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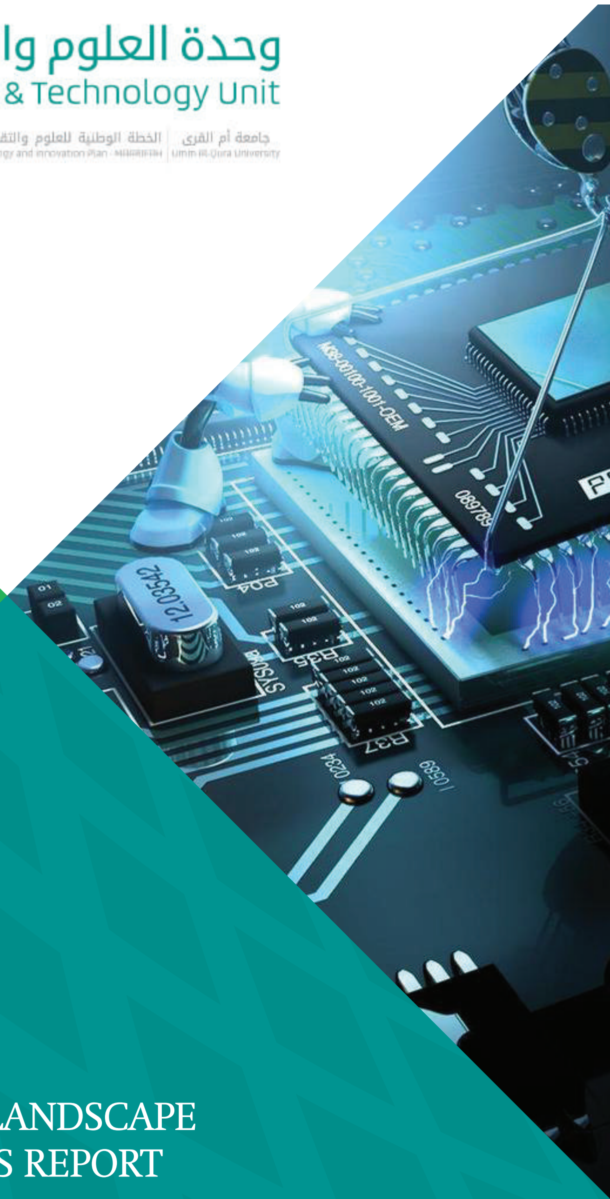
Science & Technology Unit

جامعة أم القرى | الخطة الوطنية للعلوم والتقنية والابتكار- معرفة
Umm Al-Qura University | National Science Technology and Innovation Plan - MAARIFAH



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بسم الله الرحمن الرحيم

IN THE NAME OF ALLAH, THE MOST BENEFICENT, THE MOST MERCIFUL

HIS MAJESTY

KING SALMAN BIN ABDULAZIZ AL SAUD

THE CUSTODIAN OF THE TWO HOLY MOSQUES

HIS ROYAL HIGHNESS

PRINCE MOHAMMAD BIN NAIF BIN ADBULAZIZ AL SAUD

CROWN PRINCE OF KINGDOM OF SAUDI ARABIA

FIRST DEPUTY PRIME MINISTER

MINISTER OF INTERIOR

HIS ROYAL HIGHNESS

PRINCE MOHAMMAD BIN SALMAN BIN ADBULAZIZ AL SAUD

DEPUTY CROWN PRINCE OF KINGDOM OF SAUDI ARABIA

MINISTER OF DEFENSE

HIS ROYAL HIGHNESS
PRINCE KHALED AL FAISAL AL SAUD

GOVERNOR OF MAKKAH AL MUKKARAMAH

PRINCE DR. TURKI BIN SAUD BIN MOHAMMAD AL SAUD

HIS ROYAL HIGHNESS CHAIRMAN OF THE ADVISORY COMMITTEE FOR THE NATIONAL SCIENCE TECHNOLOGY AND INNOVATION PLAN (NSTIP)

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Foreword

In 2008, the Kingdom of Saudi Arabia established the National Science Technology & Innovation Plan (NSTIP) to promote the advancement and sustainability of innovative technologies in 15 Strategic Technology Areas throughout the kingdom.

One of the key components of the National Plan was to assess the overall makeup and achievements of the Science & Technology Unit (STU) at Umm Al-Qura University (UQU).

Since its establishment, the STU at Umm Al-Qura University has set an example in the rapid growth of its list of achievements. Based on the recommendations of international peer review bodies, the NSTIP board has approved funding of 110 out of 320 STU Strategic Technology Program research projects submitted to the American Association for the Advancement of Science (AAAS) making its success rate 35%. The approved budget for Strategic Technology research projects at the STU by the end of 2015 totaled at 194,356,725 SAR.

STU is committed to increasing the number of Research Projects and Faculty Research positions at the University.

The STU-UQU hosts a number of training workshops & seminars on a regular basis and conducts ongoing awareness campaigns to help motivate research faculty on campus and to attract qualified non-teaching candidates at other institutions to take part in the National Plan.

STU aims to maintain this impressive momentum and has set a goal of obtaining a success ratio of 70% in strategic technology projects by making the following administrative and managerial improvements:

- Quality Control
- Social & Economic Benefits
- Grant Writing & Submission Process

STU encourages researchers & scientists to develop Operational Projects, Core Facilities and Technology Innovation Centers, and welcomes International Faculty/ Scientist and Post Graduate visits as part of NSTIP.

Competition is a key element in science and research, both for researchers and for research institutions. Intellectual Property benchmarking and ranking provides innovative estimates on research outputs as well as recommendations for achieving excellence in areas of interest. This report commissioned by Science and Technology Unit and prepared by Thomson Reuters, provides valuable insights into research landscape and performance of Science and Technology Unit in comparison with the Kingdom of Saudi Arabia, MENA as well as the World.

Dr. Faisal Al-Allaf
Director Science & Technology Unit
Umm Al-Qura University

Introduction

Science and technology planning has been high on the list of Saudi Arabia's priorities as it aims to raise its achievements in this vital field to a world-class level and transform it into a major driving force in the development of the kingdom. In 2002 (1423H), the Council of Ministers approved the National Policy for Science and Technology as a key step towards transforming Saudi Arabia's oil-based economy to a knowledge-based one through developing fifteen strategic technological areas. Implementing the government's science and technology policies resulted in the National Science, Technology and Innovation Plan (NSTIP) which is supervised by King Abdul Aziz City for Science and Technology (KACST) and assigned to the coordinated efforts of a number of universities, ministries and governmental agencies.

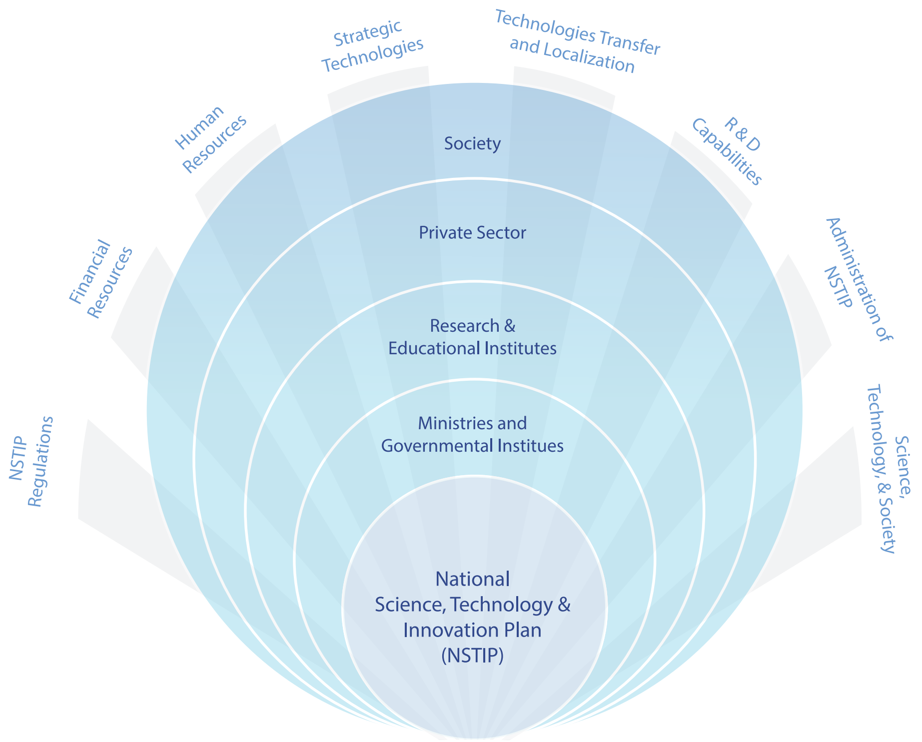
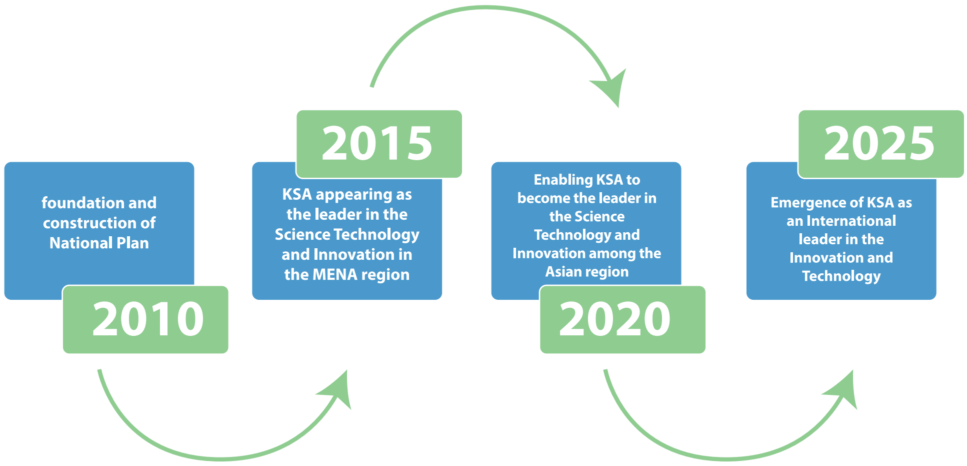


FIGURE 1.0 NSTIP core activities and how they effect the public and private sectors of KSA

As part of the implementation of the National Science, Technology and Innovation Plan, science and technology units in the appointed participant institutions have been established with the aim of supporting strategic science and technology projects and programs which will enable Saudi Arabia to emerge as a major knowledge-based economic force by 2025.



Science technology, innovation and economy pre 2010

1. An economy driven by consumption and the cheap cost of raw materials
2. Advanced technology developed and produced abroad
3. Imported technology
4. Conventional products
5. Exhausted natural resources for manufacturing conventional products

Science Technology and Innovation Industry post 2025

1. An economy driven by knowledge and locally developed science
2. Locally conducted research, development, and innovation
3. Locally produced technology
4. Significant scientific contributions
5. Expanding production and establishing totally new markets

FIGURE 2.0 THE OBJECTIVES OF THE NATIONAL SCIENCE, TECHNOLOGY AND INNOVATION PLAN AS STAGES OF THE FIVE-YEAR PLANS FOR BUILDING A KNOWLEDGE-BASED ECONOMY AND COMMUNITY.

Technology Areas

NSTIP provides funding for 15 different technology areas. These areas have specific strategic priorities that cater to the needs of the Kingdom to advance and get self-reliant technologically. Figure 3.0 displays all the 15 Strategic Technology Priority Areas of NSTIP.
Each Strategic Technology Area has a vision and a mission which must be followed by the researchers.

List of the 15 technology areas:

1. Medical and Health Technology
2. Biotechnology
3. Mathematics and Physics
4. Nanotechnology
5. Water Technology
6. Information technology
7. Environmental Technology
8. Energy
9. Petrochemicals
10. Advanced Materials
11. Agricultural Technology
12. Building and Construction
13. Space and Aeronautics
14. Oil and Gas
15. Electronics, Photonics and Communications

SCIENCE & TECHNOLOGY UNIT

UMM AL-QURA UNIVERSITY

2.1 FOUNDATION AND PROGRESS

The Science & Technology Unit at Umm Al-Qura University (STU-UQU) is an independent research facility under the supervision of Vice President for Graduate Studies & Scientific Research, Umm Al-Qura University. STU-UQU conducts its work in coordination with the General Secretariat of the National Science, Technology & Innovation Plan (NSTIP) and King Abdul Aziz City for Science & Technology (KACST). Its mission is to coordinate all projects related to scientific and technological activity at the university and to ensure that they adhere to policy directives set-forth in NSTIP and strike far-reaching social and economic benefits throughout the Kingdom of Saudi Arabia (KSA).
STU-UQU is responsible for the management of the six NSTIP funding programs: the Advanced Strategic Technology Program, the Technology Innovation Centers Program, the Faculty Scientific Visit Program, the Operational Projects Program, the Core Facility Program, and the Graduate Student Research Visit Program. In addition to administering Project Management Services, STU is also responsible for carrying out awareness campaigns within the university regarding NSTIP funding. Furthermore, STU-UQU holds regular presentations and training sessions on how to write successful grant applications and submit research project proposals for funding which target professors and researchers.

2.2 VISION

The fulfillment of the long-term strategic objectives of the National Science Technology & Innovation Plan through highly distinguished scientific contributions by Umm Al-Qura University researchers.

2.3 MESSAGE

Supporting, funding, developing and overseeing scientific and technological research activities and projects at Umm Al Qura University in such a manner as to ensure their consistency with the strategic objectives of the National Science Technology & Innovation Plan.

2.4 STRATEGIC OBJECTIVES

- Promoting the National Science, Technology & Innovation Plan (NSTIP) within UQU.
- Raising the level of UQU's researchers and faculty member’s contribution and involvement in NSTIP quantitatively and qualitatively.
- Providing scientific advice to researchers with the aim of ensuring the quality of their research proposals and their compatibility with the goals of NSTIP.
- Administrative and technical supervision of NSTIP projects within UQU.
- Working as the link between UQU and the Secretariat of the Comprehensive National Plan for Science Technology and Innovation.
- Encouraging and motivating faculty, researchers and graduate students to actively contribute to the Comprehensive National Plan for Science Technology and Innovation.
- Providing assistance for faculty and researchers in the preparation and formulation of project proposals.
- Following up the progress of research projects and clearing any obstacles standing in the way of their prompt, successful implementation.
- Consolidating the university's relationship with the public and the private sectors, and the community at large.
- Establishing a professional work environment which facilitates the expansion of UQU's local and international research partnerships.
- Commitment to the development of the fifteen Strategic Technology Priority Areas and overcoming any obstacles in the transition to or the nationalization of the knowledge-based economy.

2.5 VALUES

1. Financial, scientific and administrative transparency and fairness.
2. Commitment to assisting researchers and graduate students in achieving their goals.
3. Assuming responsibility for our actions and consolidating excellence.
4. Openness to multiple approaches, nurturing innovative thinking and accomplishing the best results.
5. Fulfilling contracts in accordance with the highest standards of scientific rigor, professionalism, and quality assurance.
6. Devoting our knowledge, expertise and power to the service of our community.

2.6 CONSOLIDATING STU RESEARCH POTENTIAL AND CAPACITY

Nurturing research potential of every type has always been a priority in the National Science, Technology & Innovation Plan (NSTIP). Such dedicated care has included not only investing generously in the facilities and equipment required for research, but, most importantly, in researcher development. As shown below, various internal training programs and workshops have been set up to ensure the constant progress of each participant in any research work conducted by the unit.

2.6.1 TEAM DEVELOPMENT (CHAMPIONS)

A smooth-running, well-coordinated business team is available on campus to help set you up for long-term growth and success.

The Science & Technology Unit's success stems from its human resources comprised of highly trained, competent professionals with diversified skill-sets in fields of Information Technology, Business Management, Project Management, Consulting as well as Audit & Finance.

The activities of STU-UQU are overseen by the Rector and Vice President of the University. The main activities are managed and controlled by the Director of STU-UQU with the support of Coordinator STU-UQU.

Both the Director and Coordinator also oversee the activities of Scientific & Financial Committees.

The Scientific Committee reviews and evaluates research projects.

The Financial Committee is responsible for evaluating and approving tenders for the procurement of equipment and supplies for any given project.

SECTIONS

EXECUTIVE SUMMERY

ADVANCED MATERIALS

ADVANCED MEDICAL & HEALTH RESEARCH

BIOTECHNOLOGY

ELECTRONICS, COMMUNICATION & PHOTONICS

ENVIRONMENTAL TECHNOLOGY

INFORMATION TECHNOLOGY

MATHEMATICS & PHYSICS

NANOTECHNOLOGY

SPACE TECHNOLOGY

WATER TECHNOLOGY

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Current Situation

This Executive Summary report summarizes the ten Strategic Technology Areas (STAs) identified by Science & Technology Unit – Umm Al Qura University (STU-UQU). The report focuses on the current situation in each of the STAs around:

- Number of projects approved
- Research output
- Emerging areas
- Potential other tracks for consideration
- Specific Recommendations for current/future technologies

The recommendations are based on the data analysis found in each individual report and through the on-line dashboards. Identification of and recommendations for specific technologies within each of the STAs are also based on current and future potential of technologies.

Collaborative efforts with other institutions across the world have been identified, based on patent and scientific paper outputs. Large institutions such as the Russian Academy of Sciences are an amalgam of various smaller institutions and may have several thousand researchers. For example, the Russian Academy of Sciences encompasses close to 500 institutions, and has about 55,000 researchers. Similarly, the Chinese Academy of Sciences encompasses about 30 research institutes with over 4000 researchers (PhD graduates). The French Government CNRS is divided into 10 institutes and employs about 26,000 employees (including researchers, engineers, and administrative staff).

The following table summarizes the current situation for STU-UQU in the 10 strategic technology areas:

Technology Area	Number of Approved Projects	Number of scientific literature articles	Number of Patents
Advanced Materials	1	7	
Advanced Medical & Health Research	10	25	
Biotechnology	8	16	
Electronics, Communication & Photonics	5	7	5
Environmental Technology	2	15	1
Information Technology	19	13	1
Mathematics & Physics	3	4	
Nanotechnology	7	25	
Space & Aeronautics	1	1	
Water Technology	1	18	

The two largest areas in terms of projects approved are Information Technology and Advance Medical & Health Research.

Environmental, and water technology areas have considerable article output for very few approved projects; this may indicate an area of opportunity to build more projects. Similarly, Nanotechnology has among the largest article output for relatively fewer approved projects.

Electronics, Communications and Photonics is the only area that appears to have a noticeable number of published patents. It is noted other areas may have patents in the system but have not had them published. This indicates a huge opportunity across all technology areas to start to build a patent portfolio.

It is clear with 19 projects Information Technology is an important area, however there is concern over the lack of research output being generated from this area.

Advanced Materials

Technology Track	Technology sub-track	Number of Approved Projects	STU-UQU Research Output	Patent	Scientific Literature
1.0 Material Properties	1.1 High Strength				
	1.2 High Temperature-Pressure		x		
	1.3 Light Weight			emerging	
	1.4 Corrosion-Abrasion resistant		x		
2.0 Type of Materials	2.1 Metals & Alloys		x		
	2.2 Polymers		x		
	2.3 Ceramics		x		
	2.4 Composites				
	2.5 Nanomaterials				
3.0 Design methodology	3.1 Modelling	1		emerging	
	3.2 Simulation	1			
	3.3 Analysis				
	3.4 Optimization				

Other Tracks
Membranes
Smart Materials
Silicone based materials

STU-UQU may focus future project submissions on Light Weight materials, and Modelling based Design methodologies. These are emerging areas particularly in the commercialization (patenting) phase, and out of the conceptualization phase (indicated by slowing scientific literature output).

Collaborations with industry leading organizations will likely be well received, since material design is a highly specialized discipline, and modelling and simulation solutions will help rapid prototyping, and testing of materials – saving costs in the material design cycle. Regionally, in the Middle East and Africa, King Abdulaziz City for Science & Technology (KACST) and the University of Witswatersrand (South Africa) are potentially strong collaborators. In Europe, collaborations with Russia's Aviation Materials Research Institute, Russian Academy of Science; the French CNRS, and Germany's Technical University of Dresden may be fruitful. Within Asia, the Chinese Academy of Science, and Zhejiang University can be strong partners.

It is recommended to have 15 to 20 scientists holding PhDs, with specialization in ceramics, or composites, and 3 to 4 experts (MSc post graduates) in computer aided modelling and simulation, for short term (next 2-3 years) growth. It will be greatly beneficial to have convergent teams on such projects, and development on both the material science aspect, as well as the software deployment aspect occurs simultaneously, in close synchronization. Material scientists can focus on the scientific and implementation aspects of material design. Software experts can focus on defining the modelling, and simulation software system.

IT solutions providers and technology consultants (onshore and offshore) can be particularly useful for deploying the modelling and simulation systems. Cloud computing resources to keep infrastructure costs down may also be evaluated.

In addition to these opportunities, tracks that STU-UQU has not focused on may offer opportunities for project submissions e.g.

– Membranes
– Smart materials
– Silicone based materials

Advanced Medical & Health Research

Technology Track	Technology sub-track	Number of Approved Projects	STU-UQU Research Output	Patent	Scientific Literature
1 Communicable Diseases	1.01.01 Bacterial Infections				
	1.01.02 Viral infections				
	1.01.03 Fungal Infections				
	1.01.04 Protozoan Infections				
	1.01.05 Hepatitis	1			
	1.01.06 HIV AIDS				
	1.01.07 Pandemic Influenza		x		emerging
	1.01.08 Parasites		x		
	1.01.09 Sexually Transmitted Infections	1	x		
	1.01.10 Skin Diseases				
	1.01.11 Tuberculosis	1			
	1.01.12 Food Borne Diseases		x		emerging
	1.01.13 Animal or Insect Borne Diseases		x		
	1.02 Treatment		x		
	1.03 Diagnosis				
2 Non-communicable Diseases (Cancer)	2.01.01 colorectal cancer		x		
	2.01.02 Liver Cancer				
	2.01.03 Brain Tumors				
	2.02 Screening / Diagnosis				
	2.03.01 Gene-Viro-Therapy			emerging	
	2.03.02 HerbalPlant Products	5			
	2.03.03 Pharmaceutical Drugs				
	2.03.04 Chemotherapy				
	2.03.05 Radiation Therapy				
	2.03.06 Vaccines				
	2.03.07 Cell Trasnplantation				
3 Medical & Health Technology	3.01.01 Diagnosis				
	3.01.02.01 Pharmaceutical Drugs				
	3.01.02.02 Gene Therapy				
	3.01.02.03 Nerve Regeneration Therapy				
	3.01.02.04 Low-Level Laser Therapy (LLLT)				
	3.01.02.05 Near-Infrared Phototherapy	1			
	3.01.02.06 Static and Pulsed Magnetic Field Therapies				
	3.01.02.07 Transcutaneous Electrical Nerve Stimulation				
	3.01.02.08 Percutaneous Electrical Nerve Stimulation				
	3.01.02.09 Spinal Cord Electrostimulation				
	3.01.02.10 Stem Cell Therapy				
4 Ectopic Pregnancy	4.01.01.01 Ectopic Pregnancy Types		x		
	4.01.02.01 Pelvic Inflammatory Disease				
	4.01.02.02 Infertility				
	4.01.02.03 Endometriosis				
	4.01.02.04 Abdominal Pain				
	4.01.02.05 Sexually Transmitted Diseases	1		emerging	
5 Reproductive Medicine	5.01.01.01 Fertility Medications			emerging	
	5.01.01.02 In Vitro Fertilization		x		
	5.01.01.03 Intrauterine insemination				
	5.01.01.04 Intra-Cytoplasmic Sperm Injection		x		
	5.01.01.05 Surrogacy				
	5.01.02.01 Ultrasound Imaging				
	5.01.02.02 Magnetic Resonance Imaging/Hysterosalpingography				
	5.01.02.03 Endoscopic Techniques				
	5.01.02.04 Inhibin				
	5.01.02.05 Activin				

There are sub-tracks within the current tracks that STU-UQU could focus on for future project submissions e.g.

- Pandemic influenza
- Food borne diseases
- Gene-Viro-Therapy
- Abdominal pain
- Sexually transmitted diseases

The full report highlights potential collaborators to partner with around these opportunities, as does the on-line dashboards

Further, the field of Medical & Health technologies (Diagnostics) exhibits much higher growth than other areas within this field. Newer and more accurate methods for diagnostics are quite sought after within the medical and health sector.

While improvements of all diagnostics technologies can be beneficial to STU-UQU, particular focus can be placed on Low level Laser Therapy (LLLT), Transcutaneous Electrical nerve simulation, percutaneous electrical nerve stimulation, spinal cord electrostimulation, and magnetic field therapies. Other highly trending areas in the fundamental research phase include stem cell therapy, and nerve regeneration therapy, which are not being heavily commercialized at the moment; and gene-viro therapy which seems to have entered commercialization phase.

Strong collaborations within the Middle East and Africa region can be formed with South Africa's University of the Witwatersrand, and University of Cape Town. Within Europe, collaborations with CNRS, France; and University of London will be fruitful. In the rest of the world, the largest collaborator will be the University of California.

For near term growth (next 2-3 years), the medical & health research team can have 50 to 60 scientists (PhDs), with higher focus towards for physical therapies stated above, stem cell research, nerve regeneration therapy research, and gene-viro therapy research.

Specialized labs for stem cell and tissue engineering, and genetics research (particularly for gene-viro therapy) will be required to focus on these areas. An advanced electronics lab will be required for testing improvements to physical therapy equipment, as well as labs for preclinical studies.

Biotechnology

Technology Track	Technology sub-track	Number of Approved Projects	STU-UQU Research Output	Patent	Scientific Literature
	1.01.01 Computer-Aided Drug Design (CADD)		x		
	1.01.02 Non-Computed-Aided Drug Design		x		
	1.02 Synthesis of Antitumor Drugs		x		
	1.03 Biological Evaluation		x		
1 Medicinal Chemistry (Drug Design)	1.04.01 Nanoparticles	2			emerging
	1.04.02 Liposomes				
	1.04.03 Micelles				emerging
	1.04.04 Dendrimers			emerging	
	1.04.05 Others				
	2.01 Bacterial Infections				
	2.02 Viral Infections				
	2.03 Fungal Infections				
2 Communicable Diseases	2.04 Protozoan Infections	2			
	2.05.01 Bacteriophage Therapy				
	2.05.02 Gene Therapy				emerging
	2.05.03 Virotherapy				
	2.05.04 Pharmaceutical Drugs				
	3.01.01Single Gene / Chromosomal Disorder				
3 Genetic Disorders	3.01.02 Multifactorial and Polygenic (Complex) Disorders	3		emerging	
	3.01.03 Teratogenic Disorders			emerging	
	3.02 Treatment				

Other Tracks
Protemics and Biomarkers
Stem cell Technology/Therapy
Toxicology
Agricultural Biotech
Environmental Biotech

There are sub-tracks within the current tracks that STU-UQU could focus on for future project submissions e.g.

- Nanoparticles
- Micelles
- Dendrimers
- Gene Therapy
- Multifactorial and polygenic disorders
- Teratogenic

A number of areas within biotechnology are good candidates for fundamental research, as well as for commercialization. Particularly, in the area of Drug Design, nanoparticles, micelles, and dendrimers appear to be in the fundamental research and development phase, with micelles and dendrimers moving towards commercialization as well. Both computer aided, as well as non-computer aided drug design are highly researched areas. Apart from drug design, genetics research is also a hot area in fundamental research.

Locally, the King Saud University can potentially be a strong, close collaborator. In Europe, collaborative efforts can be helpful with leaders CNRS, France; and the University of London, UK. In other parts of the world, University of California is a noteworthy institution for collaborative efforts.

Experts (PhDs) specializing in pharmaceuticals (drug design), and scientists (PhDs) in genetics will be required to focus R&D efforts in these important areas.

Specialized labs will be required for genetics research. For drug design endeavors, both – a wet lab for non-computer aided design, as well as a dry lab for in silico (computer aided) design will be required. The dry lab will also aid in laying a foundation for proteomics research – which is a sub-track STU-UQU has not focused on within the biotechnology field.

Further to these opportunities, a track that STU-UQU has not focused on may offer opportunities for project submissions e.g.

- Proteomics & biomarkers
- Stem cell technology/therapy

- Toxicology
- Agricultural biotech
- Environmental biotech

The full report highlights potential collaborators to partner with around these opportunities, as does the on-line dashboards

Electronics, Communication & Photonics

Technology Track	Technology sub-track	Number of Approved Projects	STU-UQU Research Output	Patent	Scientific Literature
1 Wireless Sensor network	1.01 Power saving and efficiency		x		
	1.02 Cross layer Design		x	emerging	
	1.03 Fault tolerance/Robustness				
	1.04 Network configuration		x		
2 Wireless Sensor Network - Communication	2.01 In-network processing		x	emerging	
	2.02 Localization	1			
	2.03 Timing Synchronization				
	2.04 Sensor communication and collaborative data		x		
3 Oil & Gas pipeline monitoring	3.01 Corrosion/Leakage sensors				
	3.02 Pressure sensors				emerging
	3.03 Flow sensors	1			emerging
	3.04 Temperature sensors				
	3.05 Seismic sensors			emerging	
	3.06 Computational Pipeline Monitoring				
4 Under Water Sensors	4.01 Optical				
	4.02 Acoustic				
	4.03 Electrochemical/Electromagnetic				
	4.04 Biosensor				
5 Ultra Wide Band - Modulation	5.01 Pulse Position Modulation				
	5.02 Pulse Amplitude Modulation				
	5.03 ON-Off Keying				
	5.04 Pulse Shape Modulation				
	5.05 Phase Modulation				
6 Ultra Wide Band - Localization and tracking	6.01 Angle/Time of Arrival				
	6.02 Received Signal Strength	1			
	6.03 Range Based				
	6.04 UWB RADAR				
7 FPGA - Architecture	7.01 Coarse Grained				
	7.02 Asynchronous FPGAs				
	7.03 Nano-Technology				
	7.04 FPGA Embedded Processors				
8 FPGA - CAD tools	8.01 Routing algorithms				
	8.02 Placement algorithms				emerging
	8.03 Timing analysis	1			
	8.04 Simulation and verification				
9 IC - Design	9.01 Floorplanning/Placement				
	9.02 Logical Sythesis				
	9.03 Clock insertion				
	9.04 Routing	1			emerging
	9.05 Signal integrity analysis		x		
	9.06 Timing performance analysis		x		

Other Tracks
Optoelectronics
MEMS Sensors & Actuators
Microwave Systems

The fields of Wireless Sensor Networks (both sensors, as well as communication) are hot areas for patent filings as well as new research. With more technologies being subject to automation and control, and to prognostics and monitoring, wireless sensor networks appear to be a main stay in electronics technology. The field is conducive to licensing, and patents can likely be used for commercial gains, particularly if filed broadly – (at least in the US, and Europe).
Focus should remain on lowering power consumption, and improving accuracy, precision, and sensitivity of sensor networks. Miniaturization and monolithic (sensor + communication on single semiconductor device) sensors are currently trending technologies.
Collaborations with other academic institutions is possible, with King Fahd University of Petroleum & Minerals locally; CNRS, France; University of California (US), a number of Chinese universities including the Chinese Academy of Science, Zhejiang University; and the South Korean ETRI. However, collaborations with the corporate sector should also be evaluated – academic-industrial collaborations help combine academic knowledge and research, with industry know-how and problem solving experience.
In terms of human resources, the R&D team should include a scientists and engineers, with experience and/or specialization in Wireless communication, and sensors and telemetry. Since experts are more accessible within this field, and output per expert also typically higher, scaling capacity is relatively easier as compared to other fields. A target of 2 to 5 senior scientists (PhDs) and about 15 to 20 engineers (MSc) should be sufficient for near term (next 2 – 3 years growth).
No specialized lab may be required. Sensors networks are best tested in field conditions. However, field testing may not always be convenient or accessible. Therefore, equipment to simulate field conditions – particularly heat, electrical noise, and electromagnetic interference should be invested in.STU-UQU has already begun investments within these fields, and can continue work within the fields, and may evaluate expansion in research and development.
Apart from these two tracks, there are sub-tracks within the current tracks that STU-UQU could focus on for future project submissions e.g.

- Oil / Gas pipeline monitoring
  - Pressure sensors
  - Flow sensors
  - Seismic sensors
- FPGA
  - Placement algorithms
- IC Design
  - Routing

Further, tracks that STU-UQU has not focused on may offer opportunities for project submissions e.g.

- Optoelectronics
- MEMs Sensors & Actuators
- Microwave Systems

Environmental Technology

Technology Track	Technology sub-track	Number of Approved Projects	STU-UQU Research Output	Patent	Scientific Literature
1.0 Pollution Monitoring/ Treatment	1.01 Air Pollution	1	x		
	1.02 Soil Contamination		x		
	1.03 Water Contamination		x		emerging
	1.04 Diagnosis/Mitigation		x	emerging	
2.0 Waste Treatment	2.01 Municipal/Domestic Waste Treatment	1	x	emerging	
	2.02 Industrial Waste				
	2.03 Electric Component Manufacturing Waste				emerging
	2.04 Eco Friendly Synthesis		x	emerging	emerging

Environmental technologies are experiencing fairly high growth across all areas – either in terms of fundamental research, or in the commercialization phase. STU-UQU should focus on developing improvements to commercial solutions for soil contamination, and industrial waste management. STU-UQU should focus fundamental research on electronic component manufacturing waste management.

For a couple of areas, STU-UQU should focus on both – fundamental research as well as developing improved techniques and solutions for water contamination management, as well as for eco-friendly synthesis.

Collaborations with field leading academic institutions may be possible with King Abdulaziz City for Science & Technology; Institut Francais de Petrole, France, CNRS, France, the Chinese Academy of Science, and Zhejiang University, China.

To focus research and development in this field, BSc, as well as MSc engineers in environmental engineering, environmental management, or waste management will be required. Chemical engineers (BSc or MSc) with expertise in hazardous chemicals may also be good contributors to the program. About 4 to 6 senior researchers (PhD holders) can direct and guide the research efforts.

An environmental testing lab may be set-up to test and develop new approaches to waste diagnosis and mitigation. However, waste analysis services may also be outsourced to specialist waste labs.

The full report highlights potential collaborators to partner with around these opportunities, as does the on-line dashboards

Information Technology

Technology Track	Technology sub-track	Number of Approved Projects	STU-UQU Research Output	Patent	Scientific Literature
1.0 High Performance Computing	1.01 Supercomputing	1			
	1.02 Parallel Computing				
	1.03 Computer Modelling	4			
	1.04 Computer Simulation				
2.0 Computer Networks	2.01 Computer Networks	3	x	emerging	emerging
	2.02 Cloud Computing				
	2.03 IT Security				
	2.04 Database Systems	2			
3.0 Software Applications	3.01 Open Source Software	2		emerging	
	3.02 E-Learning	1			
	3.03 E-Health	1			
	3.04 Special Needs Applications	1			
4.0 Localization	4.0 RFID and Sensor Networks	5			
5.0 Energy Efficient IT	5.01 Servers and datacenters			emerging	emerging
	5.02 Network devices		x		emerging
6.0 Intelligent Transportation	6.0 Intelligent Transportation	2			

Other Tracks	
Language and Speech Technologies	NLP
	Machine Translation
	Search Engines
	Computational Linguistics
	Text/Speech Processing
	OCR

Information Technology is a very fast evolving field, with the industry moving more towards centralized computing, from high levels of localized computing seen currently. Cloud storage and computing are becoming more and more relevant. This is only possible with high performance servers, datacenters, and network appliances.

It is recommended that STU-UQU evaluate in-depth, more focus towards cloud storage and computing, datacenters technologies, and network appliances. Particularly, for cloud computing and storage: Focus on more efficient virtualization of storage, and compute resources; for datacenters focus on reliability, and high availability, along with low power consumption, and efficient cooling; and for network appliances – focus on software defined networking.

The networking and computing labs will suffice for such projects – however, capacity enhancements may be made in accordance with projected funding of research in the short term (upcoming 3-5 years). All such endeavors will be well facilitated by networking engineers and scientists (MSc); and to a lower extent to computer engineer and scientists (MSc). The primary challenges remain in efficient communication of data between various systems in the connected environment, whereas the actual computing/processing are secondary challenges with the industry having effective solutions in the state-of-the-art.

In addition to these, another hot area is that of intelligent transportation. With increasing reliance on technology to ease transportation, this area appears to be a mainstay in IT. Researches can be guided primarily by scientists and experts (PhDs or MSc) in transportation, and people/crowd dynamics and analytics. IT engineers and scientists can provide the solutions for effective deployment of intelligent transportation solutions. The larger challenge remains effective scheduling and channeling of limited available transportation.

Again, specialized labs may not be required – the computing lab should be sufficient for computer aided modelling and simulations for transport and crown dynamics analysis.

All areas discussed in the recommendations section show high growth in patent filings as well as research literature, while having low to medium existing volumes. Further, these areas are also conducive to patent licensing, and thus may generate commercial gains if STU-UQU obtains patents in these areas, and out-licenses them.

Further to these opportunities, a track that STU-UQU has not focused on may offer opportunities for project submissions e.g.

– Language & speech technologies

The full report highlights potential collaborators to partner with around these opportunities, as does the on-line dashboards

Mathematics & Physics

Technology Track	Technology sub-track	Number of Approved Projects	STU-UQU Research Output	Patent	Scientific Literature
1.0 Fluid Dynamics	1.01 Flow Modeling	3	x	emerging	
	1.02 Convection modeling		x		
	1.03 Aerodynamics		x		
	1.04 Hydrodynamics				emerging
	1.05 Computational fluid dynamics			emerging	emerging
2.0 Fluid Statics	2.01 Halocline				
	2.02 Thermocline				
	2.03 Aerostatics				
	2.04 Hydrostatics		x		

There are sub-tracks within the current tracks that STU-UQU could focus on for future project submissions e.g.

– Flow modelling
– Hydrodynamics
– Computational fluid dynamics

The Fluid Dynamics area within Mathematics and Physics is particularly interesting for further research and development – with high growth in flow modelling, hydrodynamics, and computation fluid dynamics.
Most significant entities for collaborations may lie outside the Middle East and Africa – the Central Aerohydrodynamic Institute, Urals Federal University, and the Russian Academy of Science, in Russia; CNRS, France, the Beijing University of Aeronautics and Astronautics, and the Chinese Academy of Science; and the University of California, US.
For the near term (2 – 3 year) growth, STU-UQU should have about 8 – 10 senior researchers (PhD) specializing in aerodynamics or hydrodynamics. Capacity can be scaled with aeronautics engineers (MSc).
For a complete all-round research and development, STU-UQU should invest in a wind tunnel, a water tunnel, as well as a dry lab for computational fluid dynamics – including a state-of-the-art compute cluster.
The full report highlights potential collaborators to partner with around these opportunities, as does the on-line dashboards

Nanotechnology

Technology Track	Technology sub-track	Number of Approved Projects	STU-UQU Research Output	Patent	Scientific Literature
1.0 Nano Materials	1.01 Photosensitive Nanoparticle / Nanomaterial		x		emerging
	1.02 Nanocomposites	2	x		
	1.03 Nanosilver / Antimicrobial	1	x		emerging
	1.04 Block Copolymers	1			
	1.05 Material Enhancement Using Nanoparticles, NWs or NTs				emerging
	1.06 Nanocatalyst	1	x		
	1.07 Organic Nanoparticle				
	1.08 Inorganic Nanoparticle				
2.0 Nano Fabrication	2.01 Self-assembly	1	x		
	2.02 Other Nanofabrication		x		
3.0 Nanomechanics/NEMS	3.0 Nanomechanics / NEMS		x		
4.0 Nanobiotechnology	4.0 Nanobiotechnology				
5.0 Modeling / Monitoring	5.01 New Material and Nanostructure Modeling		x		
	5.02 Nano Devices Modeling		x	emerging	
	5.03 Error Modeling			emerging	emerging

Other Tracks
MEMS
Water Purification
Adhesives

There are sub-tracks within the current tracks that STU-UQU could focus on for future project submissions e.g.

- Photosensitive nanoparticle nanomaterial
- Material enhancement using nanoparticles, NWs or NTs
- New material and nanostructure modelling
- Error Modelling

Nanotechnology is an emerging field, with high growth rates across all areas. Although somewhat matured, nanotech shows sustained interest in all areas – indicating that there is still vast swathes of unexplored capabilities of nanotechnology. STU-UQU will do well if research in any area of nanotechnology is pursued. Particularly noteworthy areas, which show higher growth than other areas include Antimicrobial nanosilver, material enhancement using nanoparticles, nanowires, and nanotubes, nanofabrication other than self assembly, and all areas of nano modelling/monitoring.
Within the Middle East and Africa, Saudi Arabian institutes are most suitable collaboration partners – including King Abdulaziz City for Science and Technology, King Fahd University of Petroleum and Minerals, and King Saud University. In Europe, collaborations can be made with CNRS, France, and with Russian institutes – People's Friendship University, and the Russian Academy of Science. In other parts of the world, the Chinese institutes are the largest, including the Chinese Academy of Sciences, Qinghua University, and Zhejiang University; followed by the University of California, US.
With such high amount of interest in the field, STU-UQU will require 25 – 30 researchers (PhDs) to grow in the near term (3 – 5 years). Broadly, scientists can be experts in any one of nano material sciences, nanotech fabrication, or nanobiotechnology.
Nanotechnology research will require a specialized lab with state-of-the-art equipment for synthesizing nanostructures, and testing them – including furnaces, vapor deposition equipment (thermal and chemical), sputtering equipment, and so forth.
In addition to the lab, nanotechnology research will also be aided by a computing lab for nanotech modelling and simulations – including a state-of-the-art compute cluster.
Further to these opportunities, a track that STU-UQU has not focused on may offer opportunities for project submissions e.g.

- MEMs
- Water purification
- Adhesives

The full report highlights potential collaborators to partner with around these opportunities, as does the on-line dashboards

Space Technology

Technology Track	Technology sub-track	Number of Approved Projects	STU-UQU Research Output	Patent	Scientific Literature
1.0 Electronic Navigation	1.01 Radio/RADAR Navigation	1			emerging
	1.02 Satellite Navigation		x	emerging	
2.0 Inertial Navigation					
3.0 Celestial Navigation					
4.0 Navigation System Components	4.01 Sensing Components			emerging	
	4.02 Hybrization / Augmentation				
	4.03 Navigation Data Processing				
5.0 Testing / Calibration / Monitoring					

Other Tracks	
Propulsion & fuels	
Avionics	Aircraft Management
	Flight Controls
	Weather Systems

There are sub-tracks within the current tracks that STU-UQU could focus on for future project submissions e.g.

- Radio / RADAR navigation
- Sensing components
- Satellite navigation

Although satellite based navigation is the most prolific area, with high growth – most satellite navigation systems (GPS, GLONASS, Galileo) are based on standard implementations of the system, and leave little room for development.

The most notable area for development is hybridization/augmentation. This discipline deals with combining inputs from various other technologies (inertial sensors, magnetometers, cellular networks, Wireless data networks, and so forth) to enhance the accuracy and speed of satellite navigation locking and tracking. This is not a standardized field, and therefore open to research and development to a much larger extent.

Scientists and experts (MSc) in sensor fusion will best drive research and development in this discipline. A focused team of 8 to 10 scientists led by 2 to 3 senior researchers (PhDs) will help provide near term (coming 3-5 years) growth.

Specialized labs may not be required – navigation systems are best field tested. However, field testing may not always be possible. Equipment to simulate field conditions, (particularly signal interference and blocking from large buildings, and electromagnetic noise) should be evaluated for inclusion. The primary challenge is speed of operation, and obtaining sensitivity, accuracy, and precision from sensors other than the satellite navigation module.

Similar research may also be extended to inertial navigation. This type of system provides "off-line" navigation, when satellite signals are weak or otherwise unavailable. This can be particularly useful in critical military applications – where failsafe is critical, as well as in urban, extra-urban, and dense tree cover settings – where satellite navigation may not be completely reliable.

Further to these opportunities, a track that STU-UQU has not focused on may offer opportunities for project submissions e.g.

- Propulsion & fuel
- Avionics
- • Aircraft management
- • Flight controls
- • Weather systems

Water Technology

Technology Track	Technology sub-track	Number of Approved Projects	STU-UQU Research Output	Patent	Scientific Literature
1.0 Waterwaste Sources	1.01 Agricultural		x		
	1.02 Municipal Domestic		x		
	1.03 Petrochemical Industry				emerging
	1.04 Other Industries				emerging
2.0 Treatment Techniques	2.01 Primary Treatment			emerging	
	2.02 Secondary Treatment		x		
	2.03 Advanced Treatment	1	x		
	2.04 Natural Biological Treatment				
3.0 Plants and Reactors			x		
4.0 Wastewater Management				emerging	

Other Tracks
Drinking water treatment
Desalination

Environmental technologies are experiencing fairly high growth across all areas – either in terms of fundamental research, or in the commercialization phase. STU-UQU can innovate on any area of waste water treatment – both for fundamental research as well as for commercial applications.
There are sub-tracks within the current tracks that STU-UQU could focus on for future project submissions e.g.

- Petrochemical industry
- Primary treatment
- Wastewater management

Collaborations with field leading academic institutions may be possible with King Abdulaziz City for Science & Technology; King Fahd University of Petroleum and Minerals; Ufa State Petroleum Technology Institute; Institut Francais de Petrole, France; the Chinese Academy of Science, Zhejiang University, China; and the University of California, US.
To focus research and development in this field, BSc, as well as MSc engineers in environmental engineering, environmental management, or waste management will be required. Chemical engineers (BSc or MSc) with expertise in hazardous chemicals may also be good contributors to the program. About 4 to 6 senior researchers (PhD holders) can direct and guide the research efforts.
A wastewater analysis and treatment lab may be set-up to test and develop new approaches to wastewater analysis and treatment. However, waste analysis services may also be outsourced to specialist waste labs.
Further to these opportunities, a track that STU-UQU has not focused on may offer opportunities for project submissions e.g.

- Drinking water treatment
- Desalination

METHODOLOGY

Taxonomy design

For each Strategic Technology Area, a taxonomy was designed based on the tracks and sub-tracks of various project proposals approved for funding by the STU-UQU. Tracks were used to define broad technical areas of the taxonomy, while sub-tracks were used to defined the specific technical areas of the taxonomy. The taxonomies also include appropriate scope expansion to include other technologies similar to the sub-track, and potentially part of the same track, but not currently within the funded project proposals.

Collection Building

Based on the taxonomy, various searches were developed – one for each specific technical area, to cover patents and/or literature relevant to that specific technical area. A judicious combination of keywords and patent classification codes, including International Patent Classification (IPC), Derwent Manual Classification Codes (DWPI Manual Codes), and Co-operative Patent Classification (CPC) was used to define the search strategies.

Collection building typically includes:

- Initial searching to acquire a small high relevance sample collection.
- Review of the sample collection using text mining to identify terms and phrases of art in the technical area.
- Review of the sample collection to identify candidate indexing codes and testing of the indexing candidates for appropriateness.
- Iteration of the searching strategies to assemble a well-balanced substantive collection that covers the field of interest robustly while keeping unwanted topics to a minimum. The importance of a high quality collection to reliable analysis cannot be understated, and typically collection building takes about 1/3 of the project effort.

The search strategies were selected to provide a substantive overview of the subject matter that is sufficiently precise to avoid high noise levels. Exhaustive search strategies produce high noise levels and are not effective for obtaining a correct overview of a technical field. Exhaustive strategies are more effective for narrower, more invention-specific searches done for different purposes than obtaining an overview.

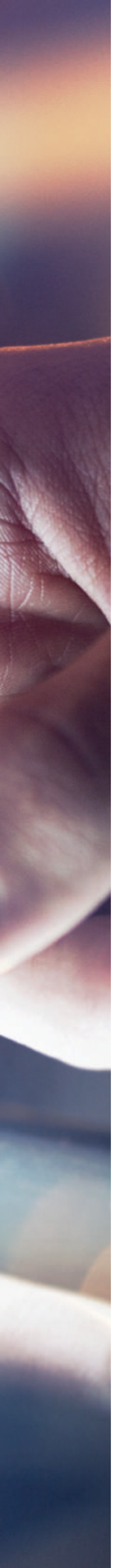
Data Standardization

Bibliographic data to be used for preparing the various analytics was then standardized to provide a clear picture of the statistics.

- Country names were standardized to remove non-existent countries (such as Scotland merged into the United Kingdom), and remove province/state names particularly in the Literature data.
- Assignee Names standardized to remove name variations, thus eliminating different variants of the same entity occurring more than once within the analytics. Within each strategic technology area, The assignee standardization was performed for:
- The top 30 entities in the patent dataset, and the literature dataset
- Top 30 entities within Middle East & Africa
- All Entities in the Kingdom of Saudi Arabia

Performing assignee standardization for the complete datasets is prohibitively effort intensive due to the large datasets. Therefore, the above approach was used.

- For the patent data, all patent applications filed by entities of the Kingdom of Saudi (KSA) entities were assigned KSA as the country of origin. Patents may or may not be filed in the home country. Therefore, to present a more realistic picture of patent applications originating from the KSA, this step was performed. Performing this step for all countries is prohibitively effort intensive due to the large data sets.



LANDSCAPE OF MATERIAL DESIGN

SCIENCE & TECHNOLOGY UNIT, UMM AL-QURA UNIVERSITY (STU-UQU)

THOMSON REUTERS IP SERVICES
April 2014

Executive Summery

This study has been commissioned by Science & Technology Unit, Umm Al-Qura University (STU-UQU) to evaluate and describe the global scientific research and patent activity within sub-tracks that they have achieved funding for projects. Within the Advanced Materials track, the sub-track of focus was Material Design technology.

The study has looked at both scientific papers and patents to form an understanding of the overall scientific and technology landscape.

The scientific papers are sourced from the Web of Science™, a database containing journal articles from approximately 12,500 peer-reviewed journals.

The patent information is sourced from the Derwent World Patents Index™, a database of patents and patent applications from 47 international patent issuing authorities.

Both databases have been selected because they provide a method of defining a unit of science or technology. A single paper defined by the Web of Science is required to have met a minimum threshold of scientific rigor: publication within a journal of repute, peer review sign off, etc. Furthermore, a patent included within DWPI is defined credibly as an attempt to protect a piece of innovation within at least one territory.

Aggregating this information across technologies and countries provides a method of tracking Material Design innovation and science trends.

Included in this document are measurements of research and patent quality and direction changes in research and patent activity. It should be noted that in many areas the report utilizes metrics such as average annual percentage growth in scientific and research output to compare activities across technologies and geographies. Such metrics should be treated with care for analyses containing low volumes, as some volatility is expected. Also to be noted is that the global high volume nature of this analysis within Material Design technology necessarily entails some level of noise and is not intended to be completely comprehensive. Instead, the analyses enclosed should be treated as a survey of the technology, and the trends and findings interpreted in this manner.

Overall, the fact that the number of patents in the area surpasses the number of papers by a factor of 2.5 suggests that research activity is generally focused more on practical technical commercialization as opposed to more fundamental research.

For STU-UQU, it is interesting to note the patent and scientific literature collections differ with respect to the breakdown in technology segments. The most active segment in both data sets is composites, however thereafter the breakdown differs. This suggests that on a global level, there is greater focus on technology commercialization of areas such as high temperature-pressure, lightweight and nanomaterials and more fundamental research in areas such as ceramics, metals & alloys and corrosion-abrasion resistance. This insight may give STU-UQU direction on future projects and research focus.

Similarly with regard to growth rates, the patent technology segments experiencing growth includes ceramics, light weight and high temperature-pressure. While all areas in the scientific literature collection have seen a decrease over time, indicating this area is now more commercially focused, with less fundamental research taking place. This may represent an opportunity for STU-UQU University to focus on material property areas such as light weight and high temperature-pressure.

Technology category overlap analysis can also yield insights for STU-UQU future project planning. Opportunities may exist around corrosion-abrasion resistant property and also around nanomaterials.

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INTRODUCTION TO GLOBAL ADVANCED MATERIALS SCIENTIFIC ACTIVITY

This study presents an analysis of patents and scientific papers that fall within specific topics of interest to Science & Technology Unit, Umm Al-Qura University (STU-UQU) concerning the Material Design technology area.

The study was commissioned by STU-UQU as part of a wider program to review the scientific paper and intellectual property activity in specific topics that they have gained approved funding for projects. Within the Advanced Materials technology area, they have gained funding approval for one project related to the Material Engineering track, but specifically in the sub-track of Material Design. The title of the project is “Designer Materials: Achieving the Materials Properties via Controlling the Deformation Conditions”.

A large scale data collation process using globally recognized search processes from Thomson Reuters was undertaken to produce practical and insightful sets of information for analysis regarding the trends, geographies and ultimately the institutions and patent applicants working in the field of Material Design within Advanced Materials.

As shown in Figure 1, the overall volume of patents in this area filed since 2006 is approximately 2½ times larger than the volume of scientific papers published since 2008, however in the same time period from 2008 the patent output is some almost twice the scientific paper output.

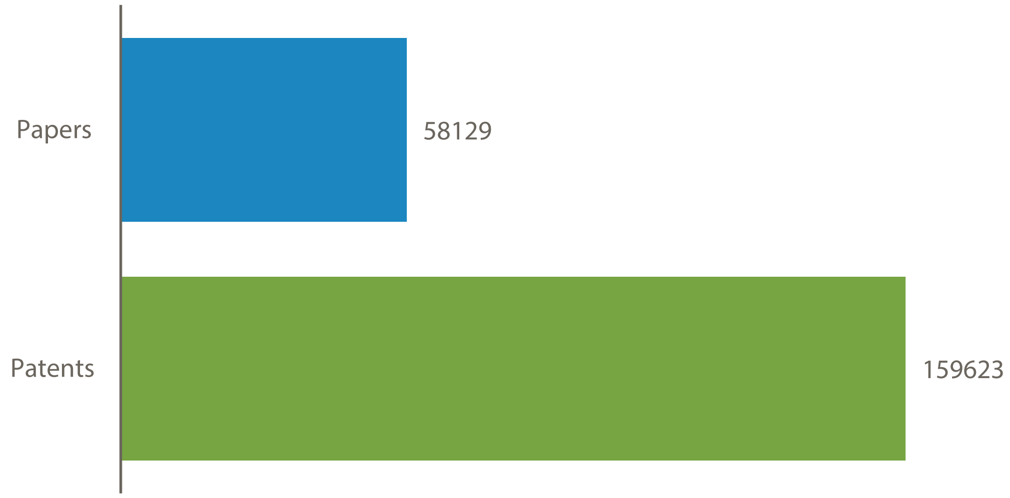

Figure 1 – Scientific Paper and Patent Families in Material Design

Additionally, patent protection activity related to Material Design technology had increased at a much faster pace (Figure 2, Timeline of Activity) than publications in scientific journals, which are likely to address more fundamental science. This might suggest that the focus of technology development globally related to Material Design is increasingly directed towards commercialization and practical application. However, in recent years both patents and scientific paper output has declined.

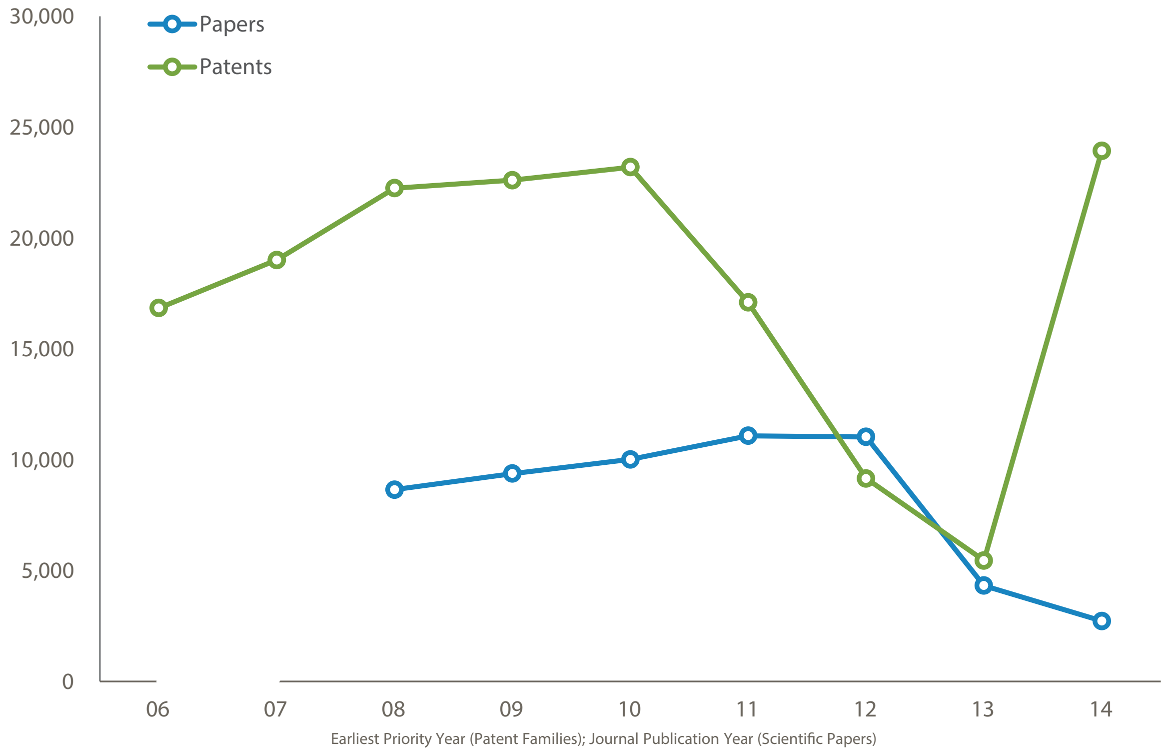

Figure 2 – Timeline of Scientific Paper and Patent Family Activity

Figures 3 through 5 show three further analyses on each of the data collections (patents, left; papers, right) concerning the nature and high level technology trends occurring within the global Material Design area.

The patent and scientific literature collections differ with respect to the breakdown in technology segments. The most active segment in both data sets is composites, however thereafter the breakdown differs. The patent data suggests that on a global level, there is greater focus on technology commercialization of areas such as high temperature-pressure, lightweight and nanomaterials. With regard to growth rates of these collections (2006 – 2011 for patents), the patent technology segments experiencing growth includes ceramics, light weight and high temperature-pressure. Within the computational material Design Methodology, modeling appears to be a hot area for technology commercialization, with a fairly large volume of patenting activity, and high growth rates. Such areas of high volume and high growth rates indicate opportunities for securing patents through patent filings, as well as through in-licensing and acquisitions.

On the other hand, the scientific literature data indicates higher focus on fundamental research in areas such as ceramics, metals & alloys and corrosion-abrasion resistance. All areas in the scientific literature collection have seen a decrease over time (based on growth rate during 2008 – 2013 for papers).

Such trends of growing patenting activity and declining scientific paper publications indicate that Material Design is now more commercially focused, with less fundamental research taking place. In other words, such trends indicate that the fundamental techniques of material design appear to be well established, while incremental improvements to these fundamental techniques are being continually patented. This presents an opportunity for newer fundamental techniques of material design to be researched. Incremental improvements to existing fundamental techniques of material design will be better served by patent filings.

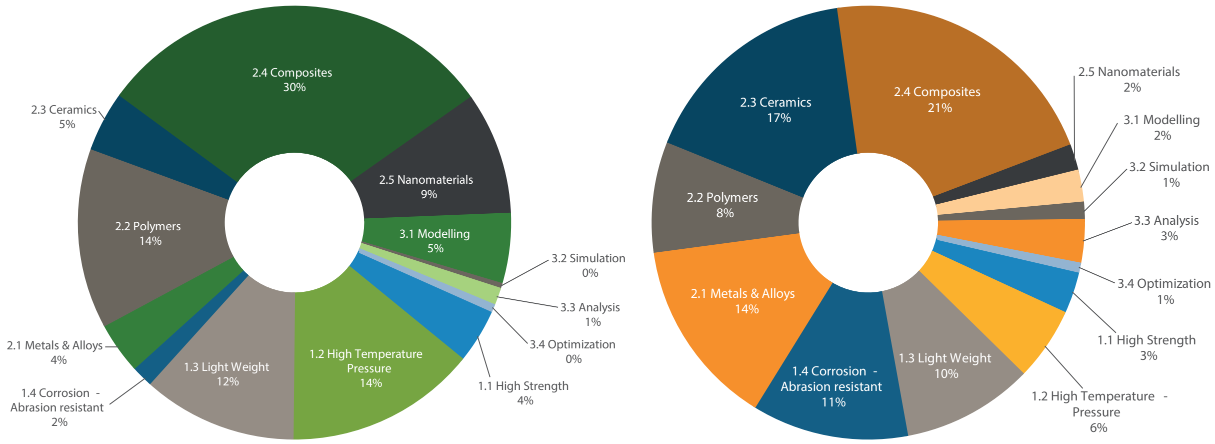

Figure 3 – % of Patent (left) and Scientific Paper (right) collections by Material Design Topic

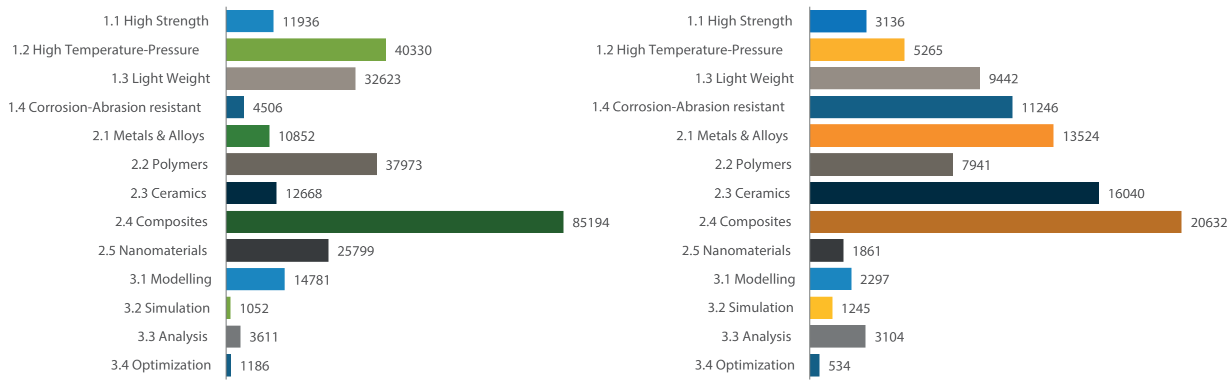

Figure 4 – Number of Patents Families (left) and Scientific Papers (right) per Material Design Topic

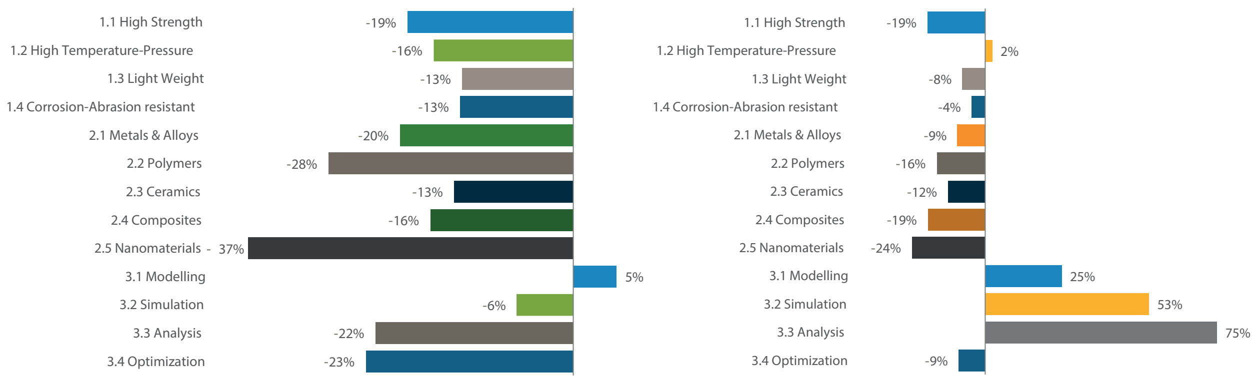

Figure 5 – Average Annual % Growth or Decline in Patent Family (left) or Scientific Paper (right) output between 2006 and 2011 (patents) or between 2008 and 2013 (papers)

Growth trends for scientific literature (Figure 6) since 2008 are approximately similar for all technology segments, but with a sharp decline from 2012. Patenting trends since 2006 (Figure 7) shows nanomaterials experiencing a significant spike from 2007 through 2009, before declining. Further patenting trends to note include the emergence of high temperature-pressure and light weight topics, and most notably the precipitous rise in Modeling.

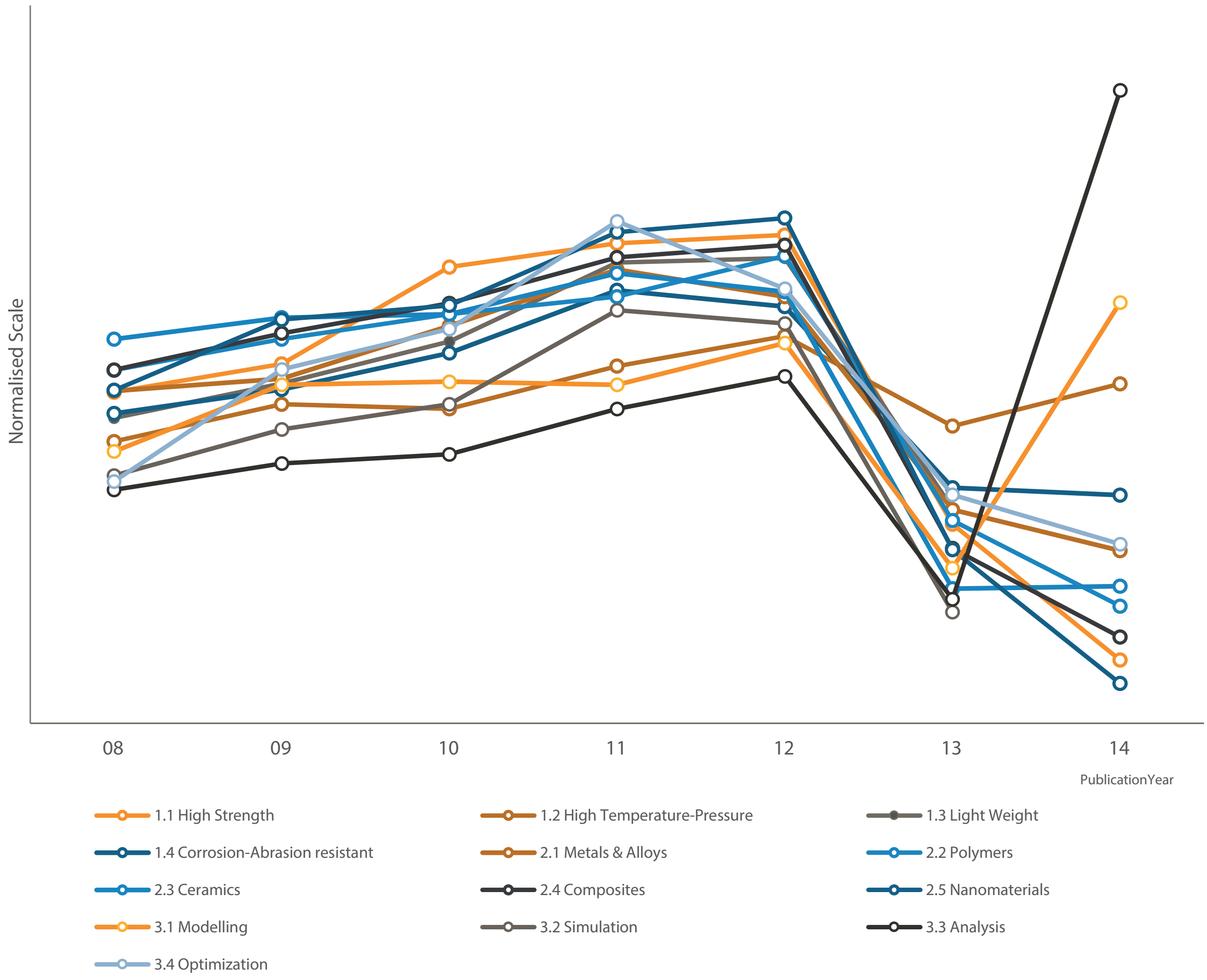

Figure 6 – Normalized Timeline of Activity for Scientific Paper Collection by Material Design Topic

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Average annual growth or decline is calculated by the average percentage increase or decrease between one year and the next. For example; 5 patents in 2006 followed by 6 patents in 2007 would represent an annual increase of 20%. An increase of 20% in one year, followed by a 10% increase the following year would be represented as a 15% average increase across the two years. This process is followed for 2006 (patents) or 2008 (papers) through to the most recently available year in patent and paper collections, to provide an indicator of the level and direction of recent changes in Material Design technology topics.

The timelines on these charts have been normalised to allow for side by side comparison. Individually, each topic has varying volumes of patent families and scientific papers, however for visualisation purposes, the charts represent the proportion of each topic's activity filed or published in each calendar year.

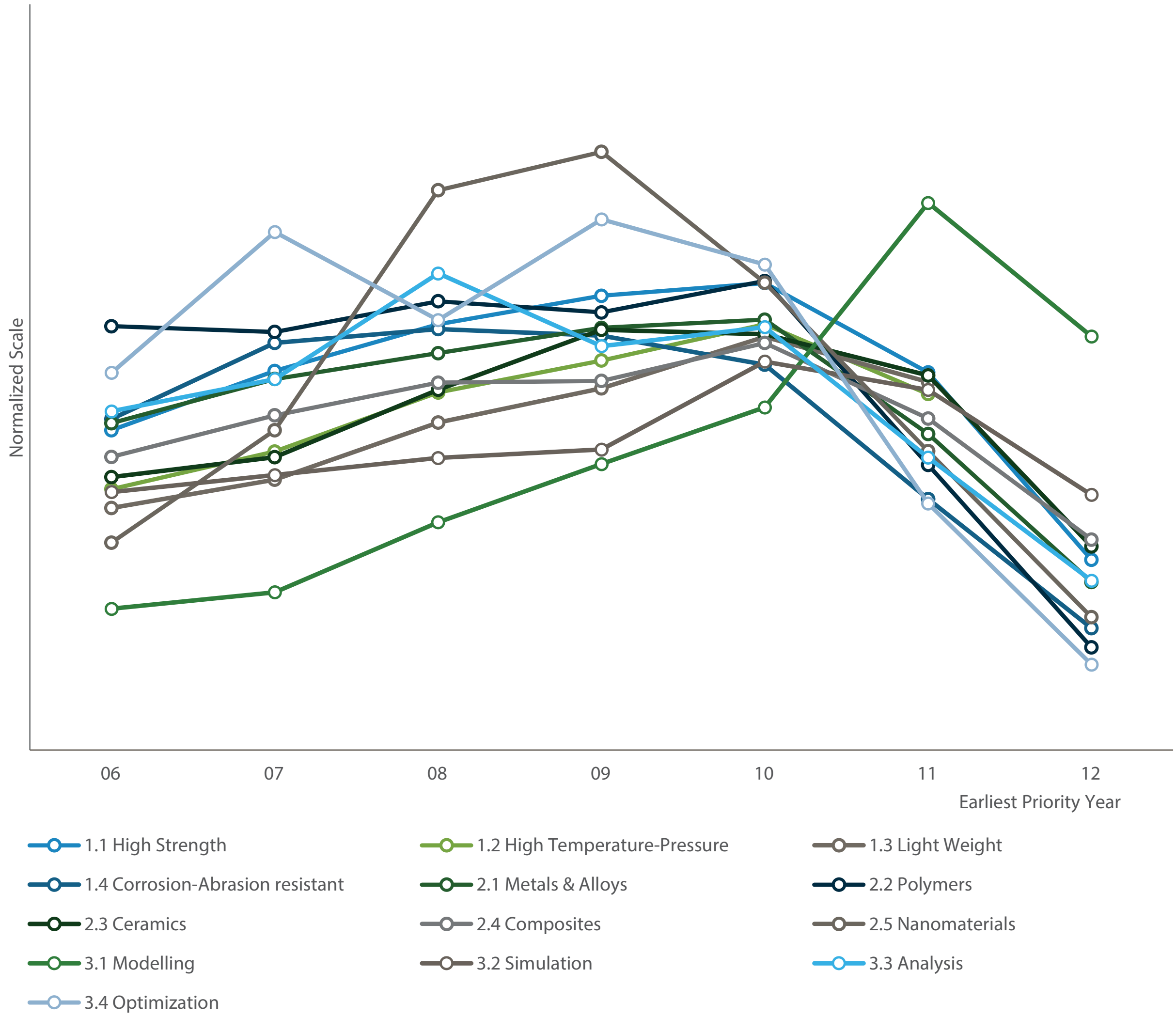

Figure 7 Normalized Timeline of Activity for Patent Family Collection by Material Design Topic

GLOBAL MATERIAL DESIGN SCIENTIFIC LITERATURE TECHNOLOGY TRENDS

This section of the report focuses on the scientific paper collection and the activity and technological trends seen within it. Based on the Thomson Reuters-produced Web of Science database, the collection only includes papers published in pre-selected journals of influence.
In total, over 54,000 peer reviewed papers were incorporated into the Material Design technology collection. The Red dots indicate Science & Technology Unit, Umm Al-Qura University (STU-UQU) scientific papers.

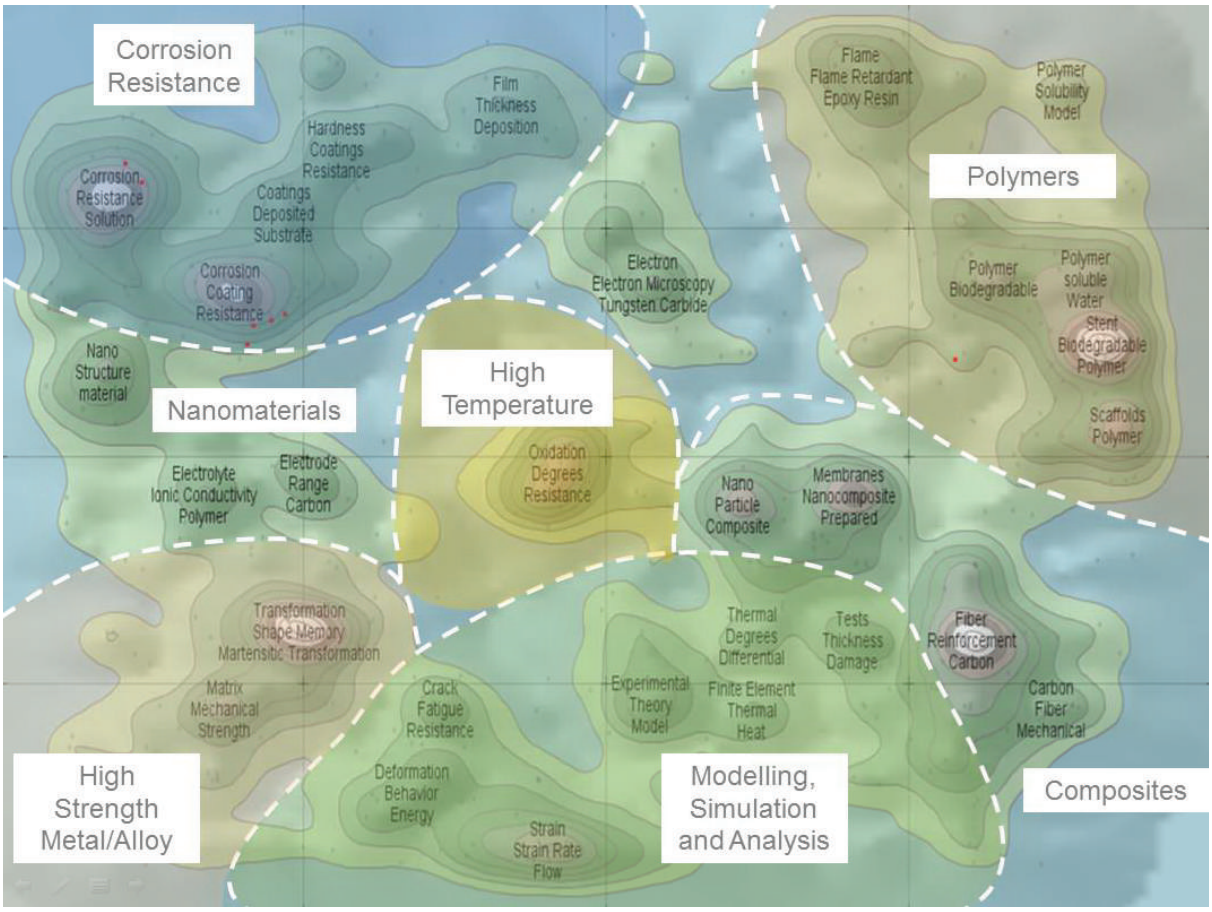

Figure 8 – ThemeScape Map of Scientific Paper Material Design Collection; Annotated by Major Theme

Key themes present throughout this collection of papers are illustrated in Figure 8 as a "ThemeScape map" - a visualization method for understanding the common themes and concepts within thousands of documents. Used for market analysis, government intelligence and primarily technology landscapes, the algorithm parses large amounts of text into a topological map of peaks and

troughs.
Themes that are commonly shared between documents are represented by mountainous peaks, whereas documents that share little commonality are located within the valleys of the map. The large number of documents in this map means that there are rather few valleys to be found.
The location of an individual document is the vector sum of all the attractions to other documents in the collection based on shared phraseology and the frequency and proximity of these terms.
This map has been manually annotated to summarize the major technology areas within the scientific literature collection. Some technologies will necessarily overlap, and the delineation of one technical area versus another is therefore only approximate. However the map is very useful in describing what topics are common features of global Material Design scientific research.
Key themes revealed in this Themescape map focus mainly on corrosion resistance, polymers, nanomaterials, high strength metal/alloy, modeling, simulation & analysis and composites.

ThemeScape® is a text-mining application that acquires and analyzes free text. The algorithms it uses require no application of thesauri or other outside sources of information, and only the free text itself is used by this text-mining tool. The more text the application acquires, the more likely it will be that the output will provide an accurate summary of the major themes present. After analyzing the text in multiple documents, it pulls together those documents that share related text and pulls apart those with less related text. The outcome 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 pick out topics of interest. It aggregates word forms that share a common stem, but it does not directly aggregate synonyms. Instead, synonyms may be gathered under a common theme because of the other words that co-occur with those synonyms. Thus, “battery” and “cell” may be clustered together because of the co-occurrence in the same documents of terms like “electrode, rechargeable, electrolyte” and so on. Conversely, “battery” and “cell” may be separated if the map contains a mixture of documents on metals and biology, where the two terms have different meanings. In other words, terms are identified as synonyms only by co-clustering based on common context.

The topographical maps presented by ThemeScape are mathematical solutions built on a random selection of a first document and sequential calculation of the relationships of all the other documents. The orientation of the map is random, and the directions up, down, left, or right have no significance, because the n-dimensional solution might have been presented from any angle. Only the proximity of points within the map has meaning, and co-localized documents are highly likely to share concepts.

In this report there are separate ThemeScape maps covering scholarly papers or patents. The two types of documents are not pooled and analyzed together. This is because ThemeScape is context-sensitive, and it would separate patent and literature documents from one another based on the very different formal styles of writing that are reflected in these two types of content. Likewise, if documents in two languages are pooled, it will separate them based on the language, and then each language region will be clustered based on term frequency in that language.

The ThemeScape maps in this report analyze large numbers of documents. The contour lines on the maps diminish in circumference, encircling regions of higher and higher concentration. The density is also shown by the map coloration. White snow-capped peaks represent the highest density, while blue expanses (sea level) indicate low density.

The labels in black on the map are selected by ThemeScape based on term frequency in that map region, and they may have been adjusted by the analyst. The large color-overlay regions enclosed by broken lines have been added by the analyst to identify content at an even higher level of abstraction. The dots on the map represent single documents. Dots are not shown for all the documents, and instead represent a sampling that allows the other features of the map to be discerned. Within the ThemeScape application, the map can be magnified, searched, probed and highlighted to learn more about its contents.

ThemeScape is reliant on statistical methods that are not equivalent to reading by human judges, and in compensation, it analyzes millions of documents on a scale of minutes and quickly presents an intuitive, high level summary. It enables and guides further review, and provides a first level overview of very complex datasets.

MATERIAL DESIGN SCIENTIFIC LITERATURE TECHNOLOGY SEGMENTATION

Table 1 shows the further segmentation of Material Design technology topics. There appears to be a lot more interest in Composites and Ceramics; and corrosion-abrasion resistance and light weight materials in properties. Design Methodology, which includes methods for computationally designing materials such as modeling, simulation, analysis, and optimization forms a relatively smaller part of the Material Design technology topics. Since this area is more related to commercial technology, the amount of scientific literature is understandably smaller.

Technology Segmentation		Total Inventions	Average % Growth or Decline ('09-'14)
1.0 Material Properties	1.1 High Strength	3136	-19%
	1.2 High Temperature-Pressure	5265	2%
	1.3 Light Weight	9442	-8%
	1.4 Corrosion-Abrasion resistant	11246	-4%
2.0 Type of Materials	2.1 Metals & Alloys	13524	-9%
	2.2 Polymers	7941	-16%
	2.3 Ceramics	16040	-12%
	2.4 Composites	20632	-19%
	2.5 Nanomaterials	1861	-24%
3.0 Design methodology	3.1 Modelling	2297	25%
	3.2 Simulation	1245	53%
	3.3 Analysis	3104	75%
	3.4 Optimization	534	-9%

Table 1 – Scientific Literature Technology Segmentation

MATERIAL DESIGN SCIENTIFIC LITERATURE COLLECTION TECHNOLOGY CATEGORY OVERLAP

The technology categories and that were created to enumerate and describe the material design landscape were not intended to be mutually exclusive. A single scientific paper can be included in multiple categories or segments.

Figure 9 visualizes the relationship between the technology segments used in this study. Each number in the diagram shows the number of papers that have content related to both the corresponding row-wise and column-wise segments.

The most highly correlated segment pairings are composites with light weight and high strength. In contrast, smaller sets are generally observed for pairings of any segment with the nanomaterial segment or the ceramic segment.

	1.1 High Strength	1.2 High Temperature-Pressure	1.3 Light Weight	1.4 Corrosion-Abrasion resistant	2.1 Metals & Alloys	2.2 Polymers	2.3 Ceramics	2.4 Composites	2.5 Nanomaterials	3.1 Modelling	3.2 Simulation	3.3 Analysis	3.4 Optimization
1.1 High Strength	3051	60	496	26	46	47	333	2758	7	275	68	275	22
1.2 High Temperature-Pressure		4401	72	685	681	1227	164	2491	14	160	127	232	55
1.3 Light Weight			8671	114	144	67	120	8671	454	253	132	342	67
1.4 Corrosion-Abrasion resistant				########	7897	31	2201	343	22	151	206	215	85
2.1 Metals & Alloys					########	36	225	283	22	378	286	385	103
2.2 Polymers						7487	18	136	31	210	51	175	48
2.3 Ceramics							########	325	35	315	158	385	134
2.4 Composites								19808	470	861	436	1068	199
2.5 Nanomaterials									1811	41	26	41	10
3.1 Modelling										1770	109	148	29
3.2 Simulation											936	45	15
3.3 Analysis												2017	20
3.4 Optimization													483

Figure 9 - Number of Scientific Papers per Pair of Technology Categories, 2008 to 2012

SCIENTIFIC PAPER GEOGRAPHIC VOLUME BENCHMARKING

Figure 10 shows the number of scientific papers for the ten most prolific countries within the material design paper collection.
China is the largest source of material design-related peer-reviewed papers, followed by the United States, Japan, Germany, South Korea and India.

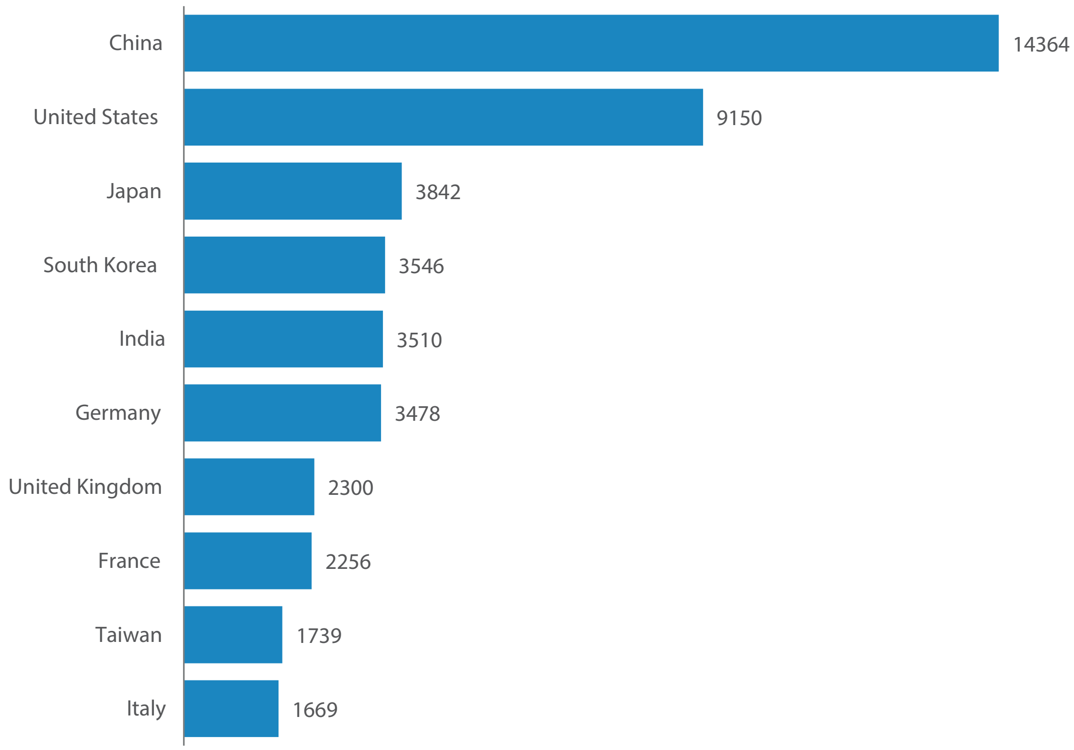

Figure 10 - Number of Scientific Papers per Country; Top 10 Sources, 2008 to 2012

SCIENTIFIC PAPER GEOGRAPHIC ACTIVITY TRENDS

The chart below shows the highest grow rates sources in the scientific literature collection.

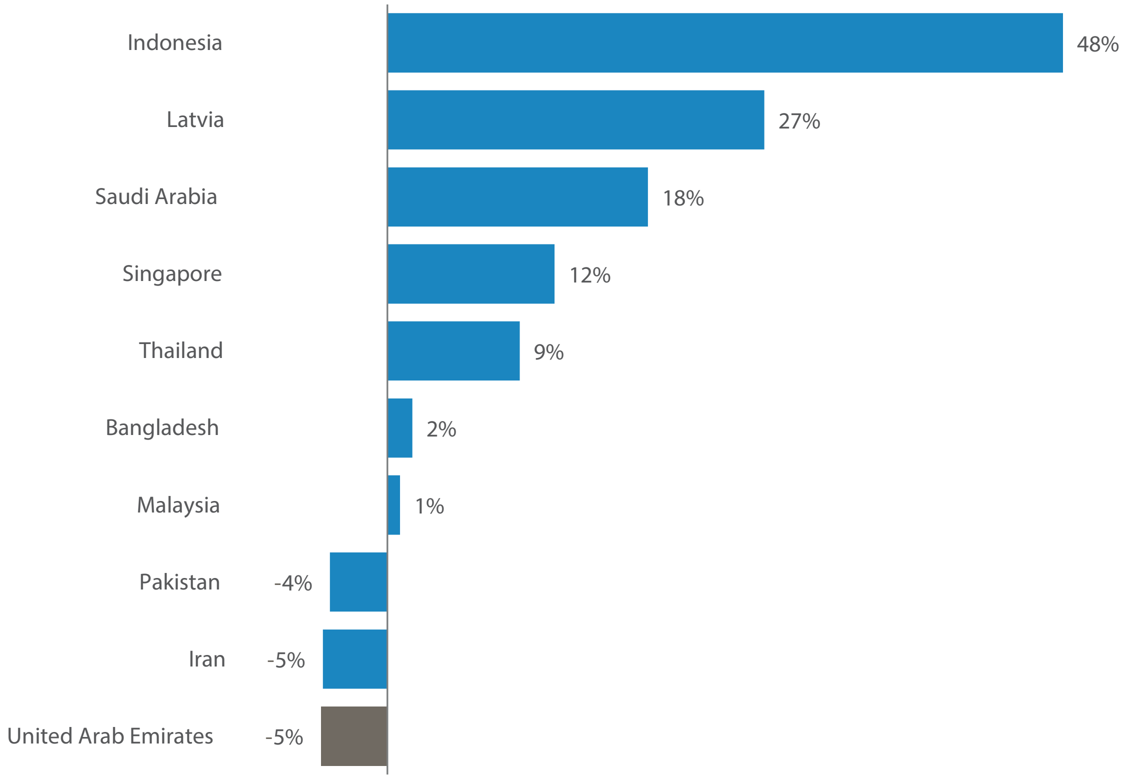

Figure 11 – Highest growth rate geographies in Material Design Paper Output

While Saudi Arabia's scientific literature collection is small relative to the collections of the most prolific countries, the growth rate of the KSA collection far exceeds that of other countries.

SCIENTIFIC PAPER GEOGRAPHIC CITATION IMPACT BENCHMARKING

Scientific paper and patent citations are routinely used in technology bibliometrics for assessing the inherent impact and potential quality of research and the downstream technical and scientific relevance of the underlying research.
Figure 12 shows the "Citation Impact", the average citation per paper for all papers in a country's collection and has been sorted by highest citation impact. This shows that output from Netherlands, Switzerland, and Denmark, are having the highest impact in the material design topic.

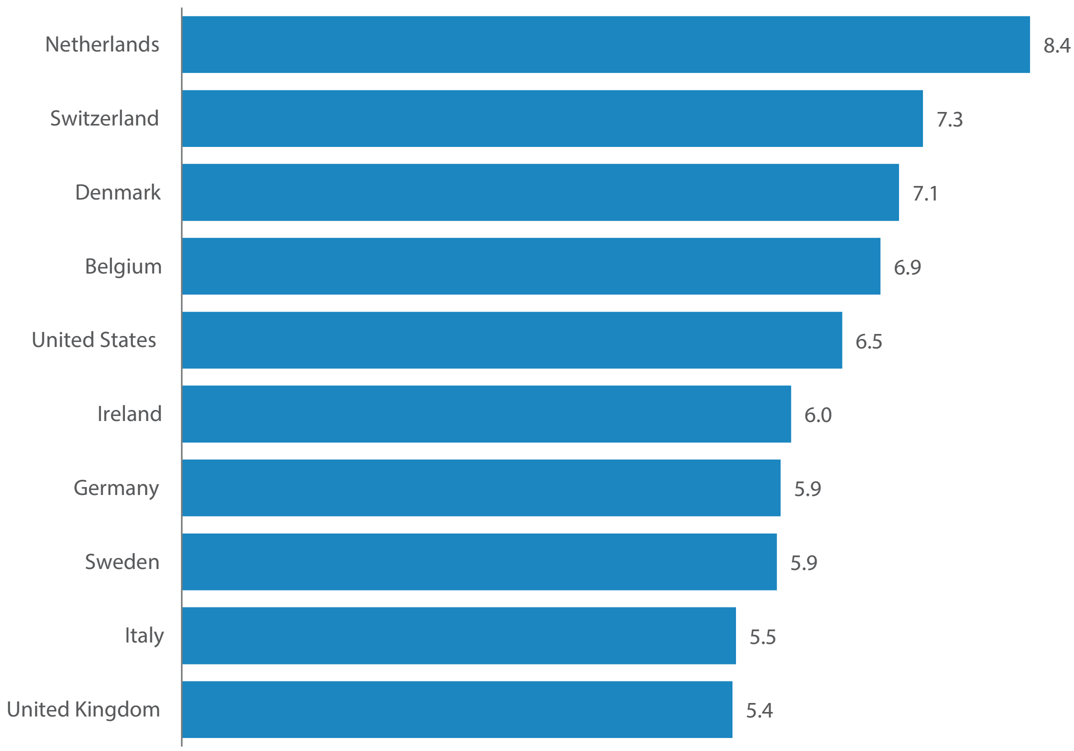

Figure 12 – Highest citation impact geographies of material design Scientific Publications

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Note that the journals included in the project source data (Web of Science) are selected on the basis of both quantitative and qualitative selection criteria, such as editorial quality, peer review robustness and citation impact. Further details of the journal selection process is available from : http://thomsonreuters.com/products_services/science/free/essays/journal_selection_process/

ADVANCED MATERIALS RESEARCH TOPIC BY GEOGRAPHY

Table 1 shows the split of Material Design science and research specialization for the top nations. Saudi Arabia appears to have focus on composites, ceramics, metals & alloys, light weight and corrosion-abrasion resistant. Less focus has been spent on nanomaterials, high strength and high temperature-pressure. Overall, the focus on Design Methodology related scientific literature remains low across the countries.

	1.0 Material Properties				2.0 Type of Material					3.0 Design Methodology			
Country of Origin	1.1 High Strength	1.2 High Temperature-Pressure	1.3 Light Weight	1.4 Corrosion-Abrasion resistant	2.1 Metals & Alloys	2.2 Polymers	2.3 Ceramics	2.4 Composites	2.5 Nanomaterials	2.2 Polymers	2.3 Ceramics	2.4 Composites	2.5 Nanomaterials
China	4%	12%	23%	26%	26%	12%	21%	40%	4%	3%	3%	6%	1%
United States	6%	7%	13%	12%	20%	15%	30%	34%	3%	6%	2%	5%	1%
Japan	4%	11%	15%	20%	21%	15%	30%	33%	4%	2%	2%	5%	1%
South Korea	3%	8%	17%	17%	17%	14%	37%	30%	5%	2%	2%	5%	1%
India	5%	8%	21%	21%	25%	15%	23%	37%	3%	4%	1%	6%	1%
Germany	4%	9%	13%	15%	19%	12%	34%	35%	2%	4%	3%	5%	1%
United Kingdom	10%	8%	15%	14%	24%	14%	25%	38%	3%	6%	2%	5%	1%
France	4%	10%	13%	16%	22%	13%	32%	33%	2%	7%	3%	5%	1%
Taiwan	1%	7%	14%	18%	17%	10%	46%	25%	6%	2%	1%	4%	1%
Italy	7%	8%	12%	14%	23%	17%	24%	35%	2%	6%	2%	7%	1%
Canada	11%	10%	15%	20%	29%	15%	20%	36%	3%	7%	2%	6%	1%
Iran	5%	7%	34%	21%	23%	9%	21%	46%	8%	4%	2%	6%	2%
Spain	6%	8%	7%	19%	27%	17%	29%	28%	2%	4%	2%	6%	1%
Russia	2%	10%	7%	19%	16%	6%	46%	32%	2%	3%	2%	4%	0%
Brazil	6%	8%	6%	23%	30%	19%	25%	28%	1%	3%	2%	7%	1%
Australia	11%	8%	17%	17%	23%	16%	23%	38%	3%	4%	2%	5%	1%
Poland	4%	9%	8%	26%	31%	14%	24%	30%	2%	4%	1%	5%	0%
Singapore	4%	9%	25%	18%	20%	18%	26%	33%	6%	6%	2%	5%	1%
Turkey	12%	9%	13%	18%	24%	14%	21%	41%	2%	3%	1%	6%	1%
Malaysia	8%	6%	21%	15%	18%	16%	27%	38%	4%	3%	1%	7%	2%
Netherlands	4%	7%	9%	6%	16%	22%	37%	25%	1%	4%	1%	7%	1%
Switzerland	8%	9%	11%	11%	14%	23%	27%	36%	2%	6%	2%	6%	1%
Romania	7%	4%	11%	33%	37%	14%	19%	31%	2%	3%	5%	6%	0%
Portugal	14%	7%	12%	13%	20%	22%	24%	34%	1%	5%	2%	6%	2%
Belgium	3%	7%	11%	16%	23%	19%	29%	28%	1%	4%	1%	4%	1%
Sweden	5%	8%	14%	12%	16%	16%	34%	34%	3%	5%	2%	5%	1%
Egypt	8%	4%	20%	28%	32%	10%	22%	36%	2%	4%	1%	5%	1%
Austria	6%	12%	13%	22%	24%	14%	29%	34%	2%	4%	2%	8%	0%
Greece	8%	9%	13%	16%	23%	19%	24%	36%	1%	4%	2%	4%	1%
Czech Republic	5%	9%	13%	19%	21%	18%	26%	35%	4%	5%	1%	7%	1%
Finland	10%	10%	7%	11%	15%	19%	35%	30%	2%	2%	2%	5%	0%
Mexico	2%	4%	7%	21%	23%	11%	46%	21%	2%	4%	3%	7%	3%
Ukraine	1%	7%	12%	30%	29%	2%	39%	30%	3%	3%	1%	3%	1%
Saudi Arabia	5%	10%	23%	23%	25%	8%	27%	38%	3%	3%	2%	9%	0%

Table 2 – Material Design Specialization by Country; % of Literature Activity per Technical Stream

SCIENTIFIC PAPER - PROLIFIC ENTITIES

Universities appear to dominate the scientific paper publications in Material Design technologies. Notably, a large number of Chinese universities feature in the top 30 entities publishing scientific literature in this area. While Science & Technology Unit, Umm Al-Qura University (STU-UQU) has only 7 papers published in this space, the citation per paper is relatively high, as compared to other entities within the top 30, indicating that the papers are regarded as important technology disclosures.

Entity	Total	Times Cited	Citation per paper
Science & Technology Unit, Umm Al Qura University (STU-UQU)	7	46	6.57
Chinese Acad Sci	1530	9603	6.28
Univ Sci & Technol Beijing	634	2351	3.71
Russian Acad Sci	580	1077	1.86
Harbin Inst Technol	568	1816	3.20
Indian Inst Technol	518	2417	4.67
Tohoku Univ	445	2090	4.70
CNRS	405	2581	6.37
Shanghai Jiao Tong Univ	389	1576	4.05
Seoul Natl Univ	367	1850	5.04
Tsinghua Univ	317	1424	4.49
Zhejiang Univ	309	1726	5.59
Natl Univ Singapore	305	2528	8.29
Sichuan Univ	280	1111	3.97
City Univ Hong Kong	276	1736	6.29
Cent S Univ	266	756	2.84
S China Univ Technol	256	1159	4.53
Osaka Univ	255	978	3.84
Dalian Univ Technol	252	956	3.79
Natl Inst Adv Ind Sci & Technol	250	1319	5.28
Univ Tokyo	246	1138	4.63
Nanyang Technol Univ	243	1721	7.08
Hanyang Univ	239	1206	5.05
Shandong Univ	237	704	2.97
Natl Inst Technol	234	787	3.36
Natl Inst Mat Sci	232	1070	4.61
CSIC	227	1470	6.48
NW Polytech Univ	223	510	2.29
Univ Tehran	219	765	3.49
Northeastern Univ	214	494	2.31
Islamic Azad Univ	211	490	2.32

Table 3 – Material Design – Top entities for Scientific Literature

SCIENTIFIC LITERATURE OVERVIEW OF PROLIFIC ENTITIES

Table 4 shows the technology profile of the top 30 entities within the scientific literature space of Material Design. Entities appear to be researching most in corrosion-abrasion resistance, metals and alloys, ceramics, and composites. Most companies are not researching much new Design Methodologies such as modeling, simulation, analysis, and optimization. Science & Technology Unit, Umm Al-Qura University (STU-UQU) has 7 publications across high strength, polymers, ceramics, and most notably within corrosion-abrasion resistance, and metals & alloys.

Entity	1.1 High Strength	1.2 High Temperature-Pressure	1.3 Light Weight	1.4 Corrosion-Abrasion resistant	2.1 Metals & Alloys	2.2 Polymers	2.3 Ceramics	2.4 Composites	2.5 Nanomaterials	3.1 Modelling	3.2 Simulation	3.3 Analysis	3.4 Optimization
Science & Technology Unit, Umm Al Qura University	1			4	4	1	2						
Chinese Acad Sci	13	164	257	431	435	171	441	469	59	11	22	29	7
Univ Sci & Technol Beijing	12	95	149	199	197	83	107	235	36	9	14	12	5
Russian Acad Sci	4	41	38	92	54	59	295	172	11	13	9	9	
Harbin Inst Technol	44	50	143	164	193	21	65	288	20	12	20	23	5
Indian Inst Technol	23	34	85	145	142	40	157	183	13	21	7	12	6
Tohoku Univ	24	70	57	152	163	23	107	150	12	14	12	19	3
CNRS	8	44	49	42	74	43	153	125	11	19	8	16	3
Shanghai Jiao Tong Univ	6	29	72	149	136	47	81	124	12	9	8	12	5
Seoul Natl Univ	8	12	60	41	44	58	148	107	29	9	5	15	1
Tsinghua Univ	14	35	76	46	50	50	63	153	16	8	13	12	4
Zhejiang Univ	10	31	73	73	79	52	61	115	10	4		15	
Natl Univ Singapore	15	5	64	44	32	65	100	89	26	8		6	4
Sichuan Univ	7	47	93	32	19	87	51	125	12	1		1	1
City Univ Hong Kong	41	26	36	78	76	37	72	95	6	10	11	11	
Cent S Univ		32	52	135	131	6	47	83	8	4	2	4	
S China Univ Technol	11	26	55	53	47	63	51	90	14	2	8	7	3
Osaka Univ	3	29	35	48	63	27	77	83	9	8	6	12	
Dalian Univ Technol	26	13	47	106	88	7	60	92	9	15	10	11	5
Natl Inst Adv Ind Sci & Technol	2	27	40	42	38	28	87	85	15	2	1	9	2
Univ Tokyo	14	21	32	25	30	48	83	78	13	12	4	5	4
Nanyang Technol Univ	8	10	35	32	60	38	78	63	12	9	6	4	2
Hanyang Univ	4	10	34	45	49	37	89	52	23	3	3	5	4
Shandong Univ	9	14	64	42	41	26	37	135	5	8	17	10	2
Natl Inst Technol	27	13	38	67	68	26	48	90	7	8		11	2
Natl Inst Mat Sci	5	32	26	84	73	11	80	63	9	2	3	8	2
CSIC	8	18	8	36	49	33	93	53	5	4	6	8	1
NW Polytech Univ	7	33	50	48	60	12	22	126	6	11	7	9	2
Univ Tehran	10	10	122	53	53	8	27	139	8	6	3	8	4
Northeastern Univ	5	15	38	90	93	8	34	81	3	1	8	7	2
Islamic Azad Univ	5	11	80	28	48	14	46	97	23	9	2	6	7

Table 4 – Scientific literature overview of top entities

SCIENTIFIC LITERATURE OVERVIEW OF ASIA PACIFIC PROLIFIC ENTITIES

Entity	Country of Origin	Total	1.1 High Strength	1.2 High Temperature-Pressure	1.3 Light Weight	1.4 Corrosion-Abrasion resistant	2.1 Metals & Alloys	2.2 Polymers	2.3 Ceramics	2.4 Composites	2.5 Nanomaterials	3.1 Modelling	3.2 Simulation	3.3 Analysis	3.4 Optimization
Science & Technology Unit, Umm Al Qura University (STU-UQU)	Saudi Arabia	7	1			4	4	1	2						
Chinese Acad Sci	China	1530	13	164	257	431	435	171	441	469	59	11	22	29	7
Univ Sci & Technol Beijing	China	634	12	95	149	199	197	83	107	235	36	9	14	12	5
Russian Acad Sci	Russia	580	4	41	38	92	54	59	295	172	11	13	9	9	
Harbin Inst Technol	China	568	44	50	143	164	193	21	65	288	20	12	20	23	5
Indian Inst Technol	India	518	23	34	85	145	142	40	157	183	13	21	7	12	6
Tohoku Univ	Japan	445	24	70	57	152	163	23	107	150	12	14	12	19	3
Shanghai Jiao Tong Univ	China	389	6	29	72	149	136	47	81	124	12	9	8	12	5
Seoul Natl Univ	South Korea	367	8	12	60	41	44	58	148	107	29	9	5	15	1
Tsinghua Univ	China	317	14	35	76	46	50	50	63	153	16	8	13	12	4
Zhejiang Univ	China	309	10	31	73	73	79	52	61	115	10	4		15	
Natl Univ Singapore	Singapore	305	15	5	64	44	32	65	100	89	26	8		6	4
Sichuan Univ	China	280	7	47	93	32	19	87	51	125	12	1		1	1
City Univ Hong Kong	Hong Kong	276	41	26	36	78	76	37	72	95	6	10	11	11	
Cent S Univ	China	266		32	52	135	131	6	47	83	8	4	2	4	
S China Univ Technol	China	256	11	26	55	53	47	63	51	90	14	2	8	7	3
Osaka Univ	Japan	255	3	29	35	48	63	27	77	83	9	8	6	12	
Dalian Univ Technol	China	252	26	13	47	106	88	7	60	92	9	15	10	11	5
Natl Inst Adv Ind Sci & Technol	China	250	2	27	40	42	38	28	87	85	15	2	1	9	2
Univ Tokyo	Japan	246	14	21	32	25	30	48	83	78	13	12	4	5	4
Nanyang Technol Univ	China	243	8	10	35	32	60	38	78	63	12	9	6	4	2

Table 5 – Scientific literature overview of top Asia Pacific entities

MIDDLE EAST & AFRICA – PROLIFIC ENTITIES

Table 6 visualizes the prolific entities in the Middle East and Africa. The list is dominated by Middle Eastern entities, reflecting the trends seen in Table 5 above. Most of the prolific entities in these regions follow the global focus trends on satellite navigation and space components, while not focusing heavily on other technologies.

Entity	Country of Origin	Total	1.1 High Strength	1.2 High Temperature-Pressure	1.3 Light Weight	1.4 Corrosion-Abrasion resistant	2.1 Metals & Alloys	2.2 Polymers	2.3 Ceramics	2.4 Composites	2.5 Nanomaterials	3.1 Modelling	3.2 Simulation	3.3 Analysis	3.4 Optimization
Science & Technology Unit, Umm Al Qura University (STU-UQU)	Saudi Arabia	7		1		4	4	1	2						
Islamic Azad Univ	Iran	200	5	10	72	28	46	13	46	89	23	7	2	6	6
Univ Tehran	Iran	199	8	5	109	47	47	8	27	125	8	4	3	8	4
Tarbiat Modares Univ	Iran	175		3	63	47	47	8	25	68	53	2	2	2	2
Amir Kabir University of Technology	Iran	115	10	5	29	29	31	18	21	44	5	6	1	3	6
Isfahan Univ Technol	Iran	106	3	8	19	42	39	11	23	34	3	3	1	4	7
Sharif Univ Technol	Iran	88		3	23	23	20	4	24	37	6	1	1	3	
King Saud University	Saudi Arabia	87	12	3	24	20	24	7	15	41	3	1	2	3	1
Istanbul Tech Univ	Turkey	72	8	3	15	13	10	23	13	27	2	3		2	1
Ain Shams Univ	Egypt	68	5		13	20	21	3	20	20	7	2		2	
Iran Univ Sci & Technol	Iran	65	4	3	16	10	7	1	19	40		1		1	
Cairo Univ	Egypt	59		2	3	35	36	7	8	9	1	1	1	1	1
King Fahd University of Petroleum & Minerals	Saudi Arabia	58		9	11	10	14	4	16	22	2	2		6	
Natl Res Ctr	Egypt	56	6	6	14	11	12	3	20	20	3	2		1	
Middle E Tech Univ	Turkey	52	6	8	3		5	16	17	15	1			2	
Gazi Univ	Turkey	49	8	8	6	7	9	8	14	21				1	
Univ Witwatersrand	South Africa	48	1	4	3	21	18	2	15	12	2			1	
Univ Tabriz	Iran	46			13	13	11	6	9	16	10	1		1	3
Univ Tehran Med Sci	Iran	45	2	1	27			5	3	33	5			2	
King Abdulaziz University	Saudi Arabia	43	1	1	7	2	3	7	14	19	1		2	7	
Shiraz Univ	Iran	42	1	3	11	13	14	2	8	20		4		1	2
Hacettepe Univ	Turkey	41	4	6	6	4	5	8	11	17	1	2		3	
Iran Polymer & Petrochem Inst	Iran	40	3	9	15			18	3	17	6	1		2	
KN Toosi Univ Technol	Iran	38	4		12	5	10		3	21	5	3	1	5	1
Ataturk Univ	Turkey	37	1	2	3	16	20	2	7	10	1	1	1		1
Shahid Bahonar Univ Kerman	Iran	36	1	2	6	7	6	2	14	14				2	1
Ferdowsi Univ Mashhad	Iran	35	6		6	10	14	1	6	15					1
Mat & Energy Res Ctr	Iran	34		1	18	9	4	1	7	23	1		2		
CMRDI	Egypt	33			5	23	24		5	6					
Univ Kashan	Iran	33		1	4	1		3	24	7				1	

Table 6 – Scientific Literature overview of Middle East & Africa top entities

SCIENTIFIC LITERATURE OVERVIEW OF SAUDI ARABIA PROLIFIC ENTITIES

Entity	Total	1.1 High Strength	1.2 High Temperature-Pressure	1.3 Light Weight	1.4 Corrosion-Abrasion resistant	2.1 Metals & Alloys	2.2 Polymers	2.3 Ceramics	2.4 Composites	2.5 Nanomaterials	3.1 Modelling	3.2 Simulation	3.3 Analysis	3.4 Optimization
Science & Technology Unit, Umm Al Qura University (STU-UQU)	7		1		4	4	1	2						
King Saud University	103	14	3	35	20	24	8	18	53	3	5	2	6	1
King Fahd University of Petroleum & Minerals	68		13	12	19	20	4	19	23	2	4	1	8	
King Abdulaziz University	59	2	6	10	8	9	8	20	22	1		2	9	
King Saud Univ	18	2		13			1	3	14		4		3	
Taif University	18		1	1	10	11	1	5	1	1		1	1	
King Abdullah University of Science and Technology	16			3	1	2	1	10	3				1	
Ain Shams Univ	14			2	7	7		3	2	2				
King Abdulaziz City for Science and Technology	5		2	2			1	1	3					
SABIC	4			1	2	2			2					
Saudi Aramco	4		2		3	2	1	1						
Taibah University	4			1				1	3					
King Faisal University	2			1			1		1					
King Saud bin Abdulaziz University for Health Sciences	2							2						
Tabuk University	2							1	1					

Table 7 – Scientific literature overview of top Saudi Arabia entities

MIDDLE EAST & AFRICA SPACE TECHNOLOGY SCIENTIFIC LITERATURE TRENDS

This section of the report focuses on the scientific paper collection and the activity and technological trends observed in the Middle East and Africa regions.

MIDDLE EAST & AFRICA – PROLIFIC COUNTRIES

Figure 13 below shows the prolific countries by scientific literature volume in the Middle East & Africa regions. The gray bars indicate Middle East, blue indicates Africa, and green indicates the Kingdom of Saudi Arabia. As seen from the figure, the most prolific countries within these regions are Iran and Turkey, followed by Egypt, Saudi Arabia, and South Africa.

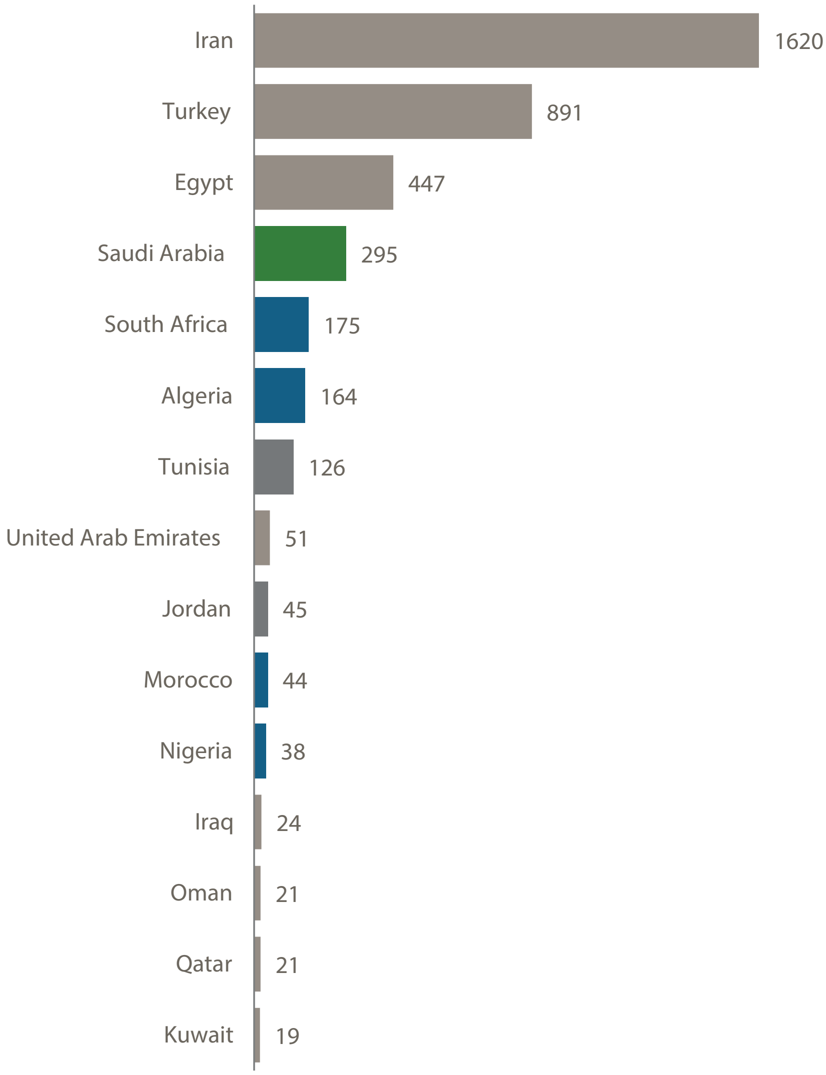

Figure 13 – Middle East & Africa – Prolific countries in scientific literature

A more detailed analysis of the technologies of focus in each of the countries within the Middle East and Africa is presented with reference to Tables 5 and 6. Focus appears to be on composites, light weight, corrosion/abrasion resistant, and metals and alloys. Interestingly, the countries in these regions have lower focus on modelling, simulation, analysis, and optimization.

Country of Origin	1.1 High Strength	1.2 High Temperature-Pressure	1.3 Light Weight	1.4 Corrosion-Abrasion resistant	2.1 Metals & Alloys	2.2 Polymers	2.3 Ceramics	2.4 Composites	2.5 Nanomaterials	3.1 Modelling	3.2 Simulation	3.3 Analysis	3.4 Optimization
Iran	70	68	433	289	329	127	294	620	121	42	21	48	30
Turkey	101	67	94	147	201	122	179	347	21	21	12	33	5
Egypt	33	13	65	115	130	36	86	141	11	11	4	12	2
Saudi Arabia	14	17	54	48	59	25	72	98	10	4	4	18	1
South Africa	14	17	15	41	57	24	32	52	4	1	3	4	1
Tunisia	7	11	8	17	37	9	52	37	1	7	1	3	3
Algeria	21	8	11	23	17	9	37	55	1	13	4	12	2
United Arab Emirates	26	2	17	5	7	8	3	39	1	9	3	7	
Morocco	2	3	6	11	12	8	13	15	1	2	1		
Jordan	9	2		5	7	3	13	23	1	3	1		1
Nigeria	1	1	2	7	11	10	6	6	1				1
Kuwait		2		7	7	1	11	2				1	
Oman	5	1	2	4	4	2	7	7					
Iraq	5	3	2	2	3	2	4	9	1	2	1		
Libya	4	1	1	7	7	4	4	4			1		
Syria	1	1	2			1	3	11					
Lebanon	2		2	1			8	6	2				1
Qatar			5		2			6					
Bahrain		1		2	2		1	2		1			
Cameroon					1	1	1	2		1			
Kenya	1		1		1	1	2	1		1			
Sudan				1	2	1	1						
Botswana							3						
Malawi				1			1	2					
Mauritius	1			2	2	1	1				1		
Senegal							1	1	1				
Yemen	1						2		1				
Tanzania			1		1			1					
Central African Republic						1				1			
Ghana		1						1					
Madagascar							1			1			
Togo		1						1					

Table 8 – Middle East & Africa – Prolific countries over technical categories

GLOBAL ADVANCED MATERIALS PATENT TECHNOLOGY TRENDS

This section of the report focuses on the patent collections produced for the study and the activity and technological trends seen within it. Based on the Thomson Reuters-produced Derwent World Patents Index database, the collection includes both pending patent applications and granted patents published in 47 countries around the world.
A total of approximately 135,000 patented inventions were gathered that are applicable to the Material Design topics of interest to Science & Technology Unit, Umm Al-Qura University (STU-UQU). These inventions and their technical nature have been summarized using the ThemeScape software described in the previous section.

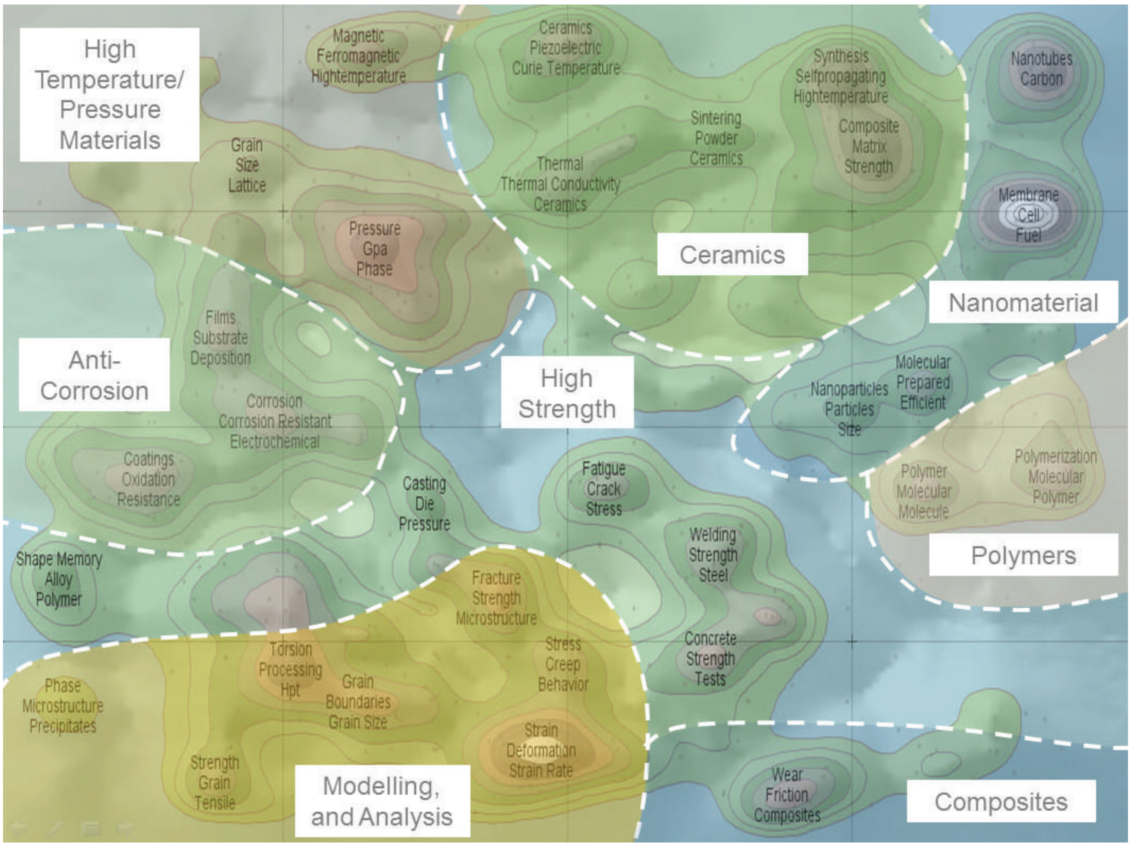

Figure 14 ThemeScape Map of Patents Material Design Collection; Annotated by Major Theme.

As previously noted, the ThemeScape map is not designed to provide a detailed accurate view of each patented invention; instead the visual is designed to highlight the common themes shared by hundreds or thousands of patents and patent applications published since 2006.
The words included in the map are those shared by the patent documents in their DWPI abstracted form. Some of the key themes revealed in this Themescape map include high temperature-pressure, ceramics, anti-corrosion, high strength, nanomaterials, polymers, composites and modeling & Analysis. This annotation has been provided to guide the reader around the landscape. However, it should be noted that this annotation is only approximate.

MATERIAL DESIGN PATENT TECHNOLOGY SEGMENTATION

Table 3 shows the segmentation patents and patent applications in the material design technology. Much like the non-patent literature, there is significant patenting activity in Composites, and Light Weight materials. However, Corrosion resistance, and Ceramics show relatively low levels of patenting activity. Within computational material Design Methodologies, Modeling appears to be an area of high activity, and also shows significant growth. Such a trend indicates opportunities for patent filings, as well as for in-licensing or purchase of patent rights from other entities. On the other hand, Simulation (of materials and processes of material manufacture) appears to be a prominent white space, with low volume of patenting activity and a positive growth, illustrating a potential for filing new patents.

Technology Segmentation		Total Inventions	Average % Growth or Decline ('06-'11)
1.0 Material Properties	1.1 High Strength	11936	-19%
	1.2 High Temperature-Pressure	40330	-16%
	1.3 Light Weight	32623	-13%
	1.4 Corrosion-Abrasion resistant	4506	-13%
2.0 Type of Materials	2.1 Metals & Alloys	10852	-20%
	2.2 Polymers	37973	-28%
	2.3 Ceramics	12668	-13%
	2.4 Composites	85194	-16%
	2.5 Nanomaterials	25799	-37%
3.0 Design methodology	3.1 Modelling	14781	5%
	3.2 Simulation	1052	-6%
	3.3 Analysis	3611	-22%
	3.4 Optimization	1186	-23%

Table 9 – Patent Technology Segmentation

MATERIAL DESIGN PATENT COLLECTION TECHNOLOGY CATEGORY OVERLAP

The technology categories and their top level segments that were created to enumerate and describe the Material Design technology landscape were not intended to be mutually exclusive. A single patent family can be included in multiple categories.

Figure 14 visualizes the relationship between select technology segments. Each number in the diagram shows the number of inventions that have content related to both the corresponding row-wise and column-wise segments.

The most highly correlated segment pairings are composites with light weight, which also had the most records in the literature set. On the other hand, the least amount of overlap is observed in multiple areas, including corrosion-abrasion resistant with polymers and nanomaterials.

	1.1 High Strength	1.2 High Temperature-Pressure	1.3 Light Weight	1.4 Corrosion-Abrasion resistant	2.1 Metals & Alloys	2.2 Polymers	2.3 Ceramics	2.4 Composites	2.5 Nanomaterials	3.1 Modelling	3.2 Simulation	3.3 Analysis	3.4 Optimization
1.1 High Strength	10724	2663	798	217	2372	301	4702	4473	103	1034	60	137	72
1.2 High Temperature-Pressure		32269	758	356	2511	12658	4616	14179	621	3690	195	686	177
1.3 Light Weight			25290	181	323	682	241	25290	4507	3194	153	592	154
1.4 Corrosion-Abrasion resistant				3721	3072	52	159	1212	85	228	13	51	29
2.1 Metals & Alloys					9664	129	96	1271	173	1282	47	170	105
2.2 Polymers						33600	158	1277	1175	1498	164	580	213
2.3 Ceramics							9662	882	96	1623	47	106	43
2.4 Composites								69376	4885	6694	493	1794	563
2.5 Nanomaterials									22460	736	124	728	277
3.1 Modelling										11389	191	247	70
3.2 Simulation											816	130	34
3.3 Analysis												3142	93
3.4 Optimization													1090

Figure 14 - Number of Patent Families per Pair of Technology Segments, 2006 to 2011

PATENT ACTIVITY GEOGRAPHIC VOLUME BENCHMARKING

Figure 15 shows the number of patent families or inventions within the Material Design patent collection that can be attributed to each nation . Patenting activity within the Material Design topic is lead by China, followed by the United States, Japan, South Korea and India.

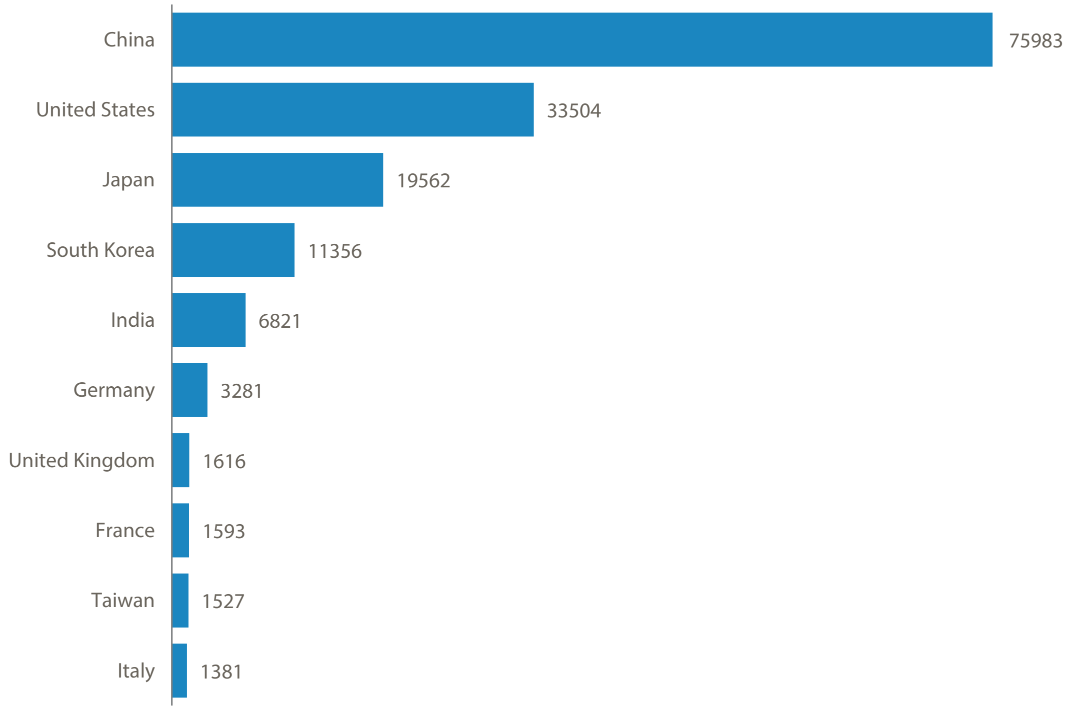

Figure 16 - Number of Patent Families per Country; 2006 to 2011

National attribution of patent activity is primarily performed via the priority filing location of the invention – this is the first filing event that occurs in the international protection of an invention at the various patent offices around the world. Actual geographic location of the inventor or the innovating corporation may vary from the priority filing location. This effect is exhibited primarily by Saudi Arabian entities, few of which file for patents within the Kingdom.

PATENT GEOGRAPHIC ACTIVITY TRENDS

Although overall patent volumes from Saudi Arabia are low, Figures 16 illustrates the continuing growth of the Saudi Arabian patent portfolio in this field. The figure also illustrates growth in Indonesia, and Latvia. Like the scientific literature collection, most major countries have experienced a decline with China the exception.

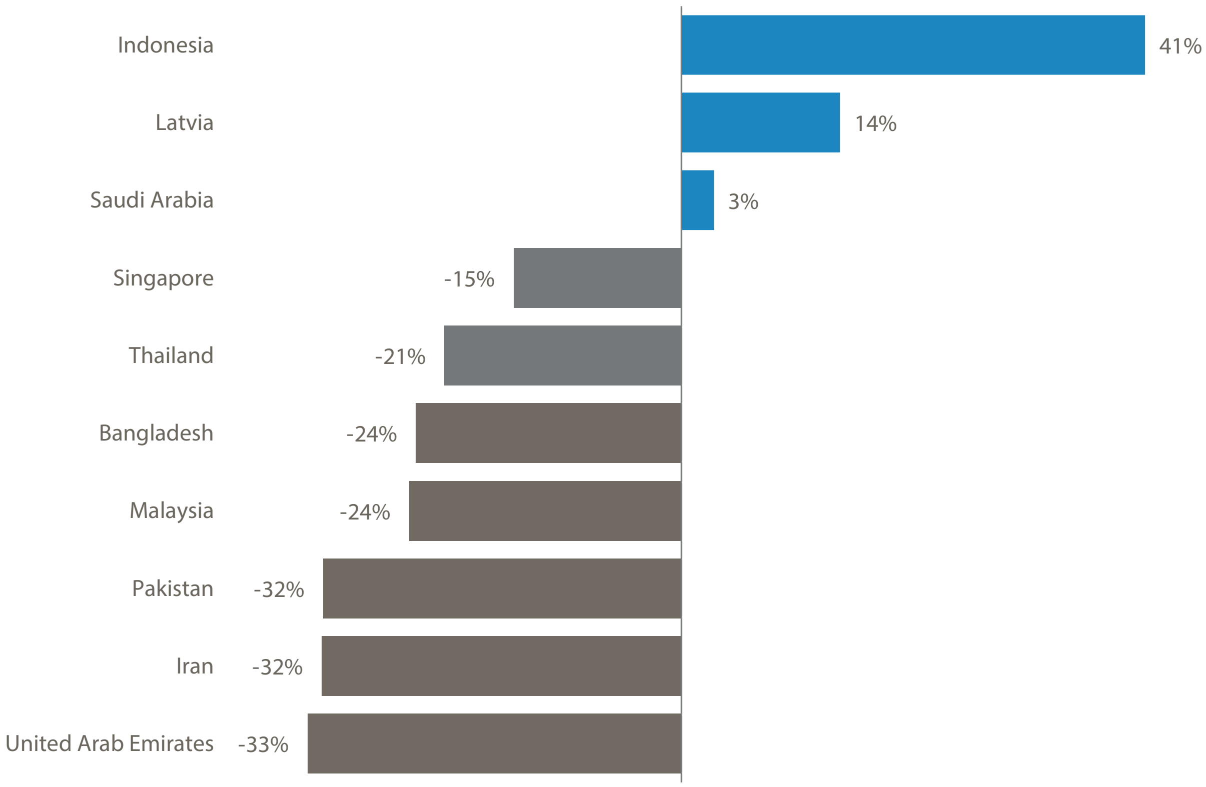

Figure 17 - Growth or Decline in Material Design Patent Output

PATENT GEOGRAPHIC CITATION IMPACT BENCHMARKING

Figure 17 details the highest citation impact by nation. Patent citation is a widely utilized measurement of the impact and recognition of an individual patent, and by extension, aggregated groups of patents such as those assigned to a company or associated with the innovation of a nation or region. The measurement is useful as it provides an independent assessment of the quality and impact of the innovation contained within the patent. When aggregated, it provides a method of benchmarking collections of patents for the average impact in comparison to others, e.g. between two competing entities or between nations.

Patent citation information within this study is measured via citations to patent family members of the Derwent World Patents Index and from citation events of 26 national patent collections.

On this metric, the Netherlands leads with the highest citation impact, followed by Switzerland, and Denmark.

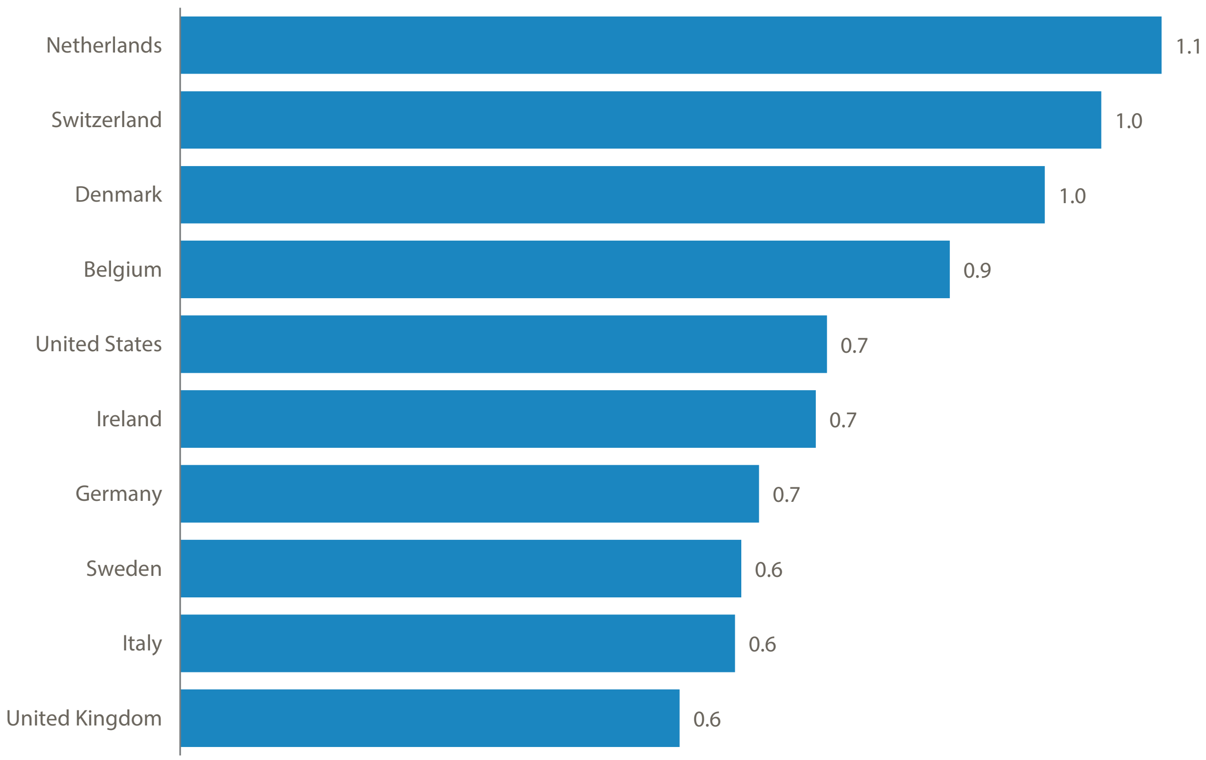

Figure 18 - Citation Impact of Material Design Patents

ADVANCED MATERIALS RESEARCH TOPIC BY GEOGRAPHY

Table 4 shows the split of Material Design science and research specialization for the top nations. Saudi Arabia appears to have focus on high temperature-pressure, polymers, composites and nano-materials. There appears to be little focus on corrosion-abrasion resistance in the patent collection for Saudi Arabia.

	1.0 Material Properties				2.0 Type of Material					1.0 Material Properties			
Country of Origin	1.1 High Strength	1.2 High Temperature-Pressure	1.3 Light Weight	1.4 Corrosion-Abrasion resistant	2.1 Metals & Alloys	2.2 Polymers	2.3 Ceramics	2.4 Composites	2.5 Nanomaterials	3.1 Modelling	3.2 Simulation	3.3 Analysis	3.4 Optimization
China	9%	33%	28%	3%	8%	19%	10%	53%	18%	20%	1%	2%	0%
Japan	8%	20%	8%	3%	5%	34%	4%	52%	9%	1%	0%	2%	0%
United States	5%	12%	13%	3%	10%	28%	2%	46%	22%	1%	1%	4%	3%
South Korea	7%	26%	24%	1%	3%	29%	8%	42%	27%	1%	0%	3%	0%
Germany	8%	13%	16%	3%	6%	12%	6%	72%	8%	1%	0%	2%	0%
European Patent Office	7%	17%	7%	3%	7%	32%	6%	46%	17%	1%	1%	3%	1%
Russia	17%	28%	16%	8%	27%	15%	19%	31%	14%	1%	0%	1%	
France	5%	12%	9%	2%	11%	20%	7%	51%	16%	1%	1%	3%	0%
Taiwan	3%	21%	32%	3%	5%	17%	2%	59%	30%	1%	0%	1%	0%
United Kingdom	9%	10%	14%	2%	10%	31%	4%	52%	11%	1%	0%	5%	1%
Italy	8%	12%	11%	2%	7%	22%	8%	54%	15%	1%	1%	3%	1%
Spain	11%	8%	19%	1%	6%	22%	12%	49%	19%	1%	1%	3%	
Australia	9%	10%	22%	4%	7%	27%	7%	51%	14%	2%	1%	6%	3%
Brazil	10%	13%	20%	1%	8%	29%	15%	29%	24%	1%		1%	1%
India	5%	12%	8%	3%	5%	49%	7%	23%	19%	1%	2%	3%	3%
Sweden	7%	12%	17%	5%	12%	20%	4%	55%	20%	0%	0%	4%	2%
Austria	12%	34%	14%	2%	9%	26%	15%	55%	4%	1%		4%	1%
Canada	10%	19%	16%	3%	12%	28%	2%	54%	8%	4%		3%	2%
Finland	8%	12%	17%	1%	6%	28%	3%	54%	18%	1%	1%	2%	2%
Patent Co-operation Treaty	7%	18%	10%	1%	9%	35%	5%	39%	24%	2%	1%	1%	1%
Switzerland	23%	16%	15%	4%	15%	18%	10%	47%	19%	1%	1%	1%	1%
Denmark	10%	8%	14%	2%	9%	25%	6%	48%	18%	2%		5%	2%
Netherlands	13%	12%	15%	1%	3%	36%	3%	55%	4%	3%		3%	2%
Poland	18%	24%	9%	1%	11%	22%	21%	29%	22%				
Czech Republic	14%	8%	14%			19%	19%	23%	47%				3%
Singapore	4%	11%	14%	5%	16%	28%	4%	36%	32%	3%		4%	1%
Saudi Arabia	4%	39%	13%		8%	41%	6%	30%	24%			4%	3%
South Africa	5%	11%	16%		14%	30%	2%	34%	23%			2%	5%
Israel		14%	17%	3%	25%	22%		51%	15%	3%	2%	2%	
Norway	6%	18%	16%	4%	18%	14%	4%	66%	8%			4%	
Malaysia	4%	8%	20%		4%	22%		41%	35%	4%		10%	
Mexico	8%	23%	8%	2%	2%	40%	17%	13%	29%	4%		2%	2%
Belgium	14%	14%	17%	11%	8%	25%	6%	50%	11%				
Turkey	22%	14%	8%		3%	19%	19%	39%	22%	3%			
	12%	21%	12%	6%	6%	32%	3%	53%	15%				3%
Portugal	13%	10%	10%		6%	19%	13%	52%	26%	3%		10%	6%
Hungary	17%	17%	10%			27%	17%	37%	33%	3%			3%
Romania	8%	28%	16%	4%	8%	12%	12%	36%	32%				
Greece	8%		15%		8%	8%		62%	31%	8%	8%	8%	
Slovenia	9%	9%			9%	36%	9%	18%	27%				9%
Ukraine	9%	27%	18%	9%	18%		9%	73%	9%				9%
Chile	10%	10%	10%			40%		40%	20%			10%	
Hong Kong	10%		10%			20%		50%	30%	20%			
Estonia		11%	33%	11%		22%		67%	22%	11%			
Slovakia	56%	44%				11%	78%	11%					
Argentina			50%		17%	33%		67%	17%		17%	17%	
Luxembourg		80%		20%			60%	60%		20%			
Morocco		20%	20%			40%		40%	20%				
Lithuania	25%						25%	50%	25%				
Bulgaria	67%		33%				67%	67%					
Georgia	33%	67%	33%				67%	33%					
Latvia	33%					33%	33%	33%					
San Marino			33%			33%		33%	33%				
Vietnam		67%	33%				33%	67%					
Armenia	50%						50%	50%					
Azerbaijan	50%						50%		50%				
Belarus			50%				50%	50%					
Egypt		100%				50%	50%						
EM								100%					
Iceland		50%				50%		50%					
Serbia					50%			50%					
Thailand	50%						50%	50%					
Colombia								100%					
Croatia	100%						100%						
Eurasian Patent Organization									100%				
Iran									100%				
Jamaica		100%				100%							
Kazakhstan		100%						100%					
Philippines		100%				100%							
Sri Lanka									100%				
Tunisia						100%							

Table 10 – Material Design Specialization by Country; % of Patent Activity per Technical Stream

PATENT FILINGS - PROLIFIC ENTITIES

The list of prolific entities filing patents includes a mix of chemicals and materials manufacturing companies, as well as electronics manufacturers. Science & Technology Unit, Umm Al-Qura University (STU-UQU) appears to have no patent filings in the Materials Design technology space. While the space appears to be crowded, there are opportunities for filing patents as discussed previously, in conjunction with table 4.

Entity	Total	Times Cited	Citation per family
FUJI FILM CO LTD	1431	878	0.61
UNIV BEIJING CHEM TECHNOLOGY	729	104	0.14
MATSUSHITA DENKI SANGYO KK	642	262	0.41
TORAY IND INC	639	328	0.51
UNIV ZHEJIANG	554	158	0.29
GENERAL ELECTRIC CO	529	537	1.02
BASF SE	468	333	0.71
MURATA MFG CO LTD	461	263	0.57
HITACHI CHEM CO LTD	454	253	0.56
MITSUBISHI MATERIALS CORP	447	174	0.39
KOREA ADV INST SCI&TECHNOLOGY	431	181	0.42
UNIV DONGHUA	420	78	0.19
UNIV SHANGHAI JIAOTONG	405	120	0.30
TOYOTA JIDOSHA KK	401	109	0.27
HARBIN INST TECHNOLOGY	389	66	0.17
KYOCERA CORP	381	147	0.39
TDK CORP	381	154	0.40
SAMSUNG ELECTRONICS CO LTD	379	327	0.86
HON HAI PRECISION IND CO LTD	367	383	1.04
UNIV SHANGHAI	366	81	0.22
BOSCH GMBH ROBERT	365	149	0.41
DAINIPPON PRINTING CO LTD	350	111	0.32
TOSHIBA KK	348	151	0.43
SIEMENS AG	330	208	0.63
UNIV QINGHUA	329	90	0.27
NIPPON STEEL CORP	324	133	0.41
UNIV TIANJIN	323	39	0.12
CANON KK	322	167	0.52
TOPPAN PRINTING CO LTD	317	149	0.47
UNIV TONGJI	303	78	0.26

Table 11 – Material Design – Top entities for Patents

TECHNOLOGY OVERVIEW OF PROLIFIC ENTITIES

Table 8 shows the technology profile of the top 30 entities within the patent landscape of Material Design. Composites appear to be the most patented topic within the landscape. Most companies are not investing much in protecting innovations in the Design Methodologies such as modeling, simulation, analysis, and optimization. Fuji Film, BASF, Hitachi Chemical, and Canon are the only entities with focus on Polymers comparable to their efforts in composites.

