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Examining the Patenting Activities of Universities in the Middle East and North Africa

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Abstract

This paper aims to examine universities' patenting activities in the Middle East and North Africa (MENA) region. Patent data from Derwent Innovation is analyzed to provide key insights about such activities. Saudi Arabia leads the region in terms of the number of patents, followed by Turkey and Morocco. These three countries, which represent 87% of all academic patents, are also home to the most patenting academic institutions. Although the academic sector in MENA grew its patenting activity faster than the world, its patent volume base is still relatively low. The results also show the profile of the technological developments covered in MENA academic patents. Some of these inventions directly tackle societal health-related issues but also public environmental ones. The main academic assignees show a certain degree of collaboration with academic and corporate organizations. This study provides important input to research managers as well as policymakers to assess the research produced by universities from a technological and economic perspective.

Introduction

For the past 20 years, research-intensive universities have been increasingly subject to quantitative research evaluation with various expectations to contribute more to societal and economic development (Clark, 1998; Mejlgaard & Ryan, 2017). At the same time, numerous calls have been made to reform research evaluation and move from quantitative to more inclusive and qualitative assessment. For example, Wilsdon et al. (2015) argue that evaluation should promote the diversity and plurality of research in *The Metric Tide* report. In Europe, 350 institutions, including research organizations, funding agencies and assessment groups have recently pledged to sign such a reform call (Directorate-General for Research and Innovation, 2022). This call to reform research assessment encompasses multiple dimensions such as the recognition of various contributions that researchers make to both science and society. Such contributions extend beyond traditional journal publications and include diverse scientific outputs. This study addresses this issue from the perspective of assessing the economic impact of research produced by Universities.

Historical models of research and innovation have traditionally described a uni-directional flow of funding and knowledge between government, academia, and industry (Pavitt & Walker, 1976). Later, Gibbons et al. (1994) introduced the Mode 2 knowledge production framework, which represents a more collaborative and interdisciplinary approach to knowledge production. Mode 2 is characterized by the integration of different knowledge systems, including academic and non-academic

perspectives, and emphasizes the co-production of knowledge by multiple stakeholders, including researchers, industry partners, and policymakers. Mode 2 research tends to be more applied and problem-oriented, with a focus on addressing real-world challenges. This framework can help to contextualize the knowledge dynamics of universities in the Middle East and North Africa, where there is often a tension between the traditional academic knowledge production and the demand for practical, socially relevant knowledge (Altbach, 2009; Hanafi & Arvanitis, 2015).

The economic impact of scientific research is a component of its societal impact. It is widely acknowledged that technological innovation has a significant role in the economic growth and competitiveness of institutions, regions, and countries (Tödtling & Trippl, 2005). The two most popular indirect measures of innovation are R&D expenditures, which serve as an indicator of the process' input, and patent data, which serves as a measure of inventive activity's output (Basberg, 1987). Patents are mainly used due to the large amount of information available across borders and regions. Also, in the context of a knowledge-intensive economy, patents are a crucial tool in the protection of intellectual property.

There is a massive literature on innovation activities in the academic sector (Dornbusch et al., 2013; Lissoni, 2013; Perkmann et al., 2013; van Zeebroeck et al., 2008). This literature covers mostly Western countries. However, literature on patenting activities by universities in emerging nations such as in the Middle East and North Africa (MENA) region is rather scarce. Only a few studies covered the patenting activity by the academic sector in North Africa (Landini et al., 2015), in Iran (Noruzi & Abdekhoda, 2012) and Turkey (Uzun, 2001). In this paper, I attempt to address this gap by examining certain aspects of the innovation activities of universities in this specific region in recent years. Although innovation studies go beyond patentometrics, various insights can be gained by examining the data of patent documents. Indeed, patents constitute a rich source of data from technology and scientific research perspectives. This quantitative and empirical study explores the patenting activities of research universities in MENA. Based on this topic, the following general hypothesis is proposed to investigate the knowledge dynamics involved in creating and transferring knowledge within the MENA region:

Hypothesis: The Mode 2 framework of university-industry collaboration is positively associated with the patenting activities of universities in the Middle East and North Africa.

Specifically, in this empirical study, I address the following research questions:

- What are the recent trends of technological advancements developed by research universities in the Middle Eastern and North African nations from a patent’s perspective?
- What are the technological characteristics of such developments?

- To which extent does academia collaborate with the industry in MENA in terms of patenting activity?

These aspects provide insights into the contribution of research universities to societal impact from a patent's lens and support a country's future development. Such insights are also particularly helpful for research assessment and decision-making when formulating science and technology policies. This study is organized as follows. The next section describes the data used to analyze the patenting activities by the academic sector in MENA. Then, the findings are presented in the following section. Finally, the results of this study are discussed in the last section of this paper.

Methods and data

Data source

The patent collection used for this study was developed by using the full patent content on Derwent Innovation, provided by Clarivate. Derwent Innovation includes the Derwent World Patent Index (DWPI), which covers over 59 patent authorities worldwide and 2 journal sources. DWPI provides curated data including editorially enhanced titles and abstracts in the English language.

