, 1337349. [CrossRef]
20. Islam, M.T.; Ali, A. Sustainable green energy transition in Saudi Arabia: Characterizing policy. *Next Energy* **2024**, *5*, 100161. [CrossRef]
21. Al-Jamimi, H.A.; BinMakhashen, G.M.; Bornmann, L.; Wajih, Y.A.A. Saudi Arabia research: Academic insights and trend analysis. *Scientometrics* **2023**, *128*, 5595–5627. [CrossRef]
22. Ding, H. What kinds of countries have better innovation performance?–A country-level fsQCA and NCA study. *J. Innov. Knowl.* **2022**, *7*, 100215. [CrossRef]
23. Skare, M.; Soriano, D.R. How globalization is changing digital technology adoption: An international perspective. *J. Innov. Knowl.* **2021**, *6*, 222–233. [CrossRef]