Entity	1.1 High Strength	1.2 High Temperature-Pressure	1.3 Light Weight	1.4 Corrosion-Abrasion resistant	2.1 Metals & Alloys	2.2 Polymers	2.3 Ceramics	2.4 Composites	2.5 Nanomaterials	3.1 Modelling	3.2 Simulation	3.3 Analysis	3.4 Optimization
FUJI FILM CO LTD	11	79	41	4	9	618	6	593	245	3	2	16	3
UNIV BEIJING CHEM TECHNOLOGY	65	224	259	34	83	93	66	402	205	7	2	8	
MATSUSHITA DENKI SANGYO KK	14	104	46	2	11	102	5	484	52	6		5	1
TORAY IND INC	226	162	136	1	10	235	6	342	83	5	2	20	4
UNIV ZHEJIANG	9	96	234	14	15	74	14	317	216	20	8	14	1
GENERAL ELECTRIC CO	41	122	64	36	82	83	20	329	59	4	2	15	8
BASF SE	20	113	8	7	16	269	17	78	117	1	1	5	
MURATA MFG CO LTD	4	15	1	1	6	2	6	450	2	3		4	1
HITACHI CHEM CO LTD	35	175	22	8	34	190	7	206	31	3		3	1
MITSUBISHI MATERIALS CORP	98	150	19	146	90	103	161	211	25	2		19	
KOREA ADV INST SCI&TECHNOLOGY	10	49	132	3	9	88	6	171	214	1		7	
UNIV DONGHUA	4	63	181	1	3	89	4	215	192	17	4	9	1
UNIV SHANGHAI JIAOTONG	24	77	152	10	18	66	16	209	153	9	5	9	2
TOYOTA JIDOSHA KK	109	67	54	8	11	37	4	331	27	3		7	
HARBIN INST TECHNOLOGY	40	119	133	16	55	22	30	265	64	11	1	7	
KYOCERA CORP	9	25	5	10	3	24	8	348	3		1	9	
TDK CORP		20	3	6	1	12	9	367	1	4		7	1
SAMSUNG ELECTRONICS CO LTD	4	40	105	3	7	49	2	188	172	1		16	2
HON HAI PRECISION IND CO LTD	2	10	100	38	48	5	4	174	189	2		1	
UNIV SHANGHAI	20	82	167	17	25	43	25	228	105	12	1	17	
BOSCH GMBH ROBERT	8	34	25	4	3	6	5	326	35	1		6	1
DAINIPPON PRINTING CO LTD	8	43	22	3	3	95	5	177	84	2		1	
TOSHIBA KK	42	89	22	22	53	30	11	241	25	1	3	14	2
SIEMENS AG	17	30	48	28	32	11	7	270	26	2		3	
UNIV QINGHUA	21	87	118	3	15	20	19	213	106	16	10	17	
NIPPON STEEL CORP	62	181	17	53	99	82	58	88	8			4	2
UNIV TIANJIN	5	49	153	7	11	27	11	220	100	6	6	16	
CANON KK	2	16	16		2	131	1	162	27	2		14	1
TOPPAN PRINTING CO LTD	2	18	21	5	6	159		124	30	2		12	
UNIV TONGJI	52	46	119	4	6	53	39	165	83	10	5	5	

Table 12 – Technology overview of top entities

TECHNOLOGY OVERVIEW OF ASIA PACIFIC PROLIFIC ENTITIES

Entity	Country of Origin	Total	1.1 High Strength	1.2 High Temperature-Pressure	1.3 Light Weight	1.4 Corrosion-Abrasion resistant	2.1 Metals & Alloys	2.2 Polymers	2.3 Ceramics	2.4 Composites	2.5 Nanomaterials	3.1 Modelling	3.2 Simulation	3.3 Analysis	3.4 Optimization
FUJI FILM CO LTD	Japan	1431	11	79	41	4	9	618	6	593	245	3	2	16	3
UNIV BEIJING CHEM TECHNOLOGY	China	729	65	224	259	34	83	93	66	402	205	7	2	8	
MATSUSHITA DENKI SANGYO KK	Japan	642	14	104	46	2	11	102	5	484	52	6		5	1
TORAY IND INC	Japan	639	226	162	136	1	10	235	6	342	83	5	2	20	4
UNIV ZHEJIANG	China	554	9	96	234	14	15	74	14	317	216	20	8	14	1
MURATA MFG CO LTD	Japan	461	4	15	1	1	6	2	6	450	2	3		4	1
HITACHI CHEM CO LTD	Japan	454	35	175	22	8	34	190	7	206	31	3		3	1
MITSUBISHI MATERIALS CORP	Japan	447	98	150	19	146	90	103	161	211	25	2		19	
KOREA ADV INST SCI&TECHNOLOGY	South Korea	431	10	49	132	3	9	88	6	171	214	1		7	
UNIV DONGHUA	China	420	4	63	181	1	3	89	4	215	192	17	4	9	1
UNIV SHANGHAI JIAOTONG	Chia	405	24	77	152	10	18	66	16	209	153	9	5	9	2
TOYOTA JIDOSHA KK	Japan	401	109	67	54	8	11	37	4	331	27	3		7	
HARBIN INST TECHNOLOGY	China	389	40	119	133	16	55	22	30	265	64	11	1	7	
KYOCERA CORP	Japan	381	9	25	5	10	3	24	8	348	3		1	9	
TDK CORP	Taiwan	381		20	3	6	1	12	9	367	1	4		7	1
SAMSUNG ELECTRONICS CO LTD	South Korea	379	4	40	105	3	7	49	2	188	172	1		16	2
HON HAI PRECISION IND CO LTD	China	367	2	10	100	38	48	5	4	174	189	2		1	
UNIV SHANGHAI	China	366	20	82	167	17	25	43	25	228	105	12	1	17	
DAINIPPON PRINTING CO LTD	Japan	350	8	43	22	3	3	95	5	177	84	2		1	
TOSHIBA KK	Japan	348	42	89	22	22	53	30	11	241	25	1	3	14	2

Table 13 – Patent overview of top Asia Pacific entities

MIDDLE EAST & AFRICA – PROLIFIC ENTITIES

Table 12 illustrates the top patenting entities in the Middle East and Africa. The space appears to be dominated by smaller, local players, particularly from Saudi Arabia, South Africa and Turkey.

Entity	Country of Origin	Total	1.1 High Strength	1.2 High Temperature-Pressure	1.3 Light Weight	2.1 Metals & Alloys	2.2 Polymers	2.3 Ceramics	2.4 Composites	2.5 Nanomaterials	3.1 Modelling	3.3 Analysis	3.4 Optimization
SABIC	Saudi Arabia	36	1	23		3	24		2	8		2	
Saudi Aramco	Saudi Arabia	15		4	2	1	4		7	3			
King Abdulaziz City for Science and Technology	Saudi Arabia	10	2		4			2	6	3		1	1
CSIR	South Africa	4		1		2	1			1			
UNIV WITWATERSRAND JOHANNESBURG	South Africa	4							1	3			
King Fahd University of Petroleum & Minerals	Saudi Arabia	3		1			1	2	2				
King Saud University	Saudi Arabia	3			1	2			1	1			
UNIV STELLENBOSCH	South Africa	3		1			1		1	2			
VESTEL ELEKTRONIK SANAYI VE TICARET SA	Turkey	3		1			1		2				
UNIV WITWATERSRAND	South Africa	2					1			1			2
AAT COMPOSITES PTY LTD	South Africa	1	1						1				
AFS BORU SANAYI ANONIM SIRKETI	Turkey	1								1			
AIR REVOLUTION TECHNOLOGIES PTY LTD	South Africa	1								1			
AMFI CRAFT CC	South Africa	1			1				1				
ARCELIK ANONIM SIRKETI	Turkey	1	1	1		1							
BAE SYSTEMS LAND SYSTEMS SOUTH AFRICA PT	South Africa	1				1							
BOYTEKS TEKSTIL SANAYI VE TICARET AS	Turkey	1								1			
CHEMFIT SPECIALITY CHEM PTY LTD	South Africa	1		1			1						
DAMASCUS ARMOUR DEV PTY LTD	South Africa	1				1							
DE BEER S P	South Africa	1					1						
DIABETES SCI INT FOUND	Saudi Arabia	1			1				1	1			
DURMUS YASAR VE OGULLARI BOYA VERNIK VE	Turkey	1								1			
ECZACIBASI YAPI GERECLERI SANAYI VE TICA	Turkey	1							1				
EURO CHEM NANOTECHNOLOGY AB	Iran	1								1			
FORMOSA SAINT JOSE CORP	South Africa	1			1				1				
GEOSYNFUELS LLC	South Africa	1					1						
GURALLAR YAPI MALZEMELERI VE KIMYA SANAYII ANONIM SIRKET	Turkey	1							1				
INFOTOX PTY LTD	South Africa	1			1				1				
INNOVCOAT NANOCOATINGS&SURFACE PROD	Turkey	1								1			
King Abdullah University of Science and Technology	Saudi Arabia	1							1				1

Table 14 – Patent Overview of Middle East & Africa entities

TECHNOLOGY OVERVIEW OF SAUDI ARABIA PROLIFIC ENTITIES

Entity	Total	1.1 High Strength	1.2 High Temperature-Pressure	1.3 Light Weight	2.1 Metals & Alloys	2.2 Polymers	2.3 Ceramics	2.4 Composites	2.5 Nanomaterials	3.1 Modelling	3.3 Analysis	3.4 Optimization
SABIC	36	1	23		3	24		2	8		2	
Saudi Aramco	15		4	2	1	4		7	3			
King Abdulaziz City for Science and Technology	10	2		4			2	6	3		1	1
King Fahd University of Petroleum & Minerals	3		1			1	2	2				
King Saud University	3			1	2			1	1			
King Abdullah University of Science and Technology	1							1				1

Table 15 – Patent overview of top Saudi Arabia entities

MIDDLE EAST & AFRICA INFORMATION TECHNOLOGY PATENT TRENDS

This section of the report focuses on the patent collection and the activity and technological trends seen within it – in the Middle East and Africa.

MIDDLE EAST & AFRICA – PROLIFIC COUNTRIES

Patent filing trends appear to be very different from the scientific literature trends. Figure 19 shows that Saudi Arabia to be the most popular country for filing patents within the two regions, followed by South Africa and Turkey. The remaining jurisdictions see only marginal patent filings.

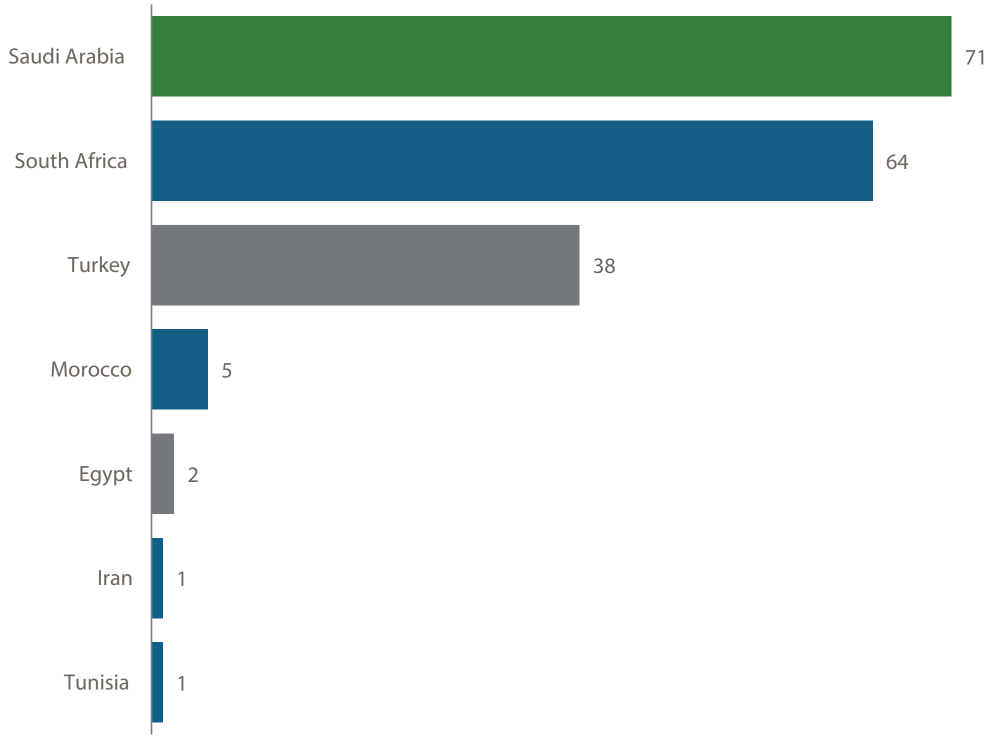

Figure 19 – Middle East & Africa – Prolific countries in patents

Diving deeper, Table 11 shows that South Africa, Saudi Arabia and Turkey to be consistent with the global patent focus on Space Technology.

Country of Origin	1.1 High Strength	1.2 High Temperature-Pressure	1.3 Light Weight	2.1 Metals & Alloys	2.2 Polymers	2.3 Ceramics	2.4 Composites	2.5 Nanomaterials	3.1 Modelling	3.3 Analysis	3.4 Optimization
Saudi Arabia	3	28	9	6	29	4	21	17		3	2
South Africa	3	7	10	9	19	1	22	15		1	3
Turkey	8	5	3	1	7	7	14	8	1		
Morocco		1	1		2		2	1			
Egypt		2			1	1					
Iran								1			
Tunisia					1						

Table 16 – Middle East & Africa – Prolific countries over technical categories

APPENDIX A – SCIENTIFIC PAPERS TOP AFFILIATIONS

ENTITY-LEVEL DATA TABLES FOR SCIENTIFIC LITERATURE COLLECTION

Table 7 on the following pages shows the top 10 author organizations for each of the technology categories. This information is intended to provide an assessment of the depth and location of the research expertise available in each category.

Top 10 Entities per Technology Stream

Technology	Entity	Total
1.1 High Strength	Harbin Institute of Technology	43
	Hong Kong Polytechnic	38
	Monash University	34
	West Virginia University	34
	University of Turku	30
	University of London Imperial College of Science Technology and Medicine	29
	Unviersity of Sherbrooke	28
	Ecole Polytechnique Federale de Lausanne	27
	Dalian University of Technology	26
	National Institute of Technology	26
1.2 High Temperature-Pressure	Chinese Academy of Sciences	164
	Tohoku University	70
	University of Science and Technology of China	59
	Sichuan University	47
	Sch Mat Sci & Engn	47
	Harbin Institute of Technology	46
	Russian Academy of Sciences	41
	Dept of Material Science and Engineering	38
	Tsinghua University	35
	Northwestern Polytech University	33
1.3 Light Weight	Chinese Academy of Sciences	256
	Harbin Institute of Technology	131
	University of Tehran	122
	Sichuan University	93
	Indian Institute of Technology	85
	Islamic Azad University	80
	Tsinghua University	76
	Zhejiang University	73
	Shanghai Jiao Tong University	72
	Tarbiat Modares University	68
1.4 Corrosion-Abrasion resistant	Chinese Academy of Sciences	431
	Harbin Institute of Technology	162
	Tohoku University	152
	Shanghai Jiao Tong University	149
	Indian Institute of Technology	138
	Central South University	135
	University of Science and Technology Beijing	114
	Dalian University of Technology	106
	Harbin Engineering University	102
	Russian Academy of Sciences	92

Top 10 Entities per Technology Stream
continued

Technology	Entity	Total
2.1 Metals & Alloys	Chinese Academy of Sciences	435
	Harbin Institute of Technology	188
	Tohoku University	163
	Shanghai Jiao Tong University	136
	Indian Institute of Technology	135
	Central South University	131
	University of Science and Technology Beijing	110
	Harbin Engineering University	109
	University of Manchester	100
	Northeastern University	93
2.2 Polymers	Chinese Academy of Sciences	169
	Sichuan University	87
	University of Science and Technology of China	67
	National University of Singapure	65
	South China University of Technology	63
	Russian Academy of Sciences	58
	Seoul National University	56
	Zhejiang University	52
	Tsinghua University	50
	Beijing University of Chemical Technology	50
2.3 Ceramics	Chinese Academy of Sciences	441
	Russian Academy of Sciences	295
	Seoul National University	143
	National Chiao Tung University	135
	Indian Institute of Technology	124
	Tohoku University	107
	CNRS	102
	National University of Singapure	100
	Sungkyunkwan University	95
	CSIC	93
2.4 Composites	Chinese Academy of Sciences	468
	Harbin Institute of Technology	271
	Indian Institute of Technology	181
	Russian Academy of Sciences	171
	Tsinghua University	153
	Tohoku University	150
	University of Tehran	139
	Shandong University	135
	Northwestern Polytech University	126
	Sichuan University	125
2.5 Nanomaterials	Chinese Academy of Sciences	59
	Tarbiat Modares University	54
	Seoul National University	28
	National University of Singapure	26
	Islamic Azad University	23
	Hanyang University	23
	Korea University	20
	Harbin Institute of Technology	18
	Tsinghua University	16
	Beijing University of Chemical Technology	15

Top 10 Entities per Technology Stream

continued

Technology	Entity	Total
3.1 Modelling	Indian Inst Technol	21
	CNRS	18
	Dalian Univ Technol	15
	Tohoku Univ	14
	Russian Acad Sci	13
	Northwestern Univ	13
	Univ Manchester	12
	Hong Kong Polytech Univ	12
	Politecn Milan	12
	Chinese Acad Sci	11
3.2 Simulation	Chinese Acad Sci	22
	Harbin Inst Technol	20
	Shandong Univ	17
	Tsinghua Univ	13
	Tohoku Univ	12
	Univ Florida	11
	Chongqing Univ	11
	Dalian Univ Technol	10
	Russian Acad Sci	9
	CNRS	8
3.3 Analysis	Chinese Acad Sci	29
	Harbin Inst Technol	23
	Tohoku Univ	19
	Seoul Natl Univ	15
	Zhejiang Univ	15
	Texas A&M Univ	13
	Univ Sao Paulo	13
	Tsinghua Univ	12
	Shanghai Jiao Tong Univ	12
	Osaka Univ	12
3.4 Optimization	Chinese Acad Sci	7
	Islamic Azad Univ	7
	Isfahan Univ Technol	7
	Indian Inst Technol	6
	Shanghai Jiao Tong Univ	5
	Dalian Univ Technol	5
	Penn State Univ	5
	Tsinghua Univ	4
	Univ Tehran	4
	Tokyo Inst Technol	4

Table 17 - Top 10 Paper Publishing Organizations per Technology Category

APPENDIX B – PATENT STATISTICS AND TABLES

ENTITY-LEVEL DATA TABLES FOR PATENT COLLECTION

The table below and on the following pages show the top 10 patent applicants or patent assignees for each of the technology categories. This information is intended to provide an assessment of expertise and patent commercialization intent per category.

Top 10 Entities per Technology Stream

Technology	Entity	Total
1.1 High Strength	TORAY IND INC	226
	MITSUBISHI MATERIALS CORP	168
	TOYOTA JIDOSHA KK	109
	SHCHEPOCHKINA YU A	60
	DAIWA SEIKO KK	59
	UNIV TONGJI	51
	NIPPON STEEL CORP	50
	KAWASAKI STEEL CORP	45
	TOSHIBA KK	42
	GENERAL ELECTRIC CO	41
1.2 High Temperature-Pressure	CHEIL IND INC	197
	TORAY IND INC	162
	KAWASAKI STEEL CORP	144
	HITACHI CHEM CO LTD	137
	KANEKA CORP	127
	GENERAL ELECTRIC CO	122
	MITSUBISHI MATERIALS CORP	116
	BASF SE	113
	SUMITOMO BAKELITE CO LTD	109
	HARBIN INST TECHNOLOGY	108
1.3 Light Weight	UNIV SHANGHAI	288
	UNIV ZHEJIANG	233
	UNIV DONGHUA	176
	UNIV TIANJIN	149
	TORAY IND INC	136
	UNIV BEIJING CHEM TECHNOLOGY	129
	UNIV FUDAN	128
	HARBIN INST TECHNOLOGY	126
	UNIV NANJING	123
	UNIV TONGJI	117
1.4 Corrosion-Abrasion resistant	MITSUBISHI MATERIALS CORP	146
	KAWASAKI STEEL CORP	73
	NIPPON STEEL CORP	53
	JIANGSU LINLONG NEW MATERIAL CO LTD	41
	HON HAI PRECISION IND CO LTD	38
	GENERAL ELECTRIC CO	36
	SIEMENS AG	28
	UNIV JILIN	22
	TOSHIBA KK	22
	UNIV CENT SOUTH	21

Top 10 Entities per Technology Stream
continued

Technology	Entity	Total
2.1 Metals & Alloys	MITSUBISHI MATERIALS CORP	157
	KAWASAKI STEEL CORP	104
	NIPPON STEEL CORP	97
	GENERAL ELECTRIC CO	94
	UNITED TECHNOLOGIES CORP	71
	BOEING CO	58
	TOSHIBA KK	55
	SANYO ELECTRIC CO LTD	54
	HARBIN INST TECHNOLOGY	53
	HON HAI PRECISION IND CO LTD	49
2.2 Polymers	FUJI FILM CO LTD	596
	BASF SE	269
	KAO CORP	250
	TORAY IND INC	235
	SUMITOMO GROUP	219
	CHEIL IND INC	213
	KANEKA CORP	199
	RICOH KK	180
	HITACHI CHEM CO LTD	172
	TOPPAN PRINTING CO LTD	159
2.3 Ceramics	KAWASAKI STEEL CORP	75
	NIPPON STEEL CORP	50
	TAIHEIYO CEMENT CORP	48
	UBE IND LTD	45
	UNIV TONGJI	39
	KUROSAKI REFRACTORIES CO	36
	DENKI KAGAKU KOGYO KK	31
	NGK INSULATORS LTD	30
	HARBIN INST TECHNOLOGY	28
	WUHAN IRON&STEEL GROUP CORP	28
2.4 Composites	FUJI FILM CO LTD	579
	MATSUSHITA DENKI SANGYO KK	484
	MURATA MFG CO LTD	450
	TDK CORP	367
	TORAY IND INC	342
	KYOCERA CORP	331
	TOYOTA JIDOSHA KK	331
	GENERAL ELECTRIC CO	329
	ROBERT BOSCH GMBH	326
	UNIV ZHEJIANG	316
2.5 Nanomaterials	FUJI FILM CO LTD	243
	UNIV ZHEJIANG	214
	UNIV DONGHUA	191
	HON HAI PRECISION IND CO LTD	189
	SAMSUNG ELECTRONICS CO LTD	172
	UNIV SHANGHAI JIAOTONG	151
	UNIV NANJING	121
	BASF SE	117
	UNIV BEIJING CHEM TECHNOLOGY	116
	UNIV CALIFORNIA	115

Top 10 Entities per Technology Stream
continued

Technology	Entity	Total
3.1 Modelling	HENAN KOSEN CABLE CO LTD	89
	UNIV SOUTHEAST	37
	UNIV ZHEJIANG	20
	SUZHOU JUNYUE NEW MATERIAL TECHNOLOGY CO	20
	UNIV SHANDONG	19
	PETROCHINA CO LTD	18
	UNIV SOUTH CHINA TECHNOLOGY	18
	UNIV DONGHUA	17
	UNIV BEIJING TECHNOLOGY	17
	UNIV NORTHWESTERN POLYTECHNICAL	17
3.2 Simulation	UNIV QINGHUA	10
	UNIV ZHEJIANG	8
	UNIV SOUTHWEST PETROLEUM	8
	PETROCHINA CO LTD	7
	UNIV NORTHWESTERN POLYTECHNICAL	6
	UNIV TIANJIN	6
	UNIV JIANGNAN	6
	UNIV XIAN JIAOTONG	5
	UNIV TONGJI	5
	UNIV SHANGHAI JIAOTONG	5
3.3 Analysis	UNIV TAIYUAN TECHNOLOGY	35
	ATYR PHARMA INC	21
	TORAY IND INC	20
	MITSUBISHI MATERIALS CORP	19
	UNIV QINGHUA	17
	UNIV SHANGHAI	17
	UNIV CALIFORNIA	17
	UNIV TIANJIN	16
	FUJI FILM CO LTD	16
	SAMSUNG ELECTRONICS CO LTD	16
3.4 Optimization	UNIV CALIFORNIA	17
	AMBRX INC	16
	MASSACHUSETTS INST TECHNOLOGY	10
	TOKYO ELECTRON LTD	9
	MITSUBISHI PAPER MILLS LTD	9
	GENERAL ELECTRIC CO	8
	3M INNOVATIVE PROPERTIES CO	7
	BOSCH H W	7
	NOVA CHEM INC	7
	CORNING INC	6

Table 18 - Top 10 Patent Applicants/Owners per Technology Category

LANDSCAPE OF ADVANCED MEDICAL AND HEALTH RESEARCH

SCIENCE & TECHNOLOGY UNIT, UMM AL-QURA UNIVERSITY (STU-UQU)

THOMSON REUTERS IP SERVICES
MAY 2015

Executive Summery

This study has been commissioned by Science & Technology Unit, Umm Al-Qura University (STU-UQU) to evaluate and describe the global scientific research and patent activity within sub-tracks that they have achieved funding for projects in Anti-cancer and Anti-viral", "Communicable diseases", "Non-communicable diseases(cancer)", "Medical & health technology", "Genetics", "Cancer therapy", "Reproductive medicine". The sub-tracks in focus were "Medicinal Chemistry and Microbiology", "Tuberculosis", "Viral hepatitis C infection", "Gene-Viro-Therapy of Hepatocellular Carcinoma", "Neurodegenerative Diseases", "Colorectal Carcinoma", "Sexually transmitted infections", "Reproductive endocrinology", "Cancer" and "Bioactive Natural products and their Semisynthetic Derivatives". The study has looked at both scientific papers and patents to form an understanding of the overall scientific and technology landscape.

The scientific papers are sourced from the Web of Science™, a database containing journal articles from approximately 12,500 peer-reviewed journals.

The patent information is sourced from the Derwent World Patents Index™, a database of patents and patent applications from 47 international patent issuing authorities.

Both databases have been selected because they provide a method of defining a unit of science or technology. A single paper defined by the Web of Science is required to have met a minimum threshold of scientific rigor: publication within a journal of repute, peer review sign off, etc. Furthermore, a patent included within DWPI is defined credibly as an attempt to protect a piece of innovation within at least one territory.

Aggregating this information across technologies and countries provides a method of tracking innovation in the field of Anti-cancer and Anti-viral, Communicable diseases, Non-communicable diseases(cancer), Medical & health technology, Genetics, Cancer therapy, Reproductive medicine. Included in this document are measurements of research and patent quality and direction changes in research and patent activity. It should be noted that in many areas the report utilizes metrics such as average annual percentage growth in scientific and research output to compare activities across technologies and geographies. Such metrics should be treated with care for analysis containing low volumes, as some volatility is expected. Also to be noted is that the global high volume nature of this analysis within Anti-cancer and Anti-viral, Communicable diseases, Non-communicable diseases (cancer), Medical & health technology, Genetics, Cancer therapy, Reproductive medicine technology necessarily entails some level of noise and is not intended to be completely comprehensive. Instead, the analysis enclosed should be treated as a survey of the technology, and the trends and findings interpreted in this manner.

Overall, the fact that the number of patents in this area is about 65% of the number of scientific papers suggests that the fundamental research activity is more focused than the practical technical commercialization.

For STU-UQU, it is interesting to note the patent and scientific literature collections differ with respect to the breakdown in technology segments. The most active technology segments in both data sets are Communicable Diseases and Non- Communicable Diseases, however thereafter the breakdown differs. The analysis also suggests that on a global level, there is greater focus on fundamental research in most of the broad technology areas.

Similarly with regard to average growth rates of these collections (years 2008 - 2013 for patents; years 2009 - 2014 for papers), in the patent collection the technology segment which is experiencing growth is Medical & Health technology. Reproductive endocrinology in patent collection has declined over the time period. All of the technology segments in the scientific literature collection have seen a growth over the time period with Medical & Health technology leading the growth.

Overall Kingdom of Saudi Arabia (KSA) output is pretty low compared to other global resources with the US and United Kingdom leading in published literature and the US and China leading in patent output. However, KSA are showing impressive growth and compared with output of the Middle East and Africa (MENA) countries they rank third behind Turkey and Iran in patent filings. In published literature output, KSA is amongst top 10 MENA countries.

STU-UQU does lag behind in terms of both published literature and patent output as compared to other prolific entities active in Middle East and Africa. In published literature a number of international universities are active in MENA. This may be indicative of collaboration between foreign universities and MENA regional organizations – an avenue worth exploring. KSA entities appear to have low volumes - both in patent and literature output, which may indicate greater opportunities for research expansion in the field of Advanced Medical and Health Research.

For STU-UQU, it is interesting to note the patent and scientific literature collections differ with respect to the breakdown in technology segments. Some technologies are clearly within the commercialization and practical implementation phase, while others exhibit new fundamental technology research.

Bacterial Infections, Fungal Infections, Protozoan Infections, Hepatitis, Skin Diseases, Treatment-Communicable Diseases, Diagnosis-Communicable Diseases and Pharmaceutical Drugs (Medical & Health Technology) ; all are in the technology commercialization and practical implementation phase – with volumes for patent protection far exceeding the volume of scientific literature being published.

On the other hand, Pandemic Influenza , Food Borne Diseases , Animal or Insect Borne Diseases, Chemotherapy , Radiation Therapy , Vaccines-Non-Communicable disease (Cancer), Diagnosis-Medical & Health Technology, Stem Cell Therapy, Ectopic Pregnancy Types , Fertility Medications, In Vitro Fertilization, Intrauterine insemination, Intra-Cytoplasmic Sperm Injection , Magnetic Resonance Imaging/Hysterosalpingography and Endoscopic Techniques exhibit significantly more scientific literature publications as compared to patents filings – indicative of emerging fields of more fundamental research.

Viral Infections, HIV/AIDS, Parasites, Sexually Transmitted Infections, Tuberculosis, Colorectal Cancer, Liver Cancer, Brain Tumors, Screening / Diagnosis and Pharmaceutical Drugs (Non-communicable Diseases (Cancer) are fairly developed within the patent landscape as well as within the scientific literature landscape. This indicates evolving and maturing technology – technologies already in the commercialization and practical implementation phase, with new fundamental research and development still continuing, indicated by the comparable number of patent filings and scientific literature publications.

The patent technology segments experiencing significant growth include Abdominal Pain and Sexually Transmitted Diseases.

Viral Infections, HIV/AIDS, Skin Diseases, Gene-Viro-Therapy, Cell Transplantation, Static and Pulsed Magnetic Field Therapies, Abdominal Pain, Sexually Transmitted Diseases and Magnetic Resonance Imaging/Hysterosalpingography exhibit high growth in patent activity that significantly exceeds the growth in scientific literature. This indicates opportunities for “improvement” type of patent filings that focus on implementation improvements, rather than on fundamental technologies.

It is recommended to further analyze the space of Abdominal Pain and Sexually Transmitted Diseases, since this technology has a small number of patent filings but high growth – indicating a nascent technology area.

Scientific literature data indicates strong growth on fundamental research in area of Food Borne Diseases.

Pandemic Influenza, Food Borne Diseases, Diagnosis-Communicable Diseases, Diagnosis-Medical & Health Technology, Pharmaceutical Drugs (Medical & Health Technology), Stem Cell Therapy and Endometriosis are areas where scientific literature growth far exceeds the growth of patent filings. This is indicative of avenues and opportunities for fundamental research and development.

Percutaneous Electrical Nerve Stimulation and Low-Level Laser Therapy (LLLT) shows significant growth in both patent filings as well as scientific literature publications. Such trend is indicative of an emerging technology, which has not fully matured yet. Interest to develop fundamental technologies continues, while simultaneously technology is being commercialized and practically implemented. This presents an opportunity for newer fundamental technology within these technologies to be researched. Any improvements to existing fundamental techniques of these technologies will be better served by patent filings.

For further information regarding the data used in this study, and for deeper or variations in the analysis presented, please review the interactive dashboards.

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INTRODUCTION TO GLOBAL ADVANCED MEDICAL AND HEALTH RESEARCH SCIENTIFIC ACTIVITY

This study presents an analysis of patents and scientific papers that fall within specific topics of Advanced medical & Health research which are of interest to Umm Al-Qura University concerning the “Anti-cancer and Anti-viral”, “Communicable diseases”, “Non-communicable diseases(cancer)”, “Medical & health technology”, “Genetics”, “Cancer therapy”, “Reproductive endocrinology”. The study was commissioned by Science & Technology Unit, Umm Al-Qura University (STU-UQU) as part of a wider program to review the scientific and intellectual property activity in specific topics that they have gained approved funding for projects.

Within Advanced medical & Health research, they have gained funding approval for 10 projects related to “Anti-cancer and Anti-viral”, “Communicable diseases”, “Non-communicable diseases(-cancer)”, “Medical & health technology”, “Genetics”, “Cancer therapy”, “Reproductive endocrinology” specifically in the sub-tracks of “Medicinal Chemistry and Microbiology”, “Tuberculosis”, “Viral hepatitis C infection”, “Gene-Viro-Therapy of Hepatocellular Carcinoma”, “Neurodegenerative Diseases”, “Colorectal Carcinoma”, “Sexually transmitted infections”, “Reproductive endocrinology”, “Cancer” and “Bioactive Natural products and their Semisynthetic Derivatives”. The titles of the projects are “Preparation and Development Through Computer-Aided Molecular Drug Design of Isoxazolidine Nucleosides and Isoxazolidinyl and Nucleosidyl Podophyllotoxin Derivatives with Potential Antiviral and Anticancer Activities”, “Molecular characterization and cloning of a 60 Kda Mycobacterium bovis-specific antigen as a recombinant protein: Towards the development of a reliable skin test for control of tuberculosis among humans and animals.”, “Novel host markers for the prediction of treatment outcome in patients with chronic hepatitis C infection in Saudi Arabia: The role of activins, interleukin–10, interferon-γ-inducible protein-10 and interleukin-28B gene polymorphism.”, “A study of cancer-targeting dual gene virotherapy as a promising therapeutic strategy for treatment of hepatocellular carcinoma”, “Effect of High and Low Intensity Laser Therapy on Sciatic Nerve Regeneration in Rats. A Randomized Double-Blind Placebo Controlled Trial.”, “Novel Combinatorial Therapeutic Strategies by Vitamin D or its analogue Paricalcitol, Thymoquinone and Conventional Cytotoxic Drugs against Colorectal Carcinoma: Efficacy, safety and mechanisms.”, “Exploring the pathogenesis of ectopic pregnancy: The role of sexually transmitted organisms and their effect on the expression of implantation markers by the Fallopian tube.”, “Activins and follistatin as markers of endometrial receptivity and pregnancy rate in patients undergoing intrauterine insemination, in vitro fertilization and intra-cytoplasmic sperm injection”, “Development of Mutation Screening Strategy in Brain Tumours (Gliomas)” and “Plants with Potential Anti-cancer Effect: Phytochemical, Biological and Mechanistic Studies. Development of the Production of Active Natural Compounds in vitro and the Optimization of the Biological Activity by Chemical Modifications”.

A large scale data collation process using globally recognized search processes from Thomson Reuters was undertaken to produce practical and insightful sets of information for analysis regarding the trends, geographies and ultimately the institutions and patent applicants working in the fields of “Anti-cancer and Anti-viral”, “Communicable diseases”, “Non-communicable diseases(cancer)”, “Medical & health technology”, “Genetics”, “Cancer therapy”, “Reproductive endocrinology”. As shown in Figure 1, the overall volume of patents in these technology areas filed since 2006 is about 65% of the volume of scientific papers published since 2008, however in the same time period from year 2008 onwards the scientific papers output is about 78% higher than the patents output.

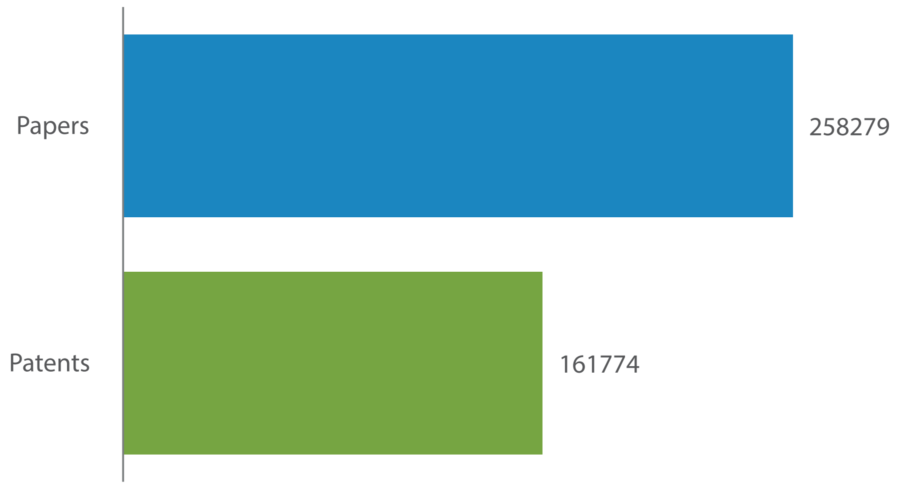

Figure 1 – Scientific Paper and Patent Families in Advanced Medicine and Health Research

Additionally, year 2007 onwards patent protection activity related to Advanced medical & Health research has gradually increased however a significant drop is observed in years 2012-13 (refer to Figure 2, Timeline of Activity). Whereas publications in scientific journals in these areas, which are likely to address more fundamental research in science, during years 2008-11 has continuously increased at an average rate of about 4% over the last year. This might suggest that the focus of technology development globally related to "Anti-cancer and Anti-viral", "Communicable diseases", "Non-communicable diseases(cancer)", "Medical & health technology", "Genetics", "Cancer therapy", "Reproductive endocrinology" is increasingly directed towards fundamental scientific research.

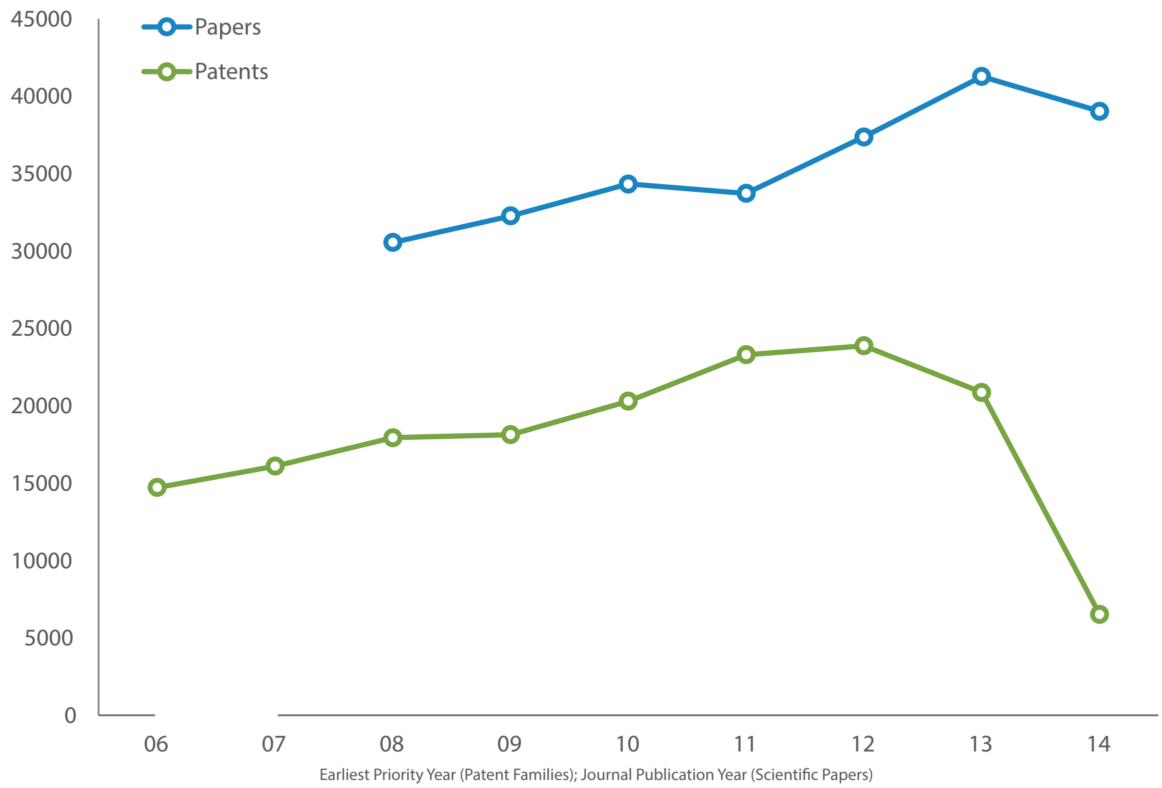

Figure 2 – Timeline of Scientific Paper and Patent Family Activity

Figures 3 through 5 show three further analysis on each of the data collections (patents, left; papers,

right) concerning the nature and high level technology trends occurring within “Anti-cancer and Anti-viral”, “Communicable diseases”, “Non-communicable diseases(cancer)”, “Medical & health technology”, “Genetics”, “Cancer therapy” and “Reproductive endocrinology” areas.
The patent and scientific literature collections differ with respect to the breakdown in broad technology segments. Five broad level technology segments within Advanced medical & Health research, which were identified for the purpose of this study, include “Communicable diseases”, “Non-communicable diseases (cancer)”, “Medicinal & Health technology”, “Ectopic pregnancy” and “Reproductive medicine”. The active segments in both data sets are communicable and non-communicable diseases. The analysis also suggests that on a global level, there is an almost equal and significant work being carried out in areas of communicable diseases as well as non-communicable diseases (cancer) in technology commercialization and fundamental research.

Note that the dates used for the collation of the timeline information differ for patent and scientific literature information. Patent Families are measured by the earliest known “priority” or first filing event in the inventions history. Patents are typically retained by patent offices for 18 months or more after filing before they are published. This delay means that the last complete year of information available for patent information is 2012. For scientific papers, the dates used for analyses are the publication dates of the journal containing the paper. These metrics are used throughout the report.

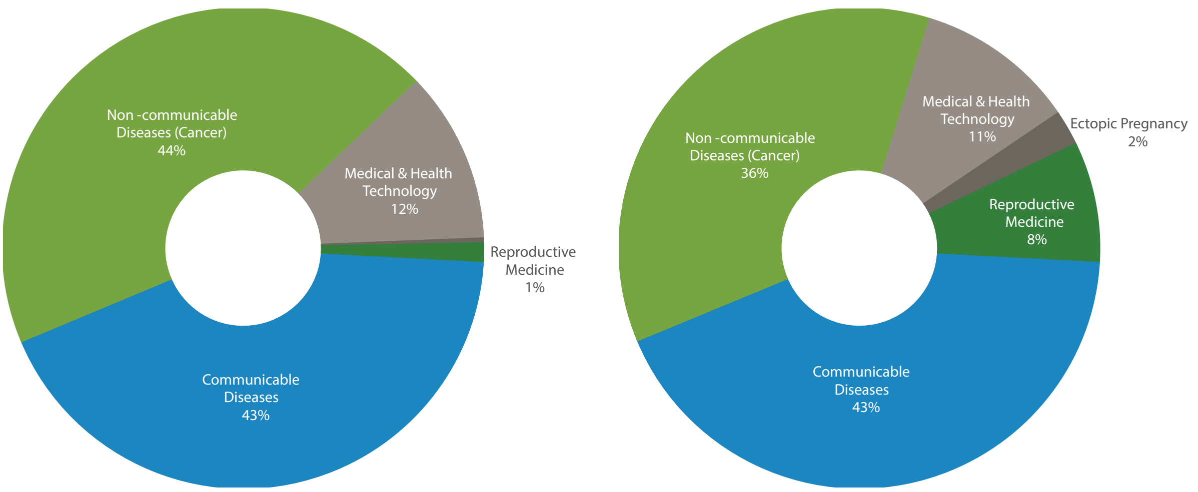

Figure 3 – % of Patent (left) and Scientific Paper (right) Collections by Technology Segments

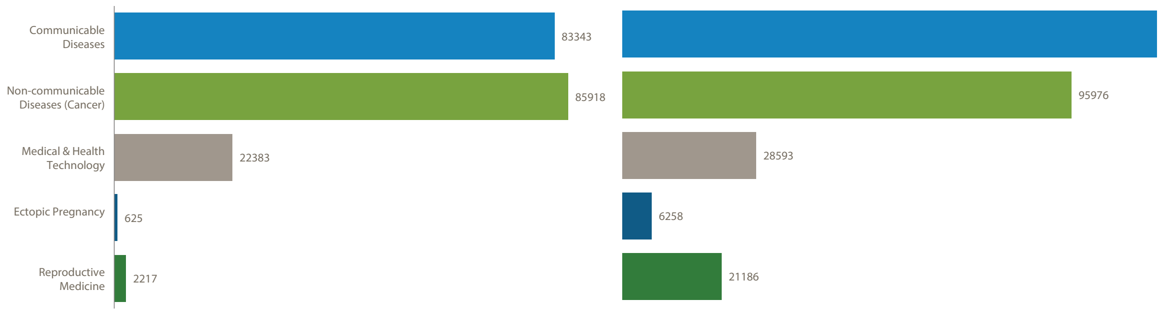

Figure 4 – Number of Patents Families (left) and Scientific Papers (right) per Technology Segments

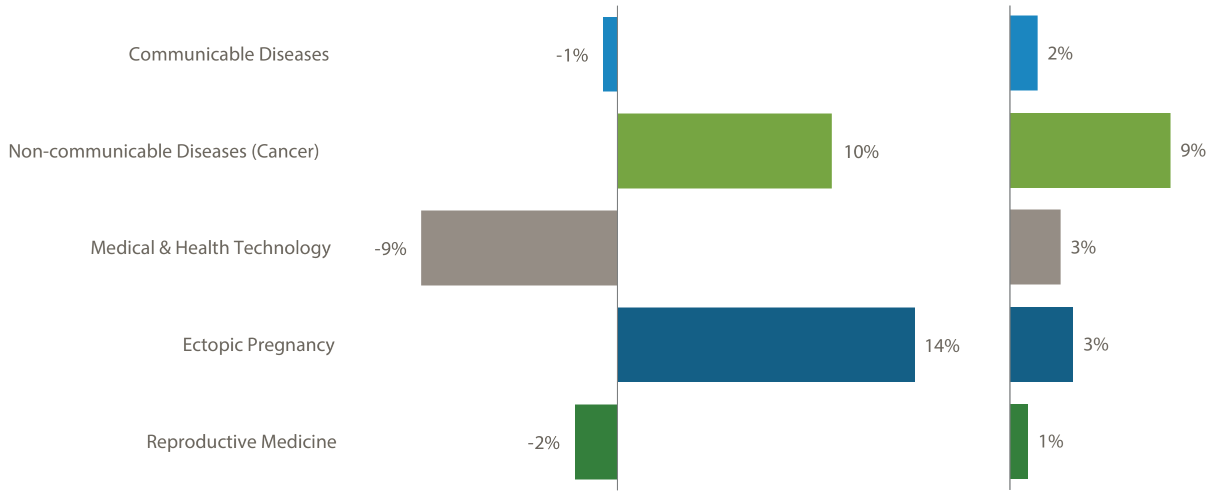

Figure 5 – Average Annual % Growth or Decline in Patent Family (left) or Scientific Paper (right) Output by Technology Segments

With regard to average growth rates of these collections (years 2008 - 2013 for patents; years 2009 - 2014 for papers), in the patent collection the technology segment which is experiencing growth is Medical & Health technology. Reproductive endocrinology in patent collection has declined over the time period. All of the technology segments in the scientific literature collection have seen a growth over the time period with Medical & Health technology leading the growth.

Average annual growth or decline is calculated by the average percentage increase or decrease between one year and the next. For example; 5 patents in 2006 followed by 6 patents in 2007 would represent an annual increase of 20%. An increase of 20% in one year, followed by a 10% increase the following year would be represented as a 15% average increase across the two years. This process is followed for 2006 (patents) or 2008 (papers) through to the most recently available year in patent and paper collections, to provide an indicator of the level and direction of recent changes in technology topics.

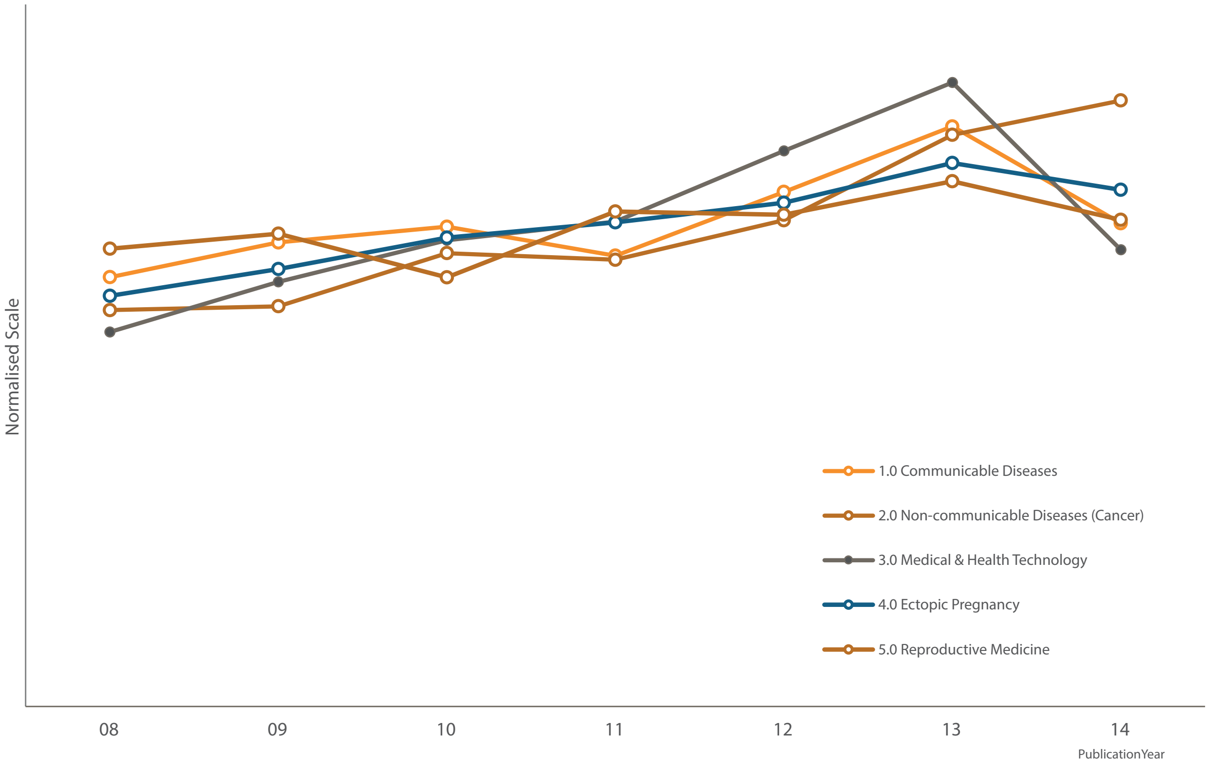

Figure 6 – Normalized Timeline of Activity for Scientific Paper Collection by Various Technology Topics

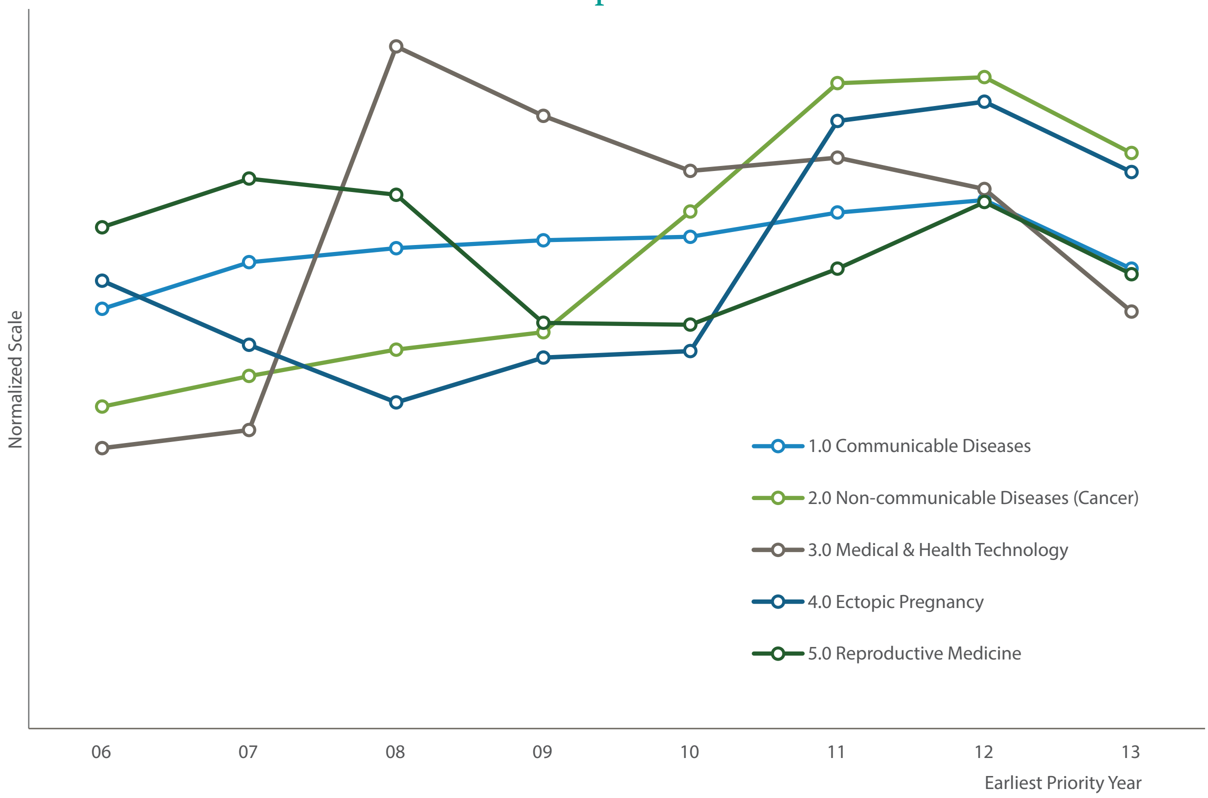

Figure 7 – Normalized Timeline of Activity for Patent Family Collection by Various Technology Topics

The timelines on these charts have been normalised to allow for side by side comparison. Individually, each topic has varying volumes of patent families and scientific papers, however for visualisation purposes, the charts represent the proportion of each topic's activity filed or published in each calendar year.

Figures 8 through 10 show similar analysis on each of the data collections (patents, left; papers, right) concerning the nature and technology trends occurring within the "Communicable diseases" segment. In "communicable diseases" segment viral infections is an active topic in both data sets, however in this topic the focus is more on the fundamental research than technology commercialization. A large number of patent records within communicable diseases segment are related to "Hepatitis", "Skin diseases" and "Treatment". On the other hand "HIV/AIDS" and "Animal or Insect borne diseases" are the topics with greater focus in fundamental research.

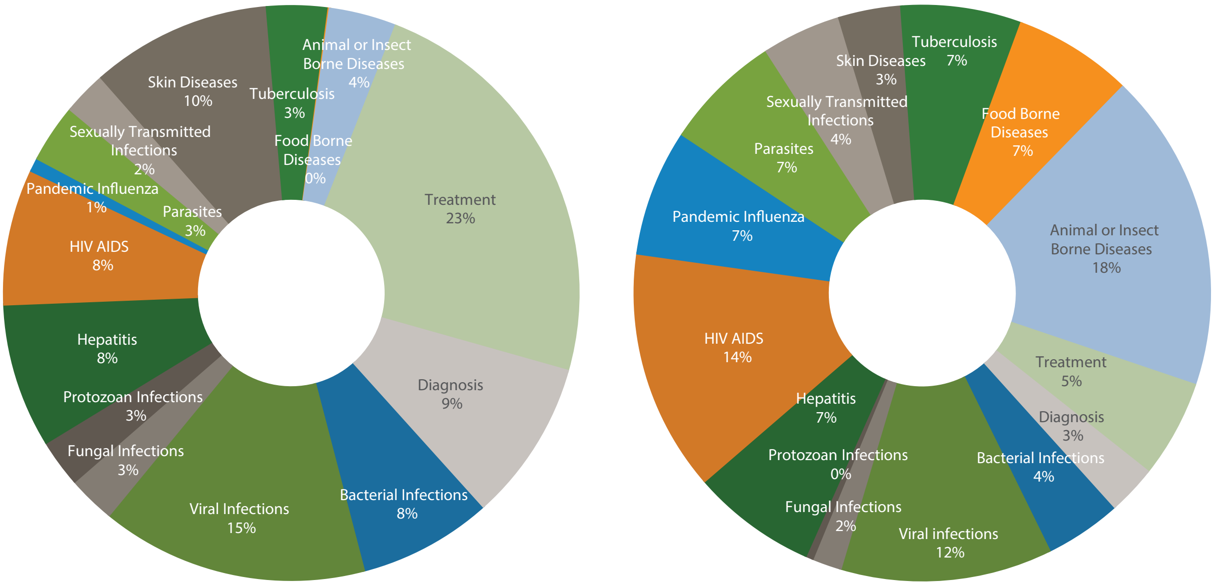

Figure 8 – % of Patent (left) and Scientific Paper (right) Collections by Various Topics in Communicable diseases

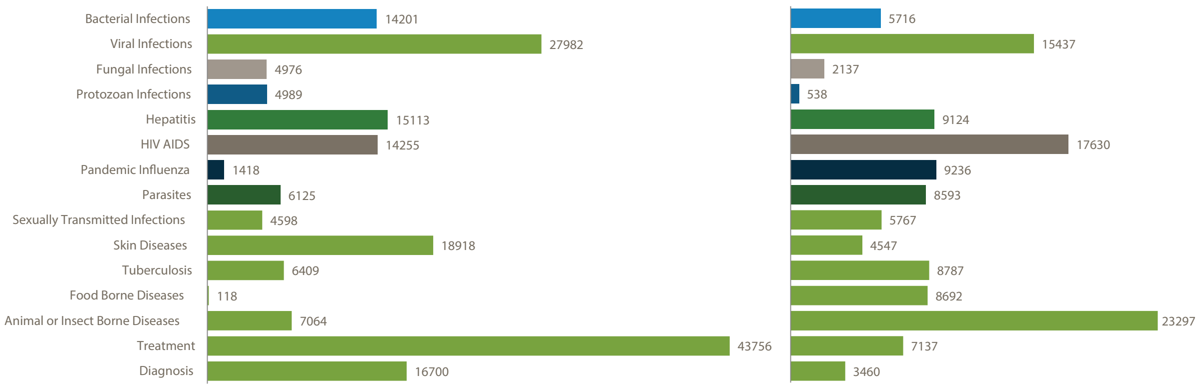

Figure 9 – Number of Patents Families (left) and Scientific Papers (right) per Topic in Communicable diseases

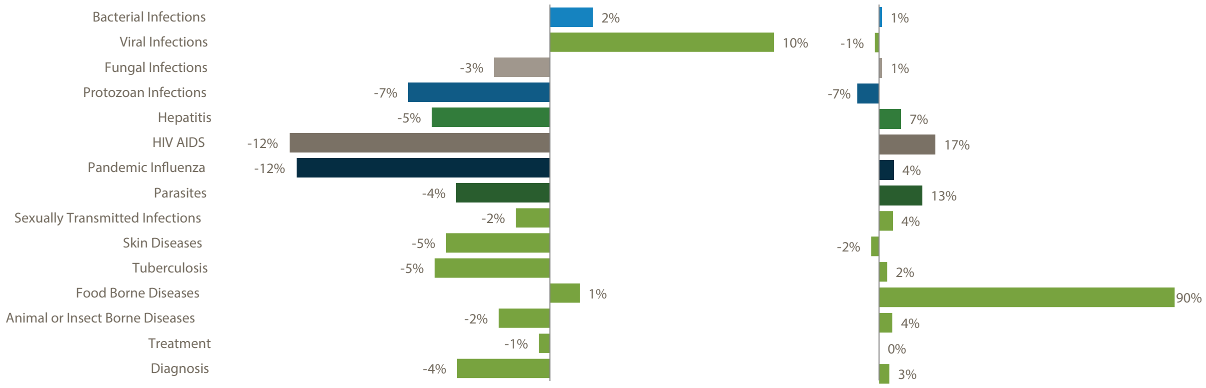

Figure 10 – Average Annual % Growth or Decline in Patent Family (left) or Scientific Paper (right) Output

Topics which have observed good growth in the sector of fundamental research are Food borne diseases followed by HIV/AIDS and Parasites.
Figures 11 through 13 show analysis on each of the data collections (patents, left; papers, right) concerning the nature and technology trends occurring within the "Non-Communicable diseases" segment. Within the Non-Communicable diseases segment Colorectal cancer, screening & diagnosis, Liver cancer and pharmaceutical drugs are active topics in both data sets. Chemotherapy and Radiation therapy are substantially active in fundamental research than in technology focus.

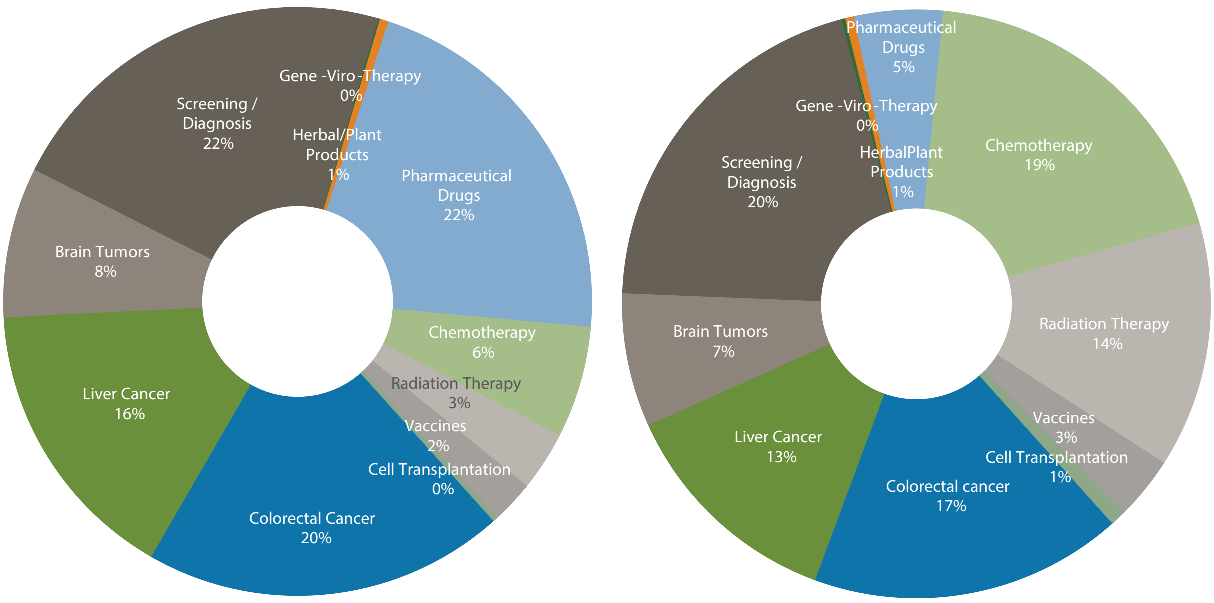

Figure 11 – % of Patent (left) and Scientific Paper (right) Collections by Various Topics in Non-Communicable Diseases

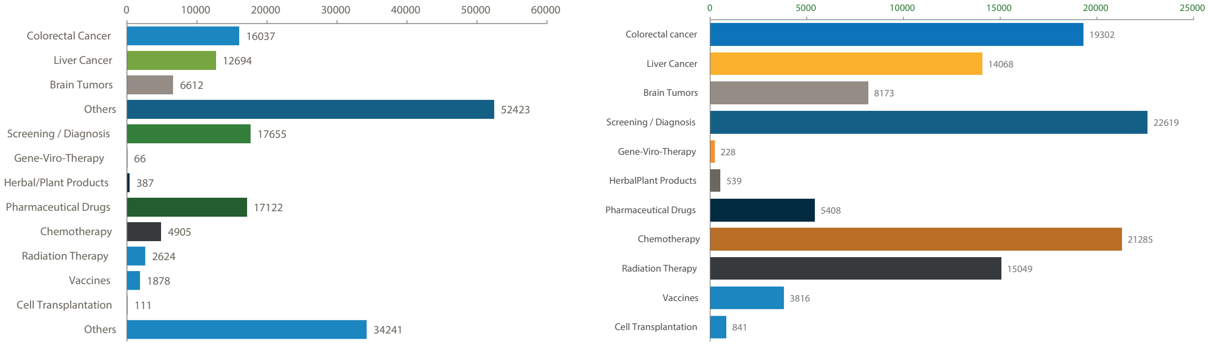

Figure 12 – Number of Patents Families (left) and Scientific Papers (right) per Topic in Non-Communicable Diseases

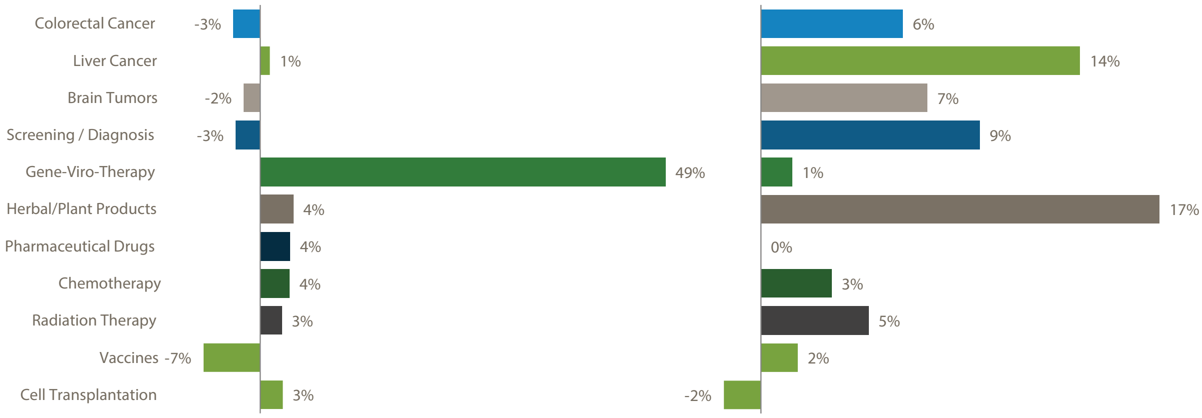

Figure 13 – Average Annual % Growth or Decline in Patent Family (left) or Scientific Paper (right) Output

The field of technology focus sees a notable increase in patents in the area of Gene-viro therapy and cell transplantation followed by herbal/plant products. On the contrary vaccines topic experiences a decline in the patent collection. A considerable growth in the scientific paper publications is observed in the Herbal & Plant products sector followed by colorectal cancer and liver cancer. A substantial decline in the scientific publications is observed in Cell Transplantion.

Figures 14 through 16 show analysis on each of the data collections (patents, left; papers, right) concerning the nature and technology trends occurring within the Medical & Health technology. Pharmaceutical drugs and Diagnosis fields in different proportions are active in both the data sets with pharmaceutical drugs showing a greater presence in patent collection and diagnosis in scientific journals. Stem cell therapy and Transcutaneous Electrical Nerve Stimulation are other active fields in fundamental research.

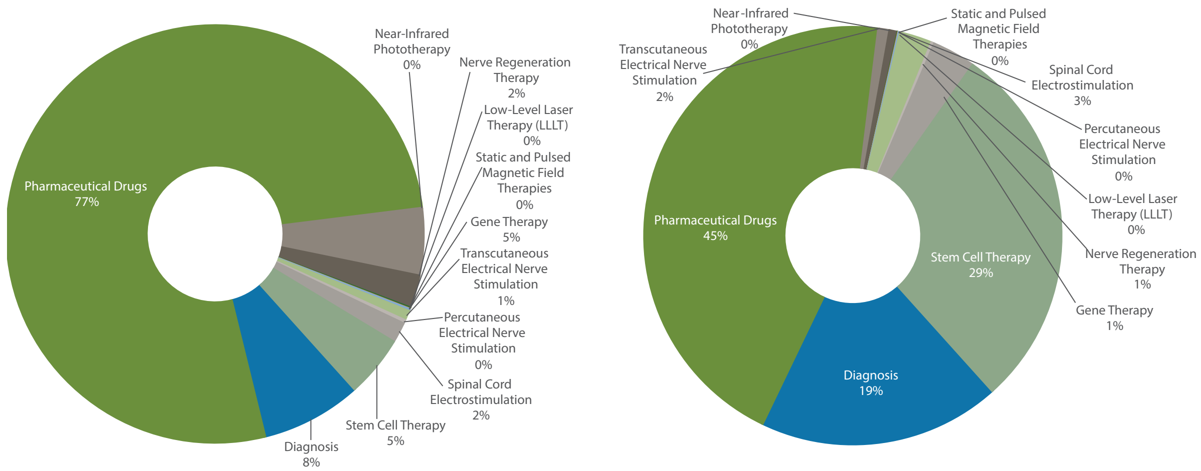

Figure 14– % of Patent (left) and Scientific Paper (right) Collections by Various Topics in Medical & Health Technology

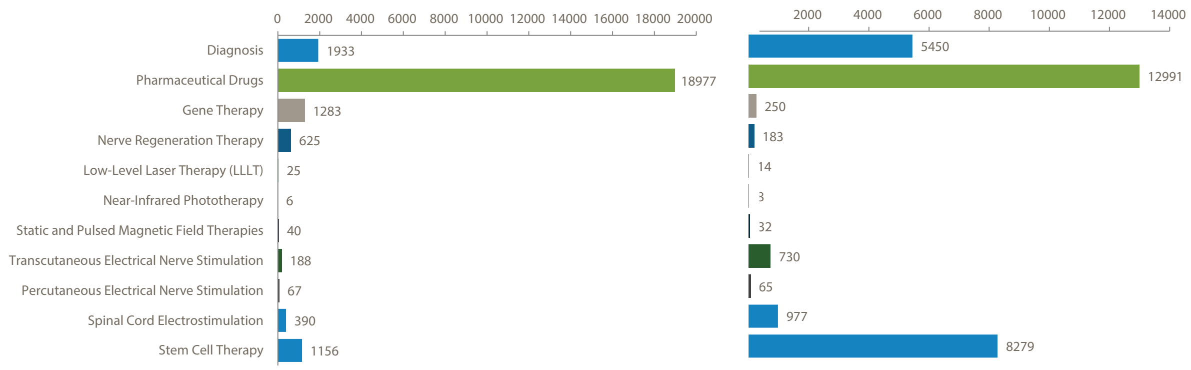

Figure 15 – Number of Patents Families (left) and Scientific Papers (right) per Topic in Medical & Health Technology

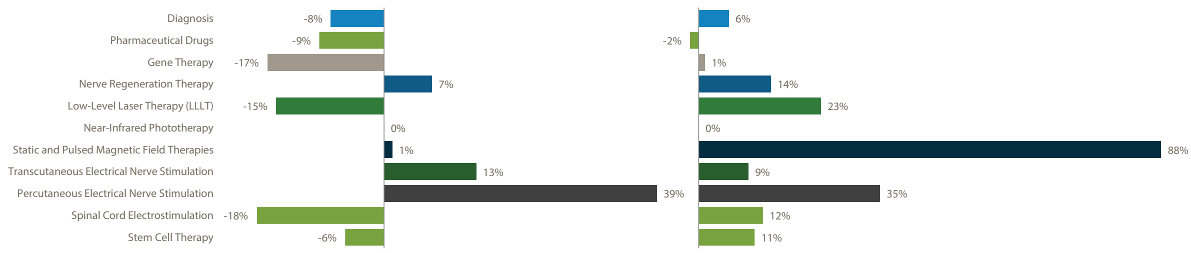

Figure 16 – Average Annual % Growth or Decline in Patent Family (left) or Scientific Paper (right) Output

The field of technology focus sees a notable increase in pharmaceutical drugs and a decline is observed in Gene therapy and Spinal Cord Electrostimulation. Static and Pulsed Magnetic Field Therapies show a considerable increase in the scientific publication area, whereas on the other hand decline in Pharmaceutical Drugs is observed in the scientific publication area.

Figures 17 through 19 show analysis on each of the data collections (patents, left; papers, right) concerning the nature and technology trends occurring within the Ectopic pregnancy segment. Ectopic pregnancy is highly active in both data sets, however the Infertility topic has more focus on the fundamental research than commercialization.

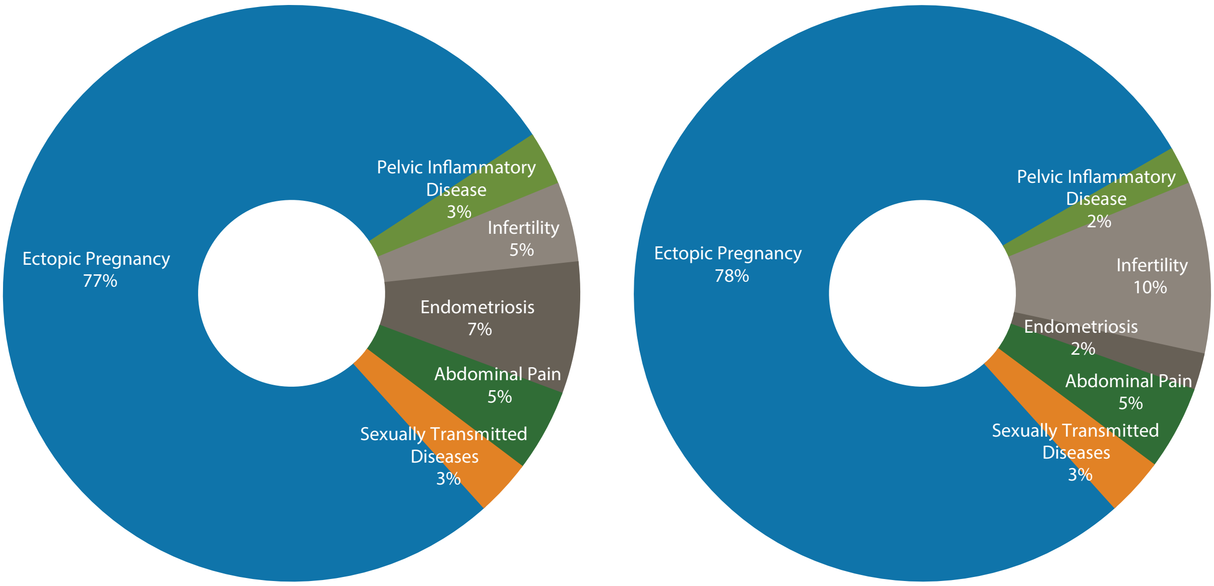

Figure 17 – % of Patent (left) and Scientific Paper (right) Collections by Various Topics in Ectopic pregnancy

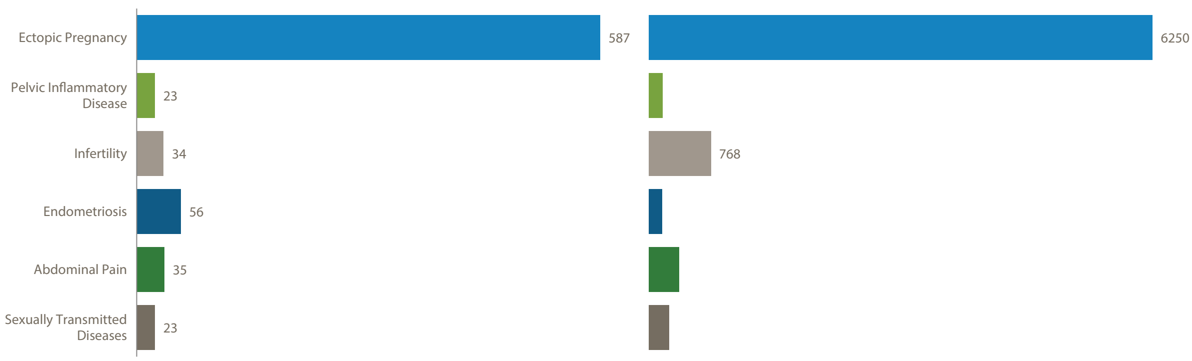

Figure 18 – Number of Patents Families (left) and Scientific Papers (right) per Topic in Ectopic pregnancy

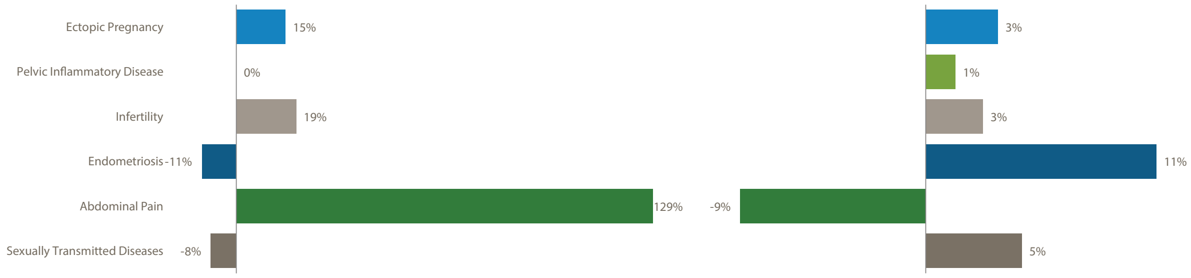

Figure 19 – Average Annual % Growth or Decline in Patent Family (left) or Scientific Paper (right) Output

Ectopic pregnancy shows a moderate growth in patenting activity as well as in fundamental research arena, whereas Pelvic inflammatory disease shows no growth in patent activity and a minor growth in fundamental research. Infertility topic shows significant growth in Technology focus (patent) as compared to the Fundamental research (Scientific papers). In spite of the decline in fundamental research area in Abdominal Pain, there is a considerable rise in it in the Patenting activity. Endometriosis and Sexually transmitted diseases appear to have declining trend in technology focus but have moderate growth in fundamental research,

Figures 20 through 22 show analysis on each of the data collections (patents, left; papers, right) concerning the nature and technology trends occurring within the Reproductive Endocrinology segment. Fertility medications is considerably active in both data sets, however the intrauterine insemination topic has more focus on commercialization than fundamental research. In Vitro Fertilization, Inhibin and Intra-Cytoplasmic Sperm Injection are more active fields in fundamental research.

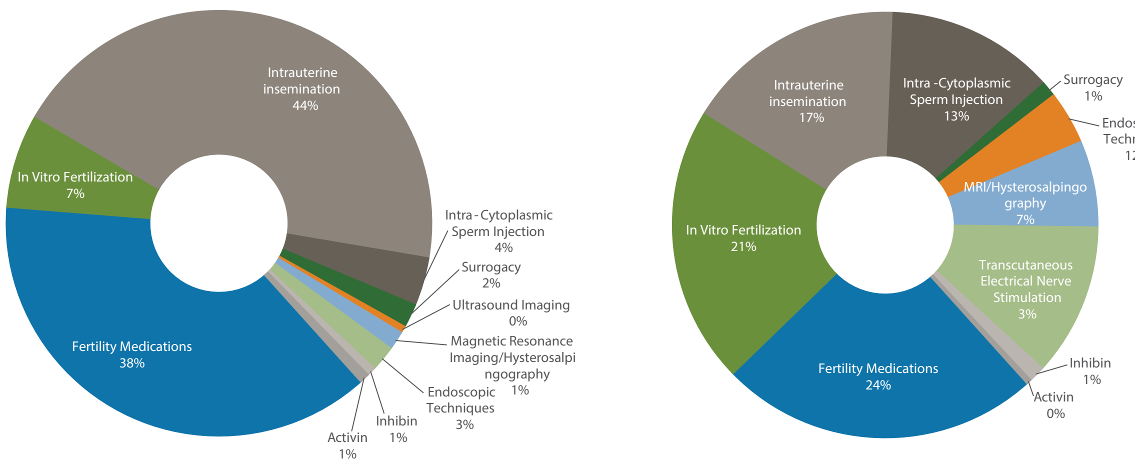

Figure 20 – % of Patent (left) and Scientific Paper (right) Collections by Various Topics in Reproductive Endocrinology

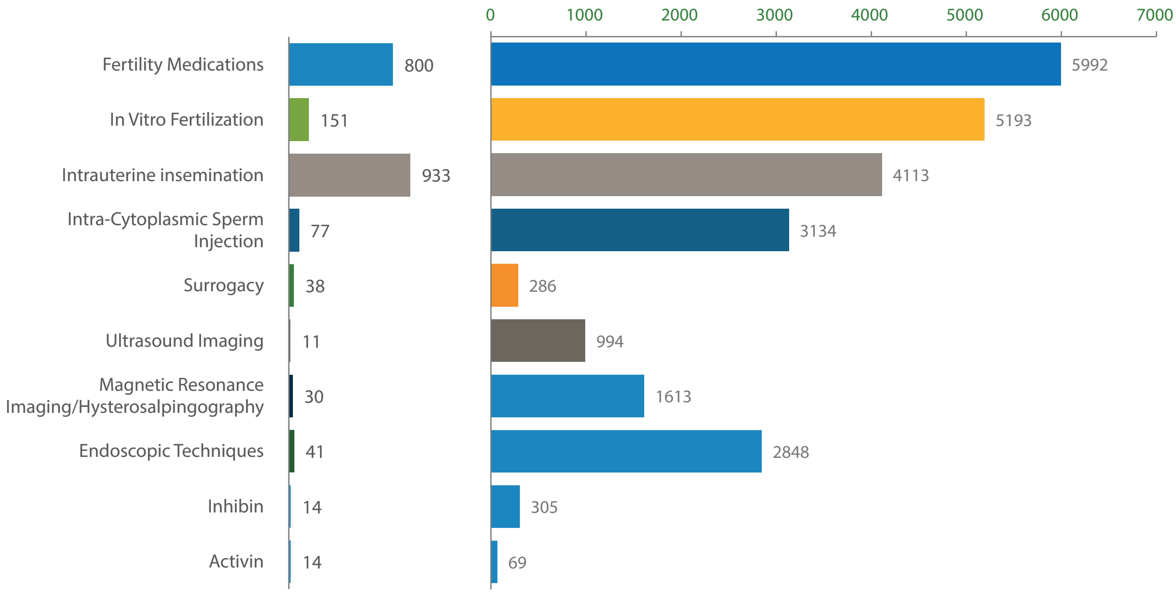

Figure 21 – Number of Patents Families (left) and Scientific Papers (right) per Topic in Reproductive Endocrinology

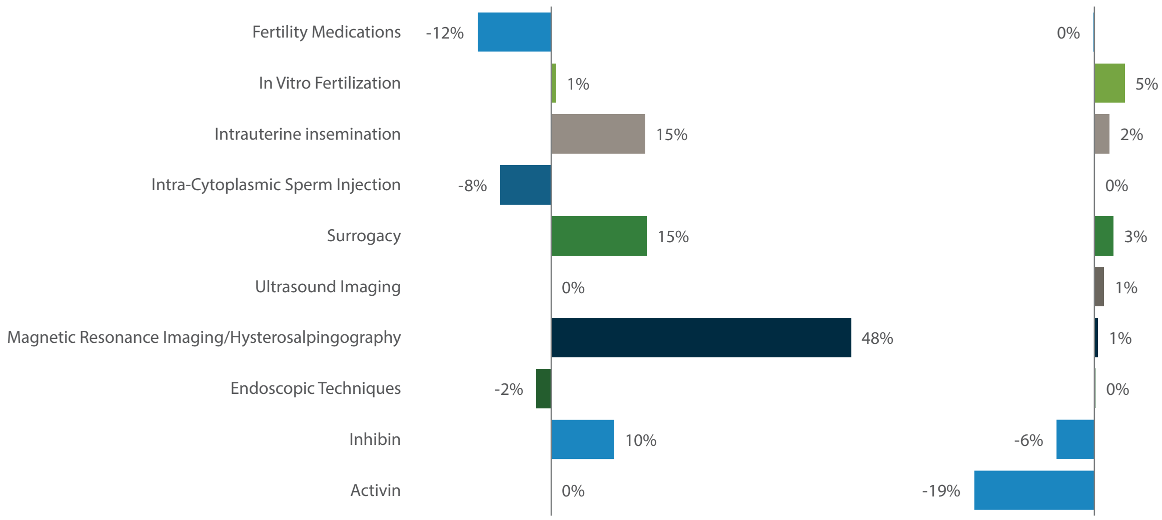

Figure 22 – Average Annual % Growth or Decline in Patent Family (left) or Scientific Paper (right) Output

Fertility medications field shows a considerable decline in both technology commercialization and fundamental research. In-vitro fertilization shows an increase in both technology commercialization and fundamental research. A notable increase in the annual growth is observed for Intrauterine insemination and Magnetic Resonance Imaging/Hysterosalpingography in technology commercialization.

ADVANCED MEDICAL AND HEALTH RESEARCH SCIENTIFIC LITERATURE TECHNOLOGY TRENDS

This section of the report focuses on the scientific paper collection and the activity and technological trends seen within it. Based on the Thomson Reuters-produced Web of Science database, the collection only includes papers published in pre-selected journals of influence.
In total, over 250,000 peer reviewed papers were incorporated into the Advanced Medical and Health Research collection.

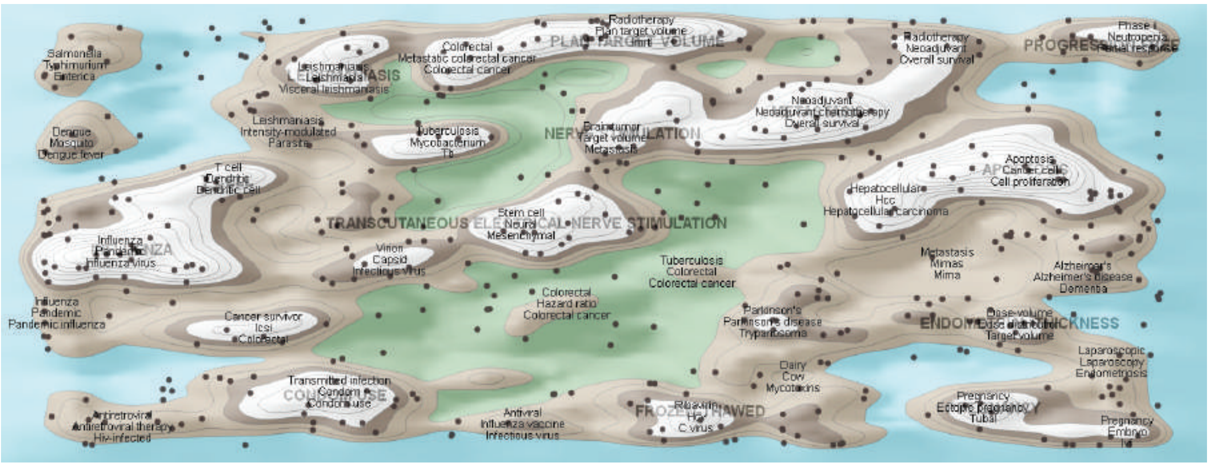

Figure 23 – ThemeScape Map of Scientific Paper Collection; Annotated by Major Themes

Key themes present throughout this collection of papers are illustrated in Figure 23 as a "ThemeScape map" - a visualization method for understanding the common themes and concepts within thousands of documents. Used for market analysis, government intelligence and primarily technology landscapes, the algorithm parses large amounts of text into a topological map of peaks and troughs.
Themes that are commonly shared between documents are represented by mountainous peaks, whereas documents that share little commonality are located within the valleys of the map. The large number of documents in this map means that there are rather few valleys to be found.
The location of an individual document is the vector sum of all the attractions to other documents in the collection based on shared phraseology and the frequency and proximity of these terms.
This map has been manually annotated to summarize the major technology areas within the scientific literature collection. Some technologies will necessarily overlap, and the delineation of one technical area versus another is therefore only approximate. However the map is very useful in describing what topics are common features of global Advanced Medical and Health Research.
Key themes revealed in this Themescape map are Communicable Diseases, Non-Communicable Diseases, Neurodegenerative Diseases, and Ectopic Diseases.

ThemeScape® is a text-mining application that acquires and analyzes free text. The algorithms it uses require no application of thesauri or other outside sources of information, and only the free text itself is used by this text-mining tool. The more text the application acquires, the more likely it will be that the output will provide an accurate summary of the major themes present. After analyzing the text in multiple documents, it pulls together those documents that share related text and pulls apart those with less related text. The outcome 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 pick out topics of interest. It aggregates word forms that share a common stem, but it does not directly aggregate synonyms. Instead, synonyms may be gathered under a common theme because of the other words that co-occur with those synonyms. Thus, "battery" and "cell" may be clustered together because of the co-occurrence in the same documents of terms like "electrode, rechargeable, electrolyte" and so on. Conversely, "battery" and "cell" may be separated if the map contains a mixture of documents on metals and biology, where the two terms have different meanings. In other words, terms are identified as synonyms only by co-clustering based on common context.

The topographical maps presented by ThemeScape are mathematical solutions built on a random selection of a first document and sequential calculation of the relationships of all the other documents. The orientation of the map is random, and the directions up, down, left, or right have no significance, because the n-dimensional solution might have been presented from any angle. Only the proximity of points within the map has meaning, and co-localized documents are highly likely to share concepts.

In this report there are separate ThemeScape maps covering scholarly papers or patents. The two types of documents are not pooled and analyzed together. This is because ThemeScape is context-sensitive, and it would separate patent and literature documents from one another based on the very different formal styles of writing that are reflected in these two types of content. Likewise, if documents in two languages are pooled, it will separate them based on the language, and then each language region will be clustered based on term frequency in that language.

The ThemeScape maps in this report analyze large numbers of documents. The contour lines on the maps diminish in circumference, encircling regions of higher and higher concentration. The density is also shown by the map coloration. White snow-capped peaks represent the highest density, while blue expanses (sea level) indicate low density.

The labels in black on the map are selected by ThemeScape based on term frequency in that map region, and they may have been adjusted by the analyst. The large color-overlay regions enclosed by broken lines have been added by the analyst to identify content at an even higher level of abstraction. The dots on the map represent single documents. Dots are not shown for all the documents, and instead represent a sampling that allows the other features of the map to be discerned. Within the ThemeScape application, the map can be magnified, searched, probed and highlighted to learn more about its contents.

ThemeScape is reliant on statistical methods that are not equivalent to reading by human judges, and in compensation, it analyzes millions of documents on a scale of minutes and quickly presents an intuitive, high level summary. It enables and guides further review, and provides a first level overview of very complex datasets.

SCIENTIFIC LITERATURE COLLECTION TECHNOLOGY SEGMENTATION

Table 1 shows activity for scientific paper collection by various technology segments in Communicable diseases, Non-Communicable diseases, Medical & health Technology, Ectopic pregnancy and Reproductive Endocrinology areas. A number of research opportunities exist – technology areas with relatively low volumes but high growth rates. These include fungal infections, herbal plant products for non-communicable diseases (cancer); low level laser therapy (LLLT), transcutaneous and percutaneous electrical nerve simulation in medical and health technology; endometriosis in ectopic pregnancy; and surrogacy in reproductive medicine. One noteworthy area is food borne diseases: although having moderate volumes, has a staggering 90% growth rate – indicating a very active research area.

Table 1 – Scientific Literature Technology Segmentation (continued on next page)

Technology Segmentation		Total Publications	Average % Growth or Decline ('09-'14)
1 Communicable Diseases	Bacterial Infections	5716	1%
	Viral infections	15437	-1%
	Fungal Infections	2137	1%
	Protozoan Infections	538	-7%
	Hepatitis	9124	7%
	HIV AIDS	17630	17%
	Pandemic Influenza	9236	4%
	Parasites	8593	13%
	Sexually Transmitted Infections	5767	4%
	Skin Diseases	4547	-2%
	Tuberculosis	8787	2%
	Food Borne Diseases	8692	90%
	Animal or Insect Borne Diseases	23297	4%
	Treatment	7137	-
	Diagnosis	3460	3%
2 Non-communicable Diseases (Cancer)	Colorectal cancer	19302	6%
	Liver Cancer	14068	14%
	Brain Tumors	8173	7%
	Screening / Diagnosis	22619	9%
	Gene-Viro-Therapy	228	1%
	HerbalPlant Products	539	17%
	Pharmaceutical Drugs	5408	-
	Chemotherapy	21285	3%
	Radiation Therapy	15049	5%
	Vaccines	3816	2%
	Cell Transplantation	841	-2%

Technology Segmentation		Total Publications	Average % Growth or Decline ('09-'14)
3 Medical & Health Technology	Diagnosis	5450	6%
	Pharmaceutical Drugs	12991	-2%
	Gene Therapy	250	1%
	Nerve Regeneration Therapy	183	14%
	Low-Level Laser Therapy (LLLT)	14	23%
	Near-Infrared Phototherapy	8	-
	Static and Pulsed Magnetic Field Therapies	32	88%
	Transcutaneous Electrical Nerve Stimulation	730	9%
	Percutaneous Electrical Nerve Stimulation	65	35%
	Spinal Cord Electrostimulation	977	12%
	Stem Cell Therapy	8279	11%
4 Ectopic Pregnancy	Ectopic Pregnancy	6250	3%
	Pelvic Inflammatory Disease	170	1%
	Infertility	768	3%
	Endometriosis	164	11%
	Abdominal Pain	376	-9%
	Sexually Transmitted Diseases	251	5%
5 Reproductive Medicine	Fertility Medications	5992	0%
	In Vitro Fertilization	5193	5%
	Intrauterine insemination	4113	2%
	Intra-Cytoplasmic Sperm Injection	3134	-
	Surrogacy	286	3%
	Ultrasound Imaging	994	1%
	Magnetic Resonance Imaging/Hysterosalpingography	1613	1%
	Endoscopic Techniques	2848	0%
	Inhibin	305	-6%
	Activin	69	-19%

SCIENTIFIC LITERATURE COLLECTION TECHNOLOGY CATEGORY OVERLAP

The technology segments, that were created to enumerate and describe the Advanced Medical And Health Research landscape in the areas of Communicable diseases, Non-communicable diseases, Medical & health technology, Ectopic pregnancy and Reproductive endocrinology. A single scientific paper can be included in multiple categories or segments.
Figure 24 visualizes the relationship between the five broad technology segments used in this study. Each number in the diagram shows the number of papers that have content related to both the corresponding row-wise and column-wise segments.
The most correlated segment pairing is Medical and Health Technology with Non-communicable diseases (Cancer).

	1 Communicable Diseases	2 Non-communicable Diseases (Cancer)	3 Medical & Health Technology	4 Ectopic Pregnancy	5 Reproductive Medicine
1.0 Communicable Diseases	114266	330	150	94	131
2.0 Non-communicable Diseases (Cancer)		95976	5843	63	389
3.0 Medical & Health Technology			28593	10	125
4.0 Ectopic Pregnancy				6258	947
5.0 Reproductive Medicine					21186

Figure 24 – Number of Scientific Papers per Pair of Technology Segments

SCIENTIFIC PAPER GEOGRAPHIC VOLUME BENCHMARKING

Figure 25 shows the number of scientific papers for the ten most prolific countries within the scientific paper collection.
United Sates is the largest source of Communicable diseases, Non-communicable diseases, Medical & health technology, Ectopic pregnancy and Reproductive endocrinology -related peer-reviewed papers, followed by the China, United Kingdom, Germany and France. These 10 most prolific countries contribute to about 66% of the scientific publications in the field of Communicable diseases, Non-communicable diseases, Medical & health technology, Ectopic pregnancy and Reproductive endocrinology.

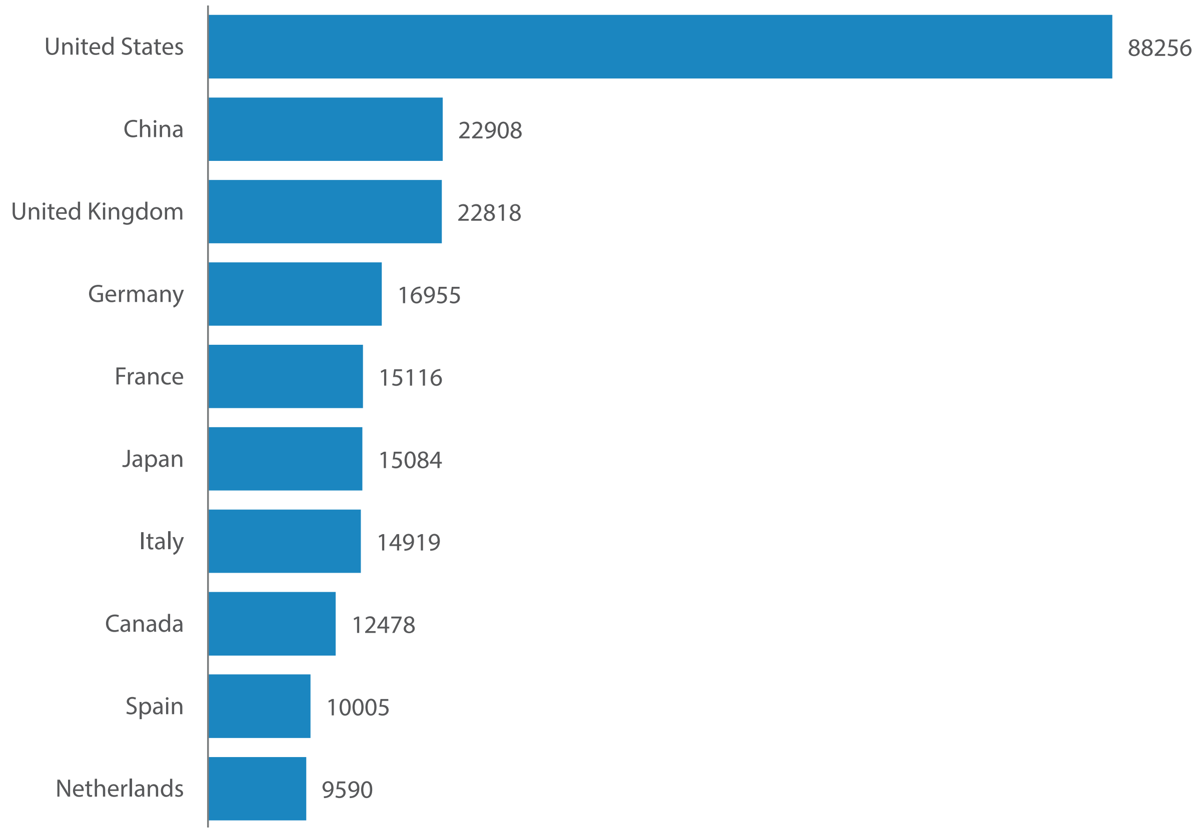

Figure 25 – Number of Scientific Papers per Country; Top 10 Sources

SCIENTIFIC PAPER GEOGRAPHIC ACTIVITY TRENDS

The chart below shows the highest grow rates sources in the scientific literature collection.

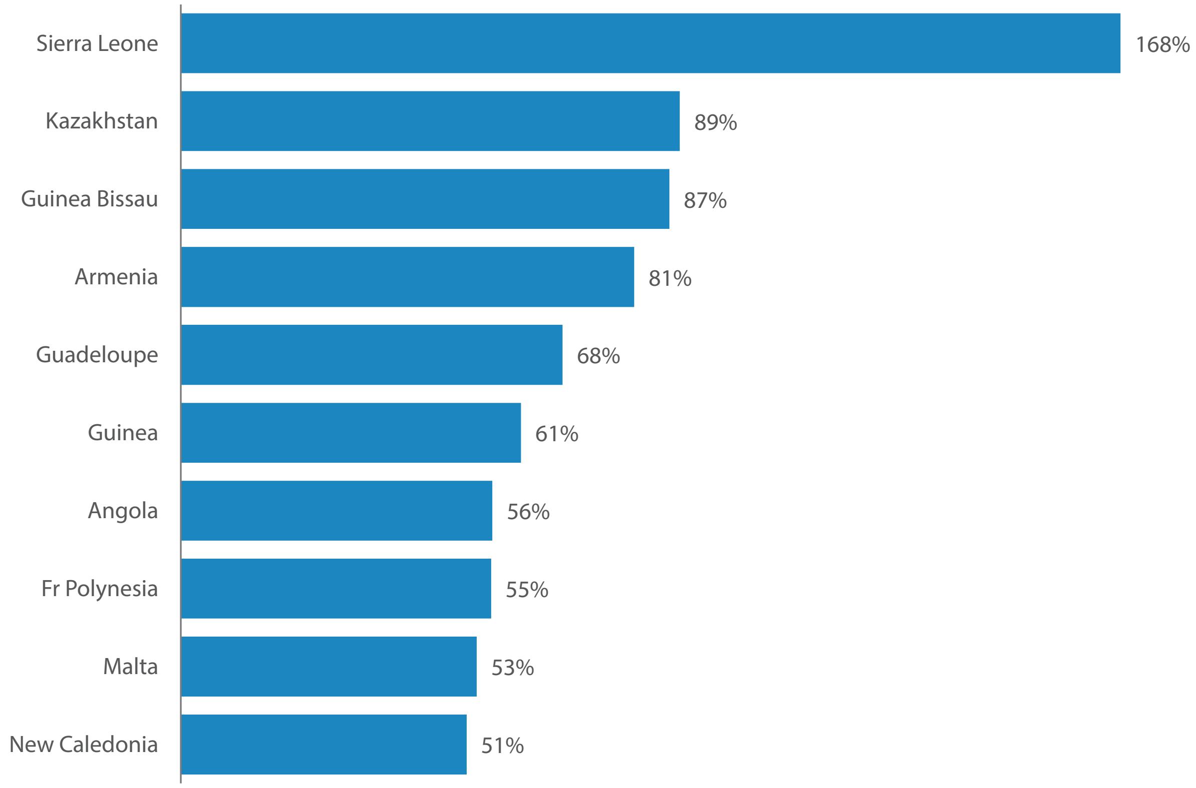

Figure 26 – Highest Growth Rate Geographies in Scientific Publications Output

While the average number of scientific literature publication from Armenia, Fr Polynesia, Malta and New Caledonia is about 23.6 which is very less relative to the collections of the most prolific countries, the growth rate of Armenia, Fr Polynesia, Malta and New Caledonia collection far exceeds that of other countries.

SCIENTIFIC PAPER GEOGRAPHIC CITATION IMPACT BENCHMARKING

Scientific paper and patent citations are routinely used in technology bibliometrics for assessing the inherent impact and potential quality of research and the downstream technical and scientific relevance of the underlying research.
Figure 27 shows the "Citation Impact", the average citation per paper for all papers in a country's collection (which are having at least 500 publications) and has been sorted by highest citation impact. This shows that output from Switzerland, Belgium, Netherlands and Finland are having the highest impact in the field of Communicable diseases, Non-communicable diseases, Medical & health technology, Ectopic pregnancy and Reproductive endocrinology.

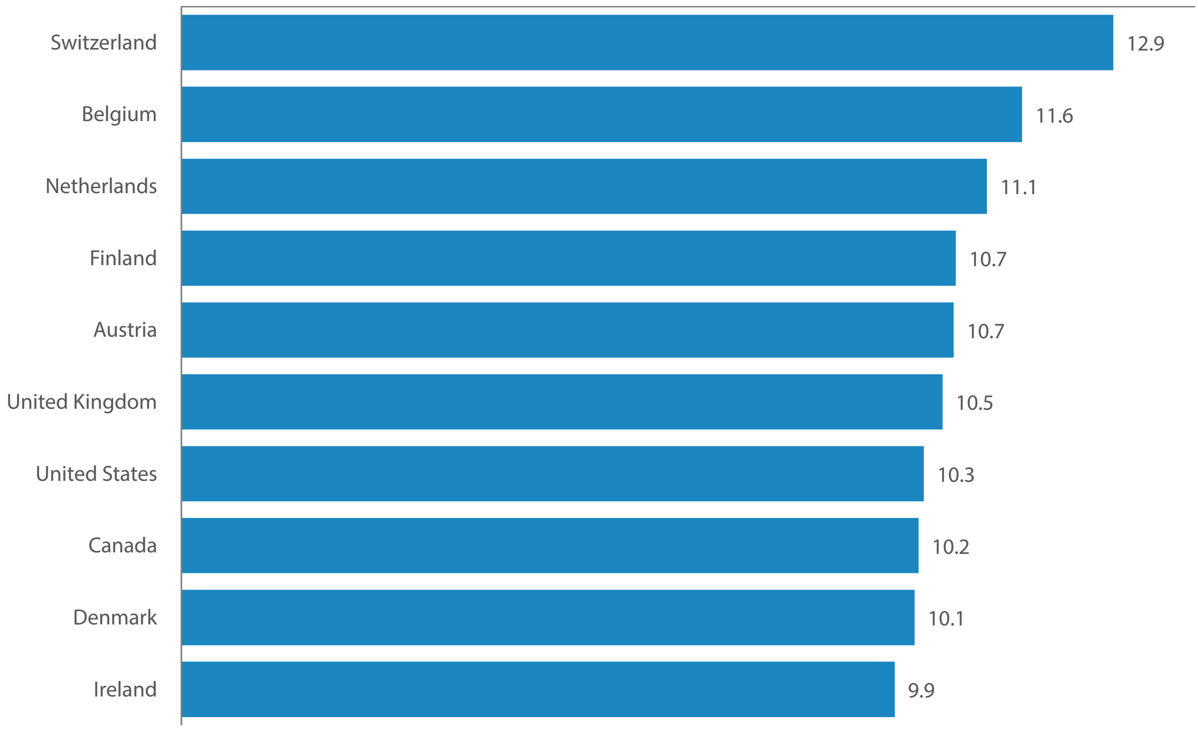

Figure 27 – Highest Citation Impact Geographies of Scientific Publications

Note that the journals included in the project source data (Web of Science) are selected on the basis of both quantitative and qualitative selection criteria, such as editorial quality, peer review robustness and citation impact. Further details of the journal selection process is available from : http://thomsonreuters.com/products_services/science/free/essays/journal_selection_process/

SCIENTIFIC LITERATURE COLLECTION BY GEOGRAPHY

Table 2 shows the split of Communicable diseases, Non-communicable diseases, Medical & health technology, Ectopic pregnancy and Reproductive endocrinology and research specialization for the top nations. Most of the prolific entities appear to focus on Communicable diseases and Non-communicable diseases, with exception of developing countries like Brazil, South Africa, Iran, Argentina, Kenya and Uganda have major focus on Communicable diseases. Turkey and Egypt seem to have focus on Reproductive medicine along with Communicable diseases and Non-communicable diseases. Ectopic pregnancy seems to be the technology area having least publication activity.

Country of Origin	1.0 Communicable Diseases	2.0 Non-communicable Diseases (Cancer)	3.0 Medical & Health Technology	4.0 Ectopic Pregnancy	5.0 Reproductive Medicine
United States	46%	37%	12%	2%	7%
China	32%	52%	12%	2%	5%
United Kingdom	54%	28%	10%	3%	7%
Germany	36%	45%	14%	1%	7%
France	47%	37%	10%	2%	8%
Japan	27%	55%	12%	2%	8%
Italy	34%	43%	14%	2%	10%
Canada	43%	40%	12%	2%	7%
Spain	50%	30%	12%	2%	9%
Netherlands	42%	41%	10%	2%	8%
Australia	50%	32%	10%	3%	8%
Brazil	72%	11%	6%	2%	11%
South Korea	28%	55%	13%	2%	6%
India	64%	22%	6%	2%	8%
Switzerland	56%	31%	9%	1%	5%
Belgium	44%	37%	8%	2%	12%
Sweden	40%	38%	15%	2%	7%
Turkey	36%	34%	9%	6%	19%
Taiwan	40%	45%	11%	2%	6%
Denmark	43%	40%	8%	2%	9%
South Africa	90%	5%	1%	1%	4%
Iran	53%	19%	10%	4%	16%
Austria	33%	45%	13%	3%	9%
Greece	33%	44%	9%	4%	13%
Thailand	77%	14%	3%	1%	5%
Poland	37%	38%	11%	4%	13%
Israel	33%	36%	16%	5%	15%
Norway	40%	44%	10%	3%	6%
Argentina	71%	11%	7%	2%	10%
Singapore	46%	39%	14%	2%	3%
Finland	37%	42%	11%	3%	10%
Mexico	69%	15%	7%	2%	8%
Egypt	47%	27%	5%	4%	21%
Portugal	56%	23%	13%	2%	9%
Ireland	45%	31%	13%	3%	10%
Kenya	96%	2%	0%	0%	1%

SCIENTIFIC LITERATURE - PROLIFIC GLOBAL ENTITIES

The top 30 entities in the advanced medical and health research are very active, each having more than a thousand papers to their credit. The area also appears to be one with a higher number of citations across the board. Science & Technology Unit, Umm Al Qura University (STU-UQU) has 25 papers in the field, with low peer citations.

Entity	Total	Times Cited	Citation per paper
Science & Technology Unit, Umm Al Qura University (STU-UQU)	25	22	0.9
Harvard Univ	5126	75334	14.7
Univ Calif	5010	69096	13.8
Univ Texas Md Anderson Canc Ctr	3489	49782	14.3
Ctr Dis Control & Prevent	3042	44569	14.7
Univ Toronto	2652	29173	11.0
Univ Washington	2652	32609	12.3
Johns Hopkins Univ	2643	33631	12.7
Nci	2593	45017	17.4
Mem Sloan Kettering Canc Ctr	2220	34220	15.4
Duke Univ	2189	31219	14.3
Univ Pittsburgh	2106	29957	14.2
Univ N Carolina	2103	26163	12.4
Emory Univ	2046	26736	13.1
Mayo Clin	1974	30646	15.5
Univ Penn	1954	23946	12.3
Univ Sao Paulo	1898	10220	5.4
Karolinska Inst	1871	17226	9.2
Univ London Imperial Coll Sci Technol & Med	1861	21691	11.7
Inserm	1794	19460	10.8
Massachusetts Gen Hosp	1755	25600	14.6
Univ Oxford	1738	24424	14.1
Univ Michigan	1702	25230	14.8
Stanford Univ	1653	21288	12.9
Ucl	1637	21800	13.3
Mcgill Univ	1600	17167	10.7
Univ Melbourne	1577	16092	10.2
Yale Univ	1573	17505	11.1
Niaid	1557	20712	13.3
Natl Canc Ctr	1526	12347	8.1
Columbia Univ	1514	17982	11.9

Table 3 – Advanced Medical & Health Research – Top Global entities for Scientific Literature

SCIENTIFIC LITERATURE OVERVIEW OF TOP GLOBAL ENTITIES

Table 4 shows the technology profile of the top 30 entities within the scientific literature space of advanced medical and health research. HIV/AIDs, and non-communicable diseases (Cancer) appear to be the major focus areas for research and scientific paper publications among the top entities in the field. Other areas of interest include viral infections, animal or insect borne diseases (in communicable diseases), and stem cell research (in medical and health technology). Science & Technology Unit, Umm al Qura University (STU-UQU) has publications primarily in communicable diseases; Colorectal cancer (non-communicable diseases); ectopic pregnancy, in-vitro fertilization, and intra-cytoplasmic sperm injection.

Table 4 – Scientific literature overview of top Global entities (continued over next pages)

Entity	1.01.01 Bacterial Infections	1.01.02 viral infections	1.01.03 Fungal Infections	1.01.04 Protozoan Infections	1.01.05 Hepatitis	1.01.06 HIV AIDS	1.01.07 Pandemic Influenza	1.01.08 Parasites	1.01.09 Sexually Transmitted Infections	1.01.10 Skin Diseases	1.01.11 Tuberculosis	1.01.12 Food Borne Diseases	1.01.13 Animal or Insect Borne Diseases	1.02 Treatment	1.03 Diagnosis
Science & Technology Unit, Umm Al Qura University (STU-UQU)	1						2	1	1			1	5	1	
Harvard Univ	95	245	28	5	161	1020	153	119	103	66	238	215	135	144	47
Univ Calif	67	199	35	5	274	1230	49	150	231	107	148	78	129	170	61
Univ Texas Md Anderson Canc Ctr	13	26	24		20	16	5	3	6	38	8	12	11	61	11
Ctr Dis Control & Prevent	39	218	7	3	181	543	512	267	359	86	238	157	572	39	114
Univ Toronto	31	69	16		96	231	150	65	69	27	53	42	65	76	34
Univ Washington	48	162	14	4	80	709	106	114	227	47	64	49	96	80	30
Johns Hopkins Univ	32	132	11	4	150	691	66	82	193	55	212	54	72	84	45
Nci	10	122	7	1	52	202	9	22	14	35	16	26	14	32	17
Mem Sloan Kettering Canc Ctr	14	21	7	1	9	8	3	3	5	14	7	6	4	29	5
Duke Univ	35	78	36	1	61	305	37	43	36	74	60	26	66	73	15
Univ Pittsburgh	19	111	16	1	89	271	114	28	60	36	32	41	73	61	25
Univ N Carolina	26	144	6	5	53	508	28	76	147	30	67	54	40	81	28
Emory Univ	28	144	7	8	45	403	146	83	113	34	69	31	160	66	35
Mayo Clin	25	58	28	3	27	18	23	15	17	24	16	27	32	83	19
Univ Penn	36	107	12	3	67	242	29	40	25	30	45	42	97	89	27
Univ Sao Paulo	44	102	42	20	96	134	37	152	23	27	69	74	561	70	41
Karolinska Inst	24	69	4		37	192	34	95	34	35	86	35	71	65	20
Univ London Imperial Coll Sci Technol & Med	29	119	26	3	81	309	144	128	104	29	182	52	131	63	38
Inserm	45	130	14	5	136	261	78	51	16	33	57	40	53	79	17
Massachusetts Gen Hosp	26	39	5		49	300	13	17	18	12	50	35	32	39	12
Univ Oxford	54	113	9	4	51	203	99	280	33	15	69	44	162	51	24
Univ Michigan	39	72	19	2	33	49	76	21	31	34	27	33	44	53	20
Stanford Univ	24	83	11	1	43	128	46	31	23	25	39	29	37	54	17
Ucl	22	75	2		108	413	46	43	105	35	142	22	27	77	33
Mcgill Univ	17	76	6	4	51	205	58	85	16	34	123	42	73	44	18
Univ Melbourne	34	109	11	3	53	106	112	100	122	67	58	39	54	65	27
Yale Univ	33	83	5	1	70	222	38	45	35	25	68	40	82	52	23
Niaid	30	257	16	3	77	517	148	186	86	45	109	11	237	32	24
Natl Canc Ctr	3	14	1		11		3				2	11		9	2
Columbia Univ	25	68	4		59	415	44	27	89	22	82	33	60	59	10

Entity	2.01.01 colorectal cancer	2.01.02 Liver Cancer	2.01.03 Brain Tumors	2.02 Screening / Diagnosis	2.03.01 Gene-Viro-Therapy	2.03.02 Herbal Plant Products	2.03.03 Pharmaceutical Drugs	2.03.04 Chemotherapy	2.03.05 Radiation Therapy	2.03.06 Vaccines	2.03.07 Cell Trasnplantation
Science & Technology Unit, Umm Al Qura University (STU-UQU)	2			1							
Harvard Univ	312	178	239	632	5	7	146	323	262	66	20
Univ Calif	231	156	353	507	1	4	99	329	282	58	12
Univ Texas Md Anderson Canc Ctr	425	269	349	656	5	11	170	871	564	92	46
Ctr Dis Control & Prevent	38	7	5	122			10	6	4	27	
Univ Toronto	179	114	134	393	2	3	88	266	347	18	9
Univ Washington	99	46	68	337	1	5	54	181	95	56	22
Johns Hopkins Univ	106	111	123	164			60	152	92	67	5
Nci	301	211	179	719	5	2	120	249	117	190	15
Mem Sloan Kettering Canc Ctr	340	177	182	481	11	8	101	519	359	85	31
Duke Univ	172	64	229	177	3	1	62	301	204	57	11
Univ Pittsburgh	179	113	101	207	6	1	52	218	126	97	
Univ N Carolina	204	62	52	223	1	2	63	208	103	32	8
Emory Univ	71	60	83	201		2	34	141	147	15	12
Mayo Clin	330	95	106	243	17	2	67	274	183	35	9
Univ Penn	104	52	76	225	1	3	55	156	155	63	9
Univ Sao Paulo	48	28	22	56		2	10	48	24	7	4
Karolinska Inst	162	57	67	352	1	1	34	103	113	40	11
Univ London Imperial Coll Sci Technol & Med	119	56	26	114	1		20	79	16	17	3
Inserm	147	97	57	119	1	1	37	140	65	42	5
Massachusetts Gen Hosp	153	84	148	225	5		63	200	183	18	2
Univ Oxford	149	55	20	163	3		21	60	54	12	
Univ Michigan	117	91	71	258		3	57	195	232	24	5
Stanford Univ	68	89	112	257		2	55	115	211	29	4
Ucl	82	24	25	118			19	53	54	13	2
Mcgill Univ	114	49	46	177	1	1	29	98	78	20	1
Univ Melbourne	147	24	18	153			21	68	101	20	2
Yale Univ	67	37	69	190		3	36	165	107	18	5
Niaid	1	5		6			2	2			
Natl Canc Ctr	299	295	70	310	2	1	55	367	153	30	16
Columbia Univ	38	63	40	139	1	2	35	86	48	16	4

Entity	3.01.01 Diagnosis	3.01.02.01 Pharmaceutical Drugs	3.01.02.02 Gene Therapy	3.01.02.03 Nerve Regeneration Therapy	3.01.02.04 Low-Level Laser Therapy (LLLT)	3.01.02.05 Near-Infrared Phototherapy	3.01.02.06 Static and Pulsed Magnetic Field Therapies	3.01.02.07 Transcutaneous Electrical Nerve	3.01.02.08 Percutaneous Electrical Nerve
Science & Technology Unit, Umm Al Qura University (STU-UQU)									
Harvard Univ	100	300	7	3	1		2	8	
Univ Calif	164	279	15	2				3	
Univ Texas Md Anderson Canc Ctr	1	380	1					1	
Ctr Dis Control & Prevent	1	17							
Univ Toronto	84	188	3				1	3	
Univ Washington	63	118	1				1	2	
Johns Hopkins Univ	37	121		2				2	
Nci	1	332							
Mem Sloan Kettering Canc Ctr		209	1						
Duke Univ	31	157	5					1	2
Univ Pittsburgh	51	142	2	1				10	1
Univ N Carolina	30	113	4					2	
Emory Univ	26	86	6	1					
Mayo Clin	173	113	2	1				1	1
Univ Penn	126	113	2	1				1	
Univ Sao Paulo	33	33		2			2	18	1
Karolinska Inst	95	94	8					3	1
Univ London Imperial Coll Sci Technol & Med	45	51	1					2	
Inserm	57	82						3	
Massachusetts Gen Hosp	46	117	4		1			1	
Univ Oxford	48	60	1					4	
Univ Michigan	26	106	4				1	3	
Stanford Univ	33	85	3	1		1		2	
Ucl	122	55	2	1			1		1
Mcgill Univ	68	73	1	1				5	
Univ Melbourne	52	39	1					5	
Yale Univ	12	83	1					1	
Niaid		4							
Natl Canc Ctr	8	137						1	
Columbia Univ	56	70		1				3	1

Entity	4.01.01.01 Ectopic Pregnancy	4.01.02.01 Pelvic Inflammatory Disease	4.01.02.02 Infertility	4.01.02.03 Endometriosis	4.01.02.04 Abdominal Pain	4.01.02.05 Sexually Transmitted Diseases	5.01.01.01 Fertility Medications	5.01.01.02 In Vitro Fertilization	5.01.01.03 Intrauterine insemination	5.01.01.04 Intra-Cytoplasmic Sperm Injection	5.01.01.05 Surrogacy	5.01.02.01 Ultrasound Imaging	5.01.02.02 Magnetic Resonance Imaging/Hysterosalpi	5.01.02.03 Endoscopic Techniques	5.01.02.04 Inhibin	5.01.02.05 Activin
Science & Technology Unit, Umm Al Qura University (STU-UQU)	5	1	1					5		3		1		1		
Harvard Univ	77		9		5	2	100	104	27	31	4	13	25	30	6	
Univ Calif	73	1	15	2	2	5	118	80	17	28	6	6	22	20	3	
Univ Texas Md Anderson Canc Ctr	9		2	1	1		90	2		2	2	4	16	14		1
Ctr Dis Control & Prevent	25	10	8			13	9	21	4	7				1	1	
Univ Toronto	39		8		1	2	90	37	12	26	2	6	17	7	2	
Univ Washington	26	1	2	1	1	2	26	12	2	4	3	5	13	8	1	
Johns Hopkins Univ	18	2	4		3	4	60	16	1	3	3	5	5	4		
Nci	5		1		1		44	8			1	1	1	4		
Mem Sloan Kettering Canc Ctr	11		2	1		1	50	5		1		3	16	12	1	
Duke Univ	40	1	9		3	3	40	8	1	3		3	8	13		
Univ Pittsburgh	49	14	19	2	3	11	80	14		6			4	5		
Univ N Carolina	34	1	4	1	1	2	36	18		2	3		4	14	4	
Emory Univ	13	3	2		1	6	25	21	1	9	1		5	7		
Mayo Clin	21		2	1	2		95	13	6	2	3	5	12	22		
Univ Penn	78	2	17	4	4	4	60	33	13	20	1	3	9	7	5	
Univ Sao Paulo	37	1	2			5	23	47	101	23	1	13	8	26	7	1
Karolinska Inst	27	2	3	2		2	32	35	5	7	2	3	5	5	3	
Univ London Imperial Coll Sci Technol & Med	58		1	2	1	4	47	12	2	4	1	13	7	7	1	
Inserm	34	1	7	1	2		25	41	8	29	1	5	6	19	2	
Massachusetts Gen Hosp	17				1		59	17	5	4		9	6	10	2	1
Univ Oxford	13			1	1	1	25	27	8	22	2	1	4	9		
Univ Michigan	27		9		1	1	81	34	8	13	1	1	7	9	6	1
Stanford Univ	44	2	14	1	3		35	47	4	13	1	5	7	26	2	
Ucl	12	2	2			3	16	23	3	20	2	1	3	2	1	
Mcgill Univ	30		6	1		1	28	89	26	43	1	2	14	19	1	
Univ Melbourne	42	3	5			5	27	29	7	15	2	2	5	9	1	
Yale Univ	50	1	19	6	1	2	54	85	12	16		5	9	19	2	
Niaid							1	2								
Natl Canc Ctr	3				1		10						10	4		
Columbia Univ	32		2				39	26	5	8	2	5	7	12	7	

SCIENTIFIC LITERATURE OVERVIEW OF TOP ASIA PACIFIC ENTITIES

Table 5 – Scientific literature overview of top Asia Pacific entities (continued over next pages)

Entity	Country of Origin	Total	1.01.01 Bacterial Infections	1.01.02 Viral Infections	1.01.03 Fungal Infections	1.01.04 Protozoan Infections	1.01.05 Hepatitis	1.01.06 Hiv Aids	1.01.07 Pandemic Influenza	1.01.08 Parasites	1.01.09 Sexually Transmitted Infections	1.01.10 Skin Diseases	1.01.11 Tuberculosis	1.01.12 Food Borne Diseases	1.01.13 Animal Or Insect Borne Diseases	1.02 Treatment	1.03 Diagnosis	2.01.01 Colorectal Cancer	2.01.02 Liver Cancer
Science & Technology Unit, Umm Al Qura University (Stu-Uqu)	Saudi Arabia	25	1						2	1	1			1	5	1		2	
Fudan Univ	China	1500	12	37	2		38	37	26	10	11	12	64	5	82	10	6	161	436
Sun Yat Sen Univ	China	1378	12	69	4		41	11	23	7	13	8	14	17	36	11	5	157	343
Natl Taiwan Univ Hosp	Taiwan	1226	16	91	8	3	85	56	70	16	23	47	120	23	75	29	21	59	244
Seoul Natl Univ	South Korea	1219	13	43	11		19	7	23	5	8	14	47	56	67	32	7	108	142
Shanghai Jiao Tong Univ	China	1064	10	24	3		28	9	8	3	8	11	15	18	25	29	2	160	229
Univ Hong Kong	China	1060	11	67	7		32	28	234	1	5	12	23	13	132	14	5	67	175
Univ Tokyo	Japan	1055	23	79	3	1	26	29	88	14	8	14	9	28	122	23	6	134	115
Mahidol Univ	Thailand	1018	28	79	8	1	42	172	52	238	14	18	74	14	177	24	35	16	23
Chinese Acad Sci	China	940	17	144	9	2	15	31	74	7	3	5	7	20	208	20	5	51	74
Zhejiang Univ	China	925	12	63	11	2	28	5	21	2	4	14	19	28	66	20	10	115	177
Osaka Univ	Japan	915	26	63	3		22	26	39	9	4	6	11	12	48	17	4	124	101
China Med Univ	China	906	5	24	2		31	45	37	7	24	19	22	9	15	15	6	74	184
Yonsei Univ	South Korea	899	6	17	5		31	20	30	4	4	15	59	7	32	22	5	128	145
Sungkyunkwan Univ	South Korea	848	3	21	5		9	2	12	3	2	12	39	15	7	18	4	129	116
Chinese Acad Med Sci	China	804	4	24	2		31	35	34	9	43	13	17	9	41	24	6	75	107
Natl Univ Singapore	Singapore	742	16	58	3		16	11	77	25	13	10	18	24	44	15	12	60	83
Chinese Univ Hong Kong	China	732	11	29	1		46	18	74	2	18	2	34	15	29	17	6	64	184
Kyoto Univ	Japan	705	5	55	5		14	9	7	5	7	7	7	10	20	15	3	42	65
Peking Univ	China	686	4	26	6		49	10	22	1	6	13	14	5	23	13	8	74	125
Sichuan Univ	China	665	17	26	3	3	19	9	5	3	8	7	19	7	30	9	4	92	97

Entity	Country of Origin	Total	2.01.03 Brain Tumors	2.02 Screening / Diagnosis	2.03.01 Gene-Viro-Therapy	2.03.02 Herbal/Plant Products	2.03.03 Pharmaceutical Drugs	2.03.04 Chemotherapy	2.03.05 Radiation Therapy	2.03.06 Vaccines	2.03.07 Cell Transplantation	3.01.01 Diagnosis	3.01.02.01 Pharmaceutical Drugs	3.01.02.02 Gene Therapy	3.01.02.03 Nerve Regeneration Therapy	3.01.02.05 Near-Infrared Phototherapy	3.01.02.06 Static And Pulsed Magnetic Field Therapies	3.01.02.07 Transcutaneous Electrical Nerve	3.01.02.08 Percutaneous Electrical Nerve
Science & Technology Unit, Umm Al Qura University (Stu-Uqu)	Saudi Arabia	25		1															
Fudan Univ	China	1500	43	169	8	6	44	194	150	18	1	17	72	1	1			3	
Sun Yat Sen Univ	China	1378	40	119	5	10	54	197	144	14		11	76	2	2				
Natl Taiwan Univ Hosp	Taiwan	1226	26	106		3	23	86	61	19		8	47					3	
Seoul Natl Univ	South Korea	1219	58	145	1	6	40	198	79	18	6	21	66					2	
Shanghai Jiao Tong Univ	China	1064	29	119	2	10	52	140	29	11	1	27	72		4				
Univ Hong Kong	China	1060	17	70	1	5	21	62	27	8	5	4	43						
Univ Tokyo	Japan	1055	19	82			16	113	31	40	5	19	54				1	1	4
Mahidol Univ	Thailand	1018	7	31			4	25	20	6		5	11	1					
Chinese Acad Sci	China	940	7	50	14	9	31	28	10	12	2	12	47	1	1	2			
Zhejiang Univ	China	925	22	81	5	3	37	95	18	5	2	3	51	1	1				
Osaka Univ	Japan	915	20	79	7	3	24	155	85	42	7	10	43	1				1	
China Med Univ	China	906	40	116	3	13	48	116	45	13		6	64		2			6	5
Yonsei Univ	South Korea	899	32	128		1	22	135	72	8	5	12	40					4	
Sungkyunkwan Univ	South Korea	848	50	111		3	22	209	89	6	10	15	67					1	
Chinese Acad Med Sci	China	804	11	128	2	4	35	96	70	25	3	6	61	1					
Natl Univ Singapore	Singapore	742	14	83		6	26	59	30	6	3	9	57	4	3				
Chinese Univ Hong Kong	China	732	10	62	1	3	22	69	26	10	6	4	43					4	
Kyoto Univ	Japan	705	22	69	1	1	19	99	103	6	2	15	41	2				1	
Peking Univ	China	686	7	78		1	25	85	32	16	1	6	38	3	1			5	
Sichuan Univ	China	665	11	95		6	29	70	53	28		9	51		1			1	

Entity	Country of Origin	Total	3.01.02.09 Spinal Cord Electrostimulation	3.01.02.10 Stem Cell Therapy	4.01.01.01 Ectopic Pregnancy	4.01.02.01 Pelvic Inflammatory Disease	4.01.02.02 Infertility	4.01.02.03 Endometriosis	4.01.02.04 Abdominal Pain	4.01.02.05 Sexually Transmitted Diseases	5.01.01.01 Fertility Medications	5.01.01.02 In Vitro Fertilization	5.01.01.03 Intrauterine Insemination	5.01.01.04 Intra-Cytoplasmic Sperm Injection	5.01.01.05 Surrogacy	5.01.02.01 Ultrasound Imaging	5.01.02.02 Magnetic Resonance Imaging/Hysterosalpi	5.01.02.03 Endoscopic Techniques	5.01.02.04 Inhibin	5.01.02.05 Activin
Science & Technology Unit, Umm Al Qura University (Stu-Uqu)	Saudi Arabia	25		1	5	1	1					5		3		1		1		
Fudan Univ	China	1500	3	37	27		6	1	2	3	16	10		4		3	9	6		
Sun Yat Sen Univ	China	1378		77	22	1	2			1	17	24	1	22		3	5	6		
Natl Taiwan Univ Hosp	Taiwan	1226	2	30	14		2		2		11	19	6	12		2	2	9	1	
Seoul Natl Univ	South Korea	1219	3	79	18		3	2			15	20	15	9	2		12	6	4	2
Shanghai Jiao Tong Univ	China	1064	3	66	30	4	4	1	3	3	7	28	4	21	1	3	5	2	1	
Univ Hong Kong	China	1060	3	30	40	1	2			6	30	24	5	4		2	2	10	2	
Univ Tokyo	Japan	1055	1	38	12		3	1	1		24	15	6	13	2		6	10	1	3
Mahidol Univ	Thailand	1018		12	7		1		1		26	4	14	7		2	1	2		
Chinese Acad Sci	China	940	2	67	6						20	19	10	18	1		2		1	
Zhejiang Univ	China	925		47	32	2	5	3	2	1	21	26	3	36		1	1	14	3	2
Osaka Univ	Japan	915	2	22	13			1	1	1	26	13	1	9			8	2		
China Med Univ	China	906	3	51	12		2	1	1		14	7	2	6		2	3	1		
Yonsei Univ	South Korea	899	2	49	11				1	2	17	3	3		1	1	7	13		
Sungkyunkwan Univ	South Korea	848		13	10		1	1			14	2		1	1	2	5	10		
Chinese Acad Med Sci	China	804	1	23	7			1	1		9			2		3		6		
Natl Univ Singapore	Singapore	742		51	6		1				6	1	1	3			2	3		
Chinese Univ Hong Kong	China	732		11	10	2	3			3	22	15	1	4	1			3		
Kyoto Univ	Japan	705		88	7		1		1		20	8	1	8			19	2		
Peking Univ	China	686		38	19		6	1	1	2	16	22	1	24			4	7	2	1
Sichuan Univ	China	665		26	16		3		2		12	7	2	6	1	1		7	1	

SCIENTIFIC LITERATURE OVERVIEW OF TOP MIDDLE EAST & AFRICA ENTITIES

Table 6 visualizes the prolific entities in the Middle East and Africa. A number of foreign universities seem to be working in the Middle East and Africa. This may be indicative of collaborative work between these foreign universities and regional organizations. Most of the prolific entities in these regions are having significant literature publication activity in Communicable Diseases – more specifically on HIV/AIDS, parasites, tuberculosis.

Table 6 – Scientific literature overview of top Middle East & Africa entities (continued over next pages)

Entity	Country of Origin	Total	1.01.01 Bacterial Infections	1.01.02 Viral Infections	1.01.03 Fungal Infections	1.01.04 Protozoan Infections	1.01.05 Hepatitis	1.01.06 Hiv Aids	1.01.07 Pandemic Influenza	1.01.08 Parasites	1.01.09 Sexually Transmitted Infections	1.01.10 Skin Diseases	1.01.11 Tuberculosis	1.01.12 Food Borne Diseases	1.01.13 Animal Or Insect Borne Diseases	1.02 Treatment	1.03 Diagnosis
Science & Technology Unit, Umm Al Qura University (STU-UQU)	Saudi Arabia	25	1						2	1	1			1	5	1	
Univ Cape Town	South Africa	850	11	52	2		19	370	6	36	43	25	334	9	33	28	15
Univ Witwatersrand	South Africa	714	9	40	4	2	34	408	22	29	55	15	132	11	22	27	14
Univ Tehran Med Sci	Iran	711	13	23	3	3	45	20	14	39	3	14	21	9	168	24	15
London Sch Hyg & Trop Med	South Africa	654	8	12		2	7	200	1	208	72	12	182	2	57	17	27
Makerere Univ	Uganda	561	3	23	1	1	9	273		113	33	14	125	8	49	9	11
Univ Stellenbosch	South Africa	561	2	26	1		18	153	4	17	13	15	257	17	31	22	16
Pasteur Inst Iran	Iran	488	8	60	6	2	47	32	11	106	3	15	23	6	182	5	23
Univ Kwazulu Natal	South Africa	463	3	18	1		12	298	4	13	29	4	105	5	31	13	8
Harvard Univ	South Africa	448	4	14	2	1	20	265	9	48	12	6	92	6	12	13	4
Istanbul Univ	Turkey	448	7	28	7	1	22	3	15	5	3	4	12	15	24	22	7
Univ Washington	Kenya	416	1	13			3	316		53	55	5	18		5	6	7
Univ Calif	Uganda	401	3	11			21	239	3	63	40	8	65	5	7	12	9
Hacettepe Univ	Turkey	400	3	15	5		12	1	15	2	2	17	4	10	20	26	10
Kenya Govt Med Res Ctr	Kenya	366	4	9			6	137	3	135	29	4	20	3	67	3	11
Cairo Univ	Egypt	354	8	19	4	1	44		4	1	2		3	6	47	11	4
Univ Pretoria	South Africa	352	9	48	4	2	4	39	8	14	4	14	51	13	127	8	11
Johns Hopkins Univ	Uganda	345	3	12	1		14	222	2	25	42	4	79	2	5	9	5
Univ Liverpool	Malawi	310	5	11	4		11	59		126	9	10	43	4	57	10	14
Univ Nairobi	Kenya	305	5	14	1		5	215	3	28	41	7	12	5	13	3	4
Islamic Azad Univ	Iran	274	15	33	5	4	5	3	3	12		1	6	25	54	1	
Ankara Univ	Turkey	266	7	15	2	1	23		8	2	2	8	7	11	14	9	6
Niaid	Uganda	244	2	13	1		9	134	1	48	24	4	30	1	16	8	7
Ege Univ	Turkey	241	9	8	3		12	1	6	9	2	2	7	5	23	7	3
Karolinska Inst	Tanzania	238	2	6			5	60		56	7	5	45	1	17	14	4
Shiraz Univ Med Sci	Iran	237	7	11	7	2	11	5	16	21	7	3	6	5	80	7	7
Gazi Univ	Turkey	230	6	5	4		12		6		1	6	1	9	14	7	2
King Saud Univ	Saudi Arabia	205	11	17	2	1	19	1	5	7	2	4	8	11	20	11	2
Emory Univ	Zambia	198	1	8		1	5	117	3	25	13	2	18	2	13	4	3
Shahid Beheshti Univ Med Sci	Iran	192	1	11	2	1	11	2	2	5		3	18	5	29	4	5
Natl Inst Communicable Dis	South Africa	190	3	8	2		7	101	17	10	17	2	13	2	36	4	1

Entity	2.01.01 Colorectal Cancer	2.01.02 Liver Cancer	2.01.03 Brain Tumors	2.02 Screening / Diagnosis	2.03.02 Herbal/Plant Products	2.03.03 Pharmaceutical Drugs	2.03.04 Chemotherapy	2.03.05 Radiation Therapy	2.03.06 Vaccines	2.03.07 Cell Trasnplantation
Science & Technology Unit, Umm Al Qura University (STU-UQU)	2			1						
Univ Cape Town	4	5	1	12		5	10	7	6	
Univ Witwatersrand	14	3	1	14			5	2	1	
Univ Tehran Med Sci	31	12	13	72	2	9	17	15	7	5
London Sch Hyg & Trop Med		1		5					2	
Makerere Univ	1	6	1	6				1	4	
Univ Stellenbosch	1		1	12		2	5	11	3	
Pasteur Inst Iran	6	7	2	5		3	4		5	
Univ Kwazulu Natal				1			1		1	
Harvard Univ	3		3	13		2	3	2	5	1
Istanbul Univ	46	19	13	58	2	12	38	30	2	1
Univ Washington		1	1	11		1	2	1		
Univ Calif			2	10		1	2	1		
Hacettepe Univ	26	17	20	52		15	41	34	6	2
Kenya Govt Med Res Ctr		1		1						
Cairo Univ	17	25	3	29	1	2	17	27	1	1
Univ Pretoria			1	6	1	1		2	3	
Johns Hopkins Univ	3	3		4			1			
Univ Liverpool	1	1		1		1	1			
Univ Nairobi	1	2		1					1	
Islamic Azad Univ	15	3	5	12	1	3	4	6	2	
Ankara Univ	8	8	3	17		3	17	11	4	7
Niaid										
Ege Univ	13	10	7	40	4	8	21	27	3	4
Karolinska Inst	8	6	1	13		4	4	1	3	1
Shiraz Univ Med Sci	9	2	2	16	1	4	6	3	3	
Gazi Univ	26	11	13	23		22	35	16	1	3
King Saud Univ	9	13	5	17	4	10	7	5	2	
Emory Univ	3	1	1				5	5	1	
Shahid Beheshti Univ Med Sci	27	1	1	33		3	3	4	1	
Natl Inst Communicable Dis										

Entity	3.01.01 Diagnosis	3.01.02.01 Pharmaceutical Drugs	3.01.02.02 Gene Therapy	3.01.02.03 Nerve Regeneration Therapy	3.01.02.04 Low-Level Laser Therapy (LLlt	3.01.02.06 Static And Pulsed Magnetic Field Therapies	3.01.02.07 Transcutaneous Electrical Nerve	3.01.02.08 Percutaneous Electrical Nerve	3.01.02.09 Spinal Cord Electrostimulation	3.01.02.10 Stem Cell Therapy
Science & Technology Unit, Umm Al Qura University (STU-UQU)										1
Univ Cape Town	3	3				1			1	2
Univ Witwatersrand		1	1							5
Univ Tehran Med Sci	19	15		1			1		1	41
London Sch Hyg & Trop Med										
Makerere Univ		1								
Univ Stellenbosch	7	2	1							3
Pasteur Inst Iran	1	6								6
Univ Kwazulu Natal	2									1
Harvard Univ	2	2							1	4
Istanbul Univ	21	13					6	1	1	4
Univ Washington		1								
Univ Calif	3									3
Hacettepe Univ	6	14		1			4			9
Kenya Govt Med Res Ctr										
Cairo Univ	4	9			1		1			8
Univ Pretoria		2								
Johns Hopkins Univ										
Univ Liverpool		1								
Univ Nairobi	1									
Islamic Azad Univ	1	4					3			34
Ankara Univ	5	6					1		1	2
Niaid										
Ege Univ	4	16		1			6		3	4
Karolinska Inst	6	2							2	
Shiraz Univ Med Sci	2	3					1			6
Gazi Univ	4	27							1	3
King Saud Univ	2	11					1		1	10
Emory Univ										
Shahid Beheshti Univ Med Sci	3	5	1							18
Natl Inst Communicable Dis										

Entity	4.01.01.01 Ectopic Pregnancy	4.01.02.01 Pelvic Inflammatory Disease	4.01.02.02 Infertility	4.01.02.03 Endometriosis	4.01.02.04 Abdominal Pain	4.01.02.05 Sexually Transmitted Diseases	5.01.01.01 Fertility Medications	5.01.01.02 In Vitro Fertilization	5.01.01.03 Intrauterine Insemination	5.01.01.04 Intra-Cytoplasmic Sperm Injection	5.01.01.05 Surrogacy	5.01.02.01 Ultrasound Imaging	5.01.02.02 Magnetic Resonance Imaging/Hysterosalpi	5.01.02.03 Endoscopic Techniques	5.01.02.04 Inhibin
Science & Technology Unit, Umm Al Qura University (STU-UQU)	5	1	1					5		3		1		1	
Univ Cape Town	3							4		2	2		1		
Univ Witwatersrand	3						7				1				
Univ Tehran Med Sci	36	1	19	2	1	2	25	41	16	31		7	10	18	2
London Sch Hyg & Trop Med															
Makerere Univ															
Univ Stellenbosch	3						14	13	10	8		1		2	1
Pasteur Inst Iran							2	1		1					
Univ Kwazulu Natal	6					1			2				1		
Harvard Univ	2					1	3	2	2	1					4
Istanbul Univ	23		7	1		1	15	20	12	8		6	5	12	4
Univ Washington	3						1	1	1			1	1		
Univ Calif							3								
Hacettepe Univ	14		6	1			27	22	4	22		5	3	3	1
Kenya Govt Med Res Ctr															
Cairo Univ	15		6	2			27	24	22	31		7	9	10	
Univ Pretoria	9		1				1	4	19	1			1	1	
Johns Hopkins Univ							1								
Univ Liverpool															
Univ Nairobi	2							1	1						
Islamic Azad Univ	4		1				6	12	16	6	1	2	2	1	
Ankara Univ	15		1		1		14	19	20	22		3	4	8	
Niaid															
Ege Univ	8		3	1	1		4	4		3		1	2	5	
Karolinska Inst	1		1				4	4	1	2			1		
Shiraz Univ Med Sci	8	1	2		1	2	7	6	3			3		7	1
Gazi Univ	8		4		1		9	15	9	7		2	1	4	
King Saud Univ	4		2	1			4	4	2	2		2	2	1	
Emory Univ															
Shahid Beheshti Univ Med Sci	6		2				2	5				1	3		
Natl Inst Communicable Dis															

SCIENTIFIC LITERATURE OVERVIEW OF TOP SAUDI ARABIA ENTITIES

Table 7 – Scientific literature overview of top Saudi Arabia entities (continued over next pages)

Entity	Total	1.01.01 Bacterial Infections	1.01.02 Viral Infections	1.01.03 Fungal Infections	1.01.04 Protozoan Infections	1.01.05 Hepatitis	1.01.06 Hiv Aids	1.01.07 Pandemic Influenza	1.01.08 Parasites	1.01.09 Sexually Transmitted Infections	1.01.10 Skin Diseases	1.01.11 Tuberculosis	1.01.12 Food Borne Diseases	1.01.13 Animal Or Insect Borne Diseases	1.02 Treatment	1.03 Diagnosis	2.01.01 Colorectal Cancer	2.01.02 Liver Cancer	2.01.03 Brain Tumors	2.02 Screening / Diagnosis	2.03.02 Herbal/Plant Products	2.03.03 Pharmaceutical Drugs
Science & Technology Unit, Umm Al Qura University (Stu-Uqu)	25	1						2	1	1			1	5	1		2			1		
King Saud Univ	206	11	17	2	1	19	1	5	7	2	4	8	11	21	11	2	8	13	5	17	4	10
King Faisal Specialist Hosp & Res Ctr	138	1	6	1		6	5	2	4		1	14		5	8	1	31	4	2	11	2	4
King Abdul Aziz Hosp	119	6	8			2	3	6	2	1	2	2	7	14	3	1	11	3	1	18	3	2
Minist Hlth	48		3			7	3	14	3			13	1	7	3	3	1	1		1		
King Saud Bin Abadulaziz Univ Hlth Sci	36	1	2			2		1	3	1	1	3	1	4	2	2		3	1	5		
Al Faisal Univ	34		3			3	1	8	2			12		1	3	3	3		1	2		1
King Faisal Univ	34	1	6	1		1	1	1				2	2	9	1		1			2		1
King Fahad Med City	33	1	2	1		2		1	7		2	1		1	1		2		4	4		1
King Abdul Aziz Med City	30	1	4	1		5		1				1		6	1	2		1	4	3		
Saad Specialist Hosp	26								1			1		3			1		4	11		1
Taif Univ	21	1	4					2	7				2	4			2	2				
Qassim Univ	20	2	4		1	1			3				1	3						2		1
Taibah Univ	19					2		1	1				1	6		1	2	1		1		
King Abdulaziz Univ Hosp	18		1			2		1	2		1			2	3					2		
King Khalid Univ	16	1	2						2	1				4	1		1			1		
King Abdullah Univ Sci & Technol	14		1			2						2		2			5	1		2		
Univ Dammam	13										1	1		5						3		1
King Fahad Specialist Hosp	12					2									1	1			2	1		
King Khalid Univ Hosp	11					2		1			1		1	1	1	2						
Saudi Aramco	10					1	1	3				2		1		3						
Int Med Ctr	9												1				3	1		4		
Jazan Univ	8											1	1	2	1			1		1		
King Abdullah Med City	8													1			3			3		
King Fahad Hosp	7	1	1											1			2			2		
Univ Hail	7												2				2	1		1		
John Hopkins Aramco Healthcare	6		2					1				3		1	2	1						
Armed Forces Hosp	5					1		1						2								
King Fahd Hosp Univ	5											1								1		

Entity	Total	2.03.04 Chemotherapy	2.03.05 Radiation Therapy	2.03.06 Vaccines	2.03.07 Cell Trasnplantation	3.01.01 Diagnosis	3.01.02.01 Pharmaceutical Drugs	3.01.02.07 Transcutaneous Electrical Nerve	3.01.02.09 Spinal Cord Electrostimulation	3.01.02.10 Stem Cell Therapy	4.01.01.01 Ectopic Pregnancy	4.01.02.01 Pelvic Inflammatory Disease	4.01.02.02 Infertility	4.01.02.03 Endometriosis	4.01.02.04 Abdominal Pain	4.01.02.05 Sexually Transmitted Diseases	5.01.01.01 Fertility Medications	5.01.01.02 In Vitro Fertilization	5.01.01.03 Intrauterine Insemination	5.01.01.04 Intra-Cytoplasmic Sperm Injection	5.01.02.01 Ultrasound Imaging	5.01.02.02 Magnetic Resonance Imaging/Hysterosalpi	5.01.02.03 Endoscopic Techniques
Science & Technology Unit, Umm Al Qura University (Stu-Uqu)	25									1	5	1	1					5		3	1		1
King Saud Univ	206	7	5	2		2	11	2	1	10	4		2	1			4	4	2	2	2	2	1
King Faisal Specialist Hosp & Res Ctr	138	12	16	1	1	4	6		1	1	2						1	6		2			
King Abdul Aziz Hosp	119	6	4	1	1	3	6			6	6	1	1	1		1	4	4	2	3		3	2
Minist Hlth	48																						
King Saud Bin Abadulaziz Univ Hlth Sci	36	2	2			2	4			4										1			
Al Faisal Univ	34						1											1					
King Faisal Univ	34			1			1			1	3								3				1
King Fahad Med City	33	3	2				2														1		1
King Abdul Aziz Med City	30	3				1	4																
Saad Specialist Hosp	26	2	16																				
Taif Univ	21																						
Qassim Univ	20	1									1						1		1				
Taibah Univ	19	1		1							1										2		2
King Abdulaziz Univ Hosp	18	1	1				1			1													
King Khalid Univ	16	1					1				1							1		1			
King Abdullah Univ Sci & Technol	14									1													
Univ Dammam	13						1		1		2		1										
King Fahad Specialist Hosp	12	4	2																				
King Khalid Univ Hosp	11					1					3		1				1				1		1
Saudi Aramco	10																						
Int Med Ctr	9																						
Jazan Univ	8	1									1												
King Abdullah Med City	8	1																					
King Fahad Hosp	7										1												
Univ Hail	7					1	1																
John Hopkins Aramco Healthcare	6																						
Armed Forces Hosp	5																					1	1
King Fahd Hosp Univ	5										2		1		1			1					1

MIDDLE EAST & AFRICA ADVANCED MEDICAL AND HEALTH RESEARCH SCIENTIFIC LITERATURE TRENDS

This section of the report focuses on the scientific paper collection and the activity and technological trends observed in the Middle East and Africa regions.