Data counting definition

The "patent families" are the building blocks of the DWPI database. As soon as it is published, each associated patent application and granted patent is added to the related DWPI family record. As a result, rather than referring to specific patent documents, all counts of records in this analysis refer to patent families or inventions. For instance, unless otherwise stated, all analyses in this study will count, for example, a combined United States patent application and European patent application as a single innovation family or one innovation. This gives a more accurate image of the overall level of innovation in a specific field as well as a more accurate measure of the level of inventive activity from a particular organization within the corresponding technological domain. Entity names for patents were cleaned and harmonized, to the greatest possible extent. Known subsidiaries and merger and acquisition entities were consolidated under a single company name for a more realistic view of the collaborating corporations. Also, in terms of co-patenting, a full counting approach is used in this study.

Geographic coverage

The following nations make up the MENA region, according to the World Bank (2019): Algeria, Bahrain, Djibouti, Egypt, Iran, Iraq, Jordan, Kuwait, Lebanon, Libya, Morocco, Oman, Palestine, Qatar, Saudi Arabia (KSA), Syria, Tunisia, the United Arab Emirates (UAE) and Yemen. In this study, Pakistan, Afghanistan and

Turkey are also considered as commonly included in the MENA region (MENAP and MENAT).

Search string creation and quality control

The search for relevant patents was conducted using the so-called 'expert search' of Derwent Innovation. The search string for the patent analysis was developed iteratively, with the search results being examined and assessed to guide and improve the search query's accuracy. Necessary changes are made to the keywords used for the assignee names of academic institutions. This procedure is repeated until only slight differences in the results are produced by revisions. The period covered in this study is 2008-2021. The final search query consists of a combination of various fields and is shown below:

PAOC=(AE or AF or BH or DJ or DZ or EG or IQ or IR or JO or KW or LB or LY or MA or OM or PK or PS or QA or SA or SY or TN or TR or YE) and PA=(univ or uni or inst* or acad*) and PY > (2007) and PY < (2022);*

- PAOC represents the country code of the patent assignee/applicant
- PA is the assignee or applicant name
- PY stands for Publication Year

The dataset under study consists of 18,348 individual patents, classified as 10,010 individual DWPI invention families.

Visualising patents landscapes with ThemeScape

ThemeScape is a text-mining application that analyzes text sources (Clarivate, 2022). Its algorithms do not require a thesaurus or other external sources of information. After analyzing the text in multiple documents, it groups together the documents that share related text and separates the documents with less related text. The result of such analysis is presented as a topographical map. Each document is placed on the map in a unique position that is the vector sum of its relatedness to all the other documents.

ThemeScape uses the frequency of occurrence and co-occurrence of words to select the topics of interest. Then, it aggregates words that have a common stem, but it does not directly aggregate synonyms. Instead, synonyms may be clustered under a common theme because of the other words that co-occur with those synonyms. In other words, terms are identified as synonyms only by co-clustering based on common themes. For example, "battery" and "cell" may be grouped together because of the co-occurrence in the same documents of terms such as "electrode" or "rechargeable". On the other hand, "battery" and "cell" may also be separated if the map contains a set of electric power and biology patents, where the term "cell" has different meanings.

The topographical maps presented by ThemeScape are built on a random selection of a first patent and sequential calculation of the relationships of all the other

patents. The orientation of the map is randomly set, and the different directions have no significance. Only the proximity of points within the map is relevant, and co-clustered patents are highly likely to share common concepts.

Findings

Recent trends of patenting activities by research universities in MENA by country

Before reporting the trends of patenting activities by assignees affiliated with research universities in MENA, I analyzed their total patent output at the country level. This analysis is shown in Figure 1. Research institutions in Saudi Arabia lead the MENA region in terms of patent filings with 48% of the patents filed by the academic sector in the region. Turkey (28%) and Morocco (11%) follow. The academic institutions in these three countries cumulate 87% of all the patents under study. Also, several countries such as Algeria, Bahrain, Iraq, Libya, Palestine, Afghanistan, Syria, Yemen and Djibouti show a very low output, with less than 10 patents filled during the study period. These results suggest that research institutions in Saudi Arabia, Turkey, and Morocco have made strides in patent registration globally.