MIDDLE EAST & AFRICA – PROLIFIC COUNTRIES

Figure 28 below shows the prolific countries by scientific literature volume in the Middle East regions. The gray bars indicate Middle East, blue indicates Africa, and green indicates the Kingdom of Saudi Arabia. As seen from the figure, the most prolific countries within these regions are Turkey and South Africa, followed by Iran and Egypt.

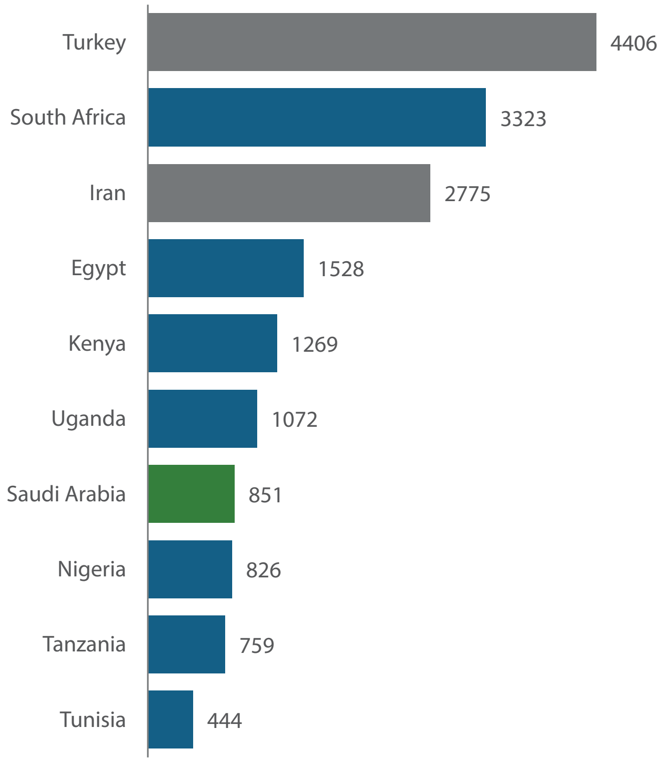

Figure 28 – Middle East & Africa – Prolific Countries in Scientific Literature

A more detailed analysis of the technologies of focus in each of the countries within the Middle East and Africa is presented with reference to tables 5 and 6. Most of the countries are focusing on Animal or Insect Borne Diseases. Middle East countries seem to appear focusing additionally on Screening/Diagnosis and Viral infections. In line with this, Kingdom of Saudi Arabia has significant publications in the field of Animal or Insect Borne Diseases and Screening/Diagnosis. African countries seem to be focusing on HIV/AIDS, parasites, tuberculosis as well as Animal or Insect Borne Diseases.

Country of Origin	1.01.01 Bacterial Infections	1.01.02 viral infections	1.01.03 Fungal Infections	1.01.04 Protozoan Infections	1.01.05 Hepatitis	1.01.06 HIV AIDS	1.01.07 Pandemic Influenza	1.01.08 Parasites	1.01.09 Sexually Transmitted Infections	1.01.10 Skin Diseases	1.01.11 Tuberculosis	1.01.12 Food Borne Diseases	1.01.13 Animal or Insect Borne Diseases	1.02 Treatment	1.03 Diagnosis
Turkey	118	194	47	6	158	15	113	50	15	63	91	128	556	139	98
South Africa	46	206	22	4	97	1377	54	132	174	76	880	91	295	105	70
Iran	66	204	21	12	169	52	52	150	22	29	110	99	580	63	53
Egypt	31	106	13	4	129	22	39	57	18	19	34	51	248	33	25
Kenya	15	56	1	3	22	517	24	369	83	18	96	32	158	25	27
Uganda	4	38	2	2	19	541	2	205	56	20	185	15	117	20	23
Saudi Arabia	27	53	5	2	45	14	42	42	5	12	47	34	107	42	14
Nigeria	15	47	5	1	23	151	12	173	18	13	47	35	189	14	16
Tanzania	12	26	1	2	13	217	2	276	46	12	117	9	111	21	23
Tunisia	18	34	5	1	12	3	8	37	7	8	22	37	123	19	8
Ethiopia	8	21	1	3	5	73		135	12	14	110	19	122	7	20
Ghana	6	17	1	2	22	44	12	170	16	22	37	12	35	10	17
Zambia	1	20		1	4	214	2	50	20	6	66	3	40	12	9
Malawi	3	17	1		9	191		97	14	3	72	5	18	8	9
Cameroon	8	18	4	3	18	109	6	102	8	9	30	10	33	11	14
Zimbabwe	3	14			4	162		35	29	8	41	4	33	6	6
Lebanon	7	11	5		23	12	6	10	3	9	11	9	36	8	10
Senegal	5	10	3	2	5	58	3	111	7	6	7	3	67	4	9
Morocco	9	12	5	1	18	9	8	17	5	1	21	7	47	6	4
Burkina Faso	5	9	2		13	53	3	115	9	6	16	3	34	7	9
U Arab Emirates	7	9	5		13	22	6	7	4	4	6	5	22	5	4
Jordan	3	16			6	1	5	1	2	4	6	19	20	3	3
Sudan	4	11		1	4	8		85	2	2	17	3	79	2	7
Cote Ivoire	4	10	1	2	8	72	6	50	3		21	2	34	4	8
Mali	2	11	1	1	6	29	2	89	1	3	11		35	6	8
Mozambique	3	7			6	68	1	56	7		21	1	18	8	4
Gambia	6	9			5	28		54	20	3	31	1	6	3	5
Rwanda					3	92	3	23	17	2	19	2	5		1
Botswana	1	5	1		3	96		3	5	1	45	3	4	7	2
Gabon	1	11	1	1	10	14	2	67	2	5	10	1	25	5	8
Qatar	1	5	1		10	24	4	8	9	3	15	6	6	4	3

Table 8 – Middle East & Africa –Countries over Technical categories (continued over next pages)

Country of Origin	2.01.01 Colorectal Cancer	2.01.02 Liver Cancer	2.01.03 Brain Tumors	2.02 Screening / Diagnosis	2.03.01 Gene-Viro-Therapy	2.03.02 Herbal/Plant Products	2.03.03 Pharmaceutical Drugs	2.03.04 Chemotherapy	2.03.05 Radiation Therapy	2.03.06 Vaccines	2.03.07 Cell Trasnplantation	3.01.01 Diagnosis	3.01.02.01 Pharmaceutical Drugs	3.01.02.02 Gene Therapy	3.01.02.03 Nerve Regeneration Therapy	3.01.02.04 Low-Level Laser Therapy (Lllt	3.01.02.06 Static And Pulsed Magnetic Field Therapies	3.01.02.07 Transcutaneous Electrical Nerve	3.01.02.08 Percutaneous Electrical Nerve	3.01.02.09 Spinal Cord Electrostimulation	3.01.02.10 Stem Cell Therapy
Turkey	262	134	100	519		15	119	326	238	30	30	89	178	1	4		2	58	1	14	61
South Africa	26	12	5	56		1	12	36	22	11		13	13	2			1			1	11
Iran	147	34	28	215		10	33	52	46	27	5	36	51	3	2			14		1	173
Egypt	68	132	22	97		3	17	59	57	6	1	8	37			1		2		2	31
Kenya	1	2	1	15			2	3	1	2		1	1							2	
Uganda	2	6	2	11			1	2	3	5			3								
Saudi Arabia	75	28	16	92		8	22	39	44	6	2	8	32					2		4	25
Nigeria	2	9	3	40		2	3	4	6	4		3	5					4			1
Tanzania	2	2	1	12			5	2	1			1	4								
Tunisia	25	4	6	24			2	13	12			9	7								1
Ethiopia			1	2		1			2	1								1			
Ghana	1	2	1	15		1	2	1	5	1		2	3								
Zambia			1	2					1	1											1
Malawi	2		1	4				4			1		1					1			
Cameroon		2		6		3	1	2		2											1
Zimbabwe		3	1						1	2											1
Lebanon	20	16	5	26		4	12	21	5	3		3	11							2	6
Senegal		1	1	5				3	3	1											1
Morocco	29	9	7	26		2	4	17	6			4	14								1
Burkina Faso				1																	
U Arab Emirates	9	4	12	33		1	3	24	5	5	1	12	13					1			1
Jordan	28	3	6	37		2	2	11	7	3	11	1	6		1						3
Sudan	2	2	1	7			1		1				3								
Cote Ivoire				2			1	1													
Mali			1	3																	
Mozambique				1					1	3											
Gambia		4		2						1											
Rwanda				2						1											
Botswana				3			1	1		2	1		1								
Gabon				2																	
Qatar	16	4	1	14			2	6	1	2		2	3								4

Country of Origin	4.01.01.01 Ectopic Pregnancy	4.01.02.01 Pelvic Inflammatory Disease	4.01.02.02 Infertility	4.01.02.03 Endometriosis	4.01.02.04 Abdominal Pain	4.01.02.05 Sexually Transmitted Diseases	5.01.01.01 Fertility Medications	5.01.01.02 In Vitro Fertilization	5.01.01.03 Intrauterine Insemination	5.01.01.04 Intra-Cytoplasmic Sperm Injection	5.01.01.05 Surrogacy	5.01.02.01 Ultrasound Imaging	5.01.02.02 Magnetic Resonance Imaging/Hysterosalpi	5.01.02.03 Endoscopic Techniques	5.01.02.04 Inhibin	5.01.02.05 Activin
Turkey	278	3	43	5	22	3	179	215	166	175	4	63	67	155	12	2
South Africa	28		1		1	1	28	29	43	13	6	1	2	4	5	
Iran	115	2	34	3	8	5	90	138	106	102	3	39	24	57	8	
Egypt	54	1	16	3	2	2	115	62	63	76		24	17	55	3	
Kenya	4						5	7	2	4			1	7	1	
Uganda									1							
Saudi Arabia	35	2	8	2	1	1	15	23	9	13		9	7	11		
Nigeria	42	2	7	1	3	3	10	12	8	2	1	2	10	7		
Tanzania	5					1										
Tunisia	5						1	10	6	18			4	5	1	
Ethiopia	1								6							
Ghana	4								1	1						
Zambia	1															
Malawi	1															
Cameroon	5		1				1	1	7					2		
Zimbabwe	6					1			1		1					
Lebanon	14	1	1		4		17	9	1	3		1	2	1		
Senegal	1								3							
Morocco	4						3	1	3	2		1	1	1		
Burkina Faso	3						1		2							
U Arab Emirates	9		1		1		5	1	12			1		1		
Jordan	10		2		1		3	5	6	6			1	5		
Sudan							3	1	2	1						
Cote Ivoire							1						1	1		
Mali	1				1											
Mozambique									1							
Gambia								1	1							
Rwanda								1					1	1		
Botswana																
Gabon	1															
Qatar	2							3	1	1		1	1	3		

ADVANCED MEDICAL AND HEALTH RESEARCH PATENT COLLECTION TECHNOLOGY TRENDS

This section of the report focuses on the patent collections produced for the study and the activity and technological trends seen within it. Based on the Thomson Reuters-produced Derwent World Patents Index database, the collection includes both pending patent applications and granted patents published in 47 countries around the world.
A total of approximately 161,000 patented inventions were gathered that are applicable to the various Advanced Medical and Health Research technology segments of interest to Science & Technology Unit, Umm Al Qura University (STU-UQU). These inventions and their technical nature have been summarized using the ThemeScape software described in the previous section.

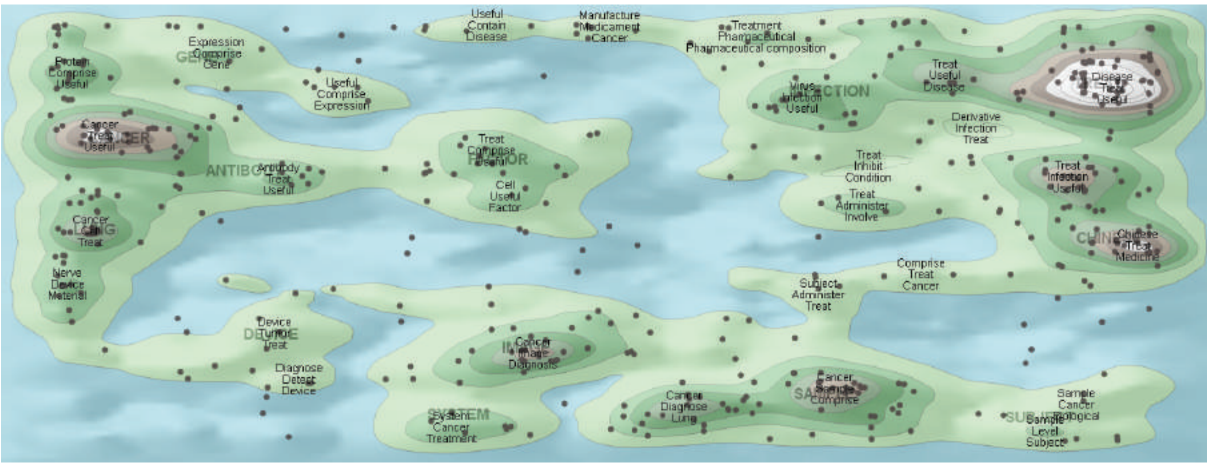

Figure 29 – ThemeScape Map of Patent Collection; Annotated by Major Themes

As previously noted, the ThemeScape map (Figure 29) is not designed to provide a detailed accurate view of each patented invention; instead the visual is designed to highlight the common themes shared by hundreds or thousands of patents and patent applications published since 2006.
Some of the key themes revealed in this Themescape are Communicable Diseases and Non-Communicable Diseases.
This annotation has been provided to guide the reader around the landscape. However, it should be noted that this annotation is only approximate.

PATENT COLLECTION TECHNOLOGY SEGMENTATION

Table 7 shows activity for patent collection by various technology segments in Communicable diseases, Non-communicable diseases, Medical & health technology, Ectopic pregnancy and Reproductive endocrinology areas. Much like the scientific literature landscape, the patent landscape offers a number of white spaces and opportunities for patenting. These white spaces which have low patent volumes and high growth rates include: Food Borne diseases (communicable diseases); gene-viro-therapy, herbal plant products, and cell transplantation (non-communicable diseases – cancer); low level laser therapy (LLLT), and percutaneous electrical nerve stimulation (medical and health technology); ectopic pregnancy, sexually transmitted diseases (ectopic pregnancy); in-vitro fertilization, intra-cytoplasmic sperm injection, MRI/Hyseterosalpingography, and activin (reproductive medicine). Particularly noteworthy is that the Science & Technology Unit, Umm Al Qura University (STU-UQU), already appears to have research programs and scientific papers in food borne diseases, ectopic pregnancy, in-vitro fertilization, and intra-cytoplasmic sperm injection – presenting an opportunity for patent filings in these white space areas.

Table 9 – Patent Technology Segmentation (continued on next page)

Technology Segmentation		Total Inventions	Average %Growth or Decline (08-13)
1 Communicable Diseases	1.01.01 Bacterial Infections	14201	2%
	1.01.02 Viral Infections	27982	10%
	1.01.03 Fungal Infections	4976	-3%
	1.01.04 Protozoan Infections	4989	-7%
	1.01.05 Hepatitis	15113	-5%
	1.01.06 HIV AIDS	14255	-12%
	1.01.07 Pandemic Influenza	1418	-12%
	1.01.08 Parasites	6125	-4%
	1.01.09 Sexually Transmitted Infections	4598	-2%
	1.01.10 Skin Diseases	18918	-5%
	1.01.11 Tuberculosis	6409	-5%
	1.01.12 Food Borne Diseases	118	1%
	1.01.13 Animal or Insect Borne Diseases	7064	-2%
	1.02 Treatment	43756	-1%
	1.03 Diagnosis	16700	-4%
2 Non-communicable Diseases (Cancer)	2.01.01 Colorectal Cancer	16037	-3%
	2.01.02 Liver Cancer	12694	1%
	2.01.03 Brain Tumors	6612	-2%
	2.01.04 Others	52423	54%
	2.02 Screening / Diagnosis	17655	-3%
	2.03.01 Gene-Viro-Therapy	66	49%
	2.03.02 Herbal/Plant Products	387	4%
	2.03.03 Pharmaceutical Drugs	17122	4%
	2.03.04 Chemotherapy	4905	4%
	2.03.05 Radiation Therapy	2624	3%
	2.03.06 Vaccines	1878	-7%
	2.03.07 Cell Transplantation	111	3%
	2.03.08 Others	34241	43%

Technology Segmentation		Total Inventions	Average %Growth or Decline (08-13)
3 Medical & Health Technology	3.01.01 Diagnosis	1933	-8%
	3.01.02.01 Pharmaceutical Drugs	18977	-9%
	3.01.02.02 Gene Therapy	1283	-17%
	3.01.02.03 Nerve Regeneration Therapy	625	7%
	3.01.02.04 Low-Level Laser Therapy (LLLT)	25	-15%
	3.01.02.05 Near-Infrared Phototherapy	6	-
	3.01.02.06 Static and Pulsed Magnetic Field Therapies	40	1%
	3.01.02.07 Transcutaneous Electrical Nerve Stimulation	188	13%
	3.01.02.08 Percutaneous Electrical Nerve Stimulation	67	39%
	3.01.02.09 Spinal Cord Electrostimulation	390	-18%
	3.01.02.10 Stem Cell Therapy	1156	-6%
4 Ectopic Pregnancy	4.01.01 Ectopic Pregnancy Types	587	15%
	4.01.02.01 Pelvic Inflammatory Disease	23	-
	4.01.02.02 Infertility	34	19%
	4.01.02.03 Endometriosis	56	-11%
	4.01.02.04 Abdominal Pain	35	129%
	4.01.02.05 Sexually Transmitted Diseases	23	-8%
5 Reproductive Medicine	5.01.01.01 Fertility Medications	800	-12%
	5.01.01.02 In Vitro Fertilization	151	1%
	5.01.01.03 Intrauterine insemination	933	15%
	5.01.01.04 Intra-Cytoplasmic Sperm Injection	77	-8%
	5.01.01.05 Surrogacy	38	15%
	5.01.02.01 Ultrasound Imaging	11	-
	5.01.02.02 Magnetic Resonance Imaging/Hysterosalpingography	30	48%
	5.01.02.03 Endoscopic Techniques	41	-2%
	5.01.02.04 Inhibin	14	10%
	5.01.02.05 Activin	14	-
	5.01.02.06 Others	240	-11%

PATENT COLLECTION TECHNOLOGY CATEGORY OVERLAP

The technology segments, that were created to enumerate and describe the Advanced Medical & health research landscape in the areas of Communicable diseases, Non-communicable diseases, Medical & health technology, Ectopic pregnancy and Reproductive endocrinology, were not intended to be mutually exclusive. A single patent family can be included in multiple categories.
Figure 30 visualizes the relationship between select technology segments. Each number in the diagram shows the number of inventions that have content related to both the corresponding row-wise and column-wise segments.
Ectopic pregnancy with Reproductive Medicine appear to be potential technical domain for further research purpose.

	1.0 Communicable Diseases	2.0 Non-communicable Diseases (Cancer)	3.0 Medical & Health Technology	4.0 Ectopic Pregnancy	5.0 Reproductive Medicine
1.0 Communicable Diseases	70346	13970	7018	98	192
2.0 Non-communicable Diseases (Cancer)		63613	5118	76	422
3.0 Medical & Health Technology			17133	35	61
4.0 Ectopic Pregnancy				517	14
5.0 Reproductive Medicine					1908

Figure 30 – Number of Patent Families per Pair of Technology Segments

PATENT ACTIVITY GEOGRAPHIC VOLUME BENCHMARKING

Figure 31 shows the number of patent families or inventions within the Advanced Medical & health research landscape in the areas of Communicable diseases, Non-communicable diseases, Medical & health technology, Ectopic pregnancy and Reproductive endocrinology patent collection that can be attributed to each nation . Patenting activity within the Advanced Medical & health research landscape in the areas of Communicable diseases, Non-communicable diseases, Medical & health technology, Ectopic pregnancy and Reproductive endocrinology fields is lead by United States, followed by China, United Kingdom, South Korea and Canada. About 94% of the patenting activity is originating from top 10 countries

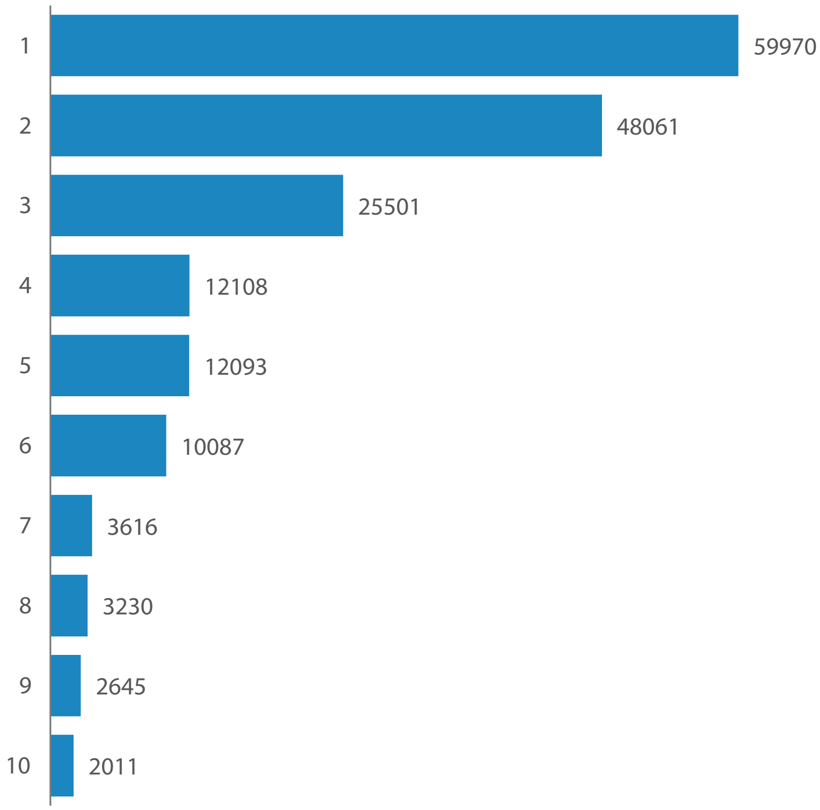

Figure 31 – Number of Patent Families per Country; Top 10 Sources

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National attribution of patent activity is primarily performed via the priority filing location of the invention – this is the first filing event that occurs in the international protection of an invention at the various patent offices around the world. Actual geographic location of the inventor or the innovating corporation may vary from the priority filing location. This effect is exhibited primarily by Saudi Arabian entities, few of which file for patents within the Kingdom.

PATENT GEOGRAPHIC ACTIVITY TRENDS

Although an average number of patent filings from Indonesia, Philippines and Argentina are about 33 which is considerably high as compared to the patenting activity in the most prolific countries, the growth rate of patenting activity in Indonesia, Philippines and Argentina exceeds that of most prolific countries and other countries. Turkey also appears to have high growth rate of patent output.

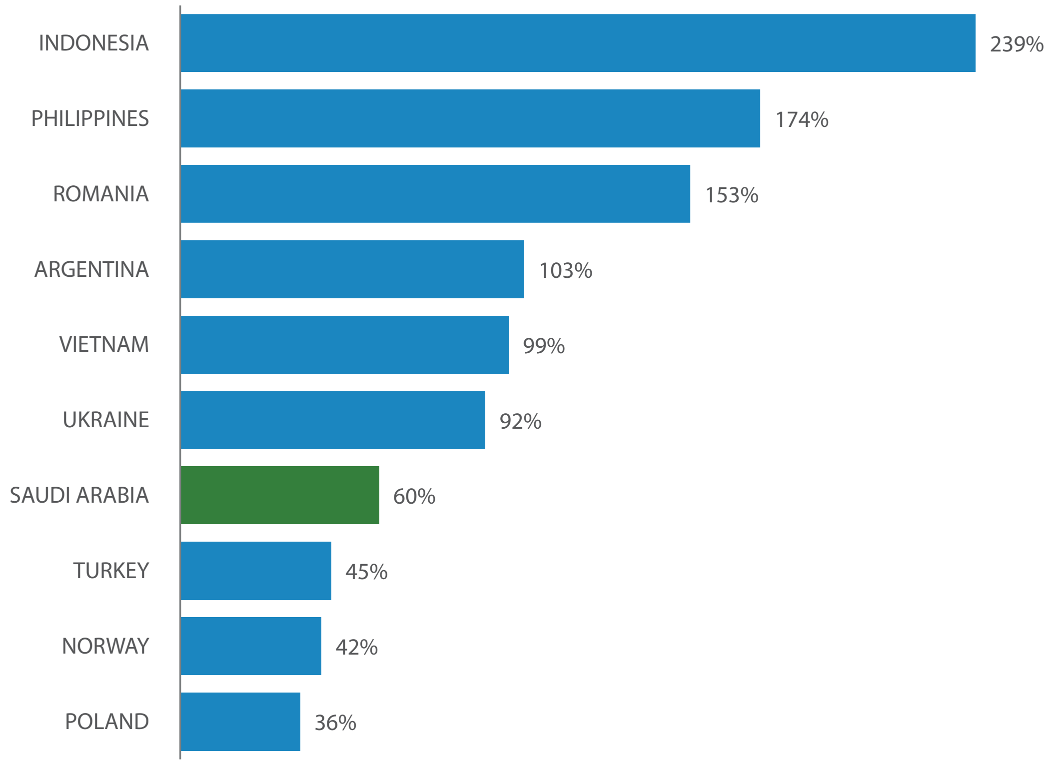

Figure 32 – Highest Growth Rate Geographies in Patent Output

PATENT GEOGRAPHIC CITATION IMPACT BENCHMARKING

Figure 33 details the highest citation impact by nation (with at least 50 patents). Patent citation is a widely utilized measurement of the impact and recognition of an individual patent, and by extension, aggregated groups of patents such as those assigned to a company or associated with the innovation of a nation or region. The measurement is useful as it provides an independent assessment of the quality and impact of the innovation contained within the patent. When aggregated, it provides a method of benchmarking collections of patents for the average impact in comparison to others, e.g.: between two competing entities or between nations.
Patent citation information within this study is measured via citations to patent family members of the Derwent World Patents Index and from citation events of 26 national patent collections.
On this metric, Denmark leads with the highest citation impact, followed by United Kingdom, Israel, United States and Sweden.

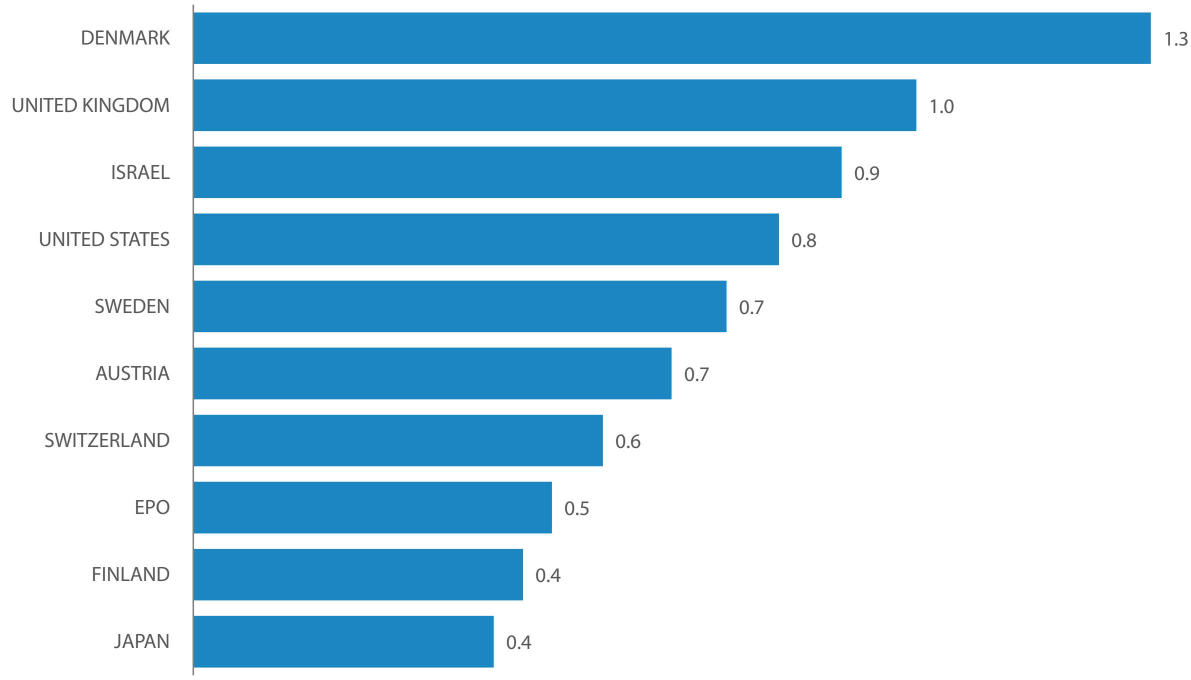

Figure 33 – Highest Citation Impact Geographies of Patents

PATENT COLLECTION BY GEOGRAPHY

Table 8 shows the split of Advance Medical and Health Research and specialization for the top nations. United States, China and Japan appear to have focus on Communicable Diseases and Non-Communicable Diseases. Kingdom of Saudi Arabia appears to be significantly focusing on non-communicable diseases.

Country of Origin	1.0 Communicable Diseases	2.0 Non-communicable Diseases (Cancer)	3.0 Medical & Health Technology	4.0 Ectopic Pregnancy	5.0 Reproductive Medicine
UNITED STATES	52%	57%	22%	0%	1%
CHINA	52%	48%	3%	1%	1%
PCT	54%	63%	25%	0%	1%
SOUTH KOREA	47%	54%	10%	0%	1%
JAPAN	45%	57%	11%	0%	1%
EPO	52%	59%	26%	0%	1%
UNITED KINGDOM	60%	49%	23%	0%	1%
RUSSIAN FEDERATION	57%	38%	4%	0%	2%
INDIA	63%	38%	16%	0%	2%
GERMANY	50%	54%	17%	0%	2%
FRANCE	55%	48%	17%	0%	2%
AUSTRALIA	57%	50%	18%	1%	2%
TAIWAN	34%	67%	5%	0%	1%
SPAIN	49%	49%	19%	0%	2%
ITALY	54%	42%	17%	0%	2%
DENMARK	67%	46%	36%	0%	2%
BRAZIL	68%	31%	5%	0%	3%
POLAND	33%	64%	9%	0%	1%
SWEDEN	54%	42%	26%	0%	2%
CANADA	56%	47%	14%	0%	3%
MEXICO	65%	35%	4%	0%	1%
SINGAPORE	56%	56%	10%	0%	1%
TURKEY	53%	20%	31%	0%	0%
NEW ZEALAND	48%	61%	16%	0%	3%
FINLAND	44%	57%	17%	0%	1%
SOUTH AFRICA	74%	37%	11%	0%	1%
NETHERLANDS	48%	54%	10%	0%	5%
CZECH REPUBLIC	46%	49%	10%	0%	2%
AUSTRIA	50%	41%	16%	0%	1%
HUNGARY	51%	44%	32%	0%	3%
SWITZERLAND	58%	40%	4%	0%	5%
MALAYSIA	68%	47%	1%	0%	0%
ISRAEL	62%	46%	20%	0%	0%
PORTUGAL	47%	55%	13%	0%	0%
NORWAY	35%	58%	6%	2%	4%
ROMANIA	37%	55%	0%	2%	6%
CUBA	44%	58%	7%	0%	0%
SAUDI ARABIA	46%	72%	10%	0%	0%
VIETNAM	64%	41%	10%	0%	0%

Table 10 – Specialization by Country; % of Patent Activity per Technical Stream

PATENT FILINGS - PROLIFIC ENTITIES

The list of prolific entities filing patents includes a mix of pharmaceutical companies, and universities. Science & Technology Unit, Umm Al-Qura University (STU-UQU) appears to have no patent filings in the advanced medical and health technology area. While the space appears to be crowded, there are opportunities for filing patents as discussed previously, in conjunction with table 9.

Entity	Total	Times Cited	Citation per family
MERCK SHARP & DOHME CORP	1185	1428	1.21
HOFFMANN LA ROCHE & CO AG F	1180	435	0.37
NOVARTIS AG	1130	1396	1.24
UNIV CALIFORNIA	981	596	0.61
US DEPT HEALTH & HUMAN SERVICES	707	476	0.67
GLAXO GROUP LTD	653	1178	1.80
GENENTECH INC	593	375	0.63
BRISTOL-MYERS SQUIBB CO	589	698	1.19
CNRS	584	118	0.20
BOEHRINGER INGELHEIM INT GMBH	548	837	1.53
UNIV TEXAS SYSTEM	535	316	0.59
UNIV JOHNS HOPKINS	525	357	0.68
ASTRAZENECA AB	514	1452	2.82
UNIV ZHEJIANG	514	84	0.16
SANOFI SA	512	168	0.33
ABBOTT LAB	504	556	1.10
UNIV FUDAN	488	88	0.18
INSERM INST NAT SANTE&RECH MEDICALE	485	199	0.41
ABBVIE INC	400	121	0.30
KONINK PHILIPS ELECTRONICS NV	393	161	0.41
ALLERGAN INC	392	187	0.48
JANSSEN PHARM NV	390	263	0.67
SCHERING CORP	381	1047	2.75
HARVARD COLLEGE	362	194	0.54
TAKEDA PHARM CO LTD	347	497	1.43
UNIV TOKYO	346	159	0.46
UNIV LELAND STANFORD JUNIOR	342	131	0.38
UNIV CHINA PHARM	339	70	0.21
UNIV PENNSYLVANIA	339	194	0.57
BAYER SCHERING PHARMA AG	331	269	0.81

Table 11 – Advanced Medical & Health Research – Top entities for Patents

PATENT OVERVIEW OF TOP GLOBAL ENTITIES

Table 10 shows the technology profile of the top 30 entities within the patent landscape of advanced medical and health technology. Most of the top entities have patents all across the categories within communicable diseases, and non-communicable diseases (cancer). The top entities show very little patenting activity in the medical and health technology (except for pharmaceutical drugs), ectopic pregnancy, and reproductive medicine.

Table 12 – Patent overview of top global entities (continued over next pages)

Entity	1.01.01 Bacterial	1.01.02 Viral Infectio	1.01.03 Fungal Infectio	1.01.04 Protozoan	1.01.05 Hepatitis	1.01.06 HIV AIDS	1.01.07 Pandemic	1.01.08 Parasites	1.01.09 Sexually	1.01.10 Skin Disease	1.01.11 Tuberculosis	1.01.12 Food Borne	1.01.13 Animal or	1.02 Treatment	1.03 Diagnosis
MERCK SHARP & DOHME CORP	93	219	57	36	211	319	1	28	15	245	23		46	770	501
HOFFMANN LA ROCHE & CO AG F	65	208	16	13	125	113		13	7	119	7		7	399	267
NOVARTIS AG	165	283	44	41	220	179	58	65	29	175	36		58	592	288
UNIV CALIFORNIA	63	196	20	25	81	117	2	32	26	61	24		48	355	154
US DEPT HEALTH & HUMAN SERVICES	72	182	13	35	76	128	29	34	23	18	32	3	56	344	181
GLAXO GROUP LTD	72	180	13	44	146	148	2	41	6	171	48		17	507	315
GENENTECH INC	32	138	29	13	73	66		21	3	99	13		10	236	156
BRISTOL-MYERS SQUIBB CO	36	142	15	33	214	179	3	32	7	76	23		18	379	240
CNRS	39	101	18	52	63	106	4	44	10	31	38		29	241	103
BOEHRINGER INGELHEIM INT GMBH	81	188	42	24	111	143		72	2	203	36		14	392	203
UNIV TEXAS SYSTEM	41	100	10	16	26	33	2	15	15	21	9		37	189	71
UNIV JOHNS HOPKINS	40	93	18	24	28	51	5	26	23	23	27		15	197	105
ASTRAZENECA AB	82	70	52	30	117	176		23	12	127	102		18	326	209
UNIV ZHEJIANG	28	78	7	2	28	13		2	7	3	17		9	26	14
SANOFI SA	60	83	6	52	23	54		58	18	48	10		16	194	74
ABBOTT LAB	64	141	26	45	150	177		46	2	98	26		16	310	185
UNIV FUDAN	10	55		2	36	66	3	5	3		37		12	31	2
INSERM INST NAT SANTE&RECH MEDICALE	28	83	9	24	72	74	3	30	16	29	37		25	206	78
ABBVIE INC	46	149	24	42	145	152		34	1	99	20		18	274	161
KONINK PHILIPS ELECTRONICS NV	2	12	2	8	4	8		7	3	15	9		2	30	17
ALLERGAN INC	76	79	72	2	29	45		76	43	177	71		2	280	105
JANSSEN PHARM NV	57	48	7	11	49	69		12		115	33		12	252	173
SCHERING CORP	65	92	83	19	91	100		15	1	48	13		13	275	157
HARVARD COLLEGE	63	117	30	34	45	73	1	32	24	40	31		36	204	92
TAKEDA PHARM CO LTD	52	66	12	5	65	74		8	5	72	20		1	192	66
UNIV TOKYO	18	45	1	4	30	16	1	7	8	14	1		4	69	25
UNIV LELAND STANFORD JUNIOR	16	61	5	10	32	27	3	8	5	28	10		10	115	61
UNIV CHINA PHARM	18	37	3	2	14	10		2	3	12	7		3	22	4
UNIV PENNSYLVANIA	27	73	5	12	35	42	8	16	10	17	9		10	153	54
BAYER SCHERING PHARMA AG	28	49	7	8	55	63		8		61	4		9	136	48

Entity	2.01.01 Colorectal	2.01.02 Liver Cancer	2.01.03 Brain Tumors	2.01.04 Others	2.02 Screening /	2.03.01 Gene-Viro-	2.03.02 Herbal/ Plant	2.03.03 Pharmaceutical	2.03.04 Chemotherapy	2.03.05 Radiation	2.03.06 Vaccines	2.03.07 Cell Transpl	2.03.08 Others
MERCK SHARP & DOHME CORP	236	79	59	362	39			52	42	26	6		337
HOFFMANN LA ROCHE & CO AG F	227	127	59	456	169			83	54	8	8		390
NOVARTIS AG	189	122	80	343	61		1	59	27	11	3	1	326
UNIV CALIFORNIA	120	86	57	364	186	2		58	33	22	21		280
US DEPT HEALTH & HUMAN SERVICES	126	64	69	189	151			31	49	21	19		197
GLAXO GROUP LTD	90	70	36	130	14			28	12		5		120
GENENTECH INC	205	139	46	270	111			46	65	14	16		292
BRISTOL-MYERS SQUIBB CO	87	50	14	133	17			20	14		4		123
CNRS	77	42	26	205	96	1		58	23	16	19	1	183
BOEHRINGER INGELHEIM INT GMBH	53	26	33	200	8		1	24	3	2			142
UNIV TEXAS SYSTEM	110	78	92	197	141			40	70	34	10	1	175
UNIV JOHNS HOPKINS	105	59	58	197	157			31	32	11	20	1	174
ASTRAZENECA AB	92	49	31	89	15			51	7	2	1		62
UNIV ZHEJIANG	25	57	13	174	52		1	153	18	5	8		116
SANOFI SA	76	61	20	241	22			48	72	5			147
ABBOTT LAB	114	57	54	154	37			15	27	14			122
UNIV FUDAN	44	104	32	171	47			192	16	5	2		129
INSERM INST NAT SANTE&RECH MEDICALE	85	47	24	155	116			40	27	17	18		137
ABBVIE INC	105	64	66	166	11			14	18	8	1		132
KONINK PHILIPS ELECTRONICS NV	17	23	10	210	135			36	6	23	8		118
ALLERGAN INC	15	9	4	165				3	3	1			43
JANSSEN PHARM NV	49	11	38	104	9			11	13				63
SCHERING CORP	70	46	42	42	16			19	7	19	1		56
HARVARD COLLEGE	41	17	22	129	36			9	8	2	7		84
TAKEDA PHARM CO LTD	90	27	31	90	14			34	9				57
UNIV TOKYO	50	47	15	98	121			40	1	5	4	2	78
UNIV LELAND STANFORD JUNIOR	34	27	13	143	69			13	25	10	13	1	96
UNIV CHINA PHARM	54	77	18	191	12			117	5	1	7	1	133
UNIV PENNSYLVANIA	38	20	15	126	58			12	14	3	22	1	97
BAYER SCHERING PHARMA AG	46	29	47	77	35			18	21	6			64

Entity	3.01.01 Diagnosis	3.01.02.01 Pharma	3.01.02.02 Gene	3.01.02.03 Nerve	3.01.02.04 Low-Level	3.01.02.07 Transcu	3.01.02.09 Spinal	3.01.02.10 Stem Cell	4.01.01 Ectopic Pregna	4.01.02.01 Pelvic	4.01.02.02 Infertilit	4.01.02.03 Endom	4.01.02.04 Abdomi	4.01.02.05 Sexuall
MERCK SHARP & DOHME CORP	8	568	7	13					1					
HOFFMANN LA ROCHE & CO AG F	12	403	7					3						
NOVARTIS AG	10	302	8					2	2					
UNIV CALIFORNIA	29	139	19	5		1	1	25						
US DEPT HEALTH & HUMAN SERVICES	2	70	14					6	2					
GLAXO GROUP LTD	1	212	4											
GENENTECH INC	12	165	13					7						
BRISTOL-MYERS SQUIBB CO	1	188	6					2						
CNRS	18	82	9	3				2						
BOEHRINGER INGELHEIM INT GMBH	5	261												
UNIV TEXAS SYSTEM	16	47	9	4		3	1	8						
UNIV JOHNS HOPKINS	9	35	8	4				6	1					
ASTRAZENECA AB	11	158	3											
UNIV ZHEJIANG		23		2				1	6					
SANOFI SA	3	231						2						
ABBOTT LAB	5	197	10	1					1	5	7	5		
UNIV FUDAN	1	29	1					1						
INSERM INST NAT SANTE&RECH MEDICALE	15	59	13	3				5						
ABBVIE INC	2	210	10	1					1	5	6	5		
KONINK PHILIPS ELECTRONICS NV	10	12	1			5	2		1				1	
ALLERGAN INC		161			3									
JANSSEN PHARM NV	5	216	6											
SCHERING CORP	1	120	1	1										
HARVARD COLLEGE	12	80	19	1	1		2	21	6	1	1			1
TAKEDA PHARM CO LTD	5	163	1	1					1					1
UNIV TOKYO	10	22	5	4										
UNIV LELAND STANFORD JUNIOR	8	47	14	1				8	1		1	1		
UNIV CHINA PHARM		37		2										
UNIV PENNSYLVANIA	14	41	21	2				6	3					
BAYER SCHERING PHARMA AG	14	107	3											

Entity	5.01.01.01 Fertility	5.01.01.02 In Vitro	5.01.01.03 Intraute	5.01.01.04 Intra-Cytopla	5.01.01.05 Surroga	5.01.02.02 Magneti	5.01.02.04 Inhibin	5.01.02.05 Activin	5.01.02.06 Others
MERCK SHARP & DOHME CORP	12	4							
HOFFMANN LA ROCHE & CO AG F	2					2	1	1	
NOVARTIS AG	28							2	
UNIV CALIFORNIA	8					1			5
US DEPT HEALTH & HUMAN SERVICES	1	1							
GLAXO GROUP LTD	3	1							
GENENTECH INC	3					2	1	1	
BRISTOL-MYERS SQUIBB CO	1								
CNRS	6	2		1					1
BOEHRINGER INGELHEIM INT GMBH									
UNIV TEXAS SYSTEM	4		1			1	1		2
UNIV JOHNS HOPKINS	5		1	1			1	1	
ASTRAZENECA AB	7								
UNIV ZHEJIANG	1	1	1						
SANOFI SA	2								
ABBOTT LAB									
UNIV FUDAN									2
INSERM INST NAT SANTE&RECH MEDICALE	6	4		2					3
ABBVIE INC									
KONINK PHILIPS ELECTRONICS NV	1								
ALLERGAN INC									
JANSSEN PHARM NV	2								
SCHERING CORP	8								
HARVARD COLLEGE	2	1							1
TAKEDA PHARM CO LTD	2					1			1
UNIV TOKYO					2				
UNIV LELAND STANFORD JUNIOR		4		1					1
UNIV CHINA PHARM	1								
UNIV PENNSYLVANIA	1								2
BAYER SCHERING PHARMA AG	20	1							2

PATENT OVERVIEW OF TOP ASIA PACIFIC ENTITIES

Table 13 – Patent overview of top Asia Pacific entities (continued over next pages)

Entity	Country of Origin	Total	1.01.01 Bacteri	1.01.02 Viral	1.01.03 Fungal	1.01.04 Protozo	1.01.05 Hepatiti	1.01.06 Hiv Aids	1.01.07 Pande	1.01.08 Parasit	1.01.09 Sexuall	1.01.10 Skin	1.01.11 Tuberc	1.01.13 Animal	1.02 Treatm	1.03 Diagnos	2.01.01 Colorec	2.01.02 Liver	2.01.03 Brain	2.01.04 Others	2.02 Screeni	2.03.02 Herbal/	2.03.03 Pharma
Science & Technology Unit, Umm Al Qura University (STU-UQU)	Saudi Arabia	-																					
Univ Zhejiang	China	509	28	77	6	2	28	13		2	7	3	17	9	25	13	24	56	12	173	50	1	152
Univ Fudan	China	479	10	55		2	36	66	3	5	3		37	12	31	2	40	101	32	171	39		190
Korea Res Inst Bioscience & Biotechnolog	South Korea	391	14	88	5	4	42	19	2	6	7	62	3	20	91	20	123	83	40	87	116	1	72
Univ China Pharm	China	339	18	37	3	2	14	10		2	3	12	7	3	22	4	54	77	18	191	12		117
Snu R&Db Found	South Korea	337	14	64	2	1	28	5	5			32	5	16	61	23	43	40	25	116	76		51
Univ Tokyo	Japan	307	14	41	1	4	26	16	1	7	7	13	1	4	59	18	37	39	10	91	103		33
Univ Yonsei Ind Academic Coop Found	South Korea	277	5	38	3	1	10	7	6	2	11	11	17	20	41	24	43	28	23	112	68		54
Univ Nanjing	China	263	9	31	2	1	11	4		2	5	1	3	4	21	3	18	36	3	147	23		124
Fuji Film Corp	Japan	245	2	17	4	2	2	5		3		9	1	2	18	3	8	12	6	104	111		26
Univ Shandong	China	242	9	30	3	4	14	33		6		1	4		22	4	10	27	3	111	17		69
Samsung Electronics Co Ltd	South Korea	240	3	18		1	1	7		2	2	2	1	2	12	11	28	29	10	185	70		29
Univ Shanghai Jiaotong	China	237	9	41	2	5	4	3		4		1	8	6	9	6	9	14	5	116	30	1	63
Univ Pla Second Military Medical	China	236	10	40	16	2	26	8		2	1	6	6	2	9	1	37	50	2	97	32		71
Univ Sichuan	China	224	6	14	3	2	18	14		1	3	13	11		18	1	19	29	6	86	17		88
Toshiba Kk	Japan	219		16			10	1			3			7	2	8	5	22	6	97	77		16
Canon Kk	Japan	216	2	4	25		3	2				2				2	3	3	2	148	125		8
Takeda Pharm Co Ltd	Japan	213	31	43	2		39	40			2	33	8	1	106	22	57	17	20	56	8		25
Univ Konkuk Ind Coop Corp	South Korea	212	5	46	1	4	23	2	4	4	2	26	4	20	18	8	42	23	25	44	17	1	49
Univ Peking	China	210	5	33		1	16	16	1	1			1	2	17	3	29	37	7	93	30		89
Univ Shenyang Pharm	China	200	9	16	12	2	8	4		4	2	3	7	1	18	1	30	31	4	95	4		79

Entity	Country of Origin	Total	2.03.04 Chemot	2.03.05 Radiati	2.03.06 Vaccine	2.03.07 Cell	2.03.08 Others	3.01.01 Diagnos	3.01.02. 01	3.01.02. 02	3.01.02. 03	3.01.02. 06	3.01.02. 10 Stem	4.01.01. 01	4.01.02. 05	5.01.01. 01	5.01.01. 02 In	5.01.01. 03	5.01.01. 04 Intra-	5.01.01. 05	5.01.02. 01	5.01.02. 02	5.01.02. 06
Science & Technology Unit, Umm Al Qura University (STU-UQU)	Saudi Arabia	-																					
Univ Zhejiang	China	509	18	5	8		114		23		2		1	6		1	1	1					
Univ Fudan	China	479	15	4	2		121	1	29	1			1										2
Korea Res Inst Bioscience & Biotechnolog	South Korea	391	1		4		79		55	3	2		2					1		1			
Univ China Pharm	China	339	5	1	7	1	133		37		2					1							
Snu R&Db Found	South Korea	337	3	4	2		73	10	43	1	5		7							2			
Univ Tokyo	Japan	307		4	2	2	66	10	22	5	4									2			
Univ Yonsei Ind Academic Coop Found	South Korea	277	2	1	2		72	6	28	6		1	6										
Univ Nanjing	China	263	3	1			110		7					2				1	1				2
Fuji Film Corp	Japan	245					39		5	2	2										1		1
Univ Shandong	China	242	1		4		58		17		1		1										
Samsung Electronics Co Ltd	South Korea	240					76		5	1													
Univ Shanghai Jiaotong	China	237	3	1	4		48	1	4		4							1					
Univ Pla Second Military Medical	China	236	5	4	3		79	1	4		1					1							
Univ Sichuan	China	224	8	5	10		67	2	13		2												
Toshiba Kk	Japan	219		29			38	4						1									
Canon Kk	Japan	216	2				27	3															
Takeda Pharm Co Ltd	Japan	213					36	3	94		1			1	1	1						1	1
Univ Konkuk Ind Coop Corp	South Korea	212			1		45	2	29				1										
Univ Peking	China	210	4	1	3		68	2	13							1							1
Univ Shenyang Pharm	China	200	4	2			68	1	19					3									

PATENT OVERVIEW OF TOP MIDDLE EAST & AFRICA ENTITIES

Table 12 illustrates the top patenting entities in the Middle East and Africa. The space appears to be dominated by smaller, local players, particularly from South Africa, Turkey and the Kingdom of Saudi Arabia (KSA) – particularly different from the literature space, where foreign universities appear to be prominently present within the top organizations (see page 43). Most of the entities include universities and government entities, which may be an indication of the possibility of more focus on fundamental research in the field of Advanced Medical and Health Research domain.

Table 14 – Patent overview of top Middle East & Africa entities (continued over next pages)

Entity	Country of Origin	Total	1.01.01 Bacterial	1.01.02 Viral Infectio	1.01.03 Fungal Infectio	1.01.04 Protozoan	1.01.05 Hepatitis	1.01.06 Hiv Aids	1.01.08 Parasites	1.01.09 Sexually	1.01.10 Skin Disease	1.01.11 Tuberculosis	1.01.13 Animal Or	1.02 Treatment	1.03 Diagnosis
Univ Witwatersrand	South Africa	21		2	1		3	8		2		2		12	6
Univ King Saud	Saudi Arabia	19		4		1	3	1	2		2	2	2	6	2
Sanovel Ilac Sanayi Ve Ticaret Anonim	Turkey	18	5	3			3	1						4	
Univ Cape Town	South Africa	12	1	1		1		3			1	3		7	2
Univ Stellenbosch	South Africa	12	1	3		2		1	2			8	1	5	6
Univ King Abdullah Sci & Technology	Saudi Arabia	9	1	2										2	1
Univ North West	South Africa	9	3	1		1		3	1	2		1		7	
South African Medical Res Council	South Africa	7	1			1		1	1		1	6	1	5	3
Univ Namibia	Namibia	7		7		7			7			7		7	
Univ Pretoria	South Africa	7						1	1			3	1	1	4
Council Sci & Ind Res South Africa	South Africa	6				1		2	1			1		4	2
King Faisal Specialist Hospital & Res Ce	Saudi Arabia	5		2	1		1	2						4	1
Univ Kochi	Turkey	5		1				1						1	
Montero Gida Sanayi Ve Ticaret As	Turkey	4							4		4			4	
Univ Yeditepe	Turkey	4	1	1						1				1	
Council Sci&Ind Res India	South Africa	3	1			1						1		3	
Icipe Int Cent Insect Physiology&Ecolo	Kenya	3				3			1					2	2
Terramark Markencreation Gmbh	Saudi Arabia	3		2	1		1							2	1
Univ Free State	South Africa	3		1		1	1	1		1				2	1
Univ Kenyatta	Kenya	3				3			1					2	2
Univ Northwestern	South Africa	3	2					2		2				3	
Abbvie Inc	South Africa	2						1			1			2	
Fargem Farmasoetaok Araaztirma Gelaoazta	Turkey	2													
Novartis Ag	Iran	2				1	1		1		2			2	2
7Tm Pharma As	South Africa	1												1	1
Abbott Gmbh&Co Kg	South Africa	1						1						1	
Astrazeneca Ab	South Africa	1					1							1	1
Bayer Schering Pharma Ag	South Africa	1													
Ilko Ilac Sanayi Ve Ticaret As	Turkey	1	1	1										1	
Janssen Pharm Nv	South Africa	1												1	

Entity	Country of Origin	Total	2.01.01 Colorectal	2.01.02 Liver Cancer	2.01.03 Brain Tumors	2.01.04 Others	2.02 Screening/Diagnosis	2.03.03 Pharmaceutical Drugs	2.03.04 Chemotherapy	2.03.06 Vaccines	2.03.08 Others	3.01.01 Diagnosis	3.01.02.01 Pharmaceutical	3.01.02.02 Gene Therap	3.01.02.10 Stem Cell Therap	5.01.02.02 Magnetic
Univ Witwatersrand	South Africa	21	2	2	2	3		2	2		4		4	1		1
Univ King Saud	Saudi Arabia	19	3	2	1	7	2		1		4		1			
Sanovel Ilac Sanayi Ve Ticaret Anonim	Turkey	18							1				9			
Univ Cape Town	South Africa	12				2	2			1	4					
Univ Stellenbosch	South Africa	12				1	2					1				
Univ King Abdullah Sci & Technology	Saudi Arabia	9	1			8	5	1	1		5	1	1			
Univ North West	South Africa	9				1					1					
South African Medical Res Council	South Africa	7					1									
Univ Namibia	Namibia	7				1										
Univ Pretoria	South Africa	7				1		2								
Council Sci & Ind Res South Africa	South Africa	6						1								
King Faisal Specialist Hospital & Res Ce	Saudi Arabia	5	1	1	1	2							1		1	
Univ Kochi	Turkey	5											5			
Montero Gida Sanayi Ve Ticaret As	Turkey	4														
Univ Yeditepe	Turkey	4	1		1	1					3					
Council Sci&Ind Res India	South Africa	3														
Icipe Int Cent Insect Physiology&Ecolo	Kenya	3														
Terramark Markencreation Gmbh	Saudi Arabia	3	1			2										
Univ Free State	South Africa	3				1			1		2		1			
Univ Kenyatta	Kenya	3														
Univ Northwestern	South Africa	3														
Abbvie Inc	South Africa	2				1							1			
Fargem Farmasoetaok Araaztirma Gelaoazta	Turkey	2											2			
Novartis Ag	Iran	2				2					1		2			
7Tm Pharma As	South Africa	1														
Abbott Gmbh&Co Kg	South Africa	1				1							1			
Astrazeneca Ab	South Africa	1														
Bayer Schering Pharma Ag	South Africa	1					1									
Ilko Ilac Sanayi Ve Ticaret As	Turkey	1														
Janssen Pharm Nv	South Africa	1														

PATENT OVERVIEW OF TOP SAUDI ARABIA ENTITIES

Table 15 – Patent overview of top Saudi Arabia entities

Entity	Total	1.01.01 Bacterial	1.01.02 Viral Infectio	1.01.03 Fungal Infectio	1.01.04 Protozoan	1.01.05 Hepatitis	1.01.06 Hiv Aids	1.01.08 Parasites	1.01.10 Skin Disease	1.01.11 Tuberculosis	1.01.13 Animal Or	1.02 Treatment	1.03 Diagnosis	2.01.01 Colorectal	2.01.02 Liver Cancer	2.01.03 Brain Tumors	2.01.04 Others	2.02 Screening/Diag	2.03.03 Pharmaceutical	2.03.04 Chemotherapy	2.03.08 Others	3.01.01 Diagnosis	3.01.02.01 Pharma	3.01.02.10 Stem Cell
Science & Technology Unit, Umm Al Qura University (STU-UQU)	-																							
Univ King Saud	19		4		1	3	1	2	2	2	2	6	2	3	2	1	7	2		1	4		1	
Univ King Abdullah Sci & Technology	9	1	2									2	1	1			8	5	1	1	5	1	1	
King Faisal Specialist Hospital & Res Ce	5		2	1		1	2					4	1	1	1	1	2						1	1
King Abdulaziz City Sci & Technology	1																1				1			
King Fahad Medical City	1																1				1			
King Khalid Eye Specialist Hospital	1		1	1								1					1							
Sabic Innovative Plastics Ip Bv	1													1					1					
Saudi Arabian Oil Co	1																1							
Univ Alfaisal	1	1										1												
Univ Dhahran King Fahd Petroleum & Miner	1																1				1			
Univ Hail	1						1					1	1				1	1						

MIDDLE EAST & AFRICA ADVANCED MEDICAL AND HEALTH RESEARCH PATENT TRENDS

This section of the report focuses on the patent collection and the activity and technological trends seen within it – in the Middle East and Africa.

MIDDLE EAST & AFRICA – PROLIFIC COUNTRIES

Figure 34 shows that Turkey is the most popular country for filing patents within the two regions, followed by South Africa, Israel and Saudi Arabia. The remaining jurisdictions see only marginal patent filings.

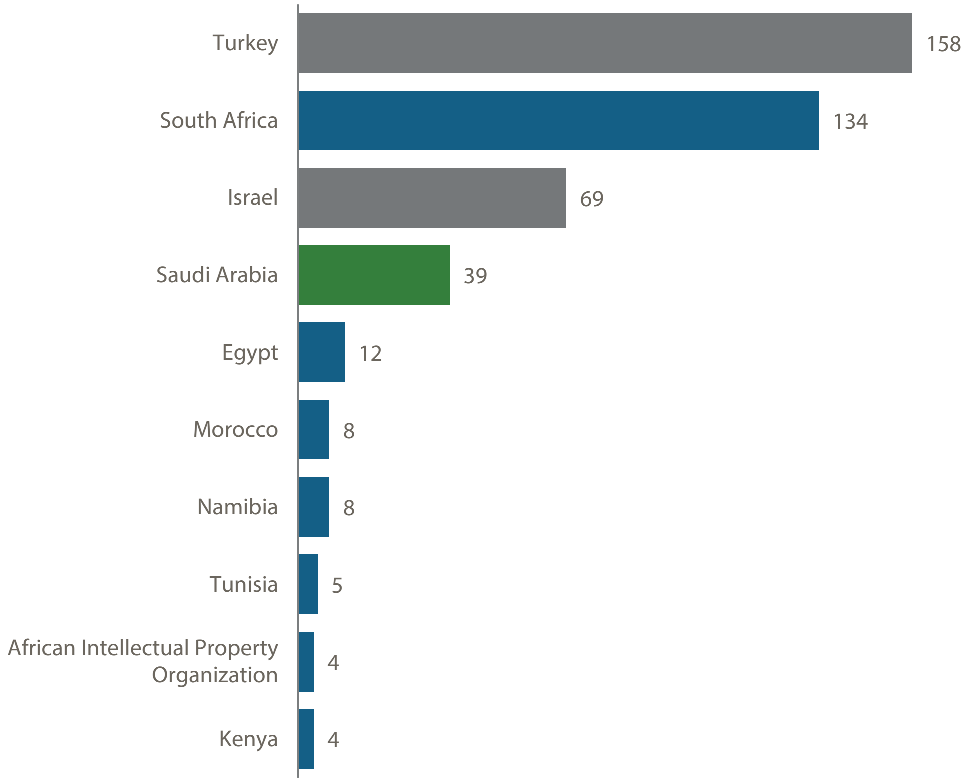

Figure 34 – Middle East & Africa – Prolific Countries in Patents

Diving deeper, Table 11 shows that skin diseases, treatment and pharmaceutical drugs appear to be most active filing technology segments. Kingdom of Saudi Arabia seems to be significantly active in Non-communicable Diseases (Cancer) technology area.

Table 16 – Middle East & Africa – Prolific Countries over Technical categories (continued over next pages)

Country of Origin	1.01.01 Bacteri	1.01.02 Viral	1.01.03 Fungal	1.01.04 Protozo	1.01.05 Hepatiti	1.01.06 Hiv Aids	1.01.07 Pande	1.01.08 Parasit	1.01.09 Sexuall	1.01.10 Skin	1.01.11 Tuberc	1.01.13 Animal	1.02 Treatm	1.03 Diagnos	2.01.01 Colorec	2.01.02 Liver	2.01.03 Brain	2.01.04 Others	2.02 Screeni	2.03.03 Pharma	2.03.04 Chemot	2.03.05 Radiati	2.03.06 Vaccine	2.03.08 Others
Turkey	18	16	2		5	2		6	3	50	3	1	73	2	1		1	27	4	4	2			13
South Africa	17	18	7	12	13	28	1	9	11	8	25	6	78	31	7	5	5	25	10	12	5	1	2	20
Israel	13	9	6	4	8	4		6	3	6	4	4	34	10	3	3	3	17	7	5	2		1	12
Saudi Arabia	2	7	1	1	3	4		2		2	2	2	13	4	6	3	2	21	8	2	2			12
Egypt			1		5	4				1			7					1						1
Morocco	1	1			1	1					2		3					4	1					3
Namibia		7		7				7			7		7					2						1
Tunisia	1	1	1			2		1					5	1				2						1
African IP Organization					1	1			1				1		1					1				
Kenya				4		1		2					2	2										
Gc				1	1			1		2			2	2				2						1
Iran				1	1			1		2			2	2				2						1
Jordan	1			1	1			1		1		1	1	1				1						
Algeria			1					1		1			1											
Georgia											1		1											
Ghana				1	1	1				1		1	1											
Kuwait															1			1						1
Nigeria				1	1	1				1		1	1											

Country of Origin	3.01.01 Diagnosis	3.01.02.01 Pharma	3.01.02.02 Gene	3.01.02.03 Nerve	3.01.02.10 Stem Cell	5.01.01.03 Intraute	5.01.02.02 Magneti
Turkey		49					
South Africa	1	12	1		1		1
Israel	3	11	1	1			
Saudi Arabia	1	3			1		
Egypt		1				1	
Morocco		1					
Namibia							
Tunisia		2					
African IP Organization							
Kenya							
Gc		1					
Iran		2					
Jordan		1					
Algeria							
Georgia							
Ghana							
Kuwait							
Nigeria							

APPENDIX A – SCIENTIFIC PAPERS TOP AFFILIATIONS

ENTITY-LEVEL DATA TABLES FOR SCIENTIFIC LITERATURE COLLECTION

Table 13 on the following pages shows the top 10 author organizations for each of the technology segments. This information is intended to provide an assessment of the depth and location of the research expertise available in each category.

Top Level Technology	Entity	Total
1.0 Communicable Diseases	Univ Calif	2427
	Harvard Univ	2365
	Univ Washington	1572
	Johns Hopkins Univ	1535
	Niaid	1531
	Univ Sao Paulo	1298
	London Sch Hyg & Trop Med	1225
	Univ London Imperial Coll Sci Technol & Med	1199
	Emory Univ	1192
	Univ N Carolina	1091
2.0 Non-Communicable Diseases (Cancer)	Univ Texas Md Anderson Canc Ctr	2947
	Mem Sloan Kettering Canc Ctr	1922
	Harvard Univ	1903
	Nci	1820
	Univ Calif	1781
	Natl Canc Ctr	1365
	Univ Toronto	1339
	Mayo Clin	1162
	Dana Farber Canc Inst	1116
	Duke Univ	1093
3.0 Medical & Health Technology	Harvard Univ	678
	Univ Calif	634
	Univ Texas Md Anderson Canc Ctr	415
	Nci	354
	Mayo Clin	338
	Univ Toronto	334
	Karolinska Inst	316
	Johns Hopkins Univ	311
	Ucl	276
	Univ Penn	274
4.0 Ectopic Pregnancy	Univ Edinburgh	93
	Univ Penn	78
	Harvard Univ	77
	Univ Calif	73
	Univ Amsterdam	70
	Tel Aviv Univ	61
	Wayne State Univ	59
	Univ London Imperial Coll Sci Technol & Med	58
	Yale Univ	50
	Univ Pittsburgh	49
5.0 Reproductive Medicine	Harvard Univ	284
	Univ Calif	274
	Univ Sao Paulo	215
	Univ Toronto	173
	Mcgill Univ	171
	Yale Univ	162
	Univ Florida	162
	Tel Aviv Univ	161
	Univ Sydney	149
	Univ Michigan	146

Table 17 – Top 10 Paper Publishing Organizations per Technology Segment

APPENDIX B — PATENT STATISTICS AND TABLES

ENTITY-LEVEL DATA TABLES FOR PATENT COLLECTION

The Table 14 below and on the following page shows the top 10 patent applicants or patent assignees for each of the technology segments. This information is intended to provide an assessment of expertise and patent commercialization intent per category.

Top Level Technology	Entity	Total
1.0 Communicable Diseases	Merck Sharp & Dohme Corp	787
	Novartis Ag	701
	Glaxo Group Ltd	519
	Univ California	443
	Hoffmann La Roche & Co Ag F	441
	Us Dept Health & Human Services	427
	Boehringer Ingelheim Int Gmbh	405
	Bristol-Myers Squibb Co	404
	Abbott Lab	356
	Astrazeneca Ab	341
2.0 Non-Communicable Diseases (Cancer	Hoffmann La Roche & Co Ag F	738
	Univ California	621
	Merck Sharp & Dohme Corp	617
	Novartis Ag	591
	Genentech Inc	484
	Univ Texas System	380
	Univ Johns Hopkins	380
	Us Dept Health & Human Services	374
	Sanofi Sa	354
	Cnrs	337
3.0 Medical & Health Technology	Merck Sharp & Dohme Corp	575
	Hoffmann La Roche & Co Ag F	410
	Novartis Ag	312
	Boehringer Ingelheim Int Gmbh	263
	Sanofi Sa	232
	Janssen Pharm Nv	219
	Glaxo Group Ltd	212
	Abbvie Inc	211
	Abbott Lab	199
	Bristol-Myers Squibb Co	192
4.0 Ectopic Pregnancy	Vertex Pharm Inc	15
	Daiichi Sankyo Co Ltd	11
	Abbott Lab	8
	Abbvie Inc	7
	Harvard College	6
	Univ Zhejiang	6
	Gaomi Simeier Clothing Co Ltd	5
	Abbott Gmbh&Co Kg	4
	Concert Pharm Inc	4
	Dingguagua Colour Cotton Garments Co Ltd	4
5.0 Reproductive Medicine	Novartis Ag	30
	Bayer Schering Pharma Ag	23
	Merck Sharp & Dohme Corp	16
	Rural Dev Administration	14
	Repros Therapeutics Inc	14
	Univ California	13
	Imv Technologies	13
	Inserm Inst Nat Sante&Rech Medicale	12
	Osteogenex Inc	10
	Wyeth	9

Table 18 – Top 10 Patent Applicants/Owners per Technology Segment

LANDSCAPE OF BIOTECHNOLOGY

SCIENCE & TECHNOLOGY UNIT, UMM AL-QURA UNIVERSITY (STU-UQU)

THOMSON REUTERS IP SERVICES
MAY 2015

Executive Summery

This study has been commissioned by Science & Technology Unit, Umm Al-Qura University (STU-UQU) to evaluate and describe the global scientific research and patent activity within sub-tracks that they have achieved funding for projects. Within the Medical Biotechnology, Cancer Research and Genetics track, the sub-track of focus was Medicinal Chemistry (Drug Design) for Cancer, Communicable Diseases and Genetic Disorders.

The study has looked at both scientific papers and patents to form an understanding of the overall scientific and technology landscape.

The scientific papers are sourced from the Web of Science™, a database containing journal articles from approximately 12,500 peer-reviewed journals.

The patent information is sourced from the Derwent World Patents Index™, a database of patents and patent applications from 47 international patent issuing authorities.

Both databases have been selected because they provide a method of defining a unit of science or technology. A single paper defined by the Web of Science is required to have met a minimum threshold of scientific rigor: publication within a journal of repute, peer review sign off, etc. Furthermore, a patent included within DWPI is defined credibly as an attempt to protect a piece of innovation within at least one territory.

Aggregating this information across technologies and countries provides a method of tracking innovation in the field of Medical Biotechnology, Cancer Research and Genetics and development trends.

Included in this document are measurements of research and patent quality and direction changes in research and patent activity. It should be noted that in many areas the report utilizes metrics such as average annual percentage growth in scientific and research output to compare activities across technologies and geographies. Such metrics should be treated with care for analyses containing low volumes, as some volatility is expected. Also to be noted is that the global high volume nature of this analysis within Medical Biotechnology, Cancer Research and Genetics technology necessarily entails some level of noise and is not intended to be completely comprehensive. Instead, the analyses enclosed should be treated as a survey of the technology, and the trends and findings interpreted in this manner.

Overall, the fact that the number of patents in this area is substantially equal to the number of papers suggests that research activity is equally focused on practical technical commercialization as well as on fundamental research.

For STU-UQU, it is interesting to note the patent and scientific literature collections differ with respect to the breakdown in technology segments. The most active technology segments in both data sets are Medicinal

Chemistry (Drug Design) and Communicable Diseases, however thereafter the breakdown differs. The analysis also suggests that on a global level, there is greater focus on technology commercialization in the technology area of Communicable Diseases and more fundamental research in areas of Medicinal Chemistry (Drug Design). This insight may give STU-UQU direction on future projects and research areas. Similarly with regard to growth rates, the patent collection the technology segment which is experiencing some growth is Communicable Diseases, while Medicinal Chemistry (Drug Design) and Genetic Disorders segments in the patent collection have seen a little decline over the time period. All of the technology segments in the scientific literature collection have seen a growth over the time period with Medicinal Chemistry (Drug Design) leading the growth.

Overall KSA output is pretty low compared to other global resources with the US and China leading both in published literature and patent output. However, KSA are showing impressive growth and compared with output of Middle East and Africa (MENA) countries they rank fourth behind Turkey, Iran and Egypt in scientific literature output, and third behind South Africa and Turkey, in patent filings.

STU-UQU does lag behind in terms of both published literature and patent output with King Saud University and King Abdulaziz University leading output from KSA. There are sub-technology areas with little or no output from these institutes, which may offer opportunity for STU-UQU to focus on. These include Bacteriophage Therapy, Virotherapy and Pharmaceutical Drugs.

For STU-UQU, it is interesting to note the patent and scientific literature collections differ with respect to the breakdown in technology segments. Some technologies are clearly within the commercialization and practical implementation phase, while others exhibit new fundamental technology research.

Bacterial Infections, Viral Infections, Fungal Infections, Protozoan Infections, Gene Therapy, Virotherapy, Pharmaceutical Drugs and Single Gene / Chromosomal Disorder; all are in the technology commercialization and practical implementation phase – with volumes for patent protection far exceeding the volume of scientific literature being published.

Computer-Aided Drug Design (CADD)- Medicinal Chemistry (Drug Design), Non-Computed-Aided Drug Design- Medicinal Chemistry (Drug Design), Biological Evaluation- Medicinal Chemistry (Drug Design), Nanoparticles- Medicinal Chemistry (Drug Design), Liposomes-Medicinal Chemistry (Drug Design), Micelles-Medicinal Chemistry (Drug Design), Multifactorial and Polygenic (Complex) Disorders, Teratogenic Disorders and Treatment- Genetic Disorders appear to be in the fundamental research and development phase – with significantly more scientific literature being published as compared to patents filings.

Synthesis of Antitumor Drugs is fairly developed within the patent landscape as well as within the scientific literature landscape. This indicates evolving and maturing technology – technologies already in the commercialization and practical implementation phase, with new fundamental research and development still continuing, indicated by the comparable number of patent filings and scientific literature publications.

The patent technology segments experiencing significant growth include Teratogenic Disorders, Multifactorial and Polygenic (Complex) Disorders and Dendrimers.

It is recommended to further analyze the space of Teratogenic Disorders and Multifactorial and Polygenic (Complex) Disorders, since this technology has a small number of patent filings but high growth – indicating a nascent technology area.

Scientific literature data indicates strong growth on fundamental research in areas such as Gene Therapy, Nanoparticles-Medicinal Chemistry (Drug Design), Micelles-Medicinal Chemistry (Drug Design) and Dendrimers (based on growth rate during 2009 – 2014 for papers).

Gene Therapy and Nanoparticles are areas where scientific literature growth far exceeds the growth of patent filings. This is indicative of avenues and opportunities for fundamental research and development.

Viral Infections shows significant growth in both patent filings as well as scientific literature publications. Such trend is indicative of an emerging technology, which has not fully matured yet. Interest to develop fundamental technologies continues, while simultaneously technology is being commercialized and practically implemented. This presents an opportunity for newer fundamental technology within these technologies to be researched. Any improvements to existing fundamental techniques of these technologies will be better served by patent filings.

For further information regarding the data used in this study, and for deeper or variations in the analysis presented, please review the interactive dashboards.

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INTRODUCTION TO GLOBAL BIOTECHNOLOGY SCIENTIFIC ACTIVITY

This study presents an analysis of patents and scientific papers that fall within specific topics of Biotechnology which are of interest to Science & Technology Unit, Umm Al-Qura University (STU-UQU) concerning the Medical Biotechnology, Cancer Research and Genetics.

The study was commissioned by STU-UQU as part of a wider program to review the scientific and intellectual property activity in specific topics that they have gained approved funding for projects. Within Biotechnology area, they have gained funding approval for 8 projects related to Medical Biotechnology, Cancer Research and Genetics, but specifically in the sub-tracks of Medicinal Chemistry (Drug Design) for Cancer, Communicable Diseases and Genetic Disorders. The titles of the projects are "Bioinformatics and Biotechnology Enhanced Drug Design and Synthesis of Flavin Analogs as Novel Potent Antitumor Agents", "The neurotropic fungus Rhinocladiella mackenziei and other related neurotropic black yeasts in patients and extreme environmental niches in Saudi Arabia", "The national screening program for genetic mutations causing autosomal recessive polycystic kidney disease in clinically diagnosed Saudi patients", "Rational Development of Novel Ellipticines That Target p53 Deficiency by Activation of p73 and Their Delivery Using Nanotechnology for Cancer Therapy", "Design, Synthesis, and Biological Evaluation of Novel Psorospermin Analogs That Rely on Topoisomerase II–Directed Alkylation of DNA and Activity against Drug-Resistant Tumors", "Bacteriophage therapy as an alternative treatment option for multi-drug resistant Acinetobacter baumannii", "The national screening program for genetic mutations causing haemophilia among Saudi population and the development of PCR/HRM molecular diagnostic test" and "The national screening program for genetic mutations causing familial hypercholesterolaemia among Saudi Arabian population and development of a molecular diagnostic test".

A large scale data collation process using globally recognized search processes from Thomson Reuters was undertaken to produce practical and insightful sets of information for analysis regarding the trends, geographies and ultimately the institutions and patent applicants working in the fields of Medical Biotechnology, Cancer Research and Genetics.

As shown in Figure 1, the overall volume of patents in these technology areas filed since 2006 is equal to the volume of scientific papers published since 2008, however in the same time period from year 2008 onwards the scientific papers output is about 24% higher than the patents output.

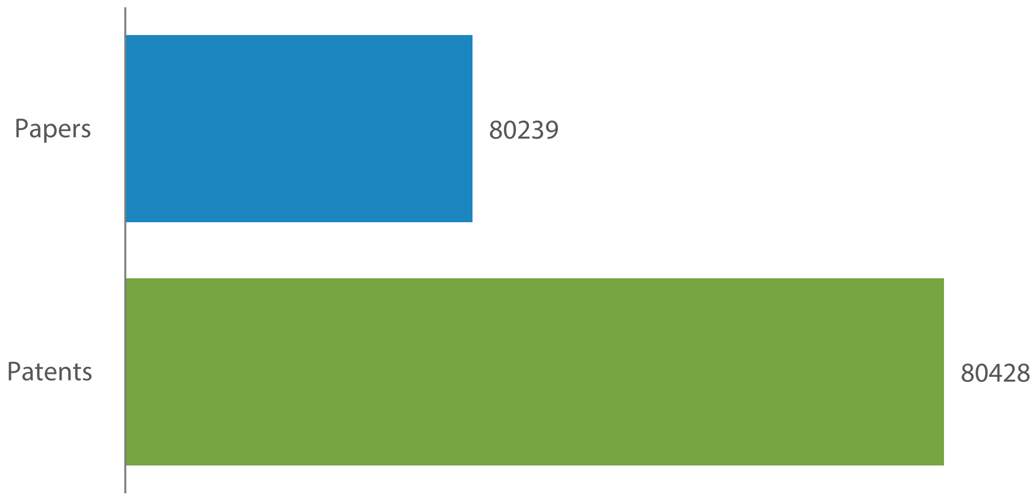

Figure 1 – Scientific Paper and Patent Families in Biotechnology

Additionally, year 2007 onwards patent protection activity related to Medical Biotechnology, Cancer Research and Genetics is decreasing and significantly dropped in years 2011-12 (refer to Figure 2, Timeline of Activity). Whereas publications in scientific journals in these areas, which are likely to address more fundamental research in science, during years 2009-14 is continuously increasing at an average rate of about 10% over the last year. This might suggest that the focus of technology development globally related to Medical Biotechnology, Cancer Research and Genetics is increasingly directed towards fundamental scientific research.

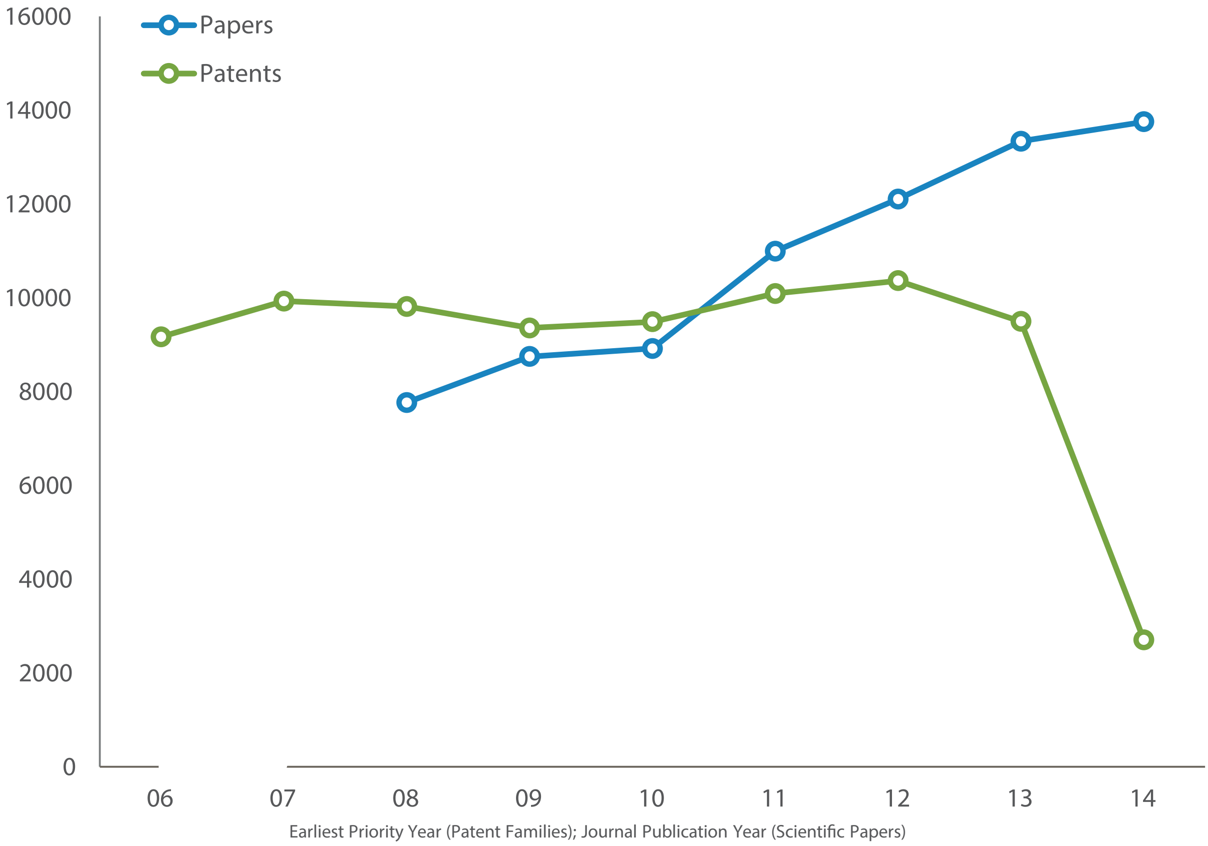

Figure 2 – Timeline of Scientific Paper and Patent Family Activity

Note that the dates used for the collation of the timeline information differ for patent and scientific literature information. Patent Families are measured by the earliest known "priority" or first filing event in the inventions history. Patents are typically retained by patent offices for 18 months or more after filing before they are published. This delay means that the last complete year of information available for patent information is 2012. For scientific papers, the dates used for analyses are the publication dates of the journal containing the paper. These metrics are used throughout the report.

Figures 3 through 5 show three further analyses on each of the data collections (patents, left; papers, right) concerning the nature and high level technology trends occurring within Medical Biotechnology, Cancer Research and Genetics areas.

The patent and scientific literature collections differ with respect to the breakdown in broad technology segments. Three broad level technology segments within Biotechnology, which were identified for the purpose of this study, include ‘Medicinal Chemistry (Drug Design) for Cancer’, ‘Communicable Diseases’ and ‘Genetic Disorders’. The active segments in both data sets are Medicinal Chemistry (Drug Design) and Communicable Diseases, however further breakdown of these technology segments differs. The analysis also suggests that on a global level, there is greater focus on technology commercialization in the technology area of Communicable Diseases and more fundamental research in areas of Medicinal Chemistry (Drug Design).

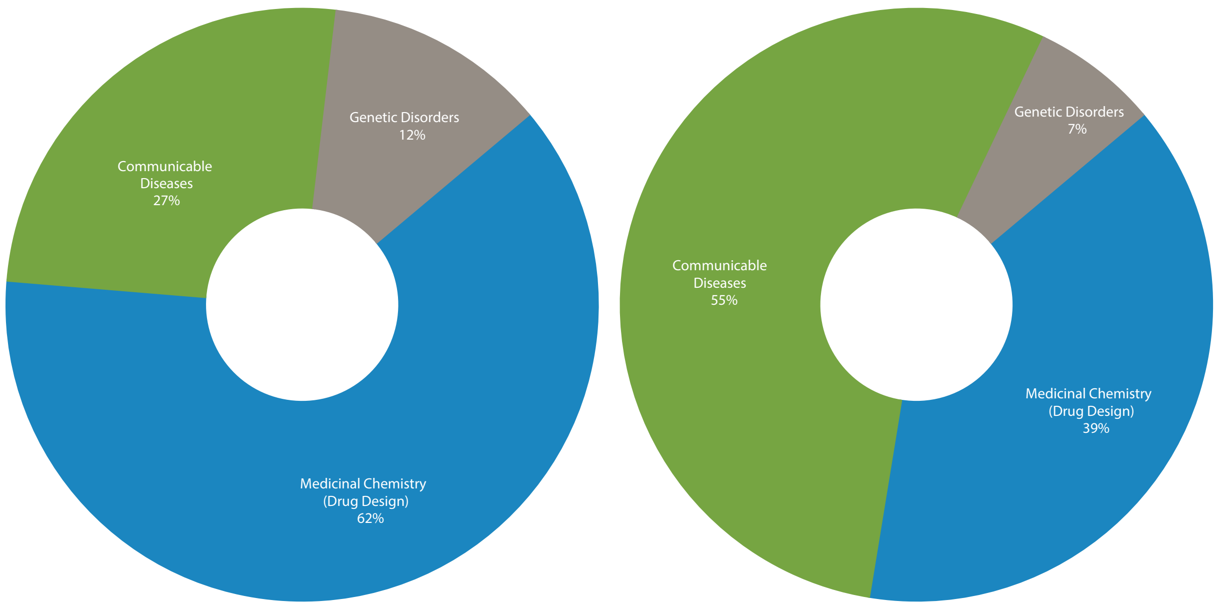

Figure 3 – % of Patent (left) and Scientific Paper (right) Collections by Technology Segments

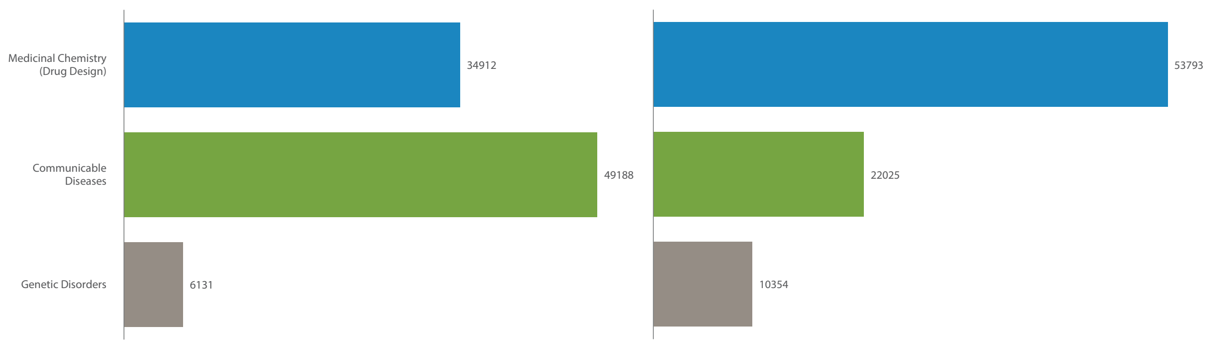

Figure 4 – Number of Patents Families (left) and Scientific Papers (right) per Technology Segments

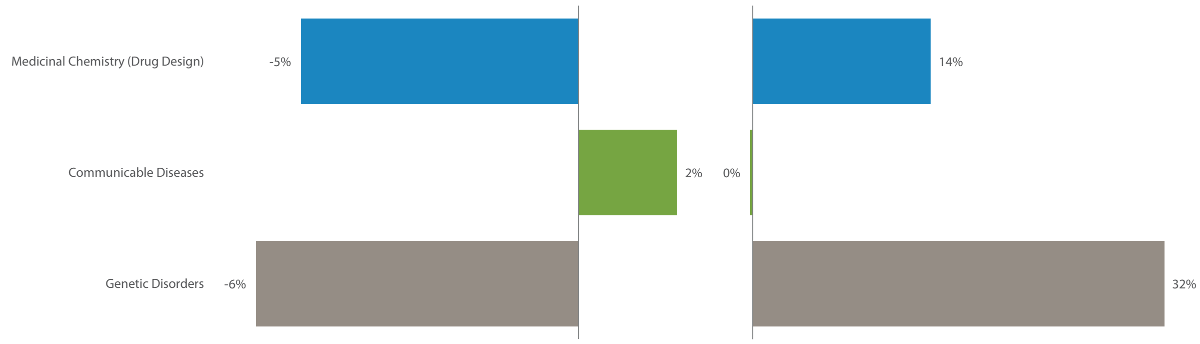

Figure 5 – Average Annual % Growth or Decline in Patent Family (left) or Scientific Paper (right) Output by Technology Segments

With regard to average growth rates of these collections (years 2008 - 2013 for patents; years 2009 - 2014 for papers), in the patent collection the technology segment which is experiencing some growth is Communicable Diseases, while Medicinal Chemistry (Drug Design) and Genetic Disorders segments in the patent collection have seen a little decline over the time period. All of the technology segments in the scientific literature collection have seen a growth over the time period with Medicinal Chemistry (Drug Design) leading the growth.

Medicinal chemistry (drug design) (Figure 6) since 2008 has undergone consistent growth since 2008. Genetic disorders has undergone dip in year 2010. Patenting trends since 2006 (Figure 7) shows that all technology segments had almost similar filing trends between 2006-08. Both medicinal chemistry (drug design) and genetic disorders seem to experience significant decline between 2007-09. Communicable diseases exhibit gradual increase in the patenting activity since 2006.

Average annual growth or decline is calculated by the average percentage increase or decrease between one year and the next. For example; 5 patents in 2006 followed by 6 patents in 2007 would represent an annual increase of 20%. An increase of 20% in one year, followed by a 10% increase the following year would be represented as a 15% average increase across the two years. This process is followed for 2006 (patents) or 2008 (papers) through to the most recently available year in patent and paper collections, to provide an indicator of the level and direction of recent changes in technology topics.

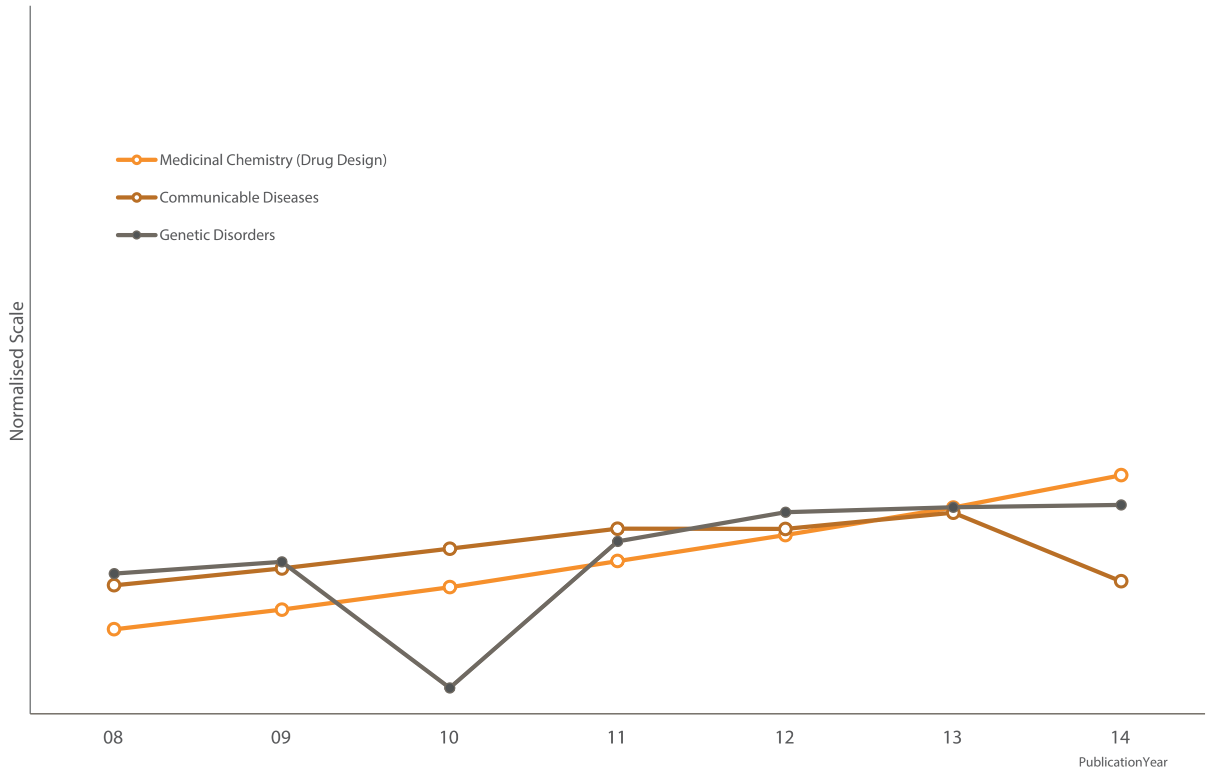

Figure 6 – Normalized Timeline of Activity for Scientific Paper Collection by Various Technology Topics

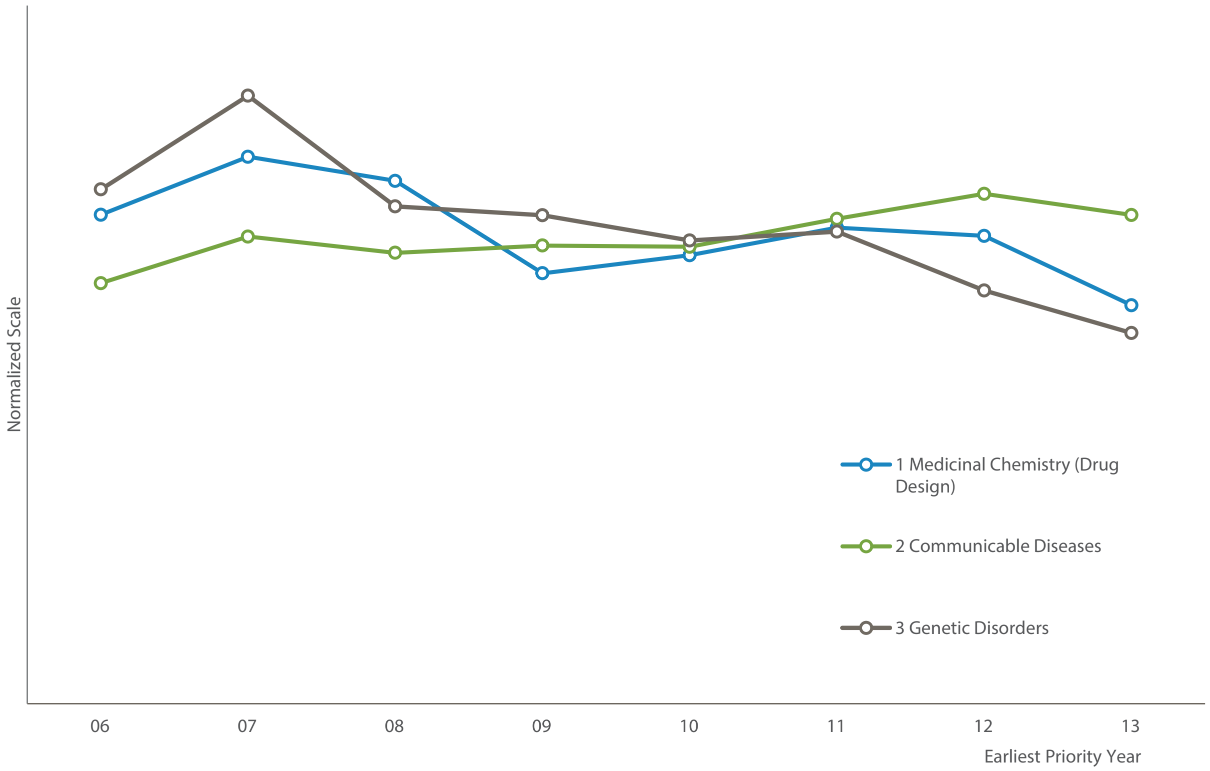

Figure 7 – Normalized Timeline of Activity for Patent Collection by Various Technology Topics

The timelines on these charts have been normalised to allow for side by side comparison. Individually, each topic has varying volumes of patent families and scientific papers, however for visualisation purposes, the charts represent the proportion of each topic's activity filed or published in each calendar year.

Figures 8 through 10 show similar analyses on each of the data collections (patents, left; papers, right) concerning the nature and technology trends occurring within the Medicinal Chemistry (Drug Design) segment. Within Medicinal Chemistry (Drug Design) segment the Synthesis of Antitumor Drugs is an active topic in both data sets, however in this topic there is more commercial focus than the fundamental research with more than 50% of the patent records within Medicinal Chemistry (Drug Design) segment are related to Synthesis of Antitumor Drugs. On the other hand Nanoparticles and Non-Computer-Aided Drug Design (CADD) are the topics with greater focus for fundamental research. The Other category in patent and literature collections includes drug delivery technologies other than Nanoparticles, Liposomes, Micelles, and Dendrimers for Cancer treatment.

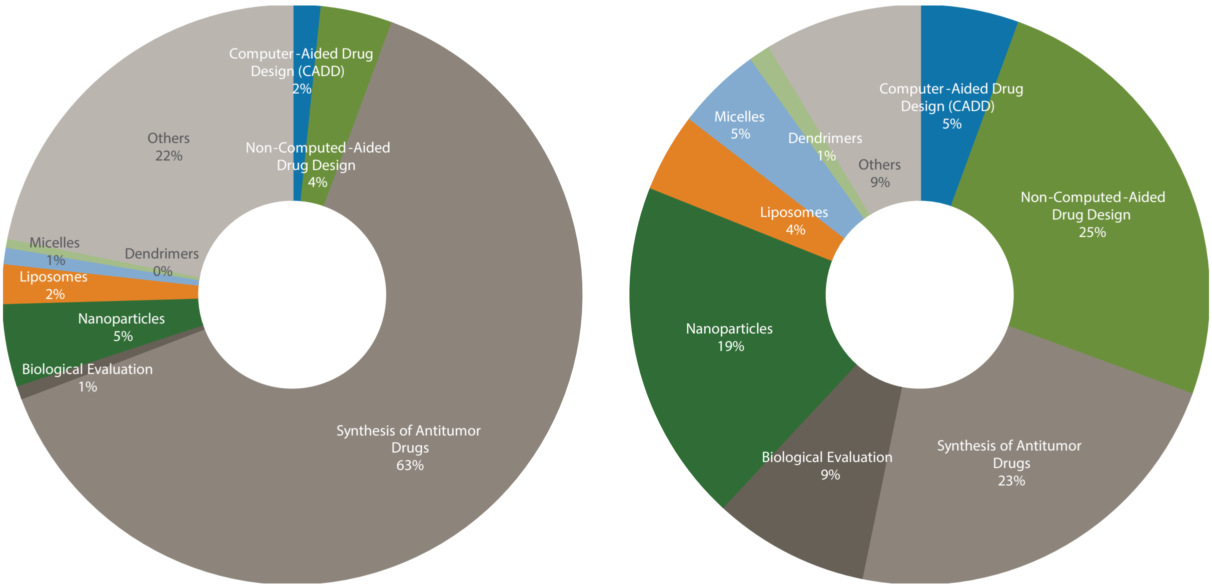

Figure 8 – % of Patent (left) and Scientific Paper (right) Collections by Various Topics in Medicinal Chemistry (Drug Design)

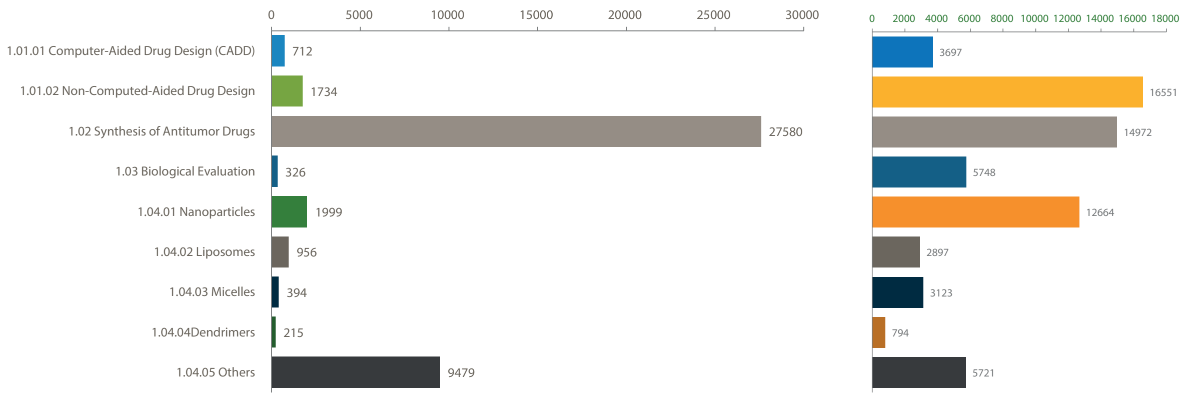

Figure 9 – Number of Patents Families (left) and Scientific Papers (right) per Topic in Medicinal Chemistry (Drug Design)

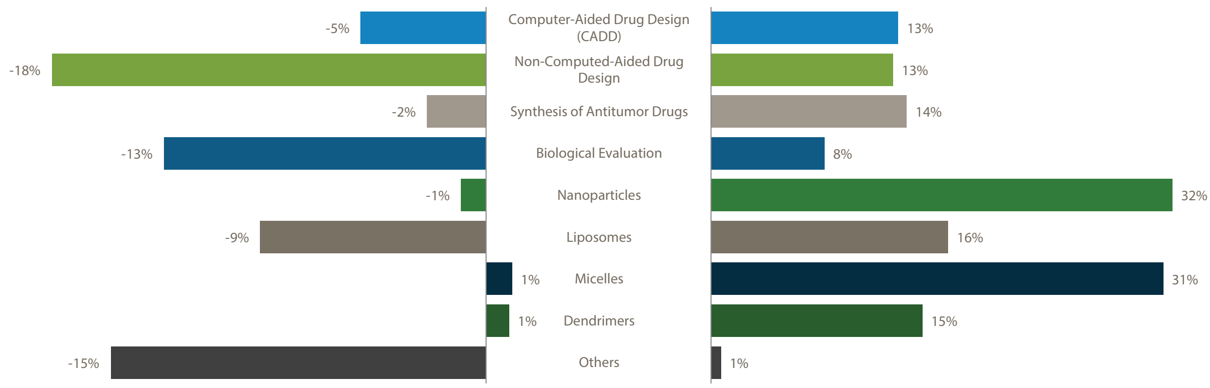

Figure 10 – Average Annual % Growth or Decline in Patent Family (left) or Scientific Paper (right) Output

In spite of the small volume of the patent activity and fundamental research in the topic of Dendrimers has shown a significant growth in both the collections. Other topics which have observed good growth in the sector of fundamental research are Micelles and Nanoparticles which are followed by Liposomes, Biological Evaluation and Computer-Aided Drug Design (CADD).
Figures 11 through 13 show analyses on each of the data collections (patents, left; papers, right) concerning the nature and technology trends occurring within the Communicable Diseases segment. Within the Communicable Diseases segment the treatment and remedial measures against Viral Infections is an active topic in both data sets, however in this topic there is more focus on the fundamental research than commercialization with more than 60% of the publications within Communicable Diseases segment are related to Viral Infections. On the other hand Pharmaceutical Drugs topic has greater focus for technology commercialization.

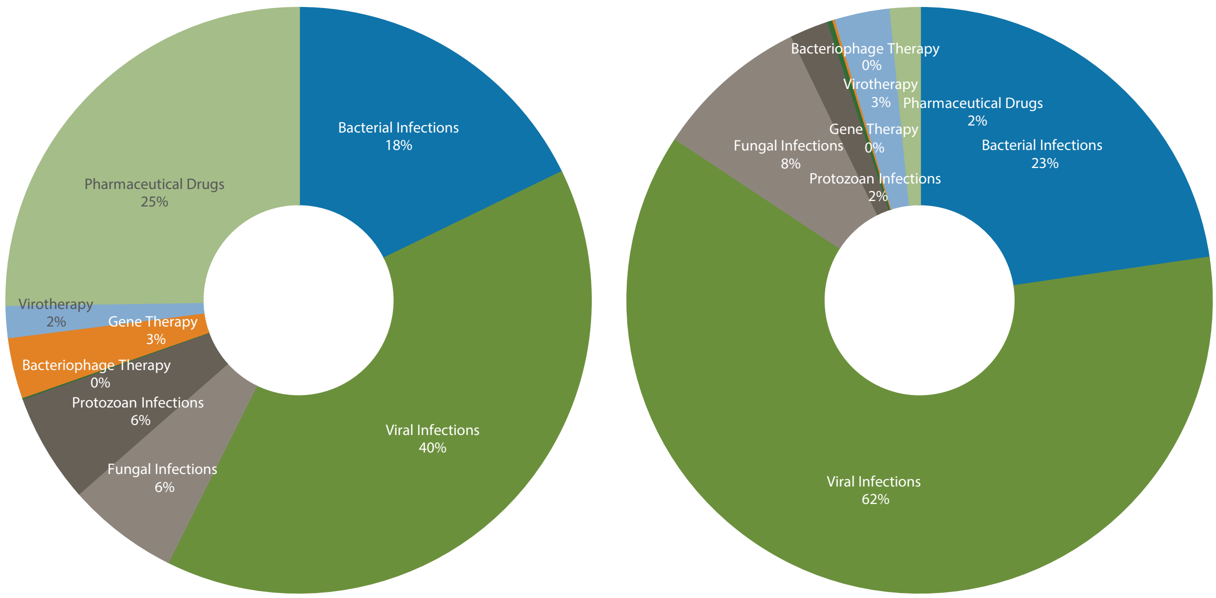

Figure 11 – % of Patent (left) and Scientific Paper (right) Collections by Various Topics in Communicable Diseases

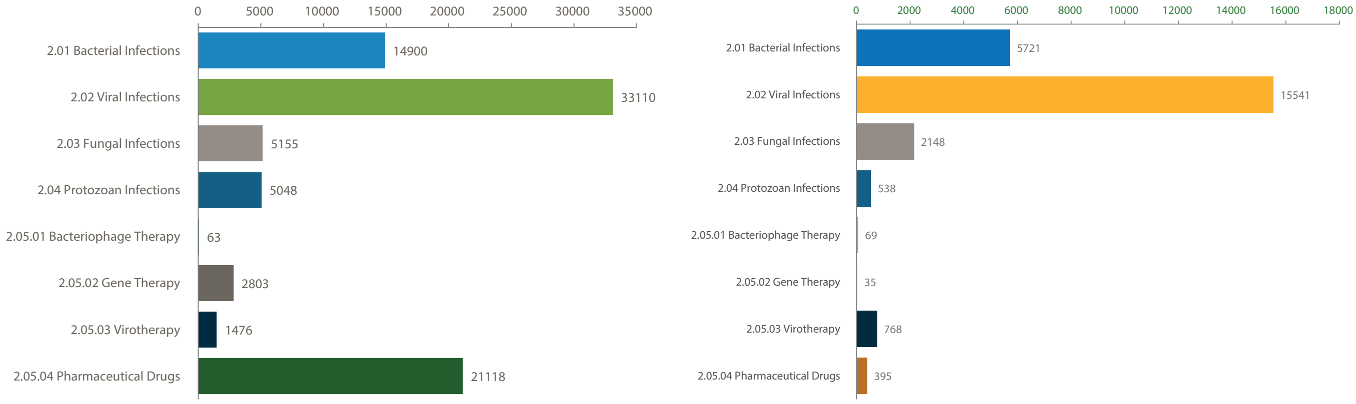

Figure 12 – Number of Patents Families (left) and Scientific Papers (right) per Topic in Communicable Diseases

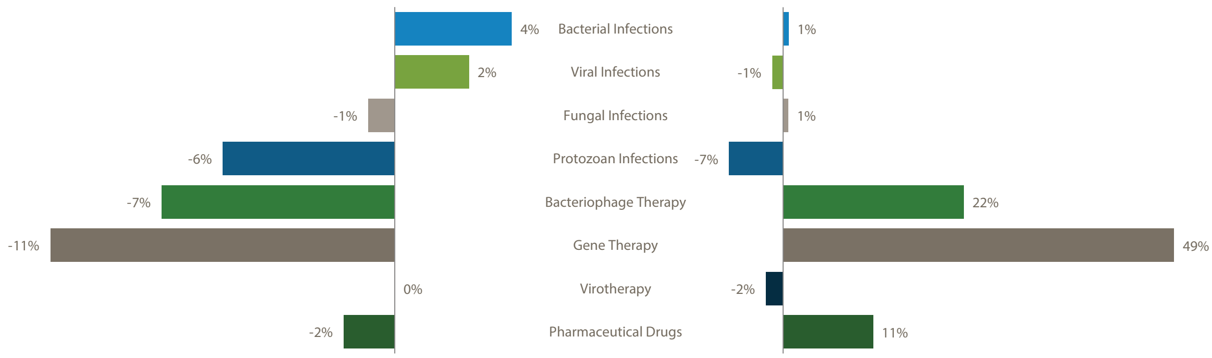

Figure 13 – Average Annual % Growth or Decline in Patent Family (left) or Scientific Paper (right) Output

In spite of the small volume of the scientific publications in the topic of Gene Therapy has shown significant growth in scientific paper collections. Other topics which have observed good growth in the sector of fundamental research are Fungal Infections, Virotherapy and Bacteriophage Therapy. There is some decline is observed for the Pharmaceutical Drugs topic in the patent collection.
Figures 14 through 16 show analyses on each of the data collections (patents, left; papers, right) concerning the nature and technology trends occurring within the Genetic Disorders segment. Within the Genetic Disorders segment Treatment and Single Gene/Chromosomal Disorder topics are active in both data sets, however the Treatment topic has more focus on the fundamental research than commercialization with about 55% of the publications within Genetic Disorders segment are related to Treatment. Further, topics of Multifactorial and Polygenic (Complex) Disorders and Teratogenic Disorders have minimal patenting activity though significant focus for scientific research.

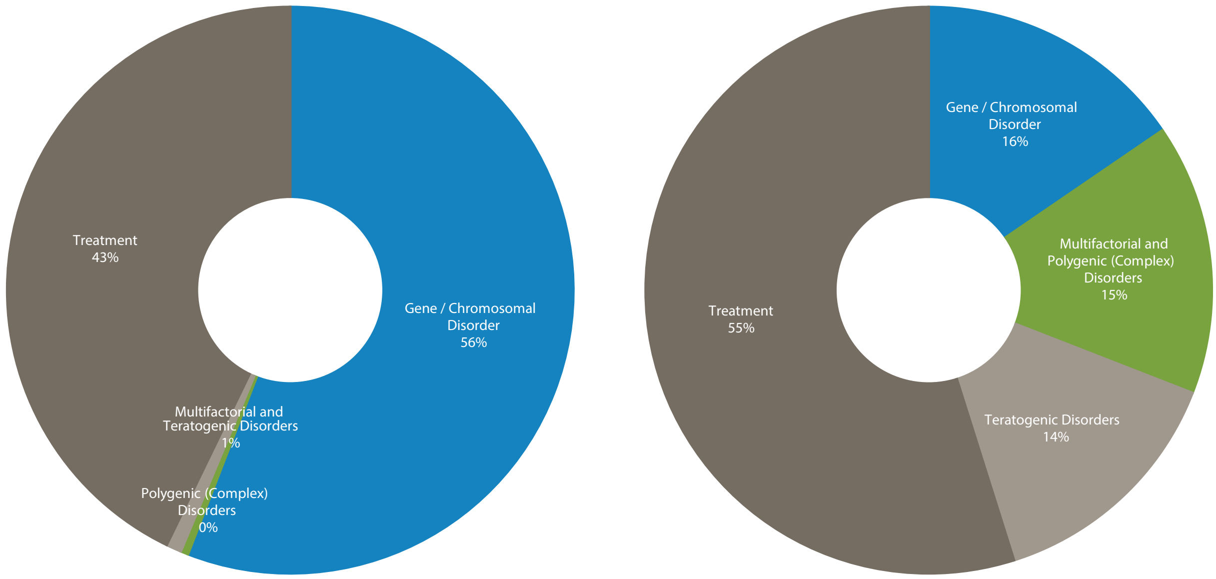

Figure 14 – % of Patent (left) and Scientific Paper (right) Collections by Various Topics in Genetic Disorders

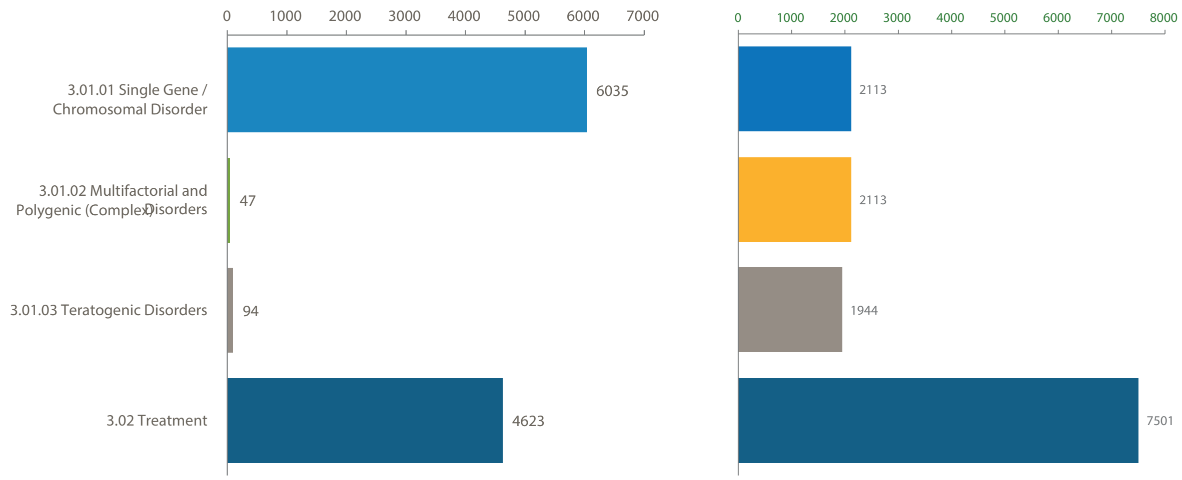

Figure 15 – Number of Patents Families (left) and Scientific Papers (right) per Topic in Genetic Disorders

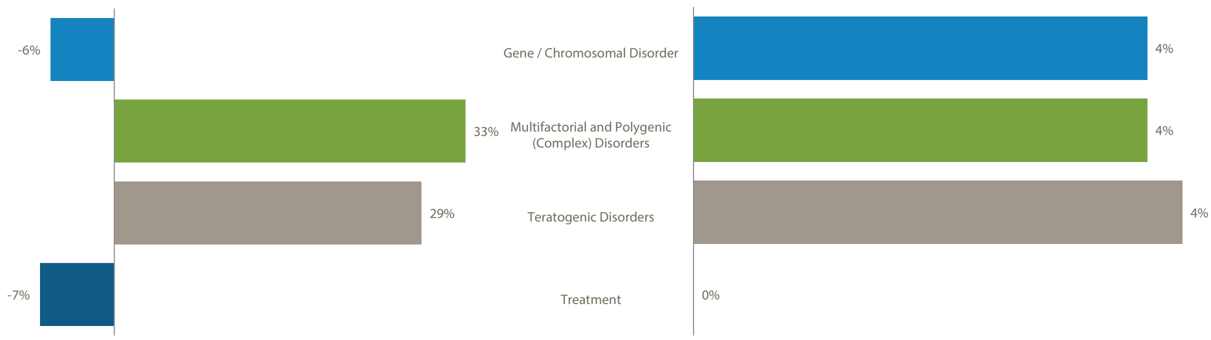

Figure 16 – Average Annual % Growth or Decline in Patent Family (left) or Scientific Paper (right) Output

In spite of the small volume of the patenting activity in the topic of Teratogenic Disorders has shown significant growth in patent collections followed by Multifactorial and Polygenic (Complex) Disorders. Almost all the topics have observed a balanced growth in the sector of fundamental research.

BIOTECHNOLOGY SCIENTIFIC LITERATURE TECHNOLOGY TRENDS

This section of the report focuses on the scientific paper collection and the activity and technological trends seen within it. Based on the Thomson Reuters-produced Web of Science database, the collection only includes papers published in pre-selected journals of influence.
In total, over 80,000 peer reviewed papers were incorporated into the Medical Biotechnology, Cancer Research and Genetics collection.

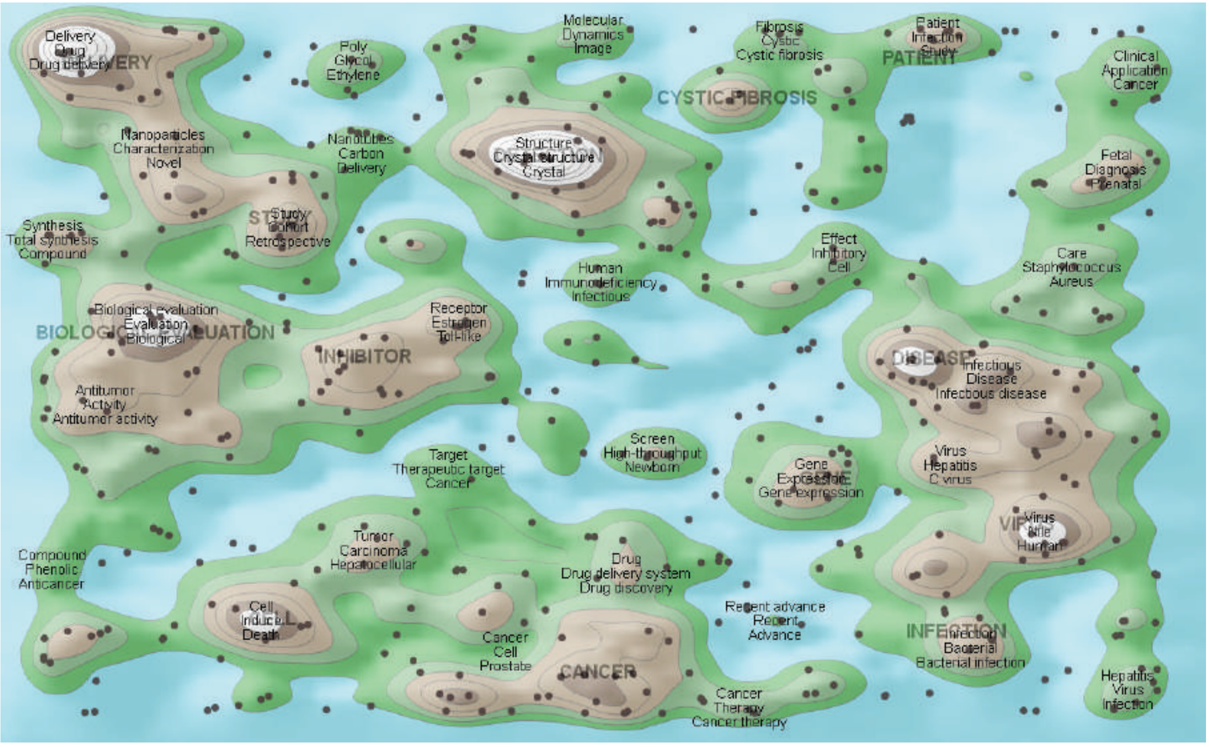

Figure 17 – ThemeScape Map of Scientific Paper Collection; Annotated by Major Themes

Key themes present throughout this collection of papers are illustrated in Figure 17 as a "ThemeScape map" - a visualization method for understanding the common themes and concepts within thousands of documents. Used for market analysis, government intelligence and primarily technology landscapes, the algorithm parses large amounts of text into a topological map of peaks and troughs.
Themes that are commonly shared between documents are represented by mountainous peaks, whereas documents that share little commonality are located within the valleys of the map. The large number of documents in this map means that there are rather few valleys to be found.
The location of an individual document is the vector sum of all the attractions to other documents in the collection based on shared phraseology and the frequency and proximity of these terms.
This map has been manually annotated to summarize the major technology areas within the scientific literature collection. Some technologies will necessarily overlap, and the delineation of one technical area versus another is therefore only approximate. However the map is very useful in describing what topics are common features of global Medical Biotechnology, Cancer Research and

Genetics research.
Key themes revealed in this Themescape map focus mainly on drug delivery, biological evaluation, drug design, communicable diseases, cancer, and synthesis of antitumor drugs.

ThemeScape® is a text-mining application that acquires and analyzes free text. The algorithms it uses require no application of thesauri or other outside sources of information, and only the free text itself is used by this text-mining tool. The more text the application acquires, the more likely it will be that the output will provide an accurate summary of the major themes present. After analyzing the text in multiple documents, it pulls together those documents that share related text and pulls apart those with less related text. The outcome 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 pick out topics of interest. It aggregates word forms that share a common stem, but it does not directly aggregate synonyms. Instead, synonyms may be gathered under a common theme because of the other words that co-occur with those synonyms. Thus, “battery” and “cell” may be clustered together because of the co-occurrence in the same documents of terms like “electrode, rechargeable, electrolyte” and so on. Conversely, “battery” and “cell” may be separated if the map contains a mixture of documents on metals and biology, where the two terms have different meanings. In other words, terms are identified as synonyms only by co-clustering based on common context.

The topographical maps presented by ThemeScape are mathematical solutions built on a random selection of a first document and sequential calculation of the relationships of all the other documents. The orientation of the map is random, and the directions up, down, left, or right have no significance, because the n-dimensional solution might have been presented from any angle. Only the proximity of points within the map has meaning, and co-localized documents are highly likely to share concepts.

In this report there are separate ThemeScape maps covering scholarly papers or patents. The two types of documents are not pooled and analyzed together. This is because ThemeScape is context-sensitive, and it would separate patent and literature documents from one another based on the very different formal styles of writing that are reflected in these two types of content. Likewise, if documents in two languages are pooled, it will separate them based on the language, and then each language region will be clustered based on term frequency in that language.

The ThemeScape maps in this report analyze large numbers of documents. The contour lines on the maps diminish in circumference, encircling regions of higher and higher concentration. The density is also shown by the map coloration. White snow-capped peaks represent the highest density, while blue expanses (sea level) indicate low density.

The labels in black on the map are selected by ThemeScape based on term frequency in that map region, and they may have been adjusted by the analyst. The large color-overlay regions enclosed by broken lines have been added by the analyst to identify content at an even higher level of abstraction. The dots on the map represent single documents. Dots are not shown for all the documents, and instead represent a sampling that allows the other features of the map to be discerned. Within the ThemeScape application, the map can be magnified, searched, probed and highlighted to learn more about its contents.

ThemeScape is reliant on statistical methods that are not equivalent to reading by human judges, and in compensation, it analyzes millions of documents on a scale of minutes and quickly presents an intuitive, high level summary. It enables and guides further review, and provides a first level overview of very complex datasets.

BIOTECHNOLOGY SCIENTIFIC LITERATURE SEGMENTATION

Table 1 shows the further segmentation of biotechnology topics. Within Medicinal Chemistry (Drug Design), computer aided drug design is an emerging field with relatively low volumes and a high growth rate. Other emerging areas with increasing interest are liposomes, micelles and dendrimers. Nanoparticles appear to be a mature area, however still has potential with high growth rate. Within communicable diseases, fungal infections, gene therapy, and virotherapy are emerging areas with growing interest.

Technology Segmentation		Total Inventions	Average % Growth or Decline ('08-'13)
1 Medicinal Chemistry (Drug Design)	1.01.01 Computer-Aided Drug Design (CADD)	3697	13%
	1.01.02 Non-Computed-Aided Drug Design	16551	13%
	1.02 Synthesis of Antitumor Drugs	14972	14%
	1.03 Biological Evaluation	5748	8%
	1.04.01 Nanoparticles	12664	32%
	1.04.02 Liposomes	2897	16%
	1.04.03 Micelles	3123	31%
	1.04.04 Dendrimers	794	15%
	1.04.05 Others	5721	1%
2 Communicable Diseases	2.01 Bacterial Infections	5721	1%
	2.02 Viral Infections	15541	-1%
	2.03 Fungal Infections	2148	1%
	2.04 Protozoan Infections	538	-7%
	2.05.01 Bacteriophage Therapy	69	22%
	2.05.02 Gene Therapy	35	49%
	2.05.03 Virotherapy	768	-2%
	2.05.04 Pharmaceutical Drugs	395	11%
3 Genetic Disorders	3.01.01Single Gene / Chromosomal Disorder	2113	4%
	3.01.02 Multifactorial and Polygenic (Complex) Disorders	2113	4%
	3.01.03 Teratogenic Disorders	1944	4%
	3.02 Treatment	7501	-

Table 1 – Scientific Literature Technology Segmentation

SCIENTIFIC LITERATURE COLLECTION TECHNOLOGY CATEGORY OVERLAP

The technology segments, that were created to enumerate and describe the Biotechnology landscape in the areas of Medical Biotechnology, Cancer Research and Genetics, were not intended to be mutually exclusive. A single scientific paper can be included in multiple categories or segments. Figure 18 visualizes the relationship between the three broad technology segments used in this study. Each number in the diagram shows the number of papers that have content related to both the corresponding row-wise and column-wise segments.
The most correlated segment pairing is Medicinal Chemistry (Drug Design) with Communicable Diseases.

	1.0 Medicinal Chemistry (Drug Design	2.0 Communicable Diseases	3.0 Genetic Disorders
1.0 Medicinal Chemistry (Drug Design	53793	5762	119
2.0 Communicable Diseases		22025	72
3.0 Genetic Disorders			10354

Figure 18 – Number of Scientific Papers per Pair of Technology Segments

SCIENTIFIC PAPER GEOGRAPHIC VOLUME BENCHMARKING

Figure 19 shows the number of scientific papers for the ten most prolific countries within the scientific paper collection.
United Sates is the largest source of Medical Biotechnology, Cancer Research and Genetics -related peer-reviewed papers, followed by the China, United Kingdom, Germany, Italy, and India. These 10 most prolific countries contribute to about 89% of the scientific publications in the field of Medical Biotechnology, Cancer Research and Genetics.

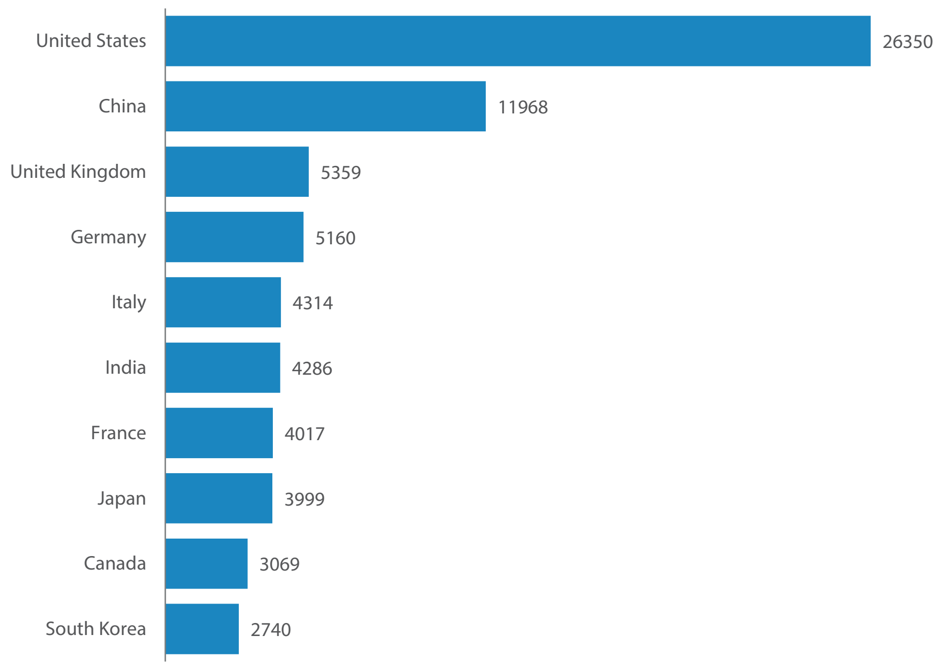

Figure 19 – Number of Scientific Papers per Country; Top 10 Sources

SCIENTIFIC PAPER GEOGRAPHIC ACTIVITY TRENDS

The chart below shows the highest grow rates sources in the scientific literature collection.

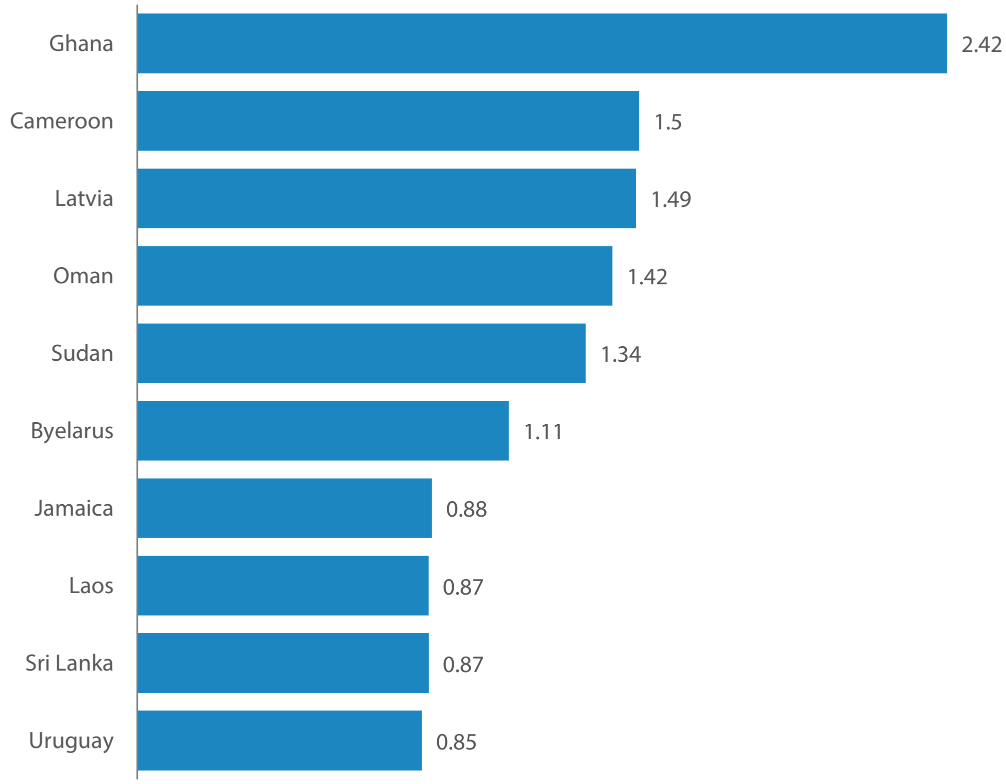

Figure 20 – Highest Growth Rate Geographies in Scientific Publications Output

While the average number of scientific literature publication from Ghana, Cameroon, Sudan and Oman is about 30 and very small relative to the collections of the most prolific countries, the growth rate of Ghana, Cameroon, Sudan and Oman collection far exceeds that of other countries.

SCIENTIFIC PAPER GEOGRAPHIC CITATION IMPACT BENCHMARKING

Scientific paper and patent citations are routinely used in technology bibliometrics for assessing the inherent impact and potential quality of research and the downstream technical and scientific relevance of the underlying research.

Figure 21 shows the "Citation Impact", the average citation per paper for all papers in a country's collection (which are having at least 500 publications) and has been sorted by highest citation impact. This shows that output from Switzerland, United States, United Kingdom, Netherlands and Belgium are having the highest impact in the field of Medical Biotechnology, Cancer Research and Genetics.

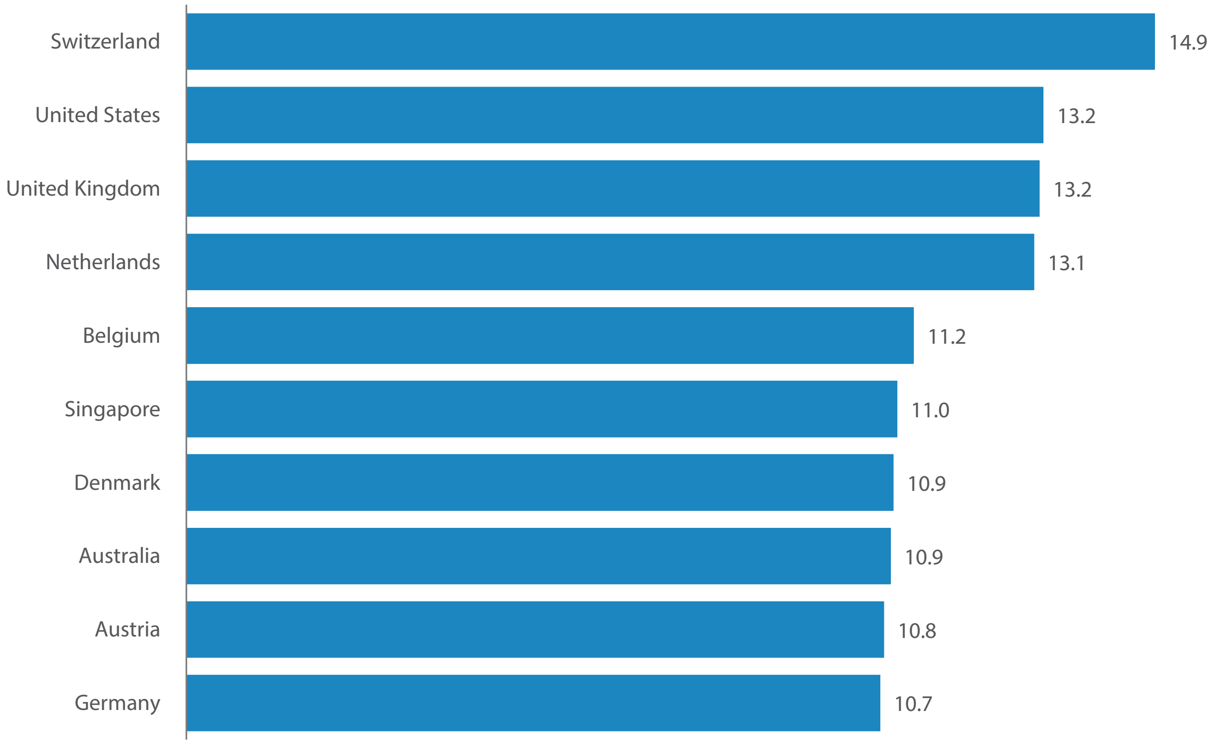

Figure 21 – Highest Citation Impact Geographies of Scientific Publications

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Note that the journals included in the project source data (Web of Science) are selected on the basis of both quantitative and qualitative selection criteria, such as editorial quality, peer review robustness and citation impact. Further details of the journal selection process is available from : http://thomsonreuters.com/products_services/science/free/essays/journal_selection_process/

SCIENTIFIC LITERATURE COLLECTION BY GEOGRAPHY

Table 2 shows the split of Medical Biotechnology, Cancer Research and Genetics science and research specialization for the top nations. China, Kingdom of Saudi Arabia, Egypt and India are dominantly active in Medicinal Chemistry (Drug Design) domain. United States, United Kingdom and Germany are focusing on Communicable diseases along with Medicinal Chemistry.

Country of Origin	1 Medicinal Chemistry (Drug Design)	2 Communicable Diseases	3 Genetic Disorders
United States	65%	29%	13%
China	83%	15%	5%
United Kingdom	56%	33%	19%
Germany	61%	30%	18%
Italy	68%	21%	17%
India	84%	15%	6%
France	57%	38%	16%
Japan	68%	28%	12%
Canada	61%	31%	16%
South Korea	81%	15%	8%
Spain	63%	31%	15%
Australia	57%	36%	16%
Brazil	50%	45%	16%
Netherlands	52%	35%	23%
Taiwan	73%	22%	9%
Switzerland	63%	32%	14%
Belgium	59%	33%	17%
Sweden	60%	31%	19%
Iran	70%	27%	9%
Turkey	57%	31%	23%
Poland	71%	22%	17%
Egypt	83%	14%	6%
Singapore	78%	22%	6%
Austria	63%	26%	20%
Israel	59%	30%	21%
Portugal	75%	20%	12%
Denmark	55%	32%	23%
Saudi Arabia	83%	13%	10%
Greece	63%	25%	20%
Norway	50%	43%	15%
Thailand	49%	47%	14%
South Africa	44%	50%	15%
Czech Republic	73%	19%	15%
Russia	78%	21%	7%
Mexico	56%	48%	11%
Finland	66%	30%	15%

Table 2 – Specialization by Country; % of Literature Activity per Technical Stream

SCIENTIFIC LITERATURE - PROLIFIC ENTITIES

Universities appear to dominate the scientific paper publications in biotechnologies. The most prolific universities appear to be primarily from the United States – University of California, Harvard University and NCI; all with high citations per paper, indicating widely recognized scientific literature. While Science & Technology Unit, Umm al Qura University (STU-UQU) has 16 papers published in this space, with a relatively low citation count, as compared to other entities within the top 30.

Entity	Total	Times Cited	Citation per paper
Science & Technology Unit, Umm Al Qura University (STU-UQU)	16	33	2.1
Chinese Acad Sci	2000	13575	6.8
Univ Calif San Francisco	1738	33070	19.0
Harvard Univ	1320	27690	21.0
Univ N Carolina	777	11889	15.3
NCI	736	15667	21.3
Univ Texas Md Anderson Canc Ctr	597	9636	16.1
Univ Toronto	579	8175	14.1
Univ Michigan	556	10517	18.9
Sichuan Univ	551	3470	6.3
Fudan Univ	545	5214	9.6
Zhejiang Univ	538	3849	7.2
Natl Univ Singapore	536	6130	11.4
Univ Washington	531	9209	17.3
Johns Hopkins Univ	527	7166	13.6
Shanghai Jiao Tong Univ	518	4584	8.8
Univ Penn	480	7580	15.8
Inserm	477	5934	12.4
Univ Pittsburgh	460	7064	15.4
Univ Sao Paulo	457	2523	5.5
Emory Univ	441	10137	23.0
Univ Minnesota	440	5215	11.9
Cnrs	434	4905	11.3
Ohio State Univ	433	4703	10.9
China Pharmaceut Univ	426	1874	4.4
Peking Univ	422	4161	9.9
Stanford Univ	421	10967	26.0
Univ Illinois	420	4281	10.2
Seoul Natl Univ	408	3449	8.5
Duke Univ	405	8119	20.0
Univ Oxford	393	6518	16.6

Table 3 – Biotechnology – Top entities for Scientific Literature

SCIENTIFIC LITERATURE OVERVIEW OF TOP GLOBAL ENTITIES

Table 4 shows the technology profile of the top 30 entities within the scientific literature space of biotechnology. The top entities appear to be researching most in non-computer aided drug design, synthesis of antitumor drugs, nanoparticles, viral infections, and treatment (of genetic disorders) – which conforms with the overall landscape. Science & Technology Unit, Umm al Qura University (STU-UQU) appears to be primarily focused on medicinal chemistry (drug design) technologies – computer aided drug design, non-computer aided drug design, biological evaluation, and most notably synthesis of anti-tumor drugs.

Table 4 – Scientific literature overview of top global entities (continued on next page)

Entity	1.01.01 Computer-Aided Drug Design (Cadd	1.01.02 Non-Computed-Aided Drug Design	1.02 Synthesis Of Antitumor Drugs	1.03 Biological Evaluation	1.04.01 Nanoparticles	1.04.02 Liposomes	1.04.03 Micelles	1.04.04 Dendrimers	1.04.05 Others
Science & Technology Unit, Umm Al Qura University (STU-UQU)	2	5	7	3					1
Chinese Acad Sci	77	409	363	197	699	50	251	24	33
Univ Calif San Francisco	73	384	215	75	230	79	46	12	140
Harvard Univ	57	442	160	42	167	40	16	3	95
Univ N Carolina	34	149	122	53	140	43	18	5	49
NCI	44	296	146	78	53	25	3	7	10
Univ Texas Md Anderson Canc Ctr	39	251	87	29	87	25	14	1	13
Univ Toronto	34	162	82	25	82	24	27	2	33
Univ Michigan	20	163	84	19	118	7	10	57	39
Sichuan Univ	48	82	122	37	257	66	145	26	17
Fudan Univ	18	78	78	26	291	41	58	19	12
Zhejiang Univ	35	97	96	69	194	42	114	13	12
Natl Univ Singapore	25	153	111	31	188	32	51	8	16
Univ Washington	15	102	44	10	64	9	14		48
Johns Hopkins Univ	23	157	52	20	53	7	4	6	32
Shanghai Jiao Tong Univ	30	88	88	39	223	31	59	24	10
Univ Penn	18	120	41	20	40	9	9	4	36
Inserm	23	82	55	25	35	11	7	1	45
Univ Pittsburgh	25	122	64	24	31	7	16	2	18
Univ Sao Paulo	17	49	67	30	42	13	2	1	43
Emory Univ	9	69	38	17	68	11	12	2	28
Univ Minnesota	21	91	65	23	56	20	13	1	37
Cnrs	12	81	73	53	94	22	12	19	36
Ohio State Univ	28	108	83	27	40	29	7	2	34
China Pharmaceut Univ	44	79	161	114	128	34	57	3	
Peking Univ	19	77	97	41	150	60	66	10	4
Stanford Univ	28	106	46	17	54	4	4	1	25
Univ Illinois	21	86	87	44	75	12	19	8	21
Seoul Natl Univ	10	99	80	30	117	19	29	1	13
Duke Univ	8	91	35	7	43	19	17	3	35
Univ Oxford	14	103	28	21	17	7			54

Entity	2.01 Bacterial Infections	2.02 Viral Infections	2.03 Fungal Infections	2.04 Protozoan Infections	2.05.01 Bacteriophage Therapy	2.05.02 Gene Therapy	2.05.03 Virotherapy	2.05.04 Pharmaceutical Drugs	3.01.01Single Gene / Chromosomal Disorder	3.01.02 Multifactorial And Polygenic (Complex) Disorders	3.01.03 Teratogenic Disorders	3.02 Treatment
Science & Technology Unit, Umm Al Qura University (STU-UQU)	1											1
Chinese Acad Sci	33	350	11	3			16	1	16	16	8	60
Univ Calif San Francisco	140	389	57	9		4	37	27	38	38	69	218
Harvard Univ	95	246	27	5	1	1	17	12	31	31	30	142
Univ N Carolina	49	182	12	6	1		15	4	27	27	12	83
NCI	10	123	7	1			6	1	16	16	3	41
Univ Texas Md Anderson Canc Ctr	13	26	25				2	8	34	34		74
Univ Toronto	33	69	17				5	7	23	23	31	78
Univ Michigan	39	74	19	2			2	2	16	16	7	56
Sichuan Univ	17	26	3	3		1	1	1	5	5	4	11
Fudan Univ	12	37	2				2		4	4	5	13
Zhejiang Univ	12	63	11	2		1	1	1	3	3	3	20
Natl Univ Singapore	16	57	3				6	2	4	4	7	15
Univ Washington	48	162	14	4	1		13	2	17	17	22	76
Johns Hopkins Univ	32	132	11	4			9	10	18	18	9	63
Shanghai Jiao Tong Univ	10	24	4				3		9	9	6	37
Univ Penn	36	108	12	3			7	6	29	29	13	88
Inserm	45	130	14	5		1	7	4	20	20	13	62
Univ Pittsburgh	18	112	15	1			5	7	20	20	11	63
Univ Sao Paulo	43	104	42	20			2	3	10	10	14	75
Emory Univ	28	143	7	8			7	6	17	17	8	69
Univ Minnesota	37	104	15	1			6	3	13	13	5	53
Cnrs	36	85	16	5					5	5		20
Ohio State Univ	34	83	4		1		3	1	21	21	4	49
China Pharmaceut Univ		1					1				1	2
Peking Univ	4	26	6					1	7	7	6	16
Stanford Univ	25	84	11	1	1			3	10	10	23	53
Univ Illinois	21	79	17	4			5	3	7	7	4	36
Seoul Natl Univ	13	43	11				1		8	8	5	31
Duke Univ	35	80	36	1		2	10	6	15	15	5	72
Univ Oxford	54	113	9	4	1		7	4	15	15	9	46

SCIENTIFIC LITERATURE OVERVIEW OF TOP ASIA PACIFIC ENTITIES

Table 5 – Scientific literature overview of top Asia Pacific entities

Entity	Country of Origin	Total	1.01.01 Computer-Aided Drug Design (Cadd	1.01.02 Non-Computed-Aided Drug Design	1.02 Synthesis Of Antitumor Drugs	1.03 Biological Evaluation	1.04.01 Nanoparticles	1.04.02 Liposomes	1.04.03 Micelles	1.04.04 Dendrimers	1.04.05 Others	2.01 Bacterial Infections	2.02 Viral Infections	2.03 Fungal Infections	2.04 Protozoan Infections	2.05.01 Bacteriophage Therapy	2.05.02 Gene Therapy	2.05.03 Virotherapy	2.05.04 Pharmaceutical Drugs	3.01.01Single Gene / Chromosomal Disorder	3.01.02 Multifactorial And Polygenic (Complex) Disorders	3.01.03 Teratogenic Disorders	3.02 Treatment
Science & Technology Unit, Umm Al Qura University (STU-UQU)	Saudi Arabia	16	2	5	7	3					1	1											1
Chinese Acad Sci	China	2000	77	409	363	197	699	50	251	24	33	33	350	11	3			16	1	16	16	8	60
Sichuan Univ	China	551	48	82	122	37	257	66	145	26	17	17	26	3	3		1	1	1	5	5	4	11
Fudan Univ	China	545	18	78	78	26	291	41	58	19	12	12	37	2				2		4	4	5	13
Zhejiang Univ	China	538	35	97	96	69	194	42	114	13	12	12	63	11	2		1	1	1	3	3	3	20
Natl Univ Singapore	Singapore	536	25	153	111	31	188	32	51	8	16	16	57	3				6	2	4	4	7	15
Shanghai Jiao Tong Univ	China	518	30	88	88	39	223	31	59	24	10	10	24	4				3		9	9	6	37
China Pharmaceut Univ	China	426	44	79	161	114	128	34	57	3			1					1				1	2
Peking Univ	China	422	19	77	97	41	150	60	66	10	4	4	26	6					1	7	7	6	16
Seoul Natl Univ	South Korea	408	10	99	80	30	117	19	29	1	13	13	43	11				1		8	8	5	31
Nanjing Univ	China	383	52	60	92	93	153	15	37	2	2	2	13	2				2				1	5
Shandong Univ	China	381	18	89	99	63	111	22	47	4	5	5	13	2						5	5	5	19
Sun Yat Sen Univ	China	381	25	86	59	48	93	18	37	3	13	13	69	4						1	1	3	10
Univ Tokyo	Japan	366	17	102	51	22	57	8	57	7	23	23	80	3	1	1		3		7	7	1	27
Natl Taiwan Univ	Taiwan	354	16	57	39	26	95	18	26	3	13	13	86	6	3		1	5	1	8	8	2	20
Soochow Univ	China	294	20	56	34	18	171	17	76	4	2	2	5		2					8	8		9
China Med Univ	Taiwan	276	30	82	66	46	17	7	5	1	5	5	24	2						5	5	16	12
Jilin Univ	China	274	4	41	46	11	121	11	57	6	10	10	37	1	1			1		4	4		15
Kyoto Univ	Japan	274	9	78	49	22	38	26	17	2	5	5	56	5				3		4	4	4	18
Shenyang Pharmaceut Univ	China	272	15	51	114	50	97	40	50	2	1	1											
Wuhan Univ	China	254	14	44	51	23	110	15	54	3	9	9	32	2		1		1		3		1	2

SCIENTIFIC LITERATURE OVERVIEW OF TOP MIDDLE EAST & AFRICA ENTITIES

Table 6 visualizes the prolific entities in the Middle East and Africa. The list is dominated by Middle Eastern entities, reflecting the trends seen in table 5 above. Most of the prolific entities in these regions seem to be focusing on non-computed-aided drug design, synthesis of antitumor drugs, viral infections and treatment segments. Most of the African entities have major focus on viral infections.

Entity	Country of Origin	Total	1.01.01 Computer-Aided Drug Design (Cadd	1.01.02 Non-Computed-Aided Drug Design	1.02 Synthesis Of Antitumor Drugs	1.03 Biological Evaluation	1.04.01 Nanoparticles	1.04.02 Liposomes	1.04.03 Micelles	1.04.04 Dendrimers	1.04.05 Others
Science & Technology Unit, Umm Al Qura University (STU-UQU)	Saudi Arabia	16	2	5	7	3					1
King Saudi Univ	Saudi Arabia	284	13	49	152	41	47	8	1		11
Cairo Univ	Egypt	275	12	40	175	44	8	6			8
Univ Tehran Med Sci	Iran	248	13	29	77	20	83	16	12	4	13
Islamic Azad Univ	Iran	142	18	9	35	10	31	7	5	4	15
King Abdul Aziz Univ	Saudi Arabia	129	6	39	44	27	18	4	2	2	7
Univ Tehran	Iran	127	15	18	38	19	28	1	6		2
Hacettepe Univ	Turkey	120	3	11	32	3	31	7	3	1	3
Univ Cape Town	South Africa	117	1	16	13	4	1			3	10
Istanbul Univ	Turkey	105		15	15	5		1			7
Ain Shams Univ	Egypt	91	9	17	55	14	7		2		2
Univ Pretoria	South Africa	91	4	10	13	2		1			9
Univ Witwatersrand	South Africa	88	1	5	6	4	4				9
Shahid Beheshti Univ Med Sci	Iran	84	3	11	32	7	24	7	8	3	1
Al Azhar Univ	Egypt	83	7	15	54	9	4				1
Mansoura Univ	Egypt	80	7	16	54	15	1				
Tabriz Univ Med Sci	Iran	79		8	14	2	38	9	8	4	2
Ankara Univ	Turkey	76	3	8	26	7	4	3			7
Shiraz Univ Med Sci	Iran	75	3	8	23	5	8	3	3	3	7
Ege Univ	Turkey	73		3	18	13	17	1	1		9
Mashhad Univ Med Sci	Iran	72	3	7	16	5	18	6	3		2
Univ Alexandria	Egypt	68	1	9	33	17	10	2	3		3
Gazi Univ	Turkey	67	3	5	27	7	8	2	1	1	6
Pasteur Inst Iran	Iran	60	4	5	8	3	20	6	2	3	2
Univ Stellenbosch	South Africa	58	2	2	10	2			1		2
Tarbiat Modares Univ	Iran	55	2	1	15	5	26	4	6	1	
Univ Jordan	Jordan	55	24	6	14	14	4	3	1		
Univ Kwazulu Natal	South Africa	50		5	14	3	6	4	2	2	3
Isfahan Univ Med Sci	Iran	48	1	4	14	4	14	4	10		
Zagazig Univ	Egypt	48	3	2	25	4	5	7	1		2
Assiut Univ	Egypt	42	5	7	23		10	3	5	1	2

Entity	Country of Origin	Total	2.01 Bacterial Infections	2.02 Viral Infections	2.03 Fungal Infections	2.04 Protozoan Infections	2.05.01 Bacteriophage Therapy	2.05.02 Gene Therapy	2.05.03 Virotherapy	2.05.04 Pharmaceutical Drugs	3.01.01 Single Gene / Chromosomal Disorder	3.01.02 Multifactorial And Polygenic (Complex) Disorders	3.01.03 Teratogenic Disorders	3.02 Treatment
Science & Technology Unit, Umm Al Qura University (STU-UQU)	Saudi Arabia	16	1											1
King Saudi Univ	Saudi Arabia	284	11	17	2	1			2		2	2	1	13
Cairo Univ	Egypt	275	8	19	4	1		1	1		5	5	7	12
Univ Tehran Med Sci	Iran	248	13	22	3	3			1	1	5	5	4	24
Islamic Azad Univ	Iran	142	15	32	5	4					1	1		3
King Abdul Aziz Univ	Saudi Arabia	129	7	9	1						3	3	1	7
Univ Tehran	Iran	127	2	21	1				2					5
Hacettepe Univ	Turkey	120	3	15	5				2	3	3	3	2	28
Univ Cape Town	South Africa	117	10	54	2				3	3	3	3	9	12
Istanbul Univ	Turkey	105	7	27	7	1			1	1	9	9	7	25
Ain Shams Univ	Egypt	91	2	6	1	1					2	2	1	4
Univ Pretoria	South Africa	91	9	49	4	2			1		2	2		4
Univ Witwatersrand	South Africa	88	9	41	4	2			5		3	3	6	22
Shahid Beheshti Univ Med Sci	Iran	84	1	11	1	1			1		1	1	2	5
Al Azhar Univ	Egypt	83	1	4	1									3
Mansoura Univ	Egypt	80		9	1				1		3	3		1
Tabriz Univ Med Sci	Iran	79	2	3		2	1				2	2	1	3
Ankara Univ	Turkey	76	7	15	2	1					3	3		8
Shiraz Univ Med Sci	Iran	75	7	11	6	2	1				9	9	1	7
Ege Univ	Turkey	73	9	8	3						6	6	2	8
Mashhad Univ Med Sci	Iran	72	2	16	2	2	1				2	2		5
Univ Alexandria	Egypt	68	3	6					1		2	2	1	4
Gazi Univ	Turkey	67	6	5	4						3	3	1	8
Pasteur Inst Iran	Iran	60	2	19	1				1	1	1	1		3
Univ Stellenbosch	South Africa	58	2	25	1			1	3	3	5	5	5	9
Tarbiat Modares Univ	Iran	55		9										2
Univ Jordan	Jordan	55		3							1	1		1
Univ Kwazulu Natal	South Africa	50	3	18	1					1	1	1	1	3
Isfahan Univ Med Sci	Iran	48		7		1					2	2		6
Zagazig Univ	Egypt	48	2	8					2		1	1	1	4
Assiut Univ	Egypt	42	2	3	3					1				1

Table 6 – Scientific literature overview of top Middle East & Africa entities

SCIENTIFIC LITERATURE OVERVIEW OF TOP SAUDI ARABIA ENTITIES

Entity	Total	1.01.01 Computer-Aided Drug Design (Cadd	1.01.02 Non-Computed-Aided Drug Design	1.02 Synthesis Of Antitumor Drugs	1.03 Biological Evaluation	1.04.01 Nanoparticles	1.04.02 Liposomes	1.04.03 Micelles	1.04.04 Dendrimers	1.04.05 Others	2.01 Bacterial Infections	2.02 Viral Infections	2.03 Fungal Infections	2.04 Protozoan Infections	2.05.03 Virotherapy	3.01.01Single Gene / Chromosomal Disorder	3.01.02 Multifactorial And Polygenic (Complex) Disorders	3.01.03 Teratogenic Disorders	3.02 Treatment
Science & Technology Unit, Umm Al Qura University (Stu-Uqu	$16.00	2	5	7	3					1	1								1
King Saud Univ	$284.00	13	49	152	41	47	8	1		11	11	17	2	1	2	2	2	1	13
King Abdulaziz Univ	$129.00	6	39	44	27	18	4	2	2	7	7	9	1			3	3	1	7
King Faisal Specialized Hosp & Res Ctr	$36.00	4	3	13	4	3				1	1	6	1			1	1	1	9
Taif Univ	$26.00	3	5	12	7	1				1	1	4							
King Khalid Univ	$19.00			13	2					1	1	2							1
King Abdullah Univ Sci & Technol	$18.00	1	5	7	1	8	1	1				1			1				
Taibah Univ	$18.00		6	10	5														
King Faisal Univ	$16.00			5	2	1				1	1	6	1			1	1		1
Qassim Univ	$16.00		2	6		1	1			2	2	4		1					
King Saud Bin Abdulaziz Univ Hlth Sci	$13.00	1		3	1	3				1	1	2							3
Jazan Univ	$10.00		2	7		1													1
Salman Bin Abdulaziz Univ	$10.00	1	5	4	2	1													
Al Jouf Univ	$8.00		1	4	1	1				1	1								1
King Abdulaziz City Sci & Technol	$7.00		1	2		5													
King Abdulaziz Univ Hosp	$7.00	1			1							1				1	1	1	3
King Abdullah Med City	$7.00			1		1				1	1	4	1						1
King Fahad Med City	$7.00		1							1	1	2	1					1	2
Al Kharj Univ	$6.00	1		3	3	1				1	1								
Alfaisal Univ	$5.00		1									2							2
Minist Hlth	$5.00											3							2
Najran Univ	$5.00		1	1		2		1	1										1
Shaqra Univ	$5.00			5	1														
King Fahd Univ Petr & Minerals	$4.00			4															
Matern & Children Hosp	$4.00															1	1		3
Univ Hail	$4.00	1		3															
Univ Tabuk	$4.00			4															
King Fahad Specialist Hosp	$3.00									1	1	1				1	1		1
Northern Border Univ	$3.00			3															
Princess Nora Bint Abdul Rahman Univ	$3.00			1	2														

Table 7 – Scientific literature overview of top Saudi Arabia entities

MIDDLE EAST & AFRICA BIOTECHNOLOGY SCIENTIFIC LITERATURE TRENDS

This section of the report focuses on the scientific paper collection and the activity and technological trends observed in the Middle East and Africa regions.

MIDDLE EAST & AFRICA – PROLIFIC COUNTRIES

Figure 22 below shows the prolific countries by scientific literature volume in the Middle East & Africa regions. The gray bars indicate Middle East, blue indicates Africa, and green indicates the Kingdom of Saudi Arabia. As seen from the figure, the most prolific countries within these regions are Iran and Turkey, followed by Egypt, Saudi Arabia, and South Africa.

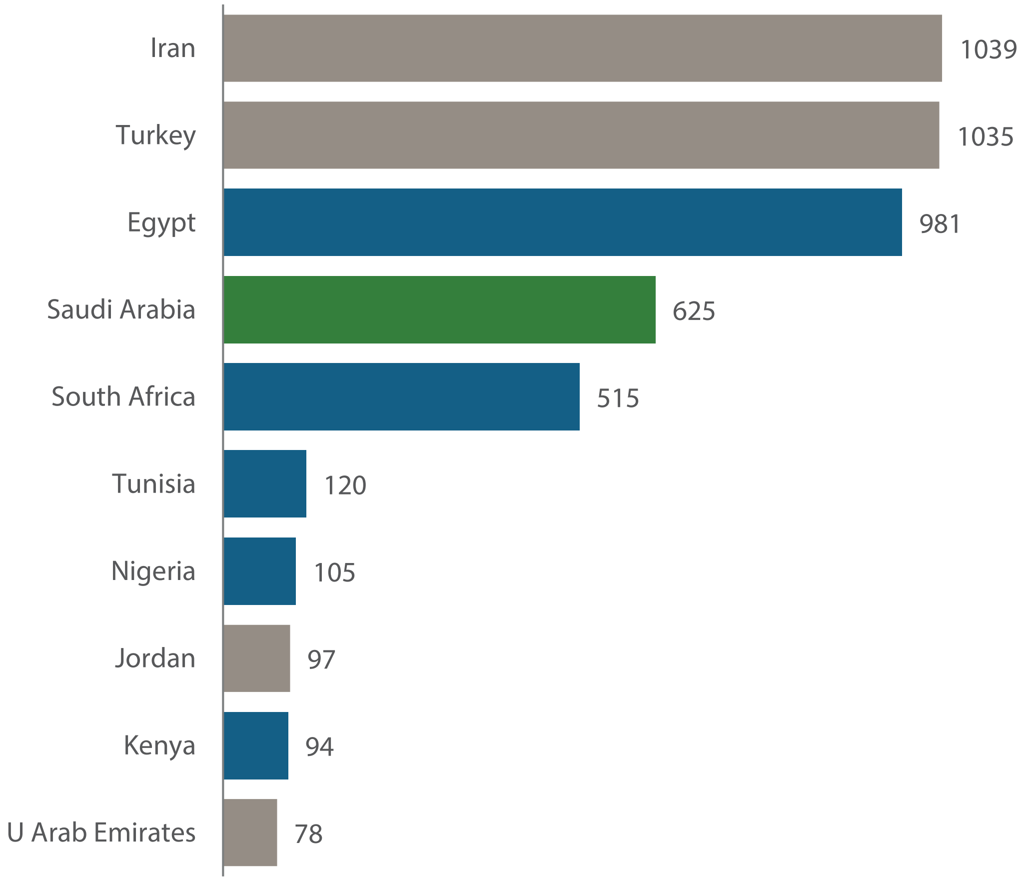

Figure 22 – Middle East & Africa – Prolific Countries in Scientific Literature

A more detailed analysis of the technologies of focus in each of the countries within the Middle East and Africa is presented with reference to tables 5 and 6. Focus appears to be on Synthesis of Antitumor Drugs, Viral Infections and Treatment of cancer. Kingdom of Saudi Arabia (KSA) is focusing on Biological Evaluation and Nanoparticles technology segments in addition to above three dominant technologies.

Country of Origin	1.01.01 Computer-Aided Drug Design (Cadd	1.01.02 Non-Computed-Aided Drug Design	1.02 Synthesis Of Antitumor Drugs	1.03 Biological Evaluation	1.04.01 Nanoparticles	1.04.02 Liposomes	1.04.03 Micelles	1.04.04 Dendrimers	1.04.05 Others	2.01 Bacterial Infections	2.02 Viral Infections	2.03 Fungal Infections	2.04 Protozoan Infections	2.05.01 Bacteriophage Therapy	2.05.02 Gene Therapy	2.05.03 Virotherapy	2.05.04 Pharmaceutical Drugs	3.01.01Single Gene / Chromosomal Disorder	3.01.02 Multifactorial And Polygenic (Complex) Disorders	3.01.03 Teratogenic Disorders	3.02 Treatment
Iran	52	102	260	70	277	57	57	25	66	66	205	20	12	3		3	3	25	25	10	69
Turkey	18	101	240	66	113	22	12	10	118	118	193	49	6		1	7	13	48	48	61	154
Egypt	59	156	549	148	64	21	16	1	31	31	107	14	4		1	6	3	13	13	11	39
Saudi Arabia	27	113	281	88	89	14	5	3	28	28	54	6	2			2		7	7	6	50
South Africa	18	61	76	22	22	8	6	5	45	45	209	22	4	2	2	12	6	19	19	20	54
Tunisia	2	12	14	7	1				18	18	34	5	1					4	4	4	22
Nigeria	1	10	14	2	3	1			15	15	48	5	1			4		5	5	3	9
Jordan	24	9	29	20	6	3	2		3	3	17							1	1	1	4
Kenya		5	6	1	1		1		15	15	58	1	3			2	1	3	3		4
U Arab Emirates	3	11	17	6	15	5	13		7	7	10	5						3	3	3	6
Morocco	2	13	16	6	4			4	9	9	12	5	1					1	1	2	6
Lebanon	4	9	9	3	11	2	4		7	7	12	5				1	1	5	5	6	8
Cameroon	4	11	15	5					8	8	19	4	3					2	2		4
Uganda		2							4	4	38	2	2			3	2	4	4	2	4
Tanzania			1	1	4		1		12	12	28	1	2			3		2	2		5
Ethiopia		2	3	1					8	8	21	1	3				2	2	2		2
Algeria	5	6	13	6	2		1		5	5	5	1				1		2	2		1
Iraq		3	17	1	4		1		3	3	5							2	2		2
Kuwait	5	6	8	2	1			1	3	3	6	1				1		3	3		5
Ghana		1	3						7	7	17	1	2			2	1				3
Oman	1	3	9	2	4	2			3	3	5	1						5	5		3
Sudan	4	3	4		1				4	4	11	1	1					2	2		1
Malawi									3	3	17	1						2	2	1	2
Qatar		5	4	1					1	1	5	1					1	3	3		5
Zambia			1						1	1	20		1				1				
Senegal		1							5	5	10	3	2			1		3	3		2
Libya	3		10	1	1				1	1	7	1					1				
Madagascar		5	3	1					4	4	9	1	1								
Cote Ivoire									4	4	10	1	2			2				1	1
Gabon		1							1	1	12	1	1								3
Zimbabwe	1		1						3	3	14							1	1		1

Table 8 – Middle East & Africa –Countries over Technical categories

BIOTECHNOLOGY PATENT COLLECTION TECHNOLOGY TRENDS

This section of the report focuses on the patent collections produced for the study and the activity and technological trends seen within it. Based on the Thomson Reuters-produced Derwent World Patents Index database, the collection includes both pending patent applications and granted patents published in 47 countries around the world.

A total of approximately 80,000 patented inventions were gathered that are applicable to the various Medical Biotechnology, Cancer Research and Genetics technology segments of interest to Science & Technology Unit, Umm al Qura University (STU-UQU). These inventions and their technical nature have been summarized using the ThemeScape software described in the previous section.

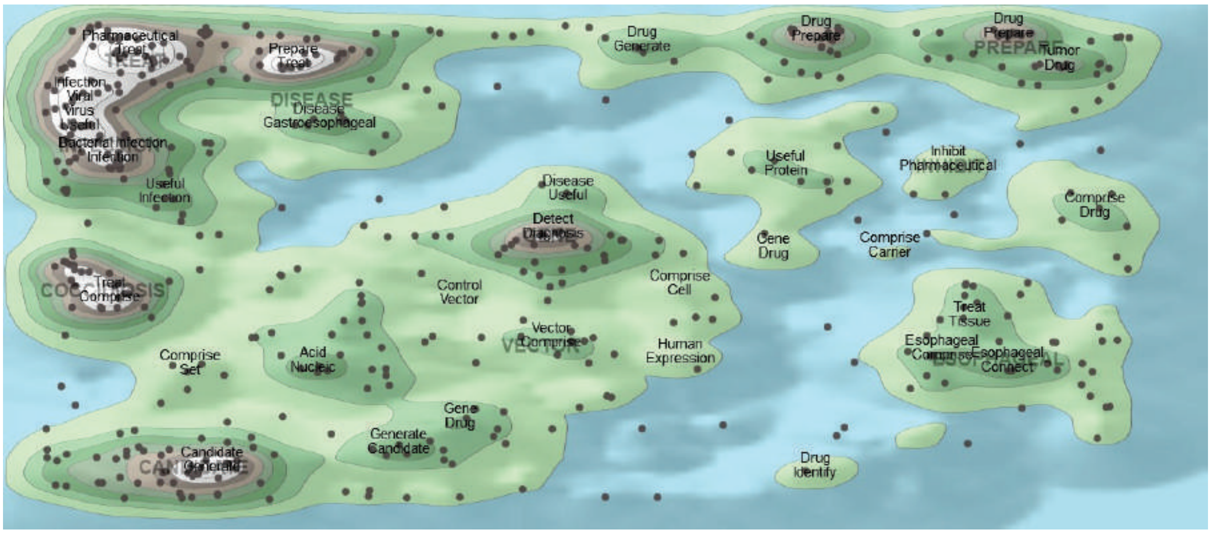

Figure 23 – ThemeScape Map of Patent Collection; Annotated by Major Themes

As previously noted, the ThemeScape map is not designed to provide a detailed accurate view of each patented invention; instead the visual is designed to highlight the common themes shared by hundreds or thousands of patents and patent applications published since 2006.

Some of the key themes revealed in this Themescape map include bacterial/viral infections and their treatments, genetic disorders diagnosis and treatment, and drug design & antitumor drugs.

This annotation has been provided to guide the reader around the landscape. However, it should be noted that this annotation is only approximate.

BIOTECHNOLOGY PATENT TECHNOLOGY SEGMENTATION

Table 7 shows the segmentation of patents and patent applications in biotechnology. Much like the non-patent literature, there is significant patenting activity in synthesis of antitumor drugs, and viral infections. Almost all areas show low growth or decline – suggesting that the field appears to be saturated. Exceptions to this observation are the areas of multifactorial and polygenic disorders and teratogenic disorders, which have low volume of activity, but moderate to high growth rates – indicating these areas as potential white spaces with opportunities for patenting.

Technology Segmentation		Total Inventions	Average % Growth or Decline ('08-'13)
1 Medicinal Chemistry (Drug Design)	1.01.01 Computer-Aided Drug Design (CADD)	712	-5%
	1.01.02 Non-Computed-Aided Drug Design	1734	-18%
	1.02 Synthesis of Antitumor Drugs	27580	-2%
	1.03 Biological Evaluation	326	-13%
	1.04.01 Nanoparticles	1999	-1%
	1.04.02 Liposomes	956	-9%
	1.04.03 Micelles	394	1%
	1.04.04 Dendrimers	215	1%
	1.04.05 Others	9479	-15%
2 Communicable Diseases	2.01 Bacterial Infections	14900	4%
	2.02 Viral Infections	33110	2%
	2.03 Fungal Infections	5155	-1%
	2.04 Protozoan Infections	5048	-6%
	2.05.01 Bacteriophage Therapy	63	-7%
	2.05.02 Gene Therapy	2803	-11%
	2.05.03 Virotherapy	1476	0%
	2.05.04 Pharmaceutical Drugs	21118	-2%
3 Genetic Disorders	3.01.01 Single Gene / Chromosomal Disorder	6035	-6%
	3.01.02 Multifactorial and Polygenic (Complex) Disorders	47	33%
	3.01.03 Teratogenic Disorders	94	29%
	3.02 Treatment	4623	-7%

Table 9 – Patent Technology Segmentation

PATENT COLLECTION TECHNOLOGY CATEGORY OVERLAP

The technology segments, that were created to enumerate and describe the Biotechnology landscape in the areas of Medical Biotechnology, Cancer Research and Genetics, were not intended to be mutually exclusive. A single patent family can be included in multiple categories.
Figure 24 visualizes the relationship between select technology segments. Each number in the diagram shows the number of inventions that have content related to both the corresponding row-wise and column-wise segments.
The most correlated segment pairing is Medicinal Chemistry (Drug Design) with Communicable Diseases.

	1.0 Medicinal Chemistry (Drug Design	2.0 Communicable Diseases	3.0 Genetic Disorders
1.0 Medicinal Chemistry (Drug Design	34912	7508	1330
2.0 Communicable Diseases		49188	1609
3.0 Genetic Disorders			6131

Figure 24 – Number of Patent Families per Pair of Technology Segments

PATENT ACTIVITY GEOGRAPHIC VOLUME BENCHMARKING

Figure 25 shows the number of patent families or inventions within the Medical Biotechnology, Cancer Research and Genetics patent collection that can be attributed to each nation . Patenting activity within the Medical Biotechnology, Cancer Research and Genetics fields is lead by United States, followed by China, European Patent Office (EPO) and Japan. About 93% of the patenting activity is originating from top 10 countries

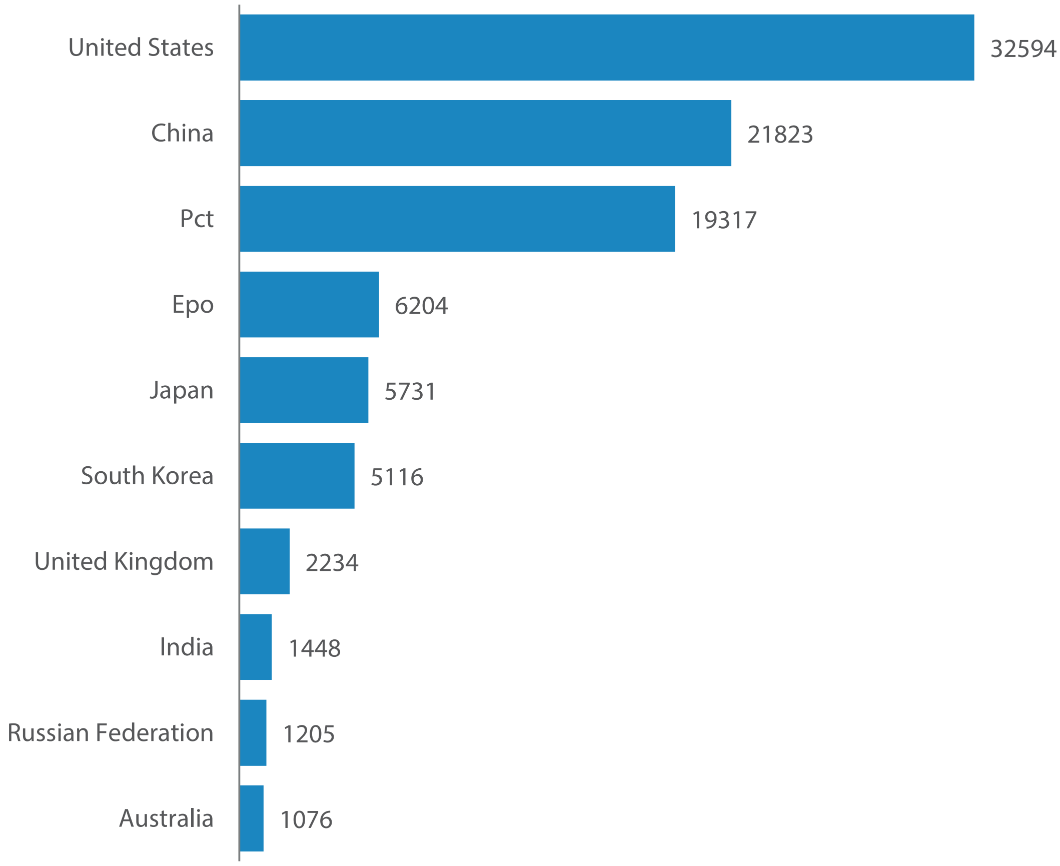

Figure 25 – Number of Patent Families per Country; Top 10 Sources

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National attribution of patent activity is primarily performed via the priority filing location of the invention – this is the first filing event that occurs in the international protection of an invention at the various patent offices around the world. Actual geographic location of the inventor or the innovating corporation may vary from the priority filing location. This effect is exhibited primarily by Saudi Arabian entities, few of which file for patents within the Kingdom.

PATENT GEOGRAPHIC ACTIVITY TRENDS

Although an average number of patent filings from Switzerland, Philippines, Netherlands, Romania and Norway is about 30 which very small as compared to the patenting activity in the most prolific countries, the growth rate of patenting activity in Switzerland, Philippines, Netherlands, Romania and Norway exceeds that of most prolific countries and other countries.

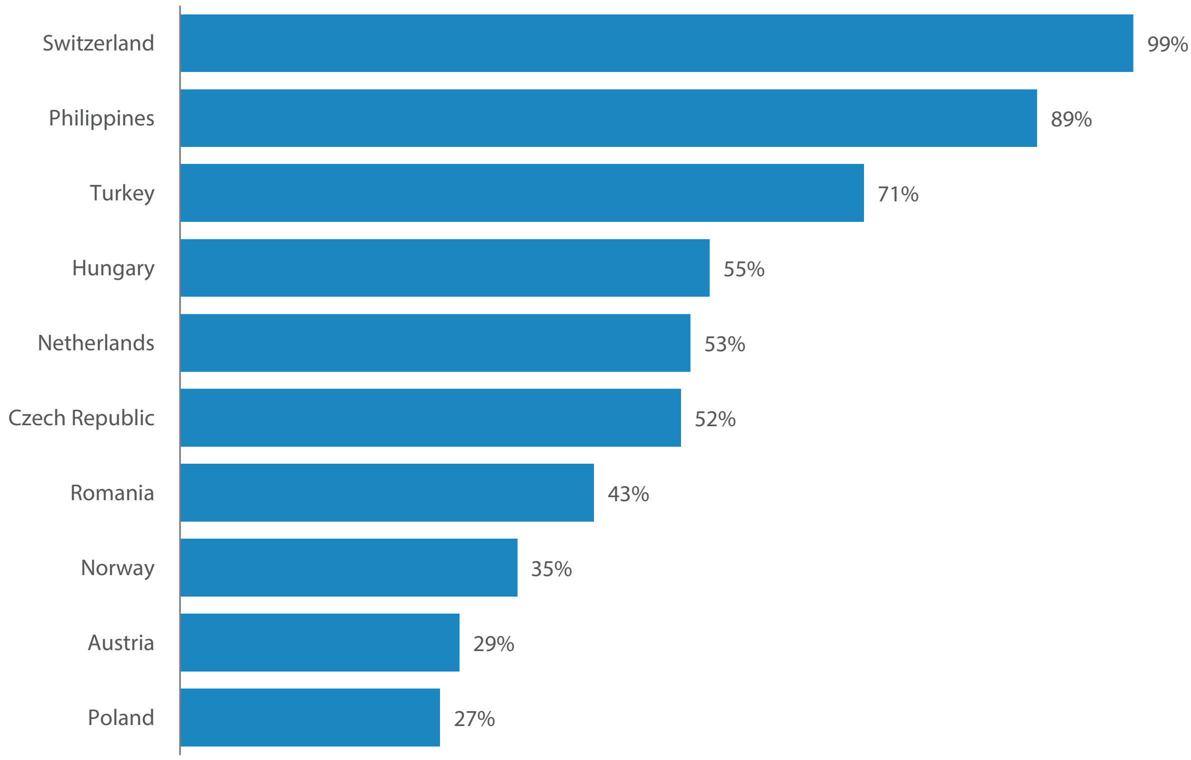


Figure 26 – Highest Growth Rate Geographies in Patent Output

PATENT GEOGRAPHIC CITATION IMPACT BENCHMARKING

Figure 27 details the highest citation impact by nation (with at least 50 patents). Patent citation is a widely utilized measurement of the impact and recognition of an individual patent, and by extension, aggregated groups of patents such as those assigned to a company or associated with the innovation of a nation or region. The measurement is useful as it provides an independent assessment of the quality and impact of the innovation contained within the patent. When aggregated, it provides a method of benchmarking collections of patents for the average impact in comparison to others, e.g. between two competing entities or between nations.
Patent citation information within this study is measured via citations to patent family members of the Derwent World Patents Index and from citation events of 26 national patent collections.
On this metric, Denmark leads with the highest citation impact, followed by Sweden, United Kingdom and United States.

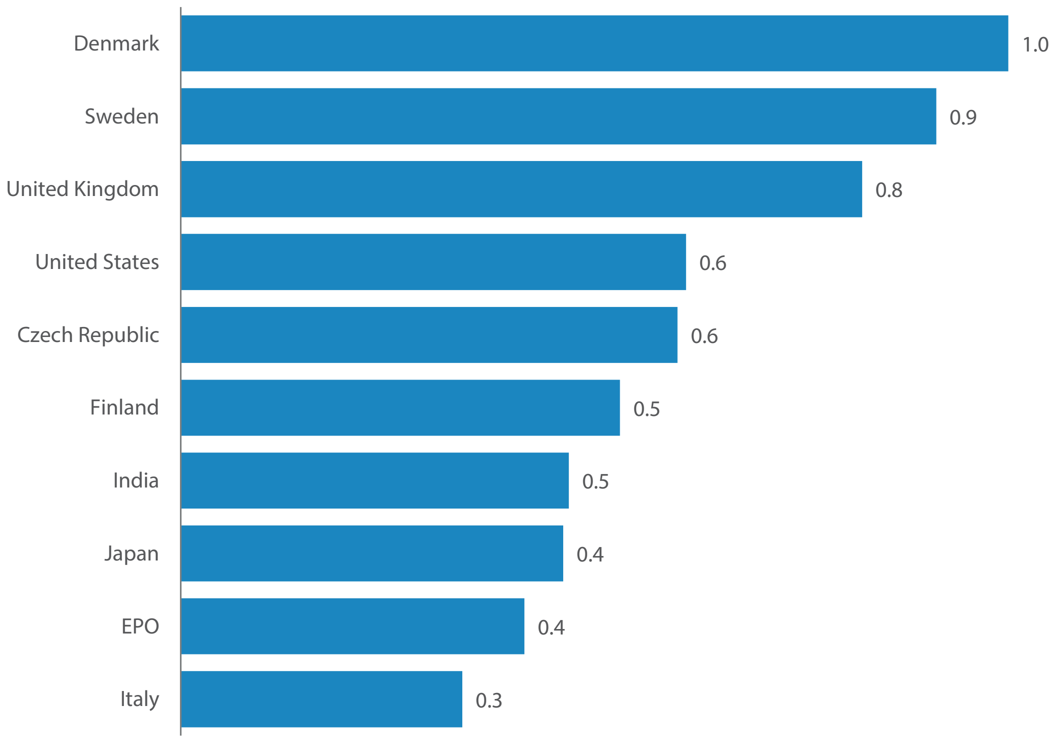


Figure 27 – Highest Citation Impact Geographies of Patents

PATENT COLLECTION BY GEOGRAPHY

Table 8 shows the split of Medical Biotechnology, Cancer Research and Genetics science and research specialization for the top nations. China and Japan appears to have focus on Communicable Diseases. Kingdom of Saudi Arabia seems to be filing heavily in both Medicinal Chemistry (Drug Design) and Communicable diseases.

Country of Origin	1 Medicinal Chemistry (Drug Design)	2 Communicable Diseases	3 Genetic Disorders
United States	47%	59%	12%
China	36%	65%	2%
Pct	49%	63%	13%
Epo	57%	57%	13%
Japan	45%	60%	4%
South Korea	49%	56%	4%
United Kingdom	50%	58%	12%
India	40%	66%	4%
Russian Federation	9%	89%	2%
Australia	50%	59%	12%
France	46%	59%	6%
Germany	30%	71%	7%
Spain	59%	49%	3%
Taiwan	57%	47%	3%
Denmark	50%	57%	13%
Brazil	34%	70%	2%
Italy	44%	58%	7%
Sweden	46%	62%	9%
Canada	41%	61%	11%
Poland	46%	55%	2%
New Zealand	52%	60%	11%
Singapore	31%	71%	9%
Mexico	28%	72%	0%
Finland	51%	50%	10%
South Africa	33%	72%	7%
Czech Republic	49%	47%	9%
Austria	35%	71%	4%
Hungary	60%	44%	4%
Israel	49%	64%	4%
Malaysia	27%	75%	0%
Ireland	42%	60%	12%
Turkey	23%	79%	0%
Netherlands	33%	79%	5%
Switzerland	21%	79%	0%
Norway	65%	35%	6%
Cuba	61%	39%	3%
Portugal	58%	42%	6%
Argentina	72%	40%	0%
Philippines	36%	64%	9%
Romania	37%	63%	5%
Indonesia	22%	78%	0%
Chile	40%	80%	7%
Saudi Arabia	67%	53%	0%

Table 10 – Specialization by Country; % of Patent Activity per Technical Stream

PATENT FILINGS - PROLIFIC ENTITIES

Within the top entities of the patent landscape of medical biotechnology, pharma companies have higher citation counts than patents held by universities. This is indicative of a space where patenting is driven in smaller increments based on existing technology, and lesser so on academic research. Science & Technology Unit, Umm Al Qura University (STU-UQU) has no patent filings in the medical biotechnology space.

Entity	Total	Times Cited	Citation per family
NOVARTIS AG	790	400	0.51
HOFFMANN LA ROCHE & CO AG F	609	237	0.39
GLAXOSMITHKLINE LLC	586	436	0.74
UNIV CALIFORNIA	558	244	0.44
MERCK SHARP & DOHME CORP	463	220	0.48
US DEPT HEALTH & HUMAN SERVICES	447	177	0.40
BOEHRINGER INGELHEIM INT GMBH	409	287	0.70
GENENTECH INC	388	99	0.26
ASTRAZENECA AB	318	453	1.42
BRISTOL-MYERS SQUIBB CO	317	152	0.48
ABBOTT LAB	314	197	0.63
MONDOBIOTECH LAB AG	312	9	0.03
INSERM INST NAT SANTE & RECH MEDICALE	308	81	0.26
CENT NAT RECH SCI	306	75	0.25
UNIV JOHNS HOPKINS	300	162	0.54
UNIV TEXAS SYSTEM	290	134	0.46
ABBVIE INC	271	8	0.03
SCHERING CORP	265	228	0.86
UNIV FUDAN	260	43	0.17
HARVARD COLLEGE	259	84	0.32
UNIV ZHEJIANG	256	60	0.23
ALLERGAN INC	254	111	0.44
VERTEX PHARM INC	248	182	0.73
SANOFI-AVENTIS	246	89	0.36
KOREA RES INST BIOSCIENCE & BIOTECHNOLOG	240	39	0.16
SANOFI SA	239	10	0.04
CNRS CENT NAT RECH SCI	231	27	0.12
JANSSEN PHARM NV	223	76	0.34
TAKEDA PHARM CO LTD	221	264	1.19
MASSACHUSETTS INST TECHNOLOGY	208	111	0.53

Table 11 – Biotechnology – Top entities for Patents

PATENT OVERVIEW OF TOP GLOBAL ENTITIES

Table 10 shows the technology profile of the top 30 entities within the patent landscape of medical biotechnology. The patenting activity of the top entities conforms with the overall landscape, with entities patenting in the same technologies as the highly patented areas in the landscape. Notably, universities are consistently filing patents for pharmaceutical drugs (for communicable diseases) – about a quarter of their total filings on an average. This may be indicative of opportunities to patent pharmaceutical drugs for communicable diseases, and license them to pharmaceutical manufacturers.

Table 12 – Patent overview of top global entities (continued on next page)

Entity	1.01.01 Computer-Aided Drug Design (CADD)	1.01.02 Non-Computed-Aided Drug Design	1.02 Synthesis of Antitumor Drugs	1.03 Biological Evaluation	1.04.01 Nanoparticles	1.04.02 Liposomes	1.04.03 Micelles	1.04.04 Dendrimers	1.04.05 Others
NOVARTIS AG	5	10	324	1	8	6			146
HOFFMANN LA ROCHE & CO AG F	8	14	318	5	7	4		1	133
GLAXOSMITHKLINE LLC		13	181		3	2			77
UNIV CALIFORNIA	8	31	149	8	54	27	10	8	95
MERCK SHARP & DOHME CORP	1	4	174	1		2			75
US DEPT HEALTH & HUMAN SERVICES	2	22	118	1	14	3		2	103
BOEHRINGER INGELHEIM INT GMBH		14	182						35
GENENTECH INC	3	26	181	7	4	5			142
ASTRAZENECA AB		2	152		3				46
BRISTOL-MYERS SQUIBB CO	1	3	95	1	3	2			40
ABBOTT LAB	1	3	131		3	3			87
MONDOBIOTECH LAB AG			300						28
INSERM INST NAT SANTE & RECH MEDICALE	2	8	135	4	6	3	1		38
CENT NAT RECH SCI	3	11	137		10	6			26
UNIV JOHNS HOPKINS	5	34	70	1	23	6	4		66
UNIV TEXAS SYSTEM	8	10	83	3	24	17	6	2	56
ABBVIE INC			141		2	2			70
SCHERING CORP		2	72		2	2			66
UNIV FUDAN	4	3	173		18	7	14	7	16
HARVARD COLLEGE	3	28	53	5	6	2	1	3	40
UNIV ZHEJIANG	3	1	131	2	4	5	7		15
ALLERGAN INC		1	94		5	1		1	40
VERTEX PHARM INC	4	2	92		2	2			92
SANOFI-AVENTIS		3	134						21
KOREA RES INST BIOSCIENCE & BIOTECHNOLOG	2	1	135						13
SANOFI SA		2	131						27
CNRS CENT NAT RECH SCI	3	11	102	3	4				21
JANSSEN PHARM NV		4	93						38
TAKEDA PHARM CO LTD	1	1	144			4			46
MASSACHUSETTS INST TECHNOLOGY	1	11	50	3	33	10	11	1	33

Entity	2.01 Bacterial Infections	2.02 Viral Infections	2.03 Fungal Infections	2.04 Protozoan Infections	2.05.01 Bacteriophage Therapy	2.05.02 Gene Therapy	2.05.03 Virotherapy	2.05.04 Pharmaceutical Drugs	3.01.01 Single Gene / Chromosomal Disorder	3.01.02 Multifactorial and Polygenic (Complex) Disorders	3.01.03 Teratogenic Disorders	3.02 Treatment
NOVARTIS AG	169	332	46	42		19	6	229	118		1	113
HOFFMANN LA ROCHE & CO AG F	66	230	17	13		12	5	165	84			79
GLAXOSMITHKLINE LLC	138	293	29	65		11	14	240	48			45
UNIV CALIFORNIA	67	201	24	25	2	42	17	109	88		1	80
MERCK SHARP & DOHME CORP	65	181	57	27		7	4	195	63			61
US DEPT HEALTH & HUMAN SERVICES	74	200	13	35		45	38	107	40			37
BOEHRINGER INGELHEIM INT GMBH	88	241	47	24		4		214	74			72
GENENTECH INC	37	144	29	13		17	1	113	72			72
ASTRAZENECA AB	82	127	52	30		1		148	86			86
BRISTOL-MYERS SQUIBB CO	38	177	15	33		6	8	162	24			24
ABBOTT LAB	65	155	26	45		13	8	140	40			39
MONDOBIOTECH LAB AG	284	292	26	279			3	302	124			124
INSERM INST NAT SANTE & RECH MEDICALE	42	131	13	26		22	13	82	32			26
CENT NAT RECH SCI	34	111	17	47		13	12	93	28			25
UNIV JOHNS HOPKINS	42	105	18	24		29	12	87	58			44
UNIV TEXAS SYSTEM	43	106	10	16		38	9	66	22	1		17
ABBVIE INC	49	152	24	42		7	6	152	42			42
SCHERING CORP	65	111	84	19		5		151	33			33
UNIV FUDAN	10	67		2		6	4	26	4			
HARVARD COLLEGE	67	113	30	34		26	7	76	43			37
UNIV ZHEJIANG	28	87	7	2		7	6	15	3			1
ALLERGAN INC	76	122	73	2		3		127	1			1
VERTEX PHARM INC	21	106		2		14	1	96	54			53
SANOFI-AVENTIS	50	95	6	46				67	27			27
KOREA RES INST BIOSCIENCE & BIOTECHNOLOG	17	111	6	4		5	3	80	6			3
SANOFI SA	37	80	5	45				66	30			30
CNRS CENT NAT RECH SCI	35	81	17	26	1	8	6	65	16			13
JANSSEN PHARM NV	57	58	7	11		7		87	49			48
TAKEDA PHARM CO LTD	52	96	12	5				85	11			11
MASSACHUSETTS INST TECHNOLOGY	24	79	18	26	1	14	8	57	23			17

PATENT OVERVIEW OF TOP ASIA PACIFIC ENTITIES

Entity	Country of Origin	Total	1.01.01 Computer-Aided Drug Design (Cadd	1.01.02 Non-Computed-Aided Drug Design	1.02 Synthesis Of Antitumor Drugs	1.03 Biological Evaluation	1.04.01 Nanoparticles	1.04.02 Liposomes	1.04.03 Micelles	1.04.04 Dendrimers	1.04.05 Others	2.01 Bacterial Infections	2.02 Viral Infections	2.03 Fungal Infections	2.04 Protozoan Infections	2.05.01 Bacteriophage Therapy	2.05.02 Gene Therapy	2.05.03 Virotherapy	2.05.04 Pharmaceutical Drugs	3.01.01 Single Gene / Chromosomal Disorder	3.01.03 Teratogenic Disorders	3.02 Treatment
Science & Technology Unit, Umm Al Qura Univ	Saudi Arabia	-																				
Univ Fudan	China	$258.00	4	1	173		18	7	14	7	16	10	67		2		6	4	26	4		
Univ Zhejiang	China	$255.00	3	1	130	2	4	5	7		15	28	86	6	2		7	6	15	3		1
Korea Res Inst Bioscience & Biotechnolog	South Korea	$236.00	1	1	134						12	16	109	6	4		5	3	79	6		3
Univ China Pharm	China	$205.00	1		158		11	2	7	2	14	18	39	3	2	1	1		35			
Univ Pla Second Military Medical	China	$171.00	2	2	105						7	11	46	17	2		6	2	39	4		4
Univ Tokyo	Japan	$154.00			78			1	2	1	14	14	61	1	4		6	2	26	9		5
Korea Inst Sci&Technology	South Korea	$149.00			79		9				11	14	69	3			15		34	13	2	6
Univ Yonsei Ind Academic Coop Found	South Korea	$147.00	2		93		10	2	1	1	17	6	50	3	1		5	4	32	9		7
Takeda Pharm Co Ltd	Japan	$145.00		1	113						19	31	64	2					45	4		4
Univ Shenyang Pharm	China	$140.00			109		7	9	5	1	3	9	16	12	2				24			
Univ Shandong	China	$130.00			82	2	6	2	2		6	9	36	3	4		2	1	28	2		1
Univ Nanjing	China	$128.00			75		2					10	34	2	1		3		19	8		4
Univ Konkuk Ind Coop Corp	South Korea	$127.00			84						4	5	50	1	4		2	3	29	1		
Snu R&Db Found	South Korea	$124.00			59		7	4	4		11	10	49	2	1		5	3	16	7		1
Univ Shanghai Jiaotong	China	$124.00			59		10	7	9		2	9	47	2	5		3		16	5		3
Univ Peking	China	$116.00			81		3	6	1	1	6	5	36		1		4	2	28	4		
Daiichi Sankyo Co Ltd	Japan	$115.00		1	82			1			5	11	38	2			1	1	35	2		2
Univ Sun Yet-Sen	China	$110.00	2		63	1	1		1		4	9	32				5	3	12	3		
Univ Sichuan	China	$108.00	2		79		3	2	2	4	3	6	18	3	2		3	2	12			
Korea Res Inst Chem Technology	South Korea	$103.00			80		1	1			4	5	29	6	3		1		33	4		

Table 13 – Patent overview of top Asia Pacific entities

PATENT OVERVIEW OF TOP MIDDLE EAST & AFRICA ENTITIES

Table 12 illustrates the top patenting entities in the Middle East and Africa. The space appears to be dominated by smaller, local players, particularly from South Africa, Turkey and the Kingdom of Saudi Arabia (KSA), Turkey, and South Africa. Further, there is no multinational player active in Middle East and Africa region. This indicates of a geographic region used only by local players and not by large multinationals.

Entity	Country of Origin	Total	1.01.01 Computer-Aided Drug Design (Cadd	1.01.02 Non-Computed-Aided Drug Design	1.02 Synthesis Of Antitumor Drugs	1.04.01 Nanoparticles	1.04.02 Liposomes	1.04.03 Micelles	1.04.05 Others	2.01 Bacterial Infections	2.02 Viral Infections	2.03 Fungal Infections	2.04 Protozoan Infections	2.05.02 Gene Therapy	2.05.03 Virotherapy	2.05.04 Pharmaceutical Drugs	3.01.01 Single Gene / Chromosomal Disorder	3.02 Treatment
Univ Witwatersrand Johannesburg	South Africa	10	1		2	5	2	2		1	2	1		1	1			
Sanovel Ilac Sanayi Ve Ticaret Anonim	Turkey	8								5	3					5		
Univ King Saud	Saudi Arabia	8		2	2				2		3		1			1		
Univ Cape Town	South Africa	7		1	1					1			1			1	2	
Univ Namibia	Namibia	7									7		7			1		
Univ North West	South Africa	5				1				3	1		1			2		
Univ Stellenbosch	South Africa	5			1				1	1	2		2			1		
South African Medical Res Council	South Africa	4								1			1				2	
Icipe Int Cent Insect Physiology & Ecolo	Kenya	3											3			1		
Univ Kenyatta	Kenya	3											3			1		
Univ King Abdullah Sci & Technology	Saudi Arabia	3			1					1	2			1		1		
Council Sci&Ind Res India	South Africa	2								1	1		1					
King Faisal Specialist Hospital & Res Ce	Saudi Arabia	2			2				1		2	1				1		
Novartis Ag	Iran	2											1				1	1
Terramark Markencreation Gmbh	Saudi Arabia	2			2				1		2	1				1		
Univ Free State	South Africa	2											1			1		
Univ Northwestern	South Africa	2			2					2								
Univ Pretoria	South Africa	2							1								1	
Ak Kimya Ithalat-Ihracat Ve Sanayii Anon	Turkey	1									1							
Ali Raif Aolac Sanayi & Ticaret Anonim	Turkey	1									1							
Arven Ilac Sanayi & Ticaret As	Turkey	1								1								
Avestha Gengraine Technologies Pvt Ltd	South Africa	1							1									
Avesthagen Ltd	South Africa	1							1									
Awistakinlan Technology Co Ltd	South Africa	1							1									
Berko Ilac Ve Kimya San As	Turkey	1									1							
Bionet-Asia Co Ltd	South Africa	1								1	1							
Chad-O Eng Pty Ltd	South Africa	1			1						1							
Clariant Int Ltd	South Africa	1			1				1	1	1	1	1			1	1	1
Council Sci&Ind Res South Africa	South Africa	1											1			1		
Deut Krebsforschungszentrum	Saudi Arabia	1							1									

Table 14 – Patent overview of top Middle East & Africa entities

PATENT OVERVIEW OF TOP SAUDI ARABIA ENTITIES

Entities	Total	1.01.01 Computer-Aided Drug Design (Cadd	1.01.02 Non-Computed-Aided Drug Design	1.02 Synthesis Of Antitumor Drugs	1.04.05 Others	2.01 Bacterial Infections	2.02 Viral Infections	2.03 Fungal Infections	2.04 Protozoan Infections	2.05.02 Gene Therapy	2.05.04 Pharmaceutical Drugs
Science & Technology Unit, Umm Al Qura University (STU-UQU)	-										
Univ King Saud	8		2	2	2		3		1		1
Univ King Abdullah Sci & Technology	3			1		1	2			1	1
King Faisal Specialist Hospital & Res Ce	2			2	1		2	1			1
King Abdulaziz City Sci & Technology	1			1							
King Khalid Eye Specialist Hospital	1			1	1		1	1			1
Univ Alfaisal	1					1					1
Univ Dhahran King Fahd Petroleum & Miner	1			1							
Univ Hail	1	1									

Table 15 – Patent overview of top Saudi Arabia entities

MIDDLE EAST & AFRICA BIOTECHNOLOGY PATENT TRENDS

This section of the report focuses on the patent collection and the activity and technological trends seen within it – in the Middle East and Africa.

MIDDLE EAST & AFRICA – PROLIFIC COUNTRIES

Patent filing trends appear to be very different from the scientific literature trends. Figure 28 shows that South Africa is the most popular country for filing patents within the biotechnology region, followed by Turkey and Saudi Arabia. The remaining jurisdictions see only marginal patent filings.

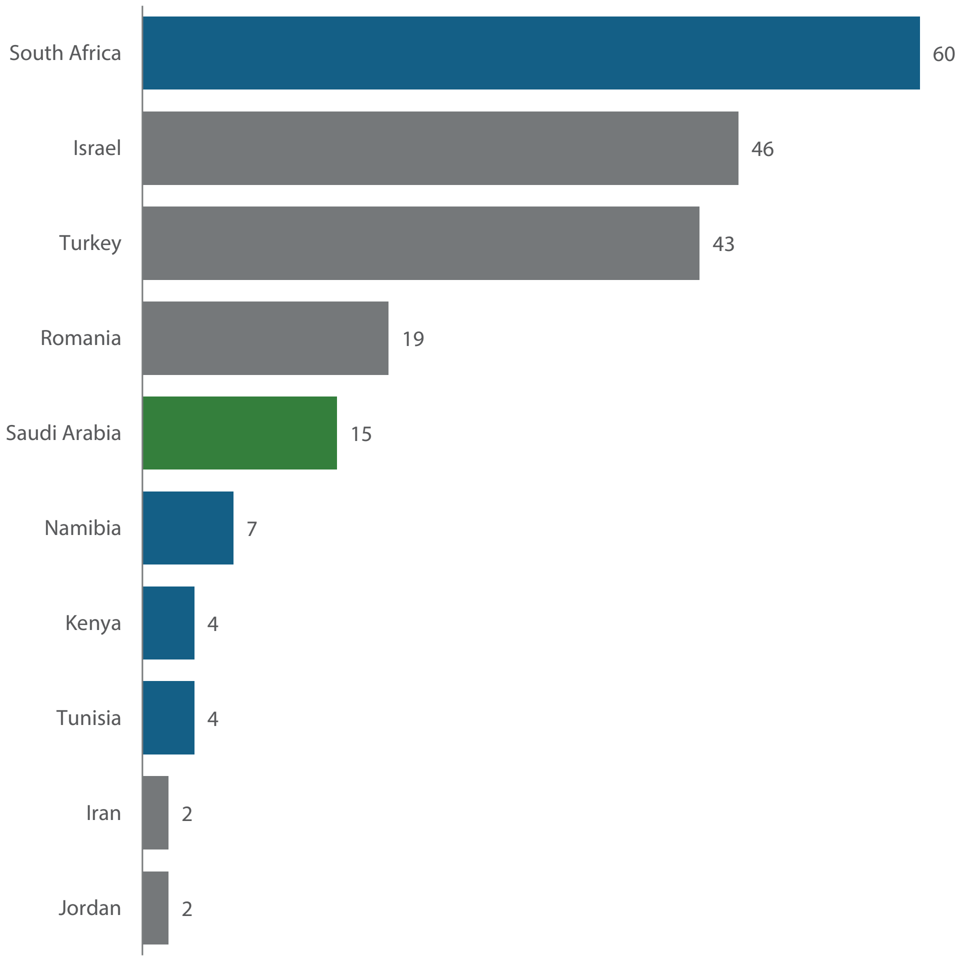


Figure 28 – Middle East & Africa – Prolific Countries in Patents

Diving deeper, Table 11 shows that South Africa and Turkey appear to be having patent focus on bacterial infections and pharmaceutical drugs. The Kingdom of Saudi Arabia has 15 patents, appears to be primarily focused on medicinal chemistry (drug design) and communicable diseases and most notably on non-computed-aided drug designing, synthesis of antitumor drugs and viral infections.

Country of Origin	1.01.01 Computer-Aided Drug Design (Cadd	1.01.02 Non-Computed-Aided Drug Design	1.02 Synthesis Of Antitumor Drugs	1.03 Biological Evaluation	1.04.01 Nanoparticles	1.04.02 Liposomes	1.04.03 Micelles	1.04.04 Dendrimers	1.04.05 Others	2.01 Bacterial Infections	2.02 Viral Infections	2.03 Fungal Infections	2.04 Protozoan Infections	2.05.02 Gene Therapy	2.05.03 Virotherapy	2.05.04 Pharmaceutical Drugs	3.01.01 Single Gene / Chromosomal Disorder	3.02 Treatment
South Africa	1	1	9		7	2	2		7	19	16	7	12	1	1	13	4	1
Israel		2	20		4	2		1	7	13	18	6	4	3		17	2	1
Turkey			8		1				4	19	17	2				16		
Romania			7	1						3	8	1				1	1	1
Saudi Arabia	1	2	5						3	2	6	1	1	1		4		
Namibia											7		7			1		
Kenya													4			1		
Tunisia										1	3	1				3		
Iran			1										1					
Jordan													1				1	1
GC			1						1	1			1			1		
Morocco			1						1	1	1					1		
Algeria												1						
Egypt												1						
Ghana													1					
Nigeria													1					

Table 16 – Middle East & Africa – Prolific Countries over Technical categories

APPENDIX A – SCIENTIFIC PAPERS TOP AFFILIATIONS

ENTITY-LEVEL DATA TABLES FOR SCIENTIFIC LITERATURE COLLECTION

Table 13 on the following pages shows the top 10 author organizations for each of the technology segments. This information is intended to provide an assessment of the depth and location of the research expertise available in each category.

Top Level Technology	Entity	Total
1 Medicinal Chemistry (Drug Design)	CHINESE ACADEMY OF SCIENCES	1987
	HARVARD UNIVERSITY	1631
	UNIVERSITY OF CALIFORNIA SYSTEM	1130
	INSERM	1122
	CNRS	801
	UNIVERSITY OF LONDON	557
	COUNCIL OF SCIENTIFIC & INDUSTRIAL RESEARCH (CSIR)	448
	UNIV WASHINGTON	408
	UNIVERSITY OF TORONTO	385
	NATIONAL UNIVERSITY OF SINGAPORE	385
2 Communicable Diseases	NATIONAL INSTITUTES OF HEALTH (NIH) - USA	937
	INSERM	697
	HARVARD UNIVERSITY	650
	UNIVERSITY OF CALIFORNIA SYSTEM	643
	UNIVERSITY OF LONDON	350
	CNRS	287
	CENTERS FOR DISEASE CONTROL & PREVENTION - USA	263
	UNITED STATES DEPARTMENT OF AGRICULTURE (USDA	261
	NIAID	261
	UNIV WASHINGTON	260
3 Genetic Disorders	HARVARD UNIVERSITY	421
	INSERM	395
	UNIVERSITY OF CALIFORNIA SYSTEM	310
	UNIVERSITY OF LONDON	275
	NATIONAL INSTITUTES OF HEALTH (NIH) - USA	160
	UNIVERSITY COLLEGE LONDON	160
	UNIVERSITY OF TORONTO	156
	UNIV WASHINGTON	154
	UNIVERSITY OF PENNSYLVANIA	153
	PRES UNIVERSITY SORBONNE PARIS CITE	128

Table 17 – Top 10 Paper Publishing Organizations per Technology Segment

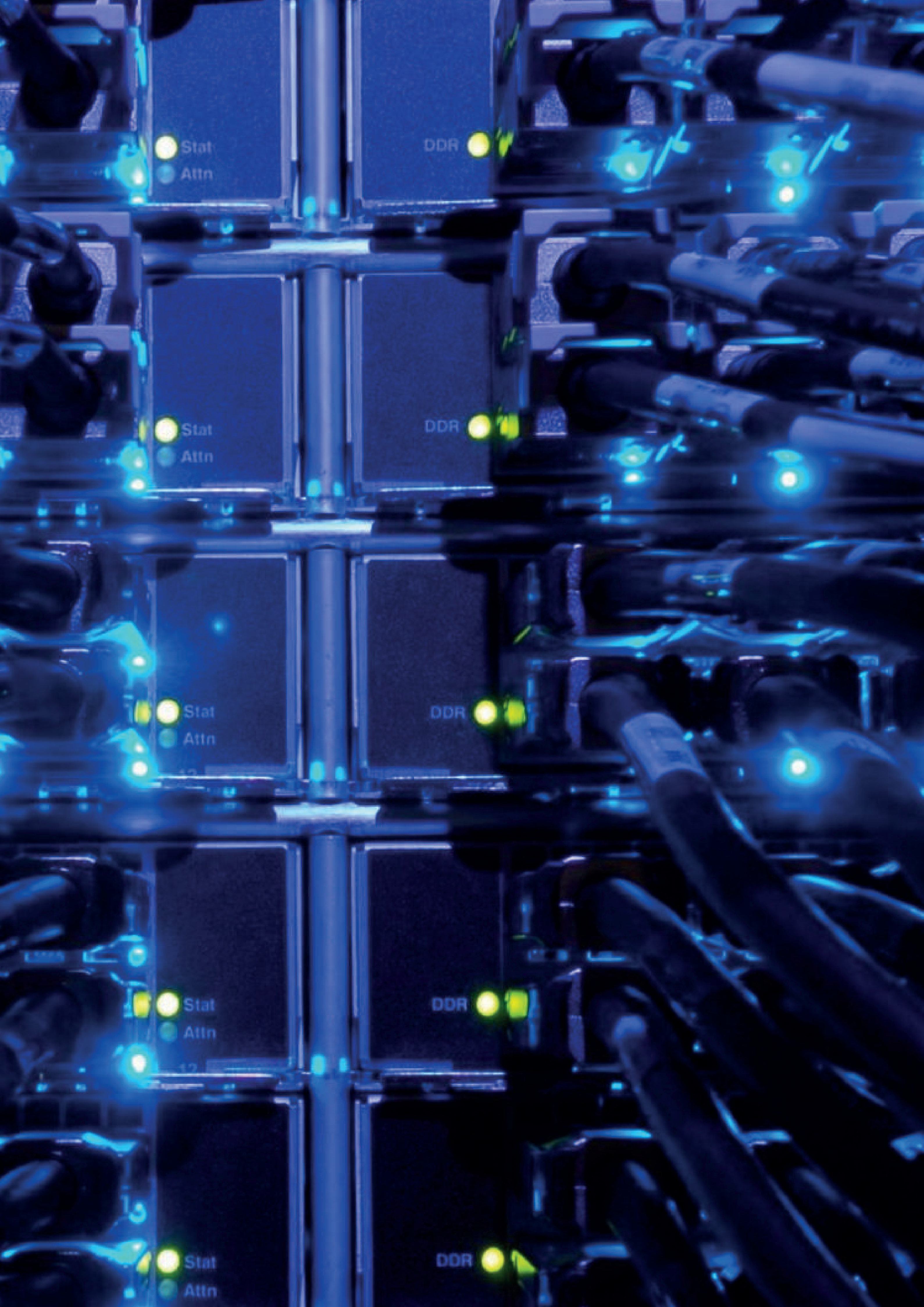
APPENDIX B – PATENT STATISTICS AND TABLES

ENTITY-LEVEL DATA TABLES FOR PATENT COLLECTION

The table 14 below and on the following page shows the top 10 patent applicants or patent assignees for each of the technology segments. This information is intended to provide an assessment of expertise and patent commercialization intent per category.

Top Level Technology	Entity	Total
1 Medicinal Chemistry (Drug Design)	HOFFMANN LA ROCHE&CO AG F	391
	NOVARTIS AG	385
	MONDOBIOTECH LAB AG	300
	UNIV CALIFORNIA	261
	GENENTECH INC	253
	GLAXOSMITHKLINE LLC	222
	MERCK SHARP & DOHME CORP	210
	BOEHRINGER INGELHEIM INT GMBH	198
	US DEPT HEALTH & HUMAN SERVICES	191
	UNIV FUDAN	190
2 Communicable Diseases	NOVARTIS AG	458
	GLAXOSMITHKLINE LLC	449
	MONDOBIOTECH LAB AG	302
	US DEPT HEALTH & HUMAN SERVICES	284
	UNIV CALIFORNIA	283
	BOEHRINGER INGELHEIM INT GMBH	281
	MERCK SHARP & DOHME CORP	278
	HOFFMANN LA ROCHE & CO AG F	270
	BRISTOL-MYERS SQUIBB CO	233
	ABBOTT LAB	212
3 Genetic Disorders	MONDOBIOTECH LAB AG	124
	NOVARTIS AG	118
	UNIV CALIFORNIA	89
	ASTRAZENECA AB	86
	HOFFMANN LA ROCHE & CO AG F	84
	BOEHRINGER INGELHEIM INT GMBH	74
	GENENTECH INC	72
	MERCK SHARP & DOHME CORP	63
	UNIV JOHNS HOPKINS	58
	VERTEX PHARM INC	54

Table 18 – Top 10 Patent Applicants/Owners per Technology Segment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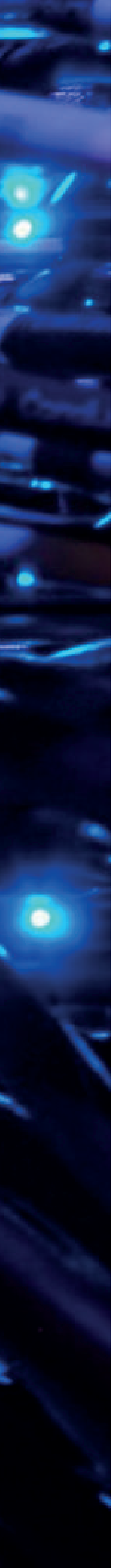

LANDSCAPE OF WIRELESS COMMUNICATION AND SENSOR NETWORKS

SCIENCE & TECHNOLOGY UNIT,
UMM AL-QURA UNIVERSITY (STU-UQU)

THOMSON REUTERS IP SERVICES
MAY 2015

Executive Summary

This study has been commissioned by Science & Technology Unit, Umm Al-Qura University (STU-UQU) to evaluate and describe the global scientific research and patent activity within sub-tracks that they have achieved funding for projects. Within the Electronics, Communications and Photonics track, the sub-track of focus was Wireless Communication and Sensor Networks.

The study has looked at both scientific papers and patents to form an understanding of the overall scientific and technology landscape.

The scientific papers are sourced from the Web of Science™, a database containing journal articles from approximately 12,500 peer-reviewed journals.

The patent information is sourced from the Derwent World Patents Index™, a database of patents and patent applications from 47 international patent issuing authorities.

Both databases have been selected because they provide a method of defining a unit of science or technology. A single paper defined by the Web of Science is required to have met a minimum threshold of scientific rigor: publication within a journal of repute, peer review sign off, etc. Furthermore, a patent included within DWPI is defined credibly as an attempt to protect a piece of innovation within at least one territory.

Aggregating this information across technologies and countries provides a method of tracking Wireless Communication and Sensor Networks innovation and development trends.

Included in this document are measurements of research and patent quality and direction changes in research and patent activity. It should be noted that in many areas the report utilizes metrics such as average annual percentage growth in scientific and research output to compare activities across technologies and geographies. Such metrics should be treated with care for analyses containing low volumes, as some volatility is expected. Also to be noted is that the global high volume nature of this analysis within Wireless Communication and Sensor Networks technology necessarily entails some level of noise and is not intended to be completely comprehensive. Instead, the analyses enclosed should be treated as a survey of the technology, and the trends and findings interpreted in this manner.

Overall, the fact that the number of patents in the area surpasses the number of papers by a factor of 2 suggests that research activity is generally focused more on practical technical commercialization as opposed to more fundamental research.

For STU-UQU, it is interesting to note the patent and scientific literature collections differ with respect to the breakdown in technology segments. The most active segment in both data sets is wireless sensor networks, however thereafter the breakdown differs. This suggests that on a global level, there is greater focus on technology commercialization of areas such as oil & gas pipeline monitoring and more focus on fundamental research in areas such as wireless sensor networks - communication and under water sensors. This insight may give STU-UQU direction on future projects and research areas.

Similarly with regard to growth rates, the patent technology segments experiencing growth includes wireless sensor network and oil & gas pipeline monitoring. While the technology segments in the scientific literature collection which have seen a growth over the time period include wireless sensor networks and wireless sensor networks – communication. This may represent an opportunity for STU-UQU to focus on technology segments such as wireless sensor networks, wireless sensor networks – communication and oil & gas pipeline monitoring.

Overall KSA output is pretty low compared to other global resources with the US and China leading both in published literature and patent output. However, KSA is showing impressive growth and compared with output of Middle East and Africa (MENA) countries, KSA rank first in patent filings and third behind Iran and Turkey in scientific literature output.

STU-UQU does lag behind in terms of both published literature and patent output with Saudi Aramco, King Saud University, King Fahd University of Petroleum & Minerals, King Abdulaziz City for Science & Technology, and King Abdullah University of Science and Technology leading output from KSA. There are sub-technology areas with little or no output from these institutes, which may offer opportunity for STU-UQU to focus on. These include Ultra Wide Band - Localization and tracking and FPGA – Architecture.

For STU-UQU, it is interesting to note the patent and scientific literature collections differ with respect to the breakdown in technology segments. Some technologies are clearly within the commercialization and practical implementation phase, while others exhibit new fundamental technology research.

Localization (Wireless Sensor Network - Communication), Timing Synchronization (Wireless Sensor Network - Communication), Pressure sensors (Oil & Gas pipeline monitoring), Flow sensors (Oil & Gas pipeline monitoring), Temperature sensors (Oil & Gas pipeline monitoring), Acoustic (Under Water Sensors) and IC - Design; all are in the technology commercialization and practical implementation phase – with volumes for patent protection far exceeding the volume of scientific literature being published.

Biosensor (Under Water) appears to be in the fundamental research and development phase – with significantly more scientific literature being published as compared to patents filings.

Seismic sensors (Oil & Gas pipeline monitoring), Computational Pipeline Monitoring (Oil & Gas pipeline monitoring), Pulse Position Modulation (Ultra Wide Band - Modulation), Pulse Amplitude Modulation (Ultra Wide Band - Modulation), ON-Off Keying (Ultra Wide Band - Modulation) and Nano-Technology (FPGA - Architecture) are fairly developed within the patent landscape as well as within the scientific literature landscape. This indicates evolving and maturing technology – technologies already in the commercialization and practical implementation phase, with new fundamental research and development still continuing, indicated by the comparable number of patent filings and scientific literature publications.

The patent technology segments experiencing significant growth include Cross layer Design (Wireless Sensor network), Seismic sensors (Oil & Gas pipeline monitoring) and In-network processing (Wireless Sensor Network - Communication).

Cross layer Design (Wireless Sensor network) exhibits high growth in patent activity that significantly exceeds the growth in scientific literature. This indicates opportunities for “improvement” type of patent filings that focus on implementation improvements, rather than on fundamental technologies.

It is recommended to further analyze the space of Cross layer Design (Wireless Sensor network), Seismic sensors (Oil & Gas pipeline monitoring) and In-network processing (Wireless Sensor Network - Communication), since this technology has a small number of patent filings but high growth – indicating a nascent technology area.

Scientific literature data indicates strong growth on fundamental research in Flow sensors (Oil & Gas pipeline monitoring). Other areas with relatively high focus on fundamental research include Routing (IC - Design), Pressure sensors (Oil & Gas pipeline monitoring) and Placement algorithms (FPGA - CAD tools) (based on growth rate during 2009 – 2014 for papers).

Routing (IC - Design) and Placement algorithms (FPGA - CAD tools) are areas where scientific literature growth far exceeds the growth of patent filings. This is indicative of avenues and opportunities for fundamental research and development.

Localization (Wireless Sensor Network - Communication), Pressure sensors (Oil & Gas pipeline monitoring), Temperature sensors (Oil & Gas pipeline monitoring), Network configuration (Wireless Sensor network), Power saving and efficiency (Wireless Sensor network) and Fault tolerance/Robustness (Wireless Sensor network) show strong growth in both patent filings as well as scientific literature publications. Such trend is indicative of an emerging technology, which has not fully matured yet. Interest to develop fundamental technologies continues, while simultaneously technology is being commercialized and practically implemented. This presents an opportunity for newer fundamental technology within these technologies to be researched. Any improvements to existing fundamental techniques of these technologies will be better served by patent filings.

For further information regarding the data used in this study, and for deeper or variations in the analysis presented, please review the interactive dashboards.

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INTRODUCTION TO GLOBAL WIRELESS COMMUNICATION AND SENSOR NETWORKS SCIENTIFIC ACTIVITY

This study presents an analysis of patents and scientific papers that fall within specific topics of interest to Science & Technology Unit, Umm Al-Qura University (STU-UQU) concerning the Wireless Sensor Network, Monitoring for Oil & Gas Pipelines using Wireless Sensor Networks, 3D positioning using Ultra Wide Band (UWB) and other enabling technologies.

The study was commissioned by STU-UQU as part of a wider program to review the scientific and intellectual property activity in specific topics that they have gained approved funding for projects. Within the Electronics, Communications and Photonics technology area, they have gained funding approval for 5 projects related to the Wireless Communications and Sensor Networks and Enabling Technologies tracks, but specifically in the sub-tracks of Wireless Sensor Networks, Oil & Gas Pipeline Monitoring, UWB (Ultra Wide Band), FPGA (Field Programmable Gate Arrays), and Integrated Circuits (ICs). The titles of the projects are "CoralSense: An Underwater Wireless Sensor Network for Monitoring Coral Reef Environments", "Reliable Monitoring for Oil and Gas Pipelines using Wireless Sensor Networks", "3D Positioning using Ultra Wide Band (UWB) Technology", "Logic Intensive Reconfigurable Architectures and Supporting CAD Tools", and "The Top K Most Critical Paths in Stochastic Networks and Timing Verification of Circuits".

A large scale data collation process using globally recognized search processes from Thomson Reuters was undertaken to produce practical and insightful sets of information for analysis regarding the trends, geographies and ultimately the institutions and patent applicants working in the fields of Wireless Sensor Networks, Oil & Gas Pipeline Monitoring, UWB (Ultra Wide Band), FPGA (Field Programmable Gate Arrays), and Integrated Circuits (ICs) within the domain of Electronics, Communications and Photonics.

As shown in Figure 1, the overall volume of patents in these technology areas filed since 2006 is more than twice the volume of scientific papers published since 2008, however in the same time period from year 2008 onwards the patent output is about 1½ times the scientific paper output.

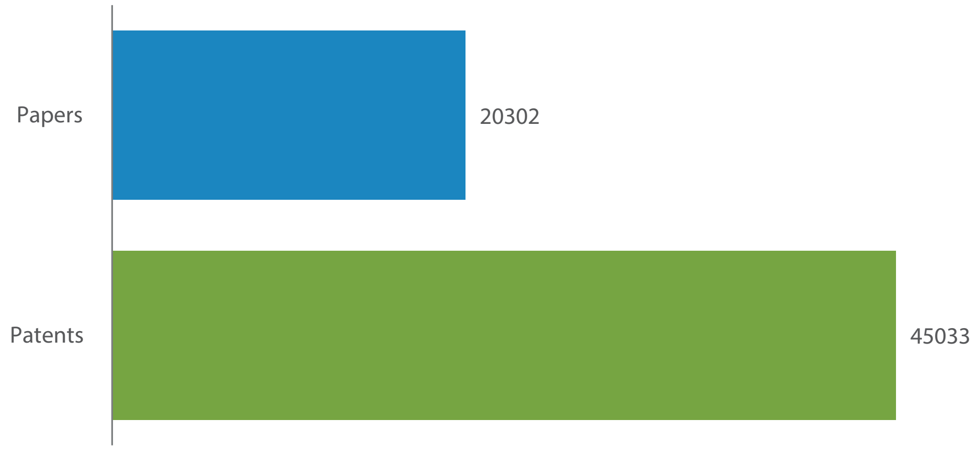

Figure 1 – Scientific Paper and Patent Families in Wireless Communication & Sensor Networks Technology

Additionally, year 2009 onwards patent protection activity related to Wireless Communication and Sensor Networks technology had increased at a faster rate (refer to Figure 2, Timeline of Activity) than publications in scientific journals, which are likely to address more fundamental science. This might suggest that the focus of technology development globally related to Wireless Communication and Sensor Networks is increasingly directed towards commercialization and practical application. However, in recent years (2012 onwards) scientific paper output has shown a slightly upward trend.

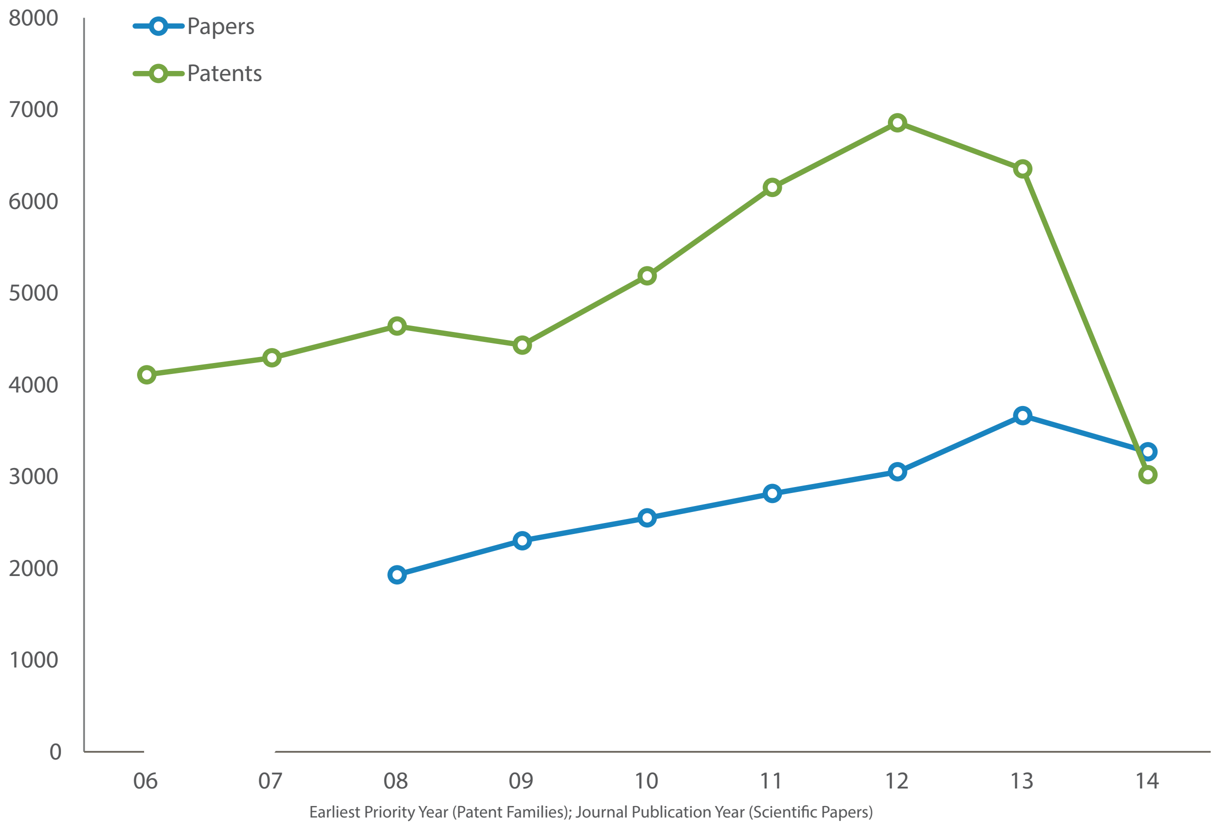

Figure 2 – Timeline of Scientific Paper and Patent Family Activity

Figures 3 through 5 show three further analyses on each of the data collections (patents, left; papers, right) concerning the nature and high level technology trends occurring within Wireless Communication and Sensor Networks technology area.

The patent and scientific literature collections differ with respect to the breakdown in technology segments. An active segment in both data sets is wireless sensor networks, however thereafter the breakdown differs. The analysis also suggests that on a global level, there is greater focus on technology commercialization in the technology areas such as IC-design, oil & gas pipeline monitoring and more fundamental research in areas such as wireless sensor networks - communication and under water sensors.

Note that the dates used for the collation of the timeline information differ for patent and scientific literature information. Patent Families are measured by the earliest known "priority" or first filing event in the inventions history. Patents are typically retained by patent offices for 18 months or more after filing before they are published. This delay means that the last complete year of information available for patent information is 2012. For scientific papers, the dates used for analyses are the publication dates of the journal containing the paper. These metrics are used throughout the report.

With regard to average growth rates of these collections (years 2008 - 2013 for patents; years 2009 - 2014 for papers), in the patent collection the technology segments which are experiencing significant growth include wireless sensor network and oil & gas pipeline monitoring. While IC-design technology segment in the patent collection, regardless of high volume of records, has seen a decline over the time period which may indicate innovation saturation in this area. The technology segments in the scientific literature collection which have seen a growth over the time period include wireless sensor networks, wireless sensor networks – communication and even IC-Design. The ultra wide band modulation segment has seen a decline in both collection indicating this area is now less commercially focused, and also less fundamental research taking place in this area.

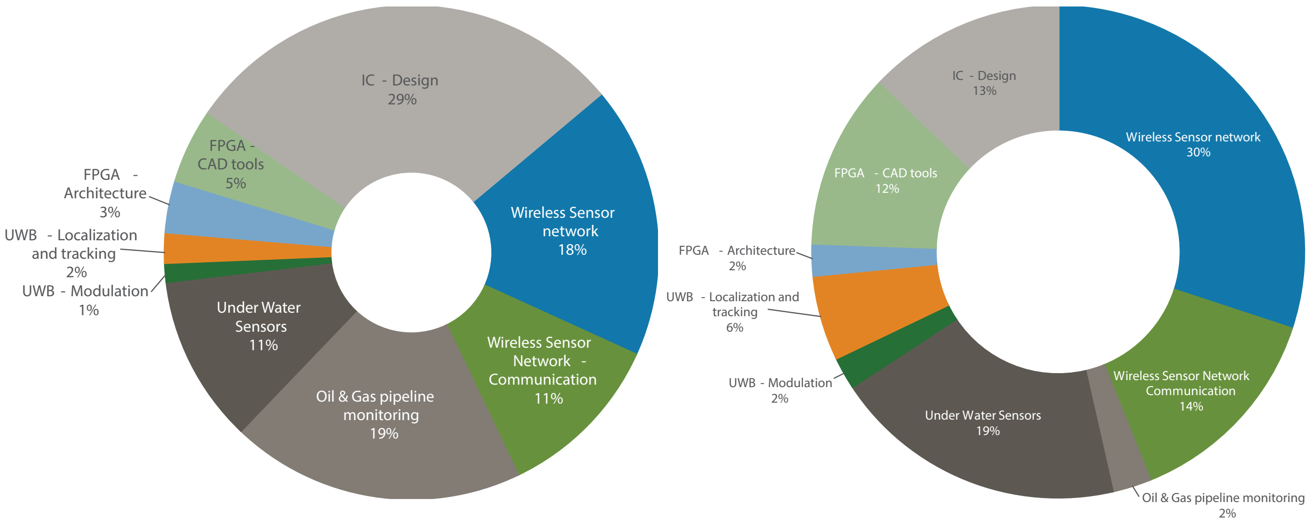

Figure 3 – % of Patent (left) and Scientific Paper (right) Collections by Various Technology Topics

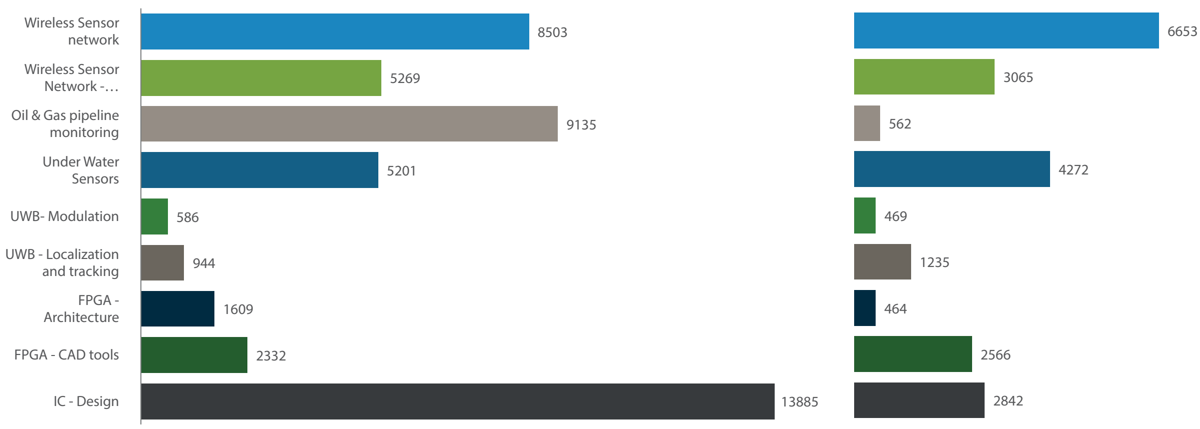

Figure 4 – Number of Patents Families (left) and Scientific Papers (right) per Technology Topic

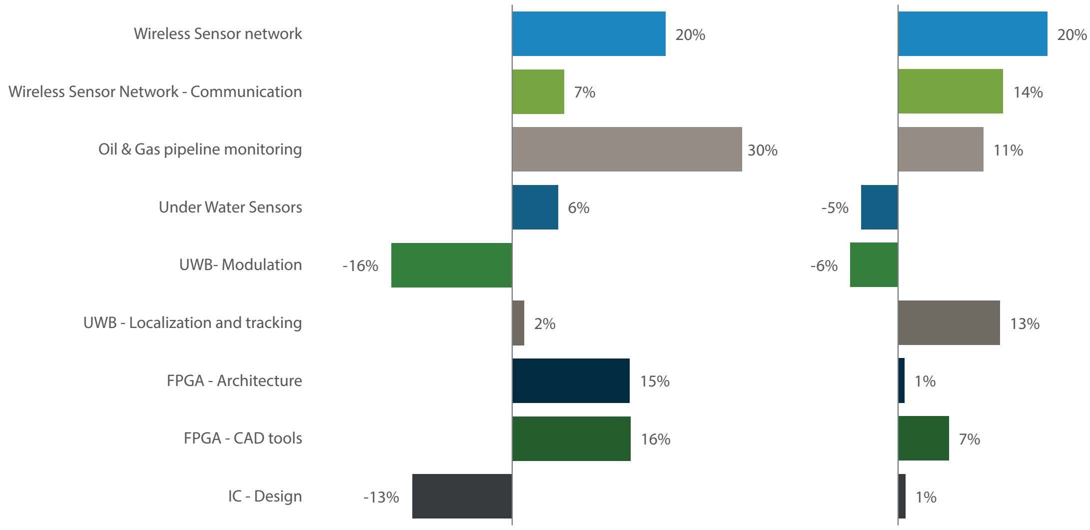

Figure 5 – Average Annual % Growth or Decline in Patent Family (left) or Scientific Paper (right) Output

Growth trends for scientific literature (Figure 6) since 2008 are approximately similar for all technology segments except UWB-Modulation which has undergone sharp decline from 2008-10. A wireless sensor network has undergone significant increase in the literature activity. FPGA-Architecture has persistently increasing publication trend except in years 2009-10, it experienced significant decline. Patenting trends since 2006 (Figure 7) shows IC-design and UWB-Modulation undergone a significant drop from 2006 through 2011. Further patenting trends to note include the emergence of wireless sensor network and oil & gas pipeline monitoring topics.

Average annual growth or decline is calculated by the average percentage increase or decrease between one year and the next. For example; 5 patents in 2006 followed by 6 patents in 2007 would represent an annual increase of 20%. An increase of 20% in one year, followed by a 10% increase the following year would be represented as a 15% average increase across the two years. This process is followed for 2006 (patents) or 2008 (papers) through to the most recently available year in patent and paper collections, to provide an indicator of the level and direction of recent changes in technology topics.

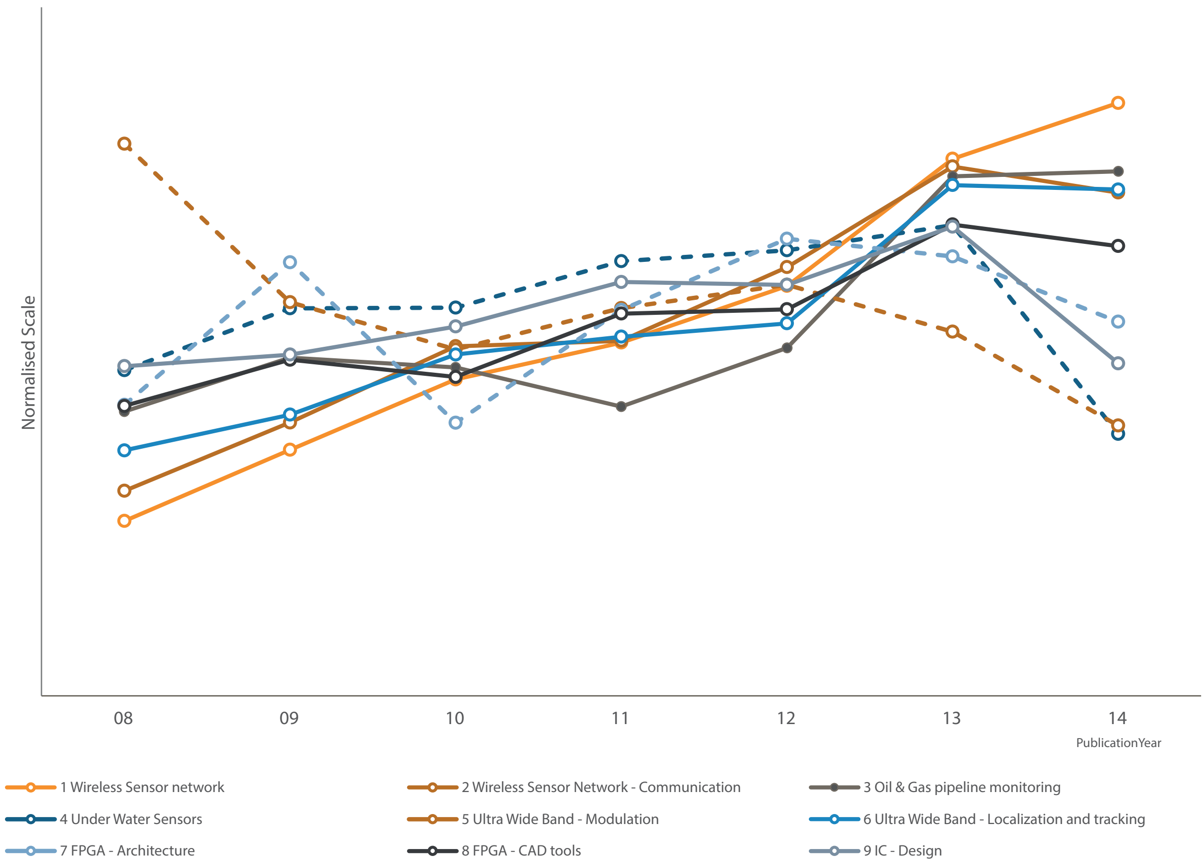

Figure 6 – Normalized Timeline of Activity for Scientific Paper Collection by Various Technology Topics

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The timelines on these charts have been normalised to allow for side by side comparison. Individually, each topic has varying volumes of patent families and scientific papers, however for visualisation purposes, the charts represent the proportion of each topic's activity filed or published in each calendar year.

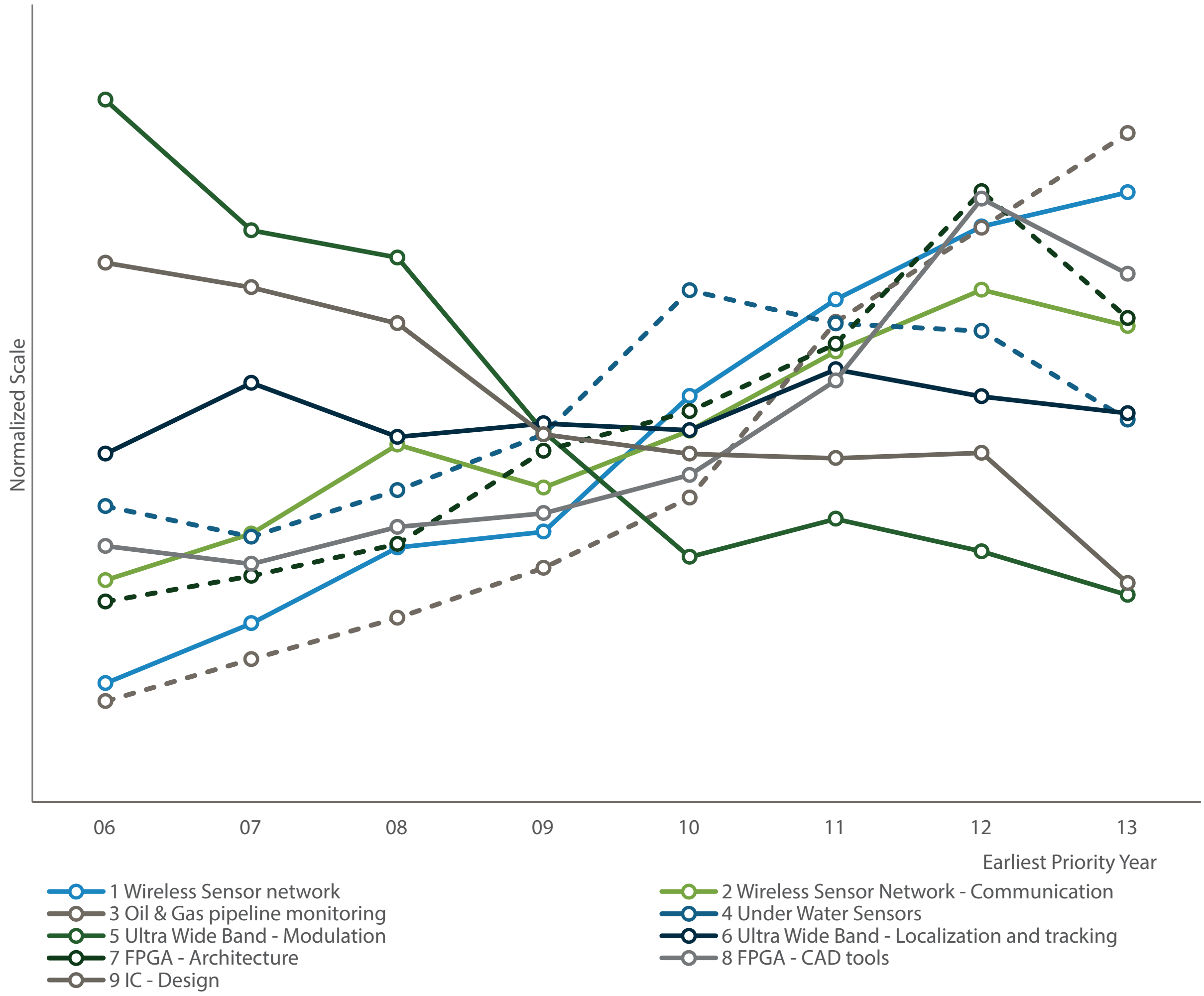

Figure 7 – Normalized Timeline of Activity for Patent Family Collection by Various Technology Topics

WIRELESS COMMUNICATION AND SENSOR NETWORKS SCIENTIFIC LITERATURE TECHNOLOGY TRENDS

This section of the report focuses on the scientific paper collection and the activity and technological trends seen within it. Based on the Thomson Reuters-produced Web of Science database, the collection only includes papers published in pre-selected journals of influence.
In total, over 20,000 peer reviewed papers were incorporated into the Wireless Communication and Sensor Networks technology collection.

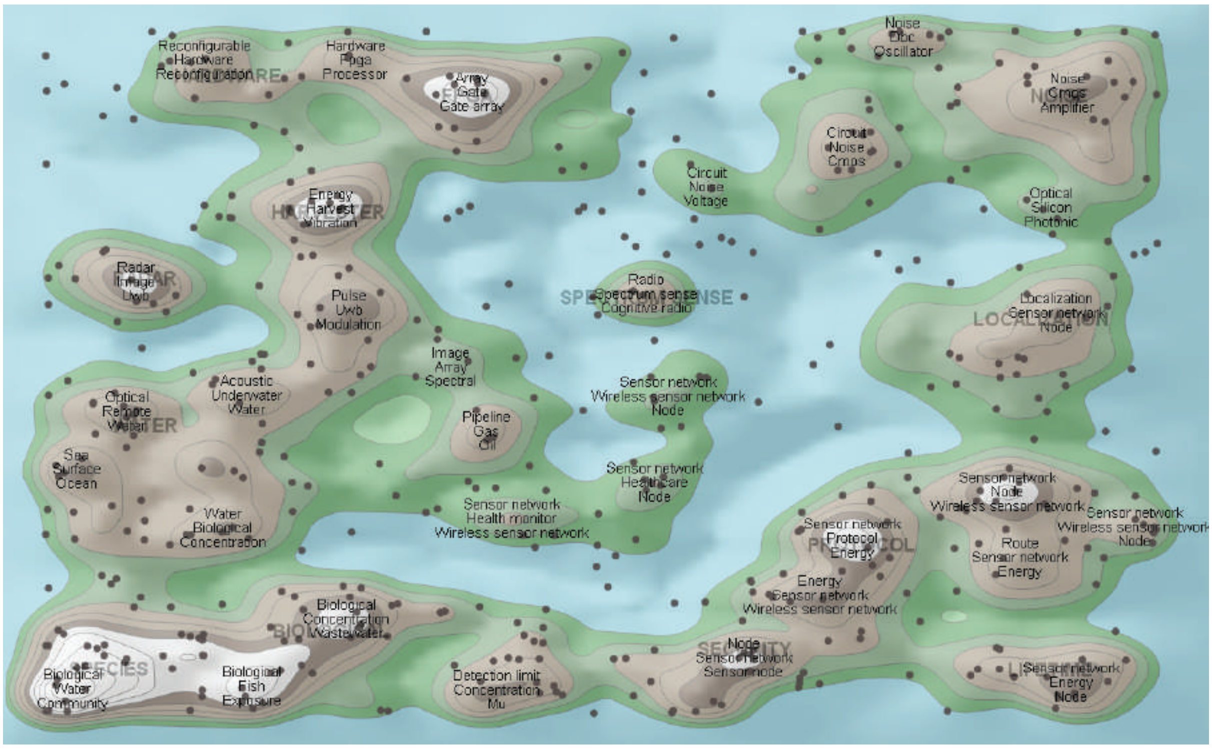

Figure 8 – ThemeScape Map of Scientific Paper Collection; Annotated by Major Themes

Key themes present throughout this collection of papers are illustrated in Figure 8 as a "ThemeScape map" - a visualization method for understanding the common themes and concepts within thousands of documents. Used for market analysis, government intelligence and primarily technology landscapes, the algorithm parses large amounts of text into a topological map of peaks and troughs.
Themes that are commonly shared between documents are represented by mountainous peaks, whereas documents that share little commonality are located within the valleys of the map. The large number of documents in this map means that there are rather few valleys to be found.

The location of an individual document is the vector sum of all the attractions to other documents in the collection based on shared phraseology and the frequency and proximity of these terms.
This map has been manually annotated to summarize the major technology areas within the scientific literature collection. Some technologies will necessarily overlap, and the delineation of one technical area versus another is therefore only approximate. However the map is very useful in describing what topics are common features of global Wireless Communication and Sensor Networks scientific research.
Key themes revealed in this Themescape map focus mainly on Wireless Sensor Network & Communication, Under Water Sensors, Oil & Gas Pipeline Monitoring, UWB – Modulation & Localization/Tracking, FPGA – Architecture / CAD Tools and IC-Design.

ThemeScape® is a text-mining application that acquires and analyzes free text. The algorithms it uses require no application of thesauri or other outside sources of information, and only the free text itself is used by this text-mining tool. The more text the application acquires, the more likely it will be that the output will provide an accurate summary of the major themes present. After analyzing the text in multiple documents, it pulls together those documents that share related text and pulls apart those with less related text. The outcome 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 pick out topics of interest. It aggregates word forms that share a common stem, but it does not directly aggregate synonyms. Instead, synonyms may be gathered under a common theme because of the other words that co-occur with those synonyms. Thus, “battery” and “cell” may be clustered together because of the co-occurrence in the same documents of terms like “electrode, rechargeable, electrolyte” and so on. Conversely, “battery” and “cell” may be separated if the map contains a mixture of documents on metals and biology, where the two terms have different meanings. In other words, terms are identified as synonyms only by co-clustering based on common context.

The topographical maps presented by ThemeScape are mathematical solutions built on a random selection of a first document and sequential calculation of the relationships of all the other documents. The orientation of the map is random, and the directions up, down, left, or right have no significance, because the n-dimensional solution might have been presented from any angle. Only the proximity of points within the map has meaning, and co-localized documents are highly likely to share concepts.

In this report there are separate ThemeScape maps covering scholarly papers or patents. The two types of documents are not pooled and analyzed together. This is because ThemeScape is context-sensitive, and it would separate patent and literature documents from one another based on the very different formal styles of writing that are reflected in these two types of content. Likewise, if documents in two languages are pooled, it will separate them based on the language, and then each language region will be clustered based on term frequency in that language.

The ThemeScape maps in this report analyze large numbers of documents. The contour lines on the maps diminish in circumference, encircling regions of higher and higher concentration. The density is also shown by the map coloration. White snow-capped peaks represent the highest density, while blue expanses (sea level) indicate low density.

The labels in black on the map are selected by ThemeScape based on term frequency in that map region, and they may have been adjusted by the analyst. The large color-overlay regions enclosed by broken lines have been added by the analyst to identify content at an even higher level of abstraction. The dots on the map represent single documents. Dots are not shown for all the documents, and instead represent a sampling that allows the other features of the map to be discerned. Within the ThemeScape application, the map can be magnified, searched, probed and highlighted to learn more about its contents.

ThemeScape is reliant on statistical methods that are not equivalent to reading by human judges, and in compensation, it analyzes millions of documents on a scale of minutes and quickly presents an intuitive, high level summary. It enables and guides further review, and provides a first level overview of very complex datasets.

SCIENTIFIC LITERATURE COLLECTION TECHNOLOGY SEGMENTATION

Table 1 shows the further segmentation of Wireless Communication and Sensor Networks technology topics. Use of biosensors as under water sensors remarkably surpasses other types of sensors (e.g. optical or acoustic sensors). Biosensors appears to be an area of early research and may be pursued for research projects.

Technology Segmentation		Total Publications	Average %Growth or Decline ('09-'14)
1 Wireless Sensor network	1.01 Power saving and efficiency	4553	19%
	1.02 Cross layer Design	280	6%
	1.03 Fault tolerance/Robustness	1448	20%
	1.04 Network configuration	1323	21%
2 Wireless Sensor Network - Communication	2.01 In-network processing	964	12%
	2.02 Localization	1211	14%
	2.03 Timing Synchronization	344	29%
	2.04 Sensor communication and collaborative data	852	12%
3 Oil & Gas pipeline monitoring	3.01 Corrosion/Leakage sensors	191	17%
	3.02 Pressure sensors	73	45%
	3.03 Flow sensors	79	23%
	3.04 Temperature sensors	53	51%
	3.05 Seismic sensors	37	-
	3.06 Computational Pipeline Monitoring	201	-3%
4 Under Water Sensors	4.01 Optical	945	11%
	4.02 Acoustic	716	1%
	4.03 Electrochemical/Electromagnetic	221	11%
	4.04 Biosensor	2532	-13%
5 Ultra Wide Band - Modulation	5.01 Pulse Position Modulation	175	-16%
	5.02 Pulse Amplitude Modulation	85	-22%
	5.03 ON-Off Keying	82	23%
	5.04 Pulse Shape Modulation	139	-6%
	5.05 Phase Modulation	138	-1%
6 Ultra Wide Band - Localization and tracking	6.01 Angle/Time of Arrival	138	0%
	6.02 Received Signal Strength	441	29%
	6.03 Range Based	23	35%
	6.04 UWB RADAR	665	9%
7 FPGA - Architecture	7.01 Coarse Grained	137	9%
	7.02 Asynchronous FPGAs	96	-3%
	7.03 Nano-Technology	110	8%
	7.04 FPGA Embedded Processors	141	4%
8 FPGA - CAD tools	8.01 Routing algorithms	106	14%
	8.02 Placement algorithms	130	6%
	8.03 Timing analysis	155	11%
	8.04 Simulation and verification	2348	6%
9 IC - Design	9.01 Floorplanning/Placement	225	14%
	9.02 Logical Sythesis	89	19%
	9.03 Clock insertion	33	2%
	9.04 Routing	251	3%
	9.05 Signal integrity analysis	2073	0%
	9.06 Timing performance analysis	279	-4%

Table 1 – Scientific Literature Collection Technology Segmentation

SCIENTIFIC LITERATURE COLLECTION TECHNOLOGY CATEGORY OVERLAP

The technology categories, that were created to enumerate and describe the Wireless Communication and Sensor Networks landscape, were not intended to be mutually exclusive. A single scientific paper can be included in multiple categories or segments.

Figure 9 visualizes the relationship between the various technology segments used in this study. Each number in the diagram shows the number of papers that have content related to both the corresponding row-wise and column-wise segments.

The most correlated segment pairing is wireless sensor network with wireless sensor network-communication. Otherwise, mostly smaller sets are generally observed as an overlap between the technology segments.

	1 Wireless Sensor network	2 Wireless Sensor Network - Communication	3 Oil & Gas pipeline monitoring	4 Under Water Sensors	5 Ultra Wide Band - Modulation	6 Ultra Wide Band - Localization and tracking	7 FPGA - Architecture	8 FPGA - CAD tools	9 IC - Design
1 Wireless Sensor network	6653	1259	9	35	14	68	8	11	21
2 Wireless Sensor Network - Communication		3065	4	33	7	106	1	5	4
3 Oil & Gas pipeline monitoring			562	2		2		2	
4 Under Water Sensors				4272		2		1	2
5 Ultra Wide Band - Modulation					469	19		1	3
6 Ultra Wide Band - Localization and tracking						1235		5	8
7 FPGA - Architecture							464	211	5
8 FPGA - CAD tools								2566	39
9 IC - Design									2842

Figure 9 – Number of Scientific Papers per Pair of Technology Segments

SCIENTIFIC PAPER GEOGRAPHIC VOLUME BENCHMARKING

Figure 10 shows the number of scientific papers for the ten most prolific countries within the scientific paper collection.
United Sates is the largest source of Wireless Communication and Sensor Networks -related peer-reviewed papers, followed by the China, South Korea, Canada, United Kingdom and Italy.

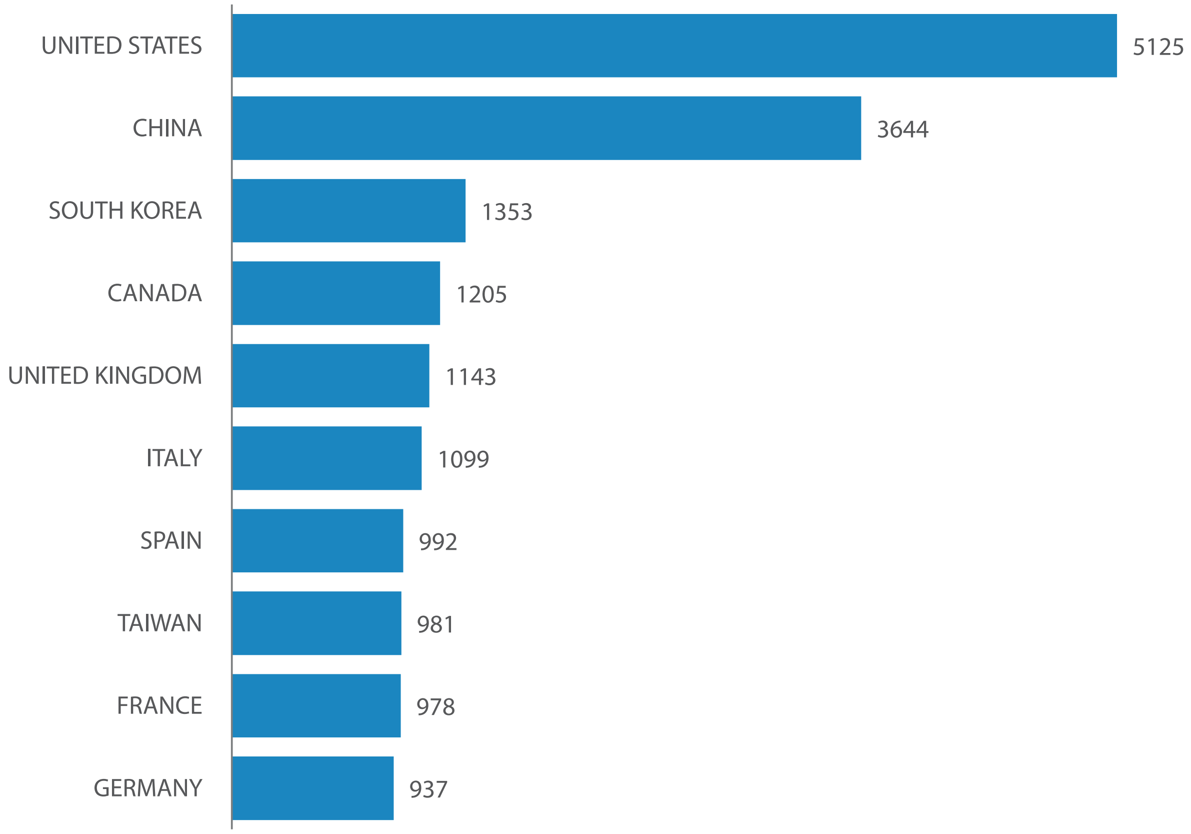

Figure 10 – Number of Scientific Papers per Country; Top 10 Sources

SCIENTIFIC PAPER GEOGRAPHIC ACTIVITY TRENDS

The chart below shows the highest grow rates sources in the scientific literature collection.

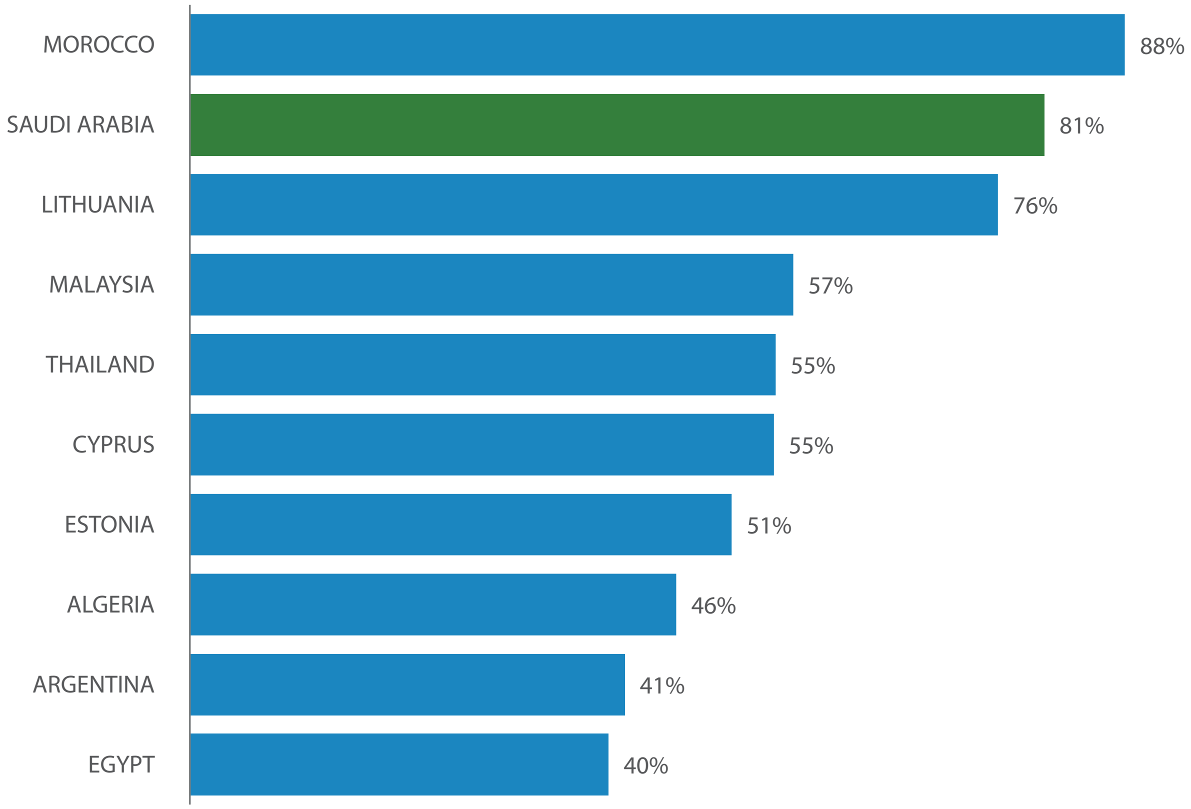

Figure 11 – Highest Growth Rate Geographies in Scientific Publications Output

While scientific literature collection for Morocco, Lithuania and Serbia is small relative to the collections of the most prolific countries, the growth rate of Morocco, Lithuania and Serbia collection far exceeds that of other countries.

SCIENTIFIC PAPER GEOGRAPHIC CITATION IMPACT BENCHMARKING

Scientific paper and patent citations are routinely used in technology bibliometrics for assessing the inherent impact and potential quality of research and the downstream technical and scientific relevance of the underlying research.
Figure 12 shows the “Citation Impact”, the average citation per paper for all papers in a country’s collection (which are having at least 50 publications) and has been sorted by highest citation impact. This shows that output from Denmark, Switzerland, United States and Belgium are having the highest impact in the wireless communication and sensor networks topic.

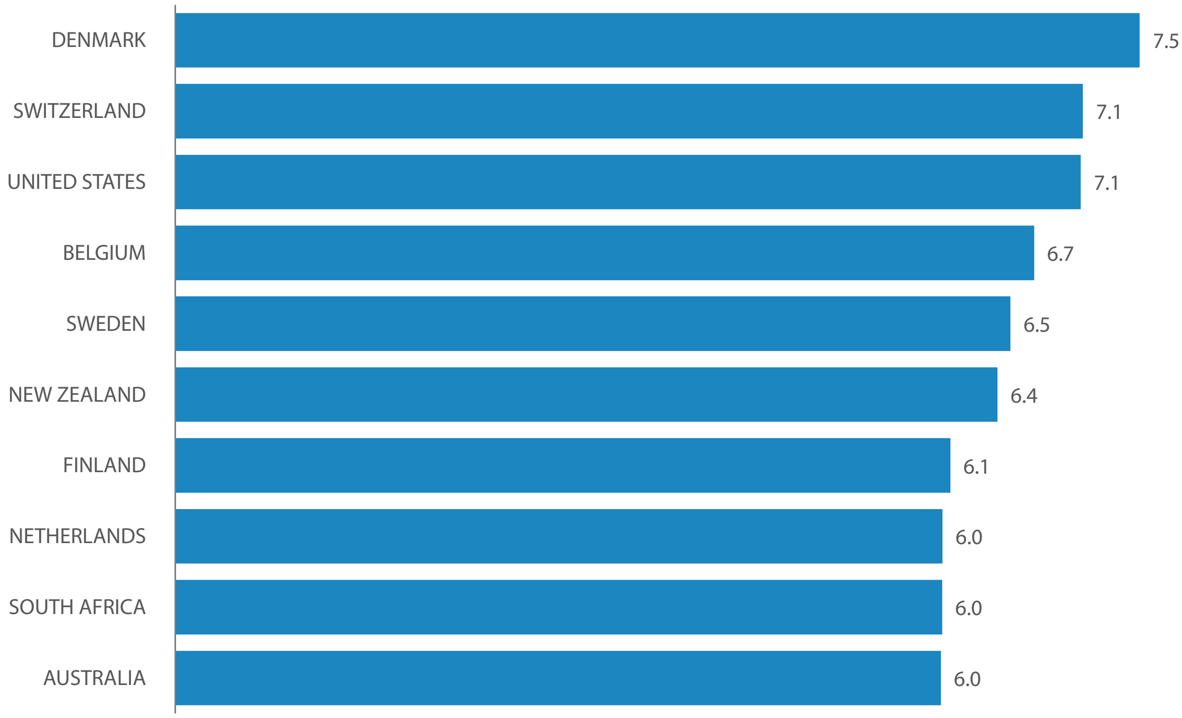

Figure 12 – Highest Citation Impact Geographies of Scientific Publications

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Note that the journals included in the project source data (Web of Science) are selected on the basis of both quantitative and qualitative selection criteria, such as editorial quality, peer review robustness and citation impact. Further details of the journal selection process is available from : http://thomsonreuters.com/products_services/science/free/essays/journal_selection_process/

SCIENTIFIC LITERATURE COLLECTION WIRELESS COMMUNICATION AND SENSOR NETWORKS TOPICS BY GEOGRAPHY

Table 2 shows the split of Wireless Communication and Sensor Networks science and research specialization for the top nations. Top 3 nations United States, China and United Kingdom appear to have focus on Wireless Sensor Network, Wireless Sensor Network-Communication, Underwater Sensors and IC-Design. Saudi Arabia is dominantly focusing in the fields of Wireless Sensor Network, Wireless Sensor Network-Communication, Underwater Sensors and FPGA-CAD tools.

Country of Origin	1 Wireless Sensor network	2 Wireless Sensor Network - Communication	3 Oil & Gas pipeline monitoring	4 Under Water Sensors	5 Ultra Wide Band - Modulation	6 Ultra Wide Band - Localization and tracking	7 FPGA - Architecture	8 FPGA - CAD tools	9 IC - Design
UNITED STATES	31%	17%	2%	25%	1%	3%	2%	11%	18%
CHINA	45%	22%	3%	14%	3%	5%	2%	8%	9%
SOUTH KOREA	52%	19%	1%	9%	3%	4%	3%	7%	14%
CANADA	28%	16%	3%	25%	5%	5%	2%	17%	9%
UNITED KINGDOM	29%	10%	3%	33%	2%	3%	2%	13%	10%
ITALY	33%	14%	2%	24%	2%	4%	2%	12%	16%
SPAIN	32%	16%	1%	28%	2%	3%	3%	18%	7%
TAIWAN	42%	19%	1%	6%	2%	3%	2%	15%	21%
FRANCE	25%	9%	2%	33%	2%	3%	2%	13%	17%
GERMANY	16%	9%	3%	32%	1%	6%	2%	12%	24%
JAPAN	26%	11%	1%	17%	2%	7%	4%	14%	25%
INDIA	35%	15%	3%	14%	1%	3%	3%	25%	10%
AUSTRALIA	31%	15%	2%	41%	1%	3%	1%	8%	7%
NETHERLANDS	25%	9%	2%	32%	2%	6%	2%	8%	18%
IRAN	33%	12%	8%	15%	4%	3%	3%	22%	8%
SINGAPORE	45%	19%	1%	7%	8%	5%	2%	8%	16%
BRAZIL	30%	16%	10%	30%	0%	2%	4%	13%	6%
TURKEY	47%	24%	2%	12%	2%	7%	1%	10%	6%
SWITZERLAND	27%	7%	1%	21%	1%	1%	3%	12%	31%
SWEDEN	27%	15%	5%	24%	3%	7%	1%	5%	20%
BELGIUM	20%	8%	2%	37%	1%	5%	4%	11%	19%
PORTUGAL	31%	15%	3%	37%	1%	1%	3%	11%	11%
GREECE	43%	16%	2%	15%	1%	2%	6%	16%	10%
MALAYSIA	44%	9%	6%	15%	1%	8%	0%	13%	9%
NORWAY	20%	8%	4%	61%	1%	4%	1%	4%	3%
IRELAND	44%	10%	1%	22%	3%	11%	1%	10%	8%
POLAND	17%	8%	4%	20%	0%	1%	4%	32%	17%
FINLAND	35%	10%	2%	27%	2%	2%	2%	8%	19%
SAUDI ARABIA	46%	27%	5%	13%	2%	7%	2%	12%	5%
AUSTRIA	26%	9%	1%	35%	0%	5%	2%	12%	18%
MEXICO	15%	9%	8%	31%	2%	1%	3%	26%	7%
RUSSIA	14%	6%	17%	35%	1%	9%	1%	4%	17%
DENMARK	20%	5%	4%	50%	8%	1%	1%	2%	11%
PAKISTAN	58%	24%	1%	6%	4%	3%	1%	11%	2%
NEW ZEALAND	28%	10%	1%	57%	0%	1%	1%	5%	3%
ISRAEL	21%	24%	0%	29%	2%	4%	1%	6%	23%

Table 2 – Specialization by Country; % of Literature Activity per Technical Stream

SCIENTIFIC LITERATURE - PROLIFIC GLOBAL ENTITIES

Universities appear to dominate the scientific paper publications in Wireless Communication and Sensor Networks technology. Notably, a large number of Chinese universities feature in the top 30 entities publishing scientific literature in this area. Science & Technology Unit, Umm al Qura University (STU-UQU) has only 7 papers published in this space, with the citation per paper relatively low as compared to other entities within the top 30. Entities from the United States appear to be leading with higher citations per paper than others – indicating potentially important research papers being published.

Entity	Total	Times Cited	Citation per paper
Science & Technology Unit, Umm Al Qura University (STU-UQU)	7	8	1.14
University Of California	508	6024	11.86
Chinese Acad Sci	406	1564	3.85
Cnrs	292	1680	5.75
Tsing Hua University	223	48	0.22
Florida State University System	215	72	0.33
Nanyang Technol Univ	202	649	3.21
Georgia Institute Of Technology	178	1176	6.61
Zhejiang University	169	832	4.92
Indian Institute Of Technology (Iit	162	1309	8.08
National Taiwan University	138	68	0.49
Seoul National University	137	730	5.33
United States Department Of Energy (e	135	595	4.41
Delft University Of Technology	134	574	4.28
National Oceanic Atmospheric Admin (Noaa) - Usa	129	455	3.53
United States Department Of Defense	126	1354	10.75
Univ Michigan	126	642	5.10
Consejo Superior De Investigaciones Cientificas (Csic	124	1068	8.61
Shanghai Jiao Tong Univ	122	718	5.89
Korea Adv Inst Sci & Technol	121	1061	8.77
Natl Chiao Tung Univ	119	1072	9.01
Pennsylvania Commonwealth System Of Higher Education (Pcshe	119	389	3.27
Texas A&M University System	119	573	4.82
State University Of New York (Suny) System	116	366	3.16
University Of Electronic Science & Technology - China	115	551	4.79
Beijing Univ Posts & Telecommun	112	799	7.13
Mit	111	882	7.95
Natl Cheng Kung Univ	111	401	3.61
Southeast Univ	110	1208	10.98
Univ British Columbia	110	434	3.95
Univ Washington	110	553	5.03

Table 3 – Wireless Communication and Sensor Networks – Top entities for Scientific Literature

SCIENTIFIC LITERATURE OVERVIEW OF TOP GLOBAL ENTITIES

Table 4 shows the technology profile of the top 30 entities within the scientific literature space of wireless communication and sensor networks. The top entities appear to be researching in the same areas as the landscape on a whole – power saving and efficiency, biosensors for underwater applications, simulation and verification, and signal integrity analysis. Science & Technology Unit, Umm Al Qura University (STU-UQU) has 7 publications across power saving and efficiency, cross layer design, network configuration, in-network processing, sensor communication and collaborative data, and simulation and verification.

Entity	1.01 Power Saving And Efficiency	1.02 Cross Layer Design	1.03 Fault Tolerance/Robustness	1.04 Network Configuration	2.01 In-Network Processing	2.02 Localization	2.03 Timing Synchronization	2.04 Sensor Communication And Collaborative Data	3.01 Corrosion/Leakage Sensors	3.02 Pressure Sensors	3.03 Flow Sensors	3.04 Temperature Sensors	3.05 Seismic Sensors	3.06 Computational Pipeline Monitoring
Science & Technology Unit, Umm Al Qura University (STU-UQU)	3	1	2	2	1	2		1						
University Of California	74	3	30	20	22	18	11	12						2
Chinese Acad Sci	83	6	15	27	22	21	11	11	3		1	1		1
Cnrs	38	1	11	8	3	2	2	5	1					4
Tsing Hua University	55	3	26	10	9	24	5	8	4	1	1			4
Florida State University System	43	3	20	13	8	14	1	10	1	1	1			1
Nanyang Technol Univ	58	4	21	9	13	29	6	6						
Georgia Institute Of Technology	63	9	16	9	11	9	9	12						
Zhejiang University	43	2	22	20	12	18	8	7	1					2
Indian Institute Of Technology (Iit	34		14	7	9	5		8	6	3	4	1		8
National Taiwan University	30	2	6	7	10	14	4	5			1		1	
Seoul National University	46		11	11	8	7		8					1	
United States Department Of Energy (e	18		13	12	1	2	2	6						1
Delft University Of Technology	20		5	1	3	6	3	1		1				1
National Oceanic Atmospheric Admin (Noaa) - Usa								3						
United States Department Of Defense	13	4	11	2	4	4	1	5						
Univ Michigan	38	2	15	14	6	5	5	3				1		
Consejo Superior De Investigaciones Cientificas (Csic	7		1	4				2					1	
Shanghai Jiao Tong Univ	49	6	15	9	7	15	4	6	1					1
Korea Adv Inst Sci & Technol	37	2	11	14	8	4	5	2						1
Natl Chiao Tung Univ	28	2	10	8	6	10	1	7						
Pennsylvania Commonwealth System Of Higher Education (Pcshe	26	2	10	13	7	4	2	8			1			
Texas A&M University System	31	1	14	7	12	14	16	9	1					1
State University Of New York (Suny) System	34	8	12	6	11	8	2	9						
University Of Electronic Science & Technology - China	27		13	5	11	8	4	5	1					1
Beijing Univ Posts & Telecommun	51	3	14	9	16	10	1	4						
Mit	15	1	7	4	6	9	1	2						
Natl Cheng Kung Univ	45	6	12	9	7	10	2	3						1
Southeast Univ	46	1	3	13	9	9	2	3		1	3			
Univ British Columbia	26	1	7	7	12	5		8	2					
Univ Washington	20	3	5	9	3	8		3						

Table 4 – Scientific literature overview of top global entities (continued on next page)

Entity	4.01 Optical	4.02 Acoustic	4.03 Electrochemical/Electro magnetic	4.04 Biosensor	5.01 Pulse Position Modulation	5.02 Pulse Amplitude Modulation	5.03 On-Off Keying	5.04 Pulse Shape Modulation	5.05 Phase Modulation
Science & Technology Unit, Umm Al Qura University (STU-UQU)									
University Of California	24	34	3	100	2		2	2	5
Chinese Acad Sci	45	6	11	77	2	1	1	2	1
Cnrs	30	10	1	88	3	2	3	3	1
Tsing Hua University	6	3		8	1		3	5	5
Florida State University System	26	10		40	2		1	1	1
Nanyang Technol Univ	1	7	1	4	7	5	4	13	3
Georgia Institute Of Technology	1	9	1	5		3	2		
Zhejiang University	5	7	3	10	1		1		1
Indian Institute Of Technology (Iit	13	7	2	8	3	1			
National Taiwan University	2	3		10			2		1
Seoul National University	6	4		5					
United States Department Of Energy (e	7	7	2	11					
Delft University Of Technology	13	10		15	2	1	1		
National Oceanic Atmospheric Admin (Noaa) - Usa	25	28	2	75					
United States Department Of Defense	17	32	3	4				1	
Univ Michigan	2	3	1	5	2		1	3	
Consejo Superior De Investigaciones Cientificas (Csic	5	4	1	64					
Shanghai Jiao Tong Univ	1			1		1		1	2
Korea Adv Inst Sci & Technol	3	1		1	1			1	1
Natl Chiao Tung Univ	2								
Pennsylvania Commonwealth System Of Higher Education (Pcshe	4	12		10	1	1			
Texas A&M University System	9	7		8			1		2
State University Of New York (Suny) System	7	6	1	14					
University Of Electronic Science & Technology - China		3		1			2		
Beijing Univ Posts & Telecommun		2			3	3		4	2
Mit	7	17	1	9	2	1	1	1	
Natl Cheng Kung Univ	2	3	1	3					
Southeast Univ	1		1				4		4
Univ British Columbia	2	6	1	17	2		2		2
Univ Washington	13	11	2	25	1				

Table 4 – Continued from previous page

Entity	6.01 Angle/Time Of Arrival	6.02 Received Signal Strength	6.03 Range Based	6.04 Uwb Radar	7.01 Coarse Grained	7.02 Asynchronous Fpgas	7.03 Nano-Technology	7.04 Fpga Embedded Processors	8.01 Routing Algorithms	8.02 Placement Algorithms	8.03 Timing Analysis	8.04 Simulation And Verification	9.01 Floorplanning/Placement	9.02 Logical Sythesis	9.03 Clock Insertion	9.04 Routing	9.05 Signal Integrity Analysis	9.06 Timing Performance Analysis
Science & Technology Unit, Umm Al Qura University (STU-UQU)												1						
University Of California		10		4	4	2	6	3	4	9	7	49	11	5	1	13	95	6
Chinese Acad Sci	1	5		23		3	4		1	1		26	2		1	7	38	7
Cnrs		2		7	1		3	2	1		1	26	3	1	1	4	42	12
Tsing Hua University	1	12		3	13		1	2	1	3	2	37	2			7	22	6
Florida State University System	1	2		1	1			3		2	2	23		1	1	3	18	
Nanyang Technol Univ	12	7		6			2	1	1	1	1	16				4	19	
Georgia Institute Of Technology									2	3	1	12	3	1		7	30	4
Zhejiang University		3		1		1			1	2		18	1			6	9	2
Indian Institute Of Technology (Iit		5		4	1	2	2		3	1	5	30	2	1	1	1	5	1
National Taiwan University		7		2	1				1	2	1	12	3	1		8	29	4
Seoul National University	1	7			15			2			2	12	2	1		1	17	2
United States Department Of Energy (e		1		3	1	1		1	1	3	1	29	2				28	1
Delft University Of Technology	3	2		18	1			1	1	1	1	13	2	1			13	2
National Oceanic Atmospheric Admin (Noaa) - Usa																		
United States Department Of Defense				13				1	1			6	1		1		13	1
Univ Michigan		1		9	1		1		2	1		12	3		1	3	16	4
Consejo Superior De Investigaciones Cientificas (Csic								2			1	9	1	1		2	18	2
Shanghai Jiao Tong Univ	1	4							1	3		17	2	1		1	3	2
Korea Adv Inst Sci & Technol		4		4				2				2			1	1	29	1
Natl Chiao Tung Univ		3				1		2	1			12	6	1		2	35	1
Pennsylvania Commonwealth System Of Higher Education (Pcshe		3		14	2		1		1			11	4	1		2	2	2
Texas A&M University System				1	3			2			1	9	2	1		1	10	1
State University Of New York (Suny) System				1			5		1			8	6	3	1	3	7	1
University Of Electronic Science & Technology - China	1	2	2	20			1		2			14	1			3	12	
Beijing Univ Posts & Telecommun	1	5		5								2				1	10	
Mit	7			1		1				1		6		3		2	23	3
Natl Cheng Kung Univ		2			3	2			3		1	15	3		1	1	11	3
Southeast Univ		5		2	9		1	1				14				1	11	
Univ British Columbia		2		1	2			3	3	1	6	15	1	1		2	4	
Univ Washington		4			1		1				1	9	1	1			10	1

SCIENTIFIC LITERATURE OVERVIEW OF TOP ASIA PACIFIC ENTITIES

Table 6 visualizes the prolific entities in the Middle East and Africa. The list is dominated by Middle Eastern entities, reflecting the trends seen in table 5 above. Most of the prolific entities in these regions follow the global focus trends on parallel computing, computer networks, and network devices, while not focusing heavily on other technologies. Notable exceptions include the King Saud University, with a large focus on Computer Networks, and additional focus on cloud computing and e-health; King Abdulaziz University, also with a large focus on cloud computing; and Gazi University, Turkey having a large focus on IT security.

Table 5 – Scientific literature overview of top Asia Pacific entities

Entity	Country of Origin	Total	1.01 Power Saving And Efficiency	1.02 Cross Layer Design	1.03 Fault Tolerance/Robustness	1.04 Network Configuration	2.01 In-Network Processing	2.02 Localization	2.03 Timing Synchronization	2.04 Sensor Communication And Collaborative Data	3.01 Corrosion/Leakage Sensors	3.02 Pressure Sensors	3.03 Flow Sensors	3.04 Temperature Sensors	3.05 Seismic Sensors	3.06 Computational Pipeline Monitoring	4.01 Optical	4.02 Acoustic	4.03 Electrochemical/Electro magnetic	4.04 Biosensor	5.01 Pulse Position Modulation	5.02 Pulse Amplitude Modulation	5.03 On-Off Keying
Science & Technology Unit, Umm Al Qura University (STU-UQU)	Saudi Arabia	7	3	1	2	2	1	2		1													
Chinese Acad Sci	China	405	83	6	15	27	22	21	11	11	3			1		1	45	6	11	77	2	1	1
Tsing Hua University	China	216	55	3	26	10	9	24	5	8	4	1	1			4	6	3		8	1		3
Nanyang Technol Univ	Singapore	190	58	4	21	9	13	29	6	6							1	7	1	4	7	5	4
Zhejiang University	China	167	43	2	22	20	12	18	8	7	1					2	5	7	3	10	1		1
Indian Institute Of Technology (Iit	India	158	34		14	7	9	5		8	5	2	3	1		8	13	7	2	8	3	1	
Seoul National University	South Korea	133	46		11	11	8	7		8					1		6	4		5			
National Taiwan University	Taiwan	131	30	2	6	7	10	14	4	5					1		2	3		10			2
University Of Electronic Science & Technology - China	China	121	27		15	7	11	9	4	5	2					1		3		1			2
Natl Chiao Tung Univ	Taiwan	119	28	2	10	8	6	10	1	7							2						
Shanghai Jiao Tong Univ	China	119	49	6	15	9	7	15	4	6	1					1	1			1		1	
Korea Adv Inst Sci & Technol	South Korea	118	37	2	11	14	8	4	5	2						1	3	1		1	1		
Natl Cheng Kung Univ	Taiwan	110	45	6	12	9	7	10	2	3						1	2	3	1	3			
Beijing Univ Posts & Telecommun	China	109	51	3	14	9	16	10	1	4								2			3	3	
Southeast University - China	China	108	46	1	3	13	9	9	2	3		1	2				1		1				4
Huazhong University Of Science & Technology	China	106	33		9	11	3	7	1	4	1					1	2	2	6	1	3	4	3
Hong Kong Univ Sci & Technol	China	102	38	4	16	13	15	12	3	4							2	1		8			
Xidian University	China	101	33	3	14	5	10	7	4	5						5					1	3	1
Korea Univ	South Korea	99	48	1	9	5	2	13	6	7								2		4			
Univ Tokyo	Japan	98	16	1	7	5	8	6	6	3					1		6	2		17			
National University Of Defence Technology - China	China	93	16	2	7	6	3	11	3								2	4					

Entity	Country of Origin	Total	5.04 Pulse Shape Modulation	5.05 Phase Modulation	6.01 Angle/Time Of Arrival	6.02 Received Signal Strength	6.03 Range Based	6.04 Uwb Radar	7.01 Coarse Grained	7.02 Asynchronous Fpgas	7.03 Nano-Technology	7.04 Fpga Embedded Processors	8.01 Routing Algorithms	8.02 Placement Algorithms	8.03 Timing Analysis	8.04 Simulation And Verification	9.01 Floorplanning/Placement	9.02 Logical Sythesis	9.03 Clock Insertion	9.04 Routing	9.05 Signal Integrity Analysis	9.06 Timing Performance Analysis
Science & Technology Unit, Umm Al Qura University (STU-UQU)	Saudi Arabia	7														1						
Chinese Acad Sci	China	405	2	1	1	5		23		3	4		1	1		26	2		1	7	38	7
Tsing Hua University	China	216	5	5	1	5		3	13		1	2	1	3	2	37	2			7	22	6
Nanyang Technol Univ	Singapore	190	13	3	3	4		6			2	1	1	1	1	16				4	19	
Zhejiang University	China	167		1		1		1		1			1	2		18	1			6	9	2
Indian Institute Of Technology (Iit	India	158				2		4	1	2	2		3	1	5	30	2	1	1	1	5	1
Seoul National University	South Korea	133			1	3			15			2			2	12	2	1		1	17	2
National Taiwan University	Taiwan	131		1		1		2	1				1	2	1	12	3	1		8	29	4
University Of Electronic Science & Technology - China	China	121			1	1	2	20			1		2			14	1			4	13	
Natl Chiao Tung Univ	Taiwan	119				3				1		2	1			12	6	1		2	35	1
Shanghai Jiao Tong Univ	China	119	1	2		2							1	3		17	2	1		1	3	2
Korea Adv Inst Sci & Technol	South Korea	118	1	1		1		4				2				2			1	1	29	1
Natl Cheng Kung Univ	Taiwan	110				1			3	2			3		1	15	3		1	1	11	3
Beijing Univ Posts & Telecommun	China	109	4	2	1	2		5								2				1	10	
Southeast University - China	China	108		4		4		2	9		1	1				14				1	11	
Huazhong University Of Science & Technology	China	106	14	18					1			1				6				1	5	3
Hong Kong Univ Sci & Technol	China	102				2					1			1	1	2			1	1	11	1
Xidian University	China	101	1	1		1		8					1	1	3	9	1			3	9	1
Korea Univ	South Korea	99				2			1			1				8					10	1
Univ Tokyo	Japan	98	1		1	3		1		2		1				3		1		1	23	6
National University Of Defence Technology - China	China	93				1	2	25	3	1	1	1	1		1	12	1			2	1	

SCIENTIFIC LITERATURE OVERVIEW OF MIDDLE EAST & AFRICA ENTITIES

Table 6 visualizes the prolific entities in the Middle East and Africa. The list is dominated by Iran, Turkey and the Kingdom of Saudi Arabia, reflecting the trends seen in table 5 above. Most of the prolific entities in these regions on power saving and efficiency of wireless sensor network; and simulation and verification of FPGA, while not focusing heavily on other technologies.