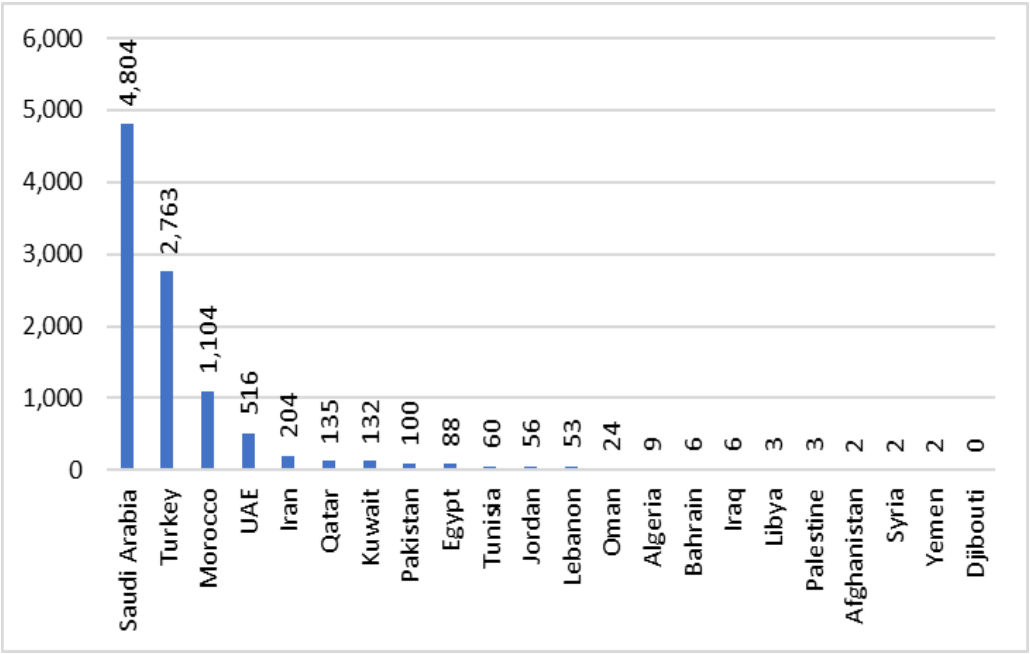

Figure 1. Number of patents published between 2008 and 2021 by assignees affiliated with research institutions in MENA.

The top 20 assignees within the dataset under study in terms of number of patents are shown in Figure 2. These most productive institutions are located in Saudi Arabia (8), Turkey (6), Morocco (2), UAE (2), Qatar (1) and the US (1). The

presence of the US suggests a certain level of international co-patenting activities by MENA universities with the US, specifically with The Massachusetts Institute of Technology (MIT) found in 72 patents as a co-assignee. Also, Saudi Arabian Oil Company (Aramco) co-patented 229 with at least one academic institution from MENA, which makes it the largest co-patenting corporate entity with Academia in MENA and more precisely with King Fahd University of Petroleum and Minerals (KFUPM). This evidence provides support to the hypothesis of this study.

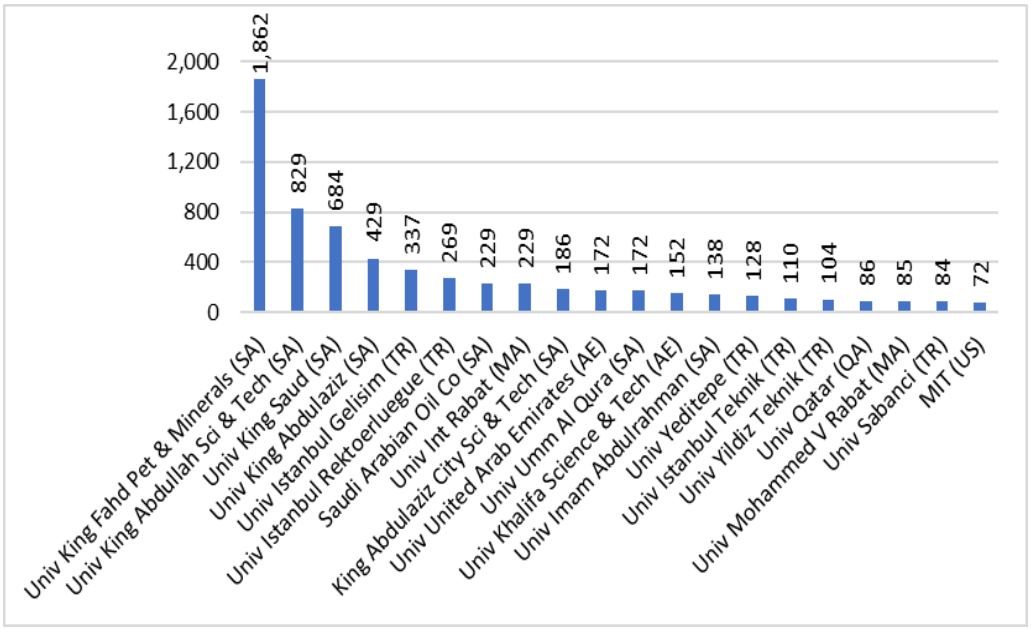

Figure 2. Top 20 Institutions by number of patents in the dataset.

Figure 3 shows the trends of patenting activities by the academic sector in MENA between 2008 and 2021 for countries with more than 200 patents (Saudi Arabia, Turkey, Morocco, UAE, and Iran). The number of patents grew from 46 in 2008 to 2,164 in 2021 for the whole region, representing a growth of 4,604%. Following the methodology explained earlier, the academic sector across the world published 16,040 patents in 2008 and 389,656 in 2021, which represents a growth of 2,329%. The patenting activity by the academic sector grew faster in MENA, although the MENA institutions started from a very low base in 2008 which explains in part this impressive increase.

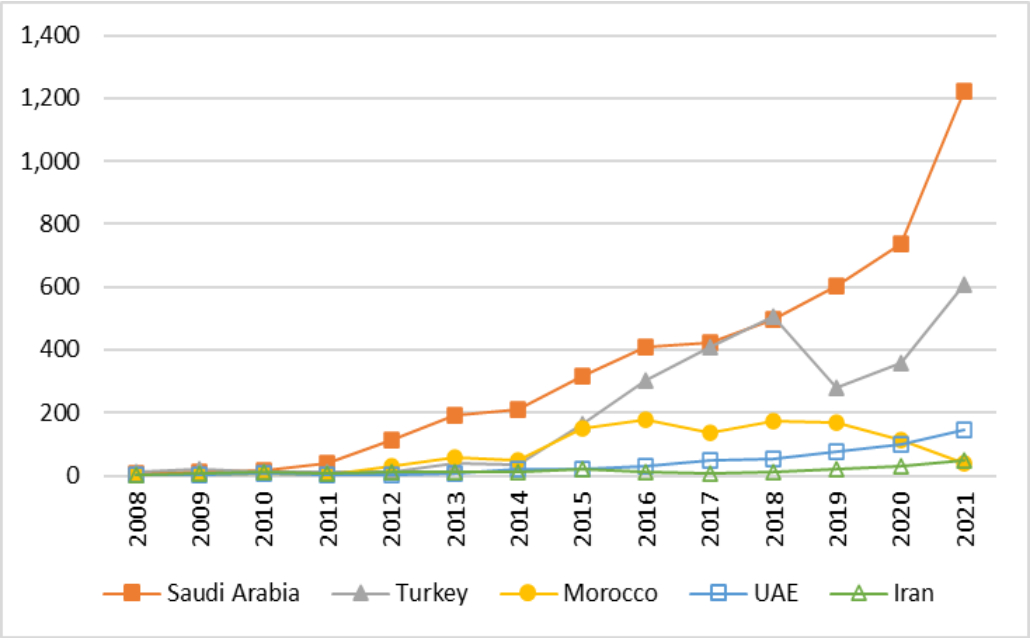

Figure 3. Trends of the number of patents published between 2008 and 2021 by research institutions in Saudi Arabia, Turkey, Morocco, UAE and Iran.

Patent filings by academic institutions in Saudi Arabia have gradually increased over the past few years. Saudi Arabia's remarkable output increase might be due to the effects of the kingdom's 'Vision 2030', the policies set locally, and initiatives led by the Saudi patent office. Saudi Arabia and Turkey had the same patent output level by academic institutions in 2018. However, Turkish research institutions saw a decrease in their patenting activity in 2019. Since then, academic institutions in Turkey and Saudi Arabia saw their output grow at the same rate. Moroccan institutions have initially shown growth in terms of the number of patents. Their output stabilized between 2015 and 2019 and then declined to reach the 2014 level. Academic institutions in the UAE have also experienced an increase in their number of patents since 2015. We notice a similar trend for research organizations in Iran.

A profile of patenting activities by Academia in MENA

In this sub-section, two aspects of the patenting activities are analyzed: their geographic distribution in terms of legal jurisdictions and then their technical coverage.

A patent application only provides a potential monopoly on the covered technology it covers within the legal jurisdiction of the issuing authority. As a result, applicants must submit patent applications to multiple patent bodies and jurisdictions in order to obtain broader geographic patent protection. The level and timeline of patent protection in the various patent jurisdictions are analyzed in Figure 4. The

authorities with more than 500 patents filed are shown individually, and the others are combined together into the 'Other' authority.