Entity	Country of Origin	Total	1.01 Power Saving And Efficiency	1.02 Cross Layer Design	1.03 Fault Tolerance/Robustness	1.04 Network Configuration	2.01 In-Network Processing	2.02 Localization	2.03 Timing Synchronization	2.04 Sensor Communication And Collaborative Data	3.01 Corrosion/Leakage Sensors	3.02 Pressure Sensors	3.03 Flow Sensors	3.04 Temperature Sensors	3.05 Seismic Sensors	3.06 Computational Pipeline Monitoring
Science & Technology Unit, Umm Al Qura University (STU-UQU)	Saudi Arabia	7	3	1	2	2	1	1		1						
Islamic Azad Univ	Iran	65	31		5	4	1	1	1	2	1				1	1
King Saud Univ Riyadh	Saudi Arabia	53	16	5	3	5	7	5	2	4	1					2
Sharif Univ Technol	Iran	49	9	3	3	1		2		3	2		1	1		
Amirkabir Univ Technol	Iran	44	18		2	2	4	3			1				1	5
Univ Tehran	Iran	41	9	2	3	2	2	2		3					1	4
King Fahd Univ Petr & Minerals	Saudi Arabia	36	8	1	4	5	5	3	1	1	3					
Bogazici Univ	Turkey	35	17	3	2	8		6	1	2						
Middle E Tech Univ	Turkey	30	12		1	2	2	2	1	1						
Shahid Beheshti Univ	Iran	27	5	1	5				1	1						
Univ Cape Town	South Africa	22	4		2	2				1						
King Abdulaziz Univ	Saudi Arabia	21	5	2	3	2	1	1		3		1	1			
Iran Univ Sci & Technol	Iran	20	4		2		2	4	1							1
King Abdullah Univ Sci & Technol	Saudi Arabia	20	4		4		1	1		1						
Bilkent Univ	Turkey	18	7		2	2	3	6	2							
Bahcesehir Univ	Turkey	17	9	3	4	6	2	1		1						
Koc Univ	Turkey	17	12	3	2	1	1	1		1						
Sabanci Univ	Turkey	17	6		1		3	2		2						
Ege Univ	Turkey	16	6	2	1		1		4							
Ferdowsi Univ Mashhad	Iran	16	5			3	1			1						1
Isfahan Univ Technol	Iran	15	3				2		1							
Tobb Univ Econ & Technol	Turkey	15	12			1	3			1						
Kuwait Univ	Kuwait	14	2	1	1		1	1	1	2						
Tarbiat Modares Univ	Iran	14	3		3	1	1	1		1					1	
Cairo Univ	Egypt	13	4	1		2	2					1				
Gazi Univ	Turkey	13	7		1	2	2									1
Istanbul Tech Univ	Turkey	13	3	1	1		1	1		1						1
Univ Pretoria	South Africa	13	4	1	2		1	1		1						
Univ Tabriz	Iran	13	2		1		1				3	1				
Amer Univ Beirut	Lebonon	12	7		3	2		2		1						
Erciyes Univ	Turkey	12					1									1

Table 6 –Scientific literature overview of Middle East & Africa entities

Entity	Country of Origin	Total	4.01 Optical	4.02 Acoustic	4.03 Electrochemical/Electro	4.04 Biosensor	5.01 Pulse Position Modulation	5.03 On-Off Keying	5.04 Pulse Shape Modulation	5.05 Phase Modulation	6.02 Received Signal Strength	6.04 Uwb Radar	7.01 Coarse Grained	7.02 Asynchronous Fpgas	7.03 Nano-Technology	7.04 Fpga Embedded Processors	8.01 Routing Algorithms	8.02 Placement Algorithms	8.03 Timing Analysis	8.04 Simulation And Verification	9.01 Floorplanning/Placeme	9.02 Logical Sythesis	9.04 Routing	9.05 Signal Integrity Analysis	9.06 Timing Performance Analysis
Science & Technology Unit, Umm Al Qura University (STU-UQU)	Saudi Arabia	7																		1					
Islamic Azad Univ	Iran	65			5	3	1			2		1			3					9		2	1	1	
King Saud Univ Riyadh	Saudi Arabia	53	1			2			2			5				3		2		8					
Sharif Univ Technol	Iran	49	1				1		2	1		1		1	1				1	19			3	5	1
Amirkabir Univ Technol	Iran	44	1	1								2					2	2		7				1	
Univ Tehran	Iran	41	1			3	2				1	2		1	1	1				8				3	1
King Fahd Univ Petr & Minerals	Saudi Arabia	36	1			1					1	2					1	2		8					
Bogazici Univ	Turkey	35					2		1								1			1	1		1	1	
Middle E Tech Univ	Turkey	30		2		2						3		1						1			1	5	
Shahid Beheshti Univ	Iran	27				1			1					1	2	1	5	2		4		2	2	2	1
Univ Cape Town	South Africa	22	2	1		10																		1	
King Abdulaziz Univ	Saudi Arabia	21			1		1				1	1								1				3	
Iran Univ Sci & Technol	Iran	20	1	2			1					2					1	1		4		1			
King Abdullah Univ Sci & Technol	Saudi Arabia	20		1		10														1			1	1	
Bilkent Univ	Turkey	18							1			1	1							1					
Bahcesehir Univ	Turkey	17													1										
Koc Univ	Turkey	17		1																			1		
Sabanci Univ	Turkey	17										3								2				1	
Ege Univ	Turkey	16		1	1	1			1											1					
Ferdowsi Univ Mashhad	Iran	16				1			1											1				3	
Isfahan Univ Technol	Iran	15	3		1				1										1	5					
Tobb Univ Econ & Technol	Turkey	15																							
Kuwait Univ	Kuwait	14				1						1						1		2		1	2		
Tarbiat Modares Univ	Iran	14	3			2		1												1					
Cairo Univ	Egypt	13				1														3			1		
Gazi Univ	Turkey	13				1														1					
Istanbul Tech Univ	Turkey	13	1	3		1														1				2	1
Univ Pretoria	South Africa	13				2																		4	
Univ Tabriz	Iran	13				2														3				1	
Amer Univ Beirut	Lebonon	12				1			1			1								1					
Erciyes Univ	Turkey	12				3														7					

Table 6– Continued from previous page

SCIENTIFIC LITERATURE OVERVIEW OF TOP SAUDI ARABIA ENTITIES

Entities	Total	1.01 Power Saving And Efficiency	1.02 Cross Layer Design	1.03 Fault Tolerance/Robustness	1.04 Network Configuration	2.01 In-Network Processing	2.02 Localization	2.03 Timing Synchronization	2.04 Sensor Communication And Collaborative Data	3.01 Corrosion/Leakage Sensors	3.02 Pressure Sensors	3.06 Computational Pipeline Monitoring	4.01 Optical	4.02 Acoustic	4.03 Electrochemical/Electro magnetic	4.04 Biosensor	5.01 Pulse Position Modulation	5.02 Pulse Amplitude Modulation	5.04 Pulse Shape Modulation	5.05 Phase Modulation	6.02 Received Signal Strength	6.04 Uwb Radar	7.04 Fpga Embedded Processors	8.01 Routing Algorithms	8.02 Placement Algorithms	8.04 Simulation And Verification	9.04 Routing	9.05 Signal Integrity Analysis	9.06 Timing Performance Analysis
Science & Technology Unit, Umm Al Qura University (Stu-Uqu)	7	3	1	2	2	1	1		1																	1			
King Saud Univ	53	16	5	3	5	7	5	2	4	1		2	1			2			2			5	3		2	8			
King Fahd University Of Petroleum & Minerals	37	8	1	4	5	5	3	1	1	3			1			1		1		1	1	2		1	2	8			
King Abdullah Univ Sci & Technol	21	4		4		1	1		1				1	1		10										1	1	1	
King Abdulaziz Univ	20	5	2	3	2	1	1		3		1				1		1				1	1				1		3	
Alfaisal University	6	5			1		3		2																				
King Faisal Univ	6	3	1						1					1	1						1					1			
Kacst	5	2			1					1												1						1	1
Al Imam Mohammad Ibn Saud Islamic Univ	4	1						1	2																				
Saudi Aramco	4	1								2					1														
Taibah Univ	4		1		2				1																				1
Coll Vet Med & Anim Resources	2																									2			
Hail Univ	2																									2			
Univ Dammam	2				1				1							1													
Univ Tabuk	2	1											1																
Al Jouf Univ	1	1																											
Al Yamamah Univ	1	1																											
Coll Telecomm & Elect	1	1																											
King Fahd Univ	1																	1		1									
King Faisal Specialist Hosp & Res Ctr	1		1																										
Prince Sultan Univ	1																				1								
Selman Bin Abdulaziz Univ	1					1																							
Taif Univ	1	1																											
Univ Hail	1	1																											

Table 7 – Scientific literature overview of top Saudi Arabia entities

MIDDLE EAST & AFRICA WIRELESS COMMUNICATION AND SENSOR NETWORKS SCIENTIFIC LITERATURE TRENDS

This section of the report focuses on the scientific paper collection and the activity and technological trends observed in the Middle East and Africa regions.

MIDDLE EAST & AFRICA – PROLIFIC COUNTRIES

Figure 13 below shows the prolific countries by scientific literature volume in the Middle East & Africa regions. The gray bars indicate Middle East, blue indicates Africa, and green indicates the Kingdom of Saudi Arabia. As seen from the figure, the most prolific countries within these regions are Iran and Turkey, followed by Saudi Arabia, South Africa and Egypt.

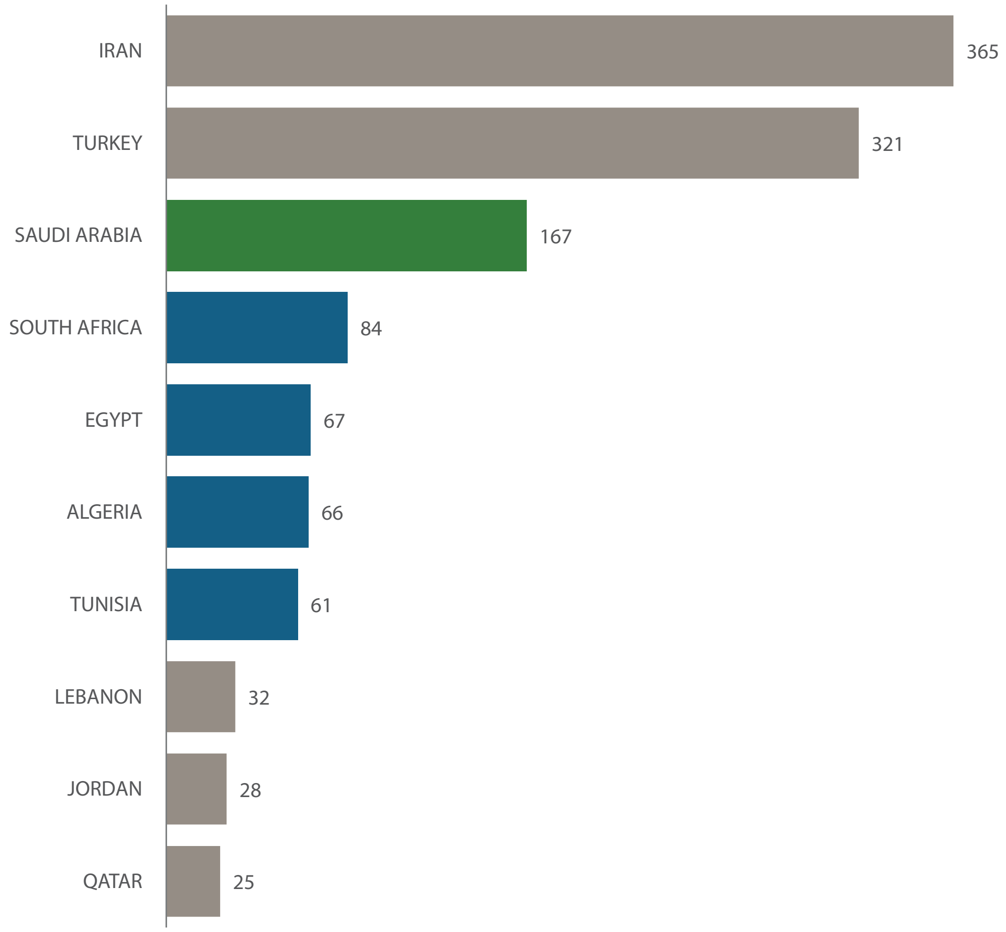

Figure 13 – Middle East & Africa – Prolific Countries in Scientific Literature

A more detailed analysis of the technologies of focus in each of the countries within the Middle East and Africa is presented with reference to tables 5 and 6. Focus appears to be on power saving and efficiency of wireless sensor network, biosensors and simulation and verification of FPGA. Iran appears to have most broad technical portfolio. Kingdom of Saudi Arabia is focusing significantly on power saving and efficiency, biosensors and simulation and verification much like other Middle East and African entities. Kingdom of Saudi Arabia is also focusing significantly on network configuration, in-network processing, sensor communication and collaborative data, similar to Iran and Turkey.

Country of Origin	1.01 Power Saving And Efficiency	1.02 Cross Layer Design	1.03 Fault Tolerance/Robustness	1.04 Network Configuration	2.01 In-Network Processing	2.02 Localization	2.03 Timing Synchronization	2.04 Sensor Communication And	3.01 Corrosion/Leakage Sensors	3.02 Pressure Sensors	3.03 Flow Sensors	3.04 Temperature Sensors	3.05 Seismic Sensors	3.06 Computational Pipeline Monitoring	4.01 Optical	4.02 Acoustic	4.03 Electrochemical/Electro	4.04 Biosensor
IRAN	90	4	25	12	20	14	4	9	9	2	5	1	5	12	20	8	11	20
TURKEY	112	13	24	29	26	35	8	18	1			1	1	5	9	10	4	18
SAUDI ARABIA	48	10	15	18	16	14	4	17	5	1	1			2	3	2	3	14
SOUTH AFRICA	11	1	10	3	1	2		3							4	3	1	40
EGYPT	14	2	1	5	8	5	1	3		2	1	1			2	1		2
ALGERIA	26	2	6	4	7	4	3	3			1			3				2
TUNISIA	16		3	1	1			1							1	1		9
LEBANON	11		3	2	2	2		2							1			1
JORDAN	16	2		3	3	2		4							1			2
QATAR	10	3	3	3	2	3	6	2	1							2		
MOROCCO	10		4		3	2		1							3	1		2
KUWAIT	3	1	1		1	1	1	2	1						1			1
IRAQ	6		2			2					1							1
OMAN	3							1										3
NIGERIA									1					1	1	2		1
REUNION	2																	3
YEMEN	1							3										
SENEGAL	3			1														
SYRIA																		1
UGANDA	1			1														2
BAHRAIN	2			1										1				
BURKINA FASO																		1
CAMEROON	1																1	
COTE IVOIRE																		1
LIBYA	1					1												
MALAWI			1															1
SEYCHELLES																		2

Table 8 – Middle East & Africa –Countries over Technical categories (continued on next page)

Country of Origin	5.01 Pulse Position Modulation	5.02 Pulse Amplitude Modulation	5.03 On-Off Keying	5.04 Pulse Shape Modulation	5.05 Phase Modulation	6.02 Received Signal Strength	6.04 Uwb Radar	7.01 Coarse Grained	7.02 Asynchronous Fpgas	7.03 Nano-Technology	7.04 Fpga Embedded Processors	8.01 Routing Algorithms	8.02 Placement Algorithms	8.03 Timing Analysis	8.04 Simulation And Verification	9.01 Floorplanning/Placeme	9.02 Logical Sythesis	9.04 Routing	9.05 Signal Integrity Analysis	9.06 Timing Performance Analysis
IRAN	6	2	1	5	4	2	10		3	6	2	9	5	3	69		4	6	19	2
TURKEY	2			4		4	17	1	2	1		3			30	1	1	3	15	1
SAUDI ARABIA	1	1		2	1	3	8				3	1	3		18			1	5	2
SOUTH AFRICA							1								3	2			5	
EGYPT	2						6						2		15	1		3	2	3
ALGERIA						1							1		20				1	
TUNISIA	3					2	1				3	1	5		14	1			2	1
LEBANON	8	5		2		1	1								5					1
JORDAN						1								1	2					
QATAR															1					
MOROCCO															2				2	
KUWAIT							1						1		2		1	2		
IRAQ							1								4			1	1	
OMAN															2					
NIGERIA															1					
REUNION																				
YEMEN						1														
SENEGAL																				
SYRIA															2					
UGANDA																				
BAHRAIN																				
BURKINA FASO																				1
CAMEROON																				
COTE IVOIRE	1																			
LIBYA															1					
MALAWI																				
SEYCHELLES																				

Table 8 – Continued from previous page

WIRELESS COMMUNICATION AND SENSOR NETWORKS PATENT COLLECTION TECHNOLOGY TRENDS

This section of the report focuses on the patent collections produced for the study and the activity and technological trends seen within it. Based on the Thomson Reuters-produced Derwent World Patents Index database, the collection includes both pending patent applications and granted patents published in 47 countries around the world.

A total of approximately 45,000 patented inventions were gathered that are applicable to the various Wireless Communication and Sensor Networks technology topics of interest to Science & Technology Unit, Umm Al-Qura University (STU-UQU). These inventions and their technical nature have been summarized using the ThemeScape software described in the previous section.

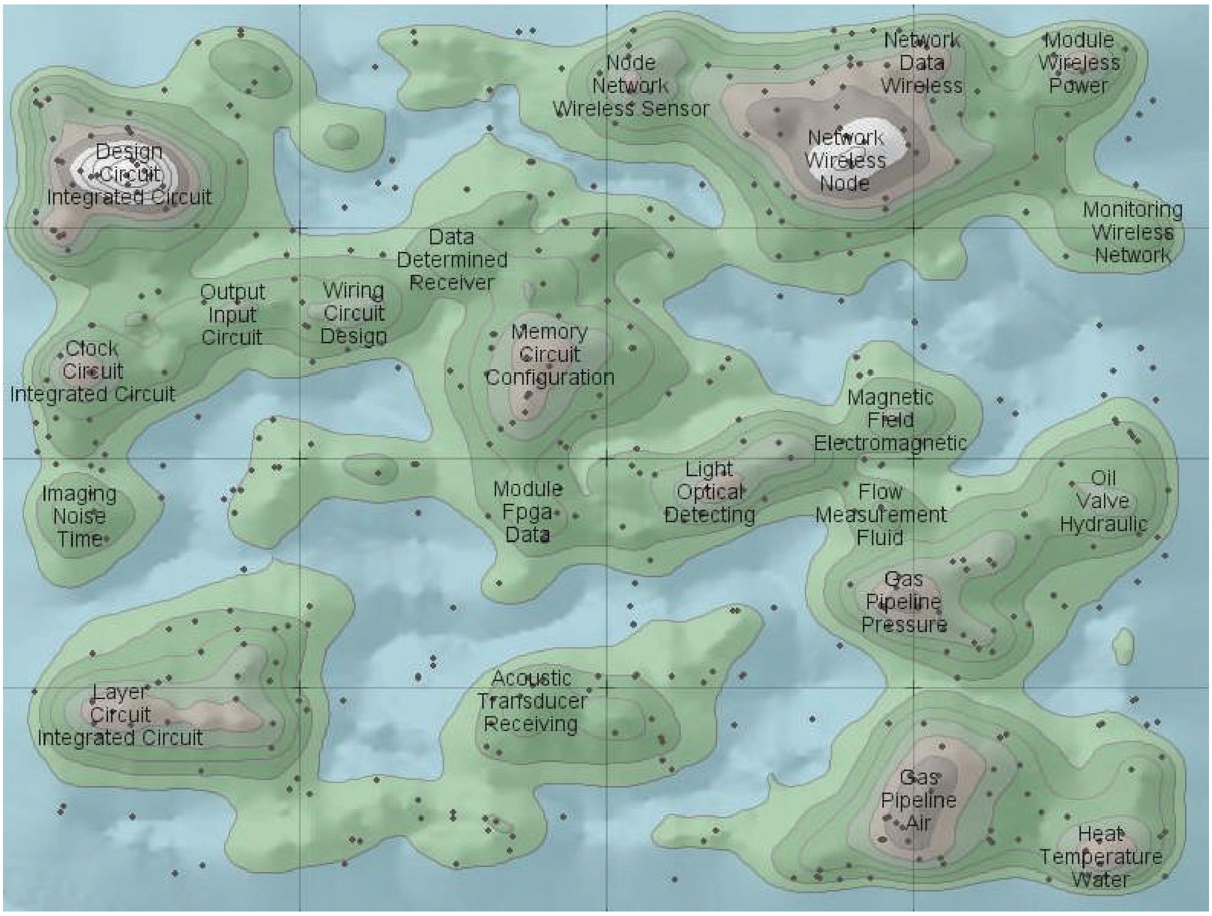

Figure 14 – ThemeScape Map of Patent Collection; Annotated by Major Themes

As previously noted, the ThemeScape map is not designed to provide a detailed accurate view of each patented invention; instead the visual is designed to highlight the common themes shared by hundreds or thousands of patents and patent applications published since 2006.
Some of the key themes revealed in this Themescape map include Wireless Sensor Network & Communication, Under Water Sensors, Oil & Gas Pipeline Monitoring, FPGA – Architecture / CAD Tools and IC-Design. Given small number of filings in UWB – Modulation & Localization/Tracking technology segment it is not observed as a major theme in the Themescape map.
This annotation has been provided to guide the reader around the landscape. However, it should be noted that this annotation is only approximate.

PATENT COLLECTION TECHNOLOGY SEGMENTATION

Table 7 shows the further segmentation of Wireless Communication and Sensor Networks technology topics. Use of pressure and temperature sensors for Oil & Gas pipeline monitoring and acoustic sensors as under water sensors remarkably surpasses other types of sensors, respectively. In other areas, a large amount of patents have been filed in power saving and efficiency in wireless sensor networks, localization in wireless sensor network communication, and across all categories of IC design. Notable white spaces include in-network processing within wireless sensor network communication, with low patent volumes and a very high growth rate. Another area of potential white space includes fault tolerance/robustness in wireless sensor networks with low volume and high growth rate. Within oil & gas pipeline monitoring, seismic sensors are a notable white space with very low patent volume and very high growth rate.

Technology Segmentation		Total Inventions	Average % Growth or Decline (08-13)
1 Wireless Sensor network	1.01 Power saving and efficiency	5248	23%
	1.02 Cross layer Design	103	62%
	1.03 Fault tolerance/Robustness	1014	16%
	1.04 Network configuration	3117	20%
2 Wireless Sensor Network - Communication	2.01 In-network processing	721	11%
	2.02 Localization	2328	2%
	2.03 Timing Synchronization	1328	7%
	2.04 Sensor communication and collaborative	1771	9%
3 Oil & Gas pipeline monitoring	3.01 Corrosion/Leakage sensors	1086	32%
	3.02 Pressure sensors	4974	31%
	3.03 Flow sensors	2224	28%
	3.04 Temperature sensors	3644	31%
	3.05 Seismic sensors	77	47%
	3.06 Computational Pipeline Monitoring	188	34%
4 Under Water Sensors	4.01 Optical	1884	2%
	4.02 Acoustic	2890	10%
	4.03 Electrochemical/Electromagnetic	618	3%
	4.04 Biosensor	488	-4%
5 Ultra Wide Band - Modulation	5.01 Pulse Position Modulation	229	-27%
	5.02 Pulse Amplitude Modulation	82	2%
	5.03 ON-Off Keying	142	9%
	5.04 Pulse Shape Modulation	63	21%
	5.05 Phase Modulation	284	-22%
6 Ultra Wide Band - Localization and tracking	6.01 Angle/Time of Arrival	361	-5%
	6.02 Received Signal Strength	156	10%
	6.03 Range Based	189	31%
	6.04 UWB RADAR	422	10%
7 FPGA - Architecture	7.01 Coarse Grained	491	27%
	7.02 Asynchronous FPGAs	502	12%
	7.03 Nano-Technology	97	37%
	7.04 FPGA Embedded Processors	563	19%
8 FPGA - CAD tools	8.01 Routing algorithms	256	-5%
	8.02 Placement algorithms	273	-3%
	8.03 Timing analysis	374	-6%
	8.04 Simulation and verification	1553	28%
9 IC - Design	9.01 Floorplanning/Placement	3442	-16%
	9.02 Logical Sythesis	1825	-19%
	9.03 Clock insertion	2207	-16%
	9.04 Routing	3331	-13%
	9.05 Signal integrity analysis	5471	-13%
	9.06 Timing performance analysis	1792	-12%

Table 9 – Patent Collection Technology Segmentation

PATENT COLLECTION TECHNOLOGY CATEGORY OVERLAP

The technology categories and their top level segments that were created to enumerate and describe the Wireless Communication and Sensor Networks landscape were not intended to be mutually exclusive. A single patent family can be included in multiple categories.

Figure 15 visualizes the relationship between select technology segments. Each number in the diagram shows the number of inventions that have content related to both the corresponding row-wise and column-wise segments.

The most correlated segment pairing is wireless sensor network with wireless sensor network-communication. Otherwise, mostly smaller sets are generally observed as overlap between the technology segments.

	1 Wireless Sensor network	2 Wireless Sensor Network - Communication	3 Oil & Gas pipeline monitoring	4 Under Water Sensors	5 Ultra Wide Band - Modulation	6 Ultra Wide Band - Localization and tracking	7 FPGA - Architecture	8 FPGA - CAD tools	9 IC - Design
1 Wireless Sensor network	8503	1402	54	23	2	10	4	3	14
2 Wireless Sensor Network - Communication		5269	12	33	9	21	5	5	21
3 Oil & Gas pipeline monitoring			9135	23		1			2
4 Under Water Sensors				5201	1	1	8	3	7
5 Ultra Wide Band - Modulation					586	76			
6 Ultra Wide Band - Localization and tracking						944		2	3
7 FPGA - Architecture							1609	163	87
8 FPGA - CAD tools								2332	485
9 IC - Design									13885

Figure 15 – Number of Patent Families per Pair of Technology Segments

PATENT ACTIVITY GEOGRAPHIC VOLUME BENCHMARKING

Figure 16 shows the number of patent families or inventions within the Wireless Communication and Sensor Networks patent collection that can be attributed to each nation . Patenting activity within the Wireless Communication and Sensor Networks topic is lead by China, followed by United States, Japan and South Korea.

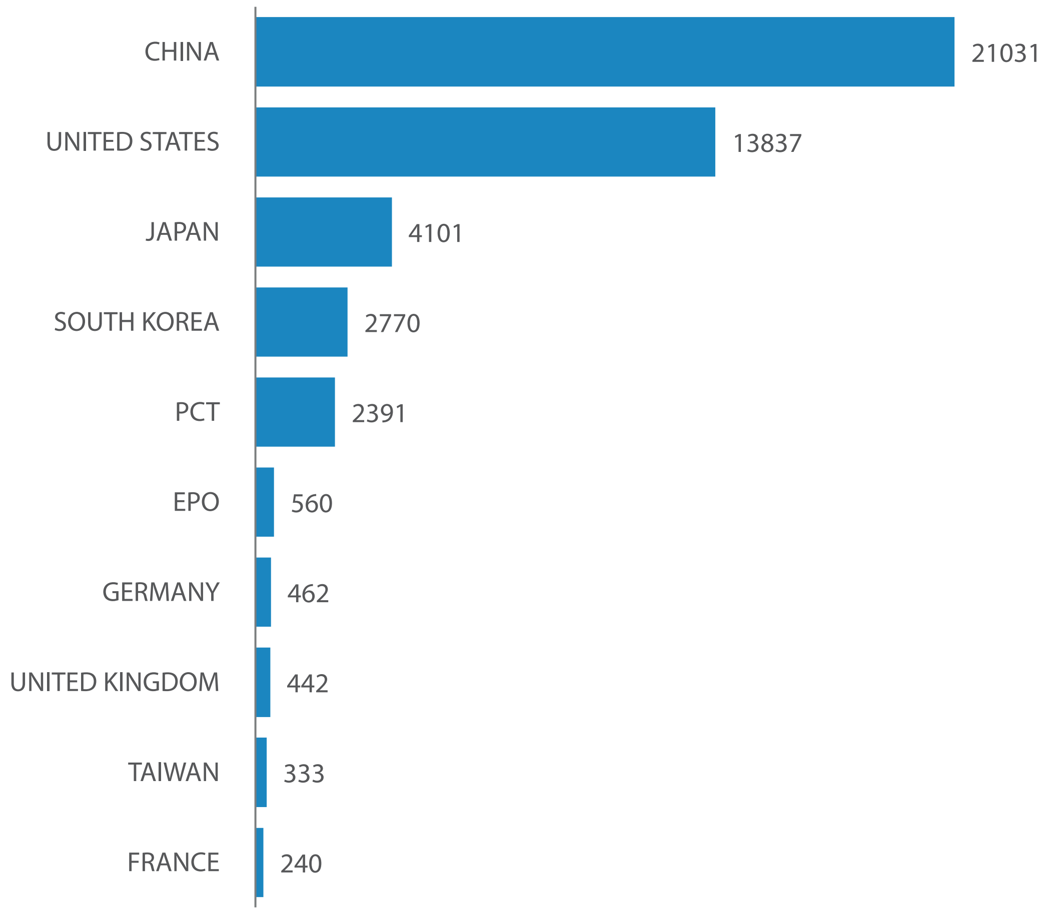

Figure 16 – Number of Patent Families per Country; Top 10 Sources

National attribution of patent activity is primarily performed via the priority filing location of the invention – this is the first filing event that occurs in the international protection of an invention at the various patent offices around the world. Actual geographic location of the inventor or the innovating corporation may vary from the priority filing location. This effect is exhibited primarily by Saudi Arabian entities, few of which file for patents within the Kingdom.

PATENT GEOGRAPHIC ACTIVITY TRENDS

Although overall patent volumes from Saudi Arabia, Italy and Canada are low, Figures 17 illustrates the continuing striking growth in the patent portfolio originating from Saudi Arabia, Israel and Brazil in this field.

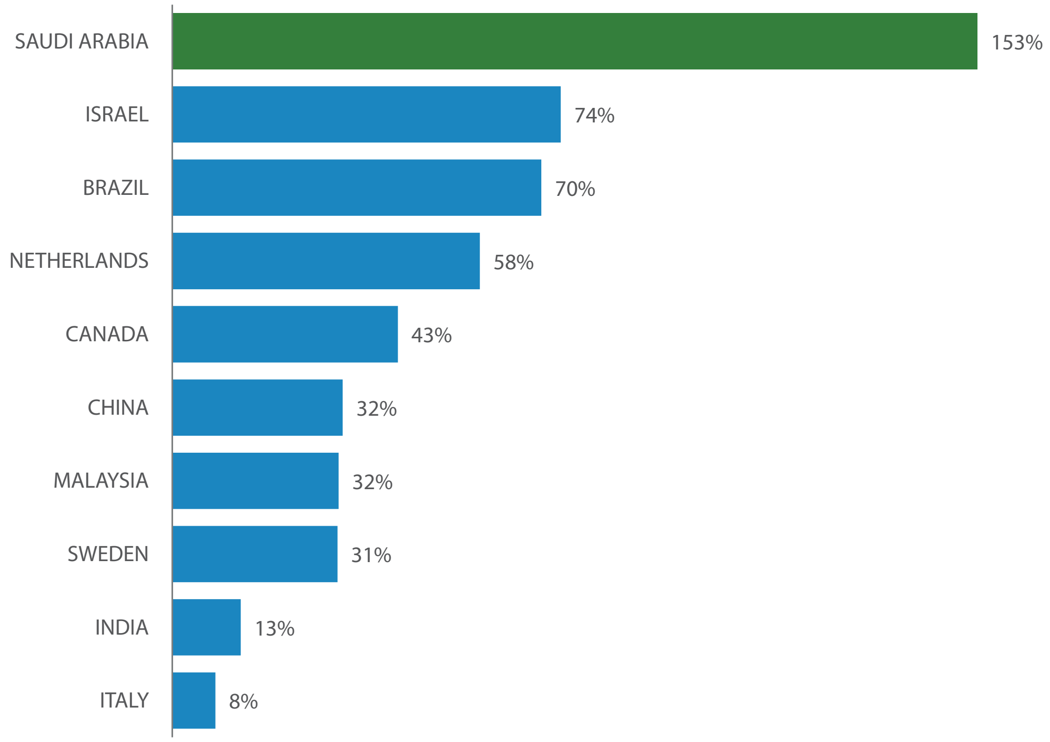

Figure 17 – Highest Growth Rate Geographies in Patent Output

PATENT GEOGRAPHIC CITATION IMPACT BENCHMARKING

Figure 18 details the highest citation impact by nation (with at least 50 patents). Patent citation is a widely utilized measurement of the impact and recognition of an individual patent, and by extension, aggregated groups of patents such as those assigned to a company or associated with the innovation of a nation or region. The measurement is useful as it provides an independent assessment of the quality and impact of the innovation contained within the patent. When aggregated, it provides a method of benchmarking collections of patents for the average impact in comparison to others, e.g. between two competing entities or between nations.

Patent citation information within this study is measured via citations to patent family members of the Derwent World Patents Index and from citation events of 26 national patent collections.

On this metric, Australia leads with the highest citation impact, followed by Canada, PCT, United States and Norway.

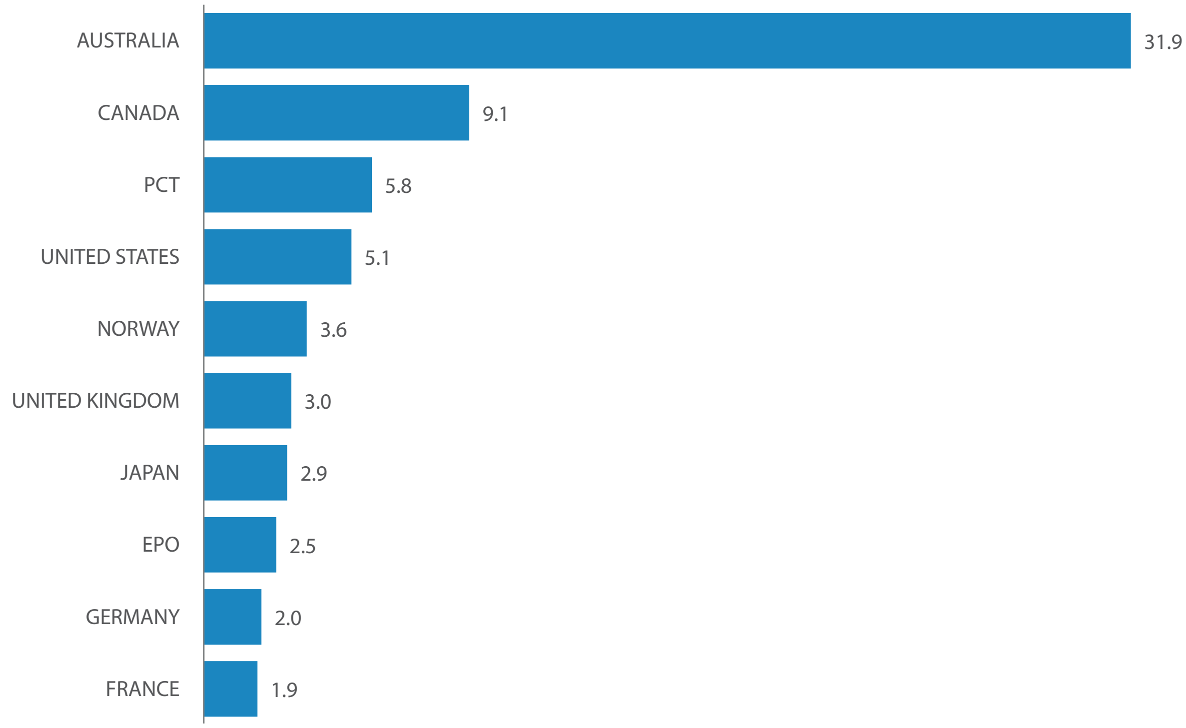

Figure 18 – Highest Citation Impact Geographies of Patents

PATENT COLLECTION WIRELESS COMMUNICATION AND SENSOR NETWORKS TOPICS BY GEOGRAPHY

Table 8 shows the split of Wireless Communication and Sensor Networks science and research specialization for the top nations. China appears to have focus on oil & gas pipeline monitoring and wireless sensor network. United States and Japan are filing significantly in IC design domain. Kingdom of Saudi Arabia is focusing dominantly on oil and gas monitoring and under water sensors. There appears to be very little focus on ultra wide band - modulation.

Country of Origin	1 Wireless Sensor network	2 Wireless Sensor Network - Communication	3 Oil & Gas pipeline monitoring	4 Under Water Sensors	5 Ultra Wide Band - Modulation	6 Ultra Wide Band - Localization and tracking	7 FPGA - Architecture	8 FPGA - CAD tools	9 IC - Design
CHINA	30%	13%	39%	5%	0%	1%	4%	7%	7%
UNITED STATES	6%	10%	2%	17%	2%	3%	4%	5%	58%
JAPAN	6%	7%	4%	9%	2%	2%	0%	2%	70%
SOUTH KOREA	23%	21%	5%	19%	3%	5%	2%	2%	26%
PCT	6%	10%	7%	53%	4%	2%	2%	2%	18%
EPO	11%	13%	3%	20%	4%	4%	2%	2%	29%
GERMANY	11%	15%	24%	18%	2%	8%	1%	2%	21%
UNITED KINGDOM	9%	8%	6%	45%	2%	5%	2%	1%	26%
TAIWAN	24%	11%	5%	3%	1%	0%	0%	1%	57%
FRANCE	6%	9%	6%	27%	13%	5%	1%	3%	34%
AUSTRALIA	7%	3%	3%	81%	4%	1%	0%	0%	4%
RUSSIAN FEDERATION	3%	7%	63%	11%	2%	3%	0%	0%	10%
INDIA	24%	20%	2%	12%	2%	2%	10%	7%	31%
EUROPEAN PATENT OFFICE	9%	10%	4%	58%	2%	2%	0%	6%	27%
ITALY	21%	13%	13%	47%	0%	3%	2%	0%	35%
CANADA	9%	17%	19%	53%	0%	0%	2%	0%	12%
NORWAY	5%	10%	17%	112%	0%	2%	0%	0%	2%
SPAIN	16%	22%	3%	49%	3%	3%	3%	3%	16%
SAUDI ARABIA	17%	23%	43%	30%	0%	7%	0%	0%	17%
DENMARK	7%	7%	0%	79%	4%	0%	0%	4%	11%
SINGAPORE	7%	0%	0%	22%	15%	33%	0%	7%	26%
ISRAEL	4%	17%	0%	65%	4%	22%	0%	0%	4%
FINLAND	17%	17%	4%	35%	9%	4%	0%	0%	22%
MALAYSIA	27%	23%	5%	9%	5%	9%	0%	9%	23%
NETHERLANDS	18%	14%	18%	36%	0%	14%	0%	0%	5%
SWEDEN	19%	38%	50%	38%	0%	0%	0%	0%	0%
BRAZIL	14%	14%	43%	7%	0%	0%	0%	0%	36%
AUSTRIA	0%	18%	64%	0%	0%	0%	0%	0%	45%
SWITZERLAND	13%	25%	25%	25%	13%	0%	0%	0%	38%
IRELAND	0%	25%	0%	50%	0%	0%	0%	0%	25%
NEW ZEALAND	14%	0%	0%	86%	0%	14%	0%	0%	0%

Table 10 – Specialization by Country; % of Patent Activity per Technical Stream

PATENT FILINGS - PROLIFIC GLOBAL ENTITIES

The list of prolific entities filing patents includes a mix of petrochemical companies and electronics manufacturers as well as Chinese entities. IBM is predominantly the most prolific entity, followed by IBM and Fujitsu. Synopsys, Cadence, Qualcomm, Sony, Schlumberger, and Canon appear to be filing patents with high citations. Science & Technology Unit, Umm Al-Qura University (STU-UQU) has only 5 patents filed in this space.
There are opportunities for filing patents as discussed previously, in conjunction with table 8.

Entity	Total	Times Cited	Citation per family
Science & Technology Unit, Umm Al Qura University (STU-UQU)	5	0	0.0
IBM	1523	5060	3.3
FUJITSU	535	1789	3.3
CADENCE DESIGN SYSTEMS INC	428	1769	4.1
ALTERA CORP	422	739	1.8
SAMSUNG	418	1072	2.6
NEC	416	1450	3.5
XILINX INC	411	833	2.0
PANASONIC	366	1178	3.2
RENESAS ELECTRONICS CORP	331	1172	3.5
TOSHIBA	318	895	2.8
SYNOPSYS	295	1572	5.3
STATE GRID CORP CHINA	270	5	0.0
TAIWAN SEMICONDUCTOR MFG CO	247	828	3.4
QUALCOMM	231	1461	6.3
TEXAS INSTR	222	1126	5.1
UNIV ZHEJIANG	194	94	0.5
SONY	191	1459	7.6
UNIV SOUTHEAST	188	96	0.5
NAT INSTR CORP	170	488	2.9
UNIV QINGHUA	160	115	0.7
FREESCALE SEMICONDUCTOR INC	158	397	2.5
ETRI	157	526	3.4
PETROCHINA CO LTD	155	21	0.1
CANON KK	154	710	4.6
LSI CORP	154	315	2.0
APPLE INC	150	342	2.3
PGS GEOPHYSICAL AS	149	436	2.9
INTEL CORP	140	395	2.8
SCHLUMBERGER	136	837	6.2
UNIV SHANGHAI JIAOTONG	136	86	0.6

Table 11 – Wireless communication and sensor networks – Top entities for Patents

PATENT OVERVIEW OF TOP GLOBAL ENTITIES

Table 10 shows the technology profile of the top 30 entities within the patent landscape of wireless communication and sensor networks. Most of the top entities seem to be focusing only on IC design related technologies. Notable exceptions include Schlumberger who seem to be focusing on patents for underwater sensors – acoustic, optical, and electrochemical/electromagnetic. Chinese entities such as Southeast University, State Grid Corp China and Shanghai Jiaotong University appear to be filing patents primarily in the wireless sensors and wireless sensor communication categories. Science & Technology Unit, Umm Al Qura University (STU-UQU) has 5 inventions across WSN based Network Configuration and Localization, signal integrity analysis and timing performance analysis of the IC design.

Table 12 – Patent overview of top global entities (continued on next pages)

Entity	1.01 Power saving and efficiency	1.02 Cross layer Design	1.03 Fault tolerance/robustness	1.04 Network configuration	2.01 In-network processing	2.02 Localization	2.03 Timing Synchronization	2.04 Sensor communication and	3.01 Corrosion/Leakage	3.02 Pressure sensors	3.03 Flow sensors	3.04 Temperature sensors	3.05 Seismic sensors	3.06 Computational Pipeline	4.01 Optical	4.02 Acoustic	4.03 Electrochemical/Electro	4.04 Biosensor
Science & Technology Unit, Umm Al Qura University (STU-UQU)				1		1												
IBM	5			1	1	12	3	3		1					2	2	1	1
FUJITSU	14	3	4	12	4	9	5	8										
CADENCE DESIGN SYSTEMS INC																		
ALTERA CORP																		
SAMSUNG	26		5	18	8	33	10	10		2		1			6	17	1	
NEC	5		1	6	3	7	2	5	5	2	1				1	39		
XILINX INC																		
PANASONIC	12		4		3	6	26	17	1	1	4				1	1		1
RENESAS ELECTRONICS CORP								1		1	1							
TOSHIBA	8		9	2	1	2	6	7	2	4	2	2	1		4	2		3
SYNOPSYS																		
STATE GRID CORP CHINA	57		24	72	5	9	15	15	7	29	11	29		1		1		
TAIWAN SEMICONDUCTOR MFG CO																		
QUALCOMM	10		2	5	1	20	17	8							1	1		
TEXAS INSTR	5		1	4		1	2	2										
UNIV ZHEJIANG	46		7	37	7	16	15	14	3	30	21	15		1	5	7	2	1
SONY	1			3		5	1	1							3	2		
UNIV SOUTHEAST	86		8	47	17	22	23	18		7	1	5				8		
NAT INSTR CORP																		
UNIV QINGHUA	29		11	18	3	10	6	10	7	28	11	5	1		1	2		
FREESCALE SEMICONDUCTOR INC	1						2	1										
ETRI	38	2	5	36	3	29	18	12							2			2
PETROCHINA CO LTD	4		3				1		32	61	40	65		1	1	1		
CANON KK	1						4	2										
LSI CORP																		
APPLE INC	1			1	1	3		2							10			
PGS GEOPHYSICAL AS	2						2	1							43	60	78	
INTEL CORP	7			1		5	2	9							1			
SCHLUMBERGER	1					4	6	5	1	4	10	2			41	58	27	
UNIV SHANGHAI JIAOTONG	37	2	11	24	13	26	5	7		13		10		2	13	4	2	

Entity	5.01 Pulse Position Modulation	5.02 Pulse Amplitude Modulation	5.03 ON-Off Keying	5.04 Pulse Shape Modulation	5.05 Phase modulation	6.01 Angle/Time of Arrival	6.02 Received Signal	6.03 Range Based	6.04 UWB RADAR	7.01 Coarse Grained	7.02 Asynchronous FPGAs	7.03 Nano-Technology	7.04 FPGA Embedded Processors	8.01 Routing algorithms	8.02 Placement algorithms	8.03 Timing analysis	8.04 Simulation and	9.01 Floorplanning/Placement	9.02 Logical Sythesis	9.03 Clock insertion	9.04 Routing	9.05 Signal integrity analysis	9.06 Timing performance analysis
Science & Technology Unit, Umm Al Qura University (STU-UQU)						1																1	1
IBM					1	1	1			3	2	3		2	10	6	25	523	355	144	308	728	208
FUJITSU	4		1		1	6	1		7	1	1	1			1	2	5	143	84	60	86	202	117
CADENCE DESIGN SYSTEMS INC															1	2	1	191	106	11	106	265	69
ALTERA CORP										3	8		4	25	58	74	4	105	125	56	192	80	66
SAMSUNG	2		9		7	5	5	2	3	42			1	2		4	2	22	10	48	35	126	21
NEC	1					1	1			1			1	2	3	2	7	91	58	63	63	133	87
XILINX INC										5	3		8	28	43	44	14	121	121	42	159	123	41
PANASONIC	3		16		5	6	3	1	4	1				1	2		1	56	22	54	29	103	48
RENESAS ELECTRONICS CORP	1			1	1											1	2	96	46	63	44	118	81
TOSHIBA						1				1	1	1				5	2	58	44	27	36	122	52
SYNOPSYS											1			2	1	3	1	115	60	7	64	177	49
STATE GRID CORP CHINA						1					7	1	8	1			28			3	2	1	1
TAIWAN SEMICONDUCTOR MFG CO									2					2			1	111	24	13	104	110	24
QUALCOMM	21	6	1	1	16	24	6	14		3						1		17	10	44	25	34	3
TEXAS INSTR	3	2	3	1	30	2			1							3	1	57	12	36	47	53	23
UNIV ZHEJIANG									1		5		15		1		7	2			3	7	1
SONY	2		1		3	5	2	2	2		1	1						18	7	23	17	108	10
UNIV SOUTHEAST						1				3	5		6			2	7			8		1	
NAT INSTR CORP										167					1	2	2	1	1		1	3	
UNIV QINGHUA	1		1		2				1		1	1	1	6		1	7	4		6	8	11	4
FREESCALE SEMICONDUCTOR INC					1		2			1			1				1	59	9	32	40	49	20
ETRI	9	1	2	3	8	8	2	5	4		2			1		6	4		2	1	5	5	2
PETROCHINA CO LTD																							1
CANON KK					1	1										2		13	1	11	11	107	12
LSI CORP													1		1	3		40	32	16	45	77	45
APPLE INC	2						1			56				1		3		11	19	17	14	29	8
PGS GEOPHYSICAL AS																							
INTEL CORP	3		2		3	2	3		1	1			5	1			2	13	7	34	31	20	8
SCHLUMBERGER								1													1		
UNIV SHANGHAI JIAOTONG	1	1			2				3	1	3	1	1	1			8			2	2		1

PATENT OVERVIEW OF TOP ASIA PACIFIC ENTITIES

Table 10 shows the technology profile of the top 30 entities within the patent landscape of wireless communication and sensor networks. Most of the top entities seem to be focusing only on IC design related technologies. Notable exceptions include Schlumberger who seem to be focusing on patents for underwater sensors – acoustic, optical, and electrochemical/electromagnetic. Chinese entities such as Southeast University, State Grid Corp China and Shanghai Jiaotong University appear to be filing patents primarily in the wireless sensors and wireless sensor communication categories. Science & Technology Unit, Umm Al Qura University (STU-UQU) has 5 inventions across WSN based Network Configuration and Localization, signal integrity analysis and timing performance analysis of the IC design.

Table 13 – Patent overview of top Asia Pacific entities (continued on next pages)

Entity	Country of Origin	Total	1.01 Power Saving And Efficiency	1.02 Cross Layer Design	1.03 Fault Tolerance/Robustness	1.04 Network Configuration	2.01 In-Network Processing	2.02 Localization	2.03 Timing Synchronization	2.04 Sensor Communication And	3.01 Corrosion/Leakage	3.02 Pressure Sensors	3.03 Flow Sensors	3.04 Temperature Sensors	3.05 Seismic Sensors	3.06 Computational Pipeline	4.01 Optical	4.02 Acoustic	4.03 Electrochemical/Electro	4.04 Biosensor	5.01 Pulse Position Modulation	5.02 Pulse Amplitude Modulation	5.03 On-Off Keying
Science & Technology Unit, Umm Al Qura University (STU-UQU)	Saudi Arabia	5				1		1															
Fujitsu	Japan	451	14	3	4	4	3	4	4	3											4		1
Nec	Japan	400	4		1	3	2	4	2	4	5	2	1				1	39			1		
Samsung	South Korea	395	25		4	17	6	28	8	9		2		1			6	17	1		2		7
Renesas Electronics Corp	Japan	367								1		1	1								1		
Panasonic	Japan	350	11		4		3	6	26	17	1	1	4				1	1		1	3		16
Toshiba	Japan	297	8		7	1			6	7	2	4	2	2	1		4	2		3			
State Grid Corp China	China	270	57		24	72	5	9	15	15	7	29	11	29		1		1					
Univ Zhejiang	China	194	46		7	37	7	16	15	14	3	30	21	15		1	5	7	2	1			
Univ Southeast	China	188	86		8	47	17	22	23	18		7	1	5				8					
Electronics & Telecom Res Inst	South Korea	181	39	2	8	45	4	29	21	15							2	1		2	9	1	2
Univ Nanjing Posts & Telecom	China	180	97	1	13	58	43	59	7	17								1					
Sony	Japan	171	1			1		1		1							2				2		1
Univ Qinghua	China	159	29		11	18	3	10	6	10	7	28	11	5	1		1	2			1		1
Petrochina Co Ltd	China	155	4		3				1		32	61	40	65		1	1	1					
Canon Kk	Japan	152	1						4	2													
Univ Shanghai Jiaotong	China	136	37	2	11	24	13	26	5	7		13		10		2	13	4	2		1	1	
Univ Beijing Aeronautics&Astronautics	China	132	25	2	6	18	11	29	6	3	1	24	8	10		1		1					
Harbin Inst Technology	China	115	12		5	20	5	15	6	4	1	1		4			3	2	2		2	1	
Univ Harbin Eng	China	108	12		1	5	3	8		1	7	8	2	3			5	57	1	1			
Hitachi Ltd	Japan	107	7				1	5	8	9	1		1	1			1	11			3		

Entity	Country of Origin	Total	5.04 Pulse Shape Modulation	5.05 Phase Modulation	6.01 Angle/Time Of Arrival	6.02 Received Signal	6.03 Range Based	6.04 Uwb Radar	7.01 Coarse Grained	7.02 Asynchronous Fpgas	7.03 Nano-Technology	7.04 Fpga Embedded Processors	8.01 Routing Algorithms	8.02 Placement Algorithms	8.03 Timing Analysis	8.04 Simulation And	9.01 Floorplanning/Placement	9.02 Logical Sythesis	9.03 Clock Insertion	9.04 Routing	9.05 Signal Integrity Analysis	9.06 Timing Performance Analysis
Science & Technology Unit, Umm Al Qura University (STU-UQU)	Saudi Arabia	5			1																1	1
Fujitsu	Japan	451		1	6	1		7		1	1			1	2	5	125	76	42	72	177	95
Nec	Japan	400			1	1						1	1	3	2	7	91	52	63	63	127	87
Samsung	South Korea	395		7	4	4	2	2	40			1	2		4	2	22	10	48	30	121	21
Renesas Electronics Corp	Japan	367	1	1											1	2	100	49	73	49	125	94
Panasonic	Japan	350		5	6	3	1	3	1					1		1	55	22	51	21	101	46
Toshiba	Japan	297							1	1					4	2	55	43	26	32	115	50
State Grid Corp China	China	270			1					7	1	8	1			28			3	2	1	1
Univ Zhejiang	China	194						1		5		15		1		7	2			3	7	1
Univ Southeast	China	188			1				3	5		6			2	7			8		1	
Electronics & Telecom Res Inst	South Korea	181	3	8	9	2	5	4		2			1		6	4	2	3	1	6	6	3
Univ Nanjing Posts & Telecom	China	180								1		1				1		1	1		2	2
Sony	Japan	171		2	5	2	2	1		1							18	7	19	16	107	8
Univ Qinghua	China	159		2				1		1	1	1	6		1	7	4		5	8	11	4
Petrochina Co Ltd	China	155																				1
Canon Kk	Japan	152		1	1										2		13	1	11	11	105	12
Univ Shanghai Jiaotong	China	136		2				3	1	3	1	1	1			8			2	2		1
Univ Beijing Aeronautics&Astronautics	China	132		2				1		8		7		1	1	16	1	2	3	1	1	2
Harbin Inst Technology	China	115		1				3		12		14			1	20		1	4	2	4	1
Univ Harbin Eng	China	108		1								1	1			6	1				3	
Hitachi Ltd	Japan	107		3	6	1	1	1									13	6	10	5	22	14

PATENT OVERVIEW OF TOP MIDDLE EAST & AFRICA ENTITIES

Table 12 illustrates the top patenting entities in the Middle East and Africa. The space appears to be dominated by smaller, local players, which are focused on oil and gas field. Further, Siemens appears to be the only large multinational that is not based in KSA, Turkey, or South Africa. This indicates of a geographic region used majorly only by local players and not often by large multinationals.

Entity	Country of Origin	Total	1.01 Power Saving And	1.04 Network	2.01 In-Network	2.02 Localization	2.04 Sensor Communicat	3.01 Corrosion/L	3.02 Pressure	3.03 Flow Sensors	3.04 Temperatur	4.01 Optical	4.02 Acoustic	4.03 Electrochem	4.04 Biosensor	6.01 Angle/Time	9.02 Logical Sythesis	9.05 Signal Integrity	9.06 Timing Performanc
Science & Technology Unit, Umm Al Qura University (STU-UQU)	Saudi Arabia	5		1		1										1		1	1
SAUDI ARABIAN OIL CO	Saudi Arabia	14	1			2	1	1	6	2	4	2	3	1					
KING FAHD UNIVERSITY OF PETROLEUM AND MINERALS	Saudi Arabia	12		2	1	1	1	3		3						1	1	1	
UNIV KING ABDULLAH SCI & TECHNOLOGY	Saudi Arabia	4		1								1	2					1	
SIEMENS	Saudi Arabia	2										2							
ARAMCO SERVICE CO	Saudi Arabia	2				1			1	1	1								
UNIV CAPE TOWN	South Africa	2	1	2			1												
KING ABDULAZIZ CITY SCI & TECHNOLOGY	Saudi Arabia	2		1			1			1									
KING FAISAL SPECIALIST HOSPITAL & RES CE	Saudi Arabia	1													1				
ABSOLUTE NDE INT INC	Angola	1											1						
ARMSCOR BUSINESS PTY LTD	South Africa	1										1	1						
DETNET SOUTH AFRICA PTY LTD	South Africa	1															1		
GROUNDMETRICS INC	Saudi Arabia	1				1								1					
KODALFA BILGI VE ILETISIM TEKNOLOJILERI SAN TIC AS	Turkey	1					1												
TERRAMARK MARKENCREATION GMBH	Saudi Arabia	1													1				
UNIV KING SAUD	Saudi Arabia	1			1	1	1												

Table 14 – Patent overview of top Middle East & Africa entities

PATENT OVERVIEW OF TOP SAUDI ARABIA ENTITIES

Table 12 illustrates the top patenting entities in the Middle East and Africa. The space appears to be dominated by smaller, local players, which are focused on oil and gas field. Further, Siemens appears to be the only large multinational that is not based in KSA, Turkey, or South Africa. This indicates of a geographic region used majorly only by local players and not often by large multinationals.

Entities	Total	1.01 Power Saving And Efficiency	1.04 Network Configuratio	2.01 In-Network Processing	2.02 Localization	2.04 Sensor Communicat ion And	3.01 Corrosion/L eakage	3.02 Pressure Sensors	3.03 Flow Sensors	3.04 Temperatur e Sensors	4.01 Optical	4.02 Acoustic	4.03 Electrochem ical/Electro	4.04 Biosensor	6.01 Angle/Time Of Arrival	9.02 Logical Sythesis	9.05 Signal Integrity Analysis	9.06 Timing Performanc e Analysis
Science & Technology Unit, Umm Al Qura University (STU-UQU)	5		1		1										1		1	1
Saudi Arabian Oil Co	14	1			2	1	1	6	2	4	2	3	1					
King Fahd University Of Petroleum And Minerals	12		2	1	1	1	3		3						1	1	1	
Univ King Abdullah Sci & Technology	4		1								1	2					1	
King Abdulaziz City Sci & Technology	2		1			1			1									
King Faisal Specialist Hospital & Res Ce	1													1				
Univ King Saud	1			1	1	1												

Table 15 – Patent overview of top Saudi Arabia entities

MIDDLE EAST & AFRICA WIRELESS COMMUNICATION AND SENSOR NETWORKS PATENT TRENDS

This section of the report focuses on the patent collection and the activity and technological trends seen within it – in the Middle East and Africa.

MIDDLE EAST & AFRICA – PROLIFIC COUNTRIES

Patent filing trends appear to be very different from the scientific literature trends. Figure 19 shows that Saudi Arabia is the most popular country for filing patents within the two regions, followed by South Africa. The remaining jurisdictions see only marginal patent filings.

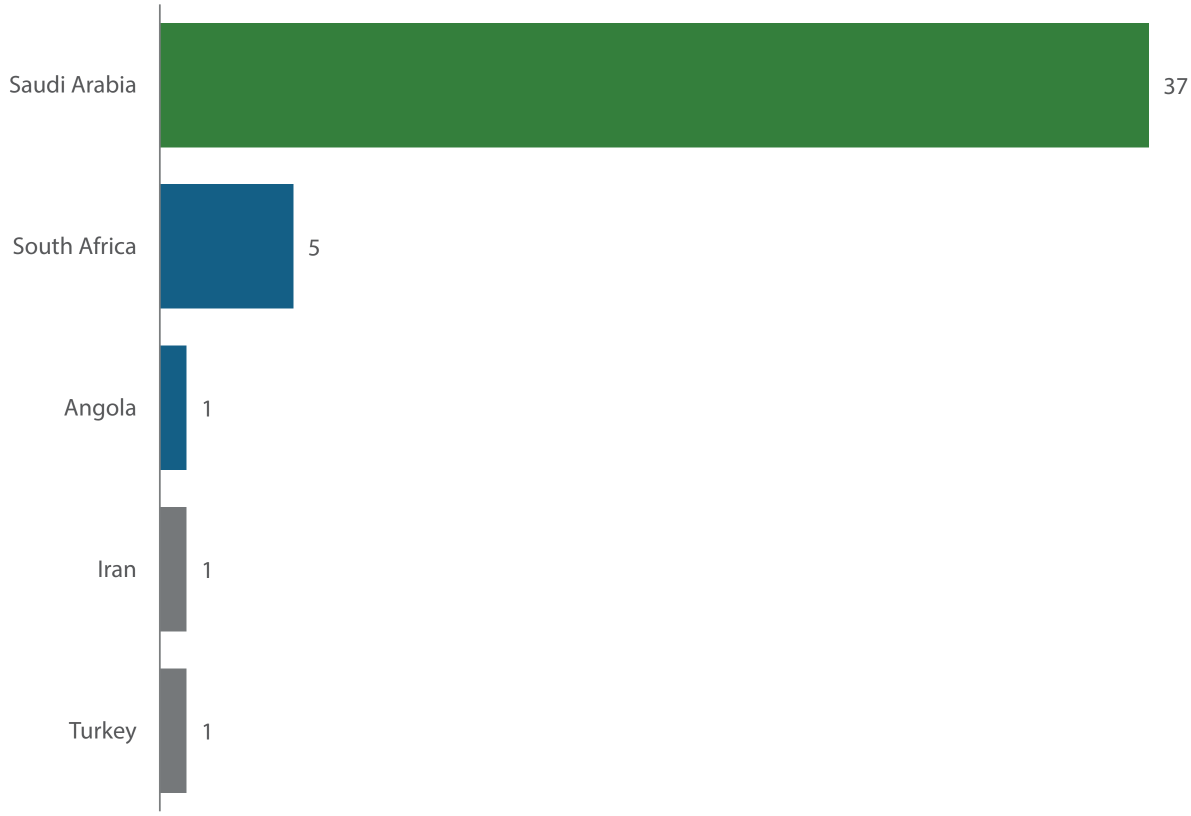

Figure 19 – Middle East & Africa – Prolific Countries in Patents

Diving deeper, Table 11 shows that the kingdom of Saudi Arabia seems to be dominantly filing in oil & gas pipeline monitoring and under water sensors. Saudi Arabia seems to be filing consistently in almost all the technology areas, except the wireless sensor network. South Africa is the only country which is active in wireless sensor network domain.

Country of Origin	Total	1.01 Power Saving And Efficiency	1.04 Network Configuratio	2.01 In-Network Processing	2.02 Localization	2.04 Sensor Communicat ion And	3.01 Corrosion/L eakage	3.02 Pressure Sensors	3.03 Flow Sensors	3.04 Temperatur e Sensors	4.01 Optical	4.02 Acoustic	4.03 Electrochem ical/Electro	4.04 Biosensor	6.01 Angle/Time Of Arrival	9.02 Logical Sythesis	9.05 Signal Integrity Analysis	9.06 Timing Performanc e Analysis
Saudi Arabia	37	1	4	2	5	3	4	6	5	4	3	5	1	1	2	1	3	1
South Africa	5	1	3			1					1	1				1		
Angola	1											1						
Iran	1						1	1										
Turkey	1					1												

Table 16 – Middle East & Africa – Prolific Countries over Technical categories

APPENDIX A – SCIENTIFIC PAPERS TOP AFFILIATIONS

ENTITY-LEVEL DATA TABLES FOR SCIENTIFIC LITERATURE COLLECTION

Table 13 on the following pages shows the top 10 author organizations for each of the technology segments. This information is intended to provide an assessment of the depth and location of the research expertise available in each category.

Top Level Technology	Entity	Total
1 Wireless Sensor network	Nanyang Technological University	192
	Chinese Academy of Sciences	178
	Tsinghua Univ	142
	Georgia Institute of Technology	135
	Shanghai Jiao Tong Univ	118
	National Cheng Kung University	112
	University of California System	111
	Korea Univ	110
	Zhejiang Univ	108
	Beijing University Posts & Telecommunications	54
2 Wireless Sensor Network - Communication	Nanyang Technological University	123
	Texas A&M Univ	115
	Chinese Academy of Sciences	93
	Tsinghua University	73
	Georgia Institute of Technology	62
	University of California System	58
	Hong Kong University of Science & Technology	58
	Zhejiang Univ	62
	Florida State University System	29
	University System of Maryland	29
3 Oil & Gas pipeline monitoring	China University of Petroleum	43
	Indian Institute of Technology (IIT	21
	Russian Academy of Sciences	20
	Carnegie Mellon Univ	16
	Tsinghua University	14
	Universidade de Sao Paulo	12
	Univ Sao Paulo	9
	Universidade Estadual de Campinas	8
	Council of Scientific & Industrial Research (CSIR) - India	8
	New Jersey Inst Technol	7
4 Under Water Sensors	Chinese Academy of Sciences	462
	National Oceanic Atmospheric Admin (NOAA) - USA	368
	Oregon University System	161
	University of California System	155
	CNRS	121
	Woods Hole Oceanog Inst	114
	NERC Natural Environment Research Council	79
	Consejo Superior de Investigaciones Cientificas (CSIC	73
	Florida State University System	67
	NERC National Oceanography Centre	54

Top Level Technology	Entity	Total
5 Ultra Wide Band - Modulation	Nanyang Technological University	56
	Huazhong University of Science & Technology	46
	University of Ottawa	34
	Wuhan Natl Lab Optoelect	22
	Technical University of Denmark	20
	Univ Alberta	20
	Tsinghua Univ	16
	Microwave Photon Res Lab	15
	University of California System	9
	University of Laval	8
6 Ultra Wide Band - Localization and tracking	Nanyang Technological University	46
	Delft University of Technology	42
	University of Electronic Science & Technology - China	39
	National University of Defence Technology - China	39
	Univ Calgary	34
	University of Electro-Communications - Japan	34
	Penn State Univ	30
	Chinese Academy of Sciences	28
	Pennsylvania Commonwealth System of Higher Education (PCSHE	17
	University of California System	14
7 FPGA - Architecture	Seoul National University	28
	Tsing Hua University	24
	Southeast Univ	18
	Tohoku University	16
	Osaka Univ	16
	University of California System	15
	Chinese Academy of Sciences	14
	Princeton University	14
	University of Colorado System	14
	Samsung	9
8 FPGA - CAD tools	Tsing Hua University	64
	University of California System	57
	Univ Calgary	46
	University of Toronto	46
	Chinese Academy of Sciences	43
	Imperial College London	29
	Univ London Imperial Coll Sci Technol & Med	28
	Indian Institute of Technology (IIT	26
	United States Department of Energy (DOE	25
	CNRS	24
9 IC - Design	University of California System	127
	Chinese Academy of Sciences	86
	National Chiao Tung University	84
	Natl Taiwan Univ	78
	Georgia Inst Technol	73
	Stanford University	69
	Tsing Hua University	60
	CNRS	54
	International Business Machines (IBM	39
	California Institute of Technology	31

Table 17 – Top 10 Paper Publishing Organizations per Technology Segment

APPENDIX B – PATENT STATISTICS AND TABLES

ENTITY-LEVEL DATA TABLES FOR PATENT COLLECTION

The table 14 below and on the following page shows the top 10 patent applicants or patent assignees for each of the technology segments. This information is intended to provide an assessment of expertise and patent commercialization intent per category.

Top Level Technology	Entity	Total
1 Wireless Sensor network	UNIV NANJING POSTS&TELECOM	131
	ELECTRONICS&TELECOM RES INST	115
	UNIV SOUTHEAST	103
	STATE GRID CORP CHINA	80
	UNIV ZHEJIANG	73
	UNIV SHANGHAI JIAOTONG	54
	UNIV QINGHUA	47
	UNIV HANGZHOU DIANZI	46
	UNIV BEIJING AERONAUTICS&ASTRONAUTICS	40
	SAMSUNG ELECTRONICS CO LTD	38
2 Wireless Sensor Network - Communication	ELECTRONICS&TELECOM RES INST	76
	UNIV NANJING POSTS&TELECOM	76
	PANASONIC CORP	67
	UNIV SOUTHEAST	55
	QUALCOMM INC	42
	SAMSUNG ELECTRONICS CO LTD	41
	UNIV ZHEJIANG	34
	UNIV SHANGHAI JIAOTONG	34
	UNIV BEIJING AERONAUTICS&ASTRONAUTICS	33
	KONINK PHILIPS ELECTRONICS NV	32
3 Oil & Gas pipeline monitoring	PETROCHINA CO LTD	127
	CHINA NAT PETROLEUM CORP	72
	CHINA PETROCHEMICAL CO LTD	57
	CHINA PETROLEUM PIPELINE BUREAU	47
	UNIV ZHEJIANG	40
	UNIV TIANJIN	39
	UNIV CHINA PETROLEUM	37
	UNIV QINGHUA	36
	UNIV BEIJING AERONAUTICS&ASTRONAUTICS	31
	CHINA NAT OFFSHORE OIL CORP	29
4 Under Water Sensors	SCHLUMBERGER CANADA LTD	214
	PGS GEOPHYSICAL AS	98
	US SEC OF NAVY	75
	GECO TECHNOLOGY BV	57
	WESTERNGECO LLC	52
	UNIV HARBIN ENG	47
	UNIV NINGBO	46
	KOREA OCEAN RES&DEV INST	38
	LOCKHEED MARTIN CORP	36
	ATLAS ELEKTRONIK GMBH	35

Top Level Technology	Entity	Total
5 Ultra Wide Band - Modulation	QUALCOMM INC	40
	PANASONIC CORP	36
	TEXAS INSTR INC	34
	COMMISSARIAT ENERGIE ATOMIQUE	18
	INHA IND PARTNERSHIP INST	15
	ELECTRONICS&TELECOM RES INST	13
	SEIKO EPSON CORP	12
	SAMSUNG ELECTRONICS CO LTD	12
	NOKIA CORP	10
	XG TECHNOLOGY INC	8
6 Ultra Wide Band - Localization and tracking	QUALCOMM INC	33
	ELECTRONICS&TELECOM RES INST	15
	NOKIA CORP	15
	UNIV CHINESE PLA FOURTH MILITARY MEDICAL	13
	FUJITSU LTD	11
	FURUKAWA ELECTRIC CO LTD	11
	BOSCH GMBH ROBERT	11
	SYMBOL TECHNOLOGIES INC	11
	COMMISSARIAT ENERGIE ATOMIQUE	10
	HITACHI LTD	10
7 FPGA - Architecture	NAT INSTR CORP	143
	SAMSUNG ELECTRONICS CO LTD	42
	APPLE INC	32
	UNIV ZHEJIANG	19
	HARBIN INST TECHNOLOGY	18
	XILINX INC	16
	UNIV BEIJING AERONAUTICS&ASTRONAUTICS	15
	STATE GRID CORP CHINA	14
	WUHAN ZHONGYUAN COMMUNICATIONS CO LTD	12
	ACHRONIX SEMICONDUCTOR CORP	11
8 FPGA - CAD tools	ALTERA CORP	115
	XILINX INC	95
	INT BUSINESS MACHINES CORP	38
	LATTICE SEMICONDUCTOR CORP	27
	UNIV NORTHWESTERN POLYTECHNICAL	20
	XI'AN FEISIDA AUTOMATION ENG CO LTD	19
	HARBIN INST TECHNOLOGY	17
	UNIV BEIJING AERONAUTICS&ASTRONAUTICS	17
	STATE GRID CORP CHINA	16
	UNIV FUDAN	16
9 IC - Design	INT BUSINESS MACHINES CORP	1332
	NEC ELECTRONICS CORP	435
	FUJITSU LTD	384
	PANASONIC CORP	373
	CADENCE DESIGN SYSTEMS INC	344
	XILINX INC	340
	RENESAS ELECTRONICS CORP	314
	ALTERA CORP	303
	SYNOPSYS INC	291
	TOSHIBA KK	263

Table 18 – Top 10 Patent Applicants/Owners per Technology Segment

LANDSCAPE OF ENVIRONMENTAL TECHNOLOGY

SCIENCE & TECHNOLOGY UNIT, UMM AL-QURA UNIVERSITY (STU-UQU)

THOMSON REUTERS IP SERVICES
MAY 2015

Executive Summary

This study has been commissioned by Science & Technology Unit, Umm Al-Qura University (STU-UQU) to evaluate and describe the global scientific research and patent activity within sub-tracks that they have achieved funding for projects. Within the Environmental Technology track, the sub-track of focus was Ambient Air Quality and Waste Avoidance Technologies. The study has looked at both scientific papers and patents to form an understanding of the overall scientific and technology landscape.

The scientific papers are sourced from the Web of Science™, a database containing journal articles from approximately 12,500 peer-reviewed journals.

The patent information is sourced from the Derwent World Patents Index™, a database of patents and patent applications from 47 international patent issuing authorities.

Both databases have been selected because they provide a method of defining a unit of science or technology. A single paper defined by the Web of Science is required to have met a minimum threshold of scientific rigor: publication within a journal of repute, peer review sign off, etc. Furthermore, a patent included within DWPI is defined credibly as an attempt to protect a piece of innovation within at least one territory.

Aggregating this information across technologies and countries provides a method of tracking Environmental Technology innovation and development trends.

Included in this document are measurements of research and patent quality and direction changes in research and patent activity. It should be noted that in many areas the report utilizes metrics such as average annual percentage growth in scientific and research output to compare activities across technologies and geographies. Such metrics should be treated with care for analyses containing low volumes, as some volatility is expected. Also to be noted is that the global high volume nature of this analysis within Environmental Technology necessarily entails some level of noise and is not intended to be completely comprehensive. Instead, the analyses enclosed should be treated as a survey of the technology, and the trends and findings interpreted in this manner. Overall, the fact that the number of patents in the area surpasses the number of papers by a factor of 3 suggests that research activity is generally focused more on practical technical commercialization as opposed to more fundamental research.

For STU-UQU, it is interesting to note the patent and scientific literature collections differ with respect to the breakdown in broad technology segments/topics. Though, most of the topics including air pollution, water contamination, diagnosis/mitigation, municipal/domestic waste treatment, industrial waste, and eco-friendly synthesis are comparably active in both patent and scientific literature data sets. Further, electric components manufacturing waste (E-waste) topic is least focused, however looking at the average growth rates in the scientific literature collection (years 2009 - 2014; refer to Figure 5) it is experiencing significant growth. This insight may give STU-UQU direction on future projects and research areas.

With regard to average growth rates in both the collections (years 2008 - 2013 for patents; years 2009 - 2014 for papers), in the patent collection the technology topics which are experiencing significant growth include eco-friendly synthesis, diagnosis/mitigation, municipal/domestic waste treatment, and industrial waste. While air pollution topic in the patent collection, regardless of high volume, has seen a little growth over the time period which may indicate innovation saturation in this area. The topics in the scientific literature collection which have seen sizable growth relative of other topics include E-waste, eco-friendly synthesis and water contamination.

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INTRODUCTION TO ENVIRONMENTAL TECHNOLOGY SCIENTIFIC ACTIVITY

This study presents an analysis of patents and scientific papers that fall within specific topics of interest to Science & Technology Unit, Umm Al-Qura University (STU-UQU) concerning the Pollution Monitoring/Treatment and Waste Treatment.

The study was commissioned by Science & Technology Unit, Umm Al-Qura University (STU-UQU) as part of a wider program to review the scientific and intellectual property activity in specific topics that they have gained approved funding for projects. Within the area of Environmental Technology, they have gained funding approval for two projects related to the Ambient Air Quality and Waste Avoidance Technologies, but specifically in the sub-tracks of Air Pollution Monitoring and Assessment Technologies and Hazardous waste. The titles of the projects are "Assessment of cancer risk associated with long term exposure of some airborne heavy metals in Makkah Region" and "Environmentally benign chemo-enzymatic synthesis of drug intermediates involving dynamic kinetic resolution using eco-friendly racemization catalysts".

A large scale data collation process using globally recognized search processes from Thomson Reuters was undertaken to produce practical and insightful sets of information for analysis regarding the trends, geographies and ultimately the institutions and patent applicants working in the fields of Pollution Monitoring/Treatment and Waste Treatment within the domain of Environmental Technology.

As shown in Figure 1, the overall volume of patents in these technology areas filed since 2006 is more than thrice the volume of scientific papers published since 2008, however in the same time period from year 2008 onwards the patent output is about 330% higher than the scientific paper output.

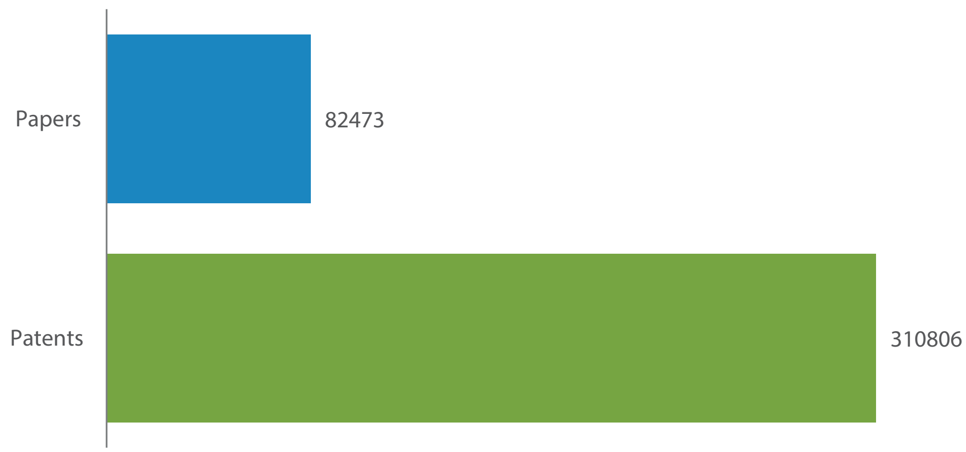

Figure 1 – Scientific Paper and Patent Families in Environmental Technology

Additionally, year 2006 onwards patent protection activity related to environmental technology had continuously increased (refer to Figure 2, Timeline of Activity) than publications in scientific journals, which are likely to address more fundamental science. This might suggest that the focus of technology development globally related to environmental technology is increasingly directed towards commercialization and practical application. However, in recent years (2012 onwards) the patenting activity has shown a downward trend. On the other hand, the scientific paper output has been balanced and increasing at a much slower rate year over year.

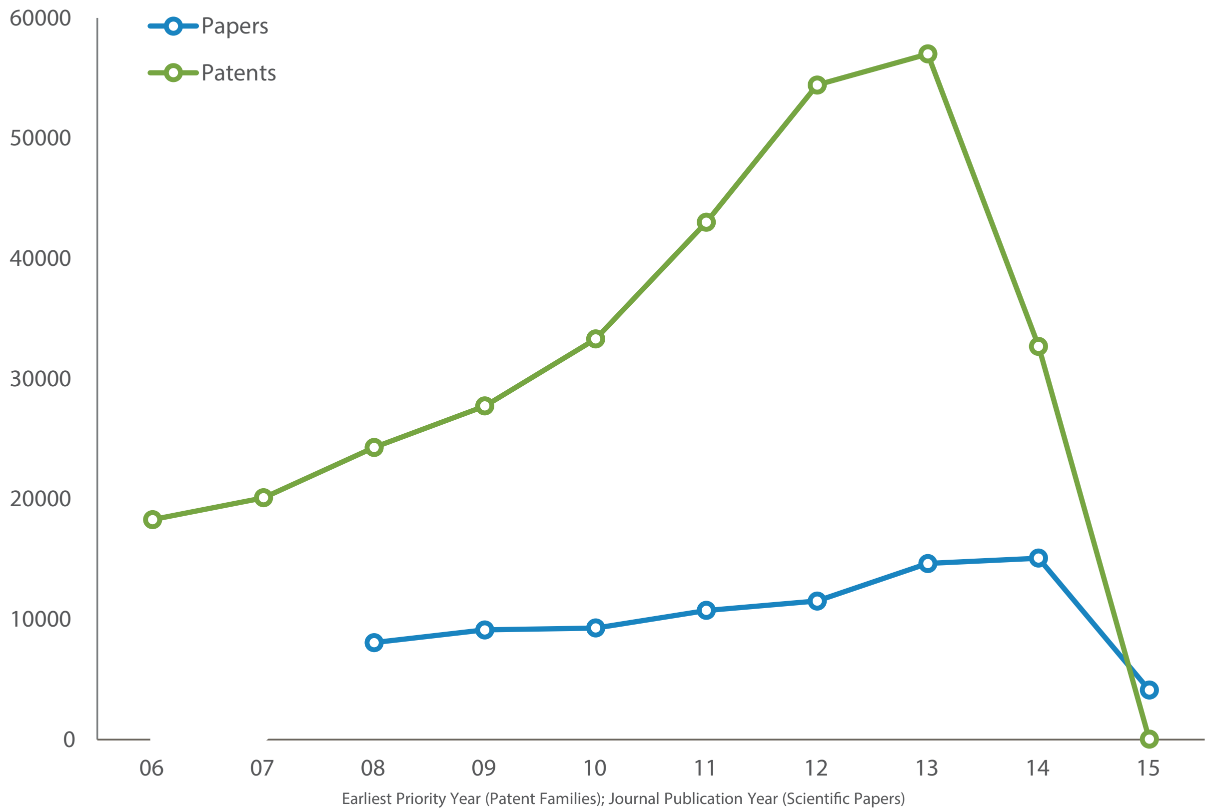

Figure 2 – Timeline of Scientific Paper and Patent Family Activity

Figures 3 through 5 show three further analyses on each of the data collections (patents, left; papers, right) concerning the nature and high level technology trends occurring within the environmental technology area.

The patent and scientific literature collections differ with respect to the breakdown in broad technology segments. Two broad level technology segments within environmental technology, which were identified for the purpose of this study, include 'pollution monitoring/treatment' and 'waste treatment'. Referring to Figure 3, a comparable patenting activity has been observed in these broad technology segments within environmental technology. While in case of scientific papers the pollution monitoring/treatment topic marginally exceeds the waste treatment topics.

Note that the dates used for the collation of the timeline information differ for patent and scientific literature information. Patent Families are measured by the earliest known "priority" or first filing event in the inventions history. Patents are typically retained by patent offices for 18 months or more after filing before they are published. This delay means that the last complete year of information available for patent information is 2012. For scientific papers, the dates used for analyses are the publication dates of the journal containing the paper. These metrics are used throughout the report.

Most of the topics namely air pollution, water contamination, diagnosis/mitigation, municipal/domestic waste treatment, industrial waste, and eco-friendly synthesis are comparably active in both patent and scientific literature data sets with the municipal/domestic waste treatment and the diagnosis/mitigation being leading topics in patent and scientific literature data sets, respectively. Electric components manufacturing waste (E-waste) topic is least focused, however looking at the average growth rates in the scientific literature collection (years 2008 – 2011; refer to Figure 5) it is experiencing significant growth.

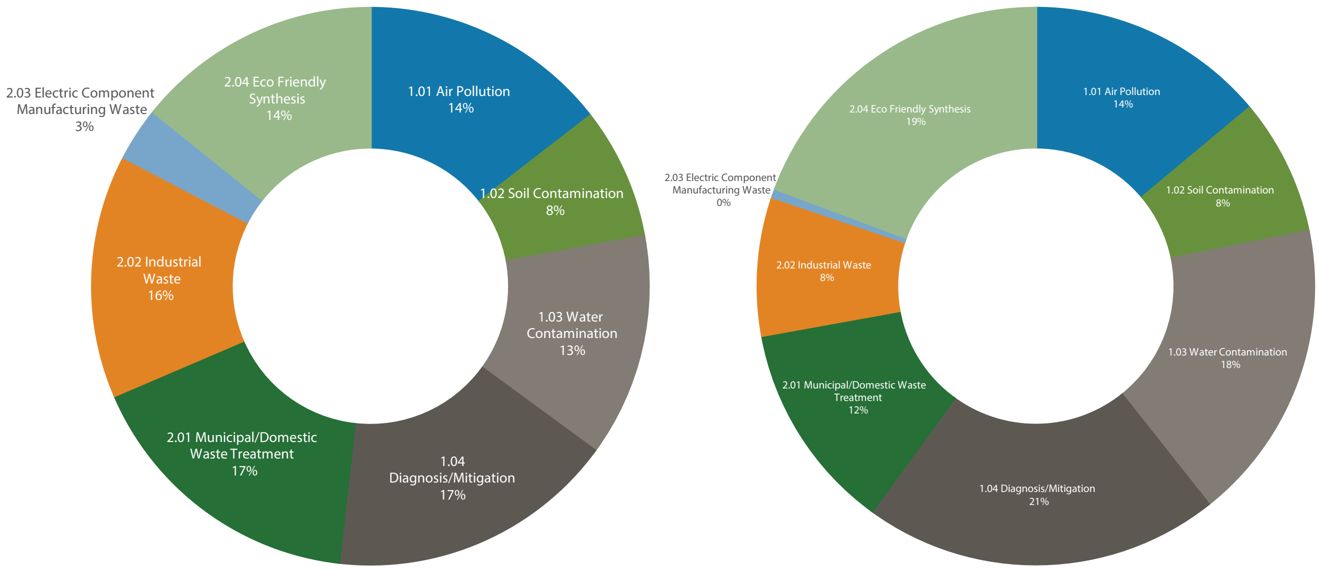

Figure 3 – % of Patent (left) and Scientific Paper (right) Collections by Technology Topics

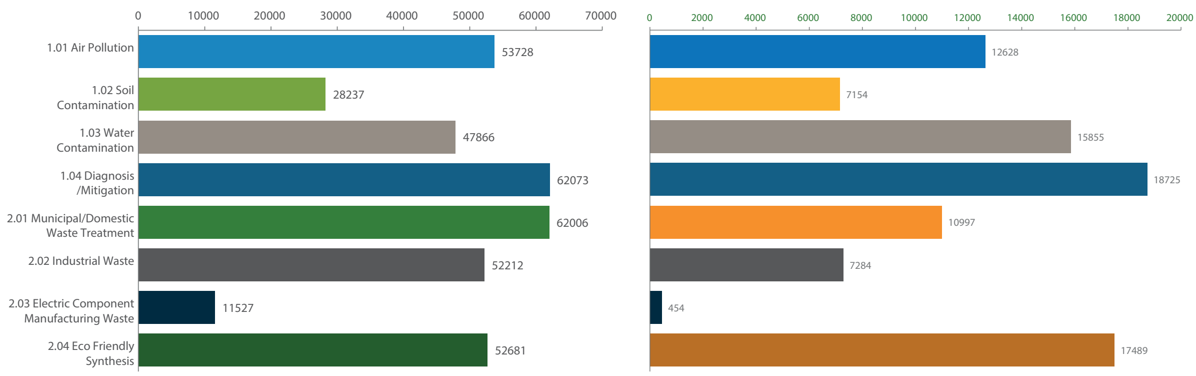

Figure 4 – Number of Patents Families (left) and Scientific Papers (right) per Technology Topic

With regard to average growth rates in both the collections (years 2008 - 2013 for patents; years 2009 - 2014 for papers), in the patent collection the technology topics which are experiencing significant growth include eco-friendly synthesis, diagnosis/mitigation, municipal/domestic waste treatment, and industrial waste. While air pollution topic in the patent collection, regardless of high volume, has seen a little growth over the time period which may indicate innovation saturation in this area. The topics in the scientific literature collection which have seen sizable growth relative of other topics include E-waste, eco-friendly synthesis and water contamination.

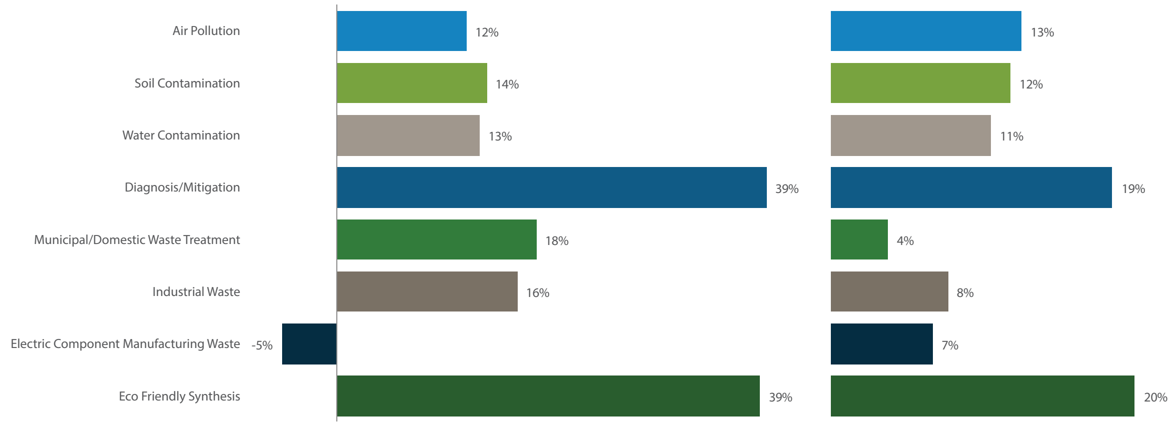

Figure 5 – Average Annual % Growth or Decline in Patent Family (left) or Scientific Paper (right) Output

Timeline activity for scientific literature (Figure 6) since 2008 shows that eco-friendly synthesis and water contamination as leading technology topics. Other topics are experiencing less focus over the time period.

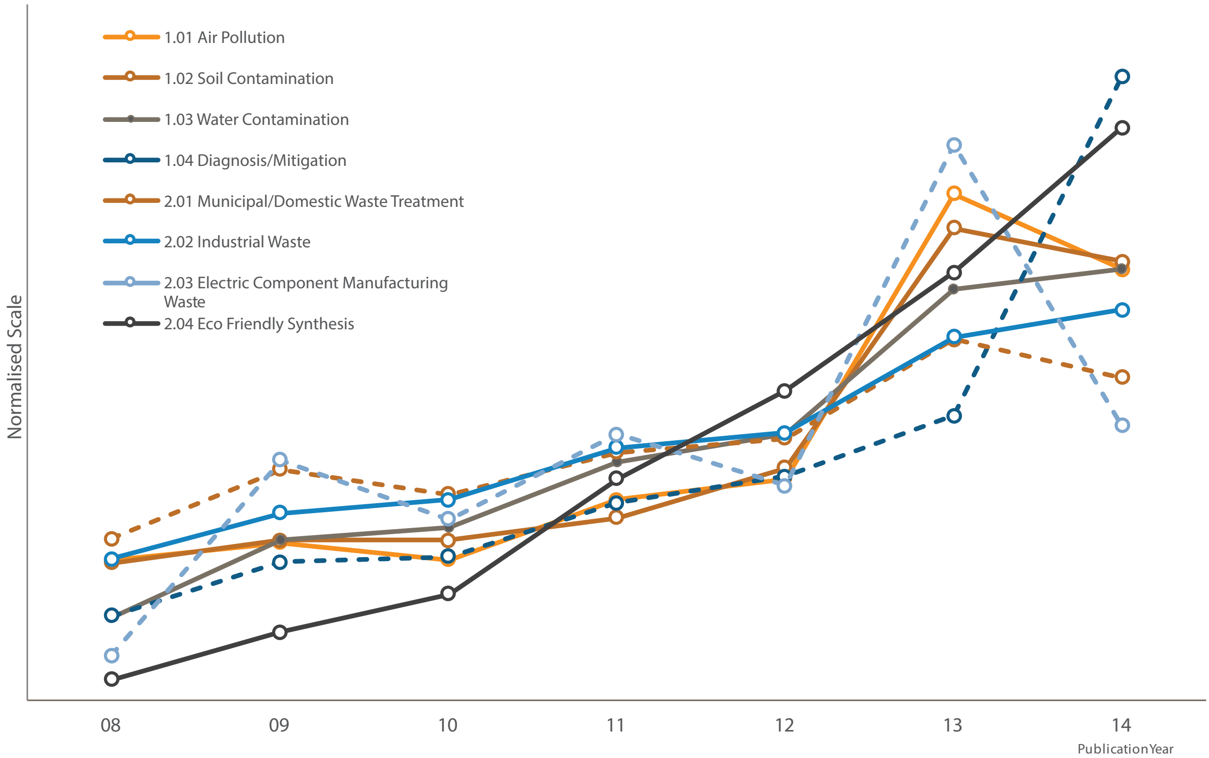

Figure 6 – Normalized Timeline of Activity for Scientific Paper Collection by Various Technology Topics

Average annual growth or decline is calculated by the average percentage increase or decrease between one year and the next. For example; 5 patents in 2006 followed by 6 patents in 2007 would represent an annual increase of 20%. An increase of 20% in one year, followed by a 10% increase the following year would be represented as a 15% average increase across the two years. This process is followed for 2006 (patents) or 2008 (papers) through to the most recently available year in patent and paper collections, to provide an indicator of the level and direction of recent changes in technology topics.

Timeline activity for patent (Figure 7) since 2006 shows that Diagnosis/Mitigation, municipal/domestic waste treatment and industrial waste as leading technology topics and E-waste is experiencing decline over the time period.

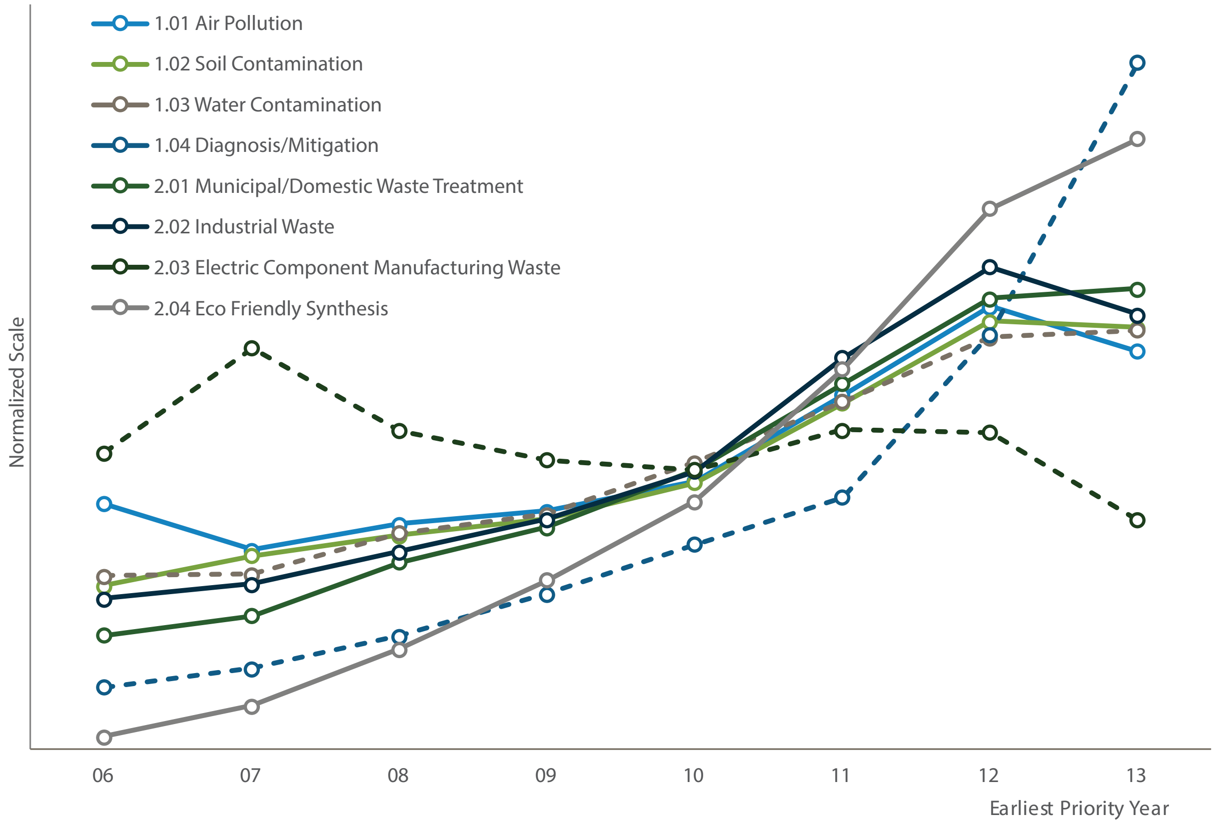

Figure 7 – Normalized Timeline of Activity for Patent Family Collection by Technology Topics

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The timelines on these charts have been normalised to allow for side by side comparison. Individually, each topic has varying volumes of patent families and scientific papers, however for visualisation purposes, the charts represent the proportion of each topic's activity filed or published in each calendar year.

ENVIRONMENTAL TECHNOLOGY SCIENTIFIC LITERATURE COLLECTION TECHNOLOGY TRENDS

This section of the report focuses on the scientific paper collection and the activity and technological trends seen within it. Based on the Thomson Reuters-produced Web of Science database, the collection only includes papers published in pre-selected journals of influence.
In total, over 82,000 peer reviewed papers were incorporated into the environmental technology collection.

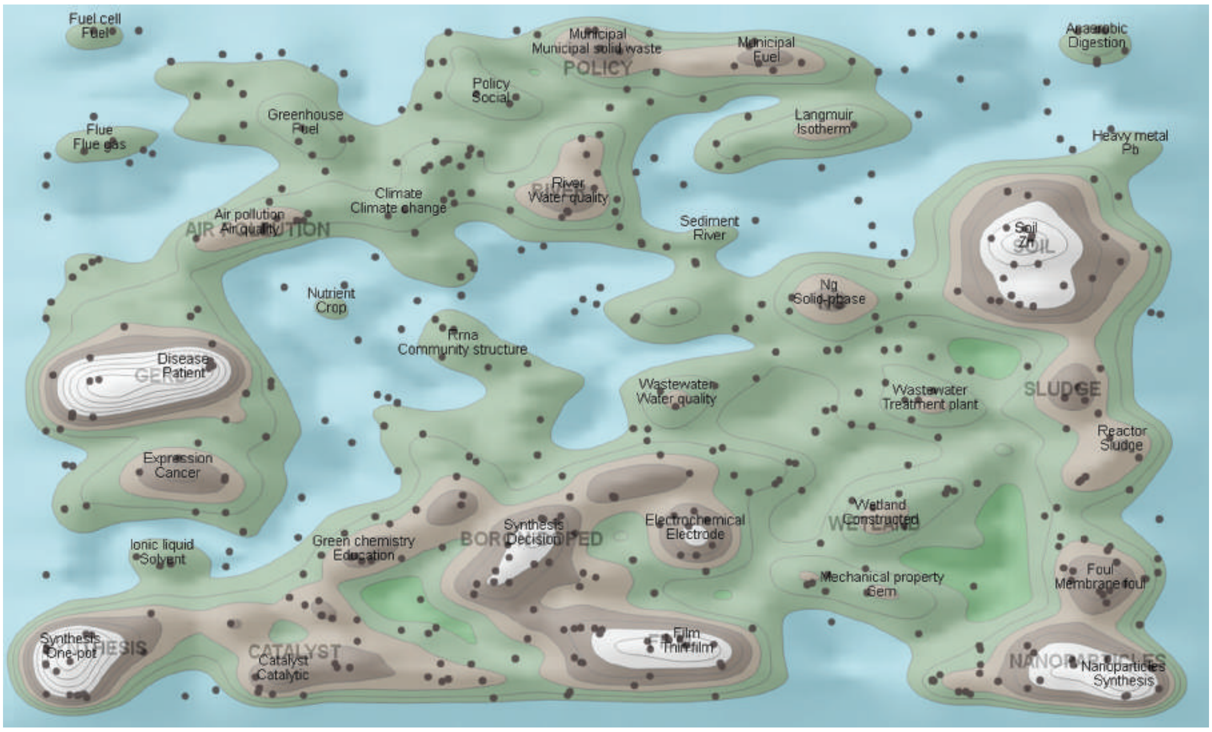

Figure 8 – ThemeScape Map of Scientific Paper Collection; Annotated by Major Themes

Key themes present throughout this collection of papers are illustrated in Figure 8 as a "ThemeScape map" - a visualization method for understanding the common themes and concepts within thousands of documents. Used for market analysis, government intelligence and primarily technology landscapes, the algorithm parses large amounts of text into a topological map of peaks and troughs.
Themes that are commonly shared between documents are represented by mountainous peaks, whereas documents that share little commonality are located within the valleys of the map. The large number of documents in this map means that there are rather few valleys to be found.
The location of an individual document is the vector sum of all the attractions to other documents in the collection based on shared phraseology and the frequency and proximity of these terms.
This map has been manually annotated to summarize the major technology areas within the scien-

tific literature collection. Some technologies will necessarily overlap, and the delineation of one technical area versus another is therefore only approximate. However the map is very useful in describing what topics are common features of global environmental technology scientific research.
Key themes revealed in this Themescape map focus mainly on eco-friendly synthesis, water contamination, municipal/domestic waste treatment, soil contamination, industrial waste and air pollution.

ThemeScape® is a text-mining application that acquires and analyzes free text. The algorithms it uses require no application of thesauri or other outside sources of information, and only the free text itself is used by this text-mining tool. The more text the application acquires, the more likely it will be that the output will provide an accurate summary of the major themes present. After analyzing the text in multiple documents, it pulls together those documents that share related text and pulls apart those with less related text. The outcome 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 pick out topics of interest. It aggregates word forms that share a common stem, but it does not directly aggregate synonyms. Instead, synonyms may be gathered under a common theme because of the other words that co-occur with those synonyms. Thus, “battery” and “cell” may be clustered together because of the co-occurrence in the same documents of terms like “electrode, rechargeable, electrolyte” and so on. Conversely, “battery” and “cell” may be separated if the map contains a mixture of documents on metals and biology, where the two terms have different meanings. In other words, terms are identified as synonyms only by co-clustering based on common context.

The topographical maps presented by ThemeScape are mathematical solutions built on a random selection of a first document and sequential calculation of the relationships of all the other documents. The orientation of the map is random, and the directions up, down, left, or right have no significance, because the n-dimensional solution might have been presented from any angle. Only the proximity of points within the map has meaning, and co-localized documents are highly likely to share concepts.

In this report there are separate ThemeScape maps covering scholarly papers or patents. The two types of documents are not pooled and analyzed together. This is because ThemeScape is context-sensitive, and it would separate patent and literature documents from one another based on the very different formal styles of writing that are reflected in these two types of content. Likewise, if documents in two languages are pooled, it will separate them based on the language, and then each language region will be clustered based on term frequency in that language.

The ThemeScape maps in this report analyze large numbers of documents. The contour lines on the maps diminish in circumference, encircling regions of higher and higher concentration. The density is also shown by the map coloration. White snow-capped peaks represent the highest density, while blue expanses (sea level) indicate low density.

The labels in black on the map are selected by ThemeScape based on term frequency in that map region, and they may have been adjusted by the analyst. The large color-overlay regions enclosed by broken lines have been added by the analyst to identify content at an even higher level of abstraction. The dots on the map represent single documents. Dots are not shown for all the documents, and instead represent a sampling that allows the other features of the map to be discerned. Within the ThemeScape application, the map can be magnified, searched, probed and highlighted to learn more about its contents.

ThemeScape is reliant on statistical methods that are not equivalent to reading by human judges, and in compensation, it analyzes millions of documents on a scale of minutes and quickly presents an intuitive, high level summary. It enables and guides further review, and provides a first level overview of very complex datasets.

ThemeScape is reliant on statistical methods that are not equivalent to reading by human judges, and in compensation, it analyzes millions of documents on a scale of minutes and quickly presents an intuitive, high level summary. It enables and guides further review, and provides a first level overview of very complex datasets.

SCIENTIFIC LITERATURE SEGMENTATION

Table 1 shows the further segmentation of environmental technology topics. Interest in water contamination, diagnosis/mitigation, and eco-friendly synthesis appears to be very high, with high volumes of papers published along with high growth rates. Electronic component manufacturing waste is a relatively niche area, with very low volumes but very high growth rates. This is indicative of an emerging area.

Technology Segmentation		Total Inventions	Average % Growth or Decline ('09-'14
1.0 Pollution Monitoring/Treatment	1.01 Air Pollution	12628	13%
	1.02 Soil Contamination	7154	12%
	1.03 Water Contamination	15855	11%
	1.04 Diagnosis/Mitigation	18725	19%
2.0 Waste Treatment	2.01 Municipal/Domestic Waste Treatment	10997	4%
	2.02 Industrial Waste	7284	8%
	2.03 Electric Component Manufacturing Waste	454	7%
	2.04 Eco Friendly Synthesis	17489	20%

Table 1 – Scientific Literature Technology Segmentation

SCIENTIFIC LITERATURE COLLECTION TECHNOLOGY CATEGORY OVERLAP

The technology categories and that were created to enumerate and describe the environmental technology landscape were not intended to be mutually exclusive. A single scientific paper can be included in multiple categories or topics.

Figure 9 visualizes the relationship between the technology categories used in this study. Each number in the diagram shows the number of papers that have content related to both the corresponding row-wise and column-wise segments.

The most correlated segment pairing of the municipal/domestic waste treatment and the Diagnosis/Mitigation with the water contamination technical segment. Otherwise, mostly smaller sets are generally observed as overlap between the technology segments.

	1.01 Air Pollution	1.02 Soil Contamination	1.03 Water Contamination	1.04 Diagnosis/Mitigation	2.01 Municipal/Domestic Waste Treatment	2.02 Industrial Waste	2.03 Electric Component Manufacturing Waste	2.04 Eco Friendly Synthesis
1.01 Air Pollution	12628	290	323	102	152	52	3	48
1.02 Soil Contamination		7154	489	208	643	79	11	28
1.03 Water Contamination			15855	1903	1970	241	4	102
1.04 Diagnosis/Mitigation				18725	884	354	68	320
2.01 Municipal/Domestic Waste Treatment					10997	242	21	45
2.02 Industrial Waste						7284	36	226
2.03 Electric Component Manufacturing Waste							454	9
2.04 Eco Friendly Synthesis								17489

Figure 9 – Number of Scientific Papers per Pair of Technology Segments

SCIENTIFIC PAPER GEOGRAPHIC VOLUME BENCHMARKING

Figure 10 shows the number of scientific papers for ten most prolific countries within the scientific paper collection.
China is the largest source of environmental technology related peer-reviewed papers, followed by United States, India, Spain, United Kingdom and Germany. It is also interesting to note that the ten most prolific countries contribute to about 60% of output for the scientific paper in the environmental technology area.

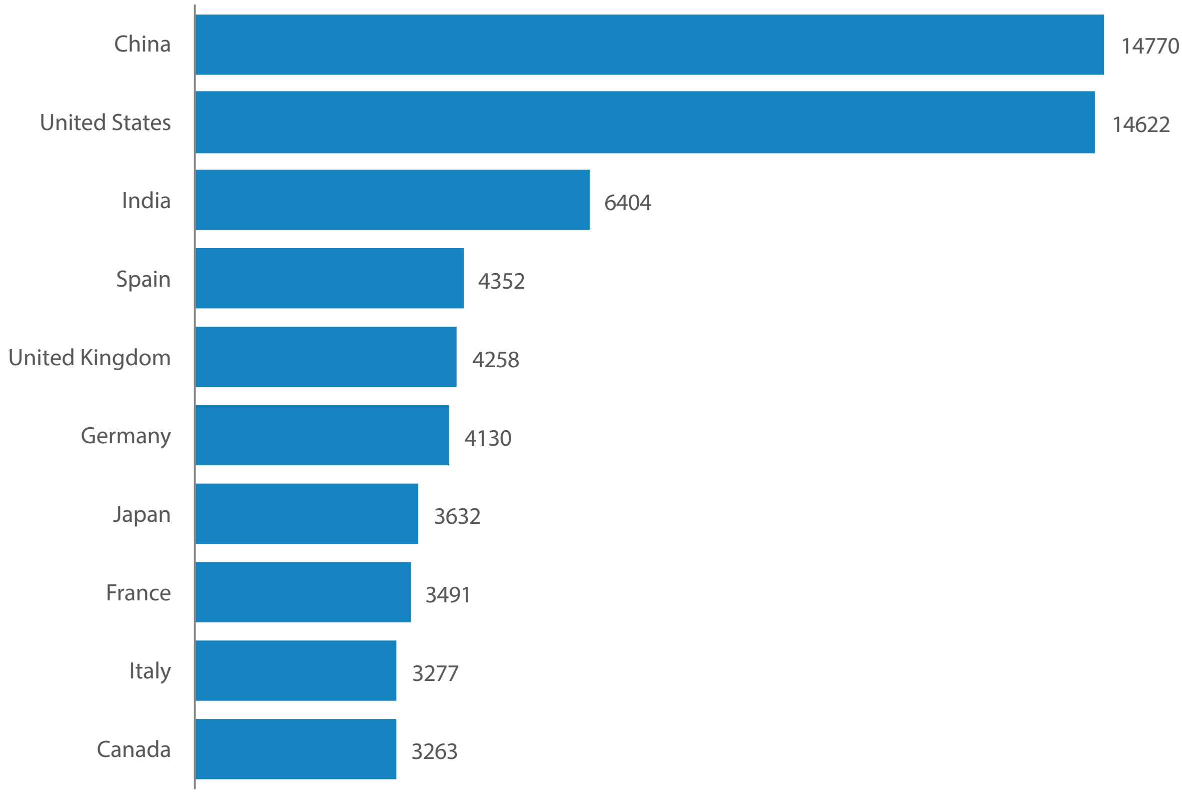

Figure 10 – Number of Scientific Papers per Country; Top 10 Sources

SCIENTIFIC PAPER GEOGRAPHIC ACTIVITY TRENDS

The chart below shows the highest grow rates sources in the scientific literature collection.

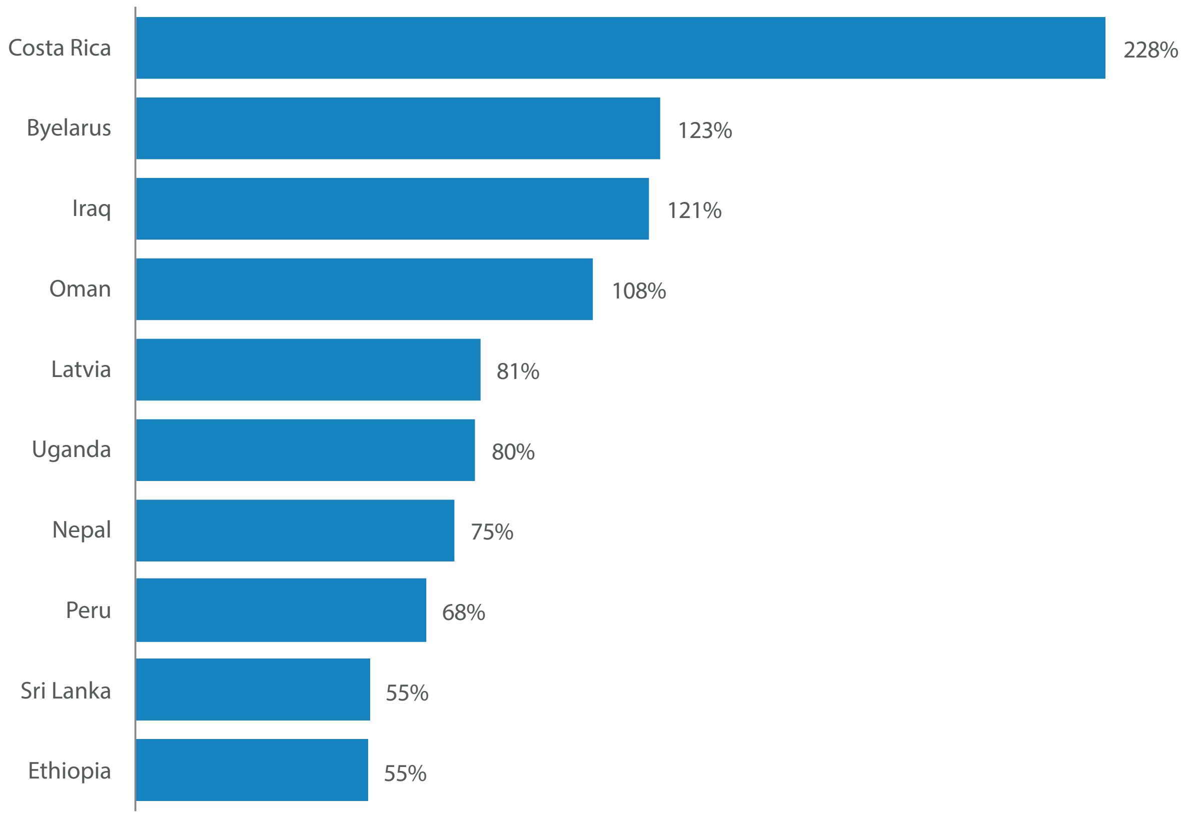

Figure 11 – Highest Growth Rate Geographies in Scientific Publications Output

While scientific literature collection for Costa Rica and Byelarus, is relatively small, the growth rate of scientific paper published in Costa Rica and Byelarus collection far exceeds that of other countries.

SCIENTIFIC PAPER GEOGRAPHIC CITATION IMPACT BENCHMARKING

Scientific paper and patent citations are routinely used in technology bibliometrics for assessing the inherent impact and potential quality of research and the downstream technical and scientific relevance of the underlying research.
Figure 12 shows the "Citation Impact", the average citation per paper for all papers in a country's collection (which are having at least 50 publications) and has been sorted by highest citation impact. This shows that output from Cyprus, Singapore, Switzerland, Denmark and Belgium are having the highest impact in the environmental technology topics.

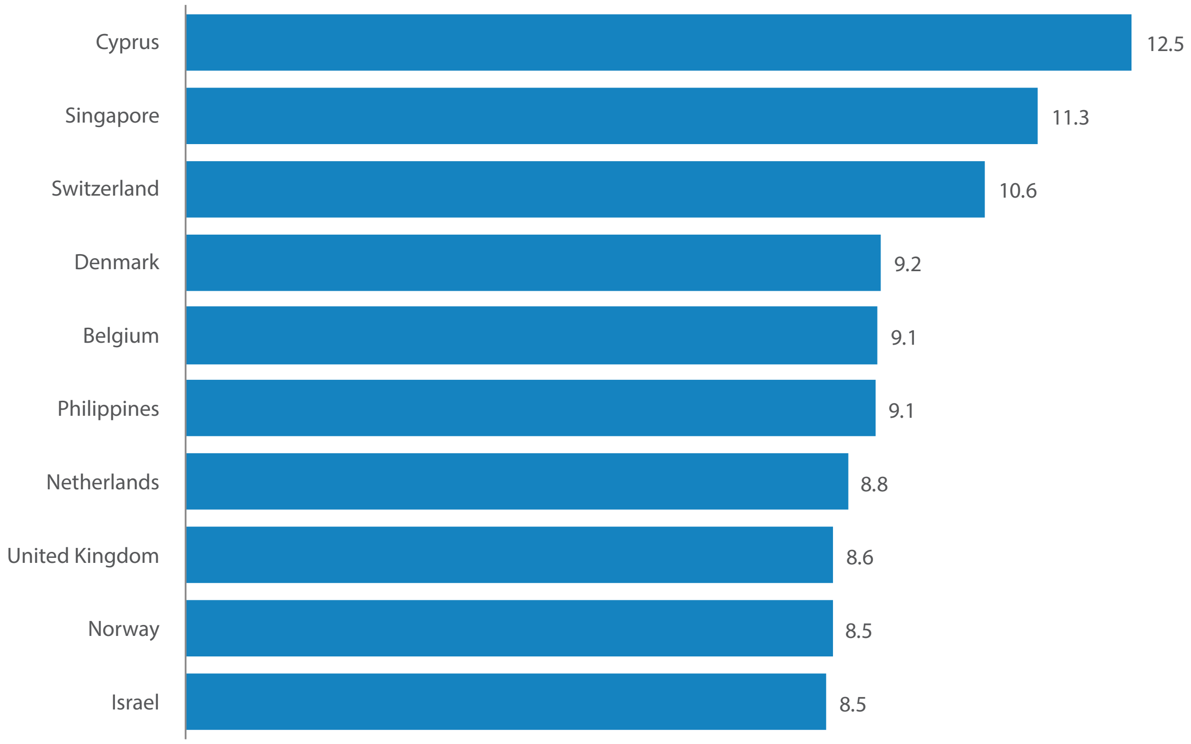

Figure 12 – Highest Citation Impact Geographies of Scientific Publications

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Note that the journals included in the project source data (Web of Science) are selected on the basis of both quantitative and qualitative selection criteria, such as editorial quality, peer review robustness and citation impact. Further details of the journal selection process is available from : http://thomsonreuters.com/products_services/science/free/essays/journal_selection_process/

SCIENTIFIC LITERATURE COLLECTION ENVIRONMENTAL TECHNOLOGY TOPICS BY GEOGRAPHY

Table 1 shows the split of environmental technology science and research specialization for top nations. The water contamination, diagnosis/mitigation and eco-friendly synthesis have been in focus for top nations.

Country of Origin	1.01 Air Pollution	1.02 Soil Contamination	1.03 Water Contamination	1.04 Diagnosis/Mitigation	2.01 Municipal/Domestic Waste Treatment	2.02 Industrial Waste	2.03 Electric Component Manufacturing Waste	2.04 Eco Friendly Synthesis
China	14%	8%	23%	18%	13%	7%	1%	26%
United States	21%	9%	18%	27%	9%	7%	0%	16%
India	7%	7%	15%	17%	6%	7%	0%	49%
Spain	11%	10%	24%	21%	23%	10%	0%	14%
United Kingdom	20%	9%	17%	28%	15%	8%	1%	12%
Germany	21%	8%	19%	23%	14%	11%	0%	14%
Japan	21%	7%	15%	23%	13%	8%	1%	21%
France	17%	9%	21%	23%	11%	8%	0%	19%
Italy	15%	10%	16%	28%	16%	11%	0%	16%
Canada	17%	9%	25%	24%	17%	8%	0%	12%
South Korea	21%	6%	14%	25%	11%	7%	0%	24%
Brazil	10%	11%	17%	24%	17%	13%	0%	17%
Australia	15%	12%	25%	24%	17%	8%	1%	10%
Iran	11%	7%	12%	14%	6%	7%	0%	50%
Taiwan	22%	8%	18%	24%	11%	10%	1%	17%
Poland	15%	11%	17%	20%	26%	11%	0%	13%
Turkey	12%	9%	24%	24%	16%	13%	0%	14%
Netherlands	20%	8%	23%	23%	14%	9%	0%	13%
Sweden	19%	9%	18%	25%	19%	9%	1%	11%
Switzerland	18%	11%	22%	22%	17%	9%	0%	10%
Belgium	19%	8%	23%	25%	14%	9%	0%	12%
Portugal	10%	8%	23%	22%	15%	13%	0%	20%
Malaysia	9%	10%	21%	24%	10%	12%	1%	25%
Mexico	15%	9%	25%	23%	11%	10%	0%	16%
Denmark	15%	11%	22%	25%	18%	12%	0%	11%
Greece	11%	9%	22%	21%	26%	10%	1%	14%
Russia	23%	8%	11%	25%	3%	14%	0%	21%
Romania	14%	10%	18%	22%	13%	14%	2%	19%
Egypt	11%	9%	19%	24%	12%	8%	0%	25%
Saudi Arabia	11%	6%	23%	23%	10%	5%	0%	30%
Austria	20%	8%	12%	28%	14%	12%	0%	15%
South Africa	11%	8%	25%	27%	15%	7%	0%	17%
Czech Republic	17%	10%	20%	28%	18%	8%	1%	12%

Table 2 – Specialization by Country; % of Literature Activity per Technical Stream

SCIENTIFIC PAPER – GLOBAL PROLIFIC ENTITIES

Universities appear to dominate the scientific paper publications in Environmental technologies. Science & Technology Unit, Umm al Qura University (STU-UQU) has 15 papers published in this space, with relatively low citations, as compared to other entities within the top 30.

Entity	Total	Times Cited	Citation per paper
Science & Technology Unit, Umm Al Qura University (STU-UQU)	15	41	2.73
Chinese Acad Sci	2450	18055	7.37
Tsinghua Univ	689	5131	7.45
Zhejiang Univ	640	3752	5.86
Islamic Azad Univ	584	1951	3.34
Tongji Univ	526	2750	5.23
Univ Sao Paulo	520	2285	4.39
CSIC	503	5527	10.99
Indian Inst Technol	487	4173	8.57
Harbin Inst Technol	457	2621	5.74
CNRS	454	3156	6.95
Us Epa	416	5525	13.28
Nanjing Univ	362	2977	8.22
Univ Queensland	359	5081	14.15
Peking Univ	356	3327	9.35
Tech Univ Denmark	343	3546	10.34
Univ Calif Berkeley	339	4185	12.35
Univ Tokyo	337	2703	8.02
Univ Ghent	332	3163	9.53
Seoul Natl Univ	327	1907	5.83
Natl Taiwan Univ	321	2272	7.08
Russian Acad Sci	319	772	2.42
Shanghai Jiao Tong Univ	312	2112	6.77
Delft Univ Technol	295	2594	8.79
CNR	291	1924	6.61
Univ Illinois	289	2342	8.10
S China Univ Technol	280	1700	6.07
CSIR	272	1105	4.06
Univ Florida	270	1978	7.33
Nanyang Technol Univ	268	3077	11.48
Natl Univ Singapore	263	2851	10.84

Table 3 – Environmental technology – Top entities for Scientific Literature

SCIENTIFIC LITERATURE OVERVIEW OF GLOBAL PROLIFIC ENTITIES

Table 4 shows the technology profile of the top 30 entities within the scientific literature space of environmental technology. The top entities' research is in line with the overall landscape, with water contamination, diagnosis/mitigation, and eco-friendly synthesis seeing most paper publications. Notably, Science & Technology Unit, Umm Al Qura University (STU-UQU), which has 15 papers in the area, have the least number of papers in water contamination and eco-friendly synthesis. STU-UQU appears to be focusing on diagnosis/mitigation for soil contamination and air pollution.

Entity	1.01 Air Pollution	1.02 Soil Contamination	1.03 Water Contamination	1.04 Diagnosis/Mitigation	2.01 Municipal/Domestic Waste Treatment	2.02 Industrial Waste	2.03 Electric Component Manufacturing Waste	2.04 Eco Friendly Synthesis
Science & Technology Unit, Umm Al Qura University (STU-UQU)	2	4	1	3	2			3
Chinese Acad Sci	289	362	550	373	375	134	64	575
Tsinghua Univ	142	39	172	131	144	63	14	94
Zhejiang Univ	94	93	139	135	83	43	11	116
Islamic Azad Univ	49	30	61	66	24	44	1	340
Tongji Univ	30	42	219	113	180	18	2	31
Univ Sao Paulo	68	41	98	131	92	57	1	91
CSIC	72	76	90	92	96	53		85
Indian Inst Technol	84	29	99	88	65	32		149
Harbin Inst Technol	35	15	217	75	136	27	1	36
CNRS	91	44	97	89	33	37		94
Us Epa	104	42	96	83	58	17		70
Nanjing Univ	37	29	113	62	61	13	1	88
Univ Queensland	59	26	116	86	78	23	3	27
Peking Univ	93	18	90	63	52	15	7	58
Tech Univ Denmark	55	34	74	71	74	58		44
Univ Calif Berkeley	108	34	63	78	26	11	2	50
Univ Tokyo	46	24	56	76	46	28	4	93
Univ Ghent	44	32	126	61	69	29		30
Seoul Natl Univ	62	15	57	97	26	20	2	78
Natl Taiwan Univ	55	36	82	76	46	21	3	48
Russian Acad Sci	66	33	36	76	5	35		83
Shanghai Jiao Tong Univ	63	16	44	63	44	31	17	72
Delft Univ Technol	32	11	105	46	85	25	3	35
CNR	42	27	45	64	35	34	1	73
Univ Illinois	73	19	59	93	16	19	1	32
S China Univ Technol	34	11	66	47	21	26	2	102
CSIR	21	20	41	55	14	16	1	131
Univ Florida	42	54	55	72	27	9	1	36
Nanyang Technol Univ	32	3	106	51	41	13	2	56
Natl Univ Singapore	31	5	68	47	39	20		74

Table 4 – Scientific literature overview of top Global entities

SCIENTIFIC LITERATURE OVERVIEW OF ASIA PACIFIC PROLIFIC ENTITIES

Entity	Country of Origin	Total	1.01 Air Pollution	1.02 Soil Contamination	1.03 Water Contamination	1.04 Diagnosis/Mitigation	2.01 Municipal/Domestic Waste Treatment	2.02 Industrial Waste	2.03 Electric Component Manufacturing Waste	2.04 Eco Friendly Synthesis
Science & Technology Unit, Umm Al Qura University (STU-UQU)	Saudi Arabia	15	2	4	1	3	2			3
Univ Chinese Acad Sci	China	2556	306	384	567	394	379	142	65	600
Tsinghua Univ	China	689	142	39	172	131	144	63	14	94
Zhejiang Univ	China	640	94	93	139	135	83	43	11	116
Tongji Univ	China	526	30	42	219	113	180	18	2	31
Indian Inst Technol	India	487	84	29	99	88	65	32		149
Harbin Inst Technol	China	457	35	15	217	75	136	27	1	36
Nanjing Univ	China	362	37	29	113	62	61	13	1	88
Peking Univ	China	356	93	18	90	63	52	15	7	58
Univ Tokyo	Japan	337	46	24	56	76	46	28	4	93
Seoul Natl Univ	South Korea	327	62	15	57	97	26	20	2	78
Natl Taiwan Univ	Taiwan	321	55	36	82	76	46	21	3	48
Shanghai Jiao Tong Univ	China	312	63	16	44	63	44	31	17	72
S China Univ Technol	China	280	34	11	66	47	21	26	2	102
Nanyang Technol Univ	Singapore	268	32	3	106	51	41	13	2	56
Natl Univ Singapore	Singapore	263	31	5	68	47	39	20		74
Dalian Univ Technol	China	259	34	8	104	47	27	15	2	60
Tohoku Univ	Japan	242	67	8	30	60	36	17	3	40
CSIR	India	240	15	18	32	45	12	15	1	125
Kyoto Univ	Japan	238	54	14	34	50	57	16	3	39
Tianjin Univ	China	237	48	3	38	39	17	22	3	83

Table 5 – Scientific literature overview of top Asia Pacific entities

SCIENTIFIC LITERATURE OVERVIEW OF MIDDLE EAST PROLIFIC ENTITIES

Table 6 visualizes the prolific entities in the Middle East and Africa. The list is equally dominated by Middle Eastern and African entities, reflecting the trends seen in Table 5 above. Most of the prolific entities in these regions predominantly focus on Eco-friendly synthesis followed by focus on Diagnosis/Mitigation and Water contamination.

Entity	Country of Origin	Total	1.01 Air Pollution	1.02 Soil Contamination	1.03 Water Contamination	1.04 Diagnosis/Mitigation	2.01 Municipal/Domestic Waste Treatment	2.02 Industrial Waste	2.03 Electric Component Manufacturing Waste	2.04 Eco Friendly Synthesis
Science & Technology Unit, Umm Al Qura University (STU-UQU)	Saudi Arabia	15	2	4	1	3	2			3
Islamic Azad Univ	Iran	584	49	30	61	66	24	44	1	340
Univ Tehran	Iran	236	41	25	51	40	35	21	1	52
Istanbul Tech Univ	Turkey	190	17	9	85	40	46	20		12
King Khalid University	Saudi Arabia	185	20	13	32	40	21	7		68
King Abdulaziz University	Saudi Arabia	168	16	8	31	36	9	6	2	76
Isfahan Univ Technol	Iran	144	10	18	11	6	4			98
Univ Tehran Med Sci	Iran	141	29	10	24	38	19	7		30
Tarbiat Modares Univ	Iran	136	7	9	30	39	13	13		39
King Fahd University Of Petroleum & Minerals	Saudi Arabia	100	13	1	42	34	5	4		8
Middle E Tech Univ	Turkey	96	8	6	17	25	15	14		24
Payame Noor Univ	Iran	94	1	3	4	12	4	6		71
Shiraz Univ	Iran	94	7	19	10	10	6	8		39
Bu Ali Sina Univ	Iran	93	3	14	10	10	6	2		53
Univ Kwazulu Natal	South Africa	88	10	12	23	14	12	4		20
Univ Kashan	Iran	86	9	1	1	7		9		63
Univ Alexandria	Egypt	83	15	12	22	18	9	3		16
King Abdullah University Of Science And Technology	Saudi Arabia	77	9	4	26	8	17	5		17
Univ Cape Town	South Africa	74	15	6	15	27	15	4	1	
Sharif Univ Technol	Iran	71	16	2	11	10	2	8		26
Univ Pretoria	South Africa	71	6	8	12	20	9	8	1	10
Ataturk Univ	Turkey	70	12	13	11	19	8	5		7
Istanbul Univ	Turkey	70	10	9	9	22	7	12		6
Ferdowsi Univ Mashhad	Iran	67	7	3	4	12	2	6		35
Cairo Univ	Egypt	66	6	3	8	15	2	7		29
Dokuz Eylul Univ	Turkey	62	3	5	20	11	6	14		11
Amirkabir Univ Technol	Iran	61	17	3	10	11		9	1	21
Shahid Beheshti Univ	Iran	61	2	4	4	7	2	2		43
Iran Univ Sci & Technol	Iran	60	14	4	7	10		5		21
Razi Univ	Iran	58	7	1	11	6	2	9		27
Selcuk Univ	Turkey	58	5	7	13	12	8	8		12

Table 6 – Scientific literature overview of top Middle East & Africa Entities

SCIENTIFIC LITERATURE OVERVIEW OF SAUDI ARABIA PROLIFIC ENTITIES

Entities	Total	1.01 Air Pollution	1.02 Soil Contamination	1.03 Water Contamination	1.04 Diagnosis/Mitigation	2.01 Municipal/Domestic Waste Treatment	2.02 Industrial Waste	2.03 Electric Component Manufacturing Waste	2.04 Eco Friendly Synthesis
Science & Technology Unit, Umm Al Qura University (STU-UQU)	15	2	4	1	3	2			3
King Khalid University	186	20	13	32	40	21	8		68
King Abdulaziz University	170	16	8	31	37	9	6	2	77
King Fahd University Of Petroleum & Minerals	100	13	1	42	34	5	4		8
King Abdullah University Of Science And Technology	76	9	4	26	8	17	5		16
Taibah University	15	1	1	5	2	2			6
Taif University	15	1		3	5		2		4
King Abdulaziz City For Science & Technology	14	2	2	2	5	1	1		4
King Faisal Univ	13	1	1		4	1	1		5
Najran Univ	12	2		2	8				1
Jazan Univ	9		1	3	1	1			4
Saudi Aramco	9	5		2	1	1			1
Qassim Univ	8			3	3	3			
Univ Dammam	7	1	2	1	2	1			1
Al Jouf Univ	5				1	2			2
SABIC	4	2		1	1				1
Shaqra Univ	4	1			1		2		
Al Imam Muhammad Ibn Saud Univ	3	1			2				
Riyadh Coll Dent & Pharm	3				3				
Salman Bin Abdulaziz Univ	3					1			2
Al Kharj Univ	2	1					1		
Albaha Univ	2			1			1		
King Faisal Specialist Hosp & Res Ctr	2				2				
Royal Commiss Jubail & Yanbu	2					2			
Schlumberger Middle East Sa	2		1	1		1			
Univ Hail	2	1		1			1		
Alfaisal Univ	1				1				
Asser Cent Hosp	1				1				
Buraydah Coll	1								1
Coll Hlth Sci	1								1

Table 7 – Scientific literature overview of top Saudi Arabia entities

MIDDLE EAST & AFRICA ENVIRONMENTAL TECHNOLOGY SCIENTIFIC LITERATURE TRENDS

This section of the report focuses on the scientific paper collection and the activity and technological trends observed in the Middle East and Africa regions.

MIDDLE EAST & AFRICA – PROLIFIC COUNTRIES

Figure 13 below shows the prolific countries by scientific literature volume in the Middle East & Africa regions. The gray bars indicate Middle East, blue indicates Africa, and green indicates the Kingdom of Saudi Arabia. As seen from the figure, the most prolific countries within these regions are Iran, followed by Turkey, Egypt, Saudi Arabia and South Africa.

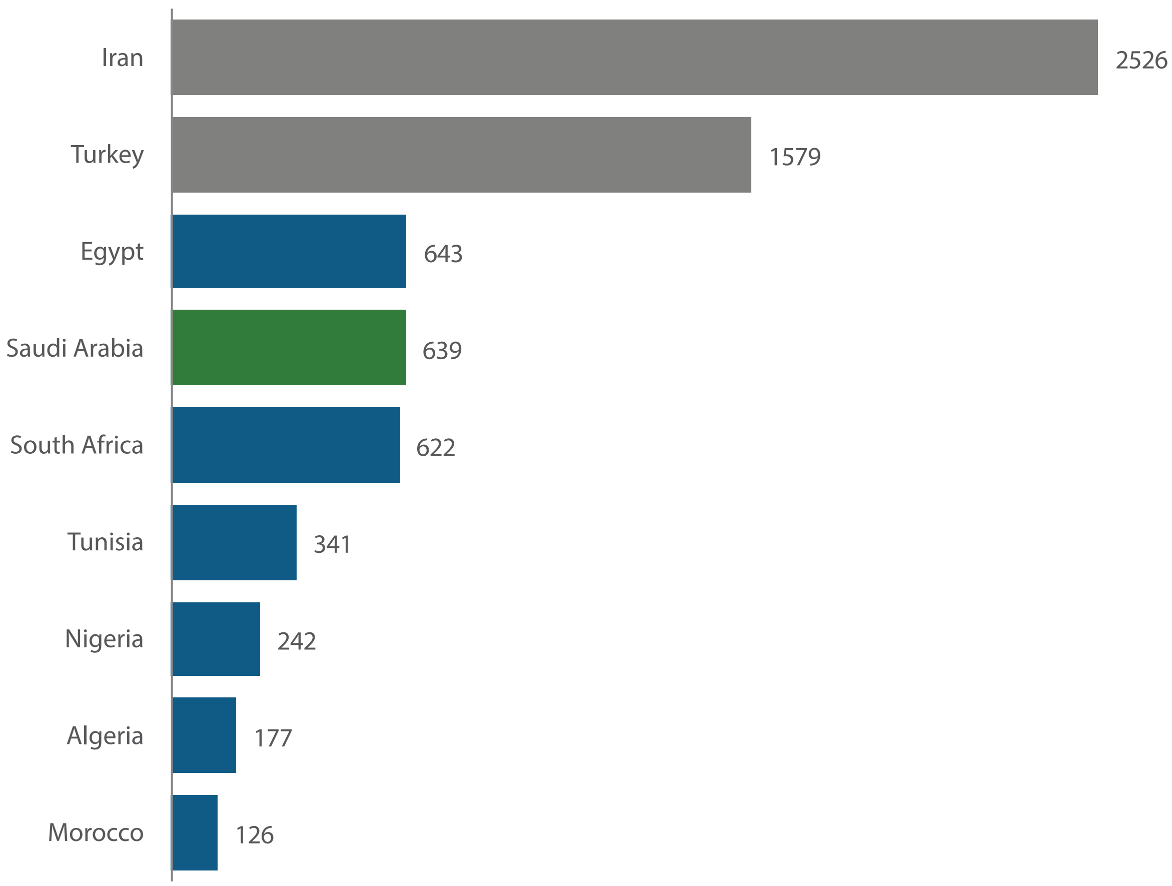

Figure 13 – Middle East & Africa – Prolific countries in scientific literature

A more detailed analysis of the technologies of focus in each of the countries within the Middle East and Africa is presented with reference to Tables 5 and 6. Focus appears to be predominantly on Eco-friendly synthesis.

Country of Origin	1.01 Air Pollution	1.02 Soil Contamination	1.03 Water Contamination	1.04 Diagnosis/Mitigation	2.01 Municipal/Domestic Waste Treatment	2.02 Industrial Waste	2.03 Electric Component Manufacturing Waste	2.04 Eco Friendly Synthesis
Iran	272	174	303	356	143	181	6	1259
Turkey	188	143	381	382	246	205	3	223
Egypt	70	56	123	155	79	49	1	161
Saudi Arabia	73	36	147	147	66	31	2	193
South Africa	69	49	155	168	94	42	2	109
Tunisia	19	33	121	82	55	51		33
Nigeria	11	65	42	69	27	23	6	25
Algeria	16	7	51	46	14	24	5	33
Morocco	5	14	28	32	33	14		18
Jordan	13	17	23	15	28	16		7
U Arab Emirates	19	8	28	21	13	14	1	14
Kenya	13	16	19	20	11	2		9
Iraq	5	7	13	12	12	9		26
Ghana	8	11	8	10	15	3	3	1
Kuwait	4	9	12	12	12	3	1	10
Oman	4	3	15	12	12	8		4
Lebanon	7	6	16	13	11	1		
Ethiopia	4	9	8	14	4	2		6
Qatar	4	5	6	7	4	9		6
Uganda	1	6	10	11	7	2	1	2
Tanzania	3	3	5	11	8	2		4
Cameroon		3	12	7	4	2	1	2
Cote Ivoire	1	1	5	9	6	2		1
Burkina Faso	3	1	3	6	9			2
Syria	1	3	7	8	3	2		2

Table 8 – Middle East & Africa – Prolific countries over technical categories

ENVIRONMENTAL TECHNOLOGY PATENT COLLECTION TECHNOLOGY TRENDS

This section of the report focuses on the patent collections produced for the study and the activity and technological trends seen within it. Based on the Thomson Reuters-produced Derwent World Patents Index database, the collection includes both pending patent applications and granted patents published in 47 countries around the world.
A total of approximately 310,000 patented inventions were gathered that are applicable to the various environmental technology topics of interest to Umm Al-Qura University. These inventions and their technical nature have been summarized using the ThemeScape software described in the previous section.

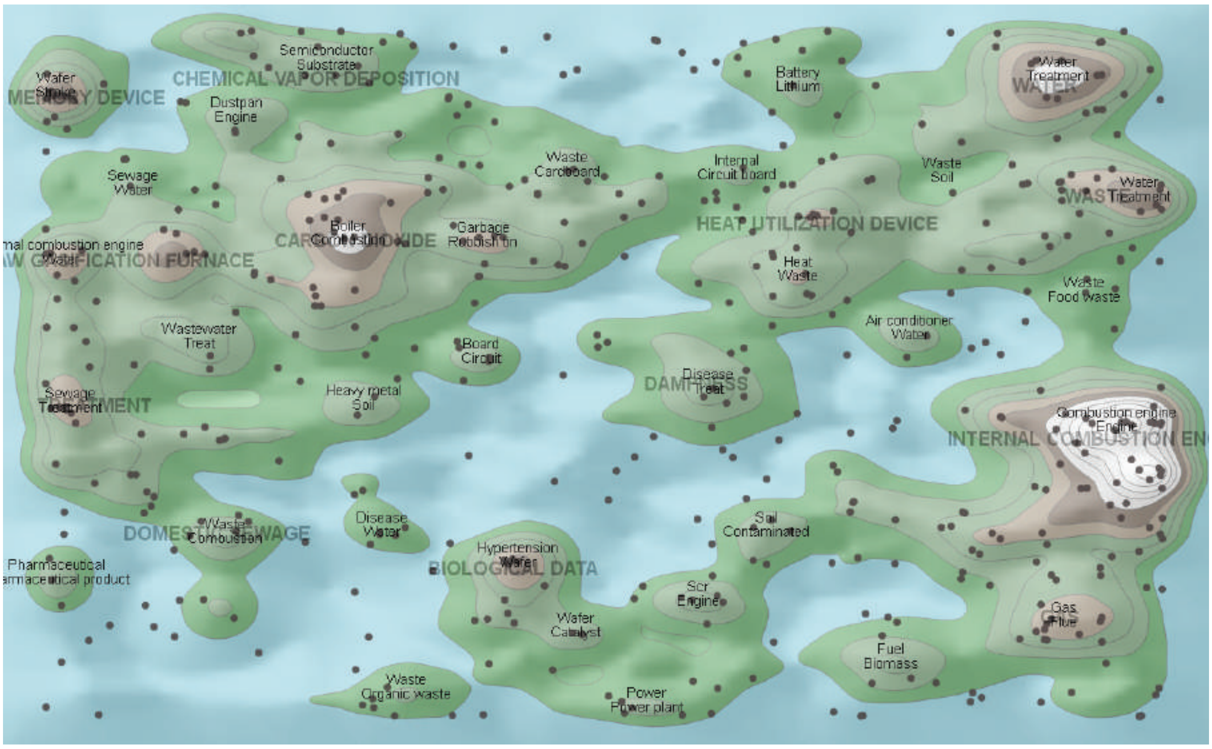

Figure 14 – ThemeScape Map of Patent Collection; Annotated by Major Themes

As previously noted, the ThemeScape map is not designed to provide a detailed accurate view of each patented invention; instead the visual is designed to highlight the common themes shared by hundreds or thousands of patents and patent applications published since 2006.
Some of the key themes revealed in this Themescape map include industrial waste, eco-friendly synthesis, water contamination, municipal/domestic waste treatment, soil contamination, E-waste and air pollution.
This annotation has been provided to guide the reader around the landscape. However, it should be noted that this annotation is only approximate.

ENVIRONMENTAL TECHNOLOGY PATENT SEGMENTATION

Table 7 shows the segmentation patents and patent applications in environmental technology. Much like the non-patent literature, there is significant patenting activity in the water contamination area. Eco friendly synthesis exhibits moderate patenting activity, however with a very high growth rate – indicating continued interest in this area. Electronic component manufacturing waste, similar to non-patent literature landscape, has low volumes. However, patenting activity in this area sees very low growth in contrast to the scientific literature landscape – indicating that this area is more in the developmental or academic phase, than in the commercialization phase. This also presents opportunities for patent filings in this area. Soil contamination, and diagnosis/mitigation, where Science & Technology Unit, Umm Al Qura University (STU-UQU) already have scientific paper publications, may also be considered as areas for filing patents, given their high growth rates.

Technology Segmentation		Total Inventions	Average % Growth or Decline (08-13)
1.0 Pollution Monitoring/Treatment	Air Pollution	53728	12%
	Soil Contamination	28237	14%
	Water Contamination	47866	13%
	Diagnosis/Mitigation	62073	39%
2.0 Waste Treatment	Municipal/Domestic Waste Treatment	62006	18%
	Industrial Waste	52212	16%
	Electric Component Manufacturing Waste	11527	-5%
	Eco Friendly Synthesis	52681	39%

Table 9– Patent Technology Segmentation

PATENT COLLECTION TECHNOLOGY CATEGORY OVERLAP

The technology categories and that were created to enumerate and describe the environmental technology landscape were not intended to be mutually exclusive. A single patent family can be included in multiple categories.

Figure 15 visualizes the relationship between select technology segments. Each number in the diagram shows the number of inventions that have content related to both the corresponding row-wise and column-wise segments.

The most correlated segment pairing is Soil contamination and water contamination with Municipal/Domestic waste treatment. Otherwise, mostly smaller sets are generally observed as overlap between the technology segments.

	1.01 Air Pollution	1.02 Soil Contamination	1.03 Water Contamination	1.04 Diagnosis/Mitigation	2.01 Municipal/Domestic Waste Treatment	2.02 Industrial Waste	2.03 Electric Component Manufacturing Waste	2.04 Eco Friendly Synthesis
1.01 Air Pollution	53728	673	1612	5496	1292	3014	344	879
1.02 Soil Contamination		28237	2448	1768	10204	1394	72	713
1.03 Water Contamination			47866	6902	8468	4511	462	1642
1.04 Diagnosis/Mitigation				62073	4331	3600	436	2616
2.01 Municipal/Domestic Waste Treatment					62006	3168	121	1381
2.02 Industrial Waste						52172	573	1651
2.03 Electric Component Manufacturing Waste							11513	172
2.04 Eco Friendly Synthesis								52681

Figure 15 – Number of Patent Families per Pair of Technology Segments

PATENT ACTIVITY GEOGRAPHIC VOLUME BENCHMARKING

Figure 16 shows the number of patent families or inventions within the patent collection relevant to environmental technology that can be attributed to each nation . Patenting activity within the environmental technology topics is lead by China, followed by Japan, Republic of Korea (South Korea) and United States. The ten most prolific countries contribute to more than 95% of patent output in the environmental technology area.

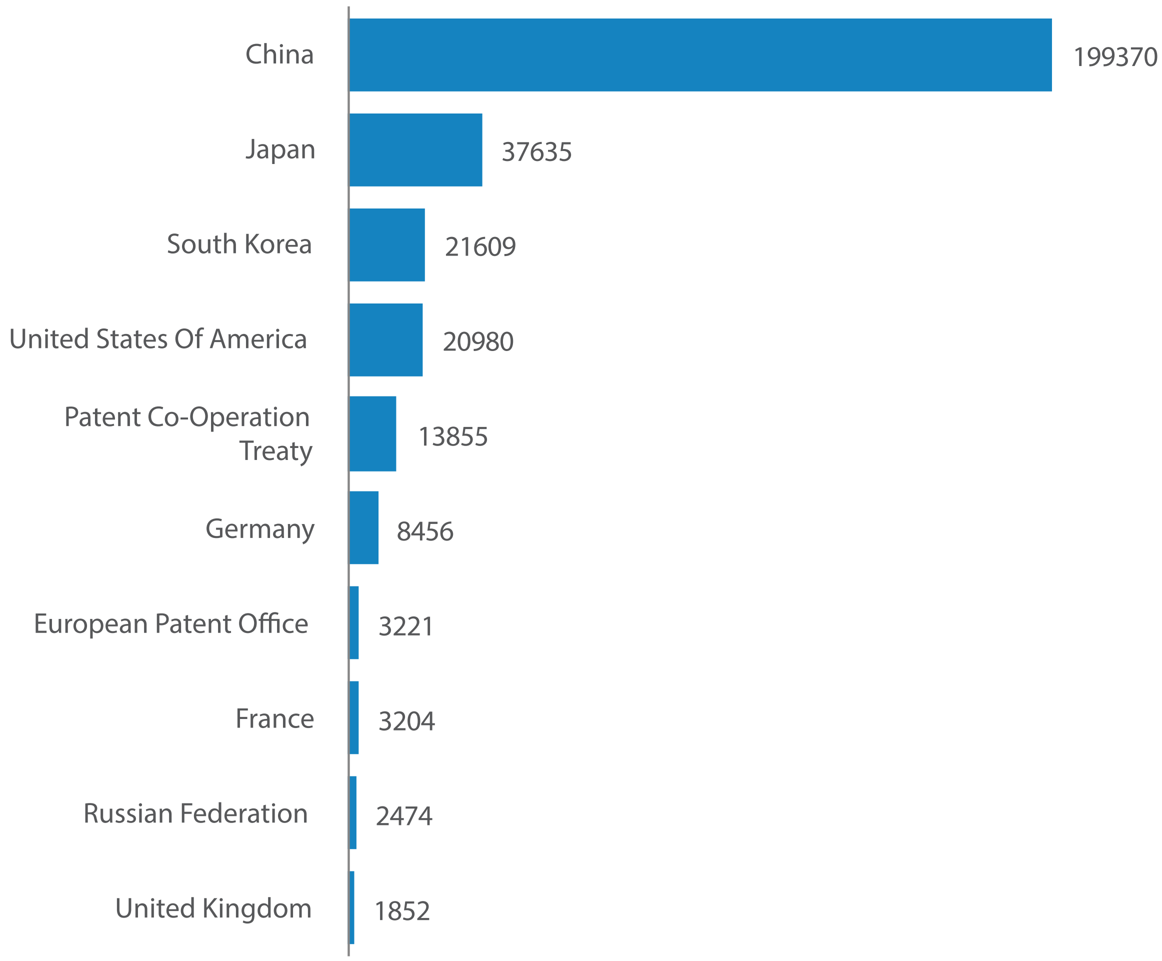

Figure 16 – Number of Patent Families per Country; Top 10 Sources

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National attribution of patent activity is primarily performed via the priority filing location of the invention – this is the first filing event that occurs in the international protection of an invention at the various patent offices around the world. Actual geographic location of the inventor or the innovating corporation may vary from the priority filing location. This effect is exhibited primarily by Saudi Arabian entities, few of which file for patents within the Kingdom.

PATENT GEOGRAPHIC ACTIVITY TRENDS

Although overall patent volumes from Turkey and Portugal are low, Figures 17 illustrates the continuing striking growth in the patent portfolio originating from Vietnam in this field. The figure also illustrates growth in Portugal, Turkey and Poland.