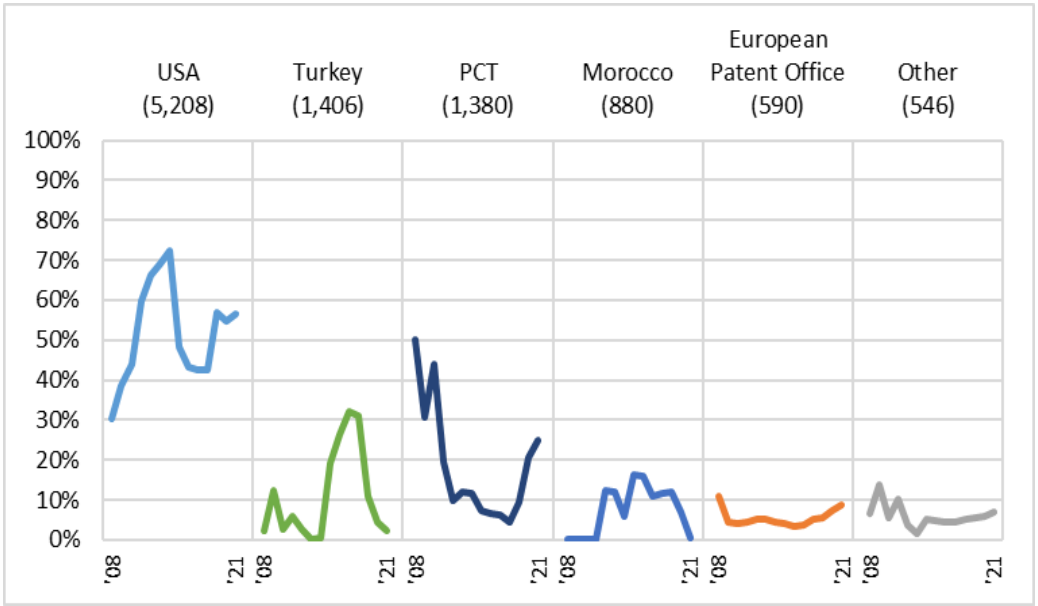

Figure 4. Share of inventions filed by patent authority and by assignees affiliated with research institutions in MENA between 2008 and 2021.

Patent protection continues to be most often sought in the United States, with filings in the US the predominant jurisdiction in the dataset under study. The academic institutions in MENA also commonly use the Patent Cooperation Treaty (PCT) application route, which provides a patent filing fast track for individual later patent applications in countries designated by the applicant. It is worth reminding that the PCT filings do not produce granted patents themselves. Indeed, patent prosecution must be still sought at individual patent authorities. On the one hand, the share of inventions at the PCT level initially decreased and then increased in the recent years. On the other hand, protection was also commonly sought at the Turkish and Moroccan Patent Office. These two authorities have seen sharp increases then declines in terms of share of inventions filed by academic institutions in MENA. Invention protection is also commonly sought at the European Patent Office. Such protection provides potential EPO member state-wide protection. Filings in the US, at the EPO and via the PCT application process are popular and recent. This is the usual protection regime within the European community, and it might suggest that MENA academic institutions collaborate with peer institutions from Europe. Second-tier application locations include China, South Korea, Saudi Arabia, Germany and Canada.

As for the technical focus of the patents dataset under study, the dataset was segmented into major research categories using the Derwent World Patents Index

(DWPI) patent classification scheme for categories with more than 100 inventions. This taxonomy is shown in Figure 5.

The largest technical fields include *Polymers & Plastics* (24%), *Pharmaceuticals* (19%) and *Computing & Control* (19%). The number of *Polymers & Plastics* patents increased from 2 patent filings in 2008 to 320 in 2021. *Pharmaceuticals* also saw a large increase in patenting activity with 14 patents in 2008 and 200 in 2021. Similarly, the number of *Computing and Control* patents increased from 2 patents in 2008 to 174 in 2021. It is worth reminding that there is a high level of overlap between some of the fields shown in Figure 5 such as *Food, Fermentation, Disinfectants, Detergents* and *General chemicals*, as patents with classifications pertinent to both fields have been categorized into multiple industrial fields.

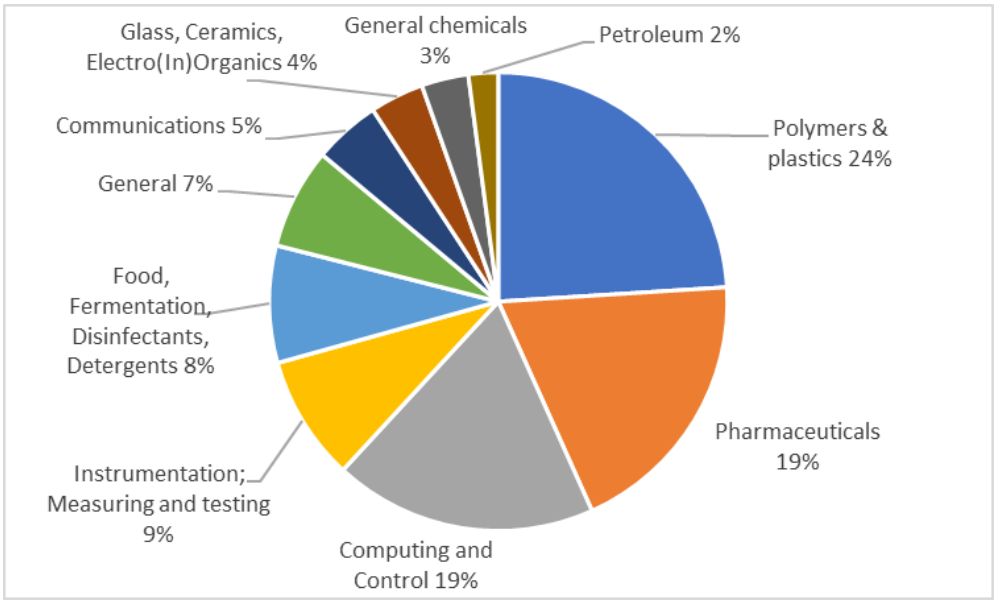

Figure 5. Number of inventions by technical area by assignees affiliated to research institutions in MENA between 2008 and 2021.

Next, the technical nature of the inventions of the dataset under study has been summarized using *ThemeScape* (Clarivate, 2022). Such visualization is shown in Figure 6 and provides the common themes and concepts within the dataset.

The contour lines on the map diminish in terms of circumference and are meant to encircle regions of higher document concentration. The density is also represented by the map colors. White snow-capped peaks represent the highest density, while blue areas indicate low density. The words included in the map are those shared by the patent documents in their DWPI abstracted form and have been selected by ThemeScape based on the term frequency. The individual dots on the map represent single patents. Dots are not shown for all the documents, and instead, represent a sampling that allows the other features of the map to be discerned.

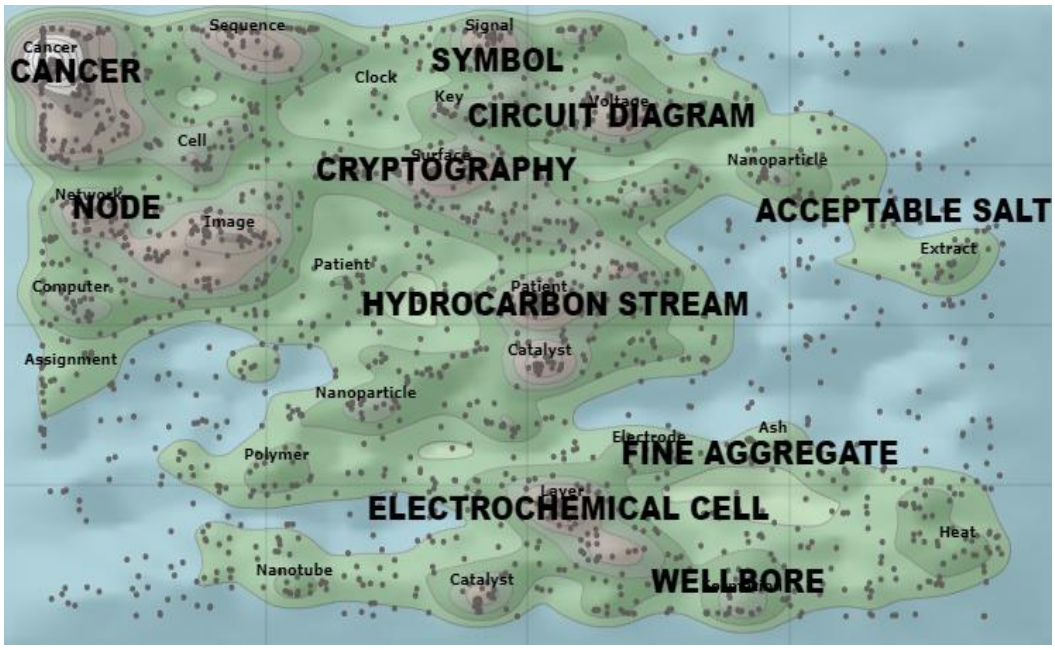

Figure 6. Thematic concept map of inventions by academic institutions in MENA between 2008 and 2021.

The major areas found within the patents dataset of this study include Cancer, SeqID, Node, Symbol, Circuit Diagram, Cryptography, Hydrocarbon stream, Electrochemical Cell, Boiling water, Acceptable Salt, Wellbore, Fine Aggregate, and Exchanger. Some technologies will necessarily overlap, and the delineation of one technical area versus another is therefore only approximative.

Table 1 shows the technologies derived from International Patent Classification (IPC) codes assigned to patents published in the past five years, based on Publication Year. The terms in the Technology column, called 'Smart Themes" supplement the dense IPC definitions with terms derived from actual patents for that technology. These terms are extracted from the DWPI Titles from all patents classified with a specific IPC code. The top key terms are reviewed and represent a clear and concise summary of the technology described by an IPC code. The terms provide fixed descriptions of the technology and do not change based on the patents set. While the technology "*Cancer, Treating, Administering, Disorder, Disease, Inhibitor, Pharmaceutical*" appears twice, these two technologies have different IPC codes, respectively A61K, A61L, C11D and A61P.

Table 1. Top innovations in the past 5 years by academic institutions in MENA by number of patents.