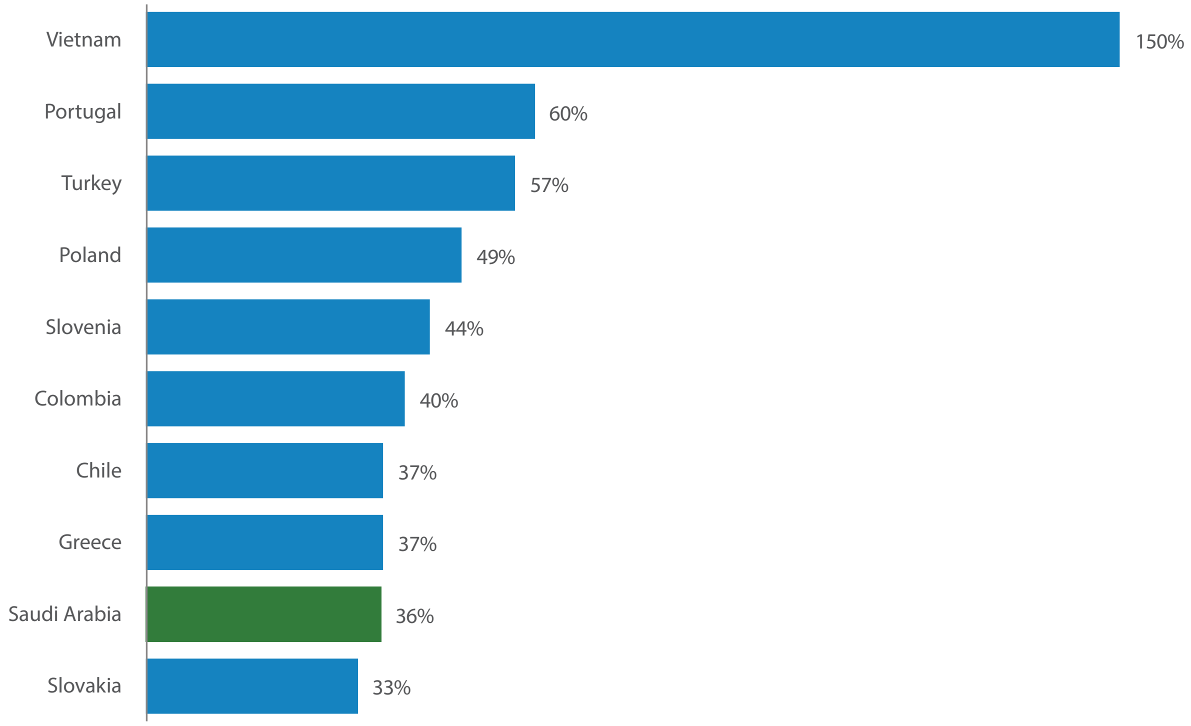


Figure 17 – Highest Growth Rate Geographies in Patent Output

PATENT GEOGRAPHIC CITATION IMPACT BENCHMARKING

Figure 18 details the highest citation impact by nation (with at least 50 patents). Patent citation is a widely utilized measurement of the impact and recognition of an individual patent, and by extension, aggregated groups of patents such as those assigned to a company or associated with the innovation of a nation or region. The measurement is useful as it provides an independent assessment of the quality and impact of the innovation contained within the patent. When aggregated, it provides a method of benchmarking collections of patents for the average impact in comparison to others, e.g. between two competing entities or between nations.
Patent citation information within this study is measured via citations to patent family members of the Derwent World Patents Index and from citation events of 26 national patent collections.
On this metric, United States leads with the highest citation impact, followed by Saudi Arabia, Germany and Japan.

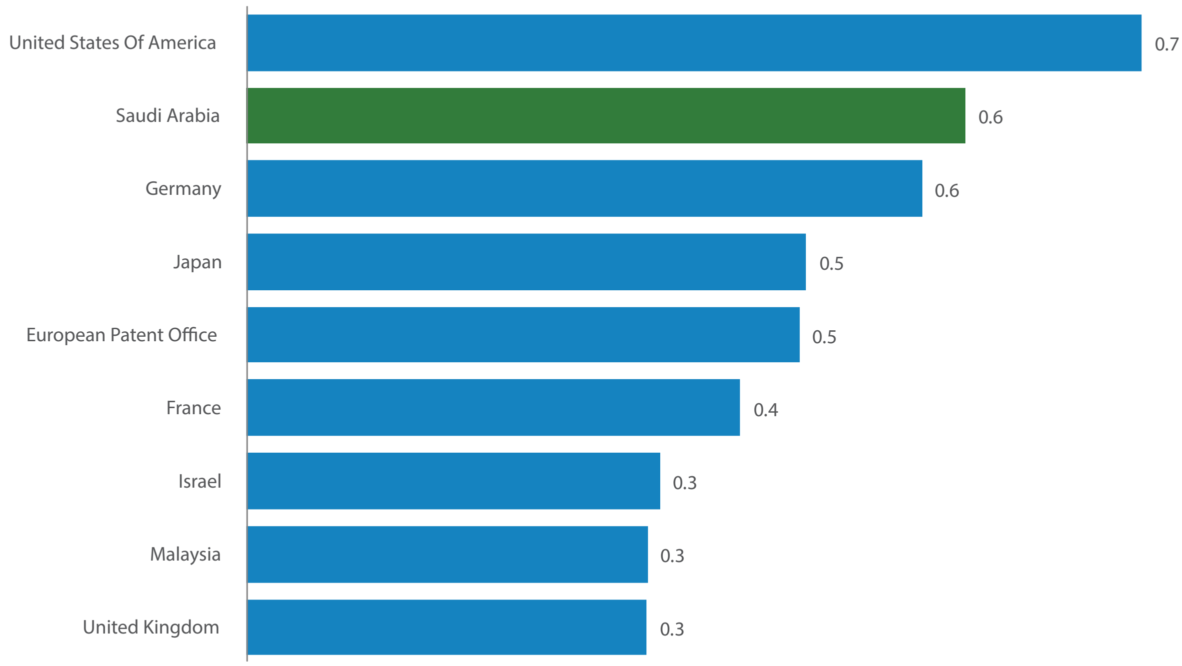


Figure 18 – Highest Citation Impact Geographies of Patents

PATENT COLLECTION ENVIRONMENTAL TECHNOLOGY TOPICS BY GEOGRAPHY

Table 8 shows the split of environmental technology science and research specialization for top nations. China appears to have focus on most of the topics except E-waste.

Country of Origin	1.01 Air Pollution	1.02 Soil Contamination	1.03 Water Contamination	1.04 Diagnosis/Mitigation	2.01 Municipal/Domestic Waste Treatment	2.02 Industrial Waste	2.03 Electric Component Manufacturing Waste	2.04 Eco Friendly Synthesis
China	12%	9%	16%	23%	24%	16%	2%	19%
Japan	32%	9%	17%	11%	14%	19%	10%	7%
South Korea	12%	16%	20%	12%	12%	15%	10%	17%
United States Of America	24%	7%	10%	24%	10%	18%	6%	15%
Patent Co-Operation Treaty	38%	3%	8%	34%	11%	21%	2%	7%
Germany	56%	2%	7%	11%	11%	13%	2%	8%
European Patent Office	27%	3%	9%	18%	10%	24%	2%	20%
France	48%	3%	8%	12%	10%	16%	4%	13%
Russian Federation	5%	12%	19%	7%	7%	37%	2%	18%
United Kingdom	32%	5%	11%	21%	14%	17%	4%	13%
India	16%	6%	10%	10%	11%	13%	1%	47%
Taiwan	10%	8%	15%	17%	5%	18%	26%	11%
Brazil	8%	9%	10%	28%	21%	15%	2%	22%
Australia	15%	7%	15%	37%	18%	16%	2%	9%
Italy	18%	9%	8%	27%	17%	20%	3%	16%
Canada	14%	11%	15%	33%	18%	16%	1%	9%
Spain	11%	10%	16%	15%	23%	14%	1%	25%
Sweden	44%	3%	9%	26%	12%	11%	1%	16%
Poland	8%	5%	12%	16%	33%	22%	3%	14%
Finland	23%	4%	13%	16%	31%	14%	1%	16%
Austria	46%	3%	8%	14%	16%	18%	1%	6%
Netherlands	13%	10%	14%	19%	21%	12%	3%	19%
Saudi Arabia	9%	4%	12%	17%	3%	34%	3%	30%
Mexico	3%	16%	26%	12%	11%	23%	3%	21%
Denmark	36%	2%	12%	20%	14%	12%	1%	12%
Switzerland	25%	3%	11%	24%	16%	22%	5%	12%
Czech Republic	11%	8%	17%	14%	40%	21%	2%	5%
Norway	23%	2%	22%	16%	15%	24%	1%	13%
Hungary	6%	5%	18%	12%	22%	20%	1%	28%
Romania	7%	14%	19%	13%	16%	33%	2%	5%
Belgium	11%	6%	10%	31%	17%	12%	1%	19%

Table 10 – Specialization by Country; % of Patent Activity per Technical Stream

PATENT FILINGS - GLOBAL PROLIFIC ENTITIES

The list of prolific entities filing patents includes a mix of automotive companies, heavy machinery companies, and universities – particularly those from China, as well as some electronics manufacturers. Science & Technology Unit, Umm al Qura University (STU-UQU) has one patent filing in the environmental technology space. While the space appears to be crowded, there are opportunities for filing patents.

Entity	Total	Times Cited	Citation per family
Science & Technology Unit, Umm Al Qura University (STU-UQU)	1		0.00
Toyota Motor Co Ltd	3228	1382	0.43
Mitsibhishi	2352	910	0.39
Hitachi	1791	900	0.50
China Petrochemical Co Ltd	1667	144	0.09
Univ Zhejiang	1369	391	0.29
Bosch Gmbh Robert	1327	897	0.68
Gm Global Technology Operations Inc	940	103	0.11
Panasonic	876	441	0.50
Univ Qinghua	792	382	0.48
Toshiba Kk	776	501	0.65
Univ South China Technology	758	195	0.26
Univ Tongji	753	239	0.32
Nippondenso Co Ltd	749	527	0.70
Ford Global Technologies Llc	723	188	0.26
Univ Nanjing	705	223	0.32
Honda Motor Co Ltd	682	332	0.49
Univ Beijing Technology	638	171	0.27
General Electric Co	604	329	0.54
Hyundai Motor Co Ltd	584	45	0.08
Univ Tianjin	566	117	0.21
Harbin Inst Technology	564	176	0.31
Univ Changzhou	538	14	0.03
Univ Shanghai Jiaotong	535	123	0.23
Renault Sas	522	336	0.64
Peugeot Citroen Automobiles Sa	516	200	0.39
Univ Jiangnan	515	98	0.19
Samsung Electronics Co Ltd	501	1038	2.07
Univ Donghua	465	115	0.25
Tokyo Electron Ltd	449	373	0.83
Denso Corp	446	283	0.63

Table 11 – Environmental Technology – Top Global entities for Patents

PATENT OVERVIEW OF GLOBAL PROLIFIC ENTITIES

Table 10 shows the technology profile of the top 30 entities within the patent landscape of environmental technology. Most top entities, particularly the automotive industry companies are filing patents mainly in the air pollution area. Further, electronics and semiconductor manufacturers are filing large numbers of patents within the electric component manufacturing waste area. Patenting in this technology appears to be mainly defensive in nature, since entities are only filing patents majorly within their areas of interest. This may indicate opportunities to license out patents to major players in the area, if patents are secured by STU-UQU.

Entity	1.01 Air Pollution	1.02 Soil Contamination	1.03 Water Contamination	1.04 Diagnosis/Mitigation	2.01 Municipal/Domestic Waste Treatment	2.02 Industrial Waste	2.03 Electric Component Manufacturing Waste	2.04 Eco Friendly Synthesis
Science & Technology Unit, Umm Al Qura University (STU-UQU)	1			1				
Toyota Motor Co Ltd	2962	5	35	487	16	71	102	25
Mitsubishi	1052	86	292	283	245	533	145	122
Hitachi	676	84	244	217	274	313	258	65
China Petrochemical Co Ltd	179	23	370	250	328	611	2	344
Univ Zhejiang	146	170	254	311	234	279	6	311
Bosch Gmbh Robert	1197	1	10	176	1	61	22	6
Gm Global Technology Operations Inc	884	1	4	261	2	23	14	12
Panasonic	142	164	215	74	185	99	167	36
Univ Qinghua	74	87	167	174	198	236	25	81
Toshiba Kk	64	39	198	79	171	328	95	17
Univ South China Technology	59	56	208	182	138	164	19	170
Univ Tongji	35	86	214	171	286	113	14	100
Nippondenso Co Ltd	628	4	7	66	5	54	29	11
Ford Global Technologies Llc	692			211	1	17	1	6
Univ Nanjing	26	56	303	160	187	121	11	97
Honda Motor Co Ltd	577	4	23	52	33	25	11	11
Univ Beijing Technology	54	42	96	105	371	55	14	73
General Electric Co	301	13	32	105	36	142	19	25
Hyundai Motor Co Ltd	497	5	15	103		24	13	21
Univ Tianjin	109	27	99	110	75	133	3	119
Harbin Inst Technology	22	22	211	99	251	71	5	57
Univ Changzhou	22	49	186	79	194	76	5	124
Univ Shanghai Jiaotong	65	46	96	120	103	93	19	103
Renault Sas	514		1	14	2	4	6	2
Peugeot Citroen Automobiles Sa	506			33	2	8	3	8
Univ Jiangnan	16	19	116	119	86	109	3	160
Samsung Electronics Co Ltd	13	51	34	109	28	35	221	39
Univ Donghua	12	9	104	76	73	45	6	199
Tokyo Electron Ltd	67	1	13	11	5	100	287	5
Denso Corp	386	2	2	34	1	30	15	5

Table 12 – Patent overview of top Global entities

PATENT OVERVIEW OF ASIA PACIFIC PROLIFIC ENTITIES

Entity	Country of Origin	Total	1.01 Photosensitive Nanoparticle / Nanomaterial	1.02 Soil Contamination	1.03 Water Contamination	1.04 Diagnosis/Mitigation	2.01 Municipal/Domestic Waste Treatment	2.02 Industrial Waste	2.03 Electric Component Manufacturing Waste	2.04 Eco Friendly Synthesis
Science & Technology Unit, Umm Al	Saudi Arab	1	1			1				
Toyota Jidosha Kk	Japan	2630	2387	4	35	318	16	64	91	24
China Petrochemical Co Ltd	China	1667	179	23	370	250	328	611	2	344
Univ Zhejiang	China	1367	146	170	252	310	234	279	6	311
Mitsubishi Jukogyo Kk	Japan	792	369	16	109	104	70	262	15	11
Univ Qinghua	China	790	74	87	166	173	197	236	25	81
Univ South China Technology	China	758	59	56	208	182	138	164	19	170
Toshiba Kk	Japan	756	63	38	197	71	167	328	89	17
Univ Tongji	China	751	35	84	214	170	286	113	14	100
Nippondenso Co Ltd	Japan	746	625	4	7	66	5	54	29	11
Univ Nanjing	China	702	26	56	302	159	187	121	11	96
Honda Motor Co Ltd	Japan	655	562	2	23	44	28	24	10	11
Univ Beijing Technology	China	638	54	42	96	105	371	55	14	73
Hyundai Motor Co Ltd	South Kore	581	494	5	15	103		24	13	21
Univ Tianjin	China	565	109	27	99	110	75	132	3	119
Harbin Inst Technology	China	564	22	22	211	99	251	71	5	57
Univ Changzhou	China	538	22	49	186	79	194	76	5	124
Univ Shanghai Jiaotong	China	535	65	46	96	120	103	93	19	103
Univ Jiangnan	China	515	16	19	116	119	86	109	3	160
Samsung Electronics Co Ltd	South Kore	485	12	47	33	109	27	32	217	36
Nissan Motor Co Ltd	Japan	479	416		7	57	2	26	16	4

Table 13 – Patent Overview of Top Asia Pacific entities

PATENT OVERVIEW OF MIDDLE EAST & AFRICA PROLIFIC ENTITIES

Table 12 illustrates the top patenting entities in the Middle East and Africa. The space appears to be dominated by Saudi Arabia, followed by South Africa. This indicates of a geographic region used majorly only by local players and not often by large multinationals.

Entity	Country of Origin	Total	1.01 Air Pollution	1.02 Soil Contamination	1.03 Water Contamination	1.04 Diagnosis/Mitigation	2.01 Municipal/Domestic Waste Treatment	2.02 Industrial Waste	2.03 Electric Component Manufacturing Waste	2.04 Eco Friendly Synthesis
Science & Technology Unit, Umm Al Qura University (STU-UQU)	Saudi Arabia	1	1			1				
Sabic	Saudi Arabia	67		3	2	10	2	36	1	19
Saudi Aramco	Saudi Arabia	63	13	1	4	9		25	3	16
King Abdulaziz City Sci & Technology	Saudi Arabia	29	2	3	11	5	3			10
General Electric Co	Saudi Arabia	16		2		5	1	4		4
Univ Dhahran King Fahd Petroleum & Miner	Saudi Arabia	11	3		4	3		1		4
King Saud University	Saudi Arabia	10		1		2		3	1	4
Univ King Abdullah Sci & Technology	Saudi Arabia	9			2	4			1	3
Sasol Technology Pty Ltd	South Africa	8	3	1		4	2			2
Council Sci & Ind Res South Africa	South Africa	6	1		1			2		2
Ford Otomotiv Sanayi Anonim Sirketi	Turkey	5	5					1		
Moroccan Found Advanced Sci Innovation	Morocco	3			1		1			1
National Titanium Dioxide Co, Ltd. (Cristal	Saudi Arabia	3								3
Sanovel Ilac Sanayi Ve Ticaret Anonim	Turkey	3								3
South African Nuclear Energy Corp Ltd	South Africa	3				1	1	2		
Univ Cape Town	South Africa	3				1				2
Univ King Abdulaziz	Saudi Arabia	3	1			1		1		
Univ Witwatersrand	South Africa	3				1	1	1		
Bosch Gmbh Robert	Turkey	2	2							
Sasol Technology	South Africa	2				1	1			
Siemens Energy Inc	Saudi Arabia	2			2	1				
Terramark Markencreation Gmbh	Saudi Arabia	2				1	1	1		
Tubitak-Turkiye Bilimsel Ve Teknolojik	Turkey	2	1						1	
Adeba Muehendislik Danismanlik Halkla	Turkey	1	1					1		
Ael Mining Services Ltd	South Africa	1								1
Afrisam South Africa Pty Ltd	South Africa	1			1					
Afs Boru Sanayi Anonim Sirketi	Turkey	1				1				
Akg Yalitim Ve Isnsaat Malzemeleri	Turkey	1						1		
Arcelik Anonim Sirketi	Turkey	1	1							
Atac Elektrik & Makina Sanayi Ticaret	Turkey	1			1	1				

Table 14 – Patent Overview of top Middle East & Africa entities

PATENT OVERVIEW OF SAUDI ARABIA PROLIFIC ENTITIES

Entities	Total	1.01 Air Pollution	1.02 Soil Contamination	1.03 Water Contamination	1.04 Diagnosis/Mitigation	2.01 Municipal/Domestic Waste Treatment	2.02 Industrial Waste	2.03 Electric Component Manufacturing Waste	2.04 Eco Friendly Synthesis
Science & Technology Unit, Umm Al Qura University (Stu-Uqu	1	1			1				
SABIC	67		3	2	10	2	36	1	19
Saudi Aramco	63	13	1	4	9		25	3	16
King Abdulaziz City Sci & Technology	29	2	3	11	5	3			10
Univ Dhahran King Fahd Petroleum & Miner	11	3		4	3		1		4
King Saud University	10		1		2		3	1	4
Univ King Abdullah Sci & Technology	9			2	4			1	3
National Titanium Dioxide Co, Ltd. (Cristal	3								3
Univ King Abdulaziz	3	1			1		1		
King Abdullah Int Medical Res Cent	1	1							
Nat Guard Health Affairs	1	1							
Univ King Fadh Petroleum & Minerals	1								1

Table 15 – Patent overview of top Saudi Arabia entities

MIDDLE EAST & AFRICA ENVIRONMENTAL TECHNOLOGY

This section of the report focuses on the patent collection and the activity and technological trends seen within it – in the Middle East and Africa.

MIDDLE EAST & AFRICA – PROLIFIC COUNTRIES

Patent filing trends appear to be very different from the scientific literature trends. Figure 19 shows that Saudi Arabia is the most popular country for filing patents, within the two regions, followed by South Africa and Turkey. The remaining jurisdictions see only marginal patent filings.

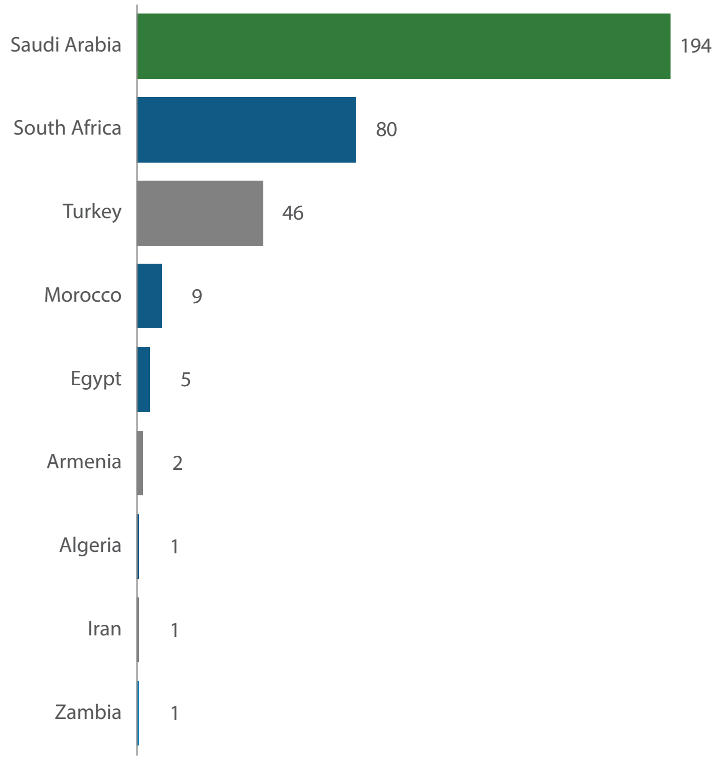


Figure 19 – Middle East & Africa – Prolific countries in patents

Diving deeper, Table 11 shows that Saudi Arabia, South Africa, and Turkey appear to be consistent with the global patent focus on Environmental Technology. The Kingdom of Saudi Arabia has 194 patents, with notable focus on Industrial waste and Eco-friendly synthesis.

Country of Origin	1.01 Air Pollution	1.02 Soil Contamination	1.03 Water Contamination	1.04 Diagnosis/ Mitigation	2.01 Municipal/ Domestic	2.02 Industrial Waste	2.03 Electric Component	2.04 Eco Friendly Synthesis
Saudi Arabia	18	8	23	33	6	66	6	58
South Africa	8	10	16	23	10	10	2	19
Turkey	15	2	6	11	3	7	1	11
Morocco	1		5	1	1			3
Egypt	1		3		1			
Algeria						1		
Iran						1		

Table 16 – Middle East & Africa – Prolific countries over technical categories

APPENDIX A – SCIENTIFIC PAPERS TOP AFFILIATIONS

ENTITY-LEVEL DATA TABLES FOR SCIENTIFIC LITERATURE COLLECTION

Table 13 on the following pages shows the top 10 author organizations for each of the technology segments. This information is intended to provide an assessment of the depth and location of the research expertise available in each category.

Technology	Entity	Total
1.01 Air Pollution	Univ Chinese Acad Sci	306
	Tsinghua Univ	142
	Univ Calif Berkeley	108
	Us Epa	104
	Zhejiang Univ	94
	Peking Univ	93
	Harvard Univ	90
	Indian Inst Technol	84
	Univ London Imperial Coll Sci Technol & Med	74
	Univ Illinois	73
1.02 Soil Contamination	Univ Chinese Acad Sci	384
	Zhejiang Univ	93
	CSIC	76
	Univ Florida	54
	Univ S Australia	47
	Eth	45
	Usda Ars	45
	Ars	43
	Us Epa	42
	Tongji Univ	42
1.03 Water Contamination	Univ Chinese Acad Sci	567
	Tongji Univ	219
	Harbin Inst Technol	217
	Tsinghua Univ	172
	Zhejiang Univ	139
	Univ Ghent	126
	Univ Queensland	116
	Nanjing Univ	113
	Nanyang Technol Univ	106
	Delft Univ Technol	105
1.04 Diagnosis/Mitigation	Univ Chinese Acad Sci	394
	Zhejiang Univ	135
	Tsinghua Univ	131
	Univ Sao Paulo	131
	Tongji Univ	113
	Seoul Natl Univ	97
	Univ Illinois	93
	CSIC	92
	Harvard Univ	89
	Indian Inst Technol	88

Technology	Entity	Total
2.01 Municipal/Domestic Waste Treatment	Univ Chinese Acad Sci	379
	Tongji Univ	180
	Tsinghua Univ	144
	Harbin Inst Technol	136
	CSIC	96
	Univ Sao Paulo	92
	Delft Univ Technol	85
	Zhejiang Univ	83
	Univ Queensland	78
	Tech Univ Denmark	74
2.02 Industrial Waste	Univ Chinese Acad Sci	142
	Tsinghua Univ	63
	Tech Univ Denmark	58
	Univ Sao Paulo	57
	CSIC	53
	Islamic Azad Univ	44
	Zhejiang Univ	43
	Russian Acad Sci	35
	CNR	34
	Indian Inst Technol	32
2.03 Electric Component Manufacturing Waste	Univ Chinese Acad Sci	65
	Shantou Univ	24
	Shanghai Jiao Tong Univ	17
	Tsinghua Univ	14
	Hong Kong Baptist Univ	12
	Zhejiang Univ	11
	Chinese Res Inst Environm Sci	9
	Aristotle Univ Thessaloniki	8
	Univ Regina	8
	Peking Univ	7
2.04 Eco Friendly Synthesis	Univ Chinese Acad Sci	600
	Islamic Azad Univ	340
	Indian Inst Technol	149
	CSIR	131
	Univ Delhi	117
	Zhejiang Univ	116
	S China Univ Technol	102
	Isfahan Univ Technol	98
	Indian Inst Chem Technol	97
	Tsinghua Univ	94

Table 17– Top 10 Paper Publishing Organizations per Technology Segment

APPENDIX B – PATENT STATISTICS AND TABLES

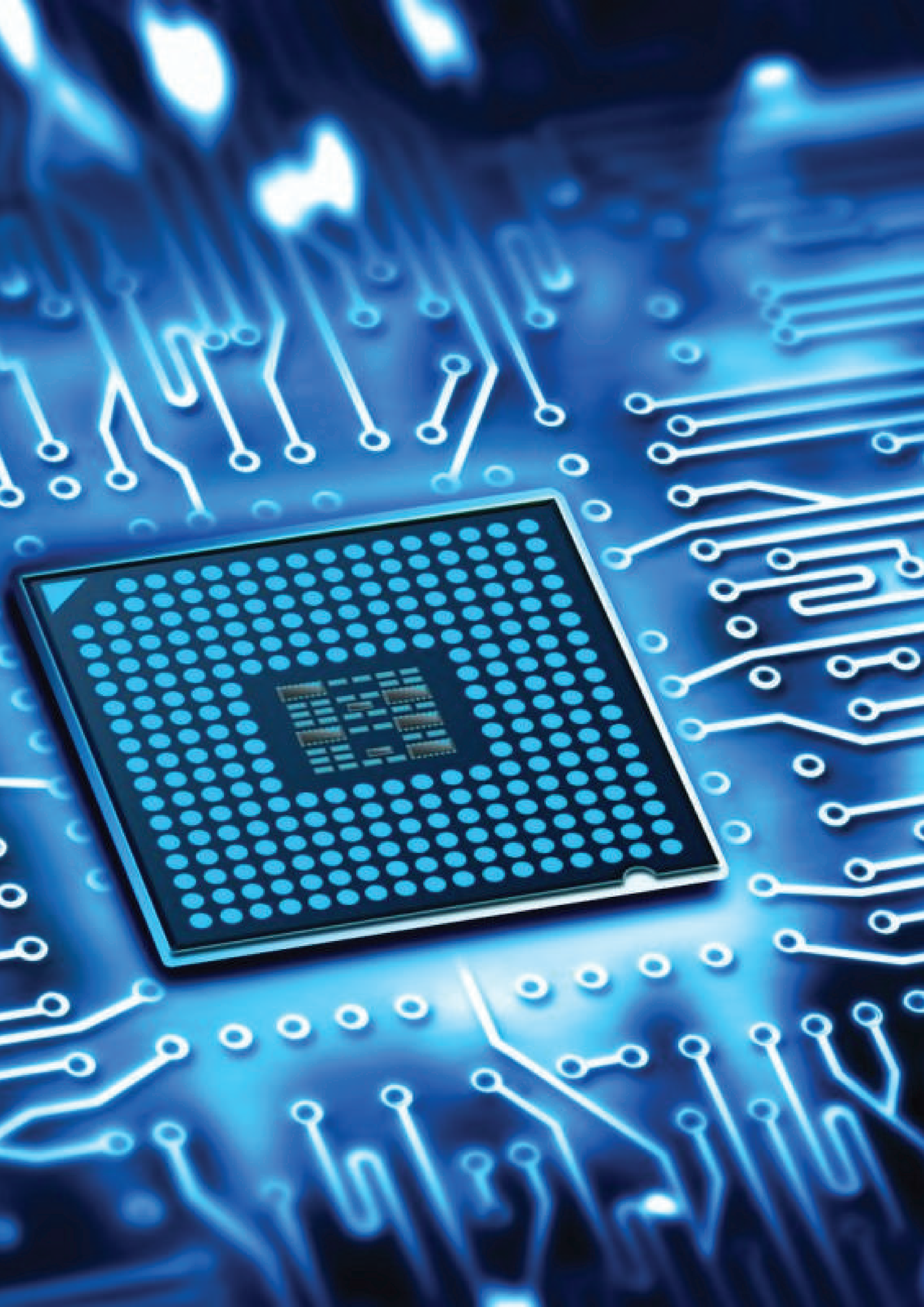
ENTITY-LEVEL DATA TABLES FOR PATENT COLLECTION

The table 14 below and on the following page shows the top 10 patent applicants or patent assignees for each of the technology segments. This information is intended to provide an assessment of expertise and patent commercialization intent per category.

Technology	Entity	Total
1.01 Air Pollution	Toyota Motor Co Ltd	2962
	Bosch Gmbh Robert	1197
	Mitsubishi	1052
	Gm Global Technology Operations Inc	884
	Ford Global Technologies Llc	692
	Hitachi	676
	Nippondenso Co Ltd	628
	Honda Motor Co Ltd	577
	Renault Sas	514
	Peugeot Citroen Automobiles Sa	506
1.02 Soil Contamination	Univ Zhejiang	170
	Panasonic	164
	Shenyang Applied Ecology Inst	90
	Univ Qinghua	87
	Mitsubishi	86
	Univ Tongji	86
	Hitachi	84
	Ohbayashi Gumi Kk	71
	Taiheiyo Cement Corp	65
	Shimizu Constr Co Ltd	65
1.03 Water Contamination	China Petrochemical Co Ltd	370
	Univ Nanjing	303
	Mitsubishi	292
	Kurita Water Ind Ltd	255
	Univ Zhejiang	254
	Hitachi	244
	Panasonic	215
	Univ Tongji	214
	Harbin Inst Technology	211
	Univ South China Technology	208
1.04 Diagnosis/Mitigation	Toyota Motor Co Ltd	487
	Univ Zhejiang	311
	Mitsubishi	283
	Huawei Technologies Co Ltd	264
	Gm Global Technology Operations Inc	261
	China Petrochemical Co Ltd	250
	Hitachi	217
	Ford Global Technologies Llc	211
	Univ South China Technology	182
	State Grid Corp China	177
2.01 Municipal/Domestic Waste Treatment	Univ Beijing Technology	371
	China Petrochemical Co Ltd	328
	Univ Tongji	286
	Hitachi	274
	Harbin Inst Technology	251
	Mitsubishi	245
	Univ Zhejiang	234
	Univ Qinghua	198
	Univ Changzhou	194
	Univ Nanjing	187

Technology	Entity	Total
2.02 Industrial Waste	China Petrochemical Co Ltd	611
	Mitsubishi	533
	Toshiba Kk	328
	Hitachi	313
	Univ Zhejiang	279
	Univ Qinghua	236
	Univ South China Technology	164
	Korea Atomic Energy Res Inst	144
	General Electric Co	142
	Ishikawajima Harima Heavy Ind	138
2.03 Electric Component Manufacturing	Hynix Semiconductor Inc	367
	Tokyo Electron Ltd	287
	Hitachi	258
	Samsung Electronics Co Ltd	221
	Kokusai Denki Kk	203
	Panasonic	167
	Semes Co Ltd	154
	Mitsubishi	145
	Toyota Motor Co Ltd	102
	Sharp Kk	96
2.04 Eco Friendly Synthesis	China Petrochemical Co Ltd	344
	Univ Zhejiang	311
	Univ Donghua	199
	Univ South China Technology	170
	Univ Jiangnan	160
	Univ Dalian Technology	139
	Univ Cent South	134
	Univ Beijing Chem Technology	125
	Univ Nanjing Technology	125
	Univ Changzhou	124

Table 18 – Top 10 Patent Applicants/Owners per Technology Segment



LANDSCAPE OF INFORMATION TECHNOLOGY

SCIENCE & TECHNOLOGY UNIT,
UMM AL-QURA UNIVERSITY (STU-UQU)

THOMSON REUTERS IP SERVICES
MAY 2015

Executive Summery

This study has been commissioned by Science & Technology Unit, Umm Al-Qura University (STU-UQU) to evaluate and describe the global scientific research and patent activity within sub-tracks that they have achieved funding for projects. Within the Information Technology track, the sub-track of focus include Database Systems, Computer Networking, Supercomputing architecture & software, systems analysis and design, e-learning, e-health, special needs applications, open source software (OSS), localization, body sensor networks, and intelligent transportation.

The study has looked at both scientific papers and patents to form an understanding of the overall scientific and technology landscape.

The scientific papers are sourced from the Web of Science™, a database containing journal articles from approximately 12,500 peer-reviewed journals.

The patent information is sourced from the Derwent World Patents Index™, a database of patents and patent applications from 47 international patent issuing authorities.

Both databases have been selected because they provide a method of defining a unit of science or technology. A single paper defined by the Web of Science is required to have met a minimum threshold of scientific rigor: publication within a journal of repute, peer review sign off, etc. Furthermore, a patent included within DWPI is defined credibly as an attempt to protect a piece of innovation within at least one territory.

Aggregating this information across technologies and countries provides a method of tracking Information Technology innovation and science trends.

Included in this document are measurements of research and patent quality and direction changes in research and patent activity. It should be noted that in many areas the report utilizes metrics such as average annual percentage growth in scientific and research output to compare activities across technologies and geographies. Such metrics should be treated with care for analyses containing low volumes, as some volatility is expected. Also to be noted is that the global high volume nature of this analysis within Information Technology necessarily entails some level of noise and is not intended to be completely comprehensive. Instead, the analyses enclosed should be treated as a survey of the technology, and the trends and findings interpreted in this manner.

Overall KSA output is pretty low compared to other global resources with the US and China leading both in published literature and patent output. However, KSA are showing impressive growth and compared with output of MENA countries they rank third behind Turkey and Iran in scientific literature output, and second behind South Africa, in patent filings.

STU-UQU does lag behind in terms of both published literature and patent output with Saudi Aramco, King Saud University, King Fahd University of Petroleum & Minerals, King Abdulaziz City for Science & Technology, and King Abdulaziz University leading output from KSA. There are sub-technology areas with little or no output from these institutes, which may offer opportunity for STU-UQU to focus on. These include OSS, special needs applications and servers & datacenters.

For STU-UQU, it is interesting to note the patent and scientific literature collections differ with respect to the breakdown in technology segments. Some technologies are clearly within the commercialization and practical implementation phase, while others exhibit new fundamental technology research.

Computer networks, cloud computing, IT security, database systems, e-learning, special needs applications, servers and datacenters (energy efficient IT), and intelligent transportation; all are in the technology commercialization and practical implementation phase – with volumes for patent protection far exceeding the volume of scientific literature being published.

Computer modelling, computer simulation, open source software (OSS), and network devices (energy efficient IT) appear to be in the fundamental research and development phase – with significantly more scientific literature being published as compared to patents filings.

Supercomputing, parallel computing, e-health, and RFID/Sensor networks are fairly developed within the patent landscape as well as within the scientific literature landscape. This indicates evolving and maturing technology – technologies already in the commercialization and practical implementation phase, with new fundamental research and development still continuing, indicated by the comparable number of patent filings and scientific literature publications.

The patent technology segments experiencing significant growth include cloud computing, open source software, servers and datacenters (energy efficient IT), network devices (energy efficient IT), and intelligent transportation.

Computer modelling, open source software, e-learning, and intelligent transportation exhibit high growth in patent activity that significantly exceeds the growth in scientific literature. This indicates opportunities for "improvement" type of patent filings that focus on implementation improvements, rather than on fundamental technologies.

It is recommended to further analyze the space of open source software, since this technology has a small number of patent filings but high growth – indicating a nascent technology area.

Scientific literature data indicates strong growth on fundamental research in areas such as cloud computing, servers and datacenters (energy efficient IT), and network devices (energy efficient IT). Other areas with relatively high focus on fundamental research include open source software, e-health, RFID and sensor networks, and intelligent transportation (based on growth rate during 2009 – 2014 for papers).

Parallel computing, computer simulation, and IT security are areas where scientific literature growth far exceeds the growth of patent filings. This is indicative of avenues and opportunities for fundamental research and development.

Cloud computing shows exceptionally strong growth in patent filings as well as scientific literature publications. Energy efficient IT (including datacenters and servers, and network devices) also shows strong growth in both patent filings as well as scientific literature publications. Such trend is indicative of an emerging technology, which has not fully matured yet. Interest to develop fundamental technologies continues, while simultaneously technology is being commercialized and practically implemented. This presents an opportunity for newer fundamental technology within these technologies to be researched. Any improvements to existing fundamental techniques of these technologies will be better served by patent filings.

Sub-tracks that STU-UQU has not focused on, which may also offer opportunity include language & speech technologies, e-commerce, e-government, software engineering and social networks. Detailed analysis would be recommended of these areas to identify possible sub-areas of focus.

For further information regarding the data used in this study, and for deeper or variations in the analysis presented, please review the interactive dashboards.

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INTRODUCTION TO GLOBAL INFORMATION TECHNOLOGY SCIENTIFIC ACTIVITY

This study presents an analysis of patents and scientific papers that fall within specific topics of interest to Science & Technology Unit, Umm Al-Qura University (STU-UQU) concerning the Information technology area.

The study was commissioned by STU-UQU as part of a wider program to review the scientific paper and intellectual property activity in specific topics that they have gained approved funding for projects. Within the Information technology area, they have gained funding approval for projects related to the sub-tracks of Database Systems, Computer Networking, Supercomputing architecture & software, systems analysis and design, e-learning, e-health, special needs applications, open source software (OSS), localization, body sensor networks, and intelligent transportation.

A large scale data collation process using globally recognized search processes from Thomson Reuters was undertaken to produce practical and insightful sets of information for analysis regarding the trends, geographies and ultimately the institutions and patent applicants working in the field of High performance computing, computer networks, software applications, localization, energy efficient IT, and Intelligent transportation, within the Information Technology space.

As shown in Figure 1, the overall volume of patents in this area filed since 2006 is approximately 2½ times larger than the volume of scientific papers published since 2008, however in the same time period from 2008 the patent output is some almost twice the scientific paper output.

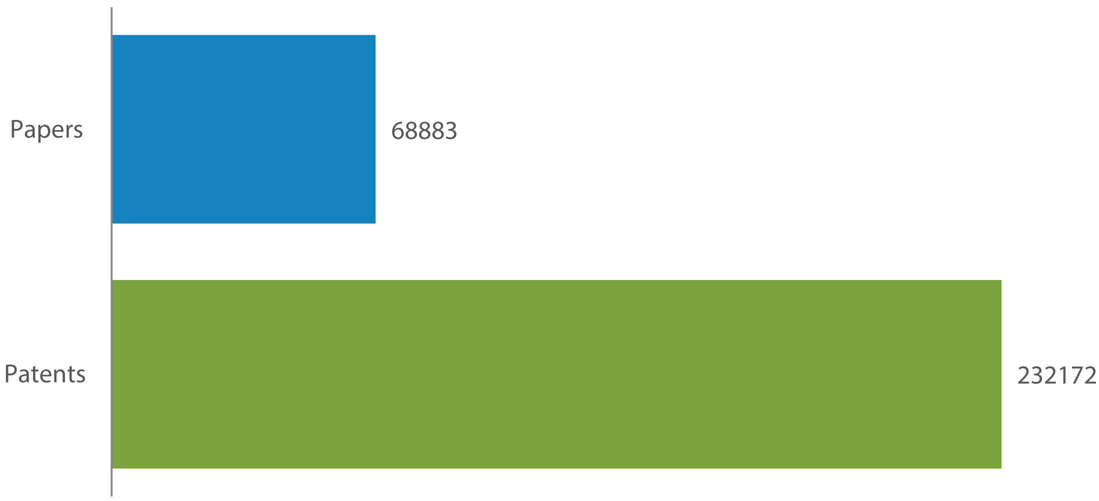

Figure 1 – Scientific Paper and Patent Families in Information Technology

The patent protection activity related to Information technology had progressed at a pace (Figure 2, Timeline of Activity) roughly similar to that of publications in scientific journals, which are likely to address more fundamental science. This might suggest that the technology development globally related to Information Technology is progressing both in terms of new fundamental technology, as well as commercialization and practical application of existing technology.

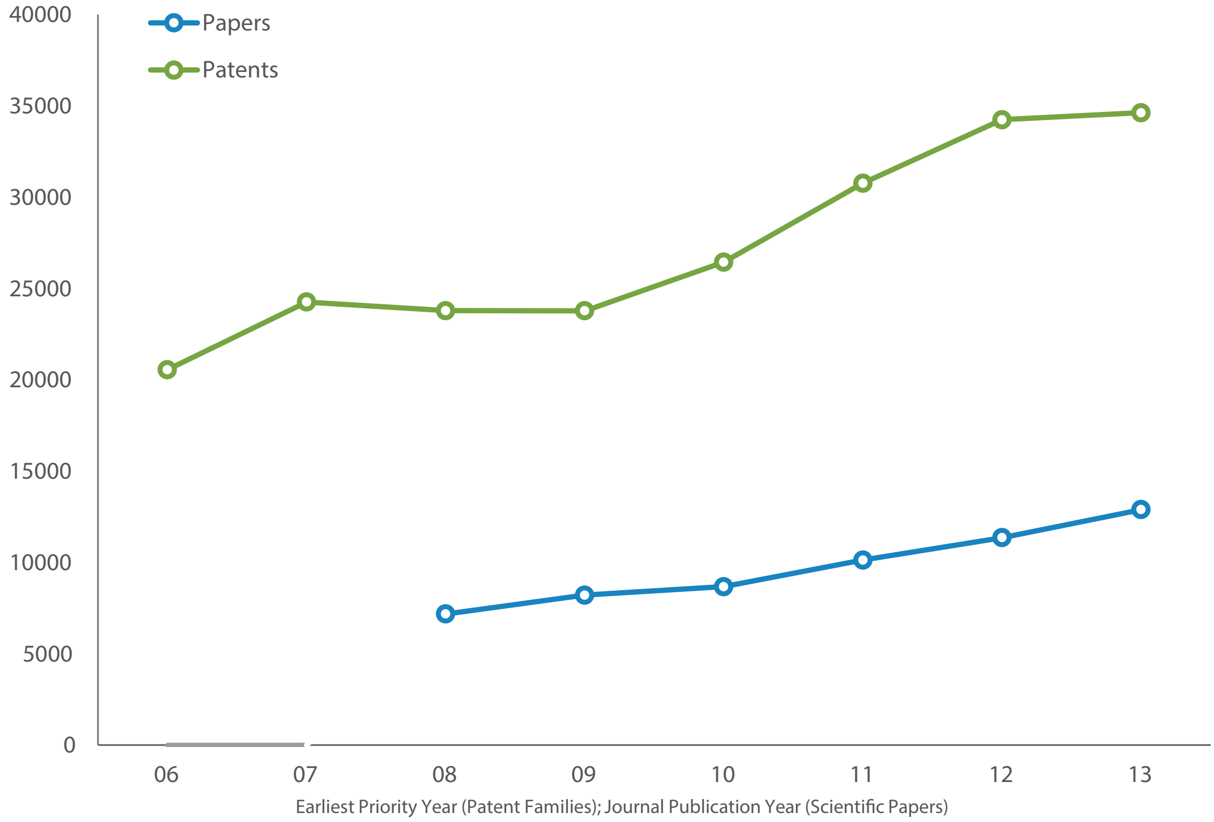

Figure 2 – Timeline of Scientific Paper and Patent Family Activity

Figures 3 through 5 show three further analyses on each of the data collections (patents, left; papers, right) concerning the nature and high level technology trends occurring within the global Information Technology area. The patent and scientific literature collections are quite distinct with respect to the breakdown in technology segments. Some technologies are clearly within the commercialization and practical implementation phase, while others exhibit new fundamental technology research.

Notably, computer networks, cloud computing, IT security, database systems, e-learning, special needs applications, servers and datacenters (energy efficient IT), and intelligent transportation; all are in the technology commercialization and practical implementation phase – with volumes for patent protection far exceeding the volume of scientific literature being published.

On the other hand, computer modelling, computer simulation, open source software (OSS), and network devices (energy efficient IT) appear to be in the fundamental research and development phase – with significantly more scientific literature being published as compared to patents filings.

Interestingly, some areas are fairly developed within the patent landscape as well as within the scientific literature landscape. These include supercomputing, parallel computing, e-health, and RFID/Sensor networks. This indicates that while these technologies are already in the commercialization and practical implementation phase, these are still evolving and maturing, with new fundamental research and development efforts, indicated by the comparable number of patent filings and scientific literature publications.

With regard to growth rates of these collections (2008 – 2013 for patents), the patent technology segments experiencing significant growth include cloud computing, open source software, servers and datacenters (energy efficient IT), network devices (energy efficient IT), and intelligent transportation.

Technologies such as computer modelling, open source software, e-learning, and intelligent transportation exhibit high growth in patent activity that significantly exceeds the growth in scientific literature. This indicates opportunities for "improvement" type of patent filings that focus on implementation improvements, rather than on fundamental technologies. It is recommended to further analyze the space of open source software, since this technology has a small number of patent filings but high growth – indicating a nascent technology area. Because open source software is traditionally associated with patent-free or royalty-free licensing, it is recommended to further understand the coverage and nature of patents in this area.

Supercomputing, and computer networks are the only exceptions which exhibit decline in patenting activity, while all other areas exhibit positive growth. Within the scientific literature, all areas exhibit positive growth.

Notably, the scientific literature data indicates strong growth on fundamental research in areas such as cloud computing, servers and datacenters (energy efficient IT), and network devices (energy efficient IT). Other areas with relatively high focus on fundamental research include open source software, e-health, RFID and sensor networks, and intelligent transportation (based on growth rate during 2009 – 2014 for papers).

Parallel computing, computer simulation, and IT security are areas where scientific literature growth far exceeds the growth of patent filings. This is indicative of avenues and opportunities for fundamental research and development.

Cloud computing is one area which shows exceptionally strong growth in patent filings as well as scientific literature publications. Energy efficient IT (including datacenters and servers, and network devices) also shows strong growth in both patent filings as well as scientific literature publications. This trend is indicative of an emerging technology, which has not fully matured yet. Interest to develop fundamental technologies continues, while simultaneously technology is being commercialized and practically implemented. This presents an opportunity for newer fundamental techniques of within these technologies to be researched. Any improvements to existing fundamental techniques of these technologies will be better served by patent filings.

Note that the dates used for the collation of the timeline information differ for patent and scientific literature information. Patent Families are measured by the earliest known “priority” or first filing event in the inventions history. Patents are typically retained by patent offices for 18 months or more after filing before they are published. This delay means that the last complete year of information available for patent information is 2012. For scientific papers, the dates used for analyses are the publication dates of the journal containing the paper. These metrics are used throughout the

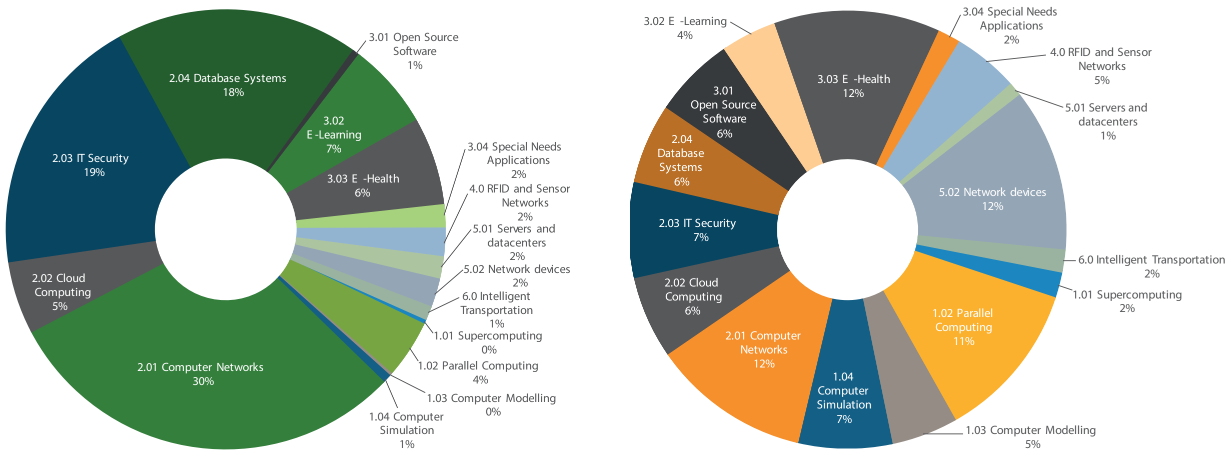

Figure 3 – % of Patent (left) and Scientific Paper (right) collections by Information Technology Topic

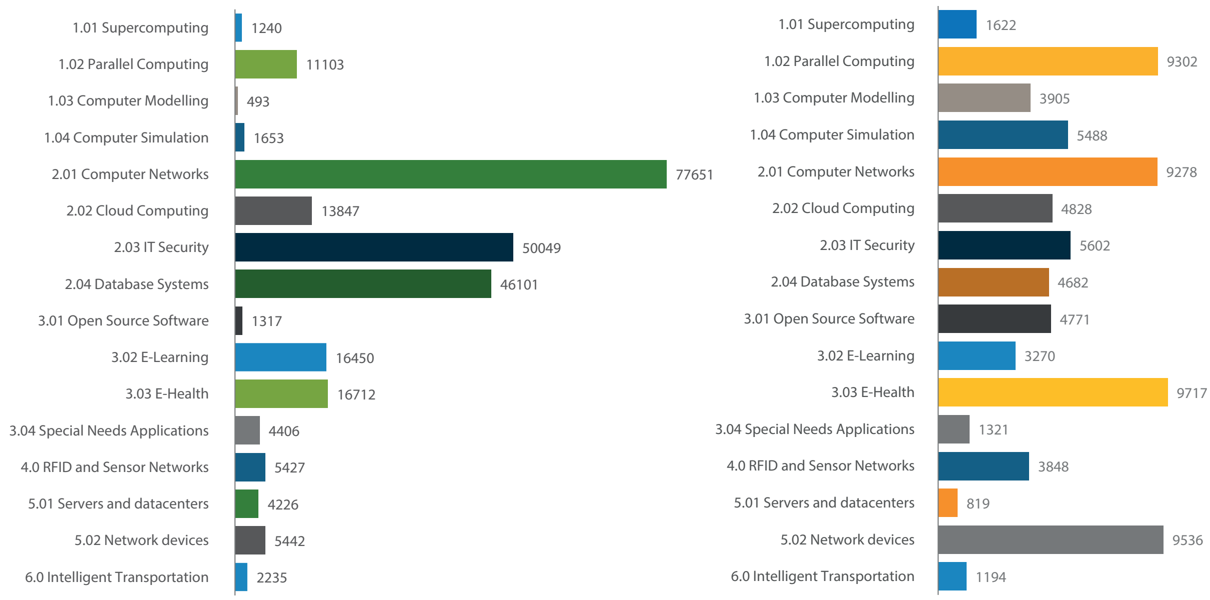

Figure 4 – Number of Patents Families (left) and Scientific Papers (right) per Information Technology Topic

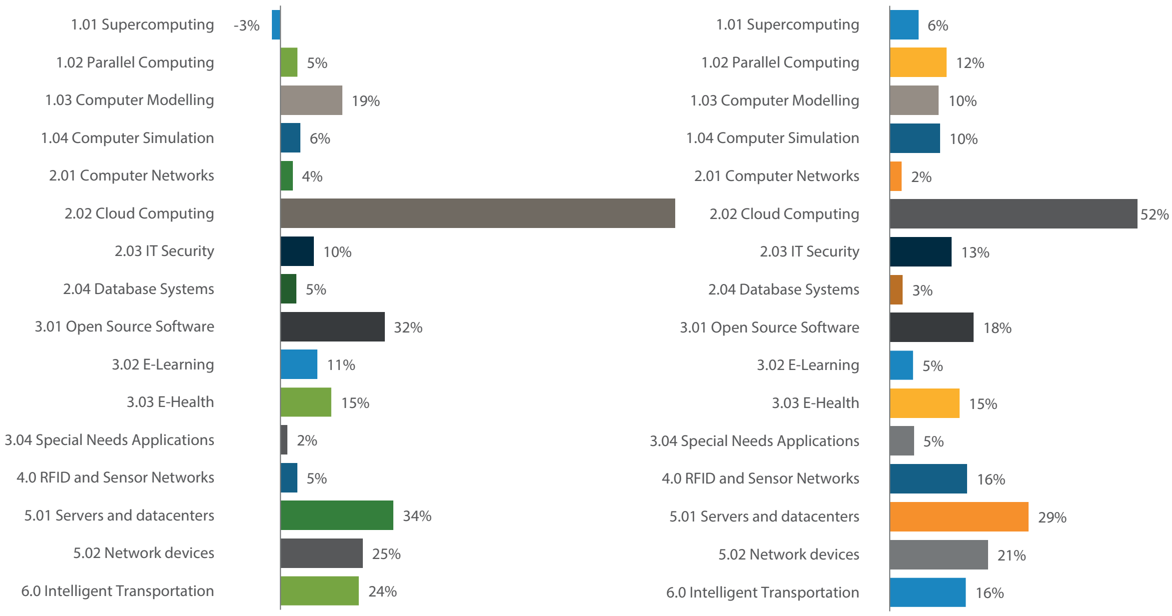

Figure 5 – Average Annual % Growth or Decline in Patent Family (left) or Scientific Paper (right) output between 2008 and 2013 (patents) or between 2009 and 2014 (papers)

Growth trends for scientific literature (Figure 6) since 2008 are approximately similar for all technology segments. Patenting trends since 2006 (Figure 7) shows energy efficient IT, and intelligent transportation experiencing a strong growth since 2006. Localization exhibits a sharp decline between 2008-2009, and regaining growth thereafter.

Average annual growth or decline is calculated by the average percentage increase or decrease between one year and the next. For example; 5 patents in 2006 followed by 6 patents in 2007 would represent an annual increase of 20%. An increase of 20% in one year, followed by a 10% increase the following year would be represented as a 15% average increase across the two years. This process is followed for 2006 (patents) or 2008 (papers) through to the most recently available year in patent and paper collections, to provide an indicator of the level and direction of recent changes in Information Technology topics.

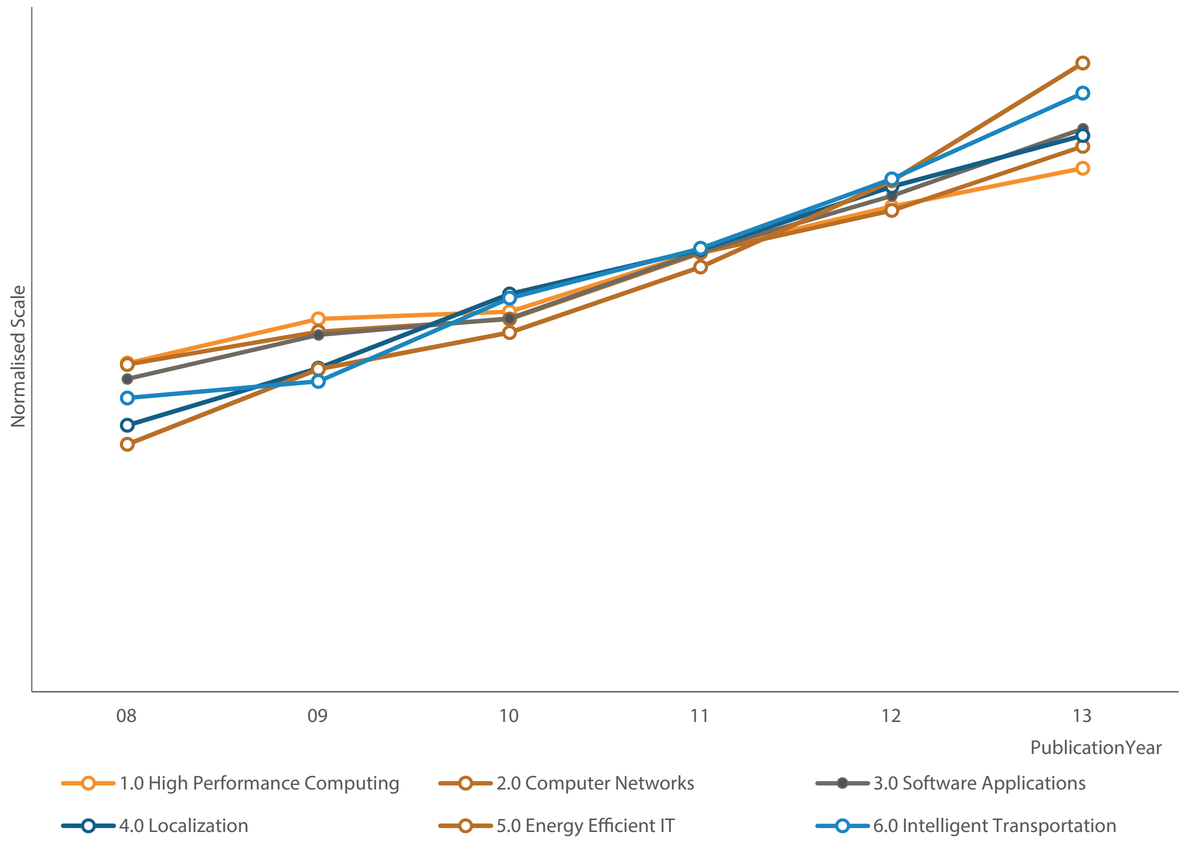

Figure 6 – Normalized Timeline of Activity for Scientific Paper Collection by Information Technology Topic

The timelines on these charts have been normalised to allow for side by side comparison. Individually, each topic has varying volumes of patent families and scientific papers, however for visualisation purposes, the charts represent the proportion of each topic's activity filed or published in each calendar year.

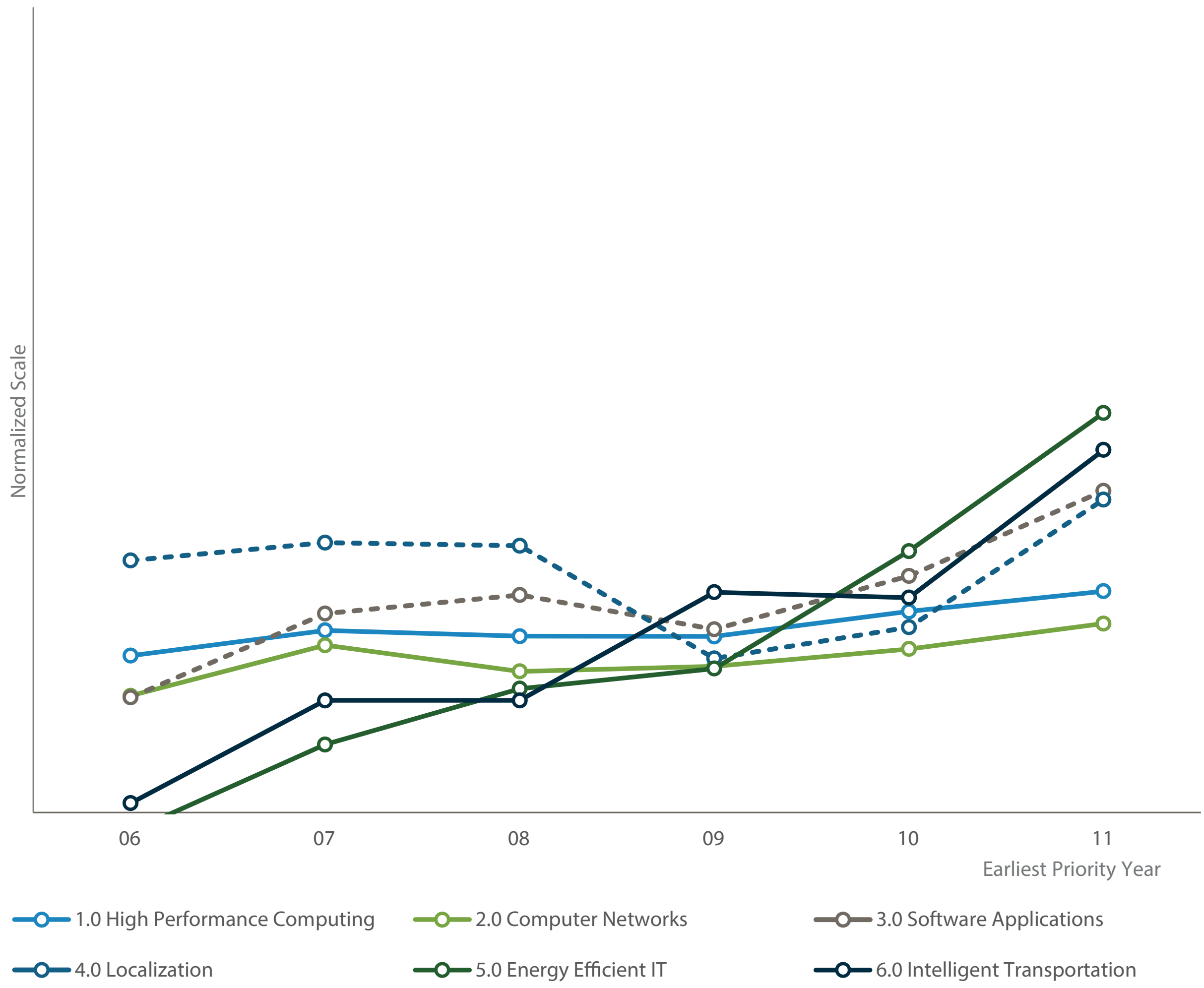

Figure 7 Normalized Timeline of Activity for Patent Family Collection by Information Technology Topic

GLOBAL INFORMATION TECHNOLOGY SCIENTIFIC LITERATURE

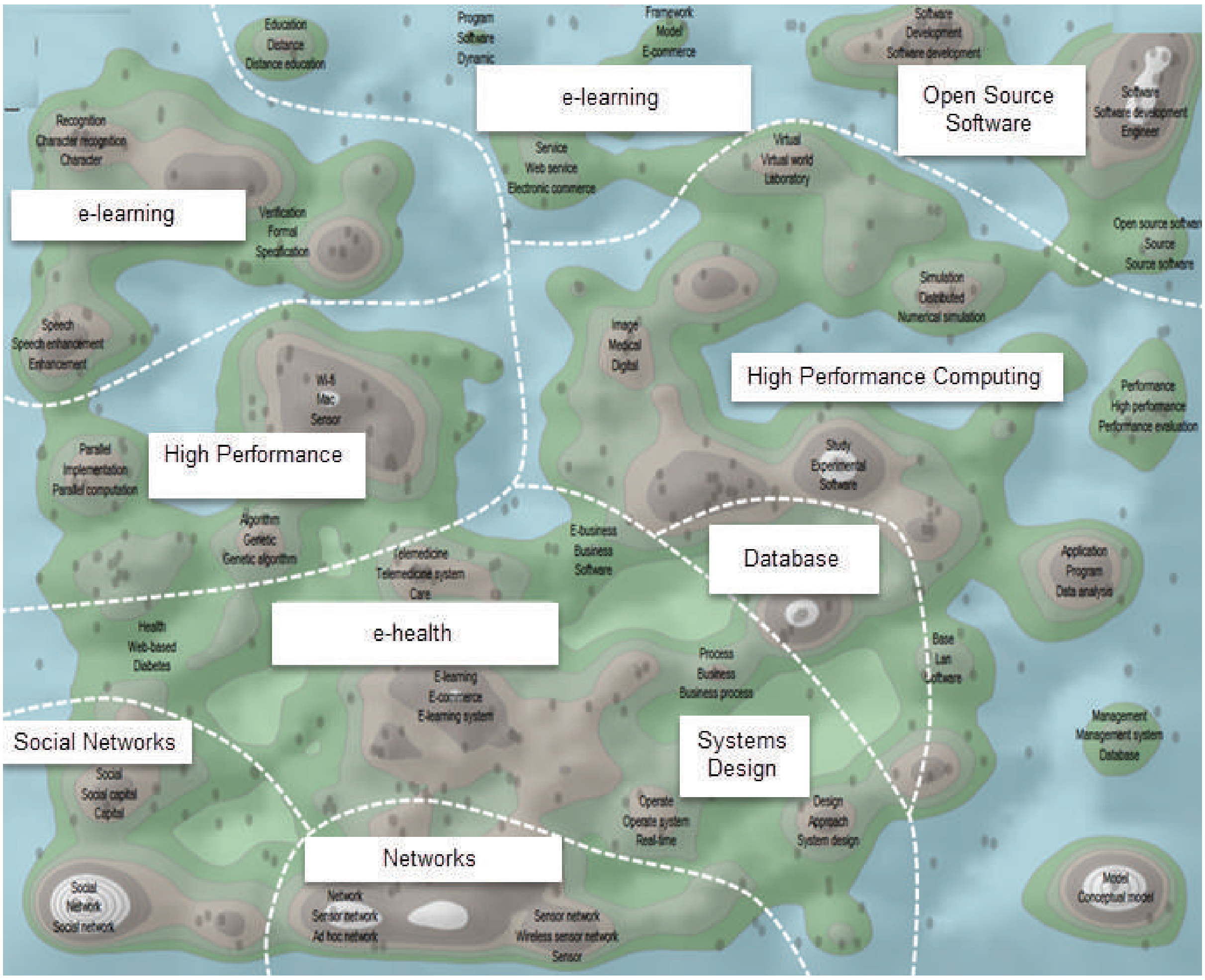

Figure 8 – ThemeScape Map of Scientific Paper Information Technology Collection; Annotated by Major Theme

Key themes present throughout this collection of papers are illustrated in Figure 8 as a “ThemeScape map” - a visualization method for understanding the common themes and concepts within thousands of documents. Used for market analysis, government intelligence and primarily technology landscapes, the algorithm parses large amounts of text into a topological map of peaks and troughs.

Themes that are commonly shared between documents are represented by mountainous peaks, whereas documents that share little commonality are located within the valleys of the map. The large number of documents in this map means that there are rather few valleys to be found.

The location of an individual document is the vector sum of all the attractions to other documents in the collection based on shared phraseology and the frequency and proximity of these terms.

This map has been manually annotated to summarize the major technology areas within the scientific literature collection. Some technologies will necessarily overlap, and the delineation of one technical area versus another is therefore only approximate. However the map is very useful in describing what topics are common features of global Information Technology scientific research.

Key themes revealed in this Themescape map focus mainly on high performance computing, e-health, open source software, e-learning, networks, database, and systems design.

ThemeScape® is a text-mining application that acquires and analyzes free text. The algorithms it uses require no application of thesauri or other outside sources of information, and only the free text itself is used by this text-mining tool. The more text the application acquires, the more likely it will be that the output will provide an accurate summary of the major themes present. After analyzing the text in multiple documents, it pulls together those documents that share related text and pulls apart those with less related text. The outcome 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 pick out topics of interest. It aggregates word forms that share a common stem, but it does not directly aggregate synonyms. Instead, synonyms may be gathered under a common theme because of the other words that co-occur with those synonyms. Thus, "battery" and "cell" may be clustered together because of the co-occurrence in the same documents of terms like "electrode, rechargeable, electrolyte" and so on. Conversely, "battery" and "cell" may be separated if the map contains a mixture of documents on metals and biology, where the two terms have different meanings. In other words, terms are identified as synonyms only by co-clustering based on common context.

The topographical maps presented by ThemeScape are mathematical solutions built on a random selection of a first document and sequential calculation of the relationships of all the other documents. The orientation of the map is random, and the directions up, down, left, or right have no significance, because the n-dimensional solution might have been presented from any angle. Only the proximity of points within the map has meaning, and co-localized documents are highly likely to share concepts.

In this report there are separate ThemeScape maps covering scholarly papers or patents. The two types of documents are not pooled and analyzed together. This is because ThemeScape is context-sensitive, and it would separate patent and literature documents from one another based on the very different formal styles of writing that are reflected in these two types of content. Likewise, if documents in two languages are pooled, it will separate them based on the language, and then each language region will be clustered based on term frequency in that language.

The ThemeScape maps in this report analyze large numbers of documents. The contour lines on the maps diminish in circumference, encircling regions of higher and higher concentration. The density is also shown by the map coloration. White snow-capped peaks represent the highest density, while blue expanses (sea level) indicate low density.

The labels in black on the map are selected by ThemeScape based on term frequency in that map region, and they may have been adjusted by the analyst. The large color-overlay regions enclosed by broken lines have been added by the analyst to identify content at an even higher level of abstraction. The dots on the map represent single documents. Dots are not shown for all the documents, and instead represent a sampling that allows the other features of the map to be discerned. Within the ThemeScape application, the map can be magnified, searched, probed and highlighted to learn more about its contents.

ThemeScape is reliant on statistical methods that are not equivalent to reading by human judges, and in compensation, it analyzes millions of documents on a scale of minutes and quickly presents an intuitive, high level summary. It enables and guides further review, and provides a first level overview of very complex datasets.

INFORMATION TECHNOLOGY SCIENTIFIC LITERATURE

Table 1 shows the further segmentation of Information Technology topics. There appears to be significant research in parallel computing, computer networks, e-health, and network devices (energy efficient IT). Among these, e-health, and network devices (energy efficient IT) still show brisk growth, indicating continued interest in research in these technologies. The technologies with exceedingly growing interest include cloud computing, and servers and datacenters (energy efficient IT). Other areas with relatively high growth rates include open source software, e-health, RFID and sensor networks, and intelligent transportation.

Technology Segmentation		Total Publications	Average %Growth or Decline ('09-'14)
1.0 High Performance Computing	1.01 Supercomputing	1622	2%
	1.02 Parallel Computing	9302	4%
	1.03 Computer Modelling	3905	2%
	1.04 Computer Simulation	5488	3%
2.0 Computer Networks	2.01 Computer Networks	9278	-3%
	2.02 Cloud Computing	4828	39%
	2.03 IT Security	5602	4%
	2.04 Database Systems	4682	-3%
3.0 Software Applications	3.01 Open Source Software	4771	5%
	3.02 E-Learning	3270	0%
	3.03 E-Health	9717	-1%
	3.04 Special Needs Applications	1321	-7%
4.0 Localization	4.0 RFID and Sensor Networks	3848	12%
5.0 Energy Efficient IT	5.01 Servers and datacenters	819	21%
	5.02 Network devices	9536	6%
6.0 Intelligent	6.0 Intelligent Transportation	1194	15%

Table 1 – Scientific Literature Technology Segmentation

INFORMATION TECHNOLOGY SCIENTIFIC LITERATURE COLLECTION TECHNOLOGY CATEGORY OVERLAP

The technology categories and that were created to enumerate and describe the Information Technology landscape were not intended to be mutually exclusive. A single scientific paper can be included in multiple categories or segments.

Figure 9 visualizes the relationship between the technology segments used in this study. Each number in the diagram shows the number of papers that have content related to both the corresponding row-wise and column-wise segments.

The most highly correlated segment pairings are parallel computing with computer simulation; parallel computing with computer modelling; and computer modelling with computer simulation. A number of white spaces are visible through out the matrix.

	1.01 Supercomputing	1.02 Parallel Programming	1.03 Computer Modeling	1.04 Computer Simulation	2.01 Computer Networks	2.02 Cloud Computing	2.03 It Security And Privacy	2.04 Database Systems	3.01 Open Source Software (Oss	3.02 E-Learning	3.03 E-Health	3.04 Special Needs Applications	4.0 Rfid And Sensor Networks	5.01 Server/Data Center	5.02 Network Device	6.0 Intelligent Transportation
1.01 Supercomputing	1622	330	112	158	35	36	5	9	25	1	1		2	7	10	
1.02 Parallel Programming		9302	1624	2143	255	195	26	160	126	28	2	4	13	15	84	4
1.03 Computer Modeling			3905	1524	159	122	21	67	47	31	1	1	12	11	52	
1.04 Computer Simulation				5488	378	113	34	78	64	23			95	23	215	2
2.01 Computer Networks					9278	119	441	112	99	187	38	20	139	34	505	28
2.02 Cloud Computing						4828	79	129	81	34	36	1	8	118	85	12
2.03 It Security And Privacy							5602	36	44	9	56	1	54	6	188	9
2.04 Database Systems								4682	69	51	20	6	25	5	32	10
3.01 Open Source Software (Oss									4771	42	24	3	5	5	11	4
3.02 E-Learning										3270	53	11	1	1	8	2
3.03 E-Health											9717	13	11	4	20	
3.04 Special Needs Applications												1321	5		1	1
4.0 Rfid And Sensor Networks													3848	16	284	14
5.01 Server/Data Center														819	269	1
5.02 Network Device															9536	17
6.0 Intelligent Transportation																1194

Figure 9 - Number of Scientific Papers per Pair of Technology Categories, 2008 to 2012

SCIENTIFIC PAPER GEOGRAPHIC VOLUME BENCHMARKING

Figure 10 shows the number of scientific papers for the ten most prolific countries within the information technology paper collection.
United States is the largest source of information technology related peer-reviewed papers, followed at a distance by China, the United Kingdom, Germany, and Canada.

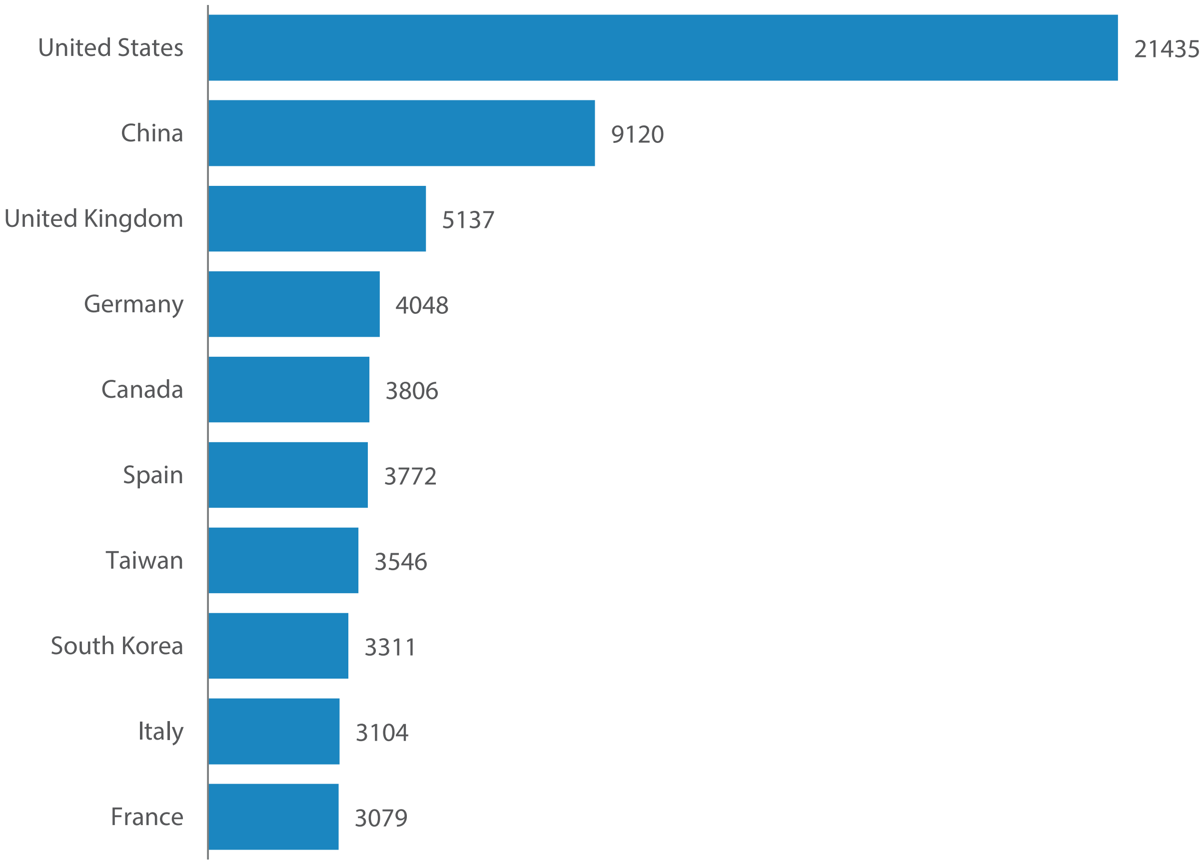

Figure 10 - Number of Scientific Papers per Country; Top 10 Sources, 2009 to 2014

SCIENTIFIC PAPER GEOGRAPHIC ACTIVITY TRENDS

The chart below shows the highest grow rates sources in the scientific literature collection.

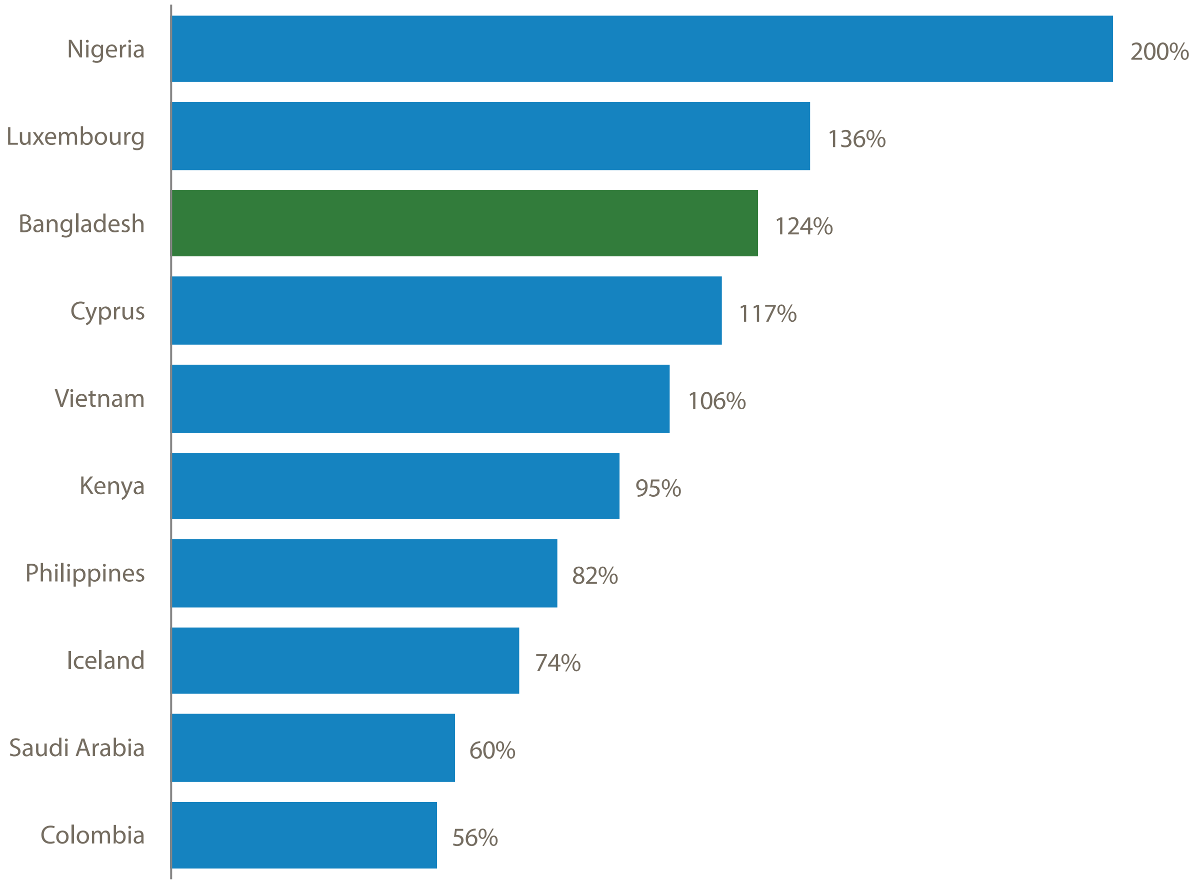

Figure 11 – Highest growth rate geographies in Information Technology Paper Output

While Saudi Arabia's scientific literature collection is small relative to the collections of the most prolific countries, the growth rate of the KSA collection far exceeds that of other countries. Prolific countries also have a high growth, but not as much those illustrated in figure 11.

SCIENTIFIC PAPER GEOGRAPHIC CITATION IMPACT BENCHMARKING

Scientific paper and patent citations are routinely used in technology bibliometrics for assessing the inherent impact and potential quality of research and the downstream technical and scientific relevance of the underlying research.
Figure 12 shows the “Citation Impact”, the average citation per paper for all papers in a country’s collection and has been sorted by highest citation impact. This shows that output from Slovenia, Germany, and Switzerland, are having the highest impact in the information technology topic.

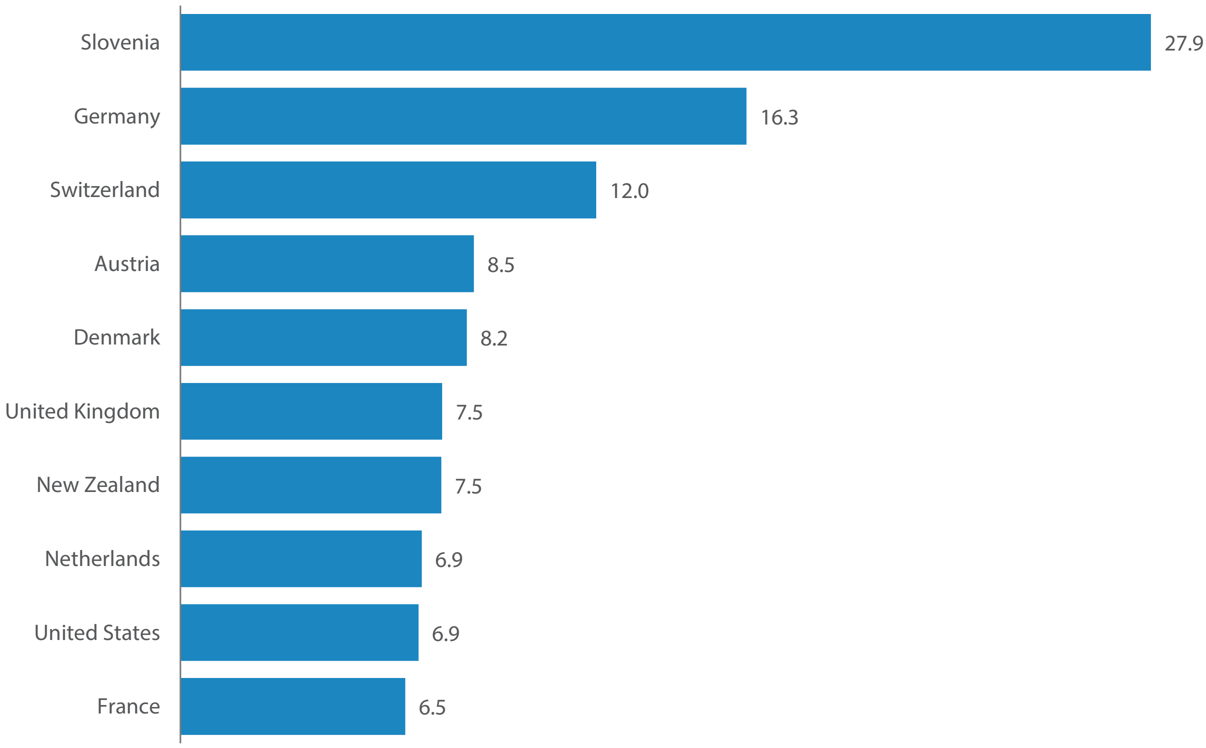

Figure 12 – Highest citation impact geographies of Information Technology Scientific Publications

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Note that the journals included in the project source data (Web of Science) are selected on the basis of both quantitative and qualitative selection criteria, such as editorial quality, peer review robustness and citation impact. Further details of the journal selection process is available from : http://thomsonreuters.com/products_services/science/free/essays/journal_selection_process/

INFORMATION TECHNOLOGY RESEARCH TOPIC BY GEOGRAPHY

Table 1 shows the split of Information Technology science and research specialization for the top nations. The Kingdom of Saudi Arabia appears to have focus on parallel computing, computer networks, IT security, e-health, and network devices (energy efficient IT). Overall, the focus in scientific literature remains fairly evenly spread out over the various Information Technology topics, across the countries.

Country of Origin	1.01 Supercomputing	1.02 Parallel Computing	1.03 Computer Modelling	1.04 Computer Simulation	2.01 Computer Networks	2.02 Cloud Computing	2.03 IT Security	2.04 Database Systems	3.01 Open Source Software	3.02 E-Learning	3.03 E-Health	3.04 Special Needs Applications	4.0 RFID and Sensor Networks	5.01 Servers and datacenters	5.02 Network Devices	6.0 Intelligent Transportation
United States	3%	14%	5%	8%	12%	8%	8%	6%	8%	3%	17%	2%	5%	1%	12%	2%
China	2%	15%	6%	11%	15%	11%	10%	7%	3%	3%	3%	1%	10%	1%	19%	2%
United Kingdom	2%	11%	6%	7%	10%	8%	7%	6%	10%	5%	20%	3%	3%	1%	12%	2%
Germany	4%	15%	6%	7%	11%	8%	7%	7%	13%	3%	18%	2%	3%	1%	8%	1%
Canada	1%	10%	5%	9%	15%	6%	8%	6%	8%	3%	17%	1%	6%	1%	16%	2%
Spain	3%	19%	7%	7%	14%	7%	7%	7%	7%	10%	10%	2%	4%	1%	10%	3%
Taiwan	1%	12%	4%	7%	22%	8%	10%	8%	2%	12%	5%	1%	7%	1%	15%	3%
South Korea	1%	9%	3%	6%	17%	7%	11%	7%	2%	3%	6%	1%	9%	3%	27%	2%
Italy	2%	11%	6%	7%	16%	6%	8%	7%	11%	3%	13%	2%	6%	1%	14%	2%
France	3%	18%	9%	9%	13%	7%	8%	7%	9%	3%	9%	2%	5%	1%	11%	2%
Australia	2%	8%	5%	6%	10%	11%	8%	8%	6%	4%	22%	2%	5%	1%	12%	2%
Japan	7%	17%	6%	8%	14%	8%	7%	6%	4%	3%	6%	1%	5%	3%	19%	2%
Netherlands	2%	9%	5%	5%	10%	6%	5%	6%	12%	5%	27%	4%	2%	0%	10%	2%
India	2%	11%	6%	9%	16%	7%	8%	9%	5%	3%	10%	1%	4%	1%	21%	1%
Switzerland	4%	16%	7%	9%	10%	6%	7%	6%	15%	3%	16%	1%	3%	1%	10%	1%
Greece	1%	13%	7%	8%	19%	8%	8%	8%	7%	9%	9%	2%	3%	1%	13%	2%
Brazil	2%	18%	8%	8%	13%	6%	6%	8%	8%	4%	15%	3%	3%	2%	12%	1%
Singapore	1%	12%	6%	10%	15%	8%	8%	12%	5%	4%	5%	1%	8%	1%	17%	2%
Sweden	2%	11%	4%	5%	11%	4%	5%	4%	10%	3%	21%	3%	7%	0%	18%	3%
Iran	2%	16%	8%	14%	17%	3%	6%	7%	2%	6%	5%	1%	6%	1%	23%	2%
Turkey	1%	16%	5%	8%	16%	3%	7%	11%	5%	8%	9%	2%	9%	1%	16%	0%
Belgium	1%	10%	4%	6%	12%	7%	6%	10%	13%	3%	12%	3%	5%	1%	15%	1%
Poland	4%	23%	10%	11%	14%	8%	5%	11%	6%	4%	10%	2%	3%	1%	9%	1%
Austria	1%	13%	8%	7%	10%	10%	9%	5%	13%	6%	14%	2%	3%	0%	9%	3%
Israel	3%	21%	7%	7%	15%	6%	9%	9%	3%	5%	12%	4%	5%	0%	6%	1%
Finland	2%	14%	5%	7%	12%	6%	8%	4%	12%	5%	12%	2%	8%	1%	18%	1%
Portugal	2%	16%	5%	4%	14%	7%	5%	7%	11%	8%	9%	2%	4%	1%	14%	2%
Denmark	3%	10%	7%	4%	9%	4%	5%	8%	15%	2%	23%	4%	3%	1%	10%	0%
Norway	1%	9%	2%	6%	12%	8%	7%	4%	12%	2%	26%	2%	2%	0%	13%	1%
Ireland	2%	9%	6%	8%	19%	8%	5%	5%	10%	8%	14%	1%	4%	1%	15%	1%
Malaysia	0%	7%	4%	5%	18%	11%	9%	9%	4%	6%	7%	1%	8%	1%	20%	2%
Saudi Arabia	3%	10%	4%	8%	15%	10%	12%	8%	3%	3%	9%	2%	6%	1%	19%	2%
Russia	14%	24%	10%	8%	8%	9%	8%	10%	8%	2%	5%	1%	4%	1%	8%	0%
New Zealand	2%	10%	7%	7%	9%	7%	10%	11%	14%	7%	15%	1%	4%	0%	8%	1%
Mexico	2%	11%	5%	9%	9%	7%	7%	9%	5%	17%	7%	2%	6%	0%	13%	0%

Table 2 – Information Technology Specialization by Country; % of Literature Activity per Technical Stream

SCIENTIFIC PAPER - PROLIFIC GLOBAL ENTITIES

Universities appear to dominate the scientific paper publications in Information technology topics. Notably, a large number of US universities feature in the top 30 entities publishing scientific literature in this area. Most notable for their high citation impact, indicating important scientific literature contributions, are Harvard University, University System of Maryland, MIT, and University of California. Science & Technology Unit, Umm Al-Qura University (STU-UQU) has only 13 papers published in this space, with relatively low citation counts.

Entity	Total	Times Cited	Citation per paper
Science & Technology Unit, Umm Al Qura University (STU-UQU)	13	16	1.23
UNIVERSITY OF CALIFORNIA SYSTEM	1503	18106	12.05
CHINESE ACAD SCI	834	3294	3.95
TSINGHUA UNIV	707	2478	3.50
NANYANG TECHNOL UNIV	557	2343	4.21
UNIV ILLINOIS	502	3020	6.02
HARVARD UNIV	470	5757	12.25
UNIV MICHIGAN	448	4860	10.85
UNIV TORONTO	431	2803	6.50
NATL CHENG KUNG UNIV	423	2017	4.77
UNIV MARYLAND	419	7193	17.17
NATL CHIAO TUNG UNIV	418	1365	3.27
MIT	412	7561	18.35
GEORGIA INST TECHNOL	406	2509	6.18
STANFORD UNIV	402	3585	8.92
SHANGHAI JIAO TONG UNIV	401	1388	3.46
PURDUE UNIV	395	1670	4.23
ZHEJIANG UNIV	388	972	2.51
NATL TAIWAN UNIV	368	1407	3.82
UNIV WASHINGTON	361	2549	7.06
NATL UNIV SINGAPORE	355	1827	5.15
SEOUL NATL UNIV	353	1055	2.99
UNIV WISCONSIN	346	3108	8.98
UNIV WATERLOO	342	1592	4.65
TEXAS A&M UNIV	340	3807	11.20
HUAZHONG UNIV SCI & TECHNOL	334	674	2.02
CITY UNIV HONG KONG	333	1387	4.17
COLUMBIA UNIV	329	2588	7.87
UNIV BRITISH COLUMBIA	329	4251	12.92
UNIV TEXAS AUSTIN	327	1667	5.10
KOREA ADV INST SCI & TECHNOL	324	985	3.04

Table 3 – Information Technology – Top entities for Scientific Literature

SCIENTIFIC LITERATURE OVERVIEW OF TOP GLOBAL ENTITIES

Table 4 shows the technology profile of the top 30 entities within the scientific literature space of Information Technology. Entities appear to be focusing their research in different technologies. For example, the top 4 – University of California, Chinese Academy of Sciences, Tsinghua University and Nanyang Tech University appear to be focusing heavily on Parallel computing, computer networks, and network devices (energy efficient IT). Additionally, the University of California also focuses heavily on e-health. Further, Harvard University, University of Washington, University of Toronto, University of Michigan and Columbia University appear to be focusing primarily on e-health – indicating a significant interest among the top entities. Science & Technology Unit, Umm Al-Qura University (STU-UQU) has 13 publications across network devices (energy efficient IT), and computer networks.

Entity	1.01 Supercomputing	1.02 Parallel Computing	1.03 Computer Modelling	1.04 Computer Simulation	2.01 Computer Networks	2.02 Cloud Computing	2.03 IT Security	2.04 Database Systems	3.01 Open Source Software	3.02 E-Learning	3.03 E-Health	3.04 Special Needs Applications	4.0 RFID and Sensor Networks	5.01 Servers and datacenters	5.02 Network Devices	6.0 Intelligent Transportation
Science & Technology Unit, Umm Al Qura University (STU-UQU)				1	3	2	1				1		2		4	
UNIVERSITY OF CALIFORNIA SYSTEM	55	227	98	128	205	105	124	80	125	34	190	23	74	33	246	30
CHINESE ACAD SCI	39	132	66	81	104	117	87	58	36	19	15	5	59	17	134	30
TSINGHUA UNIV	7	128	61	86	128	84	50	39	12	14	7	2	55	19	162	18
NANYANG TECHNOL UNIV	8	69	31	59	92	44	42	57	12	29	18	4	61	3	107	13
UNIV ILLINOIS	27	101	42	56	75	28	39	30	41	12	37	4	30	5	60	5
HARVARD UNIV	14	24	19	18	34	27	31	17	102	25	163	11	9		8	
UNIV MICHIGAN	12	56	16	29	52	24	25	21	34	15	122	5	20	13	57	3
UNIV TORONTO	5	48	19	30	50	22	20	27	36	9	148	12	13	1	28	10
NATL CHENG KUNG UNIV	5	33	6	22	106	26	47	29	7	54	28	4	27	3	71	15
UNIV MARYLAND	12	62	18	33	34	47	43	21	39	15	70	6	15	6	39	8
NATL CHIAO TUNG UNIV	1	58	14	28	101	26	41	22	7	38	11	1	41	7	83	26
MIT	12	58	24	44	34	27	35	26	60	12	11	4	39	4	74	8
GEORGIA INST TECHNOL	6	60	25	35	56	41	30	21	18	8	13	3	37	9	99	8
STANFORD UNIV	11	73	22	28	47	34	14	20	54	14	55	9	16	16	61	1
SHANGHAI JIAO TONG UNIV	9	48	21	53	48	43	47	20	7	10	25	3	37	8	81	12
PURDUE UNIV	8	61	28	39	65	34	52	27	18	17	7	6	26	4	63	9
ZHEJIANG UNIV	4	84	24	43	49	32	25	35	8	8	10	3	45	4	70	3
NATL TAIWAN UNIV	5	50	18	40	77	26	33	29	6	17	25	4	28	4	75	9
UNIV WASHINGTON	8	33	9	16	32	30	33	17	50	8	105	9	9	3	20	10
NATL UNIV SINGAPORE	4	51	34	42	50	24	20	42	31	15	21	4	22	3	50	4
SEOUL NATL UNIV	7	40	11	23	73	29	19	31	5	10	37	2	25	8	78	6
UNIV WISCONSIN	8	37	19	28	29	50	24	20	30	15	74	20	11	2	21	4
UNIV WATERLOO	2	33	25	28	80	20	50	25	21	3	10	2	26	3	65	9
TEXAS A&M UNIV	13	49	28	38	32	28	53	10	24	9	15	1	26	3	73	9
HUAZHONG UNIV SCI & TECHNOL	2	58	25	33	66	61	29	18	2	7	6		20	10	63	6
CITY UNIV HONG KONG	1	34	13	34	61	14	30	44	22	27	6	1	31	2	46	7
COLUMBIA UNIV	12	27	11	16	34	18	17	21	31	16	101	4	11	2	42	2
UNIV BRITISH COLUMBIA	4	22	12	18	45	17	29	12	31	10	68	6	21	5	71	4
UNIV TEXAS AUSTIN	20	83	15	24	41	18	10	27	31	14	29	6	20	3	28	4
KOREA ADV INST SCI & TECHNOL	2	46	6	20	38	16	29	42	6	8	3		14	17	125	2

Table 4 – Scientific literature overview of top global entities

SCIENTIFIC LITERATURE OVERVIEW OF TOP ASIA PACIFIC ENTITIES

Entity	Country of Origin	Total	1.01 Supercomputing	1.02 Parallel Computing	1.03 Computer Modelling	1.04 Computer Simulation	2.01 Computer Networks	2.02 Cloud Computing	2.03 IT Security	2.04 Database Systems	3.01 Open Source Software	3.02 E-Learning	3.03 E-Health	3.04 Special Needs Applications	4.0 RFID and Sensor Networks	5.01 Servers and datacenters	5.02 Network Devices	6.0 Intelligent Transportation
Science & Technology Unit, Umm Al Qura University (STU-UQU)	Saudi Arabia	13		1	3	2	1				1		2		4		3	
Tsinghua Univ	China	229	4	54	24	31	33	18	12	11	5	7	2	1	17	6	49	9
Nanyang Technol Univ	Singapore	200	4	25	8	22	35	12	12	22	5	13	4	1	22		45	
Chinese Acad Sci	China	175	14	33	9	8	21	21	27	13	7	4	2		11	2	33	4
Natl Cheng Kung Univ	Taiwan	163	3	13	1	7	43	6	14	12	2	24	13	1	15	1	21	5
Natl Chiao Tung Univ	Taiwan	158	1	16	5	7	49	7	20	7	2	12			20	3	32	11
Indian Inst Technol	India	147	2	14	12	18	32	6	9	17	3	1	2		6		43	6
Natl Univ Def Technol	China	133	19	48	10	14	20	15	11	8	1				16		11	
Natl Taiwan Univ	Taiwan	117	1	21	8	17	29	10	3	7		3	2	1	9		22	2
Korea Adv Inst Sci & Technol	South Korea	116		13	1	4	12	2	7	12	3	4			9	4	59	1
Zhejiang Univ	China	114	1	36	10	17	16	6	2	8	1	3	2		11	1	17	
Natl Taiwan Univ Sci & Technol	Taiwan	111	1	14	3	3	37	11	12	10	2	9	2		8	4	5	3
Shanghai Jiao Tong Univ	China	108	3	12	6	15	18	9	6	6	2	3	9		8	3	27	2
Beijing Univ Posts & Telecommun	China	99	2	5	4	11	26	15	8	1	1		1		11	2	26	1
Yonsei Univ	South Korea	97		10	4	3	22	2	7	4	4	2	14	1	17	1	17	1
Natl Tsing Hua Univ	Taiwan	89		23	2	11	24	3	8	3	3	5			7		21	
Xidian Univ	China	89	3	7	2	10	18	7	8		1				15	3	27	
Huazhong Univ Sci & Technol	China	87	1	18	9	7	18	15	7	6	1	1	1		5	5	15	2
Northeastern Univ	China	85		4	5	7	11	6	7	30	1	1	1		14		10	
Natl Univ Singapore	Singapore	84	1	16	9	11	18	3	6	2	7	3	4	1	5	1	11	2
Seoul Natl Univ	South Korea	80	5	12	3	8	13	8	3	4	1	1	6	2	6	3	16	1
Korea Univ	South Korea	78		6		1	23	4	11	6	1	4	2	1	7	1	18	1
Hong Kong Univ Sci & Technol	China	72	2	6	3	14	24	1		5	2				11		16	
Dalian Univ Technol	China	70		9	10	9	15	5	5	2		1	2		6	1	16	4
Univ Elect Sci & Technol China	China	70		8	2	8	12	9	7		1			1	10	1	20	1
Fujitsu Ltd	Japan	69	5	1				46	1		5		1			12	5	
Southeast Univ	China	69		7	3	7	8	1	3			2		2	8	2	29	4
Kyung Hee Univ	South Korea	66		3	3	3	5	12	11	3		2	7		3	3	18	3
Univ Sci & Technol China	China	64	1	16		7	8	6	4		3				5	1	24	
Harbin Inst Technol	China	63	2	12	5	9	9	4	2	11	1	5	1		10		9	

Table 5 – Scientific literature overview of top Asia Pacific entities

SCIENTIFIC LITERATURE OVERVIEW OF TOP MIDDLE EAST & AFRICA ENTITIES

Table 6 visualizes the prolific entities in the Middle East and Africa. The list is dominated by Middle Eastern entities, reflecting the trends seen in table 5 above. Most of the prolific entities in these regions follow the global focus trends on parallel computing, computer networks, and network devices, while not focusing heavily on other technologies. Notable exceptions include the King Saud University, with a large focus on Computer Networks, and additional focus on cloud computing and e-health; King Abdulaziz University, also with a large focus on cloud computing; and Gazi University, Turkey having a large focus on IT security.

Entity	Country of Origin	Total	1.01 Supercomputing	1.02 Parallel Computing	1.03 Computer Modelling	1.04 Computer Simulation	2.01 Computer Networks	2.02 Cloud Computing	2.03 IT Security	2.04 Database Systems	3.01 Open Source Software	3.02 E-Learning	3.03 E-Health	3.04 Special Needs Applications	4.0 RFID and Sensor Networks	5.01 Servers and datacenters	5.02 Network Devices	6.0 Intelligent Transportation
Science & Technology Unit, Umm Al Qura University (STU-UQU)	Saudi Arabia	13				1	3	2	1				1		2		4	
Islamic Azad Univ	Iran	174	2	29	14	30	24	5	10	11	2	7	3	4	7		55	3
King Saud Univ	Saudi Arabia	140	1	9	4	10	24	18	28	10		5	16	2	9	1	17	3
Amir Kabir Univ Technol	Iran	133	1	28	16	39	17	3	6	11		12			12	1	28	1
Sharif Univ Technol	Iran	125	4	28	10	15	37	5	4	7	2		2	1	6	1	31	
Univ Tehran	Iran	114	2	24	12	14	18	3	4	8	2	7	1		3	1	31	5
Middle E Tech Univ	Turkey	91		17	5	5	15	1	4	13	4	6	7	1	8		16	
Bilkent Univ	Turkey	90	2	22	5	9	19	3	1	10	4	1	2	2	16	1	12	
Iran Univ Sci & Technol	Iran	90		17	15	14	17	2	1	4	2	2	1		10	2	15	5
Kuwait Univ	Kuwait	76		11	4	6	13	7	8	14	10	1	2	1	5		3	
King Fahd Univ Petr & Minerals	Saudi Arabia	72	1	5	2	8	13	2	4	6	7	2	5	3	4		15	1
King Abdulaziz Univ	Saudi Arabia	69	2	10	6	4	8	10	7	7	4	4	3	2	3	2	12	1
Bogazici Univ	Turkey	67		9	2	7	12	3	3	8	2	1	5	3	6		21	
Istanbul Tech Univ	Turkey	61	2	19	5	7	6	4	3	2	4	2	1	1	9		8	
Amer Univ Beirut	Lebanon	57		7	3	8	11	2	3	2	5	2	3		4	2	18	
Gazi Univ	Turkey	57		9	5	3	10		11	2	3	10	3	1	3	1	11	
Univ Cape Town	South Africa	52		4	3	3	12	3	4	3	11	1	8		1	1	7	1
Univ Pretoria	South Africa	48		3	1	3	8		3	3	2	4	5	5	3		10	
Tarbiat Modares Univ	Iran	43		4	2	3	4			4	1	9	1	1	2		12	2
Qatar Univ	Qatar	40		1		2	4	9	11	2			4		2		9	1
Ferdowsi Univ Mashhad	Iran	38		8	8	9	6	3	2	3		1	2		2	2	10	
Shahid Beheshti Univ	Iran	37		12	2	1	4	1	4	8			1		1		9	
Sabanci Univ	Turkey	36		3		1	7	1	9	5	2	1		1	3	1	6	
Isfahan Univ Technol	Iran	34	2	4	2	3	10		4	1	2	1			1	2	7	
Univ Ottawa	Saudi Arabia	34		2		4	13	2	2	1			7		2		4	
Univ Stellenbosch	South Africa	34	1	1			3	1	3	1	2	1	15	1	2		4	
Ain Shams Univ	Egypt	32	1	4	2	2	2	1	1	5	1		4	1			9	2
King Abdullah Univ Sci & Technol	Saudi Arabia	32	7	5	2	5	3	3	3	3		1			1		9	
Koc Univ	Turkey	32		3	3	2	11	1	1	2		2					12	1
Istanbul Univ	Turkey	31		4	1		5	1	4	3	3	2	7		2		2	
Hacettepe Univ	Turkey	31	1	5	1	5	2			1	9	4	4	2			1	

Table 6 – Scientific literature overview of top Middle East & Africa entities

SCIENTIFIC LITERATURE OVERVIEW OF TOP SAUDI ARABIA ENTITIES

Entities	Total	1.01 Supercomputing	1.02 Parallel Programming	1.03 Computer Modeling	1.04 Computer Simulation	2.01 Computer Networks	2.02 Cloud Computing	2.03 It Security And Privacy	2.04 Database Systems	3.01 Open Source Software (Oss	3.02 E-Learning	3.03 E-Health	3.04 Special Needs Applications	4.0 Rfid And Sensor Networks	5.01 Server/Data Center	5.02 Network Device	6.0 Intelligent Transportation
Science & Technology Unit, Umm Al Qura University (Stu-Uqu	13				1	3	2	1				1		2		4	
King Saud Univ	143	1	10	4	10	24	19	28	10		5	16	2	9	1	18	3
King Fahd Univ Petr & Minerals	78	1	6	2	9	16	2	4	6	7	2	6	3	5		15	1
King Abdulaziz Univ	70	2	11	6	5	8	10	7	7	4	4	3	2	3	2	12	1
King Abdullah Univ Sci & Technol	52	10	9	2	7	7	6	3	3	2	1			2		15	
Taif Univ	10		1	1	2	1	1	1	2			2				2	
Alfaisal Univ	9					1						1		2		6	
King Abdul Aziz City Sci & Technol	9		1				1	2	1					1		3	
King Saud Bin Abdul Aziz Univ Hlth Sci	6									1		5					
Qassim Univ	6				1			1	3			1					
Al Baha Univ	5		1			1		3								1	
Prince Sultan Univ	5		1						1		1			2			
Taibah Univ	5		1			1	2		1							1	
Al Imam Mohammad Ibn Saud Islamic Univ	4							1				1	1	1		1	
King Faisal Univ	4							1								3	
Minist Hlth	3											3					
Saudi Aramco	3					1								1		2	
Univ Tabuk	3		1	1												2	
Fahad Bin Sultan Univ	2											2					
Jazan Univ	2		1		1												1
King Fahad Med City	2							1				1					
King Fahad Natl Guard Hosp	2											2					
Univ Hail	2															2	
Al Hada Hosp	1											1					
Al Imam Univ	1						1										
Arabian Adv Syst	1									1							
Baha Private Coll Sci	1					1											
Coll Comp & Informat Technol	1		1														
Coll Telecommun & Elect	1					1											
Dammam Univ	1								1	1							

Table 7 – Scientific literature overview of top Saudi Arabia entities

MIDDLE EAST & AFRICA INFORMATION TECHNOLOGY SCIENTIFIC LITERATURE TRENDS

This section of the report focuses on the scientific paper collection and the activity and technological trends observed in the Middle East and Africa regions.

MIDDLE EAST & AFRICA – PROLIFIC COUNTRIES

Figure 13 below shows the prolific countries by scientific literature volume in the Middle East & Africa regions. The gray bars indicate Middle East, blue indicates Africa, and green indicates the Kingdom of Saudi Arabia. As seen from the figure, the most prolific countries within these regions are Iran and Turkey, followed by Israel, Saudi Arabia, and South Africa.

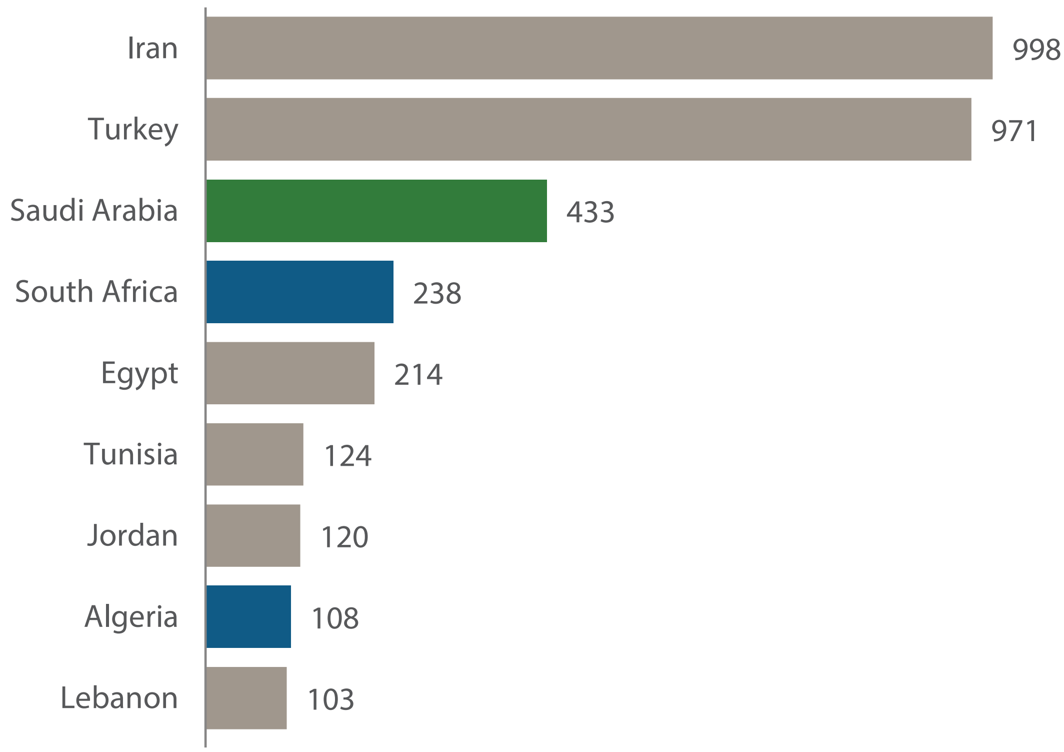


Figure 13 – Middle East & Africa – Prolific Countries in Scientific Literature

A more detailed analysis of the technologies of focus in each of the countries within the Middle East and Africa is presented with reference to tables 5 and 6. Focus appears to be on parallel computing, computer networks, e-health, and network devices (energy efficient IT), similar to the global scientific literature landscape. Also notable is the interest in database systems, and RFID/Sensor networks in these countries. Interestingly, most of the countries in these regions have lower focus on cloud computing than the global levels, with the exception of Kingdom of Saudi Arabia – that has a focus on cloud computing mirroring the global levels.

Country of Origin	1.01 Supercomputing	1.02 Parallel Computing	1.03 Computer Modelling	1.04 Computer Simulation	2.01 Computer Networks	2.02 Cloud Computing	2.03 IT Security	2.04 Database Systems	3.01 Open Source Software	3.02 E-Learning	3.03 E-Health	3.04 Special Needs Applications	4.0 RFID and Sensor Networks	5.01 Servers and datacenters	5.02 Network Devices	6.0 Intelligent Transportation
Iran	16	155	83	143	165	31	57	71	21	59	48	11	55	11	233	21
Turkey	8	160	53	77	156	33	70	106	45	79	85	21	88	8	154	2
Saudi Arabia	14	45	17	36	64	43	52	33	15	13	39	8	28	4	84	7
South Africa	4	13	6	7	32	10	27	10	24	12	61	11	6	1	30	1
Egypt	4	30	9	28	30	10	12	30	1	8	17	4	14	1	45	5
Tunisia		10	9	8	27	4	12	23	2	3	7	2	14	1	14	1
Jordan	2	14	2	13	28	4	7	12	6	8	18	2	6	1	16	1
Algeria		21	10	14	11	4	11	13	1	8	6	1	7	1	25	2
Lebanon		15	4	12	20	3	6	9	7	2	5		9	3	25	
Qatar	1	3	1	7	17	15	14	8		1	9		11	2	28	1
Kuwait		11	4	6	15	7	8	16	10	1	2	1	5		4	1
Morocco	1	5	1	5	6	4	2	4	4	1	4		2	1	5	5
Kenya		1				2	4	2	6		22	2			1	
Nigeria		2		1		2	4	4	4	4	11	2			3	
Oman	2	11	4	6	3	1	1	1	2	2	4				2	
Iraq		2	3	4	7	1	4			1	3		3		4	1
Uganda						1	2		3		10	3	1		1	
Tanzania		1	1	1				1	3		10	2				
Senegal					1	1		5			4			1		
Sudan					3		2	2			3				1	
Yemen		1			4		1	1			1				3	
Bahrain		2	1		1	2	2			1	2					
Cameroon		1			1	1	1				5					
Ghana					1		2			1	4	1	1			
Malawi									1	1	4	1			1	
Botswana						1			2	1	4					
Gabon									3		3	1				
Libya										1	2				4	
Ethiopia						2			2		4					
Zambia									1		5					

Table 8 – Middle East & Africa –Countries over Technical categories

GLOBAL INFORMATION TECHNOLOGY PATENT TECHNOLOGY TRENDS

This section of the report focuses on the patent collections produced for the study and the activity and technological trends seen within it. Based on the Thomson Reuters-produced Derwent World Patents Index database, the collection includes both pending patent applications and granted patents published in 47 countries around the world.
A total of approximately 232,000 patented inventions were gathered that are applicable to the Information Technology topics of interest to Science & Technology Unit, Umm Al-Qura University (STU-UQU). These inventions and their technical nature have been summarized using the ThemeScape software described in the previous section

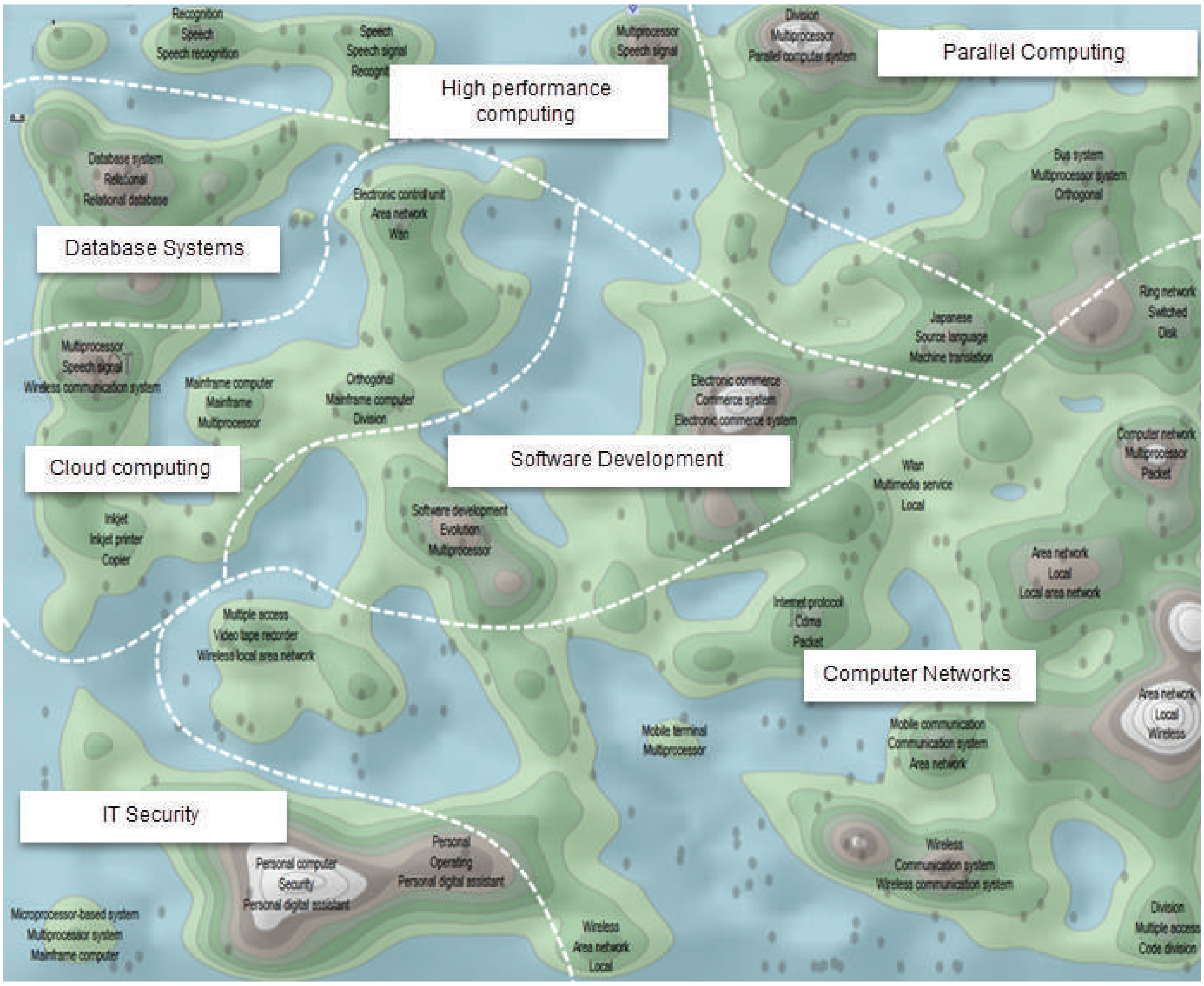


Figure 14 ThemeScape Map of Patents Information Technology Collection; Annotated by Major Theme.

As previously noted, the ThemeScape map is not designed to provide a detailed accurate view of each patented invention; instead the visual is designed to highlight the common themes shared by

hundreds or thousands of patents and patent applications published since 2006.
The words included in the map are those shared by the patent documents in their DWPI abstracted form.
Some of the key themes revealed in this Themescape map include high performance computing, parallel computing, database systems, cloud computing, computer networks, IT security, and software development.
This annotation has been provided to guide the reader around the landscape. However, it should be noted that this annotation is only approximate.

INFORMATION TECHNOLOGY PATENT TECHNOLOGY SEGMENTATION

Table 7 shows the segmentation patents and patent applications in the field of information technology. There is a significant volume of patents in computer networks, IT security, and database systems. However all three areas see very small growth, or decline – indicating that these areas appear to be saturated. Opportunities for patent filings exist in computer modelling, open source software, energy efficient IT – including servers and datacenters, and network devices, and intelligent transportation. All these technology areas exhibit relatively low volume, and high growth rates. One notable exception in the mix is cloud computing – which has relatively high patent volumes, however an extremely large growth rate – indicating a very high interest in patenting. This is also indicative of patenting opportunities in this area.

Technology Segmentation		Total Inventions	Average % Growth or Decline ('08-'13)
1.0 High Performance Computing	1.01 Supercomputing	1240	1%
	1.02 Parallel Programming	11103	6%
	1.03 Computer Modeling	493	24%
	1.04 Computer Simulation	1653	21%
2.0 Computer Networks	2.01 Computer Networks	77651	13%
	2.02 Cloud Computing	13847	89%
	2.03 It Security And Privacy	50049	3%
	2.04 Database Systems	46101	3%
3.0 Software Applications	3.01 Open Source Software (Oss	1317	29%
	3.02 E-Learning	16450	9%
	3.03 E-Health	16712	4%
	3.04 Special Needs Applications	4406	-2%
4.0 Localization	4.0 Rfid And Sensor Networks	5427	4%
5.0 Energy Efficient IT	5.01 Server/Data Center	4226	17%
	5.02 Network Device	5442	14%
6.0 Intelligent	6.0 Intelligent Transportation	2235	19%

Table 9 – Patent Technology Segmentation

INFORMATION TECHNOLOGY PATENT COLLECTION TECHNOLOGY CATEGORY OVERLAP

The technology categories and their top level segments that were created to enumerate and describe the Information Technology landscape were not intended to be mutually exclusive. A single patent family can be included in multiple categories.

Figure 15 visualizes the relationship between select technology segments. Each number in the diagram shows the number of inventions that have content related to both the corresponding row-wise and column-wise segments.

The most highly correlated segment pairings are computer networks with IT security; computer networks with database systems; and IT security with database systems. Other notable pairings include e-health and e-learning paired along with computer networks (including computer networks, IT security, and database systems). There is also a noticeable correlation between e-health and e-learning.

	1.01 Superc	1.02 Parallel Programming	1.03 Computer Modeling	1.04 Computer Simulation	2.01 Computer Networks	2.02 Cloud Computing	2.03 It Security And Privacy	2.04 Database Systems	3.01 Open Source Software (Oss	3.02 E-Learning	3.03 E-Health	3.04 Special Needs Applications	4.0 Rfid And Sensor Networks	5.01 Server/Data Center	5.02 Network Device	6.0 Intelligent Transportation	6.0 Intelligent Transportation
1.01 Superc	1240	133	9	40	155	25	49	29	1	17	17	3	1	11	2	2	2
1.02 Paralle		11103	183	664	341	218	112	372	19	61	40	2	4	27	17	3	1
1.03 Cc			493	110	25	33	9	27	2	8	2		1	4	4		
1.04 Cc				1653	73	26	23	33	2	25	10	1	2	9	7	1	
2.01 Cc					77651	1294	5196	2374	107	1133	1295	74	299	300	704	65	35
2.02 Cl						13847	1114	1249	72	320	285	7	32	148	39	20	15
2.03 It							50049	2833	115	628	685	43	122	91	62	35	26
2.04 Da								46101	113	1032	1209	59	186	152	32	29	13
3.01 Op									1317	36	14	4	3	5	1		
3.02 E-l										16450	1042	51	36	42	47	10	9
3.03 E-l											16712	103	122	86	54	16	13
3.04 Sp												4406	16	3	2	2	1
4.0 Rfic													5427	28	53	18	15
5.01 Se														4226	354	4	3
5.02 Ne															5442	7	6
6.0 Inte																2235	1800

Figure 15 - Number of Patent Families per Pair of Technology Segments, 2008 to 2013

PATENT ACTIVITY GEOGRAPHIC VOLUME BENCHMARKING

Figure 16 shows the number of patent families or inventions within the Information Technology patent collection that can be attributed to each nation . Patenting activity within the Information Technology topic is lead by the United States, followed at a distance by China, Japan, and South Korea.

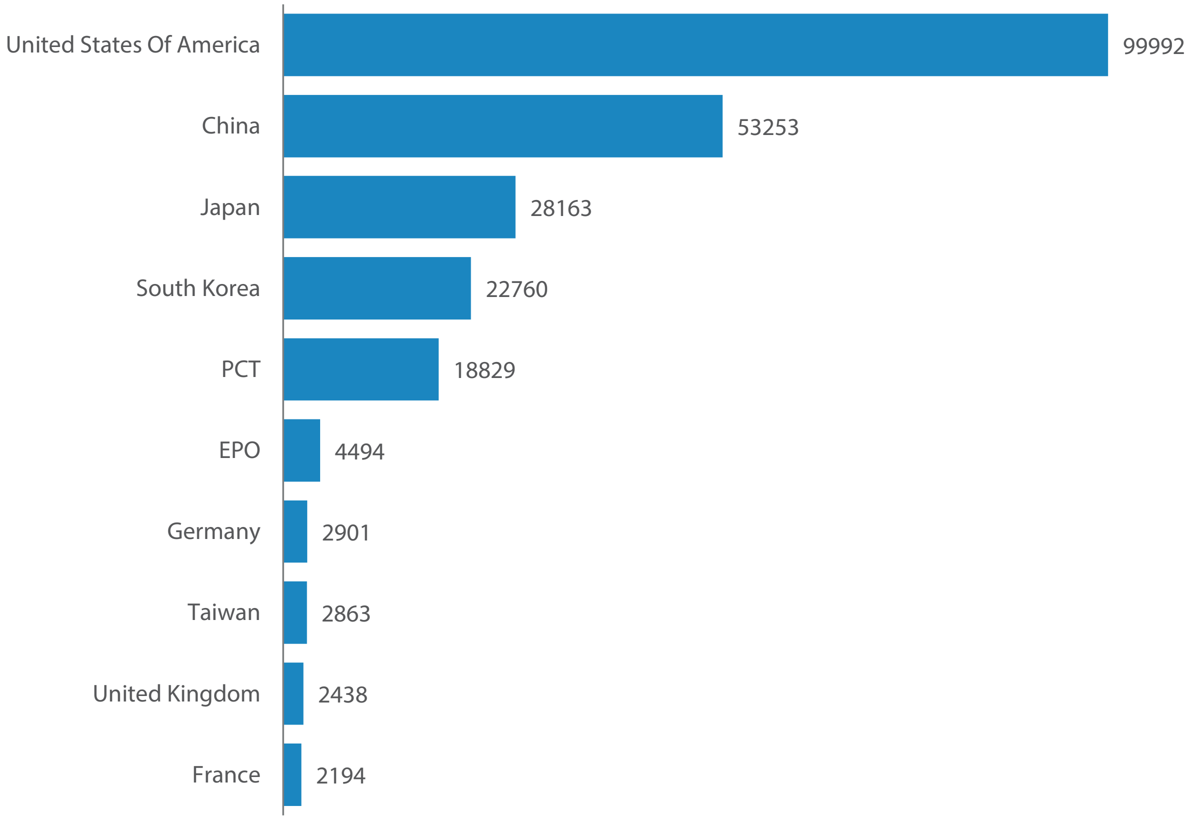


Figure 16 - Number of Patent Families per Country; 2008 to 2013

National attribution of patent activity is primarily performed via the priority filing location of the invention – this is the first filing event that occurs in the international protection of an invention at the various patent offices around the world. Actual geographic location of the inventor or the innovating corporation may vary from the priority filing location. This effect is exhibited primarily by Saudi Arabian entities, few of which file for patents within the Kingdom.

PATENT GEOGRAPHIC ACTIVITY TRENDS

Figure 17 illustrates precipitous growth of patent filings from Czech Republic, New Zealand, and Kingdom of Saudi Arabia followed by Belgium and Switzerland. Among the most prolific countries, only China features in the highest growth geographies. Most other prolific countries experience declines or no growth – including the United States, Japan, Germany, the United Kingdom, and France.

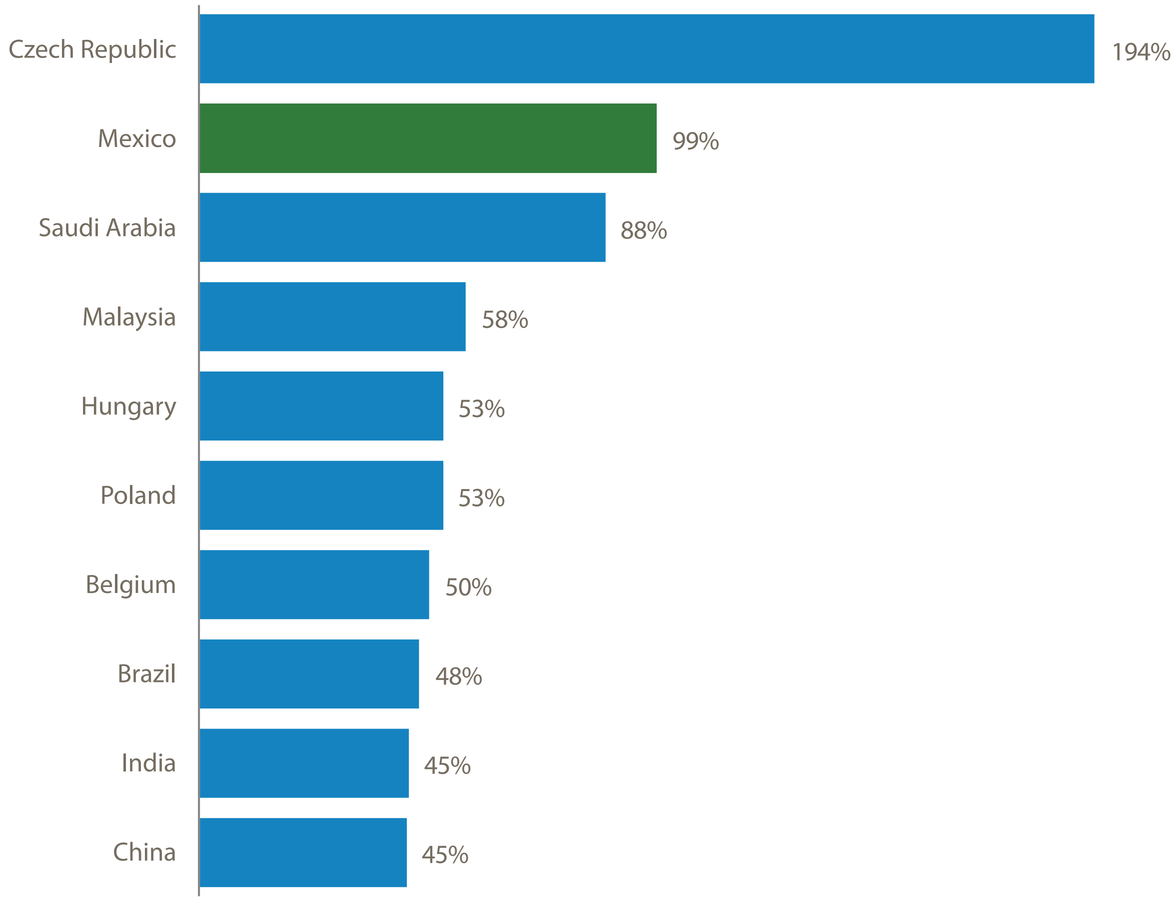


Figure 17 - Growth or Decline in Information Technology Patent Output

PATENT GEOGRAPHIC CITATION IMPACT BENCHMARKING

Figure 18 details the highest citation impact by nation. Patent citation is a widely utilized measurement of the impact and recognition of an individual patent, and by extension, aggregated groups of patents such as those assigned to a company or associated with the innovation of a nation or region. The measurement is useful as it provides an independent assessment of the quality and impact of the innovation contained within the patent. When aggregated, it provides a method of benchmarking collections of patents for the average impact in comparison to others, e.g. between two competing entities or between nations.
Patent citation information within this study is measured via citations to patent family members of the Derwent World Patents Index and from citation events of 26 national patent collections.
On this metric, Ireland the leads with the highest citation impact, followed by United States Kingdom of Saudi Arabia and New Zealand.

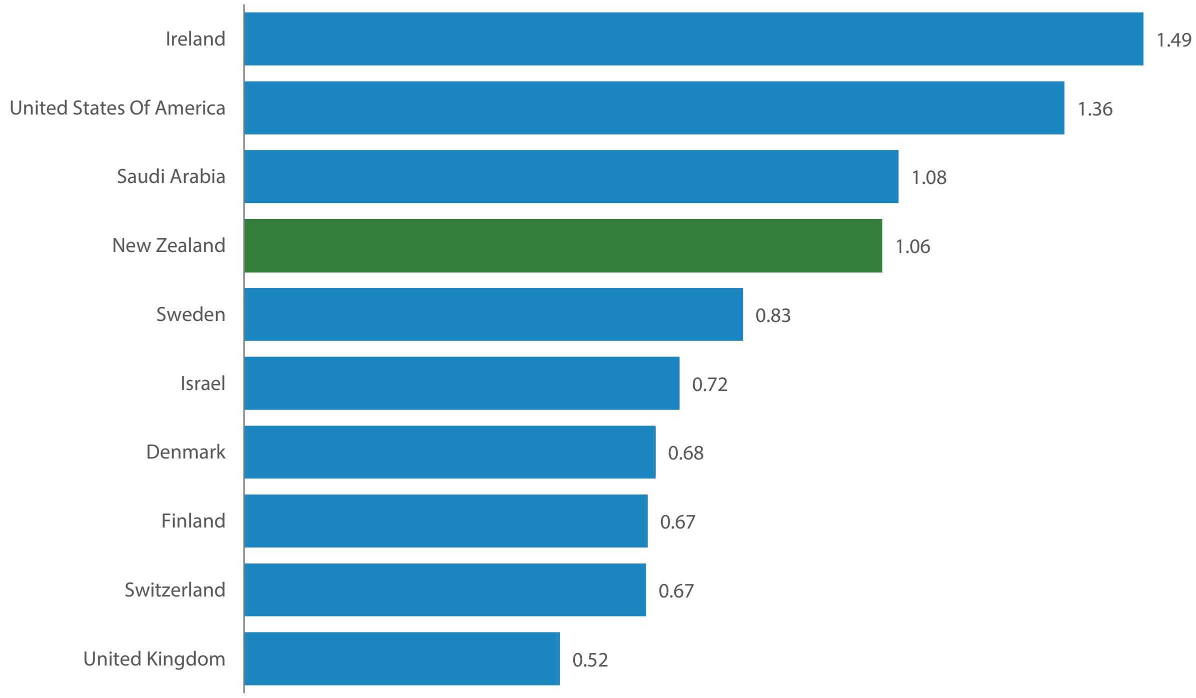


Figure 18 - Citation Impact of Information Technology Patents

INFORMATION TECHNOLOGY RESEARCH TOPIC BY GEOGRAPHY

Table 8 shows the split of Information Technology science and research specialization for the top nations. In most countries, focus appears to be high in computer networks, IT security, and database systems. All other areas see very little focus in the top jurisdictions. Kingdom of Saudi Arabia has 106 patents, focused in a variety of technologies, with highest focus on computer networks, IT security, and most notably e-health in which few other countries have high focus (such as Brazil, Canada, and Poland).

Country of Origin	1.01 Supercomputing	1.02 Parallel Computing	1.03 Computer Modelling	1.04 Computer Simulation	2.01 Computer Networks	2.02 Cloud Computing	2.03 IT Security	2.04 Database Systems	3.01 Open Source Software	3.02 E-Learning	3.03 E-Health	3.04 Special Needs Applications	4.0 RFID and Sensor Networks	5.01 Servers and datacenters	5.02 Network devices	6.0 Intelligent Transportation
United States Of America	1%	4%	0%	0%	43%	6%	22%	19%	1%	7%	7%	1%	2%	1%	1%	0%
China	0%	8%	1%	2%	25%	11%	14%	17%	1%	8%	7%	2%	4%	3%	5%	2%
Japan	1%	6%	0%	1%	18%	2%	29%	28%	0%	4%	8%	3%	0%	2%	1%	1%
South Korea	0%	3%	0%	0%	16%	4%	31%	26%	0%	11%	7%	4%	1%	2%	3%	1%
PCT	0%	4%	0%	0%	58%	4%	21%	12%	0%	4%	5%	1%	2%	1%	2%	1%
EPO	0%	3%	0%	1%	48%	2%	19%	17%	0%	4%	6%	2%	3%	1%	3%	1%
Germany	0%	4%	0%	0%	46%	2%	17%	9%	0%	4%	11%	4%	4%	1%	3%	2%
Taiwan	0%	3%	0%	0%	17%	9%	24%	28%	0%	13%	8%	2%	2%	1%	2%	1%
United Kingdom	0%	3%	0%	0%	50%	3%	19%	15%	1%	5%	5%	2%	4%	2%	3%	1%
France	0%	2%	0%	0%	52%	1%	19%	12%	0%	4%	7%	4%	3%	1%	2%	1%
India	0%	3%	0%	1%	30%	9%	19%	22%	1%	11%	7%	5%	4%	1%	2%	1%
Australia	0%	2%	0%	0%	34%	3%	22%	22%	1%	13%	9%	2%	4%	1%	1%	0%
Russian Federation	1%	4%	0%	0%	14%	2%	37%	20%	0%	12%	13%	2%	2%	0%	2%	2%
Italy	1%	3%	0%	1%	45%	1%	12%	15%	1%	4%	8%	6%	6%	0%	3%	3%
Canada	0%	2%	0%	0%	33%	4%	21%	15%	2%	13%	17%	2%	5%	2%	1%	1%
Spain	1%	2%	0%	0%	37%	1%	12%	13%	0%	5%	9%	12%	9%	1%	3%	2%
Finland	0%	2%	0%	0%	62%	3%	15%	10%	0%	3%	9%	1%	2%	1%	2%	1%
Brazil	0%	1%	0%	0%	14%	2%	13%	19%	0%	12%	20%	10%	10%	1%	4%	1%
Israel	1%	1%	0%	0%	45%	1%	33%	14%	0%	9%	5%	3%	1%	0%	1%	0%
Sweden	0%	3%	0%	1%	59%	2%	17%	11%	1%	2%	7%	5%	3%	1%	1%	0%
Malaysia	0%	2%	0%	0%	48%	6%	31%	13%	0%	5%	1%	0%	3%	2%	2%	1%
Singapore	0%	2%	0%	0%	33%	2%	27%	20%	0%	7%	11%	2%	7%	1%	2%	1%
South Africa	0%	1%	0%	1%	32%	3%	27%	31%	1%	8%	4%	2%	3%	1%	1%	1%
Netherlands	0%	3%	0%	0%	34%	0%	24%	22%	0%	4%	11%	4%	3%	2%	0%	0%
Saudi Arabia	1%	8%	0%	8%	33%	0%	24%	8%	0%	3%	16%	3%	5%	0%	5%	2%
Denmark	0%	5%	0%	2%	51%	4%	11%	12%	0%	2%	8%	12%	4%	0%	5%	0%
Norway	1%	1%	0%	0%	53%	0%	23%	19%	0%	1%	9%	6%	1%	0%	1%	2%
Poland	0%	11%	0%	1%	15%	4%	18%	16%	1%	4%	19%	16%	0%	0%	1%	0%
Austria	0%	8%	0%	3%	56%	1%	17%	4%	0%	3%	4%	8%	5%	0%	0%	1%
New Zealand	0%	7%	0%	1%	33%	1%	19%	25%	0%	10%	12%	1%	1%	0%	1%	0%

Table 10 – Information Technology Specialization by Country; % of Patent Activity per Technical Stream

PATENT FILINGS – PROLIFIC GLOBAL ENTITIES

The list of prolific entities filing patents includes a electronics manufacturers and computer systems manufacturers. Science & Technology Unit, Umm Al-Qura University (STU-UQU) appears to have no patent filings in the Information technology space. Within the space, IBM, Microsoft, and Qualcomm appear to be very highly active in patent filings, with significantly higher number of patents than other top entities. This is indicative of a monopolized space, with large players dominating the field with patent filings. While the space appears to be crowded, there are opportunities for filing patents as discussed previously, in conjunction with table 7.

Entity	Total	Times Cited	Citation per family
INT BUSINESS MACHINES CORP	7539	10704	1.42
MICROSOFT CORP	4379	8130	1.86
QUALCOMM INC	3844	1728	0.45
SAMSUNG ELECTRONICS CO LTD	2632	1446	0.55
HUAWEI TECHNOLOGIES CO LTD	2516	430	0.17
FUJITSU LTD	2254	1193	0.53
NEC CORP	2114	1081	0.51
TELEFONAKTIEBOLAGET ERICSSON L M	2051	1325	0.65
ZTE CORP	1904	176	0.09
INTEL CORP	1890	1492	0.79
NOKIA CORP	1701	1466	0.86
GOOGLE INC	1623	1393	0.86
HITACHI LTD	1603	1478	0.92
CISCO TECHNOLOGY INC	1590	1366	0.86
ELECTRONICS & TELECOM RES INST	1541	872	0.57
TOSHIBA KK	1465	825	0.56
CANON KK	1392	495	0.36
ALCATEL LUCENT	1357	610	0.45
STATE GRID CORP CHINA	1334	3	0.00
LG ELECTRONICS INC	1333	611	0.46
HEWLETT-PACKARD DEV CO LP	1318	964	0.73
APPLE INC	1209	1342	1.11
SONY CORP	1111	748	0.67
ORACLE INT CORP	1049	2112	2.01
RICOH KK	1013	542	0.54
RES IN MOTION LTD	997	595	0.60
BROADCOM CORP	968	575	0.59
AT & T INTELLECTUAL PROPERTY I LP	895	409	0.46
MITSUBISHI ELECTRIC CORP	859	368	0.43
SIEMENS AG	847	325	0.38

Table 11 – Information Technology – Top entities for Patents

PATENT OVERVIEW OF TOP GLOBAL ENTITIES

Table 10 shows the technology profile of the top 30 entities within the patent landscape of Information Technology. Almost all prolific entities focus primarily on Computer Network technologies (including computer networks, cloud computing, IT security, and database systems). IBM, Toshiba, and Canon are entities that are focusing on parallel computing in addition to computer networks. Toshiba and Siemens are notably the only entities with a significant patent portfolio in e-health technology. Science & Technology Unit, Umm al Qura University (STU-UQU) has 1 patent filed in special needs applications

Entity	1.01 Supercomputing	1.02 Parallel Computing	1.03 Computer Modelling	1.04 Computer Simulation	2.01 Computer Networks	2.02 Cloud Computing	2.03 IT Security	2.04 Database Systems	3.01 Open Source Software	3.02 E-Learning	3.03 E-Health	3.04 Special Needs Applications	4.0 RFID and Sensor Networks	5.01 Servers and datacenters	5.02 Network devices	6.0 Intelligent Transportation
INT BUSINESS MACHINES CORP	123	798	15	50	1812	1027	1746	2118	62	346	151	53	96	164	36	7
MICROSOFT CORP	37	164	13	28	1480	525	1299	885	11	366	85	16	26	46	23	3
QUALCOMM INC	9	55		1	3409	14	286	97	7	86	66	4	23	27	86	5
SAMSUNG ELECTRONICS CO LTD	7	147	1	6	1178	99	643	286	14	78	121	52	3	59	121	9
HUAWEI TECHNOLOGIES CO LTD	2	101	3	13	1815	117	256	175	3	41	6	2	1	20	84	5
FUJITSU LTD	49	197	4	36	685	55	553	495	2	91	109	17	11	48	34	19
NEC CORP	26	135	1	8	674	32	634	538	1	57	48	20	5	47	20	7
TELEFONAKTIEBOLAGET ERICSSON L M		19	5	1	1672	49	178	154	1	40	29	2	2	9	81	9
ZTE CORP		102	2	9	1254	103	236	164	7	44	8	6	8	9	49	2
INTEL CORP	65	99	5	6	1065	88	477	75	12	58	62	5	22	64	72	3
NOKIA CORP	2	9		1	1345	30	219	110	1	50	25	11	4	12	50	2
GOOGLE INC	3	102	10	3	810	98	337	220	14	163	24	7		15	2	5
HITACHI LTD	8	118	4	9	313	40	408	599	4	40	51	10	9	66	31	7
CISCO TECHNOLOGY INC	2	5	1		1249	61	244	88	2	72	6	2	8	10	110	7
ELECTRONICS & TELECOM RES INST	4	118		3	374	82	436	282	5	79	54	31	46	31	116	18
TOSHIBA KK	4	117	1	9	213	31	401	400	1	32	248	15	5	16	14	16
CANON KK		133	3	6	488	94	423	223	1	17	46	16		11	10	
ALCATEL LUCENT		14		1	1003	64	156	125	3	54	26	7	5	11	50	1
STATE GRID CORP CHINA	1	77	17	61	394	50	134	376	7	98	2	1	15	104	146	4
LG ELECTRONICS INC		17			903	19	195	120		21	43	15	4	23	45	5
HEWLETT-PACKARD DEV CO LP	4	41	2	3	550	114	346	256	10	70	18	1	12	40	20	3
APPLE INC	2	39			723	19	256	107	8	51	65	12	1	8	32	2
SONY CORP	2	92		10	422	37	254	182	2	71	61	16	5	12	16	1
ORACLE INT CORP	35	19		1	197	68	194	647	6	12	8	1	11	6		
RICOH KK		67		2	157	38	432	256	1	26	50	26	3	13	21	3
RES IN MOTION LTD		4			717	3	195	77	1	23	10	10	5	4	25	3
BROADCOM CORP	2	26		2	688	6	99	31		39	23	1	18	23	116	4
AT & T INTELLECTUAL PROPERTY I LP	1	1		2	660	22	177	87	1	33	20	5	8	1	9	2
MITSUBISHI ELECTRIC CORP		86		15	199	1	220	257	3	19	17	27	12	3	26	9
SIEMENS AG		27	1	8	375	19	135	74	1	38	164	3	37	4	38	8

Table 12 – Patent overview of top global entities

PATENT OVERVIEW OF TOP ASIA PACIFIC ENTITIES

Entity	Country of Origin	Total	1.01 Supercomputing	1.02 Parallel Programming	1.03 Computer Modeling	1.04 Computer Simulation	2.01 Computer Networks	2.02 Cloud Computing	2.03 It Security And Privacy	2.04 Database Systems	3.01 Open Source Software (Oss	3.02 E-Learning	3.03 E-Health	3.04 Special Needs Applications	4.0 Rfid And Sensor Networks	5.01 Server/Data Center	5.02 Network Device	6.0 Intelligent Transportation
Science & Technology Unit, Umm Al Qura University (STU-UQU)	Saudi Arabia	1												1				
Samsung Electronics Co Ltd	South Korea	2199	6	119	1	6	930	75	564	261	14	65	112	43	3	55	99	8
Nec Corp	Japan	2050	26	130	1	8	627	30	630	535	1	56	48	20	4	45	17	7
Zte Corp	CHina	1842		100	2	9	1204	102	227	161	7	44	8	6	8	9	48	2
Huawei Technologies Co Ltd	China	1702		75	2	12	1185	71	186	127	3	28	3	2	1	13	52	4
Fujitsu Ltd	Japan	1543	41	138	2	23	357	30	394	394	1	79	84	17	10	34	23	15
Electronics & Telecom Res Inst	South Korea	1534	4	118		3	367	82	436	282	5	79	54	31	46	31	116	18
State Grid Corp China	China	1334	1	77	17	61	394	50	134	376	7	98	2	1	15	104	146	4
Hitachi Ltd	Japan	1302	8	95	4	6	196	23	349	516	3	40	37	7	9	60	29	5
Canon Kk	Japan	1301		127	3	6	422	92	405	220	1	14	45	16		11	10	
Toshiba Kk	Japan	1276	4	106	1	9	147	28	327	373	1	28	243	13	5	13	8	16
Nippon Telegraph&Telephone Corp	Japan	920	1	46	2	3	188	17	280	305		47	37	20		15	9	
Ricoh Kk	Japan	874		62		2	124	26	374	226	1	16	40	25	1	12	21	3
Panasonic Corp	Japan	861	2	63		4	300	2	258	107		21	40	47	9	20	10	17
Sk Telecom Co Ltd	South Korea	843		6		4	127	144	261	204		100	38	5	6	9	8	8
Sony Corp	Japan	778	2	80		8	256	25	195	130		50	50	6	3	11	11	1
Kt Corp	South Korea	743		10		1	132	40	286	213	5	52	24	8	2	11	20	6
Lg Electronics Inc	South Korea	657		12			314	10	155	97		14	15	14	3	18	29	2
Mitsubishi Electric Corp	Japan	652		77		15	103	1	176	222	2	9	15	20	9	3	19	8
Tencent Technology Shenzhen Co Ltd	China	593		15			209	32	227	112	5	15	2	1		9	2	1
Hon Hai Precision Ind Co Ltd	Taiwan	558	2	12			145	52	154	142	2	9	10	17	6	32	3	

Table 13 – Patent overview of top Asia Pacific entities

PATENT OVERVIEW OF TOP MIDDLE EAST & AFRICA ENTITIES

Table 12 illustrates the top patenting entities in the Middle East and Africa. The space appears to be dominated by smaller, local players, particularly from the Kingdom of Saudi Arabia (KSA), Turkey, and South Africa. Further, General Electric appears to be the only large multinational that is not based in KSA, Turkey, or South Africa. This indicates of a geographic region used majorly only by local players and not often by large multinationals.