Technology	*Patents*
Cancer, Treating, Administering, Disorder, Disease, Inhibitor, Pharmaceutical	900
Catalyst, Reactor, Sorbent, Hydrocarbon, Catalytic, Dehydrogenation, Zeolite	455
Sample, Gas Sensor, Cancer, Cell, Inspection, Antibody, Biological	444
Filter, Membrane, Separation, Gas, Filtration, Carbon Dioxide, Sorbent	337
Surgical, Endoscope, Medical, Patient, Ultrasound, Bone, Tissue	283
Wastewater, Water, Sludge, Desalination, Reverse Osmosis, Purification, Filtration	262
Computing, Transitory, Touch, Information Processing, User, Virtual, Management	284
Semiconductor, Layer, Substrate, Oled, Gate, Source Drain, Light Emitting	248
Graphene, Carbon Nanotube, Particle, Boron Nitride, Silica, Graphite, Gas	220

Overall, there are 30 different technologies classifications represented in Table 1. The top 3 technologies are found in 24% of the records in the patents dataset of this study. The number of technologies indicates recent innovations and can provide an overview of the current state of the technological market and how it is segmented. These technologies have a direct impact on societal issues related to health (e.g. cancer, treatment, antibody, pharmaceuticals, medical, patient) but also on public environmental issues in the MENA region (water, desalination, purification, filtration). These findings support the hypothesis of this study since Mode 2 research is typically oriented towards practical applications, focusing on solving real-world problems and addressing pressing challenges. It is also the type of research that the industry sector is focused on, often in response to consumer demand.

Co-assignment network and collaboration between Academia and the Industry

This section focuses on the level of co-assignment as a proxy measure of collaboration in patenting activities by the top 18 academic MENA institutions shown in Figure 2 (Saudi Arabian Oil Company and the MIT are excluded). The co-assignment network visualization shown in Figure 7 was created by using

VOSviewer at the organization level (van Eck & Waltman, 2009), where a full counting method was used i.e. co-assigned patents are fully assigned to each co-assignee. This network map can also be explored interactively online (https://bit.ly/AcadMENAPatentsMap) and the less visible organizations' names can be seen by zooming in on specific map areas. For readability reasons, the organization name also shows the ISO country code and the colors of the nodes represent the related countries. The size of the nodes represents the number of patents.

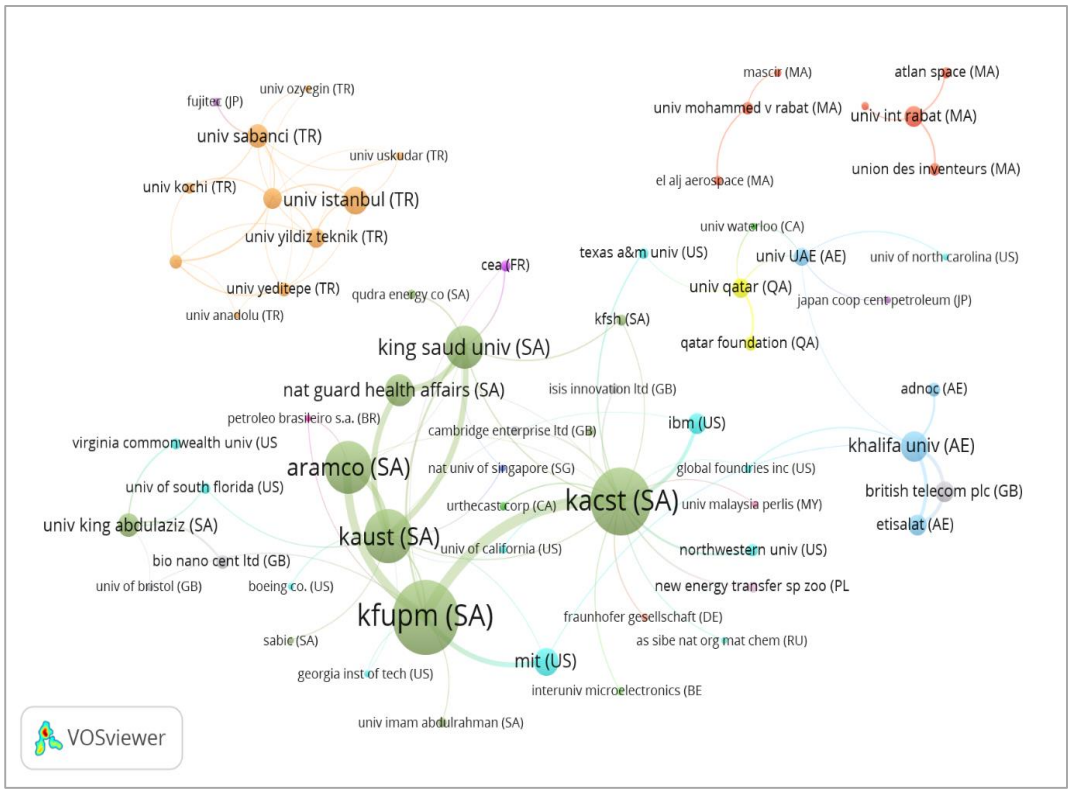

Figure 7. Co-assignment network of the main academic patent assignees in MENA (2008-2021).