Entity	Country of Origin	Total	1.01 Supercomputing	1.02 Parallel Computing	1.04 Computer Simulation	2.01 Computer Networks	2.02 Cloud Computing	2.03 IT Security	2.04 Database Systems	3.01 Open Source Software	3.02 E-Learning	3.03 E-Health	3.04 Special Needs Applications	4.0 RFID and Sensor Networks	5.01 Servers and datacenters	5.02 Network devices	6.0 Intelligent Transportation
Science & Technology Unit, Umm Al Qura University (Stu-Uqu	Saudi Arabia	1										1				5	
Saudi Aramco	Saudi Arabia	52	1	7	9	17		4	2	1	14		2	4		1	1
Univ Dhahran King Fahd Petroleum&Miner	Saudi Arabia	31		2	1	10		13	1	2			3	1	1		
Univ King Saud	Saudi Arabia	11				2		7	2			2					
Turkcell Iletisim Hizmetleri Anonim Sirk	Turkey	9				5		2	1	2	1						
Discovery Holdings Ltd	South Africa	7				1			5	2	1						
Entersect Technologies Pty Ltd	South Africa	7				2		6	1							1	
King Abdulaziz City Sci & Technology	Saudi Arabia	7				3		1	2		1			1			
Univ King Abdullah Sci&Technology	Saudi Arabia	6				4		1	1								
Visa Int Service Assoc	South Africa	6				1	1	5									
Arcelik Anonim Sirketi	Turkey	5				1				3			1				
Krea Content Services & Production Joint	Turkey	5						1	4								
Aselsan Elektronik Sanayi Ve Ticaret As	Turkey	4				4											
General Electric Co	Saudi Arabia	4				3		1					1				
Nokia Corp	South Africa	4				2	1	1	1								
Univ Cape Town	South Africa	4		1		2							1				
Fundamo Pty Ltd	South Africa	3				3											
Ipico South Africa Pty Ltd	South Africa	3				1							2				
Tubitak-Turkiye Bilimsel Ve Teknolojik	Turkey	3		1					2								
Airties Kablosuz Iletisim Sanayi Ve Dis	Turkey	2				2											
Avea Iletisim Hizmetleri Anonim Sirketi	Turkey	2				1			1								
Capital Supreme Pty Ltd	South Africa	2						2									
Fireflight Pty Ltd	South Africa	2						2		1							
Fireid Pty Ltd	South Africa	2						2		1							
Irdeto Bv	South Africa	2					1	2									
Irdeto Canada Corp	South Africa	2					1	2									
Joubert F M	South Africa	2						2		1							
Konink Philips Electronics Nv	South Africa	2					1	2									
Netas Telekomunikasyon Anonim Sirketi	Turkey	2				1			1								
Prosense Technology Pty Ltd	Saudi Arabia	2						2	1								
Radio Surveillance Technologies Pty Ltd	Saudi Arabia	2				1		1									

Table 14 – Patent overview of top Middle East & Africa entities

PATENT OVERVIEW OF TOP SAUDI ARABIA ENTITIES

Entity	Total	1.01 Supercomputing	1.02 Parallel Computing	1.04 Computer Simulation	2.01 Computer Networks	2.02 Cloud Computing	2.03 IT Security	2.04 Database Systems	3.01 Open Source Software	3.02 E-Learning	3.03 E-Health	3.04 Special Needs Applications	4.0 RFID and Sensor Networks	5.01 Servers and datacenters	5.02 Network devices	6.0 Intelligent Transportation
Science & Technology Unit, Umm Al Qura University (STU-UQU)	1											1				
Saudi Aramco	52	1	7	9	17		4	2	1	14		2	4		1	1
Univ Dhahran King Fahd Petroleum&Miner	31		2	1	10		13	1	2			3	1	1		
Univ King Saud	11				2		7	2			2					
King Abdulaziz City Sci & Technology	7				3		1	2		1			1			
Univ King Abdullah Sci&Technology	6				4		1	1								
King Abdullah Int Medical Res Cent	1				1						1	1				
Nat Guard Health Affairs	1				1						1					
Univ King Abdulaziz Health Sci Saud Bin	1				1						1					
Univ Taif	1				1											1

Table 15 – Patent overview of top Saudi Arabia entities

MIDDLE EAST & AFRICA INFORMATION TECHNOLOGY PATENT TRENDS

This section of the report focuses on the patent collection and the activity and technological trends seen within it – in the Middle East and Africa.

MIDDLE EAST & AFRICA – PROLIFIC COUNTRIES

Patent filing trends appear to be very different from the scientific literature trends. Figure 19 shows that South Africa is the most popular country for filing patents within the two regions, followed by Saudi Arabia, and Turkey. The remaining jurisdictions see only marginal patent filings.

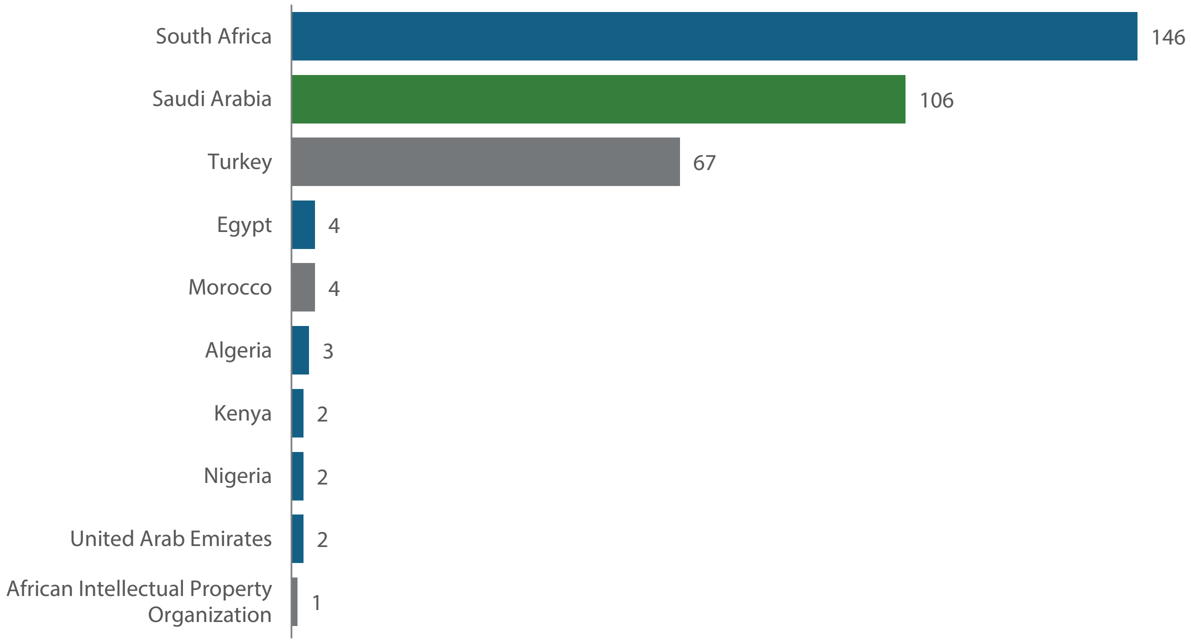


Figure 19 – Middle East & Africa – Prolific Countries in Patents

Diving deeper, Table 11 shows that South Africa, and Turkey appear to be consistent with the global patent focus on computer networks (including computer networks, IT security, and database systems); and to a lesser extent on e-learning. The Kingdom of Saudi Arabia has 106 patents, with notable focus on e-health technology. It is interesting to note that patent filings in cloud computing, and parallel computing are lagging considerably behind the global levels, in these two regions.

Country of Origin	1.01 Supercomputing	1.02 Parallel Computing	1.04 Computer Simulation	2.01 Computer Networks	2.02 Cloud Computing	2.03 IT Security	2.04 Database Systems	3.01 Open Source Software	3.02 E-Learning	3.03 E-Health	3.04 Special Needs Applications	4.0 RFID and Sensor Networks	5.01 Servers and datacenters	5.02 Network devices	6.0 Intelligent Transportation
South Africa		2	1	47	4	39	45	1	11	6	3	5	1	1	1
Saudi Arabia	1	9	9	35		25	8		3	17	3	5		5	2
Turkey		1		25		16	13	1	11	3	3	3			1
Egypt				2		2						1			
Morocco				3		1	1		1						
Algeria				3											
Kenya				2											
Nigeria										2					
United Arab Emirates				1		2									
African Intellectual Property Organization							1								
Armenia				1			1								
Azerbaijan						1	1								
Iran											1				
Tunisia										1					

Table 16 – Middle East & Africa – Prolific Countries over Technical categories

APPENDIX A – SCIENTIFIC PAPERS TOP AFFILIATIONS

ENTITY-LEVEL DATA TABLES FOR SCIENTIFIC LITERATURE COLLECTION

Table 13 on the following pages shows the top 10 author organizations for each of the technology categories. This information is intended to provide an assessment of the depth and location of the research expertise available in each category.

Technology	Entity	Total
1.01 Supercomputing	UNIVERSITY OF CALIFORNIA SYSTEM	50
	CHINESE ACAD SCI	39
	OAK RIDGE NATL LAB	38
	NATL UNIV DEF TECHNOL	34
	UNIV TENNESSEE	29
	ARGONNE NATL LAB	29
	UNIV ILLINOIS	27
	IBM CORP	23
	RUSSIAN ACAD SCI	22
	LOS ALAMOS NATL LAB	22
1.02 Parallel Computing	UNIVERSITY OF CALIFORNIA SYSTEM	154
	CHINESE ACAD SCI	132
	TSINGHUA UNIV	128
	UNIV ILLINOIS	101
	OAK RIDGE NATL LAB	88
	NATL UNIV DEF TECHNOL	84
	ZHEJIANG UNIV	84
	UNIV TEXAS AUSTIN	83
	STANFORD UNIV	73
	UNIV TENNESSEE	70
1.03 Computer Modelling	UNIVERSITY OF CALIFORNIA SYSTEM	84
	CHINESE ACAD SCI	66
	TSINGHUA UNIV	61
	UNIV ILLINOIS	42
	NATL UNIV SINGAPORE	34
	NANYANG TECHNOL UNIV	31
	OAK RIDGE NATL LAB	30
	UNIV LONDON IMPERIAL COLL SCI TECHNOL & MED	30
	ECOLE POLYTECH FED LAUSANNE	30
	PURDUE UNIV	28
1.04 Computer Simulation	TSINGHUA UNIV	86
	CHINESE ACAD SCI	81
	UNIVERSITY OF CALIFORNIA SYSTEM	81
	NANYANG TECHNOL UNIV	59
	OAK RIDGE NATL LAB	57
	UNIV ILLINOIS	56
	SHANGHAI JIAO TONG UNIV	53
	MIT	44
	ZHEJIANG UNIV	43
	NATL UNIV SINGAPORE	42

Top 10 Entities per Technology Stream

continued

Technology	Entity	Total
2.01 Computer Networks	Tsinghua Univ	128
	Natl Cheng Kung Univ	106
	Chinese Acad Sci	104
	Natl Chiao Tung Univ	101
	Nanyang Technol Univ	92
	Beijing Univ Posts & Telecommun	82
	Univ Waterloo	80
	Natl Taiwan Univ	77
	Hong Kong Univ Sci & Technol	76
	Univ Illinois	75
2.02 Cloud Computing	Chinese Acad Sci	117
	Nasa	87
	Tsinghua Univ	84
	Univ Melbourne	71
	Huazhong Univ Sci & Technol	61
	Fujitsu Ltd	51
	Univ Wisconsin	50
	Univ Maryland	47
	Nanyang Technol Univ	44
	Shanghai Jiao Tong Univ	43
2.03 IT Security	UNIVERSITY OF CALIFORNIA SYSTEM	93
	Chinese Acad Sci	87
	Texas A&M Univ	53
	Purdue Univ	52
	Tsinghua Univ	50
	Univ Waterloo	50
	Shanghai Jiao Tong Univ	47
	Natl Cheng Kung Univ	47
	Korea Univ	46
	Xidian Univ	45
2.04 Database Systems	Chinese Acad Sci	58
	Nanyang Technol Univ	57
	Northeastern Univ	49
	Hong Kong Polytech Univ	46
	City Univ Hong Kong	44
	Univ Granada	43
	Korea Adv Inst Sci & Technol	42
	Natl Univ Singapore	42
	Peking Univ	41
	Hong Kong Univ Sci & Technol	41

Top 10 Entities per Technology Stream

continued

Technology	Entity	Total
3.01 Open Source Software	HARVARD UNIV	102
	UNIVERSITY OF CALIFORNIA SYSTEM	91
	MIT	60
	STANFORD UNIV	54
	UNIV WASHINGTON	50
	UNIV GHENT	44
	UNIV ILLINOIS	41
	UCL	41
	UNIV CALIF SAN DIEGO	40
	ETH	40
3.02 E-Learning	NATL CHENG KUNG UNIV	54
	NATL TAIWAN UNIV SCI & TECHNOL	41
	NATL CHIAO TUNG UNIV	38
	UNIV CARLOS III MADRID	38
	NATL CENT UNIV	33
	NANYANG TECHNOL UNIV	29
	CITY UNIV HONG KONG	27
	NATL UNIV TAINAN	27
	HARVARD UNIV	25
	NATL CHANGHUA UNIV EDUC	24
3.03 E-Health	UNIVERSITY OF CALIFORNIA SYSTEM	330
	HARVARD UNIV	163
	UNIV TORONTO	148
	UNIV MICHIGAN	122
	UNIV PENN	106
	UNIV PITTSBURGH	105
	UNIV WASHINGTON	105
	COLUMBIA UNIV	101
	UNIV QUEENSLAND	101
	MAYO CLIN	83
3.04 Special Needs Applications	UNIV WISCONSIN	20
	UNIV CAMBRIDGE	18
	UNIV TEXAS DALLAS	18
	RADBOUD UNIV NIJMEGEN	17
	INDIANA UNIV	16
	UNIV MANCHESTER	15
	UNIV MINNESOTA	14
	HOUSE EAR RES INST	14
	UNIV TORONTO	12
	JOHNS HOPKINS UNIV	12

Top 10 Entities per Technology Stream
continued

Technology	Entity	Total
4.0 RFID and Sensor Networks	NANYANG TECHNOL UNIV	61
	CHINESE ACAD SCI	59
	TSINGHUA UNIV	55
	ZHEJIANG UNIV	45
	HONG KONG UNIV SCI & TECHNOL	42
	NATL CHIAO TUNG UNIV	41
	MIT	39
	HONG KONG POLYTECH UNIV	39
	SHANGHAI JIAO TONG UNIV	37
	GEORGIA INST TECHNOL	37
5.01 Servers and datacenters	UNIVERSITY OF CALIFORNIA SYSTEM	33
	TSINGHUA UNIV	19
	CHINESE ACAD SCI	17
	KOREA ADV INST SCI & TECHNOL	17
	STANFORD UNIV	16
	FUJITSU LTD	14
	UNIV MICHIGAN	13
	INTEL CORP	11
	HUAZHONG UNIV SCI & TECHNOL	10
	IBM CORP	10
5.02 Network Devices	TSINGHUA UNIV	162
	CHINESE ACAD SCI	134
	KOREA ADV INST SCI & TECHNOL	125
	NANYANG TECHNOL UNIV	107
	GEORGIA INST TECHNOL	99
	INDIAN INST TECHNOL	85
	NATL CHIAO TUNG UNIV	83
	SHANGHAI JIAO TONG UNIV	81
	SEOUL NATL UNIV	78
	SOUTHEAST UNIV	77
6.0 Intelligent Transportation	CHINESE ACAD SCI	30
	NATL CHIAO TUNG UNIV	26
	BEIJING JIAOTONG UNIV	20
	UNIVERSITY OF CALIFORNIA SYSTEM	19
	TSINGHUA UNIV	18
	DELFT UNIV TECHNOL	18
	NATL TECH UNIV ATHENS	17
	NATL CHENG KUNG UNIV	15
	CLEMSON UNIV	15
	MONASH UNIV	14

Table 17 - Top 10 Paper Publishing Organizations per Technology Category

APPENDIX B — PATENT STATISTICS AND TABLES

ENTITY-LEVEL DATA TABLES FOR PATENT COLLECTION

The table below and on the following pages show the top 10 patent applicants or patent assignees for each of the technology categories. This information is intended to provide an assessment of expertise and patent commercialization intent per category.

Top 10 Entities per Technology Stream

Technology	Entity	Total
1.01 Supercomputing	INT BUSINESS MACHINES CORP	123
	INTEL CORP	65
	ORACLE INT CORP	59
	FUJITSU LTD	49
	MICROSOFT CORP	37
	NEC CORP	26
	SUN MICROSYSTEMS INC	19
	MARVELL INT LTD	16
	FUSION IO INC	13
	CRAY INC	12
1.02 Parallel Computing	INT BUSINESS MACHINES CORP	798
	NVIDIA CORP	300
	FUJITSU LTD	197
	MICROSOFT CORP	164
	SAMSUNG ELECTRONICS CO LTD	147
	NEC CORP	135
	CANON KK	133
	HITACHI LTD	118
	ELECTRONICS & TELECOM RES INST	118
	TOSHIBA KK	117
1.03 Computer Modelling	STATE GRID CORP CHINA	21
	INT BUSINESS MACHINES CORP	15
	MICROSOFT CORP	13
	UNIV ZHEJIANG	11
	GOOGLE INC	10
	UNIV BEIJING AERONAUTICS&ASTRONAUTICS	10
	CHINA ELECTRIC POWER RES INST	9
	UNIV XIDIAN	9
	UNIV SOUTHEAST	9
	UNIV SHANGHAI JIAOTONG	6
1.04 Computer Simulation	STATE GRID CORP CHINA	69
	INT BUSINESS MACHINES CORP	50
	UNIV BEIJING AERONAUTICS & ASTRONAUTICS	50
	FUJITSU LTD	36
	CHINA ELECTRIC POWER RES INST	30
	MICROSOFT CORP	28
	UNIV QINGHUA	26
	UNIV NORTHWESTERN POLYTECHNICAL	20
	NVIDIA CORP	17
	MITSUBISHI ELECTRIC CORP	15

Top 10 Entities per Technology Stream

continued

Technology	Entity	Total
2.01 Computer Networks	QUALCOMM INC	3409
	HUAWEI TECHNOLOGIES CO LTD	1815
	INT BUSINESS MACHINES CORP	1812
	TELEFONAKTIEBOLAGET ERICSSON L M	1672
	MICROSOFT CORP	1480
	NOKIA CORP	1345
	ZTE CORP	1254
	CISCO TECHNOLOGY INC	1249
	SAMSUNG ELECTRONICS CO LTD	1178
	INTEL CORP	1065
2.02 Cloud Computing	INT BUSINESS MACHINES CORP	1027
	MICROSOFT CORP	525
	HUAWEI TECHNOLOGIES CO LTD	117
	HEWLETT-PACKARD DEV CO LP	114
	INSPUR ELECTRONIC INFORMATION IND CO LTD	112
	SK PLANET CO LTD	107
	ZTE CORP	103
	SAMSUNG ELECTRONICS CO LTD	99
	GOOGLE INC	98
	CANON KK	94
2.03 IT Security	INT BUSINESS MACHINES CORP	1746
	MICROSOFT CORP	1299
	SAMSUNG ELECTRONICS CO LTD	643
	NEC CORP	634
	FUJITSU LTD	553
	INTEL CORP	477
	SYMANTEC CORP	442
	ELECTRONICS & TELECOM RES INST	436
	RICOH KK	432
	CANON KK	423
2.04 Database Systems	INT BUSINESS MACHINES CORP	2118
	MICROSOFT CORP	885
	HITACHI LTD	815
	ORACLE INT CORP	647
	SALESFORCE.COM INC	568
	NEC CORP	538
	FUJITSU LTD	495
	TOSHIBA KK	400
	SAP AG	382
	STATE GRID CORP CHINA	376

Top 10 Entities per Technology Stream

continued

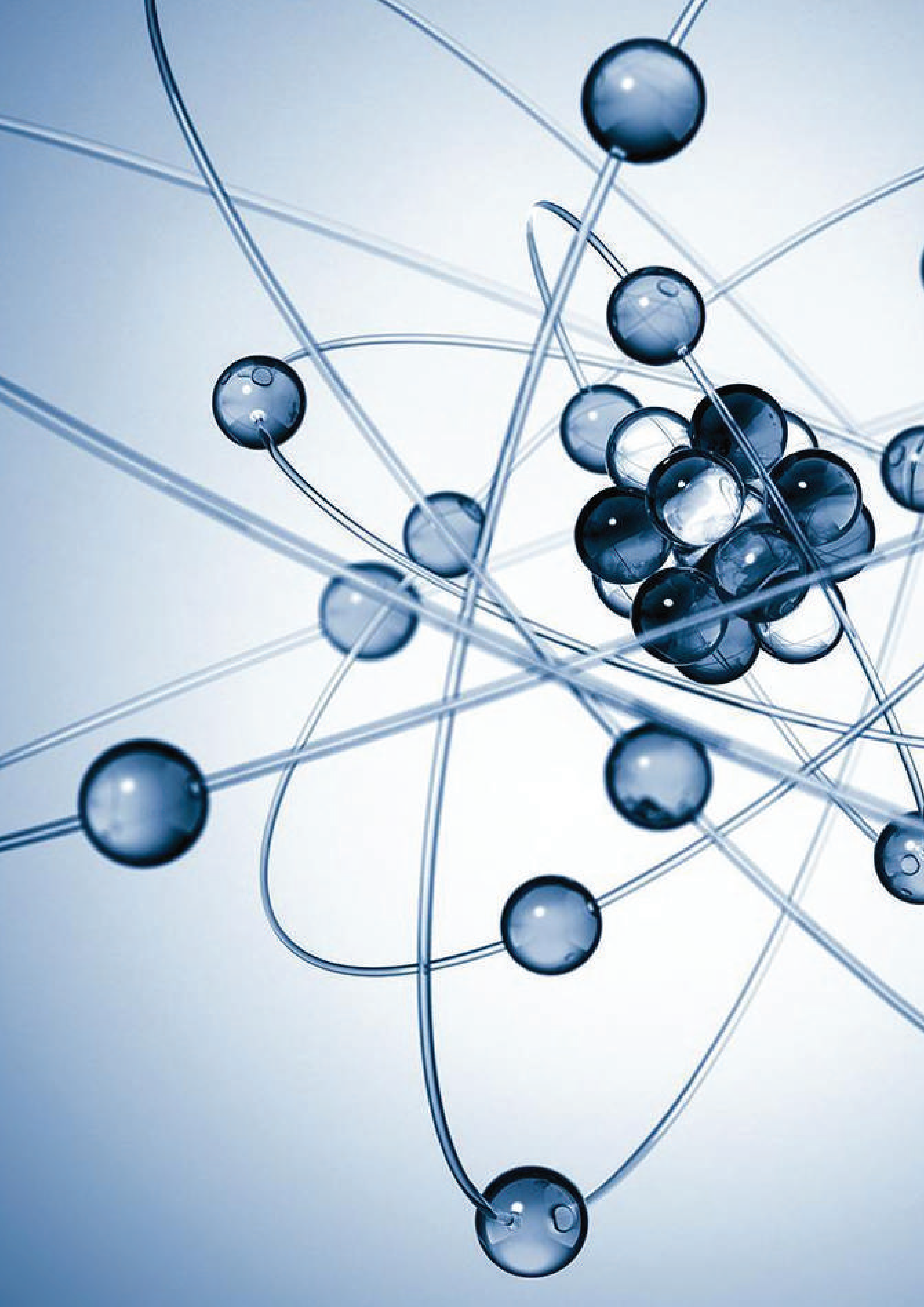
Technology	Entity	Total
3.01 Open Source Software	INT BUSINESS MACHINES CORP	69
	INSPUR ELECTRONIC INFORMATION IND CO LTD	27
	SAMSUNG ELECTRONICS CO LTD	14
	GOOGLE INC	14
	INTEL CORP	12
	MICROSOFT CORP	11
	HEWLETT-PACKARD DEV CO LP	10
	APPLE INC	8
	UNIV ZHEJIANG	8
	SONATYPE INC	8
3.02 E-Learning	MICROSOFT CORP	366
	INT BUSINESS MACHINES CORP	346
	GOOGLE INC	163
	YAHOO INC	132
	STATE GRID CORP CHINA	98
	SK TELECOM CO LTD	97
	FUJITSU LTD	91
	QUALCOMM INC	86
	ELECTRONICS & TELECOM RES INST	79
	SAMSUNG ELECTRONICS CO LTD	78
3.03 E-Health	TOSHIBA KK	509
	KONINK PHILIPS ELECTRONICS NV	190
	GENERAL ELECTRIC CO	178
	SIEMENS AG	164
	INT BUSINESS MACHINES CORP	151
	KONICA MINOLTA MG KK	141
	SAMSUNG ELECTRONICS CO LTD	121
	FUJI FILM CO LTD	120
	FUJITSU LTD	109
	CERNER INNOVATION INC	88
3.04 Special Needs Applications	INT BUSINESS MACHINES CORP	66
	SAMSUNG ELECTRONICS CO LTD	52
	ELECTRONICS & TELECOM RES INST	31
	MATSUSHITA DENKI SANGYO KK	27
	MITSUBISHI ELECTRIC CORP	27
	RICOH KK	26
	PANASONIC CORP	24
	NEC CORP	20
	OTICON AS	20
	FUJITSU LTD	17

Top 10 Entities per Technology Stream

continued

Technology	Entity	Total
4.0 RFID and Sensor Networks	INT BUSINESS MACHINES CORP	96
	ELECTRONICS & TELECOM RES INST	46
	AVERY DENNISON CORP	41
	SYMBOL TECHNOLOGIES INC	38
	SIEMENS AG	37
	KONINK PHILIPS ELECTRONICS NV	34
	GENERAL ELECTRIC CO	32
	3M INNOVATIVE PROPERTIES CO	30
	HONEYWELL INT INC	27
	IMPINJ INC	27
5.01 Servers and datacenters	INT BUSINESS MACHINES CORP	164
	STATE GRID CORP CHINA	104
	INSPUR ELECTRONIC INFORMATION IND CO LTD	76
	HITACHI LTD	66
	INTEL CORP	64
	SAMSUNG ELECTRONICS CO LTD	59
	FUJITSU LTD	48
	NEC CORP	47
	MICROSOFT CORP	46
	HEWLETT-PACKARD DEV CO LP	40
5.02 Network devices	STATE GRID CORP CHINA	146
	SAMSUNG ELECTRONICS CO LTD	121
	ELECTRONICS & TELECOM RES INST	116
	BROADCOM CORP	116
	CISCO TECHNOLOGY INC	110
	QUALCOMM INC	86
	HUAWEI TECHNOLOGIES CO LTD	84
	TELEFONAKTIEBOLAGET ERICSSON L M	81
	INTEL CORP	72
	NOKIA CORP	50
6.0 Intelligent Transportation	SUMITOMO ELECTRIC IND LTD	83
	BEIJING CENNAVI TECHNOLOGIES CO LTD	31
	KENWOOD CORP	26
	JVC KENWOOD CORP	21
	SANYO ELECTRIC CO LTD	21
	FUJITSU LTD	19
	ELECTRONICS & TELECOM RES INST	18
	TOSHIBA KK	16
	PANASONIC CORP	15
	CENNAVI TECHNOLOGIES CO LTD	15

Table 18 - Top 10 Patent Applicants/Owners per Technology Category



LANDSCAPE OF MATHEMATICS AND PHYSICS

SCIENCE & TECHNOLOGY UNIT, UMM AL-QURA UNIVERSITY (STU-UQU)

THOMSON REUTERS IP SERVICES
JUNE 2015

Executive Summery

This study has been commissioned by Umm Al Qura University, Makkah, Saudi Arabia to assess and describe the global scientific research and patent activity within sub-tracks that they have achieved funding for projects. Within the Mathematics and Physics track, the sub-tracks of focus were Fluid Dynamics and Fluid Statics.

The study has looked at both scientific papers and patents to form an understanding of the overall scientific and technology landscape.

The scientific papers are sourced from the Web of Science™, a database containing journal articles from approximately 12,500 peer-reviewed journals.

The patent information is sourced from the Derwent World Patents Index™, a database of patents and patent applications from 47 international patent issuing authorities.

Both databases have been selected because they provide a method of defining a unit of science or technology. A single paper defined by the Web of Science is required to have met a minimum threshold of scientific rigor: publication within a journal of repute, peer review sign off, etc. Furthermore, a patent included within DWPI is defined credibly as an attempt to protect a piece of innovation within at least one territory.

Aggregating this information across technologies and countries provides a method of tracking Mathematics and Physics innovation and development trends.

Included in this document are measurements of research and patent quality and direction changes in research and patent activity. It should be noted that in many areas the report utilizes metrics such as average annual percentage growth in scientific and research output to compare activities across technologies and geographies. Such metrics should be treated with care for analyses containing low volumes, as some volatility is expected. Also to be noted is that the global high volume nature of this analysis within Mathematics and Physics necessarily entails some level of noise and is not intended to be completely comprehensive. Instead, the analyses enclosed should be treated as a survey of the technology, and the trends and findings interpreted in this manner.

Overall, the number of patents filed in the respective research area is slightly less than the number of literature papers suggests, that research activity is generally focused more on theoretical technical commercialization as opposed to more practical research.

For Umm Al Qura University, Makkah, Saudi Arabia, it is interesting to note the patent and scientific literature collections differ with respect to the breakdown in broad technology segments/topics. Though, most of the topics including aerodynamics, flow modelling and hydrodynamics are comparably active in both patent and scientific literature data sets. Further, thermocline and halocline topic is least focused, however looking at the average growth rates in the scientific literature collection (years 2009 – 2014; refer to Figure 5) it is experiencing significant growth. This insight may point towards potential future projects and research areas.

With regard to average growth rates in both the collections (years 2008 - 2013 for patents; years 2009 – 2014 for scientific literature), in the patent collection the technology topics which are experiencing significant growth include flow modelling and hydrodynamics. While convection modelling topic in the patent collection, has seen a slight fall over the time period. The topics in the scientific literature collection which have seen sizable growth relative of other topics include computational fluid dynamics, hydrostatics and aerodynamics.

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INTRODUCTION TO MATHEMATICS AND PHYSICS SCIENTIFIC ACTIVITY

This study presents an analysis of patents and scientific papers that fall within specific topics of interest to Umm Al Qura University, Makkah, Saudi Arabia in relevance to mathematics and physics.

The study was commissioned by Umm Al Qura University, Makkah, Saudi Arabia as part of a wider program to review the scientific and intellectual property activity in specific topics that they have gained approved funding for projects. Within the area of Mathematics and Physics, they have gained funding approval for projects related to the Fluid Mechanics; The titles of the projects are "An investigation of the initiation, maintenance and stability of the halocline underlying the operation of solar ponds: Application to the construction and operation of an experimental solar pond" ," The instability of Rayleigh-Marangoni convection in a porous medium layer saturated by a nanofluid and affected by a vertical magnetic field" ," Unsteady Mixed Convection Flow near the Stagnation Point of a Heated Vertical Plate in a Porous Medium Saturated with a Nanofluid" .

A large scale data collation process using globally recognized search processes from Thomson Reuters was undertaken to produce practical and insightful sets of information for analysis regarding the trends, geographies and ultimately the institutions and patent applicants working in the fields of Fluid Mechanics and Fluid Statics within the domain of Mathematics and Physics.

As shown in Figure 1, the overall volume of papers published in these technology areas filed since 2008 is comparatively higher as compared to the volume of patents filed since 2006.

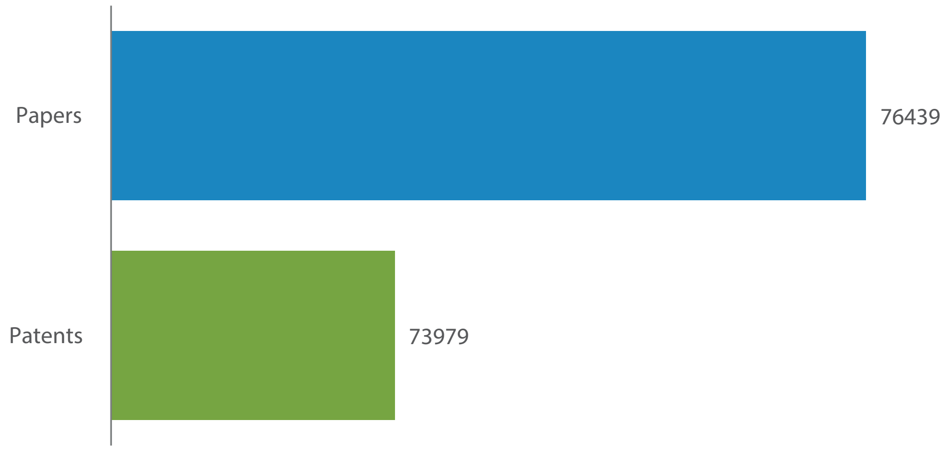

Figure 1 – Scientific Paper and Patent Families in Environmental Technology

Additionally, year 2006 onwards patent protection activity related to mathematics and physics there has been a shortfall from year 2012 (refer to Figure 2, Timeline of Activity) as compared to publications in scientific journals, which are likely to address more fundamental science, has been increasing across the year range. These trends might suggest that the focus of technology development globally related to Mathematics and Physics is more inclined towards theoretical application.

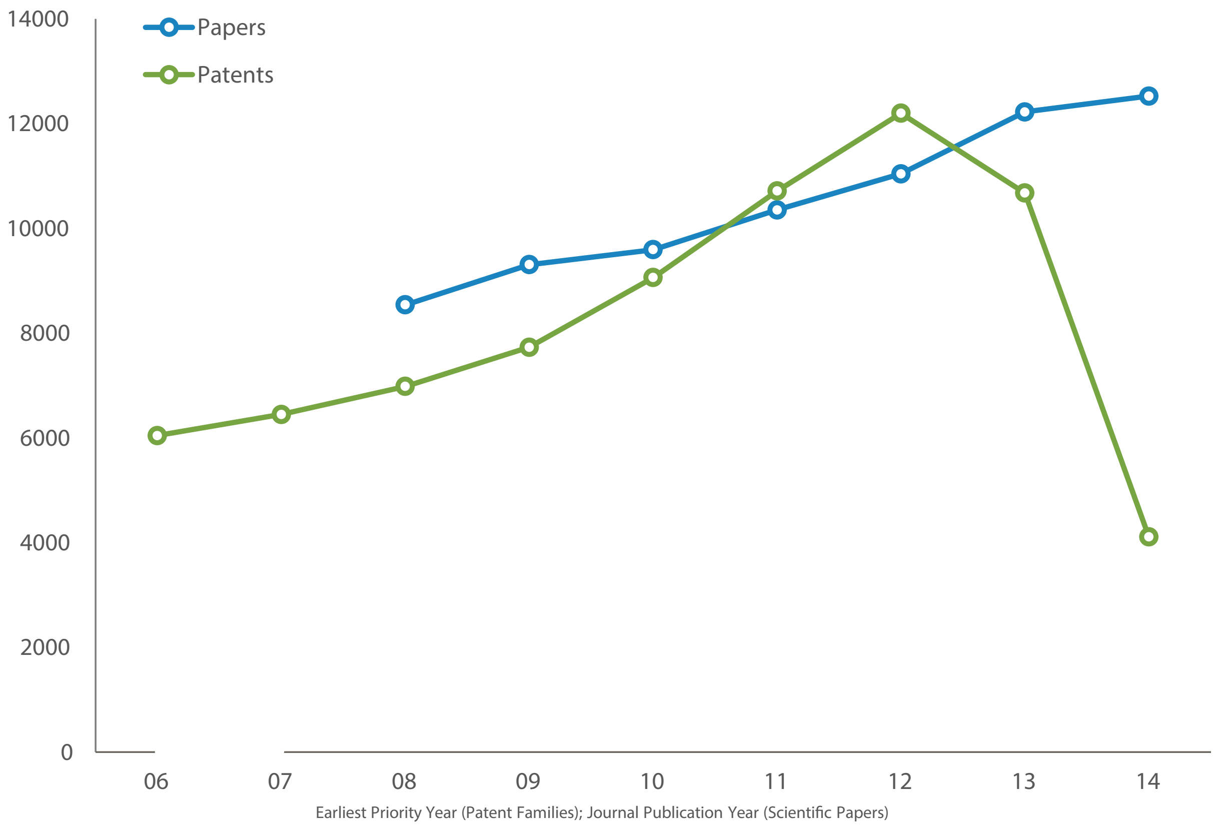

Figure 2 – Timeline of Scientific Paper and Patent Family Activity

Figures 3, 4, 5 show three further analyses on each of the data collections (patents, left; papers, right) concerning the nature and high level technology trends occurring within the mathematics and physics technology area.

The patent and scientific literature collections differ with respect to the breakdown in broad technology segments. Two broad level technology segments within mathematics and physics, which were identified for the purpose of this study, include 'fluid mechanics' and 'fluid statics'. Referring to Figure 3, patenting activity has been dominated by flow monitoring and aerodynamics. In case of scientific papers the aerodynamics topic marginally exceeds the computational fluid dynamics topics.

Most of the topics namely fluid dynamics which includes: flow modeling, aerodynamics and hydrostatics are comparably active in both patent and scientific literature data sets with the thermocline and halocline being least active topics in patent and scientific literature data sets, respectively.

Note that the dates used for the collation of the timeline information differ for patent and scientific literature information. Patent Families are measured by the earliest known "priority" or first filing event in the inventions history. Patents are typically retained by patent offices for 18 months or more after filing before they are published. This delay means that the last complete year of information available for patent information is 2012. For scientific papers, the dates used for analyses are the publication dates of the journal containing the paper. These metrics are used throughout the report.

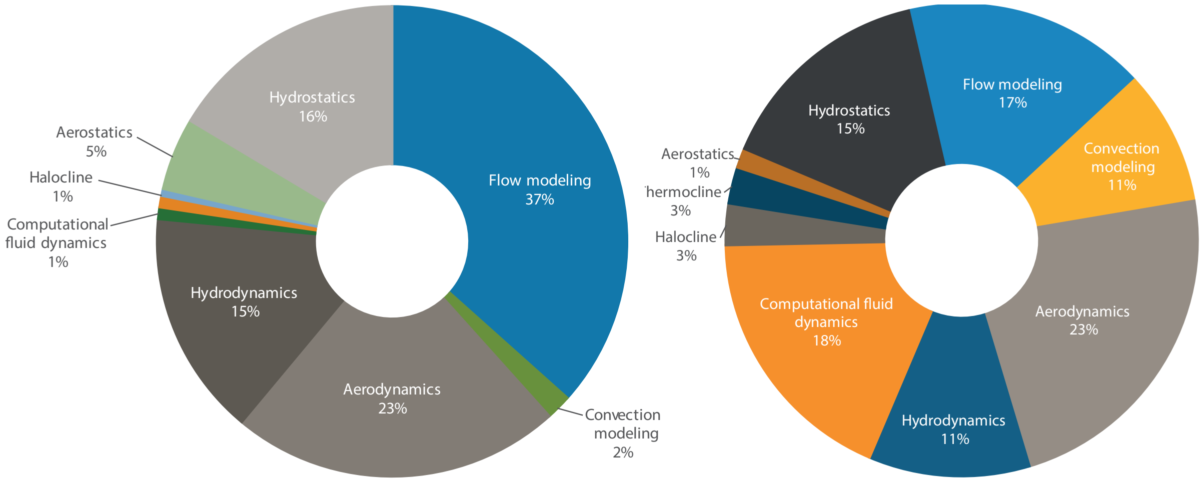

Figure 3 – % of Patent (left) and Scientific Paper (right) Collections by Technology Topics

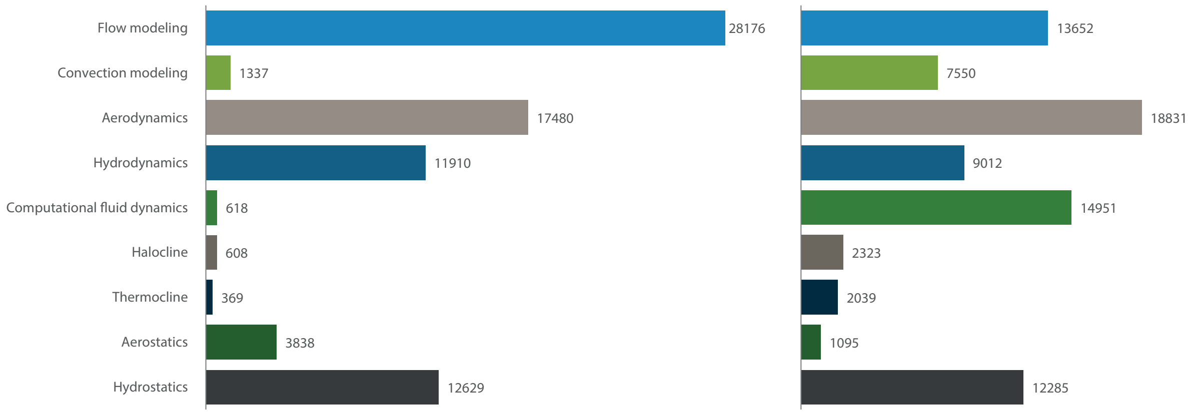

Figure 4 – Number of Patents Families (left) and Scientific Papers (right) per Technology Topic

With regard to average growth rates in both the collections (years 2008 - 2013 for patents; years 2009 - 2014 for scientific literature), in the patent collection the technology topics which are experiencing significant growth include flow modeling and computational fluid dynamics. The topics in the scientific literature collection which have seen sizable growth relative of other topics include computational fluid dynamics and hydrodynamics.

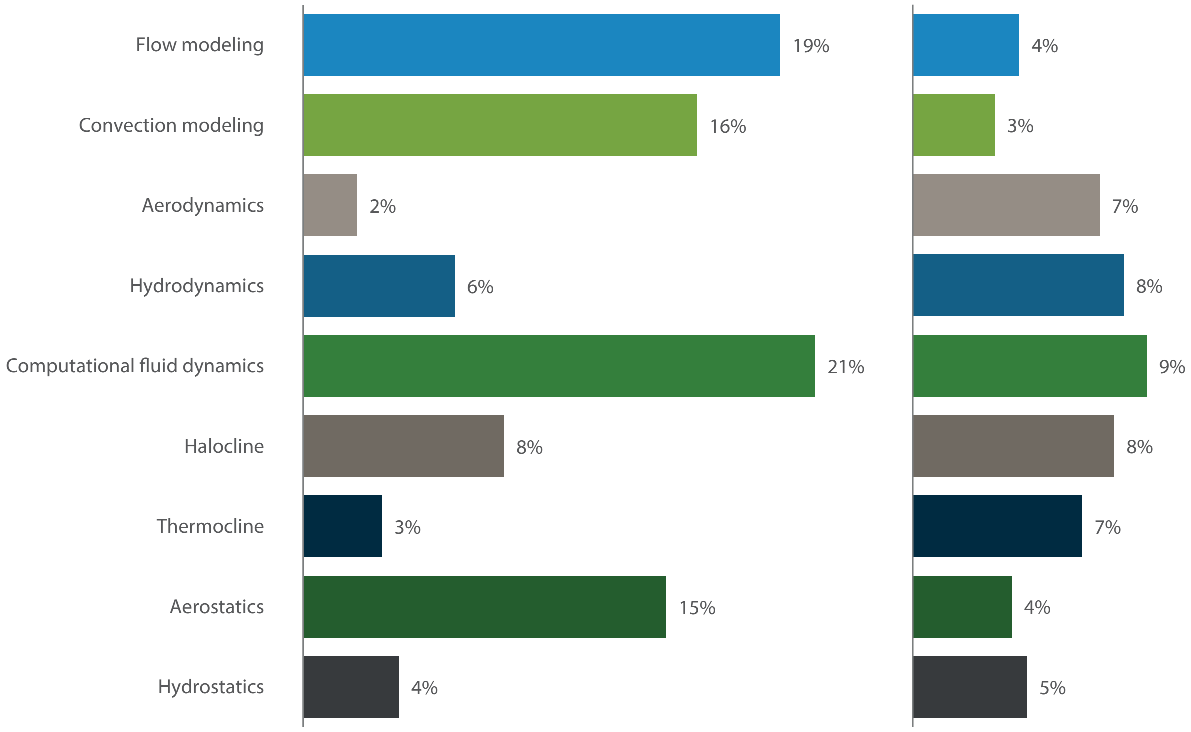

Figure 5 – Average Annual % Growth or Decline in Patent Family (left) or Scientific Paper (right) Output

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Average annual growth or decline is calculated by the average percentage increase or decrease between one year and the next. For example; 5 patents in 2006 followed by 6 patents in 2007 would represent an annual increase of 20%. An increase of 20% in one year, followed by a 10% increase the following year would be represented as a 15% average increase across the two years. This process is followed for 2006 (patents) or 2008 (papers) through to the most recently available year in patent and paper collections, to provide an indicator of the level and direction of recent changes in technology topics.

The timeline activity for scientific literature (Figure 6) since 2008, shows that computational fluid dynamics and hydrodynamics as leading technology topics.

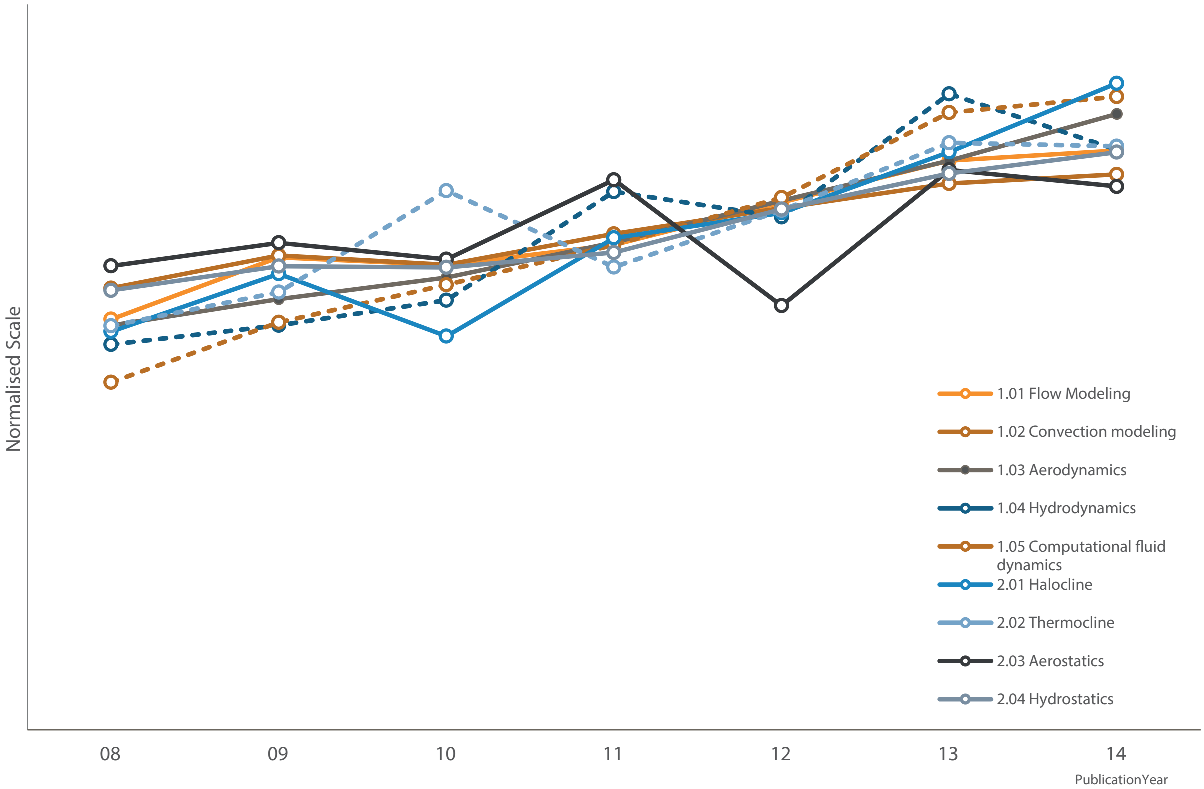

Figure 6 – Normalized Timeline of Activity for Scientific Paper Collection by Various Technology Topics

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The timelines on these charts have been normalised to allow for side by side comparison. Individually, each topic has varying volumes of patent families and scientific papers, however for visualisation purposes, the charts represent the proportion of each topic's activity filed or published in each calendar year.

Timeline activity for patent (Figure 7) since 2006 shows that computational fluid dynamics and flow modelling as leading technology topics with a marginal increase in aerostatics and aerodynamics.

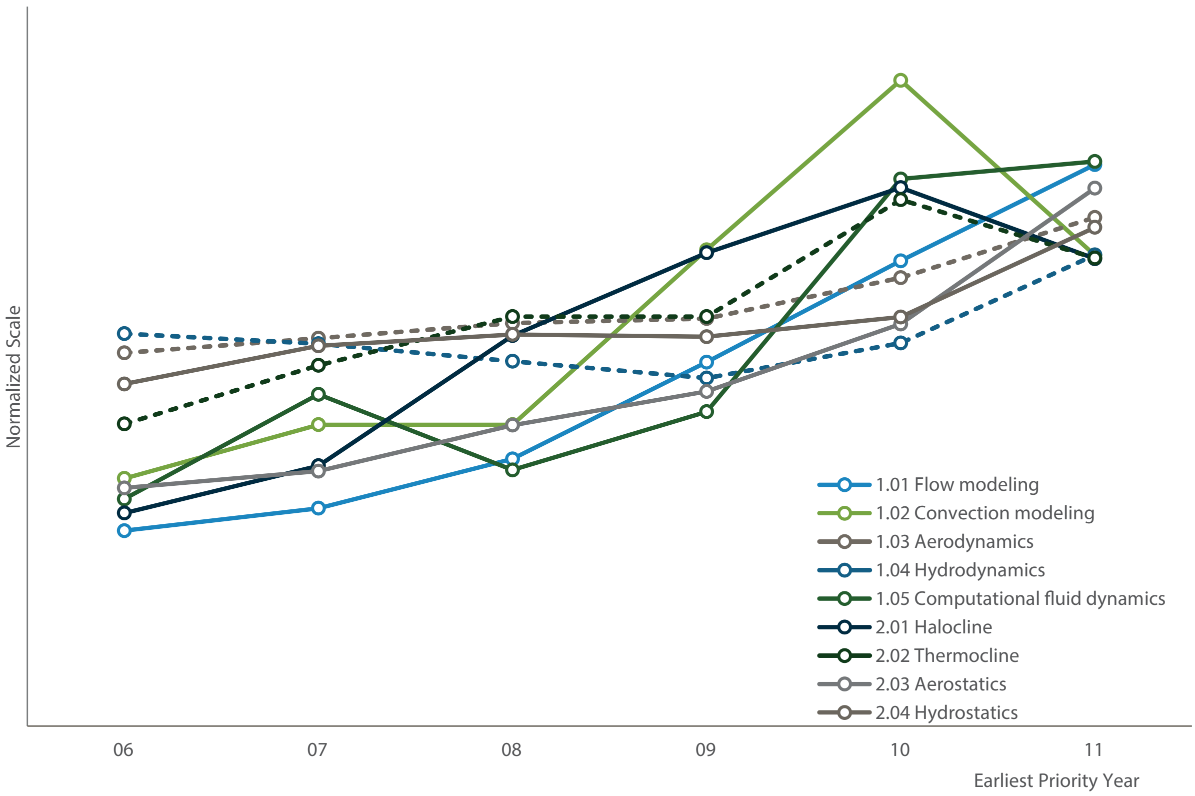

Figure 7 – Normalized Timeline of Activity for Patent Family Collection by Technology Topics

MATHEMATICS AND PHYSICS SCIENTIFIC LITERATURE COLLECTION

This section of the report focuses on the scientific paper collection and the activity and technological trends seen within it. Based on the Thomson Reuters-produced Web of Science database, the collection only includes papers published in pre-selected journals of influence.
In total, over 76,000 peer reviewed papers were incorporated into the mathematics and physics technology collection.

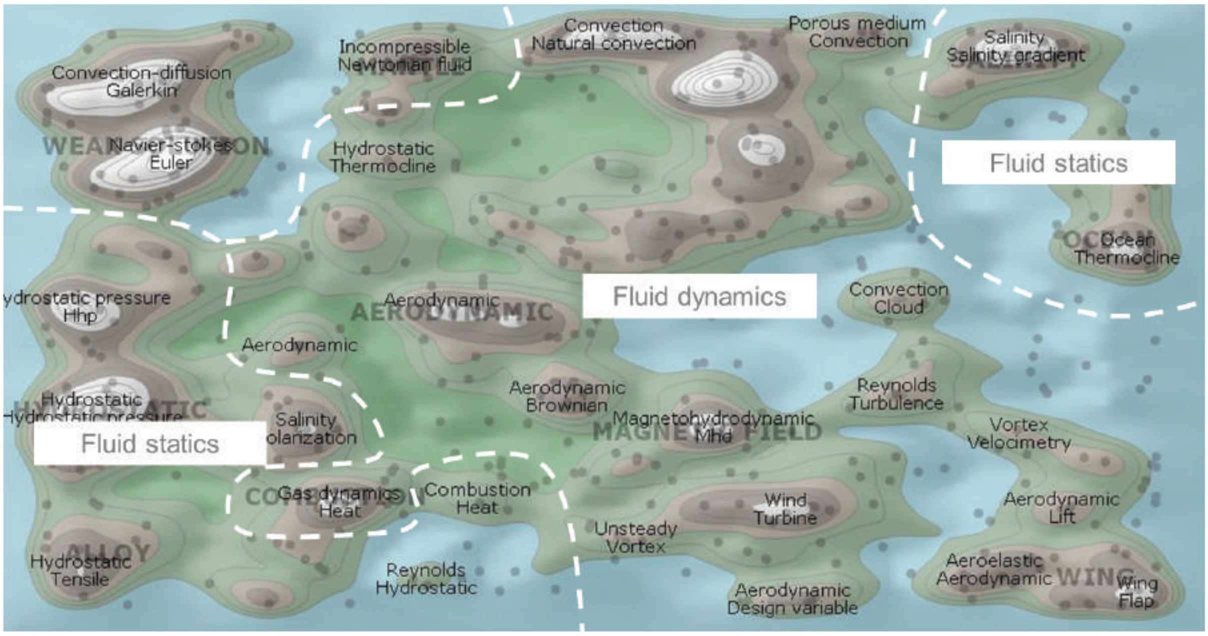

Figure 8 – ThemeScape Map of Scientific Paper Collection; Annotated by Major Themes

Key themes present throughout this collection of papers are illustrated in Figure 8 as a "ThemeScape map" - a visualization method for understanding the common themes and concepts within thousands of documents. Used for market analysis, government intelligence and primarily technology landscapes, the algorithm parses large amounts of text into a topological map of peaks and troughs.
Themes that are commonly shared between documents are represented by mountainous peaks, whereas documents that share little commonality are located within the valleys of the map. The large number of documents in this map means that there are rather few valleys to be found.
The location of an individual document is the vector sum of all the attractions to other documents in the collection based on shared phraseology and the frequency and proximity of these terms.
This map has been manually annotated to summarize the major technology areas within the scientific literature collection. Some technologies will necessarily overlap, and the delineation of one technical area versus another is therefore only approximate. However the map is very useful in describing what topics are common features of global mathematics and science scientific research.
Key themes revealed in this Themescape map focus mainly on salinity gradient, hydrostatic pressure, convection diffusion and wind turbine

ThemeScape® is a text-mining application that acquires and analyzes free text. The algorithms it uses require no application of thesauri or other outside sources of information, and only the free text itself is used by this text-mining tool. The more text the application acquires, the more likely it will be that the output will provide an accurate summary of the major themes present. After analyzing the text in multiple documents, it pulls together those documents that share related text and pulls apart those with less related text. The outcome 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 pick out topics of interest. It aggregates word forms that share a common stem, but it does not directly aggregate synonyms. Instead, synonyms may be gathered under a common theme because of the other words that co-occur with those synonyms. Thus, "battery" and "cell" may be clustered together because of the co-occurrence in the same documents of terms like "electrode, rechargeable, electrolyte" and so on. Conversely, "battery" and "cell" may be separated if the map contains a mixture of documents on metals and biology, where the two terms have different meanings. In other words, terms are identified as synonyms only by co-clustering based on common context.

The topographical maps presented by ThemeScape are mathematical solutions built on a random selection of a first document and sequential calculation of the relationships of all the other documents. The orientation of the map is random, and the directions up, down, left, or right have no significance, because the n-dimensional solution might have been presented from any angle. Only the proximity of points within the map has meaning, and co-localized documents are highly likely to share concepts.

In this report there are separate ThemeScape maps covering scholarly papers or patents. The two types of documents are not pooled and analyzed together. This is because ThemeScape is context-sensitive, and it would separate patent and literature documents from one another based on the very different formal styles of writing that are reflected in these two types of content. Likewise, if documents in two languages are pooled, it will separate them based on the language, and then each language region will be clustered based on term frequency in that language.

The ThemeScape maps in this report analyze large numbers of documents. The contour lines on the maps diminish in circumference, encircling regions of higher and higher concentration. The density is also shown by the map coloration. White snow-capped peaks represent the highest density, while blue expanses (sea level) indicate low density.

The labels in black on the map are selected by ThemeScape based on term frequency in that map region, and they may have been adjusted by the analyst. The large color-overlay regions enclosed by broken lines have been added by the analyst to identify content at an even higher level of abstraction. The dots on the map represent single documents. Dots are not shown for all the documents, and instead represent a sampling that allows the other features of the map to be discerned. Within the ThemeScape application, the map can be magnified, searched, probed and highlighted to learn more about its contents.

ThemeScape is reliant on statistical methods that are not equivalent to reading by human judges, and in compensation, it analyzes millions of documents on a scale of minutes and quickly presents an intuitive, high level summary. It enables and guides further review, and provides a first level overview of very complex datasets.

SCIENTIFIC LITERATURE COLLECTION TECHNOLOGY SEGMENTATION

Table 1 shows the further segmentation of Mathematics and Physics technology topics. There appears to be a lot more interest in Aerodynamics and Computational fluid dynamics. Halocline and Thermocline are areas with low volume, and high growth – indicating emerging research areas.

Technology Segmentation		Total Inventions	Average % Growth or Decline ('09-'14)
1.0 Fluid Dynamics	Flow modeling	13652	4%
	Convection modeling	7550	3%
	Aerodynamics	18831	7%
	Hydrodynamics	9012	8%
	Computational fluid dynamics	14951	9%
2.0 Fluid Statics	Halocline	2323	8%
	Thermocline	2039	7%
	Aerostatics	1095	4%
	Hydrostatics	12285	5%

Table 1 – Scientific Literature Technology Segmentation

SCIENTIFIC LITERATURE COLLECTION TECHNOLOGY CATEGORY OVERLAP

The technology categories and that were created to enumerate and describe the mathematics and physics technology landscape were not intended to be mutually exclusive. A single scientific paper can be included in multiple categories or topics.

Figure 9 visualizes the relationship between the technologies categories used in this study. Each number in the diagram shows the number of papers that have content related to both the corresponding row-wise and column-wise segments.

The most correlated segment pairing is aerodynamics with computational fluid dynamics. Otherwise, mostly smaller sets are generally observed as overlap between the technology segments.

	1.01 Flow Modeling	1.02 Convection Modeling	1.03 Aerodynamics	1.04 Hydrodynamics	1.05 Computational Fluid Dynamics	2.01 Halocline	2.02 Thermocline	2.03 Aerostatics	2.04 Hydrostatics
1.01 Flow Modeling	13652	270	530	973	756	6	6	4	76
1.02 Convection Modeling		7550	36	180	209	8	13	2	53
1.03 Aerodynamics			18831	182	1537	1	4	75	44
1.04 Hydrodynamics				9012	296	10	12	2	92
1.05 Computational Fluid Dynamics					14951	3	7	19	39
2.01 Halocline						2323	57		6
2.02 Thermocline							2039		8
2.03 Aerostatics								1095	42
2.04 Hydrostatics									12285

Figure 9 – Number of Scientific Papers per Pair of Technology Segments

SCIENTIFIC PAPER GEOGRAPHIC VOLUME BENCHMARKING

Figure 10 shows the number of scientific papers for ten most prolific countries within the scientific paper collection.
United Sates is the largest source of mathematics and physics related peer-reviewed papers, followed by China, United Kingdom, Germany and France. It is also interesting to note that the ten most prolific countries contribute to about 66% of output for the scientific paper in the mathematics and physics area.

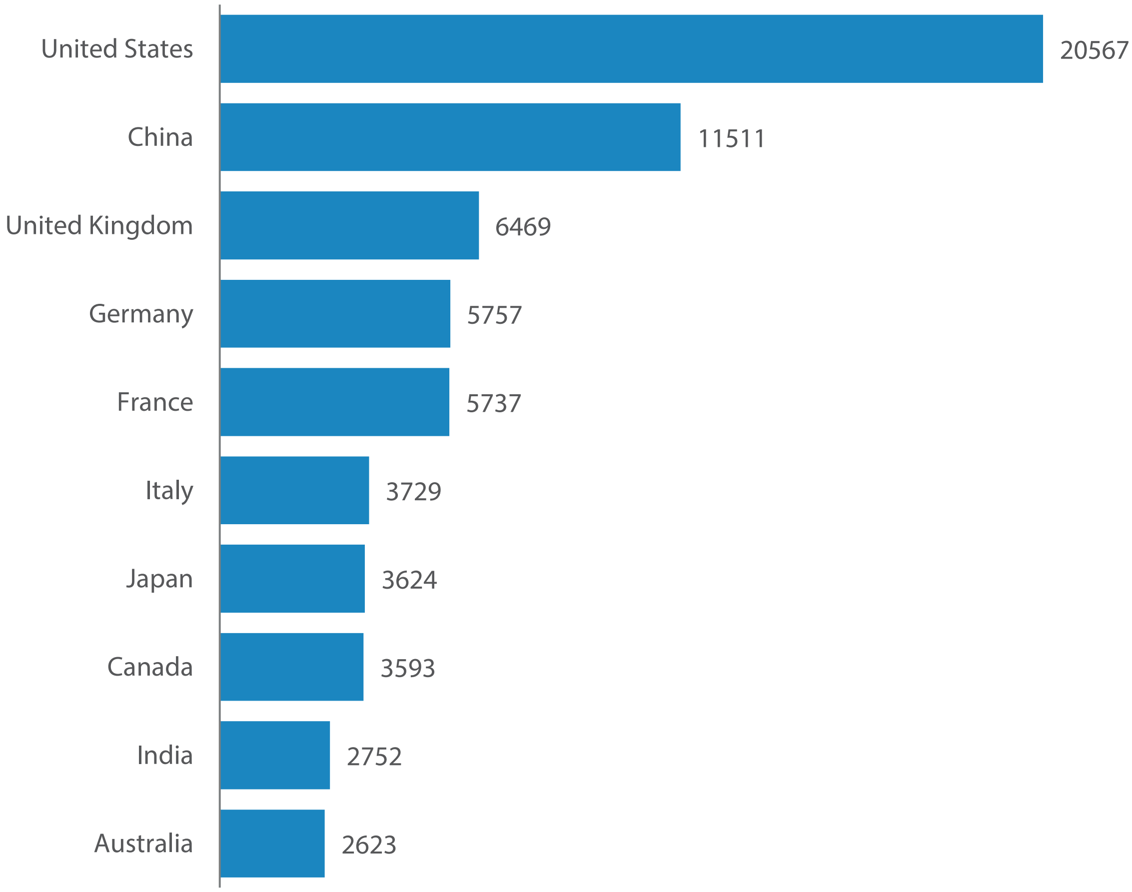

Figure 10 – Number of Scientific Papers per Country; Top 10 Sources

SCIENTIFIC PAPER GEOGRAPHIC ACTIVITY TRENDS

The chart below shows the highest grow rates sources in the scientific literature collection.

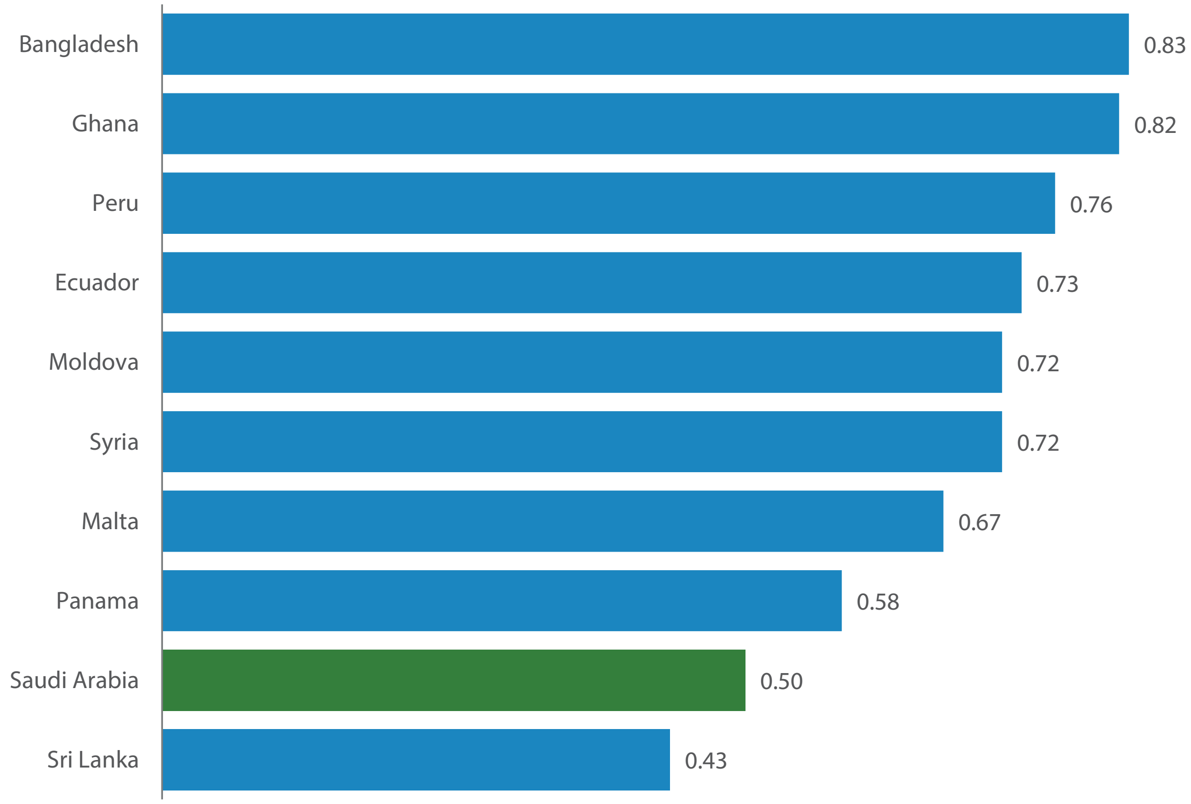

Figure 11 – Highest Growth Rate (%) Geographies in Scientific Publications Output

While scientific literature collection for Bangladesh, Ghana and Peru is relatively small, the growth-rate of scientific paper published in Bangladesh, Ghana and Peru collection exceeds that of other countries with high volume of papers.

SCIENTIFIC PAPER GEOGRAPHIC CITATION IMPACT BENCHMARKING

Scientific paper and patent citations are routinely used in technology bibliometrics for assessing the inherent impact and potential quality of research and the downstream technical and scientific relevance of the underlying research.
Figure 12 shows the “Citation Impact”, the average citation per paper for all papers in a country’s collection (which are having at least 50 publications) and has been sorted by highest citation impact. This shows that output from Ireland, Denmark, Netherlands, Switzerland, Sweden and Belgium are having the highest impact in the mathematics and physics technology topics.

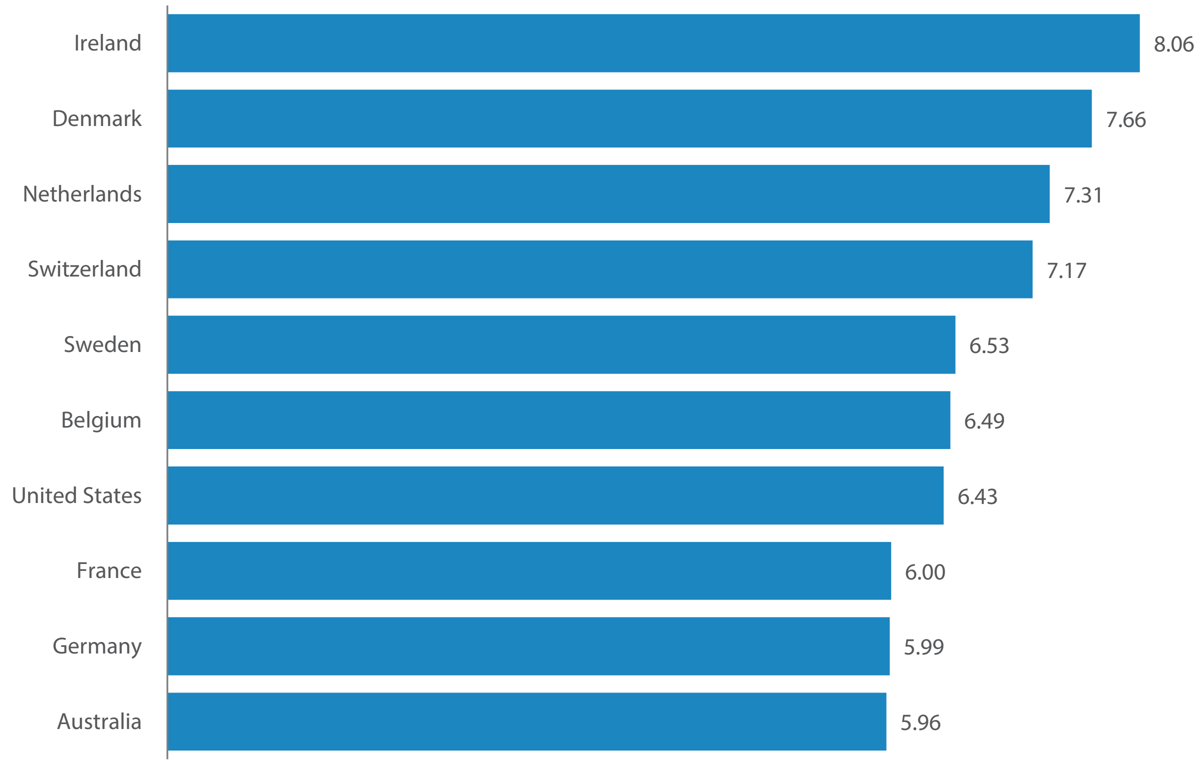

Figure 12 – Highest Citation Impact Geographies of Scientific Publications

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Note that the journals included in the project source data (Web of Science) are selected on the basis of both quantitative and qualitative selection criteria, such as editorial quality, peer review robustness and citation impact. Further details of the journal selection process is available from : http://thomsonreuters.com/products_services/science/free/essays/journal_selection_process/

SCIENTIFIC LITERATURE COLLECTION MATHEMATICS AND PHYSICS TOPICS BY GEOGRAPHY

Table 2 shows the split of mathematics and physics science and research specialization for top nations. The row modeling, aerodynamics and computational fluid dynamics have been in focus for top nations.

	1.0 Fluid Dynamics					2.0 Fluid Statistics			
Country of Origin	1.01 Flow Modeling	1.02 Convection modeling	1.03 Aerodynamics	1.04 Hydrodynamics	1.05 Computational fluid dynamics	2.01 Halocline	2.02 Thermocline	2.03 Aerostatics	2.04 Hydrostatics
United States	18%	11%	27%	10%	19%	4%	4%	1%	14%
China	17%	9%	26%	12%	21%	2%	2%	3%	16%
United Kingdom	18%	10%	26%	12%	22%	2%	3%	1%	14%
Germany	17%	14%	24%	8%	16%	4%	3%	1%	19%
France	19%	13%	22%	17%	11%	3%	4%	1%	18%
Italy	18%	11%	27%	15%	17%	2%	2%	1%	14%
Japan	15%	9%	22%	7%	18%	3%	5%	2%	26%
Canada	19%	10%	26%	12%	19%	4%	3%	1%	14%
India	20%	12%	19%	13%	20%	2%	3%	2%	16%
Australia	18%	9%	19%	12%	24%	5%	5%	0%	13%
South Korea	14%	6%	30%	8%	28%	2%	2%	1%	16%
Spain	14%	9%	18%	13%	15%	5%	4%	1%	25%
Russia	9%	11%	36%	19%	3%	4%	2%	1%	20%
Iran	22%	10%	19%	16%	27%	1%	0%	1%	13%
Netherlands	22%	8%	24%	13%	18%	6%	2%	1%	13%
Switzerland	25%	12%	21%	10%	18%	1%	2%	1%	17%
Taiwan	23%	10%	23%	11%	19%	1%	3%	2%	14%
Brazil	15%	9%	22%	16%	15%	6%	2%	2%	20%
Belgium	20%	9%	22%	11%	25%	3%	1%	2%	15%
Poland	11%	7%	18%	9%	15%	3%	1%	1%	39%
Sweden	19%	10%	27%	9%	21%	8%	2%	1%	10%
Turkey	20%	8%	16%	14%	20%	2%	1%	3%	23%
Norway	21%	12%	17%	10%	18%	8%	6%	0%	14%
Greece	18%	5%	25%	11%	26%	3%	2%	2%	16%
Portugal	14%	7%	15%	21%	21%	8%	2%	1%	16%
Denmark	16%	5%	33%	6%	20%	7%	1%	1%	16%
Singapore	21%	6%	22%	14%	29%	4%	0%	1%	12%
Mexico	16%	8%	18%	12%	12%	5%	5%	1%	27%
Austria	16%	14%	19%	10%	19%	2%	1%	1%	24%
Israel	19%	11%	25%	14%	11%	4%	2%	1%	18%
Czech Republic	20%	13%	20%	11%	9%	4%	1%	1%	25%
Malaysia	22%	10%	16%	14%	34%	2%	1%	1%	11%
Finland	14%	11%	25%	6%	26%	8%	3%	0%	12%
Saudi Arabia	31%	11%	14%	12%	15%	4%	1%	3%	16%

Table 2 – Specialization by Country; % of Literature Activity per Technical Stream per Country of Origin

SCIENTIFIC PAPER - PROLIFIC GLOBAL ENTITIES

Notably, a large number of Chinese universities feature in the top 30 entities publishing scientific literature in this area. Umm Al Qura University, Makkah, Saudi Arabia has only 6 papers published in this space, and has very low citations. Caltech, Univ Colorado, Stanford Univ and University of California appear to be filing important scientific literature that is being cited more frequently than others.

Entity	Total	Times Cited	Citation per paper
Science & Technology Unit, Umm Al Qura University (STU-UC	6	1	0.17
Chinese Acad Sci	1514	6304	4.16
Russian Acad Sci	1030	2265	2.20
Univ Calif Berkeley	875	7940	9.07
Indian Inst Technol	800	3029	3.79
Cnrs	772	4816	6.24
Tsinghua Univ	657	1895	2.88
Univ Tokyo	536	3248	6.06
Delft Univ Technol	530	3004	5.67
Shanghai Jiao Tong Univ	517	1427	2.76
Xi An Jiao Tong Univ	505	1260	2.50
Univ Cambridge	492	3769	7.66
NASA	486	2691	5.54
Univ London Imperial Coll Sci Technol & Med	479	2746	5.73
Georgia Inst Technol	462	3310	7.16
Univ Michigan	461	3199	6.94
Univ Texas Austin	439	3400	7.74
Penn State Univ	438	2792	6.37
MIT	437	3823	8.75
Seoul Natl Univ	435	1541	3.54
Stanford Univ	428	4022	9.40
Univ Illinois	407	2752	6.76
Purdue Univ	403	2471	6.13
Texas A&M Univ	401	1874	4.67
ETH	392	2835	7.23
Univ Paris 06	386	2648	6.86
Univ Maryland	385	2746	7.13
Univ Colorado	381	3704	9.72
Caltech	376	3999	10.64
Zhejiang Univ	361	1233	3.42
Politecn Milan	360	1782	4.95

Table 3 – Mathematics and Physics – Top entities for Scientific Literature

SCIENTIFIC LITERATURE OVERVIEW OF TOP GLOBAL ENTITIES

Table 4 shows the technology profile of the top 30 entities within the scientific literature space of Mathematics and Physics. Entities appear to be researching most in flow modelling, convection modelling, aerodynamics, hydrodynamics, computational fluid dynamics and hydrostatics. Research in halocline and thermocline appears to be very low. Umm Al Qura University, Makkah, Saudi Arabia has 6 publications across the aforementioned high activity areas.

Entity	1.01 Flow Modeling	1.02 Convection Modeling	1.03 Aerodynamics	1.04 Hydrodynamics	1.05 Computational Fluid Dynamics	2.01 Halocline	2.02 Thermocline	2.03 Aerostatics	2.04 Hydrostatics
Science & Technology Unit, Umm Al Qura University (STU-UC	1	2	2		1				1
Chinese Acad Sci	185	163	355	138	173	91	134	44	295
Russian Acad Sci	100	117	328	188	14	41	25	6	243
Univ Calif Berkeley	121	113	233	72	75	39	88	4	164
Indian Inst Technol	235	101	129	158	152	2	6	12	73
Cnrs	110	104	154	119	131	27	26	1	155
Tsinghua Univ	140	60	146	95	174	9	4	12	66
Univ Tokyo	63	66	95	34	80	18	44	4	162
Delft Univ Technol	145	36	177	90	85	11	1	4	36
Shanghai Jiao Tong Univ	100	22	130	113	150	2	2	6	65
Xi An Jiao Tong Univ	106	43	146	41	133		9	9	62
Univ Cambridge	84	64	128	61	96	5	9	3	78
NASA	40	84	219	11	135	5	11	1	50
Univ London Imperial Coll Sci Technol & Med	135	42	98	56	99	3	2	8	65
Georgia Inst Technol	69	22	165	50	146	11	15	3	34
Univ Michigan	63	57	190	55	92	2	10	3	45
Univ Texas Austin	92	70	110	45	63	15	6	4	63
Penn State Univ	80	48	133	30	83	29	4	4	60
MIT	73	51	85	70	75	9	27	5	73
Seoul Natl Univ	46	21	174	23	122	2	15	4	55
Stanford Univ	104	44	102	33	101	16	15	1	57
Univ Illinois	112	41	87	70	65	6	5	3	51
Purdue Univ	93	37	102	23	109		18	3	42
Texas A&M Univ	108	37	83	39	81	11	20	2	43
ETH	80	66	90	32	69	1	14	3	64
Univ Paris 06	75	54	79	48	15	25	39	4	72
Univ Maryland	56	39	133	34	49	30	22	2	50
Univ Colorado	59	83	96	29	52	8	30	1	50
Caltech	34	82	110	46	10	7	21	2	73
Zhejiang Univ	59	20	55	49	114	4	4	5	80
Politecn Milan	74	19	132	29	122		2		18

Table 4 – Scientific literature overview of top global entities

SCIENTIFIC LITERATURE OVERVIEW OF TOP ASIA PACIFIC ENTITIES

Entity	Country of Origin	Total	1.01 Flow Modeling	1.02 Convection Modeling	1.03 Aerodynamics	1.04 Hydrodynamics	1.05 Computational Fluid Dynamics	2.01 Halocline	2.02 Thermocline	2.03 Aerostatics	2.04 Hydrostatics
Science & Technology Unit, Umm Al Qura U	Saudi Arabia	6	1	2	2		1				1
Chinese Acad Sci	China	1397	185	163	355	138	34	91	134	44	295
Indian Inst Technol	India	692	235	101	129	158	22	2	6	12	73
Tsinghua Univ	China	533	140	60	146	95	27	9	4	12	66
Univ Tokyo	Japan	476	63	66	95	34	7	18	44	4	162
Shanghai Jiao Tong Univ	China	431	100	22	130	113	31	2	2	6	65
Xi An Jiao Tong Univ	China	412	106	43	146	41	24		9	9	62
Seoul Natl Univ	South Korea	339	46	21	174	23	12	2	15	4	55
Natl Taiwan Univ	Taiwan	300	64	44	73	57	5	6	14	1	47
Harbin Inst Technol	China	285	47	21	143	19	15	2		20	37
Zhejiang Univ	China	277	59	20	55	49	21	4	4	5	80
Peking Univ	China	274	42	28	130	23	10	4	9	2	35
Natl Univ Singapore	Singapore	273	76	22	58	48	23	17		4	42
Tohoku Univ	Japan	272	32	39	74	24	8	4	7	3	89
Kyoto Univ	Japan	268	63	24	58	29	2	9	12	3	79
Dalian Univ Technol	China	250	69	11	73	54	10	1	1	5	45
Nanyang Technol Univ	Singapore	240	59	16	84	39	12	12		3	32
Beihang Univ	China	218	36	4	128	17	20			3	20
Univ Sci & Technol China	China	201	49	15	44	18	8	1	2	33	35
Tongji Univ	China	200	32	8	92	32	12	7	14	8	24
Huazhong Univ Sci & Technol	China	195	61	37	43	31	10	1		6	15

Table 5 – Scientific literature overview of top Asia Pacific entities

SCIENTIFIC LITERATURE OVERVIEW OF TOP MIDDLE EAST & AFRICA ENTITIES

Table 6 visualizes the prolific entities in the Middle East and Africa. The list is dominated by Middle Eastern entities, reflecting the trends seen in table 5 above. Most of the prolific entities in these regions follow the global focus trends on computational fluid dynamics and flow modeling, while not focusing heavily on halocline, thermocline and aerostatics.

Entity	Country of Origin	Total	1.01 Flow Modeling	1.02 Convection Modeling	1.03 Aerodynamics	1.04 Hydrodynamics	1.05 Computational Fluid Dynamics	2.01 Halocline	2.02 Thermocline	2.03 Aerostatics	2.04 Hydrostatics
Science & Technology Unit, Umm Al Qura University (STU-UQU)	Saudi Arabia	6	1	2	2		1				1
Islamic Azad Univ	Iran	262	54	27	43	25	75	2	2	3	51
Amirkabir Univ Technol	Iran	260	46	18	63	37	87		1	1	26
Univ Tehran	Iran	228	60	15	39	51	46	4	2	6	23
Sharif Univ Technol	Iran	220	53	14	63	32	49	1		1	18
Iran Univ Sci & Technol	Iran	168	42	9	30	38	67		1		5
Shiraz Univ	Iran	133	35	17	35	17	25			1	16
Middle E Tech Univ	Turkey	127	15	13	22	11	30	3	3		37
Kn Toosi Univ Technol	Iran	96	24	9	29	13	21			1	8
Isfahan Univ Technol	Iran	92	28	9	20	18	22				7
Istanbul Tech Univ	Turkey	88	18	1	23	19	21	2	1		7
King Abdulaziz Univ	Saudi Arabia	83	23	13	18	7	6	1	1	2	16
Tarbiat Modares Univ	Iran	83	22	7	15	23	11		2	2	10
Univ Cape Town	South Africa	83	7	5	16	3	14	5	23		13
King Abdullah Univ Sci & Technol	Saudi Arabia	77	32	10	9	10	6	7	2	2	6
King Saud Univ	Saudi Arabia	75	24	7	10	10	5	3	1	8	9
Ferdowsi Univ Mashhad	Iran	71	16	8	15	12	17	1	1	1	4
Babol Univ Technol	Iran	65	17	25	5	10	12				1
Iran University Science & Technology	Iran	65	4		5	5	65				
Univ Pretoria	South Africa	63	20	8	15	4	17		2		3
Univ Witwatersrand	South Africa	60	22	6	18	2	8				8
Univ Kwazulu Natal	South Africa	58	9	7	9	9	8	5		1	13
Kuwait Univ	Kuwait	56	14	7	6	2	31				1
Univ Tabriz	Iran	53	12	7	9	19	8			1	2
Razi Univ	Iran	52	9	7	3	3	25			1	9
Univ Stellenbosch	South Africa	49	7	2	8	3	28	4	1	1	5
Cumhuriyet Univ	Turkey	47	2		4	1	1				41
King Fahd Univ Petr & Minerals	Saudi Arabia	47	23	4	7	5	7				3
Dokuz Eylul Univ	Turkey	45	9	1			4	2			30
Univ Politehn Bucuresti	Romania	44	4	2	12	3	6				18
Univ Yasuj	Iran	43			1	3	3				37

Table 6 – Scientific literature overview of top Middle East & Africa entities

SCIENTIFIC LITERATURE OVERVIEW OF TOP SAUDI ARABIA ENTITIES

Entities	Total	1.01 Flow Modeling	1.02 Convection Modeling	1.03 Aerodynamics	1.04 Hydrodynamics	1.05 Computational Fluid Dynamics	2.01 Halocline	2.02 Thermocline	2.03 Aerostatics	2.04 Hydrostatics
Umm Al Qura University, Makkah, Saudi Arabia	6	1	2	2		1				1
King Abdul Aziz Univ	89	23	13	19	7	11	1	1	2	16
King Abdullah Univ Sci & Technol	81	32	10	9	10	10	7	2	2	6
King Saud Univ	78	24	7	10	10	8	3	1	8	9
King Fahd Univ Petr & Minerals	59	23	5	7	5	17	1			3
King Abdulaziz City for Science and Technology	33	7	5	7	4	3	2		1	7
King Faisal University	13	4	2	1		2				7
King Khalid Univ	10	1				1				8
Saudi Aramco	9	1			1	4				3
Taif Univ	8	3								5
Al Imam Mohammad Ibn Saud Islamic Univ	5	1		1		3				1
Shaqra Univ	5	1			4					1
Taibah Univ	4					2		1		1
Islamic Univ Madina	3			2		3				
Alfaisal Univ	2	1					1			
Minist Water & Elect	2	2								
Najran Univ	2									2
Prince Mohammad Bin Fahd Univ	2	1				1				
Tibah Univ	2	2								
Al Qasseem Univ	1				1					
Coll Sci Girls	1									1
Fac Girls	1	1	1							
Gtz Is	1	1								
Jubail Univ Coll	1				1					
King Abdullah Univ	1	1								
King Faisal Air Acad	1				1					
King Faisal Specialist Hosp & Res Ctr	1					1				
Kink Abdullah Univ Sci & Technol	1			1						
Matern & Children Hosp	1									1
Natl Satellite Technol Program	1	1								

Table 7 – Scientific literature overview of top Saudi Arabia entities

MIDDLE EAST & AFRICA MATHEMATICS AND PHYSICS SCIENTIFIC LITERATURE TRENDS

This section of the report focuses on the scientific paper collection and the activity and technological trends observed in the Middle East and Africa regions.

MIDDLE EAST & AFRICA – PROLIFIC COUNTRIES

Figure 13 below shows the prolific countries by scientific literature volume in the Middle East & Africa regions. The gray bars indicate Middle East, blue indicates Africa, and green indicates the Kingdom of Saudi Arabia. As seen from the figure, the most prolific countries within these regions are Iran and Turkey, followed by Saudi Arabia, and South Africa.

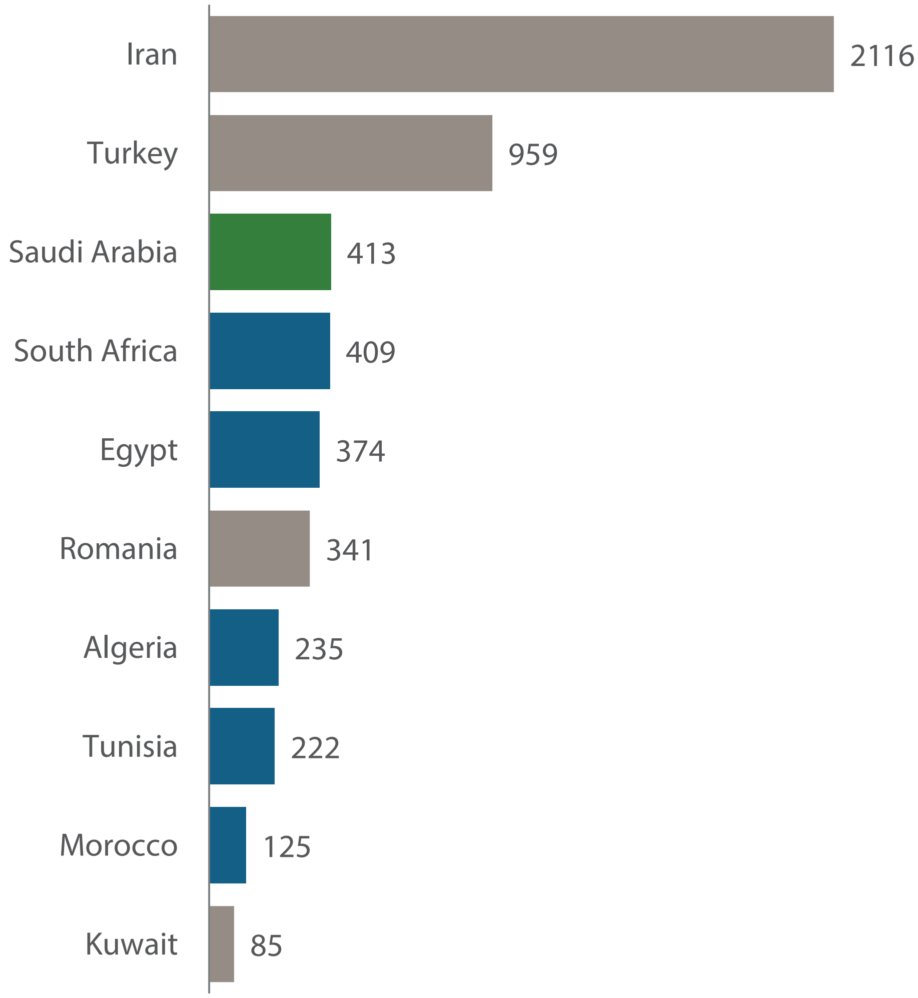

Figure 13 – Middle East & Africa – Prolific Countries in Scientific Literature

A more detailed analysis of the technologies of focus in each of the countries within the Middle East and Africa is presented with reference to tables 5 and 6. Focus appears to be on computational fluid dynamics and flow modeling, similar to the global scientific literature landscape. Also notable is the interest in aerodynamics and hydrodynamics in these countries.

Country of Origin	1.01 Flow Modeling	1.02 Convection Modeling	1.03 Aerodynamics	1.04 Hydrodynamics	1.05 Computational Fluid Dynamics	2.01 Halocline	2.02 Thermocline	2.03 Aerostatics	2.04 Hydrostatics
Iran	461	214	395	334	573	14	8	16	271
Turkey	192	76	150	138	194	19	8	24	224
Saudi Arabia	129	45	56	48	64	15	4	13	68
South Africa	85	42	85	29	94	27	28	4	44
Egypt	80	30	103	54	61	6		14	58
Romania	57	47	83	47	32	5	1	23	63
Algeria	46	30	42	45	33	5	1	2	52
Tunisia	56	24	27	56	29	24	6	2	24
Morocco	38	28	6	27	4	1	1		29
Kuwait	27	9	8	6	38			2	2
Jordan	18	6	9	11	18		1	3	12
Lebanon	15	7	14	6	7	1		2	10
Iraq	10	8	5	10	7	1		3	5
Nigeria	7	3	11	7	5		1		15
Oman	9	12	6	9	1	1	1		6
Armenia			3	1					34
Qatar	3	4	4	2	18	4			1
Ethiopia	15		1	9		1			3
Kenya	4		8	2	5	1	1		2
Azerbaijan	1		3	1					14
Ghana	9		2	2	1	1			3
Senegal		3	2	3		6	2		
Syria	1		11			1			1
Cameroon	5	1	5		1				2
Libya		1	2		5		1		4
Tanzania	3	1		1	1	2	3		

Table 8 – Middle East & Africa –Countries over Technical categories

MATHEMATICS AND PHYSICS PATENT COLLECTION TECHNOLOGY TRENDS

This section of the report focuses on the patent collections produced for the study and the activity and technological trends seen within it. Based on the Thomson Reuters-produced Derwent World Patents Index database, the collection includes both pending patent applications and granted patents published in 47 countries around the world.

A total of approximately 74,000 patented inventions were gathered that are applicable to the various environmental technology topics of interest to Umm Al Qura University, Makkah, Saudi Arabia. These inventions and their technical nature have been summarized using the ThemeScape software described in the previous section.

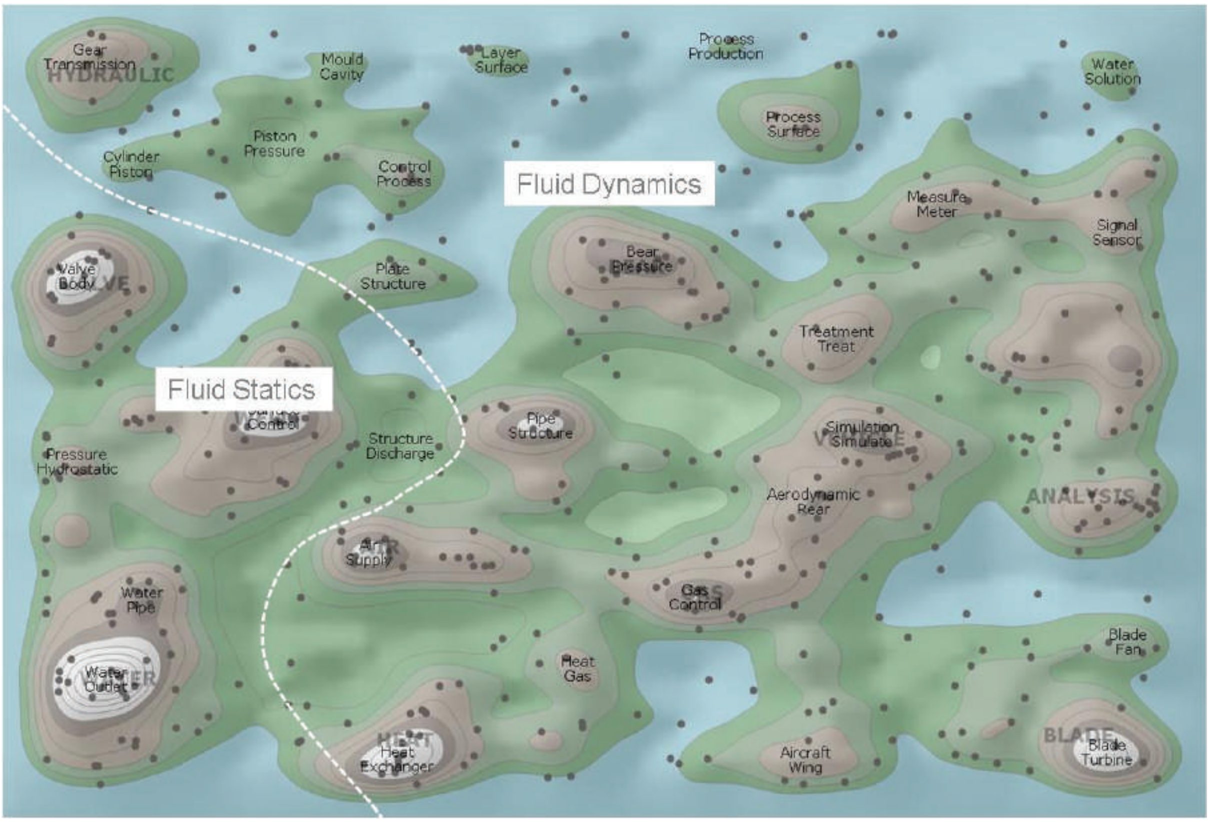

Figure 14 – ThemeScape Map of Patent Collection; Annotated by Major Themes

As previously noted, the ThemeScape map is not designed to provide a detailed accurate view of each patented invention; instead the visual is designed to highlight the common themes shared by hundreds or thousands of patents and patent applications published since 2006.

Some of the key themes revealed in this Themescape map pipe structure, valve body, water outlet and heat exchanger.

This annotation has been provided to guide the reader around the landscape. However, it should be noted that this annotation is only approximate.

PATENT COLLECTION TECHNOLOGY SEGMENTATION

Table 7 shows the further segmentation of Mathematics and Physics technology topics. There appears to be a lot more interest in flow modelling – with a large amount of patenting activity, as well as a high growth rate. Haloclines and Thermoclines appear to be white space areas, with very low patenting volumes, and high growth rates – indicating opportunities for securing patents within the technology area.

Technology Segmentation		Total Inventions	Average % Growth or Decline ('08-'13)
1.0 Fluid Dynamics	Flow modeling	28176	19%
	Convection modeling	1337	16%
	Aerodynamics	17480	2%
	Hydrodynamics	11910	6%
	Computational fluid dynamics	618	21%
2.0 Fluid Statics	Halocline	608	8%
	Thermocline	369	3%
	Aerostatics	3838	15%
	Hydrostatics	12629	4%

Table 9 – Patent Collection Technology Segmentation

PATENT COLLECTION TECHNOLOGY CATEGORY OVERLAP

The technology categories and that were created to enumerate and describe the mathematics and physics landscapes were not intended to be mutually exclusive. A single patent family can be included in multiple categories.
Figure 15 visualizes the relationship between select technology segments. Each number in the diagram shows the number of inventions that have content related to both the corresponding row-wise and column-wise segments.
The most correlated segment pairing is aerodynamics with computational fluid dynamics.

	1.01 Flow Modeling	1.02 Convection Modeling	1.03 Aerodynamics	1.04 Hydrodynamics	1.05 Computational Fluid Dynamics	2.01 Halocline	2.02 Thermocline	2.03 Aerostatics	2.04 Hydrostatics
1.01 Flow Modeling	28176	99	304	265	182		3	38	94
1.02 Convection Modeling		1337	5	11	3				1
1.03 Aerodynamics			17480	712	239	4	2	215	78
1.04 Hydrodynamics				11910	103	12	7	35	535
1.05 Computational Fluid Dynamics					618			3	1
2.01 Halocline						608	13		3
2.02 Thermocline							369		4
2.03 Aerostatics								3838	307
2.04 Hydrostatics									12629

Figure 15 – Number of Patent Families per Pair of Technology Segments

PATENT ACTIVITY GEOGRAPHIC VOLUME BENCHMARKING

Figure 16 shows the number of patent families or inventions within the patent collection relevant to mathematics and physics that can be attributed to each nation . Patenting activity within the mathematics and physics technology topics is lead by China, followed by United States, Japan and Germany. The ten most prolific countries contribute to more than 95% of patent output in the mathematics and physics area.

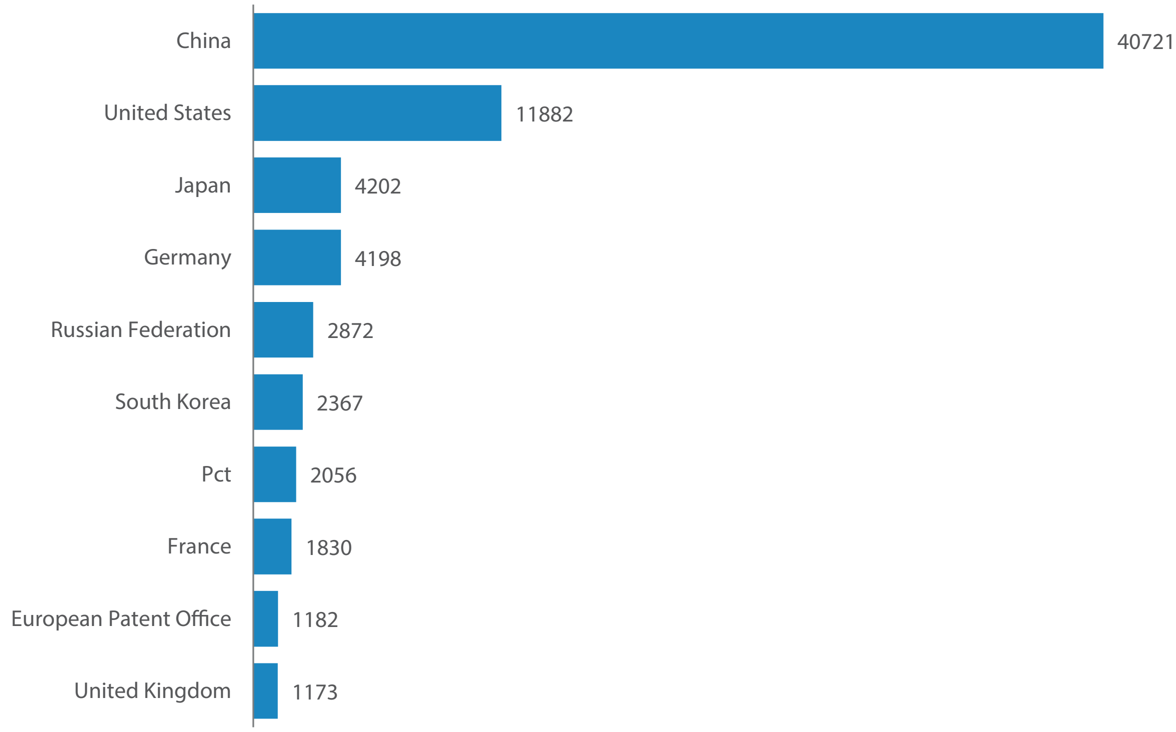

Figure 16 – Number of Patent Families per Country; Top 10 Sources

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National attribution of patent activity is primarily performed via the priority filing location of the invention – this is the first filing event that occurs in the international protection of an invention at the various patent offices around the world. Actual geographic location of the inventor or the innovating corporation may vary from the priority filing location. This effect is exhibited primarily by Saudi Arabian entities, few of which file for patents within the Kingdom.

PATENT GEOGRAPHIC ACTIVITY TRENDS

Figure 17 illustrates the continuing striking growth in the patent portfolio originating from Slovakia and Greece in this field. The figure also illustrates growth in Turkey and Belgium.

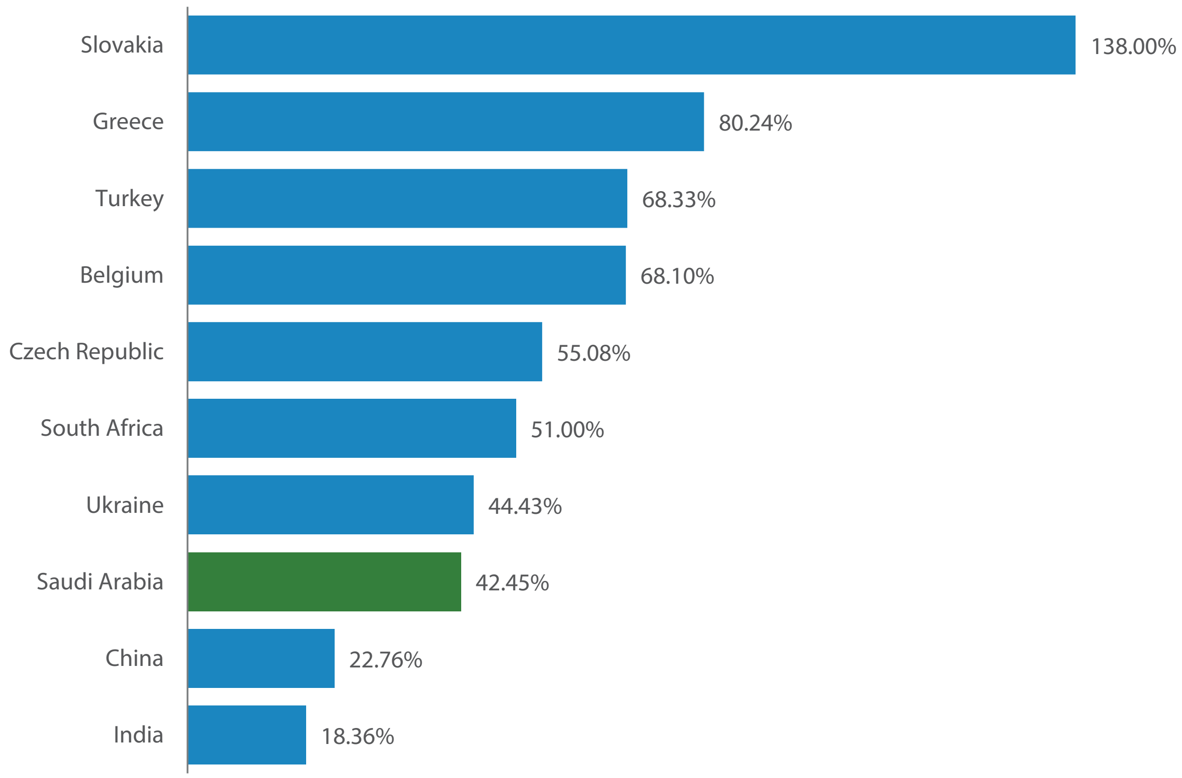


Figure 17 – Highest Growth Rate Geographies in Patent Output

PATENT GEOGRAPHIC CITATION IMPACT BENCHMARKING

Figure 18 details the highest citation impact by nation (with at least 50 patents). Patent citation is a widely utilized measurement of the impact and recognition of an individual patent, and by extension, aggregated groups of patents such as those assigned to a company or associated with the innovation of a nation or region. The measurement is useful as it provides an independent assessment of the quality and impact of the innovation contained within the patent. When aggregated, it provides a method of benchmarking collections of patents for the average impact in comparison to others, e.g., between two competing entities or between nations.

Patent citation information within this study is measured via citations to patent family members of the Derwent World Patents Index and from citation events of 26 national patent collections.

On this metric, Denmark leads with the highest citation impact, followed by Norway, United States and Finland.

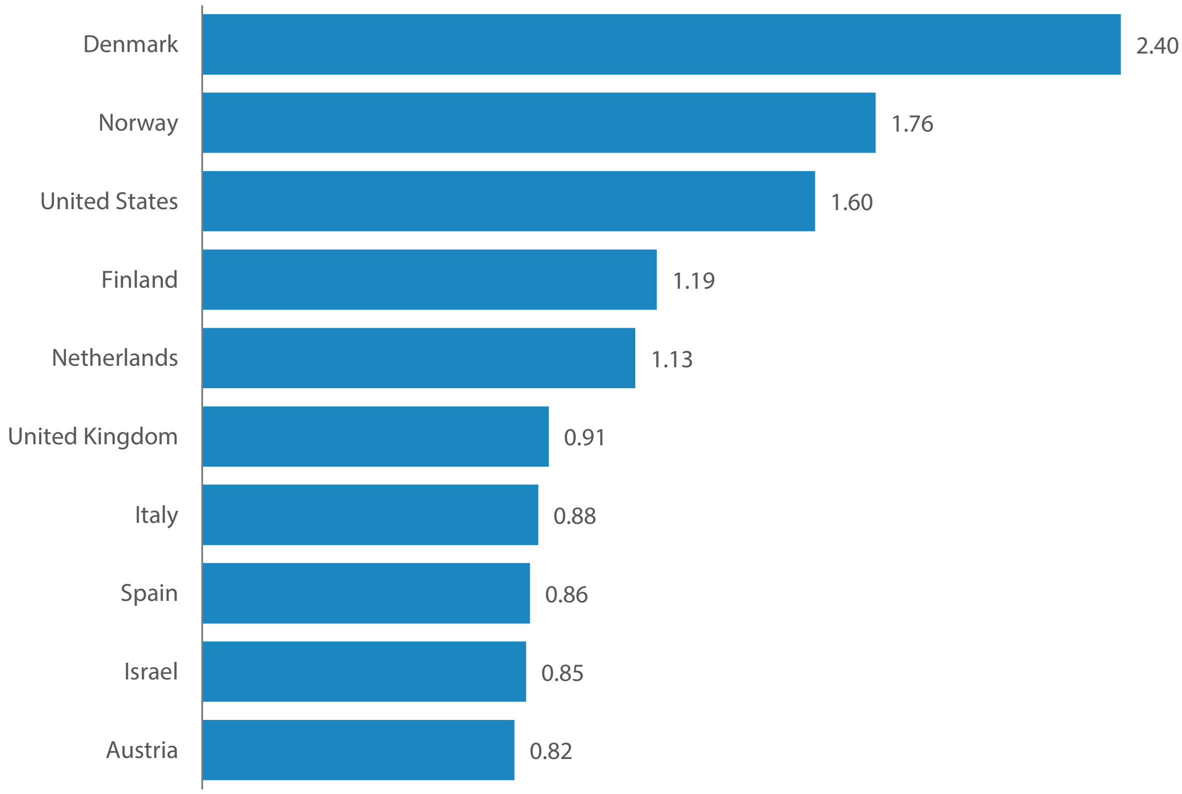


Figure 18 – Highest Citation Impact Geographies of Patents

PATENT COLLECTION ENVIRONMENTAL TECHNOLOGY TOPICS BY GEOGRAPHY

Table 8 shows the split of mathematics and physics science and research specialization for top nations. China appears to have more focus on flow modelling with respect to other areas of research.

	1.0 Fluid Dynamics					2.0 Fluid Statics			
Country of Origin	1.01 Flow modeling	1.02 Convection modeling	1.03 Aerodynamics	1.04 Hydrodynamics	1.05 Computational fluid dynamics	2.01 Halocline	2.02 Thermocline	2.03 Aerostatics	2.04 Hydrostatics
China	59%	3%	11%	11%	0%	0%	0%	6%	13%
United States	17%	0%	42%	19%	2%	2%	1%	3%	18%
Japan	22%	0%	21%	23%	1%	0%	1%	9%	27%
Germany	5%	0%	31%	27%	0%	0%	0%	3%	38%
Russian Federation	2%	0%	51%	33%	0%	0%	0%	5%	12%
South Korea	17%	1%	17%	22%	1%	4%	2%	3%	37%
Pct	18%	0%	34%	24%	1%	3%	1%	6%	23%
France	6%	0%	71%	12%	0%	0%	0%	3%	10%
European Patent Office	11%	0%	47%	21%	2%	2%	2%	2%	18%
United Kingdom	6%	0%	58%	17%	2%	1%	1%	3%	17%
Italy	2%	0%	56%	24%	0%	1%	0%	5%	18%
Australia	6%	0%	38%	26%	0%	4%	3%	3%	26%
India	16%	1%	44%	18%	8%	5%	0%	3%	13%
Spain	2%	0%	76%	12%	2%	2%	1%	4%	7%
Brazil	6%	0%	40%	30%	0%	1%	0%	10%	18%
Taiwan	28%	2%	14%	22%	1%	1%	0%	7%	27%
Canada	11%	0%	45%	15%	1%	3%	2%	6%	25%
Denmark	2%	0%	76%	6%	1%	3%	0%	1%	12%
Poland	4%	0%	40%	27%	0%	1%	0%	1%	27%
Sweden	14%	0%	25%	33%	0%	4%	1%	0%	26%
Romania	2%	0%	36%	24%	0%	0%	0%	1%	36%
Switzerland	4%	0%	52%	14%	1%	0%	0%	4%	27%
Norway	11%	0%	18%	29%	4%	1%	1%	0%	45%
Finland	18%	1%	26%	16%	1%	0%	3%	3%	40%
Austria	4%	0%	30%	24%	0%	0%	0%	4%	41%
Netherlands	8%	0%	45%	21%	0%	8%	1%	0%	24%
Israel	3%	0%	83%	8%	0%	0%	0%	2%	6%
Mexico	11%	0%	29%	29%	0%	0%	0%	7%	31%
Saudi Arabia	52%	2%	14%	17%	0%	0%	0%	0%	17%

Table 10 – Specialization by Country; % of Patent Activity per Technical Stream per Country

PATENT FILINGS - PROLIFIC GLOBAL ENTITIES

The list of prolific entities filing patents includes a mix of aeronautics companies, automobile manufacturers, and universities. Umm Al Qura University, Makkah, Saudi Arabia appears to have no patent filings in the Mathematics and Physics technology space.

Entity	Total	Times Cited	Citation per Family
General Electric Co	633	1058	1.7
Airbus Operations Sas	625	606	1.0
Robert Bosch Gmbh	424	315	0.7
Siemens Ag	412	341	0.8
Zf Friedrichshafen Ag	352	675	1.9
Samsung Corp	324	75	0.2
Boeing Co	308	556	1.8
Univ Beijing Aeronautics & Astronautics	308	68	0.2
Voith Paper Patent Gmbh	288	168	0.6
Safran	269	173	0.6
Univ Zhejiang	257	93	0.4
State Grid Corp China	251	5	0.0
United Technologies Corp	228	180	0.8
Ntn Corp	221	89	0.4
Petrochina Co Ltd	215	19	0.1
Toyota Kk	204	199	1.0
Rolls-Royce Plc	196	165	0.8
Schlumberger Technology Corp	196	324	1.7
Univ Qinghua	194	106	0.5
Univ Northwestern Polytechnical	188	46	0.2
IBM Corp	182	514	2.8
GM Global Technology Operations	176	342	1.9
Panasonic Corp	174	179	1.0
Harbin Inst Technology	166	47	0.3
Univ Shanghai Jiaotong	162	112	0.7
Daimler Ag	161	216	1.3
China Petrochemical Co Ltd	154	11	0.1
Linde Material Handling Gmbh	144	65	0.5
Univ Southeast	140	27	0.2
Univ South China Technology	139	39	0.3

Table 11 – Mathematics and Physics – Top entities for Patents

PATENT OVERVIEW OF TOP GLOBAL ENTITIES

Table 10 shows the technology profile of the top 30 entities within the patent landscape of Mathematics and Physics. None of the top entities are filing many patents in haloclines, thermocline, and convection modeling. The top entities appear to be focusing on Aerodynamics, with the exception of Robert Bosch Gmbh, who appears to be focusing on hydrostatics.

Entity	1.01 Flow Modeling	1.02 Convection Modeling	1.03 Aerodynamics	1.04 Hydrodynamics	1.05 Computational Fluid	2.01 Halocline	2.02 Thermocline	2.03 Aerostatics	2.04 Hydrostatics
General Electric Co	67		471	42	23	7	1	18	33
Airbus Operations Sas	16	1	591	5	11			9	9
Robert Bosch Gmbh	27		40	45				3	321
Siemens Ag	121		204	48	22	9		8	33
Zf Friedrichshafen Ag	2		4	270					83
Samsung Corp	30	1	57	219	1	6	1	4	33
Boeing Co	14		281	12	6	2		2	5
Univ Beijing Aeronautics & Astronautics	126	6	128	23	11			23	20
Voith Paper Patent Gmbh			7	236				1	54
Safran	3		255	3				2	7
Univ Zhejiang	158	4	30	29	1		1	11	29
State Grid Corp China	194	1	21	13	2		1	18	6
United Technologies Corp	12	1	187	11	8			5	15
Ntn Corp			9	188				19	15
Petrochina Co Ltd	119	2	17	54				9	22
Toyota Kk	76		94	13	4			7	16
Rolls-Royce Plc	5		169	18	6			4	5
Schlumberger Technology Corp	91		5	23		2		2	80
Univ Qinghua	118	3	27	33				15	19
Univ Northwestern Polytechnical	77	1	101	10	4			8	4
IBM Corp	131	2	10	27	9			1	5
GM Global Technology Operations	44		89	29	3			3	15
Panasonic Corp	31	1	14	78				27	30
Harbin Inst Technology	34	3	30	20	5			41	59
Univ Shanghai Jiaotong	93	4	22	22	6		2	7	15
Daimler Ag	4		107	31	2			4	15
China Petrochemical Co Ltd	114	7	9	15		1		3	11
Linde Material Handling Gmbh	1								143
Univ Southeast	90	5	13	13	3			13	13
Univ South China Technology	83	3	4	23	5			8	20

Table 12 – Patent overview of top global entities

PATENT OVERVIEW OF TOP ASIA PACIFIC ENTITIES

Entity	Country of Origin	Total	1.01 Flow Modeling	1.02 Convection Modeling	1.03 Aerodynamics	1.04 Hydrodynamics	1.05 Computational Fluid Dynamics	2.01 Halocline	2.02 Thermocline	2.03 Aerostatics	2.04 Hydrostatics
Samsung Corp	South Korea	311	26	1	52	216	1	6	1	4	31
Univ Beijing Aeronautics & Astronautics	China	308	126	6	128	23	11			23	20
Univ Zhejiang	China	257	158	4	30	29	1		1	11	29
State Grid Corp China	China	251	194	1	21	13	2		1	18	6
Ntn Corp	Japan	219			8	187				19	15
Petrochina Co Ltd	China	214	119	2	17	53				9	22
Univ Qinghua	China	193	117	3	27	33				15	19
Univ Northwestern Polytechnical	China	188	77	1	101	10	4			8	4
Toyota Kk	Japan	179	67		83	10	4			5	16
Panasonic Corp	Japan	170	30	1	14	76				26	30
Harbin Inst Technology	China	166	34	3	30	20	5			41	59
Univ Shanghai Jiaotong	China	162	93	4	22	22	6		2	7	15
China Petrochemical Co Ltd	China	154	114	7	9	15		1		3	11
Univ Southeast	China	140	90	5	13	13	3			13	13
Univ South China Technology	China	139	83	3	4	23	5			8	20
Univ Tianjin	China	139	81	1	9	26	6		1	8	21
Univ Xian Jiaotong	China	135	50	2	25	24	1			21	36
Univ China Petroleum	China	122	73		10	37	1			1	10
Univ Tongji	China	111	73		15	18	1			5	9

Table 13 – Patent overview of top Asia Pacific entities

PATENT OVERVIEW OF TOP MIDDLE EAST & AFRICA ENTITIES

Table 12 illustrates the top patenting entities in the Middle East and Africa. The space appears to be dominated by smaller, local players, particularly from the Kingdom of Saudi Arabia (KSA), Romania and Turkey.

Entity	Country of Origin	Total	1.01 Flow Modeling	1.02 Convection Modeling	1.03 Aerodynamics	1.04 Hydrodynamics	2.03 Aerostatics	2.04 Hydrostatics
Saudi Aramco	Saudi Arabia	30	20	1		3		6
King Fahd University Of Petroleum & Minerals	Saudi Arabia	10	1		5	4		1
Inoe 2000 Inst Nat Cerc Dezvoltare Optoe	Romania	9				1		8
Inst Nat Cerc Dezvoltare Aerospatiala El	Romania	4			3			1
Univ Suceava Stefan Cel Mare	Romania	4				2		2
Aselsan Elektronik Sanayi Ve Ticaret As	Turkey	3	1		2			
Inst Nat Cerc Dezvoltare Masini Instalat	Romania	3			1			2
Inst Nat Inventica Iasi	Romania	3				1		2
Univ Hassan Ii Casablanca	Morocco	3			3	3		
Univ Politehnica Din Bucuresti	Romania	3			3			
Arcelik Anonim Sirketi	Turkey	2				1		1
Cape Advanced Eng Pty Ltd	South Africa	2				2		
Council Sci & Ind Res South Africa	South Africa	2			2			
Hydramold Srl	Romania	2						2
Inst Nat Cerc Dezvoltare Electrochimie	Romania	2				1		1
Managementproiect Srl	Romania	2			1	1		
Massachusetts Inst Technology	Saudi Arabia	2			1			1
Univ North West	South Africa	2			1		1	
Advanced Clean Prodn Information Technology Srl	Romania	1	1					
Aerostar Sa	Romania	1			1			
Asoc Dedicata Dezvoltarii In Astronautic	Romania	1			1			
British American Tobacco Investments Ltd	South Africa	1						1
Bsh Bosch & Siemens Hausgeraete Gmbh	Turkey	1			1			
Cakmak Vinc Sanayi Ve Ticaret Anonim Sirketi	Turkey	1				1		
Camiro Eng Srl	Romania	1						1
Coal Milling Projects Pty Ltd	South Africa	1			1			
Comoti Inst Nat Cerc Dezvoltare Turbomot	Romania	1					1	
Demirer Teknolojik Sistemler Sanayi Tica	Turkey	1						1
Epsilon Eng Services Pty Ltd	South Africa	1			1			
Schlumberger Technology Corp	Saudi Arabia	1	1					

Table 14 – Patent overview of top Middle East & Africa entities

PATENT OVERVIEW OF TOP SAUDI ARABIA ENTITIES

Table 12 illustrates the top patenting entities in the Middle East and Africa. The space appears to be dominated by smaller, local players, particularly from Saudi Arabia, South Africa and Turkey.

Entity	Total	1.01 Flow Modeling	1.02 Convection Modeling	1.03 Aerodynamics	1.04 Hydrodynamics	2.04 Hydrostatics
Science & Technology Unit, Umm Al Qura University (STU-UQU)	-					
Saudi Aramco	30	20	1		3	6
King Fahd University Of Petroleum & Minerals	10	1		5	4	1
SABIC	1	1				

Table 15 – Patent overview of top Saudi Arabia entities

MIDDLE EAST & AFRICA MATHEMATICS AND PHYSICS PATENT TRENDS

This section of the report focuses on the patent collection and the activity and technological trends seen within it – in the Middle East and Africa.

MIDDLE EAST & AFRICA – PROLIFIC COUNTRIES

Patent filing trends appear to be very different from the scientific literature trends. Figure 19 shows that Romania is the most popular country for filing patents within the two regions, followed by Saudi Arabia, and South Africa. The remaining jurisdictions see only marginal patent filings.

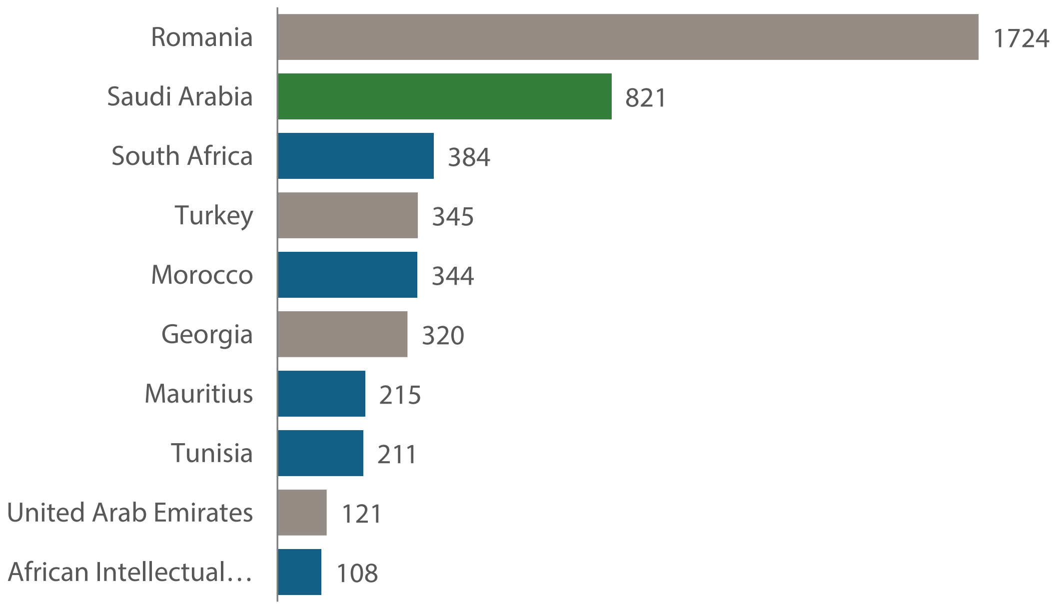


Figure 19 – Middle East & Africa – Prolific Countries in Patents

Diving deeper, Table 11 shows that Romania and Saudi Arabia appear to be consistent with the global patent focus on aerodynamics, hydrodynamics and hydrostatics; and to a lesser extent on flow modeling. The Kingdom of Saudi Arabia has 821 patents, with notable focus on flow modeling.

Country of Origin	1.01 Flow Modeling	1.02 Convection Modeling	1.03 Aerodynamics	1.04 Hydrodynamics	2.03 Aerostatics	2.04 Hydrostatics
Romania	2		33	22	1	33
Saudi Arabia	22	1	6	7		7
South Africa	2		14	4	2	5
Turkey	2		16	6		3
Morocco			6	4		
Georgia			2			
Mauritius			2			
Tunisia			1	1		
United Arab Emirates			2			
African Intellectual Property Organization				1		
Kenya			1			
Libya			1			

Table 16 – Middle East & Africa – Prolific Countries over Technical categories

APPENDIX A – SCIENTIFIC PAPERS TOP AFFILIATIONS

ENTITY-LEVEL DATA TABLES FOR SCIENTIFIC LITERATURE COLLECTION

Table 13 on the following pages shows the top 10 author organizations for each of the technology segments. This information is intended to provide an assessment of the depth and location of the research expertise available in each category.

Technology	Entity	Total
1.01 Flow Modeling	Indian Inst Technol	235
	Chinese Acad Sci	185
	Delft Univ Technol	145
	Tsinghua Univ	140
	Us Geol Survey	138
	Univ London Imperial Coll Sci Technol & Med	135
	Univ Calif Berkeley	121
	Univ Illinois	112
	Cnrs	110
	Texas A&M Univ	108
1.02 Convection Modeling	Chinese Acad Sci	163
	Natl Ctr Atmospher Res	121
	Russian Acad Sci	117
	Univ Calif Berkeley	113
	Cnrs	104
	Indian Inst Technol	101
	NASA	84
	Univ Colorado	83
	Caltech	82
	Univ Texas Austin	70
1.03 Aerodynamics	Chinese Acad Sci	355
	Russian Acad Sci	328
	Univ Calif Berkeley	233
	NASA	219
	Univ Michigan	190
	Delft Univ Technol	177
	Seoul Natl Univ	174
	Georgia Inst Technol	165
	Cnrs	154
	Harvard Univ	153
1.04 Hydrodynamics	Russian Acad Sci	188
	Indian Inst Technol	158
	Chinese Acad Sci	138
	Cnrs	119
	Shanghai Jiao Tong Univ	113
	Tsinghua Univ	95
	Delft Univ Technol	90
	Hohai Univ	83
	Univ Calif Berkeley	72
	Univ Illinois	70
1.05 Computational Fluid Dynamics	United States Department of Energy (DOE	249
	University of California System	199
	Indian Institute of Technology (IIT	181
	Tsinghua Univ	174
	Chinese Acad Sci	173
	Indian Inst Technol	152
	Shanghai Jiao Tong Univ	150
	Tsing Hua University	150
	Georgia Inst Technol	146
	United States Department of Defense	140

continued

Technology	Entity	Total
2.01 Halocline	Chinese Acad Sci	91
	Woods Hole Oceanog Inst	51
	Russian Acad Sci	41
	Univ Calif Berkeley	39
	Univ Washington	34
	Univ Gothenburg	32
	Univ Maryland	30
	Yale Univ	30
	Penn State Univ	29
	Cnrs	27
2.02 Thermocline	Chinese Acad Sci	134
	Noaa	114
	Univ Hawaii Manoa	92
	Univ Calif Berkeley	88
	Ocean Univ China	63
	Univ Washington	60
	Japan Agcy Marine Earth Sci & Technol	58
	Woods Hole Oceanog Inst	56
	Univ Miami	53
	Columbia Univ	49
2.03 Aerostatics	Chinese Acad Sci	44
	Univ Sci & Technol China	33
	Harbin Inst Technol	20
	Univ Catania	19
	Katholieke Univ Leuven	14
	Indian Inst Technol	12
	Tsinghua Univ	12
	Eskisehir Osmangazi Univ	10
	Xi An Jiao Tong Univ	9
	Tianjin Univ	9
2.04 Hydrostatics	Chinese Acad Sci	295
	Russian Acad Sci	243
	Univ Calif Berkeley	164
	Univ Tokyo	162
	Polish Acad Sci	159
	Cnrs	155
	Csic	96
	Tohoku Univ	89
	Zhejiang Univ	80
	Kyoto Univ	79

Table 17 – Top 10 Paper Publishing Organizations per Technology Segment

APPENDIX B – PATENT STATISTICS AND TABLES

ENTITY-LEVEL DATA TABLES FOR PATENT COLLECTION

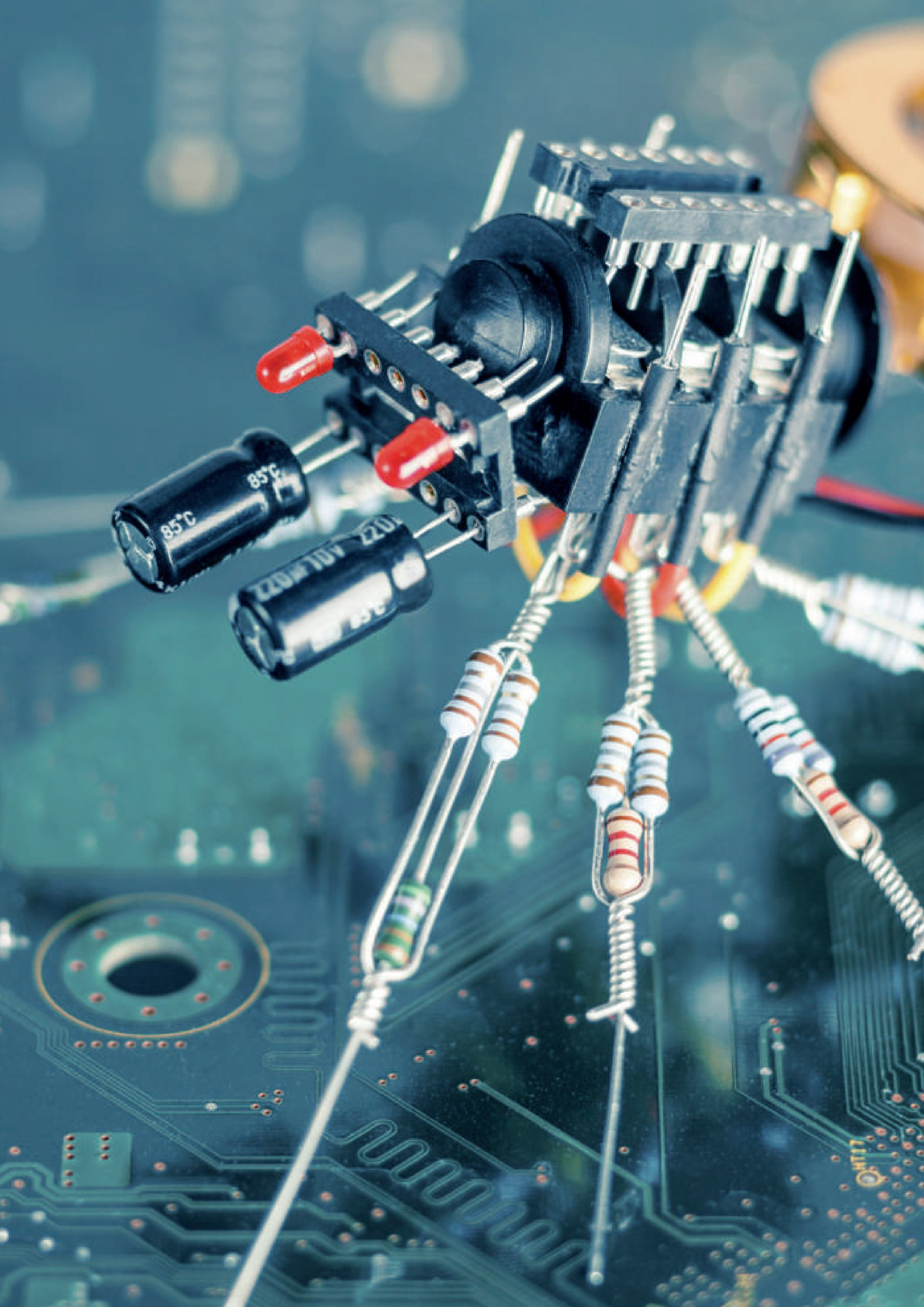
The table 14 below and on the following page shows the top 10 patent applicants or patent assignees for each of the technology segments. This information is intended to provide an assessment of expertise and patent commercialization intent per category.

Technology	Entity	Total
1.01 Flow Modeling	State Grid Corp China	194
	Univ Zhejiang	158
	Ibm Corp	131
	Univ Beijing Aeronautics & Astronautics	126
	Siemens Ag	121
	Petrochina Co Ltd	119
	Univ Qinghua	118
	China Petrochemical Co Ltd	114
	Univ Shanghai Jiaotong	93
	Schlumberger Technology Corp	91
1.02 Convection Modeling	Luoyang Landglass Machine Co Ltd	11
	China Petrochemical Co Ltd	7
	Univ Beijing Aeronautics & Astronautics	6
	Univ Southeast	5
	China Dongfang Electric Corp	5
	Luoyang Jierui Precision Machinery Co	5
	Univ Zhejiang	4
	Univ Shanghai Jiaotong	4
	Univ Wuhan	4
	Univ Huazhong Sci & Technology	4
1.03 Aerodynamics	Airbus Operations Sas	591
	General Electric Co	471
	Boeing Co	281
	Snecma	255
	Siemens Ag	204
	United Technologies Corp	187
	Rolls-Royce Plc	169
	Univ Beijing Aeronautics & Astronautics	128
	Aircelle	114
	Daimler Ag	107
1.04 Hydrodynamics	Zf Friedrichshafen Ag	270
	Voith Paper Patent Gmbh	236
	Samsung Corp	219
	Ntn Corp	188
	Nippon Densan Corp	99
	Panasonic Corp	78
	Nidec Corp	60
	Tatneft Stock Co	58
	Schaeffler Technologies Gmbh&Co Kg	56
	Petrochina Co Ltd	54
1.05 Computational Fluid Dynamics	General Electric Co	23
	Siemens Ag	22
	Univ Beijing Aeronautics & Astronautics	11
	Airbus Operations Sas	11
	Ibm Corp	9
	Univ Jiangsu	8
	United Technologies Corp	8
	Zhejiang Yinlun Machinery Co Ltd	8
	Hangzhou Yinlun Technology Co Ltd	8
	Heartflow Inc	7

continued

Technology	Entity	Total
2.01 Halocline	Korea Inst Energy Res	16
	Texas Instr Inc	16
	Massachusetts Inst Technology	10
	Siemens Ag	9
	Korea Inst Machinery&Materials	8
	General Electric Co	7
	Gen Hospital Corp	7
	Univ Boston	7
	Oasys Water Inc	7
	Samsung Corp	6
2.02 Thermocline	Lockheed Martin Corp	6
	BASF SE	5
	Alstom Technology Ltd	5
	Bayer Cropscience Ag	5
	Bell Independent Power Corp	5
	Biosonics Inc	5
	Blue Aqua Ind Kk	5
	Marushima Aqua System Kk	5
	Nec Corp	4
	Commissariat Energie Atomique	4
2.03 Aerostatics	Harbin Inst Technology	41
	Oiless Ind Co Ltd	36
	Nippon Seiko Kk	36
	Panasonic Corp	27
	Univ Beijing Aeronautics & Astronautics	23
	Univ Xian Jiaotong	21
	China Metrology College	21
	Ntn Corp	19
	China Electronic Technology Group Corp N	19
	General Electric Co	18
2.04 Hydrostatics	Robert Bosch Gmbh	321
	Linde Material Handling Gmbh	143
	Baker Hughes Inc	95
	Zf Friedrichshafen Ag	83
	Schlumberger Technology Corp	80
	Halliburton Energy Services Inc	75
	Caterpillar Inc	71
	Kubota Corp	67
	Iseki Agric Mach Mfg Co Ltd	64
	Harbin Inst Technology	59

Table 18 – Top 10 Patent Applicants/Owners per Technology Segment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LANDSCAPE OF NANOTECHNOLOGY

SCIENCE & TECHNOLOGY UNIT, UMM AL-QURA UNIVERSITY (STU-UQU)

THOMSON REUTERS IP SERVICES
MAY 2015

Executive Summery

This study has been commissioned by Science & Technology Unit, Umm Al-Qura University (STU-UQU) to evaluate and describe the global scientific research and patent activity within sub-tracks that they have achieved funding for projects in Nanotechnology. The sub-tracks in focus are Nano Materials, Nano Fabrication, Nano mechanics, Nano biotechnology and Modeling/Monitoring of nanostructures. The study has looked at both scientific papers and patents to form an understanding of the overall scientific and technology landscape.

The scientific papers are sourced from the Web of Science™, a database containing journal articles from approximately 12,500 peer-reviewed journals.

The patent information is sourced from the Derwent World Patents Index™, a database of patents and patent applications from 47 international patent issuing authorities.

Both databases have been selected because they provide a method of defining a unit of science or technology. A single paper defined by the Web of Science is required to have met a minimum threshold of scientific rigor: publication within a journal of repute, peer review sign off, etc. Furthermore, a patent included within DWPI is defined credibly as an attempt to protect a piece of innovation within at least one territory.

Aggregating this information across technologies and countries provides a method of tracking innovation in the field of Nanotechnology. Included in this document are measurements of research and patent quality and direction changes in research and patent activity. It should be noted that in many areas the report utilizes metrics such as average annual percentage growth in scientific and research output to compare activities across technologies and geographies. Such metrics should be treated with care for analyses containing low volumes, as some volatility is expected. Also to be noted is that the global high volume nature of this analysis within nanotechnology necessarily entails some level of noise and is not intended to be completely comprehensive. Instead, the analyses enclosed should be treated as a survey of the technology, and the trends and findings interpreted in this manner.

Overall, the fact that the number of papers published in this area is approximately twice to that of the number of patents suggests that the fundamental research activity is more focused than the practical technical commercialization.

For STU-UQU, it is interesting to note the patent and scientific literature collections differ with respect to the breakdown in technology segments. Within the Nano Materials segment the noticeable area of development in both data sets are Photosensitive Nanoparticle nanomaterial, Nano composites, Nanosilver antimicrobial, and Organic Nanoparticle. However, Inorganic Nanoparticle is majorly addressed in the patent collection as compared to the scientific paper collection. Within Nano Fabrication segment Other Nanofabrication was overly focused as compared to Self-assembly technique. While Nano mechanics are more focused for fundamental research, apparently Nano biotechnology is a least focused segment in both the collections.

Similarly with regard to average growth rates of these collections (years 2008 - 2013 for patents; years 2009 - 2014 for papers), all of the technology segments in the scientific literature collection have seen a tremendous growth whereas, the patent collection have seen a stagnation over the time period with Nanocomposites and inorganic nanoparticle is in focus. In the patent collection the technology segment which are experiencing growth are Nano devices modeling and Material enhancement using nanoparticles, NWs or NTs.

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INTRODUCTION TO GLOBAL NANOTECHNOLOGY SCIENTIFIC ACTIVITY

This study presents an analysis of patents and scientific papers that fall within specific topics of Nanotechnology which are of interest to Science & Technology Unit, Umm Al-Qura University (STU-UQU) concerning Nano Materials, Nano Fabrication, Nano mechanics, Nano biotechnology and Modeling/Monitoring.

The study was commissioned by STU-UQU as part of a wider program to review the scientific and intellectual property activity in specific topics that they have gained approved funding for projects. Within Nanotechnology, they have gained funding approval for 7 projects related to Nanotechnology specifically in the sub-tracks of Nano Materials, Nano Fabrication, Nano mechanics, Nano biotechnology and Modeling/Monitoring. The titles of the projects are "Antimicrobial Properties of Silver Nanoparticles Encapsulated Inside Mesoporous Titania Nanotubes and Carbon nanotubes Fabricated using Self-assembly Method", "Theoretical study of Oxygen vacancies influence on the properties of PMN-25%PT system in its bulk and nanostructure forms", "Experimental and Theoretical study of optical and electrical study of PbMg1/3Nb2/3O3 (PMN) thin film under various conditions", "Synthesis and Characterization of Light-Harvesting Nano materials for Renewable Energy and Photo catalysis Toward Clean Water", "Thermoelastic Waves in Gold Nano-Beams Induced by Laser Pulse", "Nanolithography with metastable atomic beam and optical characterization of the fabricated nanostructures", and "Investigation of the Different Factors Affecting the Relaxation Behavior of nano-structurally self-assembled Block copolymers".

A large scale data collation process using globally recognized search processes from Thomson Reuters was undertaken to produce practical and insightful sets of information for analysis regarding the trends, geographies and ultimately the institutions and patent applicants working in the fields of Nanotechnology.

As shown in Figure 1, the overall volume of scientific papers in this technology area published since 2008 is more than 2.2 times of the volume of patent filed since 2006, and even in the same time period from year 2008 onwards the scientific papers output is about 256% higher than the patents output.