These 18 academic institutions contributed to 7,011 inventions (70% of the patents under study). Co-assignments were found in 938 of them (or 13%). In this map, three main areas can be distinguished. On the top left, Turkish academic institutions show a high level of domestic collaboration between academic institutions, and one international co-assignment with a corporation, Fujitec (Japan). On the top right, Moroccan academic institutions show only domestic co-assignments links, including collaborations with local corporations. The third area, shown in the rest of the map, shows the co-assignment links for the institutions in Saudi Arabia (green), UAE (light blue), and Qatar (yellow) which are three countries of the Gulf Cooperation Council (GCC). This area also shows domestic

co-assignments but also a much higher level of collaboration with foreign academic and corporate institutions, mainly from the United States (11) and the United Kingdom (5). The co-assignments with domestic corporations include collaboration with Aramco and Sabic in Saudi Arabia, and ADNOC and Etisalat in the UAE. The foreign corporate organizations include Boeing, IBM, British Telecom, Cambridge enterprise, and Petroleo Brasileiro. These findings provide support to the hypothesis of this study. It is also worth noting that the first two areas of the map are not connected with the third one, which suggests that there is no co-assignment between academic institutions from Morocco and Turkey with their peers in the GCC.

Discussion and conclusion

The original subject of this study was to examine patenting activities of universities in the Middle East and North Africa region. The hypothesis of this study is that there is a positive association between the patenting activities of universities in MENA and the Mode 2 framework of university-industry collaboration as proposed by Gibbons et al. (1994). To gain a better understanding of the patenting activities in academia within this region, patent data from Derwent Innovation is analyzed to provide key insights on these activities. The findings show that Saudi Arabia lead the MENA region in terms of patent filings with 48% of the patents filled by the academic sector in the region, research institutions in Turkey (28%) and Morocco (11%) follow. The most active academic institutions in patenting activity are located in Saudi Arabia, Turkey, Morocco, UAE and Qatar. The number of patents grew by 4,604% between 2008 and 2021 for MENA academic institutions compared with a growth of 2,329% for academic institutions worldwide. The patenting activity by the academic sector grew faster in MENA compared to the World, but the region started from a relatively low base in 2008. Patent protection continues to be most often sought in the United States, and the Patent Cooperation Treaty (PCT) application route is also commonly used by academic institutions in MENA. The largest technical fields of the patents include the Polymers & Plastics, the Pharmaceuticals and Computing & Control. Some of the underlying technologies have a direct impact on societal health-related issues (e.g. cancer, treatment, antibody, pharmaceuticals, medical, patient) but also on public environmental issues (water, desalination, purification, filtration). These main academic assignees show a certain level of domestic and international collaboration with other academic institutions but also corporations. More specifically, academic institutions in Saudi Arabia, the UAE and Qatar show linkages with the industry sector which might suggest a certain potential in terms of commercialization of research done by the academic sector on practical applications and solutions to real-world problems.

This study also contributes to a more inclusive assessment of research produced in MENA by academic institutions as it includes economic and societal dimensions of

research activities. Indeed, it covers a different type of research activities beyond journal publications and practices such as patenting activities and collaboration with the industry. This study provides also insights about valuable contributions that researchers in MENA make to science for the benefit of society. The growth of patenting activities in MENA may seem impressive on a standalone basis, but when compared to the level of innovation worldwide, the region still lags behind the rest of the world. Corporates are more likely to invest in innovation when there is more patent protection (Allred & Park, 2007) and might collaborate with the Academic sector more frequently. The private sector in MENA might be encouraged to boost its patenting activity thanks to relevant national legislations that are consistent with global best practices. Due to its indirect relation to technical innovation, current government policies and funding processes to support academic research alone in MENA may not be the best mechanisms to develop further the patenting activities by research institutions. The ability to commercialize a product, typically accomplished by corporations, and collaborations with the industry are likely to be the major driving forces behind an increase in patenting in the region by the academic sector.

Another theoretical framework that could be incorporated into a future study is the Triple Helix concept which proposes a collaborative and dynamic relationship between the government, academia, and industry sectors (Etzkowitz & Leydesdorff, 1995; Leydesdorff & Meyer, 2007). According to the Triple Helix model, all three sectors play important, complex and interrelated roles in the innovation process, with knowledge, resources, and benefits flowing in multiple directions between the different sectors. The Triple Helix model acknowledges the strengths and perspectives of each sector. Academia is typically responsible for the creation of new knowledge; the government sector shapes the broader policy and regulatory landscape and the industry sector is focused on the practical application of research and innovation. To better understand the relationship between government policies and technology development in MENA, future research could focus on various aspects such as national regulatory frameworks, investment incentives, and intellectual property rights. More specifically, future studies may explore the effectiveness of these policies and identify potential trade-offs or synergies between different objectives such as economic growth, social welfare, and environmental sustainability. Another research opportunity consists of examining how policy design and implementation vary across different political regimes and institutional contexts within the MENA region, and whether there are any lessons that can be drawn from successful cases in other regions or countries.

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Competing Interests

The author is an employee of Clarivate Analytics, the provider of Derwent Innovation.

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