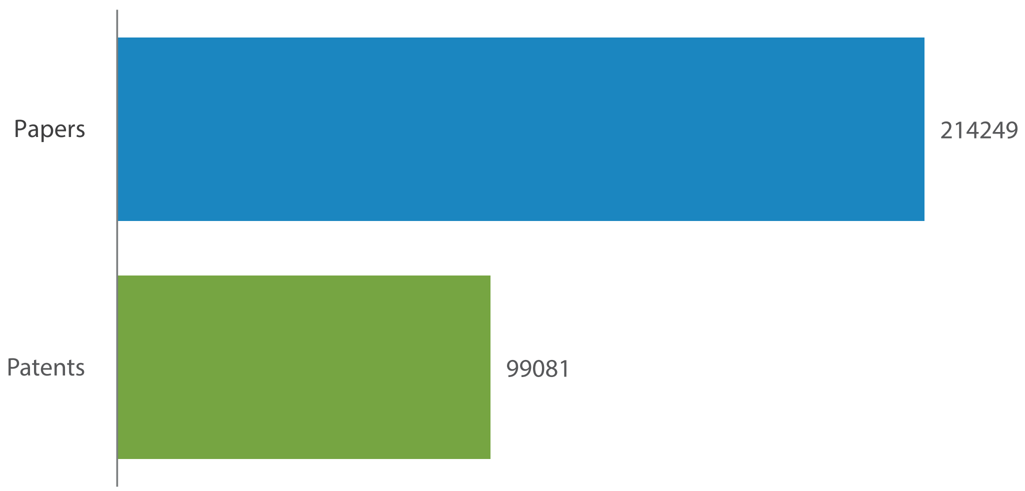

Figure 1 – Scientific paper and patent families in Nanotechnology

Additionally, year 2008 onwards scientific papers publication had continuously surpassing the patent filings in this technology area and increased at an average rate of about 13% year over year (refer to Figure 2, Timeline of Activity). While publications in scientific journals in these areas, which are likely to address more fundamental research in science, during years 2008-13 has increased. This might suggest that the focus of technology development globally related to Nanotechnology is increasingly directed towards fundamental scientific research as compared to the patenting activity.

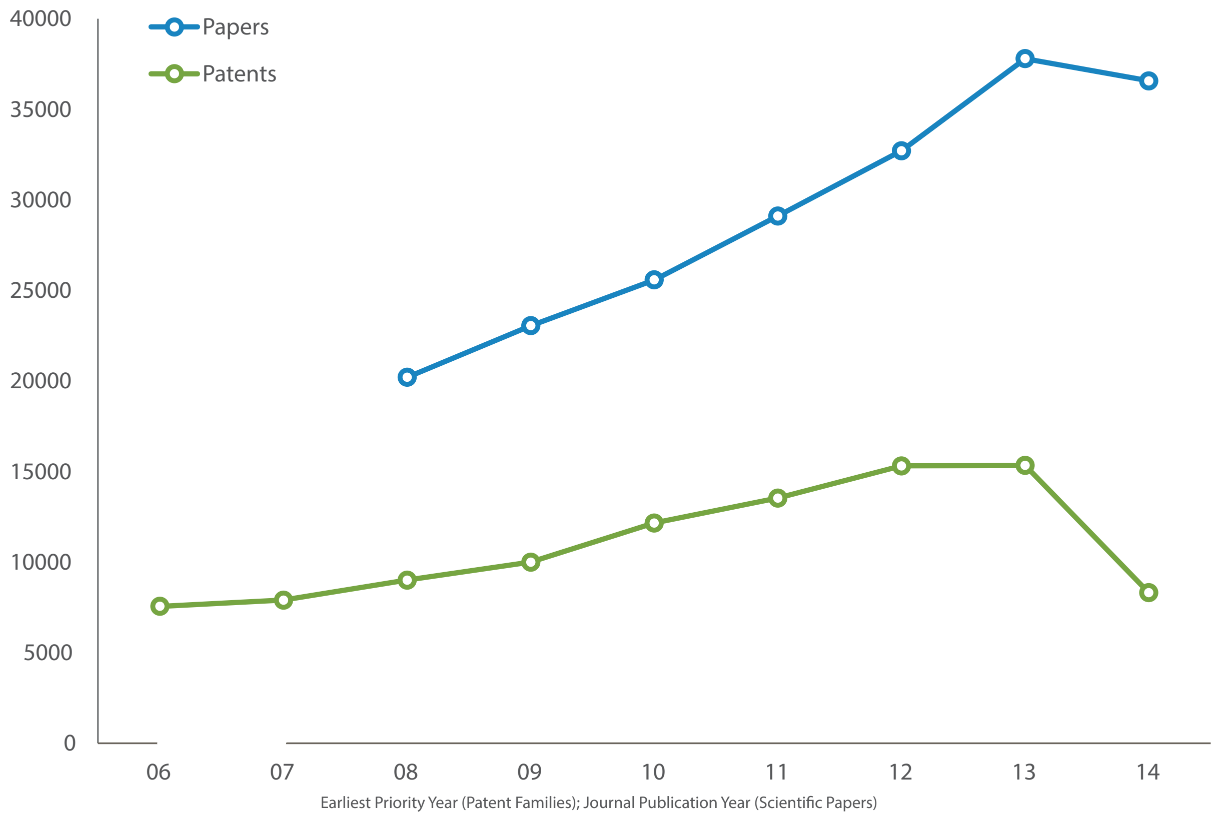

Figure 2 – Timeline of scientific patent and patent family activity

Figures 3 through 5 show three further analyses on each of the data collections (patents, left; papers, right) concerning the nature and high level technology trends occurring within Nanotechnology area.

The patent and scientific literature collections differ with respect to the breakdown in broad technology segments. Five broad level segments within Nanotechnology research, which were identified for the purpose of this study, include “Nano Materials”, “Nano Fabrication”, “Nano mechanics”, “Nano biotechnology” and “Modeling/Monitoring”. Within the Nano Materials segment the noticeable area of development in both data sets are Photosensitive Nanoparticle nanomaterial, Nano composites, Nanosilver antimicrobial, and Organic Nanoparticle. However, Inorganic Nanoparticle is majorly addressed in the patent collection as compared to the scientific paper collection. Within Nano Fabrication segment Other Nanofabrication was overly focused as compared to Self-assembly technique. While Nano mechanics is more focused for fundamental research, apparently Nano biotechnology is a least focused segment in both the collections.

Note that the dates used for the collation of the timeline information differ for patent and scientific literature information. Patent Families are measured by the earliest known “priority” or first filing event in the inventions history. Patents are typically retained by patent offices for 18 months or more after filing before they are published.

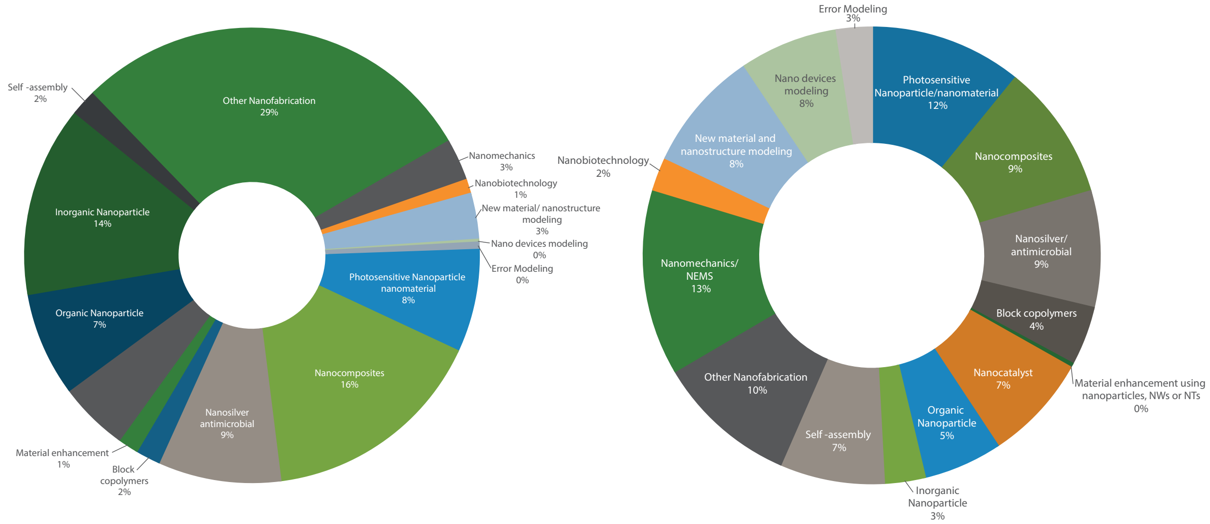

Figure 3 – % of patent (left) and scientific paper (right) collections by Nanotechnology topic

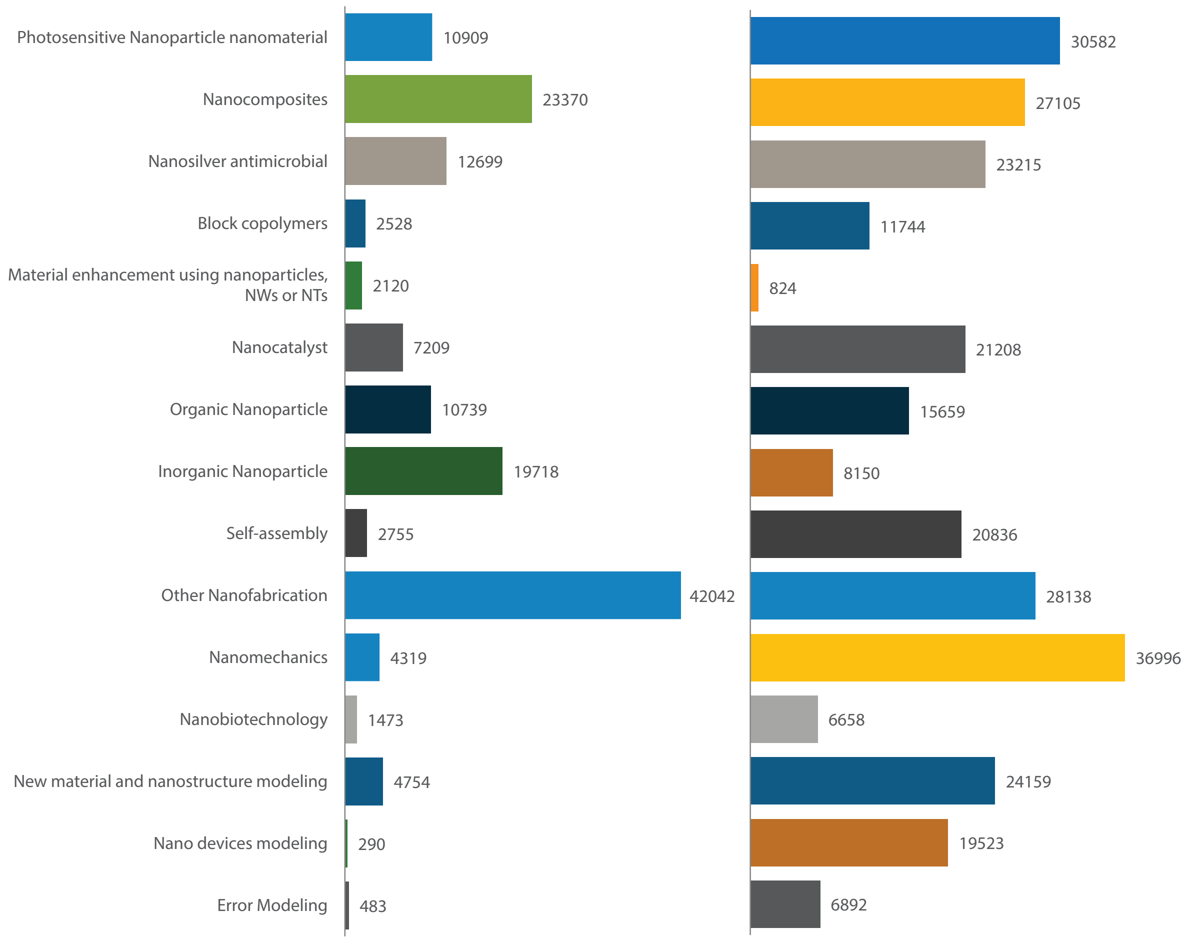

Figure 4 – Number of patent families (left) and scientific papers (right) per Nanotechnology topic

This delay means that the last complete year of information available for patent information is 2012. For scientific papers, the dates used for analyses are the publication dates of the journal containing the paper. These metrics are used throughout the report.

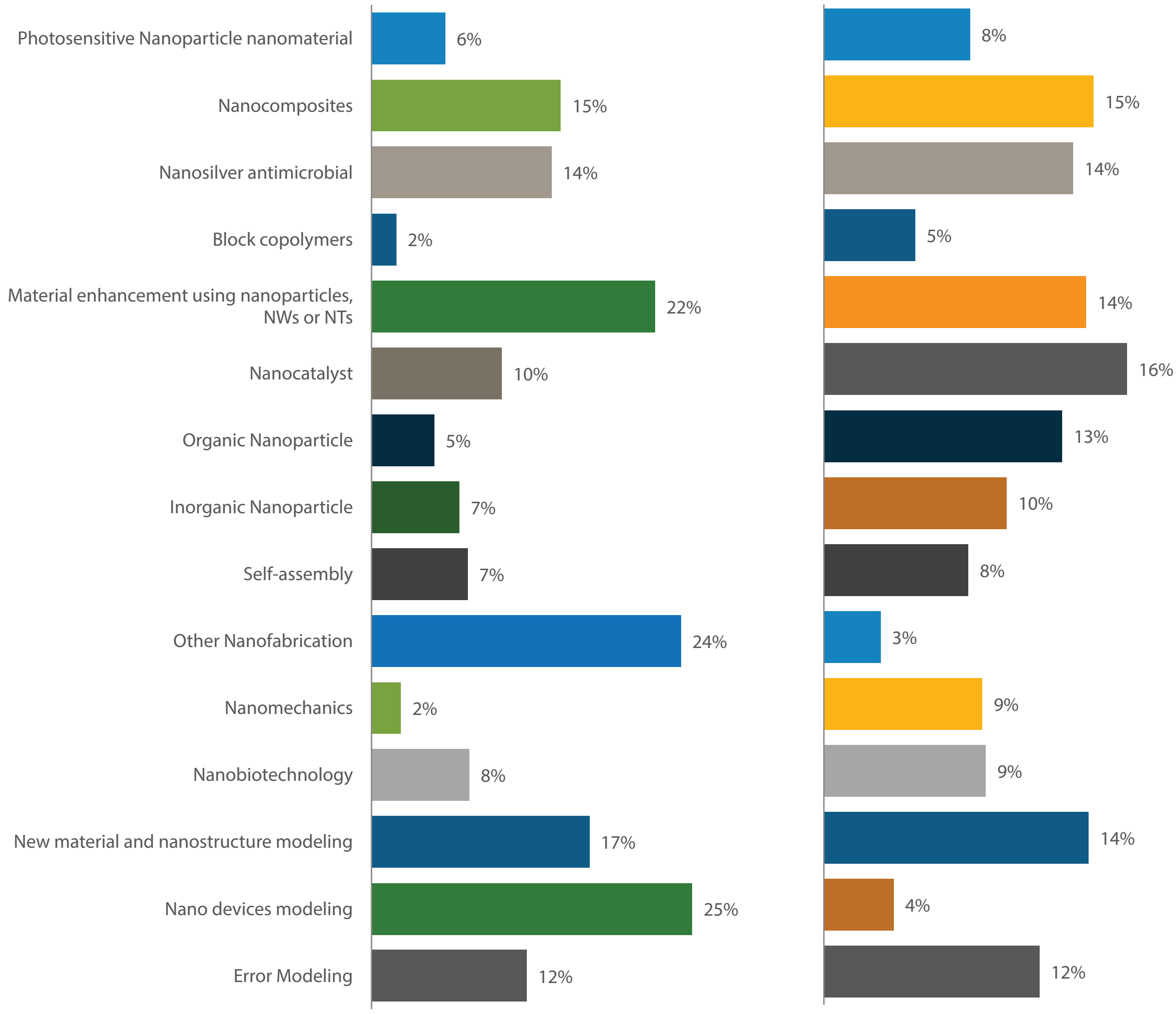

Figure 5 – Average annual % growth or decline in patent family (left) or scientific paper (right) output between 2009 and 2014 (scientific papers) or between 2008 and 2013 (patent families)

With regard to average growth rates of these collections (years 2008 - 2013 for patents; years 2009 - 2014 for papers), all of the technology segments in the scientific literature collection and the patent collection have seen a growth over the time period with Nanosilver antimicrobial, Material Enhancement using Nanoparticles, New Material and Nanostructure Modeling and Error Modeling leading. In the patent collection the technology segment which is also experiencing high growth is other Nanofabrication technique. While, in the paper collection the technology segments which are also experiencing high growth are Photosensitive Nanoparticle/nanomaterial and Nano catalyst.

Growth trends for scientific literature (Figure 6) since 2008 shows that all the technology segments in nanotechnology are growing with Nano Materials and Modeling/Monitoring segments leading. Patenting trends since 2006 (Figure 7) shows similar trends with Nano Fabrication and Modeling/-Monitoring segments leading.

Average annual growth or decline is calculated by the average percentage increase or decrease between one year and the next. For example; 5 patents in 2006 followed by 6 patents in 2007 would represent an annual increase of 20%. An increase of 20% in one year, followed by a 10% increase the following year would be represented as a 15% average increase across the two years. This process is followed for 2006 (patents) or 2008 (papers) through to the most recently available year in patent and paper collections, to provide an indicator of the level and direction of recent changes in technology topics.

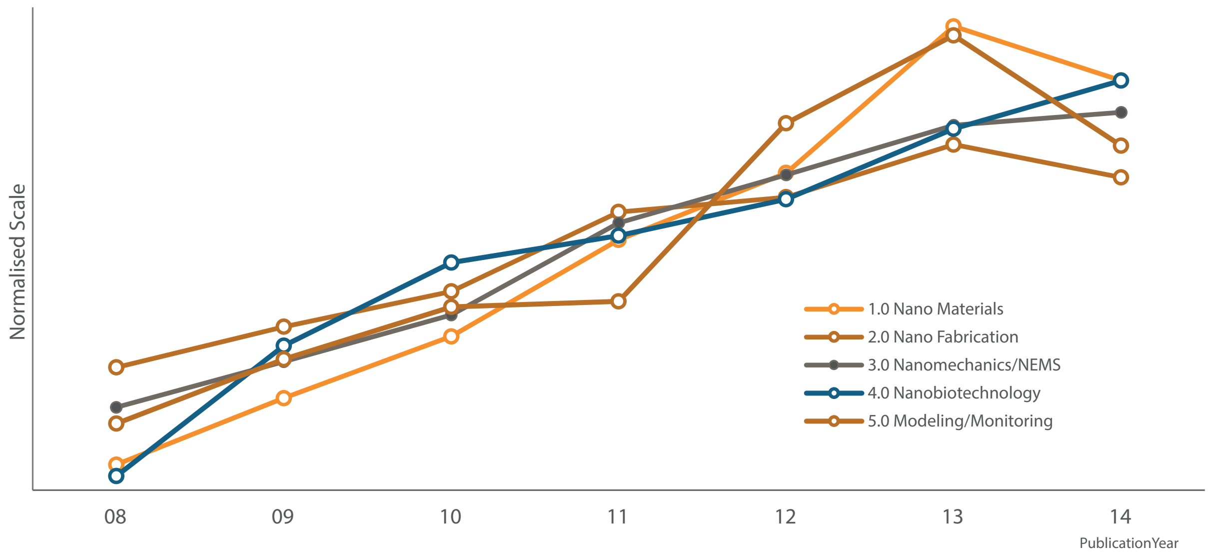

Figure 6 – Normalized timeline of activity for scientific paper collection by Nanotechnology topics

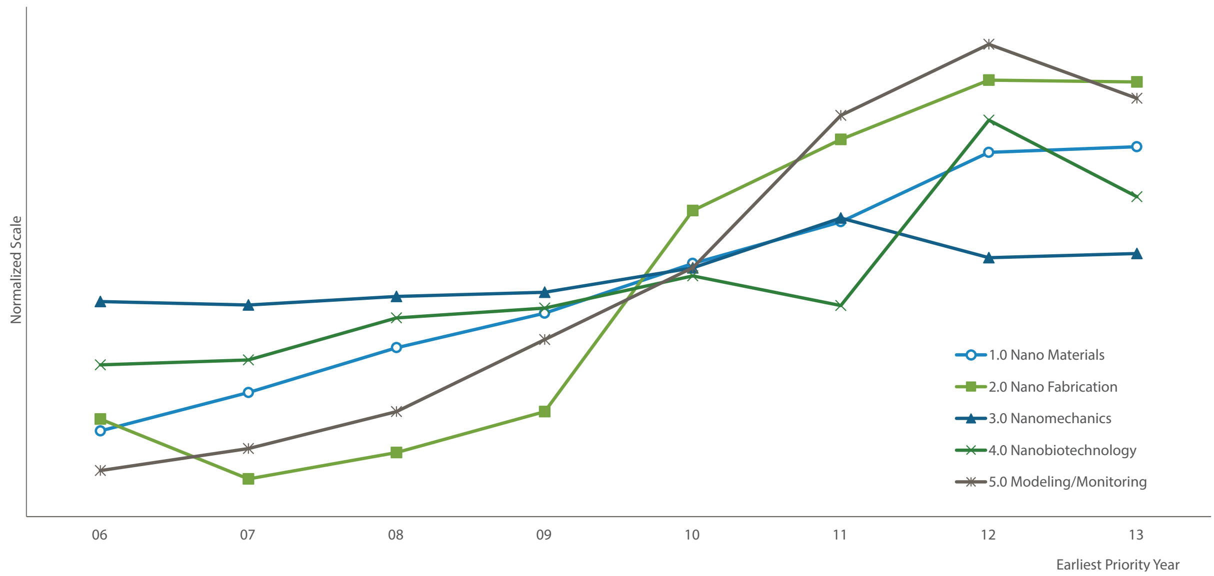

Figure 7 – Normalized timeline of activity for patent collection by Nanotechnology topics

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The timelines on these charts have been normalised to allow for side by side comparison. Individually, each topic has varying volumes of patent families and scientific papers, however for visualisation purposes, the charts represent the proportion of each topic's activity filed or published in each calendar year.

The timelines on these charts have been normalised to allow for side by side comparison. Individually, each topic has varying volumes of patent families and scientific papers, however for visualisation purposes, the charts represent the proportion of each topic's activity filed or published in each calendar year.

GLOBAL NANOTECHNOLOGY SCIENTIFIC LITERATURE

This section of the report focuses on the scientific paper collection and the activity and technological trends seen within it. Based on the Thomson Reuters-produced Web of Science database, the collection only includes papers published in pre-selected journals of influence.
In total, about 214,000 peer reviewed papers were incorporated into the Nanotechnology research.

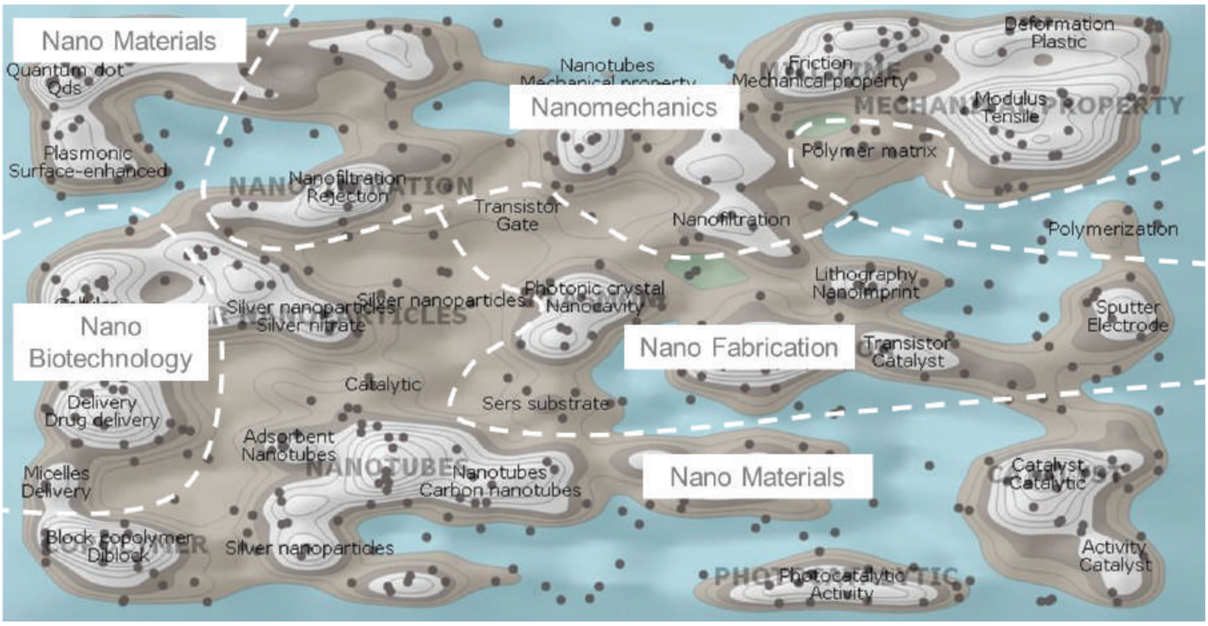

Figure 8 – ThemeScape map of scientific papers on Nanotechnology; annotated by major themes

Key themes present throughout this collection of papers are illustrated in Figure 15 as a "ThemeScape map" - a visualization method for understanding the common themes and concepts within thousands of documents. Used for market analysis, government intelligence and primarily technology landscapes, the algorithm parses large amounts of text into a topological map of peaks and troughs.
Themes that are commonly shared between documents are represented by mountainous peaks, whereas documents that share little commonality are located within the valleys of the map. The large number of documents in this map means that there are rather few valleys to be found.
The location of an individual document is the vector sum of all the attractions to other documents in the collection based on shared phraseology and the frequency and proximity of these terms.
This map has been manually annotated to summarize the major technology areas within the scientific literature collection. Some technologies will necessarily overlap, and the delineation of one technical area versus another is therefore only approximate. However the map is very useful in describing what topics are common features of global Nanotechnology Research.
Key themes revealed in this Themescape map are carbon nanotubes, sputter electrode, Nano filtration, activity catalyst, transistor catalyst, and deformation plastic.

ThemeScape® is a text-mining application that acquires and analyses free text. The algorithms it uses require no application of thesauri or other outside sources of information, and only the free text itself is used by this text-mining tool. The more text the application acquires, the more likely it will be that the output will provide an accurate summary of the major themes present. After analysing the text in multiple documents, it pulls together those documents that share related text and pulls apart those with less related text. The outcome 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 pick out topics of interest. It aggregates word forms that share a common stem, but it does not directly aggregate synonyms. Instead, synonyms may be gathered under a common theme because of the other words that co-occur with those synonyms. Thus, "battery" and "cell" may be clustered together because of the co-occurrence in the same documents of terms like "electrode, rechargeable, electrolyte" and so on. Conversely, "battery" and "cell" may be separated if the map contains a mixture of documents on metals and biology, where the two terms have different meanings. In other words, terms are identified as synonyms only by co-clustering based on common context.

The topographical maps presented by ThemeScape are mathematical solutions built on a random selection of a first document and sequential calculation of the relationships of all the other documents. The orientation of the map is random, and the directions up, down, left, or right have no significance, because the n-dimensional solution might have been presented from any angle. Only the proximity of points within the map has meaning, and co-localized documents are highly likely to share concepts.

In this report there are separate ThemeScape maps covering scholarly papers or patents. The two types of documents are not pooled and analysed together. This is because ThemeScape is context-sensitive, and it would separate patent and literature documents from one another based on the very different formal styles of writing that are reflected in these two types of content. Likewise, if documents in two languages are pooled, it will separate them based on the language, and then each language region will be clustered based on term frequency in that language.

The ThemeScape maps in this report analyse large numbers of documents. The contour lines on the maps diminish in circumference, encircling regions of higher and higher concentration. The density is also shown by the map coloration. White snow-capped peaks represent the highest density, while blue expanses (sea level) indicate low density.

The labels in black on the map are selected by ThemeScape based on term frequency in that map region, and they may have been adjusted by the analyst. The large color-overlay regions enclosed by broken lines have been added by the analyst to identify content at an even higher level of abstraction. The dots on the map represent single documents. Dots are not shown for all the documents, and instead represent a sampling that allows the other features of the map to be discerned. Within the ThemeScape application, the map can be magnified, searched, probed and highlighted to learn more about its contents.

ThemeScape is reliant on statistical methods that are not equivalent to reading by human judges, and in compensation, it analyses millions of documents on a scale of minutes and quickly presents an intuitive, high level summary. It enables and guides further review, and provides a first level overview of very complex datasets.

NANOTECHNOLOGY SCIENTIFIC LITERATURE SEGMENTATION

Table 1 shows the segmentation of the scientific literature collection of nanotechnology. There is significant interest in Nano mechanics/NEMS. Other technology segments of interest include Photo-sensitive Nanoparticle / Nanomaterial, Nanocomposites, and Nanosilver / Antimicrobial Nanoparticles. Material enhancement using nanoparticles, NWs or NTs appears to be a prominent white space, with a very small number of scientific papers, but a very high growth rate – indicating emerging interest in the technology. Other such emerging areas include Nano biotechnology, and error modeling.

Technology Segmentation		Total Publications	Average % Growth or Decline ('09-'14)
1.0 Nano Materials	1.01 Photosensitive Nanoparticle / Nanomaterial	30582	8%
	1.02 Nanocomposites	27105	15%
	1.03 Nanosilver / Antimicrobial	23215	14%
	1.04 Block Copolymers	11744	5%
	1.05 Material Enhancement Using Nanoparticles, NWs or NTs	824	14%
	1.06 Nanocatalyst	21208	16%
	1.07 Organic Nanoparticle	15659	13%
	1.08 Inorganic Nanoparticle	8150	10%
2.0 Nano Fabrication	2.01 Self-assembly	20836	8%
	2.02 Other Nanofabrication	28138	3%
3.0 Nanomechanics /	3.0 Nanomechanics / NEMS	36996	9%
4.0 Nanobiotechnology	4.0 Nanobiotechnology	6658	9%
5.0 Modeling / Monitoring	5.01 New Material and Nanostructure Modeling	24159	14%
	5.02 Nano Devices Modeling	19523	4%
	5.03 Error Modeling	6892	12%

Table 1 – Scientific literature technology segmentation

NANOTECHNOLOGY SCIENTIFIC LITERATURE COLLECTION TECHNOLOGY CATEGORY OVERLAP

The technology segments, that were created to enumerate and describe the Nanotechnology Research landscape, were not intended to be mutually exclusive. A single scientific paper can be included in multiple categories or segments.

Figure 9 visualizes the relationship between the technology segments used in this study. Each number in the diagram shows the number of papers that have content related to both the corresponding row-wise and column-wise segments.

The most correlated segment pairings are Nano mechanics/NEMS with Nano device modeling.

	1.01 Photosensitive Nanoparticle/Nanomaterial	1.02 Nanocomposites	1.03 Nanosilver/Antimicrobial	1.04 Block Copolymers	1.05 Material Enhancement Using Nanoparticles, Nws	1.06 Nanocatalyst	1.07 Organic Nanoparticle	1.08 Inorganic Nanoparticle	2.01 Self-Assembly	2.02 Other Nanofabrication	3.0 Nanomechanics/Nems	4.0 Nanobiotechnology	5.01 New Material And Nanostructure Modeling	5.02 Nano Devices Modeling	5.03 Error Modeling
1.01 Photosensitive Nanoparticle/Nanomaterial	30582	1492	1492	301	39	939	1354	571	1102	1923	1307	249	965	557	156
1.02 Nanocomposites		27105	1273	378	74	786	1270	1051	518	2875	3307	100	765	1434	485
1.03 Nanosilver/Antimicrobial			23215	240	32	813	710	411	883	1514	1020	623	1321	439	191
1.04 Block Copolymers				11744	9	183	443	379	2534	559	351	117	309	191	56
1.05 Material Enhancement Using Nanoparticles, Nws Or Nts					824	30	24	14	18	34	63	3	30	35	11
1.06 Nanocatalyst						21208	723	277	398	1106	824	101	757	311	94
1.07 Organic Nanoparticle							15659	3030	1198	1004	571	160	524	304	106
1.08 Inorganic Nanoparticle								8150	590	518	428	209	317	234	73
2.01 Self-Assembly									20836	1132	942	462	702	447	106
2.02 Other Nanofabrication										28138	2188	201	835	777	222
3.0 Nanomechanics/Nems											36996	423	2019	13129	839
4.0 Nanobiotechnology												6658	385	306	44
5.01 New Material And Nanostructure Modeling													24159	2525	797
5.02 Nano Devices Modeling														19523	1068
5.03 Error Modeling															6892

Figure 9 – Number of scientific papers per pair of technology categories

SCIENTIFIC PAPER GEOGRAPHIC VOLUME BENCHMARKING

Figure 10 shows the number of scientific papers for the ten most prolific countries within the scientific paper collection.
China is the largest source of nanotechnology-related peer-reviewed papers, followed by United States, South Korea, India and Japan. These 10 most prolific countries contribute to about 71% of the scientific publications in the field of nanotechnology.

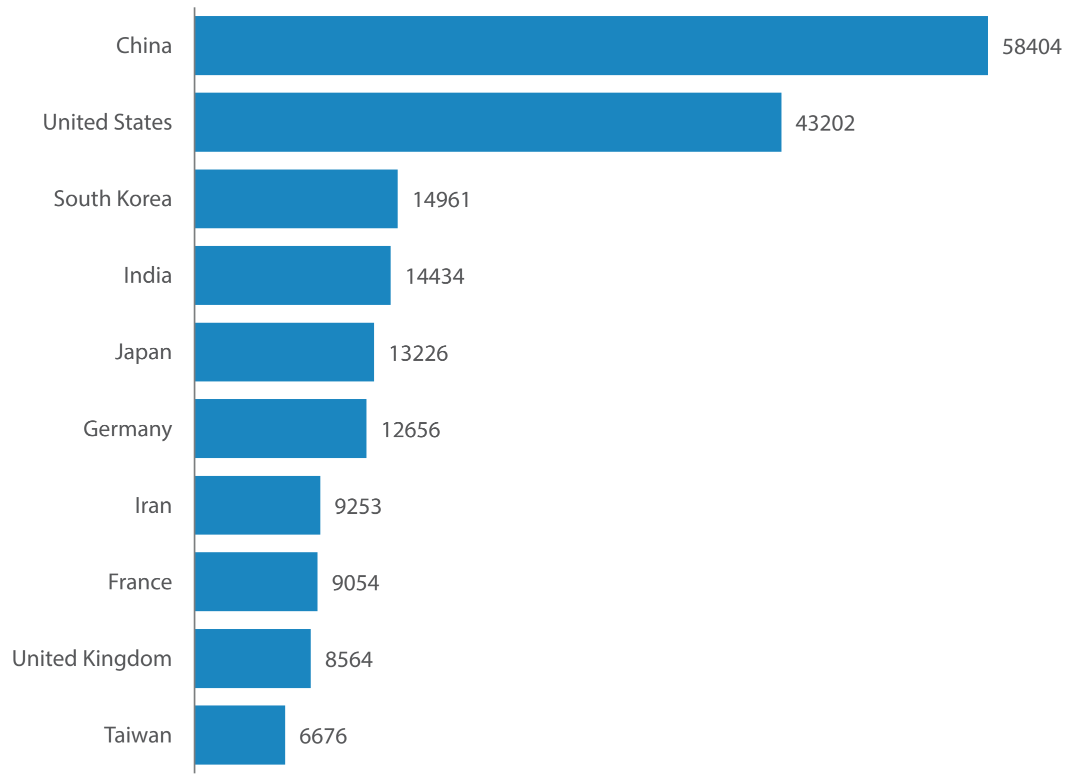

Figure 10 – Number of scientific papers per country; top 10 countries

SCIENTIFIC PAPER GEOGRAPHIC ACTIVITY TRENDS

The chart below shows the highest grow rates sources in the scientific literature collection.

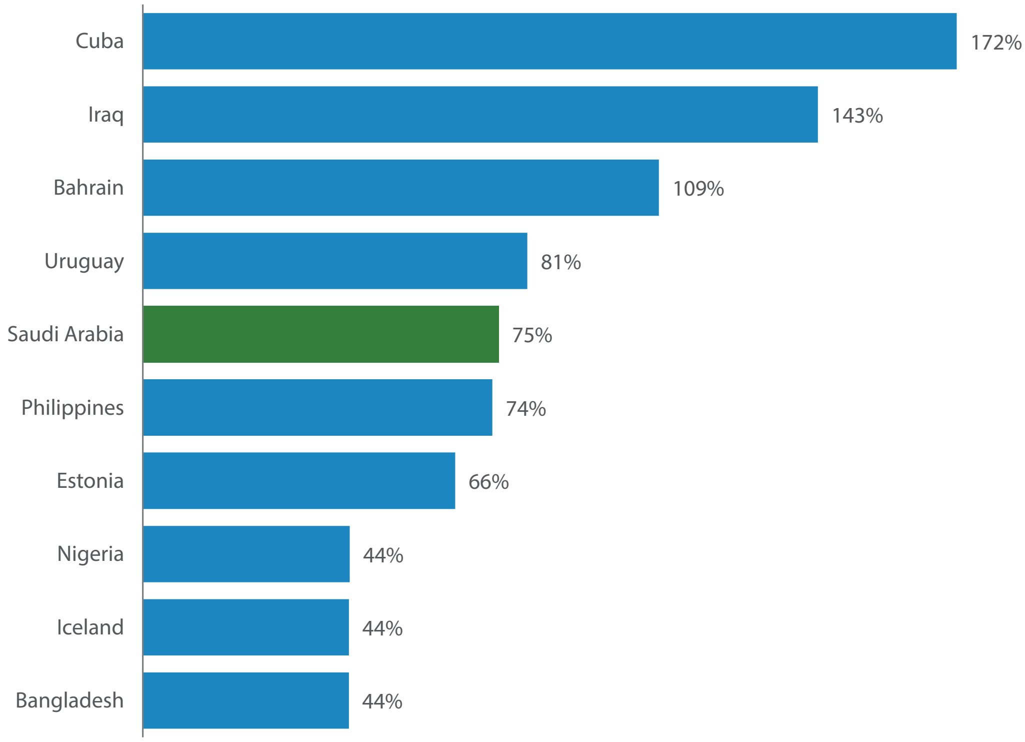

Figure 11 – Highest growth rate geographies in Nanotechnology paper output

While the total number of scientific literature publication from Cuba, Bahrain, and Philippines is very small relative to the collections of the most prolific countries, the growth rate of these countries is much higher as compared to that of other countries.

SCIENTIFIC PAPER GEOGRAPHIC CITATION IMPACT BENCHMARKING

Scientific paper and patent citations are routinely used in technology bibliometrics for assessing the inherent impact and potential quality of research and the downstream technical and scientific relevance of the underlying research.
Figure 12 shows the "Citation Impact", the average citation per paper for all papers in a country's collection (which are having at least 50 publications) and has been sorted by highest citation impact. This shows that output from United States, Switzerland, Netherlands, Denmark and Singapore are having the highest impact in the field of nanotechnology.

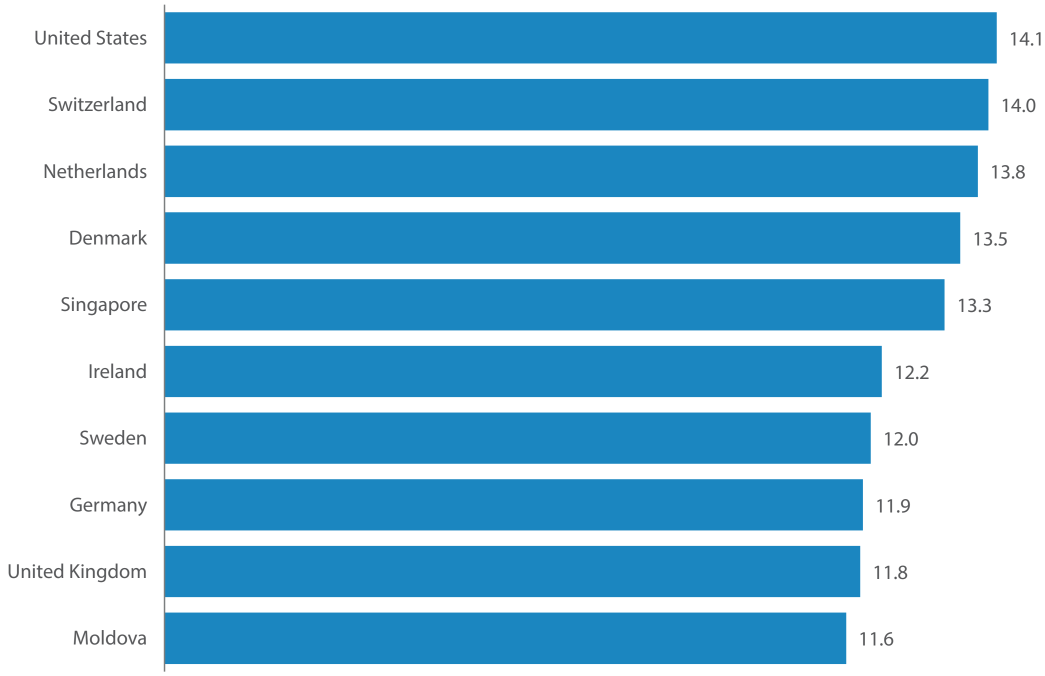

Figure 12 – Highest citation impact geographies of Nanotechnology publications

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Note that the journals included in the project source data (Web of Science) are selected on the basis of both quantitative and qualitative selection criteria, such as editorial quality, peer review robustness and citation impact. Further details of the journal selection process is available from : http://thomsonreuters.com/products_services/science/free/essays/journal_selection_process/

NANOTECHNOLOGY RESEARCH TOPIC BY GEOGRAPHY

Table 1 shows the split of nanotechnology research specialization for the top nations. Most countries appear to have more focus on Nano Materials.

Country of Origin	1.0 Nano Materials	2.0 Nano Fabrication	3.0 Nanomechanics / NEMS	4.0 Nanobiotechnology	5.0 Modeling / Monitoring
China	60%	27%	17%	2%	16%
United States	53%	20%	19%	5%	26%
South Korea	60%	28%	15%	2%	16%
India	67%	17%	14%	3%	21%
Japan	55%	29%	17%	2%	17%
Germany	53%	20%	19%	4%	25%
Iran	58%	20%	19%	2%	29%
France	54%	18%	19%	3%	27%
United Kingdom	49%	21%	20%	5%	28%
Taiwan	59%	26%	17%	2%	19%
Italy	54%	18%	16%	4%	29%
Spain	55%	19%	20%	4%	24%
Canada	56%	19%	19%	4%	26%
Australia	53%	20%	20%	4%	25%
Russia	54%	15%	18%	3%	27%
Singapore	56%	22%	19%	3%	21%
Switzerland	49%	19%	23%	5%	28%
Brazil	59%	16%	17%	4%	26%
Netherlands	52%	21%	19%	4%	25%
Poland	58%	16%	19%	3%	25%
Sweden	54%	18%	20%	3%	27%
Turkey	56%	20%	16%	3%	26%
Malaysia	62%	20%	20%	2%	22%
Belgium	54%	18%	17%	4%	28%
Saudi Arabia	64%	18%	14%	3%	20%
Israel	55%	21%	18%	4%	24%
Egypt	64%	20%	15%	3%	22%
Romania	60%	15%	14%	2%	27%
Mexico	63%	15%	15%	3%	22%
Greece	59%	16%	19%	3%	30%

Table 2 – Nanotechnology specialization by country; % of literature activity per technical stream

SCIENTIFIC LITERATURE –PROLIFIC GLOBAL ENTITIES

Universities appear to dominate the scientific paper publications in nanotechnologies. Notably, a large number of Chinese universities feature in the top 30 entities publishing scientific literature in this area. Science & Technology Unit, Umm al Qura University (STU-UQU) has only 25 papers published in this space, with relatively lower citations per paper, as compared to other entities within the top 30. STU-UQU has scope for filing more publications as discussed in conjunction with Table 1.

Entity	Total	Times Cited	Citation per Paper
Science & Technology Unit, Umm Al Qura University (STU-UQU)	25	38	1.52
Chinese Academy Of Sciences	10234	106434	10.40
CNRS	6824	69346	10.16
United States Department Of Energy (DoE)	4449	71704	16.12
University Of California System	4242	80861	19.06
Russian Academy Of Sciences	2832	11525	4.07
Indian Institute Of Technology (IIT)	2590	16618	6.42
Council Of Scientific & Industrial Research (CSIR) - India	2398	19258	8.03
Consejo Superior De Investigaciones Cientificas (CSIC)	2110	26771	12.69
Tsinghua Univ	2071	22721	10.97
Islamic Azad Univ	2016	6558	3.25
Nanyang Technological University	1939	25581	13.19
Zhejiang University	1935	18495	9.56
Max Planck Society	1911	32282	16.89
Jilin University	1835	15199	8.28
National University Of Singapore	1785	26206	14.68
Seoul National University	1696	18610	10.97
University Of Science & Technology - China	1609	16565	10.30
Nanjing University	1599	15238	9.53
Shanghai Jiao Tong University	1560	13837	8.87
Massachusetts Institute Of Technology (MIT)	1506	28341	18.82
Fudan University	1481	20487	13.83
Peking University	1441	16666	11.57
Japan Science & Technology Agency (JST)	1434	21018	14.66
Consiglio Nazionale Delle Ricerche (CNR)	1426	15209	10.67
Florida State University System	1371	15839	11.55
Changchun Inst Appl Chem	1272	18181	14.29
Harbin Institute Of Technology	1270	8168	6.43
National Taiwan University	1264	12593	9.96
Sichuan University	1254	7708	6.15
Korea Advanced Institute Of Science & Technology (KAIST)	1242	14302	11.52

Table 3 – Nanotechnology – Top Global entities for scientific literature

SCIENTIFIC LITERATURE OVERVIEW OF TOP GLOBAL ENTITIES

Table 4 shows the technology profile of the top 30 entities within the scientific literature space of nanotechnology. Most top entities are researching and publishing papers over a variety of nanotechnology segments. Notable areas of low paper volumes include material enhancement using nanoparticles, NWs and NTs, Nano biotechnology, and error modeling. Science & Technology Unit, Umm al Qura University (STU-UQU) has 25 publications across a number of areas, most notably within Nanocomposites, Nanosilver/Antimicrobial, and to a lesser extent in Nano Mechanics/NEMS.

Entity	1.01 Photosensitive Nanoparticle / Nanomaterial	1.02 Nanocomposites	1.03 Nanosilver / Antimicrobial	1.04 Block Copolymers	1.05 Material Enhancement Using Nanoparticles, NWs or NTs	1.06 Nanocatalyst	1.07 Organic Nanoparticle	1.08 Inorganic Nanoparticle	2.01 Self-assembly	2.02 Other Nanofabrication	3.0 Nanomechanics / NEMS	4.0 Nanobiotechnology	5.01 New Material and Nanostructure Modeling	5.02 Nano Devices Modeling	5.03 Error Modeling
Science & Technology Unit, Umm Al Qura University (STU-UQU)	3	10	8			2			2	2	6		2	2	1
Chinese Academy Of Sciences	1693	1011	1024	560	37	1374	939	428	1335	1442	1667	248	617	642	225
CNRS	967	608	575	494	31	668	646	329	755	570	1215	202	974	674	215
United States Department Of Energy (DoE)	630	350	300	293	17	792	327	153	515	295	855	107	616	454	152
University Of California System	715	229	373	296	15	456	347	165	527	346	883	212	474	445	132
Russian Academy Of Sciences	406	443	313	44	10	290	160	129	112	303	516	82	489	241	69
Indian Institute Of Technology (IIT)	307	680	341	69	14	224	137	69	161	259	597	39	308	315	61
Council Of Scientific & Industrial Research (CSIR) - India	351	489	353	47	11	368	189	111	193	249	294	80	192	161	45
Consejo Superior De Investigaciones Cientificas (CSIC)	236	308	216	82	12	265	197	128	249	237	403	62	224	152	37
Tsinghua Univ	315	172	143	85	7	254	169	74	205	334	447	45	198	228	78
Islamic Azad Univ	170	476	297	6	5	250	88	48	27	299	379	46	323	284	116
Nanyang Technological University	418	170	202	71	17	170	136	56	230	240	348	49	182	158	50
Zhejiang University	352	199	165	182	6	164	163	79	256	312	269	52	139	136	37
Max Planck Society	235	96	115	233	6	249	172	119	278	151	346	59	214	184	49
Jilin University	405	203	220	119	5	169	164	100	239	295	239	31	109	84	25
National University Of Singapore	280	166	163	114	12	157	121	57	182	166	376	69	177	182	48
Seoul National University	215	138	274	142	8	141	153	93	186	272	219	66	146	124	55
University Of Science & Technology - China	239	206	212	189	5	195	127	80	199	208	237	24	100	108	57
Nanjing University	302	176	219	70	2	223	107	51	191	209	187	33	146	84	38
Shanghai Jiao Tong University	258	172	113	187	4	82	87	56	205	233	328	37	124	129	50
Massachusetts Institute Of Technology (MIT)	201	91	63	150	4	64	76	34	252	103	394	112	218	249	58
Fudan University	275	197	95	171	5	184	101	72	209	214	166	48	110	81	39
Peking University	267	92	98	86	5	179	108	60	226	204	230	31	135	127	30
Japan Science & Technology Agency (JST)	334	34	82	108	1	159	152	69	247	244	177	33	97	78	9
Consiglio Nazionale Delle Ricerche (CNR)	266	167	122	50	3	139	186	91	158	121	203	46	193	123	41
Florida State University System	221	143	140	49	4	121	113	39	126	133	265	58	208	154	59
Changchun Inst Appl Chem	154	141	195	175	9	206	101	62	184	163	123	33	50	34	13
Harbin Institute Of Technology	215	207	80	14	4	106	58	38	107	193	385	9	114	154	62
National Taiwan University	317	106	175	88	1	97	130	52	118	174	136	23	110	93	25
Sichuan University	87	206	99	182	3	92	67	42	195	224	220	25	84	98	67
Korea Advanced Institute Of Science & Technology (KAIST)	186	99	135	170	4	177	121	49	176	195	169	27	78	57	24

Table 4 – Scientific literature overview of top global entities

SCIENTIFIC LITERATURE OVERVIEW OF TOP ASIA PACIFIC ENTITIES

Entity	Country of Origin	Total	1.01 Photosensitive Nanoparticle / Nanomaterial	1.02 Nanocomposites	1.03 Nanosilver / Antimicrobial	1.04 Block Copolymers	1.05 Material Enhancement Using Nanoparticles, NWs or NTs	1.06 Nanocatalyst	1.07 Organic Nanoparticle	1.08 Inorganic Nanoparticle	2.01 Self-assembly	2.02 Other Nanofabrication	3.0 Nanomechanics / NEMS	4.0 Nanobiotechnology	5.01 New Material and Nanostructure Modeling	5.02 Nano Devices Modeling	5.03 Error Modeling
Science & Technology Unit, Umm Al Qura University (STU-UQU)	Saudi Arabia	25	3	10	8			2			2	2	6		2	2	1
Chinese Academy Of Sciences	China	10234	1693	1011	1024	560	37	1374	939	428	1335	1442	1667	248	617	642	225
Indian Institute Of Technology (IIT)	India	2590	307	680	341	69	14	224	137	69	161	259	597	39	308	315	61
Council Of Scientific & Industrial Research (CSIR) - India	India	2398	351	489	353	47	11	368	189	111	193	249	294	80	192	161	45
Tsinghua Univ	China	2071	315	172	143	85	7	254	169	74	205	334	447	45	198	228	78
Nanyang Technological University	Singapore	1939	418	170	202	71	17	170	136	56	230	240	348	49	182	158	50
Zhejiang University	China	1935	352	199	165	182	6	164	163	79	256	312	269	52	139	136	37
Jilin University	China	1835	405	203	220	119	5	169	164	100	239	295	239	31	109	84	25
National University Of Singapore	Singapore	1785	280	166	163	114	12	157	121	57	182	166	376	69	177	182	48
Seoul National University	South Korea	1696	215	138	274	142	8	141	153	93	186	272	219	66	146	124	55
University Of Science & Technology - China	China	1609	239	206	212	189	5	195	127	80	199	208	237	24	100	108	57
Nanjing University	China	1599	302	176	219	70	2	223	107	51	191	209	187	33	146	84	38
Shanghai Jiao Tong University	China	1560	258	172	113	187	4	82	87	56	205	233	328	37	124	129	50
Fudan University	China	1481	275	197	95	171	5	184	101	72	209	214	166	48	110	81	39
Peking University	China	1441	267	92	98	86	5	179	108	60	226	204	230	31	135	127	30
Japan Science & Technology Agency (JST)	Japan	1434	334	34	82	108	1	159	152	69	247	244	177	33	97	78	9
Changchun Inst Appl Chem	China	1272	154	141	195	175	9	206	101	62	184	163	123	33	50	34	13
Harbin Institute Of Technology	China	1270	215	207	80	14	4	106	58	38	107	193	385	9	114	154	62
National Taiwan University	Taiwan	1264	317	106	175	88	1	97	130	52	118	174	136	23	110	93	25
Sichuan University	China	1254	87	206	99	182	3	92	67	42	195	224	220	25	84	98	67
Korea Advanced Institute Of Science & Technology (KAIST)	South Korea	1242	186	99	135	170	4	177	121	49	176	195	169	27	78	57	24

Table 5 – Scientific literature overview of top Asia Pacific entities

SCIENTIFIC LITERATURE OVERVIEW OF TOP MIDDLE EAST & AFRICA ENTITIES

Table 6 visualizes the prolific entities in the Middle East and Africa. The list is equally dominated by Middle Eastern and African entities, reflecting the trends seen in Table 5 above. Most of the prolific entities in these regions follow the global focus trends on Nanocomposites, NEMS, Nanomaterials and Nanofabrication technologies.

Entity	Country of Origin	Total	1.01 Photosensitive Nanoparticle / Nanomaterial	1.02 Nanocomposites	1.03 Nanosilver / Antimicrobial	1.04 Block Copolymers	1.05 Material Enhancement Using Nanoparticles, NWs or NTs	1.06 Nanocatalyst	1.07 Organic Nanoparticle	1.08 Inorganic Nanoparticle	2.01 Self-assembly	2.02 Other Nanofabrication	3.0 Nanomechanics / NEMS	4.0 Nanobiotechnology	5.01 New Material and Nanostructure Modeling	5.02 Nano Devices Modeling	5.03 Error Modeling
Science & Technology Unit, Umm Al Qura University (STU-UQU)	Saudi Arabia	25	3	10	8			2			2	2	6		2	2	1
Islamic Azad Univ	Iran	2016	170	476	297	6	5	250	88	48	27	299	379	46	323	284	116
Univ Tehran	Iran	806	46	188	58	17	1	93	29	12	30	144	191	18	125	120	27
Isfahan University Of Technology	Iran	801	45	283	48	3	1	77	32	35	11	181	229	14	98	117	26
Amirkabir Univ Technol	Iran	755	58	302	65	14	3	44	39	23	14	129	156	7	92	99	40
Sharif Univ Technol	Iran	734	102	144	62	9		79	23	12	19	100	217	9	139	149	33
Tarbiat Modares Univ	Iran	597	38	123	71	16	2	69	52	19	21	155	82	13	66	53	17
King Abdulaziz University	Saudi Arabia	551	97	108	70	11	1	102	37	20	21	82	69	12	55	49	6
CNRS	Tunisia	540	79	82	47	4	4	57	49	21	33	70	89	8	79	44	15
King Saud University	Saudi Arabia	516	56	90	132	5	1	56	31	23	17	75	66	24	50	29	18
Tehran University Of Medical Sciences	Iran	462	28	74	81	14	1	37	23	11	21	90	56	34	68	45	24
Univ Kashan	Iran	417	30	72	16	7		112	28	24	8	104	41	1	61	33	3
Iran Univ Sci & Technol	Iran	386	21	97	3	7		32	18	6	6	53	133	9	75	92	26
Univ Tabriz	Iran	333	62	83	19	22	2	43	19	8	8	66	34	5	48	22	7
King Abdullah University Of Science & Technology	Saudi Arabia	302	49	29	47	23		41	13	7	28	30	36	14	38	22	11
Ferdowsi Univ Mashhad	Iran	287	22	55	34	2		45	11	7		55	51	4	44	53	11
Shiraz Univ	Iran	281	7	24	36	1		77	11	7	4	39	43	5	61	32	13
Orta Dogu Teknik University	Turkey	243	33	37	29	7		75	11	2	4	26	36	3	25	12	9
Middle E Tech Univ	Turkey	238	32	36	28	7		74	11	2	4	27	35	3	24	12	8
Iran Polymer & Petrochem Inst	Iran	226	10	152	3	7		4	12	10	1	36	74		14	46	14
King Fahd University Of Petroleum & Minerals	Saudi Arabia	226	38	77	11	1		26	11	5	8	27	50	1	30	15	9
Istanbul Tech Univ	Turkey	225	27	63	39	22	1	8	16	13	18	34	46	11	16	23	18
Payame Noor Univ	Iran	212	13	58	24	7		58	13	3	1	36	8	6	22	10	1
Council For Scientific & Industrial Research (Csir) - South Africa	South Africa	197	18	69	26	3	5	21	4	6	11	15	25	3	23	17	5
Razi Univ	Iran	197	10	42	17			35	17	15	11	33	17	3	52	13	9
Bilkent Univ	Turkey	189	64	17	21	6		6	17	10	39	16	19	2	20	9	2
Kn Toosi Univ Technol	Iran	188	16	37	8			37	7	4		16	52	2	30	32	6
Univ Guilan	Iran	183	21	18	15			13	3	4	3	23	50	3	60	37	11
Univ Isfahan	Iran	172	21	47	24			26	9	4	5	49	21	5	13	14	4
Assiut University	Egypt	163	27	16	25	13	2	25	6	4	6	32	22	8	12	20	6
Cairo University	Egypt	163	26	41	33	5		28	5	2	6	23	16	4	13	9	3

Table 6 – Scientific literature overview of top Middle East & Africa entities

SCIENTIFIC LITERATURE OVERVIEW OF TOP SAUDI ARABIA ENTITIES

Entities	Total	1.01 Photosensitive Nanoparticle/Nanomateria l	1.02 Nanocomposites	1.03 Nanosilver/Antimicrobial	1.04 Block Copolymers	1.05 Material Enhancement Using Nanoparticles, Nws Or Nts	1.06 Nanocatalyst	1.07 Organic Nanoparticle	1.08 Inorganic Nanoparticle	2.01 Self-Assembly	2.02 Other Nanofabrication	3.0 Nanomechanics/Nems	4.0 Nanobiotechnology	5.01 New Material And Nanostructure Modeling	5.02 Nano Devices Modeling	5.03 Error Modeling
Science & Technology Unit, Umm Al Qura University (STU-UQU)	25	3	10	8			2			2	2	6		2	2	1
King Abdulaziz Univ	556	99	108	71	11	1	103	38	20	22	82	69	12	56	49	6
King Saud University	516	56	90	132	5	1	56	31	23	17	75	66	24	50	29	18
King Abdullah University Of Science & Technology	301	49	29	47	23		41	13	7	28	30	36	14	38	21	11
King Fahd University Of Petroleum & Minerals	226	38	77	11	1		26	11	5	8	27	50	1	30	15	9
Najran University	79	38	10	5	1		9	6	2	1	21	5			1	1
King Abdullah Inst Nanotechnol	68	12	9	28			3	2	3	4	9	4	3	5	1	3
King Abdalaziz City Sci & Technol	59	8	11	7	1		4	11		3	9	13	1	5	8	2
Taif Univ	47	9	5	9	1		3	5	1		3	4	2	11	5	
Cent Met R&D Inst	45	23	11	2			14	6		1	6	2		1		
King Khalid University	38	4	5	5			3	3	1		11	6		8	7	
King Faisal University	35	3	8	6			2	1	3	1	4	5		12		1
Al Imam Muhammad Ibn Saud Islamic Univ	33	6	18			1		1			8	4		6	3	2
Cmrdi	31	16	9	1	1		4	5			5	1		1		
Univ Tabuk	30	2	15	2			1	2			2	8		3	5	1
Jazan Univ	26	1	9	6				1		1	3	5	1	4	5	1
Science & Technology Unit, Umm Al Qura University (STU-UQU)	25	3	10	8			2			2	2	6		2	2	1
Sabic	21	1	5				6			1	3	5		2	5	1
Adv Nanofabricat Imaging & Characterizat Lab	20	2	2		1		6		1	3	2	2		5	1	
Qassim Univ	19	5	1	1			2	1			1	2		9	2	
Taibah Univ	14		2	2			1				4	1		2	1	4
Univ Aljouf	13	2	4	1			1				1	6		2	3	1
King Saud Bin Abdulaziz Univ Hlth Sci	10	3						6		1	1	2	1	1	1	
Alfaisal University	9		4	1								5			1	1
Salman Bin Abdul Aziz Univ	8		3	1				1						3		
Univ Hail	8	1						1			2			3	1	
King Abdullah Int Med Res Ctr	7	2						4		2		1	1	1	1	
Saudi Aramco	5		2				1					2			1	2
King Fahd Med Res Ctr	4			1									1	1	1	
Prince Sultan Univ	4			2				1	1		2	1			1	
Univ Dammam	4							1			1	1			2	2

Table 7 – Scientific literature overview of top Saudi Arabia entities

MIDDLE EAST & AFRICA NANOTECHNOLOGY SCIENTIFIC LITERATURE TRENDS

This section of the report focuses on the scientific paper collection and the activity and technological trends observed in the Middle East and Africa regions.

MIDDLE EAST & AFRICA – PROLIFIC COUNTRIES

Figure 13 below shows the prolific countries by scientific literature volume in the Middle East & Africa regions. The gray bars indicate Middle East, blue indicates Africa, and green indicates the Kingdom of Saudi Arabia. As seen from the figure, the most prolific countries within these regions are Iran, followed by Turkey, Saudi Arabia, Egypt and South Africa.

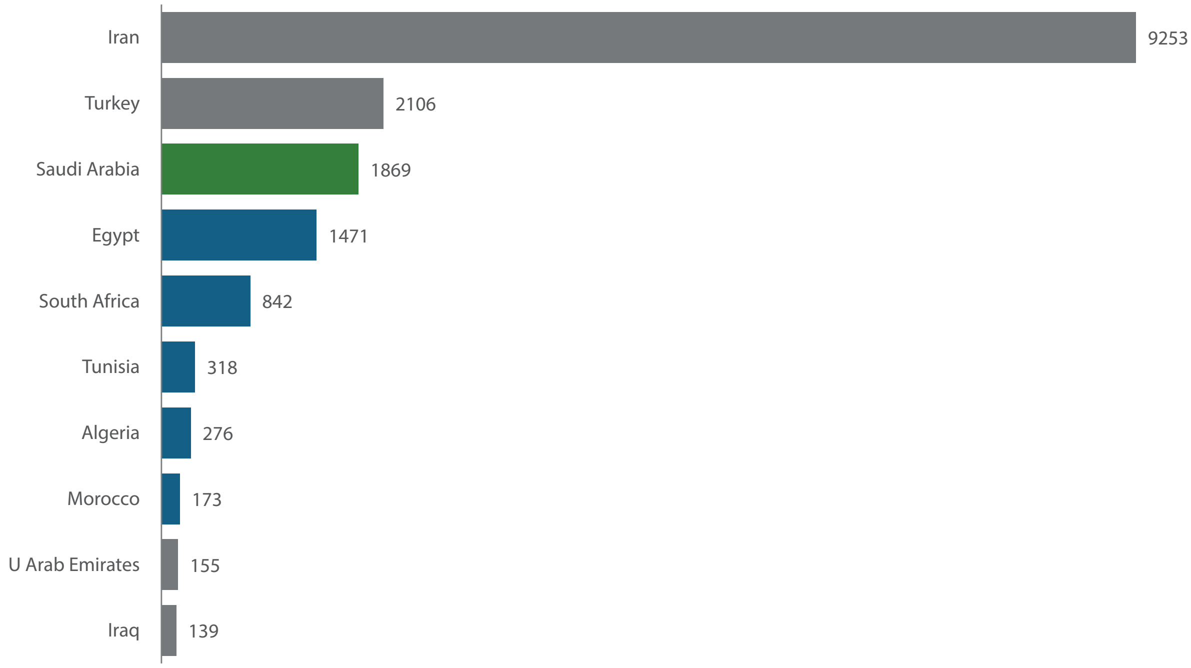


Figure 13 – Middle East & Africa – Prolific countries in scientific literature

A more detailed analysis of the technologies of focus in each of the countries within the Middle East and Africa is presented with reference to Tables 5 and 6. Focus appears to be on nanocomposites and NEMS, similar to the global scientific literature landscape.

Country of Origin	1.01 Photosensitive Nanoparticle / Nanomaterial	1.02 Nanocomposites	1.03 Nanosilver / Antimicrobial	1.04 Block Copolymers	1.05 Material Enhancement Using Nanoparticles, NWs or NTs	1.06 Nanocatalyst	1.07 Organic Nanoparticle	1.08 Inorganic Nanoparticle	2.01 Self-assembly	2.02 Other Nanofabrication	3.0 Nanomechanics / NEMS	4.0 Nanobiotechnology	5.01 New Material and Nanostructure Modeling	5.02 Nano Devices Modeling	5.03 Error Modeling
Iran	723	2231	920	142	22	1311	447	250	184	1634	1760	195	1468	1178	374
Turkey	247	416	236	89	6	204	109	56	139	289	340	61	293	209	103
Saudi Arabia	297	361	275	43	4	242	121	56	81	259	266	52	229	142	52
Egypt	211	306	245	36	5	149	82	43	55	244	221	40	148	166	44
South Africa	99	207	125	14	5	118	39	25	45	70	112	22	94	90	24
Tunisia	75	67	17	1	2	20	34	10	8	52	52	3	43	26	5
Algeria	37	65	17	3	1	18	13	5	8	47	48		49	33	13
Morocco	18	34	10	1	1	10	16	5	13	18	33	1	44	17	11
U Arab Emirates	11	43	6	6		7	13		10	15	39		15	31	8
Iraq	22	18	10			22	5	2	2	45	9	2	25	5	4
Jordan	15	36	4	2		5	5	1	8	15	11	1	19	14	10
Qatar	6	16	2	8		2	7	1	7	5	27	2	11	12	4
Oman	16	4	7			9	8	4	6	9	16	3	11	13	4
Lebanon	10		7	1		5	8	3	7	8	10	4	7	7	2
Nigeria	4	20	7			1	2		4	6	9	2	6	11	6
Azerbaijan	9	26	3	1		9			1	2	7		7	9	1
Kuwait	3	21		3		10	8	7	3	12	14		9	3	1
Armenia	8	11	5			7	1	4		6	4		5	5	1
Bahrain	7	2	2			3				15	6		13	6	1
Yemen	2	7				3	1	1		5	1		1		
Cameroon	1	1	5				1			3	4		2	2	
Syria	1		1				1			3		1	3	2	2
Ethiopia	1	2	2	1		3		1		2	2	3	2	1	
Kenya	2	2	2	1		1			1	1	5			2	
Libya	1	1		1						2	2		2	3	3
Sudan	5	2	2			2	1			1	1		1		

Table 8 – Middle East & Africa – Prolific countries over technical categories

GLOBAL NANOTECHNOLOGY PATENT TECHNOLOGY TRENDS

This section of the report focuses on the patent collections produced for the study and the activity and technological trends seen within it. Based on the Thomson Reuters-produced Derwent World Patents Index database, the collection includes both pending patent applications and granted patents published in 47 countries around the world.
A total of approximately 99,000 patented inventions were gathered that are applicable to the various nanotechnology segments of interest to Science & Technology Unit, Umm Al-Qura University (STU-UQU). These inventions and their technical nature have been summarized using the ThemeScape software described in the previous section.

Figure 14 – ThemeScape map of patent collection on Nanotechnology; annotated by major themes

As previously noted, the ThemeScape map is not designed to provide a detailed accurate view of each patented invention; instead the visual is designed to highlight the common themes shared by hundreds or thousands of patents and patent applications published since 2006.
Some of the key themes revealed in this ThemeScape are nanometer composites, nanotubes carbon, nanometer layer, optical light, and solar cell.
This annotation has been provided to guide the reader around the landscape. However, it should be noted that this annotation is only approximate.

NANOTECHNOLOGY PATENT TECHNOLOGY SEGMENTATION

Table 7 shows the segmentation patents and patent applications in nanotechnology. Unlike the non-patent literature, there is very little patenting activity in the Nanomechanics space. However, Nano Composites, Antimicrobial/Nanosilver, and Inorganic Nanoparticles are highly patented topics. Similar to the literature landscape, material enhancement using nanoparticles, NWs or NTs is a white space in the patent landscape as well, with low current patenting activity, with a high growth rate. Similar observations can be made for Error Modelling, which appears to be another white space with growing interest.

Technology Segmentation		Total Inventions	Average % Growth or Decline (08-13)
1.0 Nano Materials	1.01 Photosensitive Nanoparticle Nanomaterial	10909	6%
	1.02 Nanocomposites	23370	15%
	1.03 Nanosilver Antimicrobial	12699	14%
	1.04 Block Copolymers	2528	2%
	1.05 Material Enhancement Using Nanoparticles, NWs or NTs	2120	22%
	1.06 Nanocatalyst	7209	10%
	1.07 Organic Nanoparticle	10739	5%
	1.08 Inorganic Nanoparticle	19718	7%
2.0 Nano Fabrication	2.01 Self-assembly	2755	7%
	2.02 Other Nanofabrication	42042	24%
3.0 Nanomechanics / NEMS	3.0 Nanomechanics / NEMS	4319	2%
4.0 Nanobiotechnology	4.0 Nanobiotechnology	1473	8%
5.0 Modeling / Monitoring	5.01 New Material and Nanostructure Modeling	4754	17%
	5.02 Nano Devices Modeling	290	25%
	5.03 Error Modeling	483	12%

Table 9 – Patent collection technology segmentation

NANOTECHNOLOGY PATENT COLLECTION TECHNOLOGY CATEGORY OVERLAP

The technology segments, that were created to enumerate and describe the nanotechnology Research landscape in the areas of nano materials, nano fabrication, nano mechanics, nano biotechnology, and modelling/monitoring of nanotech, were not intended to be mutually exclusive. A single patent family can be included in multiple categories.
Figure 15 visualizes the relationship between select technology segments. Each number in the diagram shows the number of inventions that have content related to both the corresponding row-wise and column-wise segments.
The most correlated segment pairings are nano composites with other nano fabrication.

	1.01 Photosensitive Nanoparticle/Nanomaterial	1.02 Nanocomposites	1.03 Nanosilver/Antimicrobial	1.04 Block Copolymers	1.05 Material Enhancement Using Nanoparticles, Nws	1.06 Nanocatalyst	1.07 Organic Nanoparticle	1.08 Inorganic Nanoparticle	2.01 Self-Assembly	2.02 Other Nanofabrication	3.0 Nanomechanics/Nems	4.0 Nanobiotechnology	5.01 New Material And Nanostructure Modeling	5.02 Nano Devices Modeling	5.03 Error Modeling
1.01 Photosensitive Nanoparticle/Nanomaterial	10909	1233	647	117	102	2000	838	1603	217	2870	314	61	351	15	16
1.02 Nanocomposites		23370	1438	315	697	1183	2314	3572	408	7844	358	115	531	13	51
1.03 Nanosilver/Antimicrobial			12699	108	92	358	696	1241	137	2631	89	66	361	3	18
1.04 Block Copolymers				2528	29	68	260	263	350	728	28	18	30		2
1.05 Material Enhancement Using Nanoparticles, Nws Or Nts					2120	63	173	292	28	585	22	19	60		2
1.06 Nanocatalyst						7209	474	1658	87	2435	105	15	161	6	11
1.07 Organic Nanoparticle							10739	2878	294	3293	185	66	159	2	14
1.08 Inorganic Nanoparticle								19718	340	6562	205	95	299	2	24
2.01 Self-Assembly									2755	1080	68	36	84	4	5
2.02 Other Nanofabrication										42042	1035	269	825	34	70
3.0 Nanomechanics/Nems											4319	57	136	254	27
4.0 Nanobiotechnology												1473	39	4	4
5.01 New Material And Nanostructure Modeling													4754	81	126
5.02 Nano Devices Modeling														290	14
5.03 Error Modeling															483

Figure 15 – Number of patent families per pair of technology categories

PATENT ACTIVITY GEOGRAPHIC VOLUME BENCHMARKING

Figure 16 shows the number of patent families or inventions within the Nanotechnology Research landscape in the areas of Nano Materials, Nano Fabrication, Nanomechanics/NEMS, Nano Biotechnology and Modeling/Monitoring patent collection that can be attributed to each nation . Patenting activity within the Nanotechnology Research landscape is led by China, followed by United States, South Korea and Japan. About 53% of the patenting activity is originating from China and about 96% of the patenting activity is originating from the top 10 countries

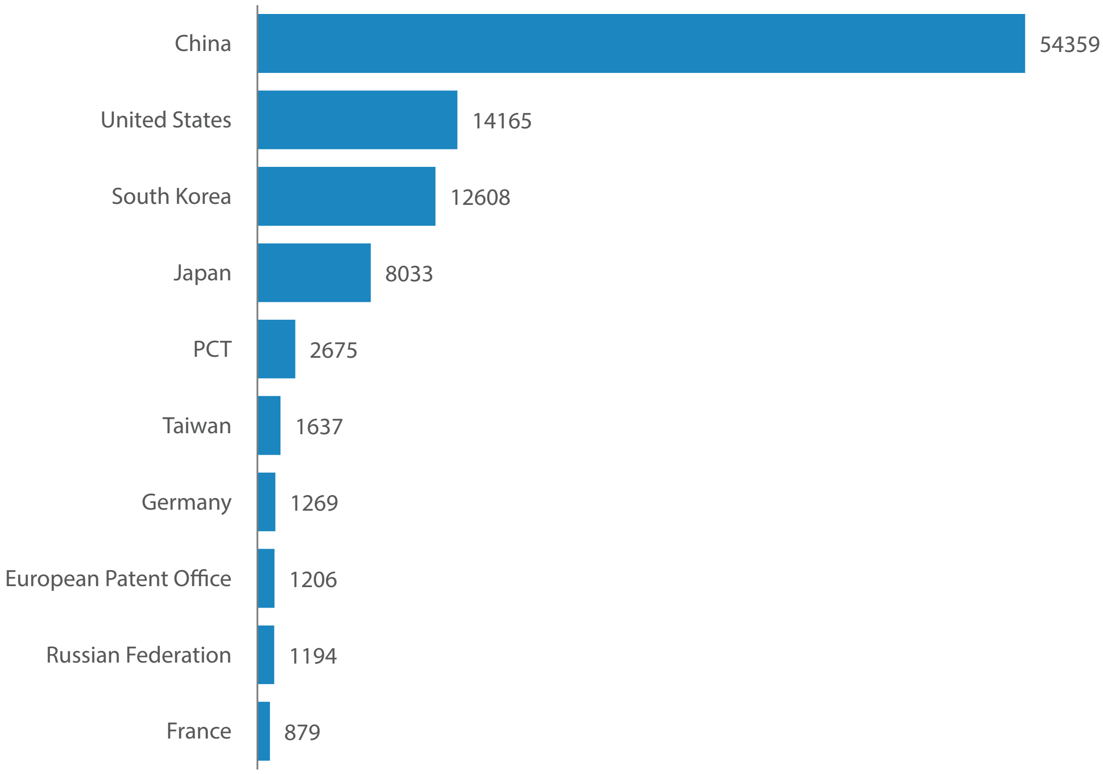


Figure 16 – Number of patent families per country; top 10 countries

National attribution of patent activity is primarily performed via the priority filing location of the invention – this is the first filing event that occurs in the international protection of an invention at the various patent offices around the world. Actual geographic location of the inventor or the innovating corporation may vary from the priority filing location. This effect is exhibited primarily by Saudi Arabian entities, few of which file for patents within the Kingdom.

PATENT GEOGRAPHIC ACTIVITY TRENDS

Although an average number of patent filings from Denmark is about 40 which very small as compared to the patenting activity in the most prolific countries, the growth rate of patenting activity in Denmark exceeds that of most prolific countries and other countries. Out of most prolific countries Poland also has a high growth rate of patent output.

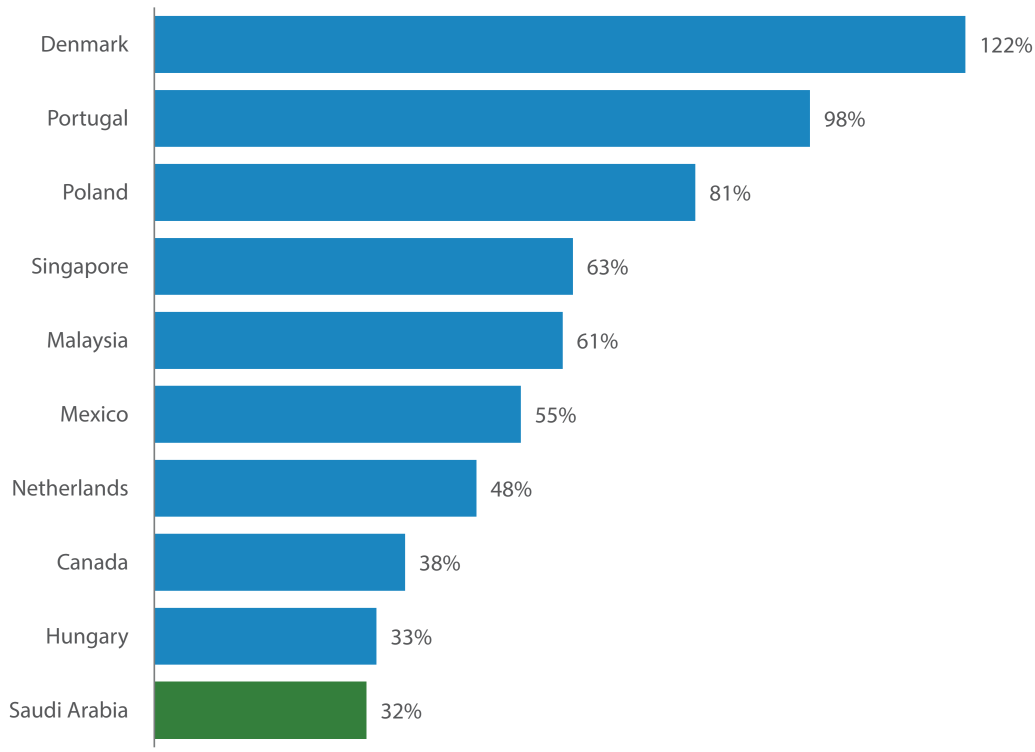


Figure 17 – Highest growth rate geographies in Nanotechnology patent output

PATENT GEOGRAPHIC CITATION IMPACT BENCHMARKING

Figure 18 details the highest citation impact by nation (with at least 50 patents). Patent citation is a widely utilized measurement of the impact and recognition of an individual patent, and by extension, aggregated groups of patents such as those assigned to a company or associated with the innovation of a nation or region. The measurement is useful as it provides an independent assessment of the quality and impact of the innovation contained within the patent. When aggregated, it provides a method of benchmarking collections of patents for the average impact in comparison to others, e.g.: between two competing entities or between nations.

Patent citation information within this study is measured via citations to patent family members of the Derwent World Patents Index and from citation events of 26 national patent collections.

On this metric, United States leads with the highest citation impact, followed by Sweden and Australia.

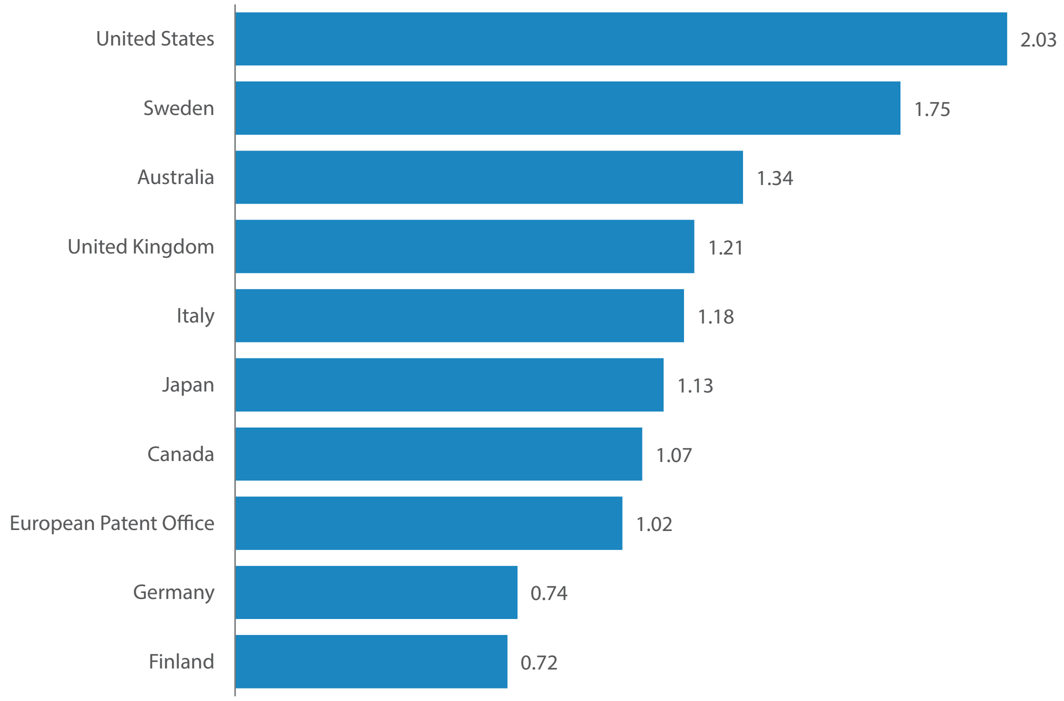


Figure 18 – Highest citation impact geographies of Nanotechnology patents

NANOTECHNOLOGY RESEARCH TOPIC BY GEOGRAPHY

Table 8 shows the split of Nanotechnology Research and specialization for the top nations. Most countries appear to have focus on Nano Materials for Nanotechnology.

Country of Origin	1.0 Nano Materials	2.0 Nano Fabrication	3.0 Nanomechanics / NEMS	4.0 Nanobiotechnology	5.0 Modeling / Monitoring
China	72%	43%	4%	1%	8%
United States	67%	40%	8%	2%	4%
South Korea	70%	54%	2%	0%	2%
Japan	63%	50%	4%	2%	2%
PCT	69%	44%	7%	1%	4%
Taiwan	70%	43%	3%	1%	2%
Germany	70%	28%	6%	6%	2%
Russian Federation	71%	27%	8%	2%	2%
European Patent Office	69%	40%	6%	3%	2%
France	59%	39%	17%	2%	2%
India	67%	53%	3%	2%	6%
United Kingdom	68%	39%	7%	2%	6%
Poland	80%	37%	1%	0%	1%
Brazil	80%	32%	1%	1%	4%
Spain	66%	42%	4%	4%	4%
Italy	72%	45%	2%	2%	2%
Saudi Arabia	85%	42%	3%	1%	0%
Australia	68%	43%	5%	3%	3%
Czech Republic	62%	54%	6%	2%	4%
Sweden	63%	38%	10%	6%	7%
Finland	62%	53%	8%	1%	1%
Mexico	75%	37%	4%	0%	4%
Singapore	60%	56%	10%	0%	0%
Canada	72%	17%	4%	0%	13%
Romania	75%	36%	1%	1%	3%
Malaysia	63%	59%	2%	2%	4%
Austria	78%	25%	5%	0%	3%
Denmark	50%	40%	10%	0%	13%
Switzerland	65%	21%	9%	3%	9%
Portugal	71%	42%	13%	0%	3%
Hungary	82%	64%	0%	4%	0%
Vietnam	80%	48%	0%	0%	0%
Indonesia	70%	57%	4%	0%	4%
South Africa	91%	27%	0%	0%	5%
Netherlands	30%	70%	5%	10%	10%
Turkey	70%	35%	15%	0%	0%
Israel	72%	39%	0%	0%	0%

Table 10 – Nanotechnology specialization by country; % of patent activity per technical stream

PATENT FILINGS – PROLIFIC GLOBAL ENTITIES

The list of prolific entities filing patents includes a number of universities. Science & Technology Unit, Umm al Qura University (STU-UQU) appears to have no patent filings in the Nanotechnology space. IBM, University of California, and Hon Hai Precision appear to have high quality patents that are cited more often than competitors. The number of Chinese universities in the prolific entities indicates that within China, the technology is being developed and commercialized by universities.

Entity	Total	Times Cited	Citation per Family
Univ Zhejiang	1403	630	0.45
Samsung Group	1119	1340	1.20
Univ Qinghua	960	1502	1.56
Univ Donghua	756	309	0.41
Hon Hai Precision Ind Co Ltd	712	1315	1.85
Univ Shanghai Jiaotong	668	335	0.50
Univ Beijing Chem Technology	612	237	0.39
Univ Tianjin	602	159	0.26
Univ Shanghai	527	200	0.38
Univ Nanjing	515	210	0.41
Univ Fudan	504	199	0.39
Harbin Inst Technology	481	122	0.25
Hongfujin Precision Ind Shenzhen Co Ltd	454	794	1.75
Univ Southeast	450	147	0.33
Univ Jiangsu	446	67	0.15
Univ Tongji	446	190	0.43
Univ Jiangnan	413	126	0.31
Univ Jilin	409	167	0.41
Univ South China Technology	398	132	0.33
Univ California	396	845	2.13
Commissariat Energie Atomique	376	157	0.42
Fuji Film Co Ltd	369	494	1.34
Univ Yonsei Ind Academic Coop Found	355	203	0.57
IBM Corp	342	1044	3.05
Korea Adv Inst Sci&Technology	339	214	0.63
Univ Xiamen	333	125	0.38
Chinese Acad Sci Chem Inst	322	133	0.41
Univ Shandong	315	135	0.43
Univ Soochow	314	75	0.24
Dokuritsu Gyosei Hojin Sangyo Gijutsu So	290	249	0.86

Table 11 – Nanotechnology – Top entities for patents

PATENT OVERVIEW OF TOP GLOBAL ENTITIES

Table 10 shows the technology profile of the top 30 entities within the Nanotechnology patent landscape. Nano Composites appear to be the most patented topic within the prolific entities. It should be noted that almost all companies are focusing either on Organic Nanoparticles, or on Inorganic Nanoparticles, but not on both.

Entity	1.01 Photosensitive Nanoparticle Nanomaterial	1.02 Nanocomposites	1.03 Nanosilver Antimicrobial	1.04 Block Copolymers	1.05 Material Enhancement Using Nanoparticles, NWs or NTs	1.06 Nanocatalyst	1.07 Organic Nanoparticle	1.08 Inorganic Nanoparticle	2.01 Self-assembly	2.02 Other Nanofabrication	3.0 Nanomechanics / NEMS	4.0 Nanobiotechnology	5.01 New Material and Nanostructure Modeling	5.02 Nano Devices Modeling	5.03 Error Modeling
Univ Zhejiang	119	458	125	29	22	129	122	386	55	583	47	10	59	11	6
Samsung Group	263	198	90	22	19	78	199	138	28	579	36	3	15		1
Univ Qinghua	90	349	30	6	15	68	181	137	10	395	98	6	33	3	6
Univ Donghua	47	299	93	9	18	27	82	207	28	342	9	4	17	1	1
Hon Hai Precision Ind Co Ltd	73	351	13		3	32	140	34	2	235	61	1	12		
Univ Shanghai Jiaotong	63	215	37	10	16	59	82	167	52	292	41	13	24	2	5
Univ Beijing Chem Technology	48	260	29	8	17	90	67	214	29	300	11	6	11		
Univ Tianjin	56	209	59	22	12	52	50	149	32	279	41	6	28	4	1
Univ Shanghai	53	186	22	6	14	46	53	182	11	265	9	4	12		7
Univ Nanjing	70	159	46	6	9	75	46	129	25	225	27	5	13	3	6
Univ Fudan	56	148	35	24	14	61	74	129	51	225	7	17	25		3
Harbin Inst Technology	36	174	31	7	15	30	44	118	22	252	22	3	14		2
Hongfujin Precision Ind Shenzhen Co Ltd	56	210	10		2	24	112	20	2	149	64	1	8		
Univ Southeast	59	140	61	5	6	25	33	58	27	209	15	15	41	1	1
Univ Jiangsu	59	161	37	2	19	53	20	122	10	272	22	2	15		
Univ Tongji	38	162	29	26	20	28	71	143	36	205	16	9	15		1
Univ Jiangnan	41	102	51	8	4	35	35	61	50	231	16	11	12		2
Univ Jilin	30	101	35	5	6	17	36	115	15	212	53	5	15	18	8
Univ South China Technology	12	151	38	11	7	13	47	97	15	194	12	5	13		
Univ California	73	71	31	29	5	24	46	63	27	143	38	14	23	2	3
Commissariat Energie Atomique	35	33	11	9	3	25	45	59	4	129	128	6	6	2	1
Fuji Film Co Ltd	91	26	49	3	3	2	94	33	1	166	31	15	3		
Univ Yonsei Ind Academic Coop Found	39	99	14	19	11	27	46	31	26	233	17	2	10		
IBM Corp	29	14	5	40	4	16	43	18	47	194	44	4	1		2
Korea Adv Inst Sci&Technology	58	92	24	36	5	25	56	47	39	212	24		10		
Univ Xiamen	33	68	47	15	4	42	36	70	20	156	12	3	3		1
Chinese Acad Sci Chem Inst	34	115	24	18	9	20	83	110	26	131	5	4	11	1	1
Univ Shandong	29	81	32	13	10	30	22	95	8	157	10	2	13	1	
Univ Soochow	31	84	44	5	5	26	36	62	28	180	10	3	8	1	
Dokuritsu Gyosei Hojin Sangyo Gijutsu So	25	62	14	5	3	24	53	63	16	168	11	1	9		1

Table 12 – Patent overview of top global entities

PATENT OVERVIEW OF TOP ASIA PACIFIC ENTITIES

Entity	Country of Origin	Total	1.01 Photosensitive Nanoparticle Nanomaterial	1.02 Nanocomposites	1.03 Nanosilver Antimicrobial	1.04 Block Copolymers	1.05 Material Enhancement Using Nanoparticles, NWs or NTs	1.06 Nanocatalyst	1.07 Organic Nanoparticle	1.08 Inorganic Nanoparticle	2.01 Self-assembly	2.02 Other Nanofabrication	3.0 Nanomechanics / NEMS	3.0 Nanomechanics	4.0 Nanobiotechnology	5.01 New Material and Nanostructure Modeling	5.02 Nano Devices Modeling	5.03 Error Modeling
Science & Technology Unit, Umm Al Qura University (STU-UQU)	Saudi Arabia	-																
Univ Zhejiang	China	1402	119	457	125	29	22	129	122	386	55	583	7	40	10	59	11	6
Samsung Group	South Korea	1092	260	192	89	20	18	75	195	135	28	567		36	3	13		1
Univ Qinghua	China	956	89	348	30	6	15	68	180	137	10	391	8	90	6	33	3	6
Univ Donghua	China	756	47	299	93	9	18	27	82	207	28	342	1	8	4	17	1	1
Hon Hai Precision Ind Co Ltd	China	726	73	361	13		3	33	145	36	2	237	4	63	1	13		
Univ Shanghai Jiaotong	China	665	63	214	37	9	16	59	82	166	51	292	4	37	13	24	2	5
Univ Beijing Chem Technology	China	610	48	259	29	8	17	90	67	214	29	299	2	9	6	11		
Univ Tianjin	China	602	56	209	59	22	12	52	50	149	32	279	4	37	6	28	4	1
Univ Shanghai	China	526	53	185	22	6	14	46	53	182	11	265		9	4	12		7
Univ Nanjing	China	512	70	159	46	6	9	75	46	129	25	222	6	20	5	13	3	6
Univ Fudan	China	503	56	147	35	24	14	61	74	129	51	225	1	6	17	25		3
Harbin Inst Technology	China	481	36	174	31	7	15	30	44	118	22	252	8	14	3	14		2
Univ Southeast	China	450	59	140	61	5	6	25	33	58	27	209	4	11	15	41	1	1
Univ Jiangsu	China	446	59	161	37	2	19	53	20	122	10	272	1	21	2	15		
Univ Tongji	China	446	38	162	29	26	20	28	71	143	36	205	1	15	9	15		1
Univ Jiangnan	China	411	41	101	50	8	4	35	35	61	50	230		16	11	12		2
Univ Jilin	China	409	30	101	35	5	6	17	36	115	15	212	10	43	5	15	18	8
Univ South China Technology	China	398	12	151	38	11	7	13	47	97	15	194	3	9	5	13		
Fuji Film Corp	Japan	391	92	26	54	4	6	2	101	34	1	177	2	32	15	3		
Univ Yonsei Ind Academic Coop Found	South Korea	353	38	98	14	19	11	27	45	31	26	231	5	12	2	10		

Table 13 – Patent overview of top Asia Pacific entities

PATENT OVERVIEW OF TOP MIDDLE EAST & AFRICA ENTITIES

Table 12 illustrates the top patenting entities in the Middle East and Africa. The space appears to be dominated by Saudi Arabia, followed by South Africa. This indicates of a geographic region used majorly only by local players and not often by large multinationals.

Entity	Country of Origin	Total	1.01 Photosensitive Nanoparticle Nanomaterial	1.02 Nanocomposites	1.03 Nanosilver Antimicrobial	1.04 Block Copolymers	1.05 Material Enhancement Using Nanoparticles, NWs or NTs	1.06 Nanocatalyst	1.07 Organic Nanoparticle	1.08 Inorganic Nanoparticle	2.01 Self-assembly	2.02 Other Nanofabrication	3.0 Nanomechanics / NEMS	4.0 Nanobiotechnology	5.01 New Material and Nanostructure Modeling
SABIC	Saudi Arabia	56	3	27		20		1	7	4		21			
KING ABDULAZIZ CITY SCI & TECHNOLOGY	Saudi Arabia	30	7	6				21	1	11		18	1		
GENERAL ELECTRIC CO	Saudi Arabia	27	1	20		7			3			13			
KING FAHD UNIVERSITY OF PETROLEUM & MINERALS	Saudi Arabia	20	1	13	3		1	4	1	4		4			
UNIV KING SAUD	Saudi Arabia	14	3	3	3	1		2		4	1	9			
SAUDI ARAMCO	Saudi Arabia	11						6	1	3		1	1		
UNIV KING ABDULLAH SCI & TECHNOLOGY	Saudi Arabia	11	1	1		2		5	1	4		3	1		
UNIV STELLENBOSCH	South Africa	5	2	2	2			1				1			
IBM CORP	Saudi Arabia	4							1			3	1		
BIO NANO CONSULTING	Saudi Arabia	3						1				3			
MOROCCAN FOUND ADVANCED SCI INNOVATION	Morocco	3	1	2				1	1			3			
UNIV ALFAISAL	Saudi Arabia	3		3	1					1		3	1		
UNIV WESTERN CAPE	South Africa	3	1	1				1		1					1
ARCELIK ANONIM SIRKETI	Turkey	2	1	1			1	1		1			1		
NIPING OIL&GAS RES DEV DES INST	Azerbaijan	2	1	1						1					
PST SENSORS PTY LTD	South Africa	2								2		1			
RUBBER NANO PROD PTY LTD	South Africa	2								2		1			
UNIV KOCHI	Turkey	2		1		1							1		
UNIV MANDELA METROPOLITAN NELSON	South Africa	2								2		1			
UNIV WITWATERSRAND JOHANNESBURG	South Africa	2		1				2							
UNIV YEDITEPE	Turkey	2	1		2							2			
AEL MINING SERVICES LTD	South Africa	1								1					

Table 14 – Patent overview of top Middle East & Africa entities

PATENT OVERVIEW OF TOP SAUDI ARABIA ENTITIES

Entity	Total	1.01 Photosensitive Nanoparticle Nanomaterial	1.02 Nanocomposites	1.03 Nanosilver Antimicrobial	1.04 Block Copolymers	1.05 Material Enhancement Using Nanoparticles, NWs or NTs	1.06 Nanocatalyst	1.07 Organic Nanoparticle	1.08 Inorganic Nanoparticle	2.01 Self-assembly	2.02 Other Nanofabrication	3.0 Nanomechanics / NEMS
SABIC	56	3	27		20		1	7	4		21	
KING ABDULAZIZ CITY SCI & TECHNOLOGY	30	7	6				21	1	11		18	1
KING FAHD UNIVERSITY OF PETROLEUM & MINERALS	20	1	13	3		1	4	1	4		4	
UNIV KING SAUD	14	3	3	3	1		2		4	1	9	
SAUDI ARAMCO	11						6	1	3		1	1
UNIV KING ABDULLAH SCI & TECHNOLOGY	11	1	1		2		5	1	4		3	1
Univ King Abdulaziz	7	2	1				3		3		4	
UNIV ALFAISAL	3		3	1					1		3	1
King Faisal Specialist Hospital & Res Ce	1	1					1					

Table 15 – Patent overview of top Saudi Arabia entities

MIDDLE EAST & AFRICA NANOTECHNOLOGY PATENT TRENDS

This section of the report focuses on the patent collection and the activity and technological trends seen within it – in the Middle East and Africa.

MIDDLE EAST & AFRICA – PROLIFIC COUNTRIES

Patent filing trends appear to be very different from the scientific literature trends. Figure 19 shows that Saudi Arabia is the most popular country for filing patents, within the two regions, followed by South Africa and Turkey. The remaining jurisdictions see only marginal patent filings.

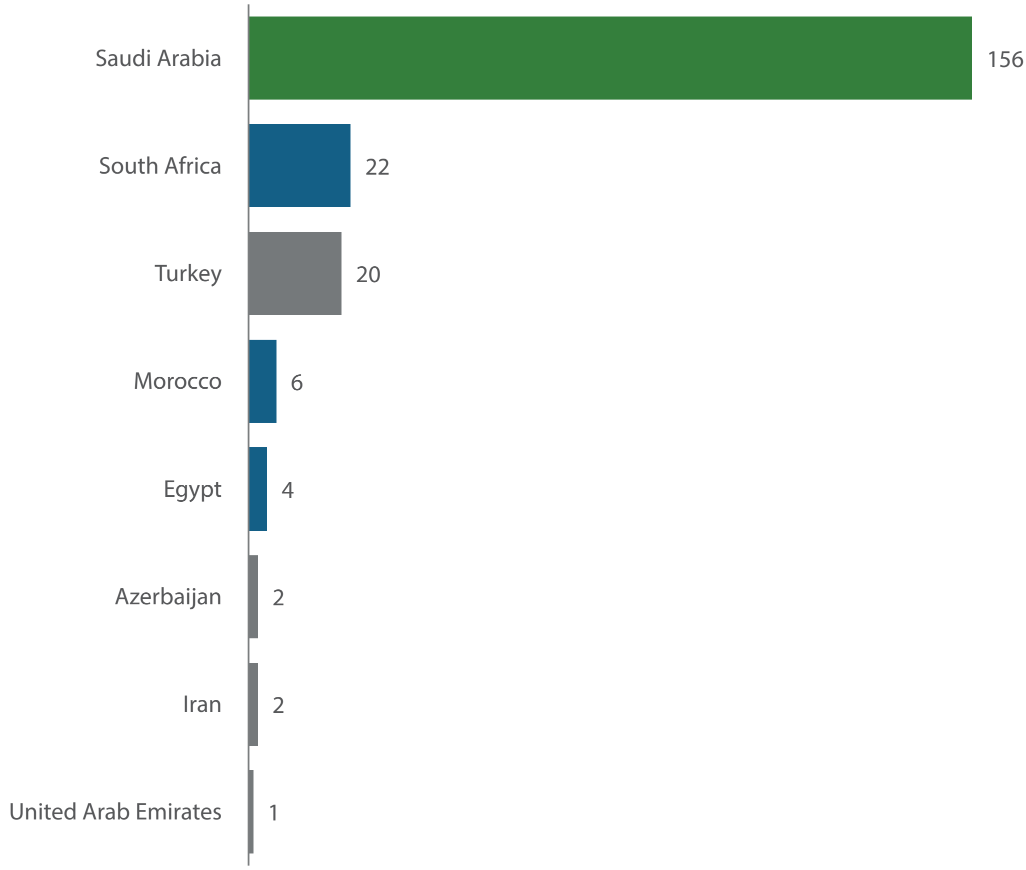


Figure 19 – Middle East & Africa – Prolific countries in patents

Diving deeper, Table 11 shows that Saudi Arabia, South Africa, and Turkey appear to be consistent with the global patent focus on Nanotechnology. The Kingdom of Saudi Arabia has 156 patents, with notable focus on Nanocomposites and Nanocatalysts.

Country of Origin	1.01 Photosensitive Nanoparticle Nanomaterial	1.02 Nanocomposites	1.03 Nanosilver Antimicrobial	1.04 Block Copolymers	1.05 Material Enhancement Using Nanoparticles, NWs or NTs	1.06 Nanocatalyst	1.07 Organic Nanoparticle	1.08 Inorganic Nanoparticle	2.01 Self-assembly	2.02 Other Nanofabrication	3.0 Nanomechanics / NEMS	4.0 Nanobiotechnology	5.01 New Material and Nanostructure Modeling	5.02 Nano Devices Modeling	5.03 Error Modeling
Saudi Arabia	16	52	7	23	1	38	12	30	1	64	4	1			
South Africa	4	7	5			4	1	8	1	5			1		
Turkey	4	6	7	1	2	4	2	4		7	3				
Morocco	1	3	1			1	1			6					
Egypt		1					1	1		1	1	1			
Azerbaijan	1	1						1							
Iran			1					1			1				
United Arab Emirates												1			

Table 16 – Middle East & Africa – Prolific countries over technical categories

APPENDIX A – SCIENTIFIC PAPERS TOP AFFILIATIONS

ENTITY-LEVEL DATA TABLES FOR SCIENTIFIC LITERATURE COLLECTION

Table 13 on the following pages shows the top 10 author organizations for each of the technology segments. This information is intended to provide an assessment of the depth and location of the research expertise available in each category.

Technology	Entity	Total
1.01 Photosensitive Nanoparticle/Nanomaterial	Chinese Academy Of Sciences	1693
	CNRS	967
	University Of California System	715
	United States Department Of Energy (DoE)	630
	Nanyang Technological University	418
	Russian Academy Of Sciences	406
	Jilin University	405
	Zhejiang University	352
	Council Of Scientific & Industrial Research (CSIR) - India	351
	Japan Science & Technology Agency (JST)	334
1.02 Nanocomposites	Chinese Academy Of Sciences	1011
	Indian Institute Of Technology (IIT)	680
	CNRS	608
	Council Of Scientific & Industrial Research (CSIR) - India	489
	Islamic Azad Univ	476
	Russian Academy Of Sciences	443
	United States Department Of Energy (DoE)	350
	Consejo Superior De Investigaciones Cientificas (CSIC)	308
	Amirkabir University Of Technology	302
	Isfahan University Of Technology	283
1.03 Nanosilver/Antimicrobial	Chinese Academy Of Sciences	1024
	CNRS	575
	University Of California System	373
	Council Of Scientific & Industrial Research (CSIR) - India	353
	Indian Institute Of Technology (IIT)	341
	Russian Academy Of Sciences	313
	United States Department Of Energy (DoE)	300
	Islamic Azad Univ	297
	Seoul National University	274
	Jilin University	220
1.04 Block Copolymers	Chinese Academy Of Sciences	560
	CNRS	494
	University Of California System	296
	United States Department Of Energy (DoE)	293
	Max Planck Society	233
	University Of Science & Technology - China	189
	Shanghai Jiao Tong University	187
	Zhejiang University	182
	Sichuan University	182
	Changchun Inst Appl Chem	175
1.05 Material Enhancement Using Nanoparticles, Nws Or Nts	Chinese Academy Of Sciences	37
	CNRS	31
	United States Department Of Energy (DoE)	17
	Nanyang Technological University	17
	University Of California System	15
	Indian Institute Of Technology (IIT)	14
	National University Of Singapore	12
	Consejo Superior De Investigaciones Cientificas (CSIC)	12
	Council Of Scientific & Industrial Research (CSIR) - India	11
	Russian Academy Of Sciences	10

Technology	Entity	Total
1.06 Nanocatalyst	Chinese Academy Of Sciences	1374
	United States Department Of Energy (DoE)	792
	CNRS	668
	University Of California System	456
	Council Of Scientific & Industrial Research (CSIR) - India	368
	Russian Academy Of Sciences	290
	Consejo Superior De Investigaciones Cientificas (CSIC)	265
	Tsinghua Univ	254
	Islamic Azad Univ	250
	Max Planck Society	249
1.07 Organic Nanoparticle	Chinese Academy Of Sciences	939
	CNRS	646
	University Of California System	347
	United States Department Of Energy (DoE)	327
	Consejo Superior De Investigaciones Cientificas (CSIC)	197
	Council Of Scientific & Industrial Research (CSIR) - India	189
	Consiglio Nazionale Delle Ricerche (CNR)	186
	Max Planck Society	172
	Tsinghua Univ	169
	Jilin University	164
1.08 Inorganic Nanoparticle	Chinese Academy Of Sciences	428
	CNRS	329
	University Of California System	165
	United States Department Of Energy (DoE)	153
	Russian Academy Of Sciences	129
	Consejo Superior De Investigaciones Cientificas (CSIC)	128
	Max Planck Society	119
	Council Of Scientific & Industrial Research (CSIR) - India	111
	Jilin University	100
	Seoul National University	93
2.01 Self-Assembly	Chinese Academy Of Sciences	1335
	CNRS	755
	University Of California System	527
	United States Department Of Energy (DoE)	515
	Max Planck Society	278
	Zhejiang University	256
	Massachusetts Institute Of Technology (MIT)	252
	Northwestern University	250
	Consejo Superior De Investigaciones Cientificas (CSIC)	249
	Japan Science & Technology Agency (JST)	247
2.02 Other Nanofabrication	Chinese Academy Of Sciences	1442
	CNRS	570
	University Of California System	346
	Tsinghua Univ	334
	Zhejiang University	312
	Russian Academy Of Sciences	303
	Islamic Azad Univ	299
	United States Department Of Energy (DoE)	295
	Jilin University	295
	Seoul National University	272

Table 17 - Top 10 paper publishing organizations per technical segment

APPENDIX B – PATENT STATISTICS AND TABLES

ENTITY-LEVEL DATA TABLES FOR PATENT COLLECTION

The Table 14 below and on the following page shows the top 10 patent applicants or patent assignees for each of the technology segments. This information is intended to provide an assessment of expertise and patent commercialization intent per category.

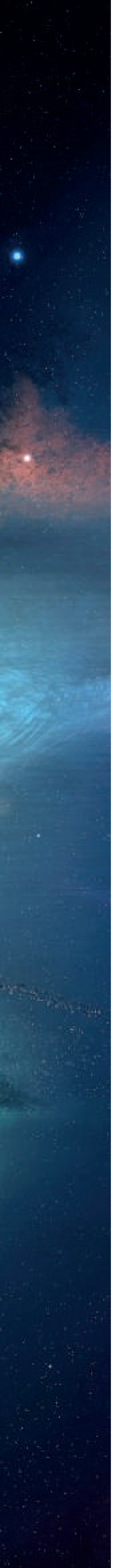
Technology	Entity	Total
1.01 Photosensitive Nanoparticle Nanomaterial	SAMSUNG GROUP	308
	FUJI FILM CO LTD	148
	UNIV ZHEJIANG	119
	UNIV QINGHUA	90
	HON HAI PRECISION IND CO LTD	73
	UNIV CALIFORNIA	73
	UNIV NANJING	70
	UNIV SHANGHAI JIAOTONG	63
	UNIV SOUTHEAST	59
	UNIV JIANGSU	59
1.02 Nanocomposites	UNIV ZHEJIANG	458
	HON HAI PRECISION IND CO LTD	351
	UNIV QINGHUA	349
	UNIV DONGHUA	299
	UNIV BEIJING CHEM TECHNOLOGY	260
	UNIV SHANGHAI JIAOTONG	215
	HONGFUJIN PRECISION IND SHENZHEN CO LTD	210
	UNIV TIANJIN	209
	SAMSUNG GROUP	198
	UNIV SHANGHAI	186
1.03 Nanosilver Antimicrobial	UNIV ZHEJIANG	125
	UNIV DONGHUA	93
	SAMSUNG GROUP	90
	FUJI FILM CO LTD	87
	LG INNOTEK CO LTD	72
	UNIV SOUTHEAST	61
	UNIV TIANJIN	59
	UNIV JIANGNAN	51
	UNIV XIAMEN	47
	UNIV NANJING	46
1.04 Block Copolymers	CHENGDU LVKE HUATONG TECHNOLOGY CO LTD	48
	IBM CORP	40
	KOREA ADV INST SCI&TECHNOLOGY	36
	ARKEMA FRANCE	30
	UNIV ZHEJIANG	29
	UNIV CALIFORNIA	29
	UNIV TONGJI	26
	KOREA ADVANCED INST SCI & TECHNOLOGY	25
	UNIV FUDAN	24
	MICRON TECHNOLOGY INC	23
1.05 Material Enhancement Using Nanoparticles, NWs or NTs	OCEANS KING LIGHTING SCI & TECHNOLOGY CO	30
	UNIV ZHEJIANG	22
	SHENZHEN OCEANS KING LIGHTING ENG CO LTD	21
	UNIV TONGJI	20
	SAMSUNG GROUP	19
	UNIV JIANGSU	19
	UNIV DONGHUA	18
	SHENZHEN OCEANS KING LIGHTING SCI & TECH	18
	UNIV BEIJING CHEM TECHNOLOGY	17
	UNIV SHANGHAI JIAOTONG	16

Technology	Entity	Total
1.06 Nanocatalyst	UNIV ZHEJIANG	129
	UNIV BEIJING CHEM TECHNOLOGY	90
	SAMSUNG GROUP	78
	UNIV NANJING	75
	UNIV QINGHUA	68
	UNIV FUDAN	61
	UNIV SHANGHAI JIAOTONG	59
	UNIV DALIAN TECHNOLOGY	59
	UNIV JIANGSU	53
	TOYOTA JIDOSHA KK	53
1.07 Organic Nanoparticle	SAMSUNG GROUP	199
	UNIV QINGHUA	181
	FUJI FILM CO LTD	152
	HON HAI PRECISION IND CO LTD	140
	UNIV ZHEJIANG	122
	HONGFUJIN PRECISION IND SHENZHEN CO LTD	112
	CHINESE ACAD SCI CHEM INST	83
	UNIV SHANGHAI JIAOTONG	82
	UNIV DONGHUA	82
	UNIV FUDAN	74
1.08 Inorganic Nanoparticle	UNIV ZHEJIANG	386
	UNIV BEIJING CHEM TECHNOLOGY	214
	UNIV DONGHUA	207
	UNIV SHANGHAI	182
	UNIV SHANGHAI JIAOTONG	167
	UNIV TIANJIN	149
	UNIV TONGJI	143
	SAMSUNG GROUP	138
	UNIV QINGHUA	137
	3M INNOVATIVE PROPERTIES CO	130
2.01 Self-assembly	UNIV ZHEJIANG	55
	UNIV SHANGHAI JIAOTONG	52
	UNIV FUDAN	51
	UNIV JIANGNAN	50
	IBM CORP	47
	KOREA ADV INST SCI&TECHNOLOGY	39
	UNIV TONGJI	36
	UNIV TIANJIN	32
	UNIV BEIJING CHEM TECHNOLOGY	29
	UNIV DONGHUA	28
2.02 Other Nanofabrication	UNIV ZHEJIANG	583
	SAMSUNG GROUP	579
	UNIV QINGHUA	395
	UNIV DONGHUA	342
	UNIV BEIJING CHEM TECHNOLOGY	300
	UNIV SHANGHAI JIAOTONG	292
	UNIV TIANJIN	279
	UNIV JIANGSU	272
	UNIV SHANGHAI	265
	HARBIN INST TECHNOLOGY	252

Top 10 Entities per Technology Stream
continued

Technology	Entity	Total
3.0 Nanomechanics / NEMS	COMMISSARIAT ENERGIE ATOMIQUE	128
	UNIV QINGHUA	98
	HONGFUJIN PRECISION IND SHENZHEN CO LTD	64
	HON HAI PRECISION IND CO LTD	61
	UNIV JILIN	53
	UNIV ZHEJIANG	47
	UNIV BEIJING TECHNOLOGY	45
	IBM CORP	44
	UNIV SHANGHAI JIAOTONG	41
	UNIV TIANJIN	41
4.0 Nanobiotechnology	FUJI FILM CO LTD	23
	LEICA MICROSYSTEMS SCHWEIZ AG	18
	UNIV FUDAN	17
	LI R	16
	ZEISS MEDITEC AG CARL	16
	UNIV SOUTHEAST	15
	UNIV CALIFORNIA	14
	TIANJIN CHAOHAI TECHNOLOGY CO LTD	14
	UNIV SHANGHAI JIAOTONG	13
	ZEISS SURGICAL GMBH CARL	12
5.01 New Material and Nanostructure Modeling	UNIV ZHEJIANG	59
	UNIV SOUTHEAST	41
	UNIV BEIJING TECHNOLOGY	34
	UNIV QINGHUA	33
	UNIV XIAN JIAOTONG	32
	UNIV JINAN	29
	UNIV TIANJIN	28
	UNIV FUDAN	25
	UNIV SHANGHAI JIAOTONG	24
	UNIV CALIFORNIA	23
5.02 Nano Devices Modeling	UNIV BEIJING TECHNOLOGY	20
	UNIV JILIN	18
	UNIV ZHEJIANG	11
	UNIV NANJING	5
	UNIV TIANJIN	4
	ZHANG Y	4
	UNIV QINGHUA	3
	UNIV QINGDAO TECHNOLOGICAL	3
	UNIV BEIJING IND	3
	ZHAO H	3
5.03 Error Modeling	CHENGDU LINGYU BIOTECHNOLOGY CO LTD	12
	UNIV XIAN JIAOTONG	11
	UNIV TAIYUAN TECHNOLOGY	9
	UNIV JILIN	8
	UNIV BEIJING TECHNOLOGY	7
	UNIV SHANGHAI	7
	UNIV ZHEJIANG	6
	UNIV QINGHUA	6
	UNIV NANJING	6
	UNIV NINGBO	6

Table 18 – Top 10 patent applicants/owners per technology segment



LANDSCAPE OF SPACE TECHNOLOGY

SCIENCE & TECHNOLOGY UNIT,
UMM AL-QURA UNIVERSITY (STU-UQU)

THOMSON REUTERS IP SERVICES
MAY 2014

Executive Summery

This study has been commissioned by Science & Technology Unit, Umm Al-Qura University (STU-UQU) to evaluate and describe the global scientific research and patent activity within sub-tracks that they have achieved funding for projects. Within the Space Technology track, the sub-tracks of focus were Electronic Navigation, Inertial Navigation, Celestial Navigation, Navigation System Components and Testing/-Calibration/Monitoring.

The study has looked at both scientific papers and patents to form an understanding of the overall scientific and technology landscape.

The scientific papers are sourced from the Web of Science™, a database containing journal articles from approximately 12,500 peer-reviewed journals.

The patent information is sourced from the Derwent World Patents Index™, a database of patents and patent applications from 48 international patent issuing authorities.

Both databases have been selected because they provide a method of defining a unit of science or technology. A single paper defined by the Web of Science is required to have met a minimum threshold of scientific rigor: publication within a journal of repute, peer review sign off, etc. Furthermore, a patent included within DWPI is defined credibly as an attempt to protect a piece of innovation within at least one territory.

Aggregating this information across technologies and countries provides a method of tracking Space Technology innovation and development trends.

Included in this document are measurements of research and patent quality and direction changes in research and patent activity. It should be noted that in many areas the report utilizes metrics such as average annual percentage growth in scientific and research output to compare activities across technologies and geographies. Such metrics should be treated with care for analyses containing low volumes, as some volatility is expected. Also to be noted is that the global high volume nature of this analysis within Space Technology necessarily entails some level of noise and is not intended to be completely comprehensive. Instead, the analyses enclosed should be treated as a survey of the technology, and the trends and findings interpreted in this manner.

Overall, the number of patents filed in the respective research area is approximately six times higher than the number of literature papers suggests that research activity is generally focused more on practical technical commercialization as opposed to more fundamental research.

For STU-UQU, it is interesting to note the patent and scientific literature collections differ with respect to the breakdown in broad technology segments/topics. Though, most of the topics including satellite navigation, sensing components and testing/calibration/monitoring are comparably active in both patent and scientific literature data sets. Further, celestial navigation topic is least focused, however looking at the average growth rates in the scientific literature collection (years 2009 – 2014; refer to Figure 5) it is experiencing significant growth. This insight may give STU-UQU direction on future projects and research areas.

With regard to average growth rates in both the collections (years 2008 - 2013 for patents; years 2009 - 2014 for scientific literature), in the patent collection the technology topics which are experiencing significant growth include radio/RADAR navigation and sensing components. While satellite navigation topic in the patent collection, regardless of high volume, has seen a drastic fall over the time period which may indicate innovation saturation in this area. The topics in the scientific literature collection which have seen sizable growth relative of other topics include electronic navigation, navigation system components and testing/calibration/monitoring.

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INTRODUCTION TO GLOBAL SPACE TECHNOLOGY

This study presents an analysis of patents and scientific papers that fall within specific topics of interest to Science & Technology Unit, Umm Al-Qura University (STU-UQU) in relevance to space navigation and monitoring.

The study was commissioned by STU-UQU as part of a wider program to review the scientific and intellectual property activity in specific topics that they have gained approved funding for projects. Within the area of Space Technology, they have gained funding approval for projects related to Navigation; the title of the project is "Advanced Filtering Algorithms for Integrated Navigation".

A large scale data collation process using globally recognized search processes from Thomson Reuters was undertaken to produce practical and insightful sets of information for analysis regarding the trends, geographies and ultimately the institutions and patent applicants working in the fields of Testing/Calibration/Monitoring and Navigation within the domain of Space Technology.

As shown in Figure 1, the overall volume of patents in these technology areas filed since 2006 is approximately eight times higher as compared to the volume of scientific papers published since 2008.

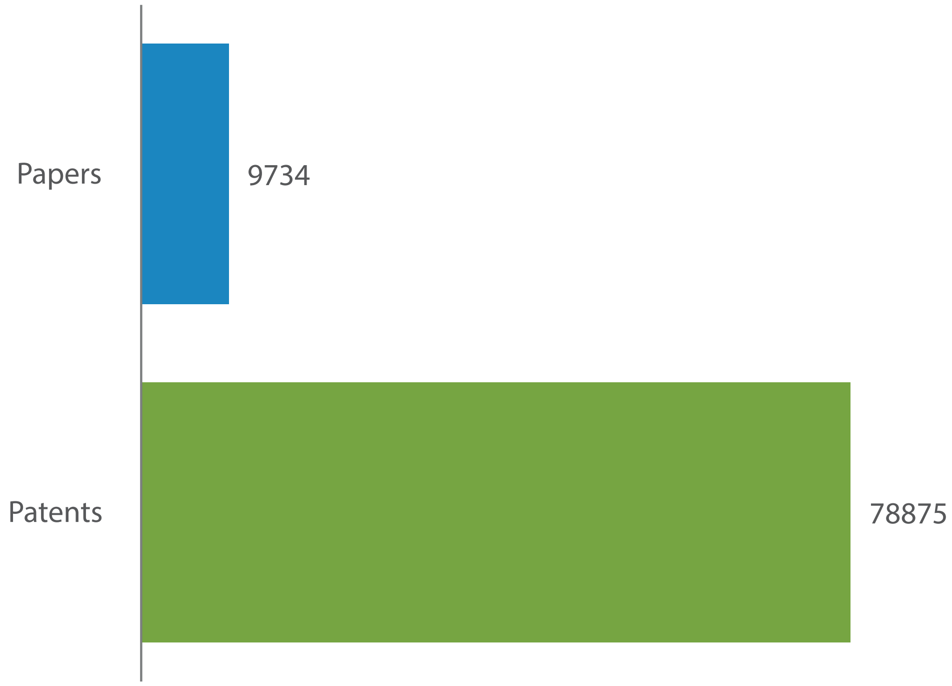


Figure 1 – Scientific Paper and Patent Families in Space Technology

Patenting activity increased significantly from 2006 to 2008; and although there was a slowdown between the years 2008 to 2011, overall the patenting activity has increased till 2011. Unlike the patenting trend, activity of scientific papers, which are likely to address more fundamental science, has been increasing across the year range. The overall increase in patenting activity and the high number of patents in this field might suggest that the focus of technology development globally related to space technology is increasingly directed towards commercialization and practical application.

In recent years (2011 onwards) the patenting activity has shown a downward trend. On the other hand, the scientific paper output has been balanced and increased at a much slower rate till the year 2013.

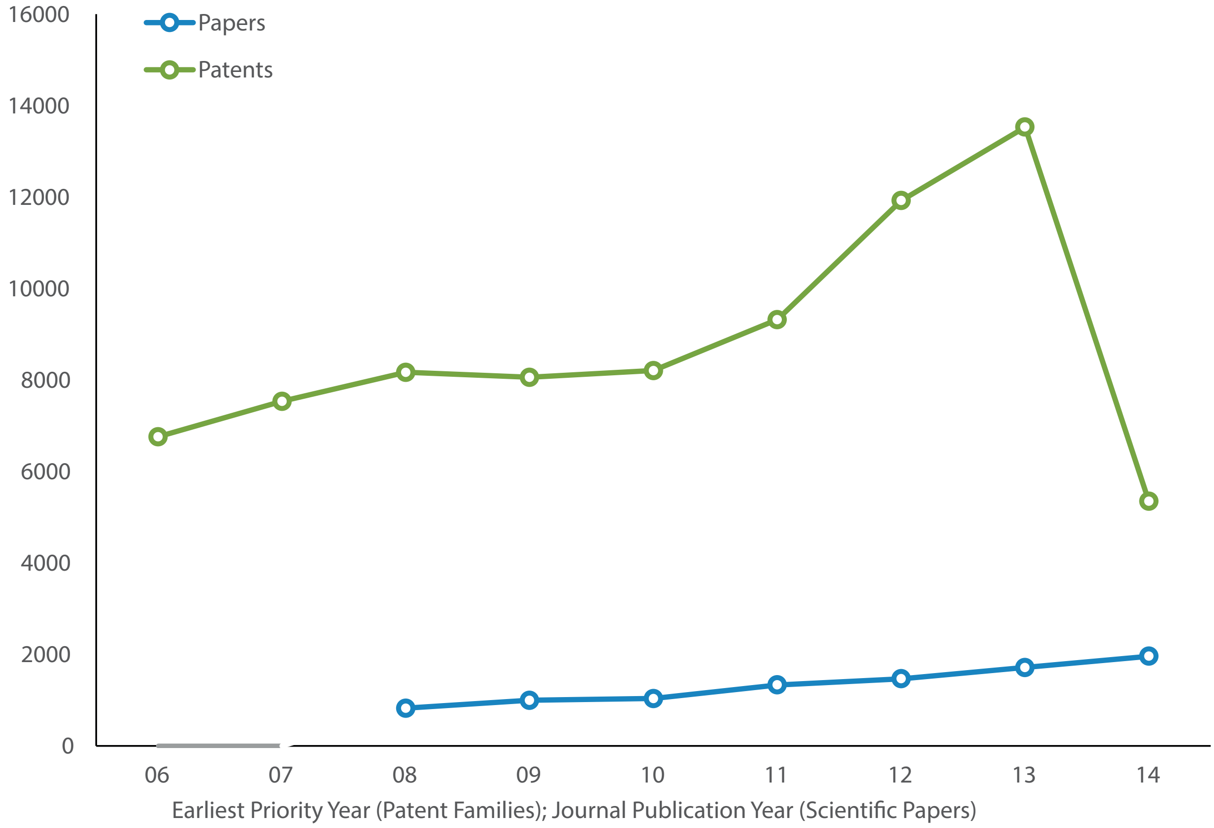


Figure 2 – Timeline of Scientific Paper and Patent Family Activity

Figures 3, 4, 5 show three further analyses on each of the data collections (patents, left; papers, right) concerning the nature and high level technology trends occurring within the space technology area.
The patent and scientific literature collections differ with respect to the breakdown in broad technology segments namely 'electronic navigation' and 'navigation system components'. Referring to Figure 3, patenting activity has been dominated by electronic navigation segment within space technology. In case of scientific papers the satellite navigation topic marginally exceeds the sensing components topics.
Most of the topics namely electronic navigation, which includes: radio/radar navigation, satellite navigation; inertial navigation, celestial navigation, celestial navigation and testing/calibration/-monitoring are comparably active in both patent and scientific literature data sets with the sensing components and satellite navigation being leading topics in patent and scientific literature data sets. Celestial navigation topic is least focused, however the average growth rates in the scientific literature collection (years 2009 – 2014; refer to Figure 5) show that this field is experiencing growth in activity.

Note that the dates used for the collation of the timeline information differ for patent and scientific literature information. Patent Families are measured by the earliest known "priority" or first filing event in the inventions history. Patents are typically retained by patent offices for 18 months or more after filing before they are published. This delay means that the last complete year of information available for patent information is 2012. For scientific papers, the dates used for analyses are the publication dates of the journal containing the paper. These metrics are used throughout the report.

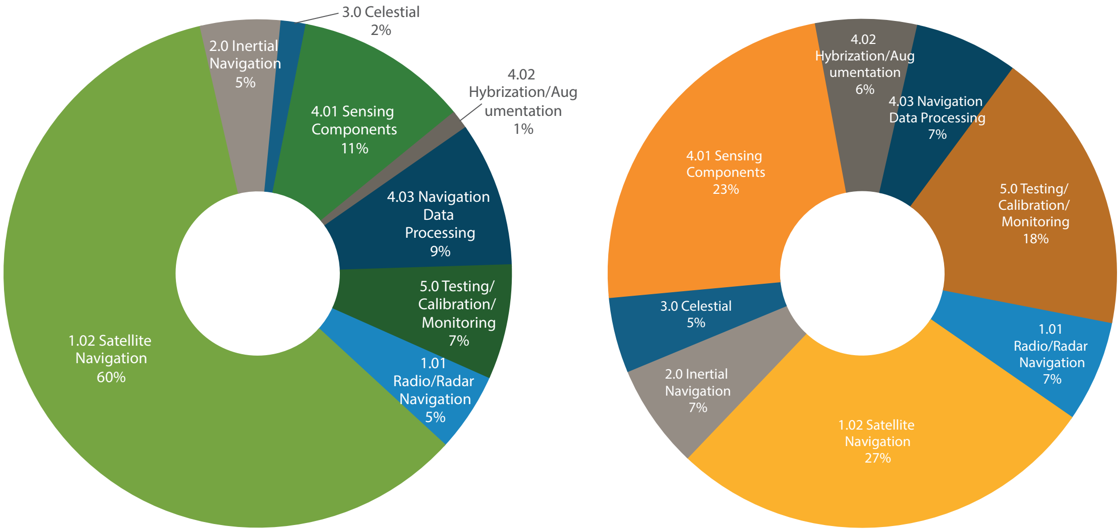


Figure 3 – % of Patent (left) and Scientific Paper (right) Collections by Technology Topics

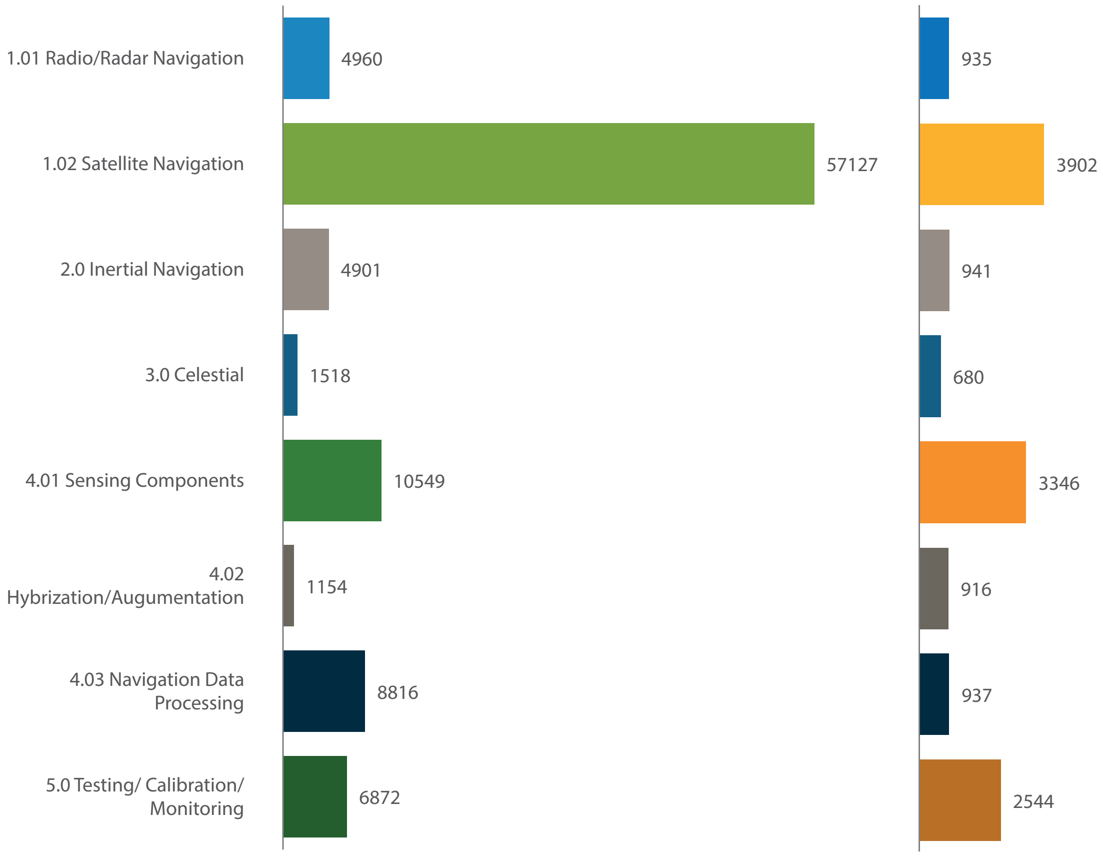


Figure 4 – Number of Patents Families (left) and Scientific Papers (right) per Technology Topic

With regard to average growth rates in both the collections (years 2008 - 2013 for patents; years 2009 - 2014 for scientific literature), in the patent collection the technology topics which are experiencing significant growth include satellite navigation and sensing components. The topics in the scientific literature collection which have seen sizable growth relative of other topics include satellite navigation and radio/radar navigation.

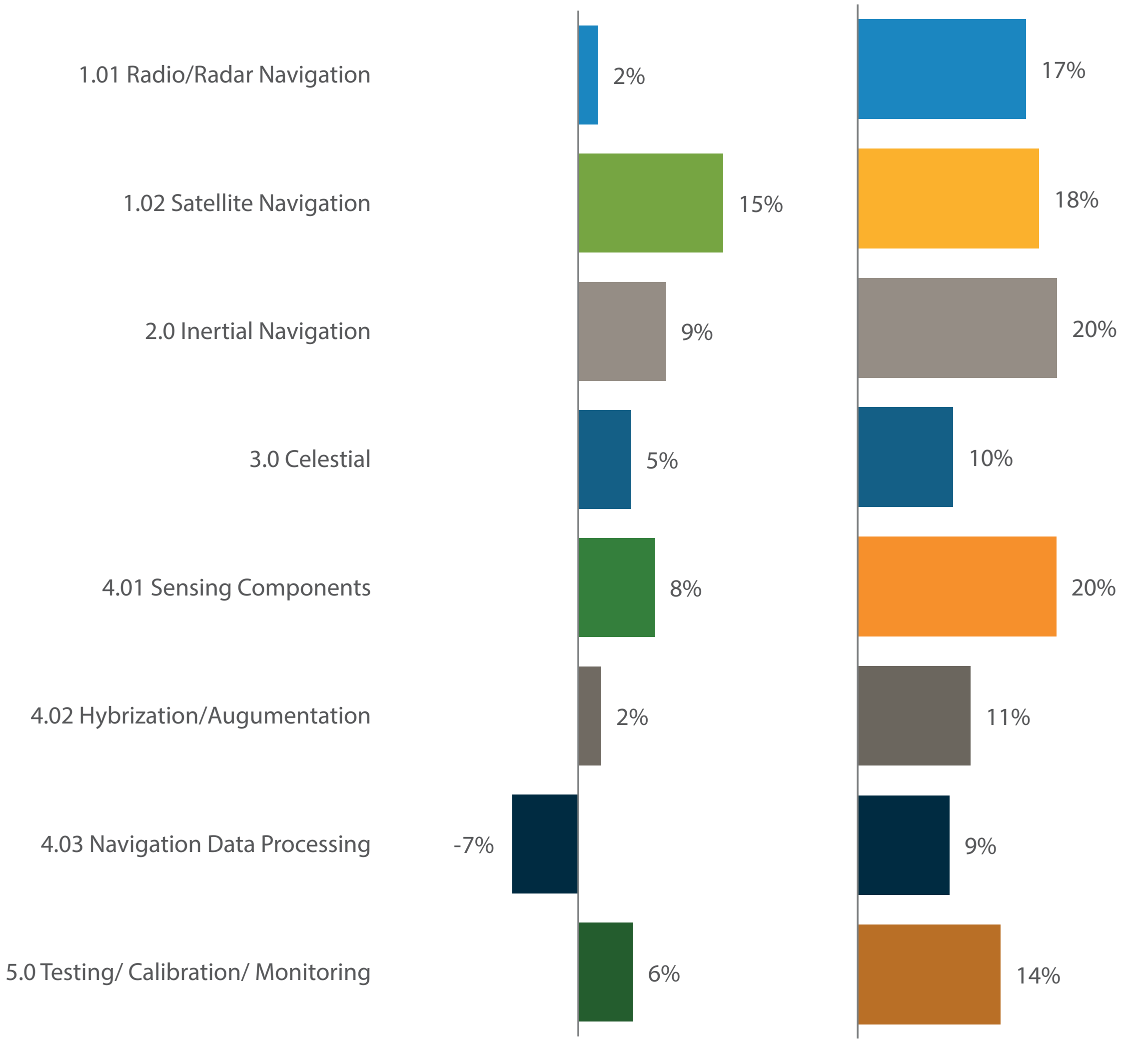


Figure 5 – Average Annual % Growth or Decline in Patent Family (left) or Scientific Paper (right) Output

The timeline activity for scientific literature (Figure 6) since 2008 shows satellite navigation and hybridization/augmentation as leading technology topics.

Average annual growth or decline is calculated by the average percentage increase or decrease between one year and the next. For example; 5 patents in 2006 followed by 6 patents in 2007 would represent an annual increase of 20%. An increase of 20% in one year, followed by a 10% increase the following year would be represented as a 15% average increase across the two years. This process is followed for 2006 (patents) or 2008 (papers) through to the most recently available year in patent and paper collections, to provide an indicator of the level and direction of recent changes in technology topics.

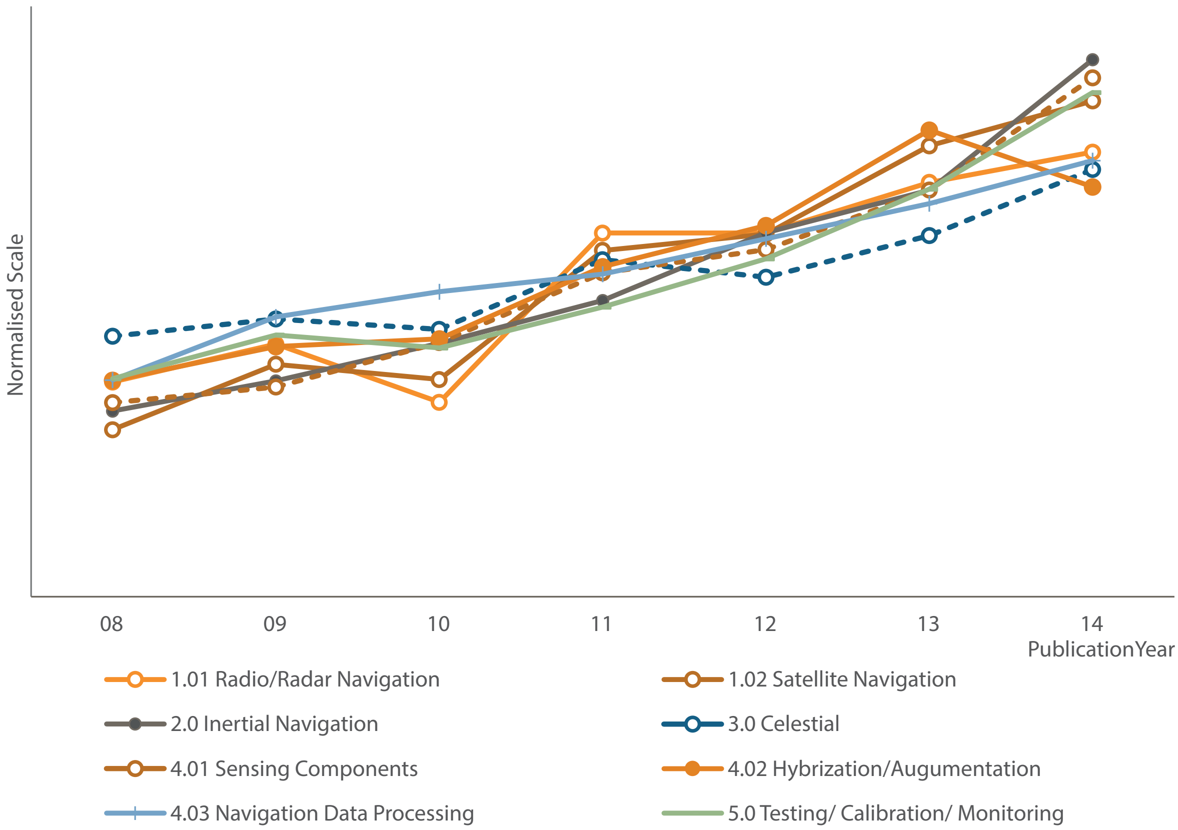


Figure 6 – Normalized Timeline of Activity for Scientific Paper Collection by Various Technology Topics

Timeline activity for patent (Figure 7) since 2006 shows sensing components and satellite navigation as leading technology topics with a marginal decrease in celestial navigation and navigation data processing.

The timelines on these charts have been normalised to allow for side by side comparison. Individually, each topic has varying volumes of patent families and scientific papers, however for visualisation purposes, the charts represent the proportion of each topic's activity filed or published in each calendar year.

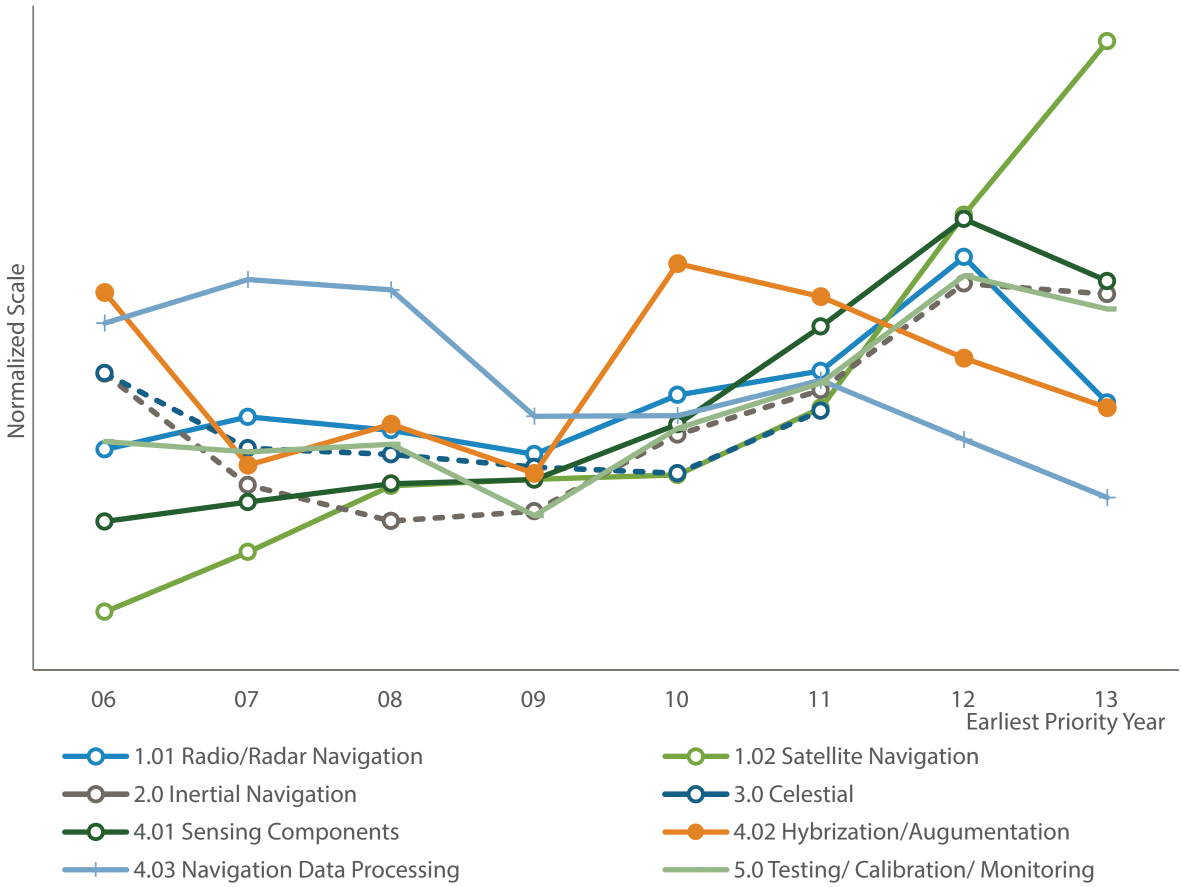


Figure 7 – Normalized Timeline of Activity for Patent Family Collection by Technology Topics

GLOBAL SPACE TECHNOLOGY SCIENTIFIC ACTIVITY TREND

This section of the report focuses on the scientific paper collection and the activity and technological trends seen within it. Based on the Thomson Reuters-produced Web of Science database, the collection only includes papers published in pre-selected journals of influence.
In total, about 9,500 peer reviewed papers were incorporated into the space technology collection.

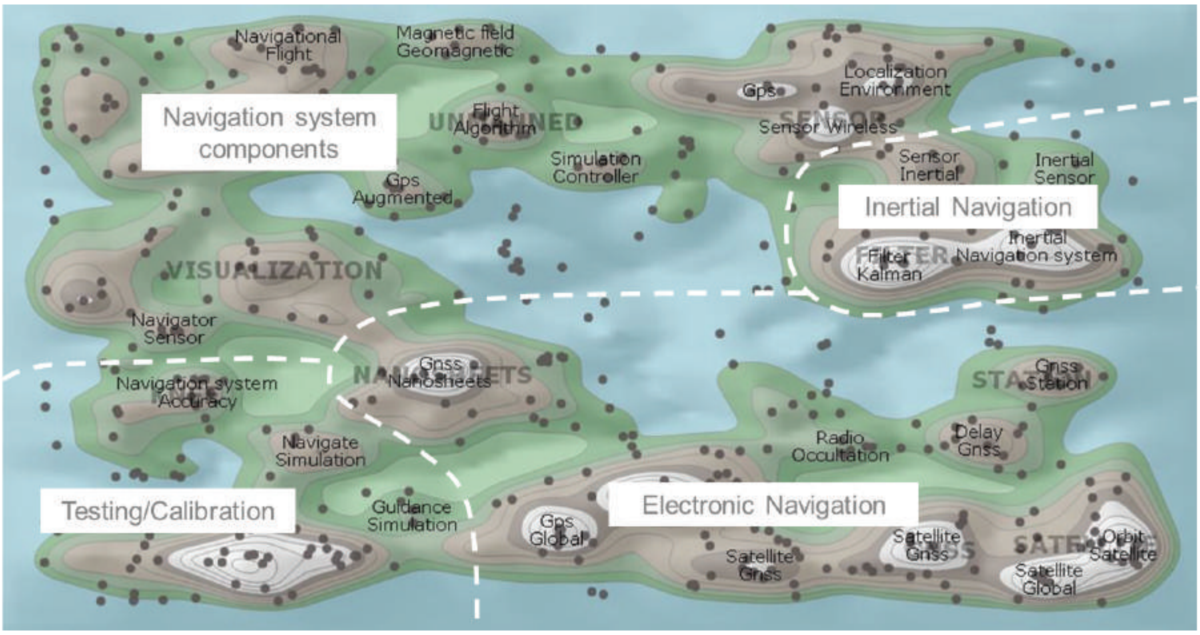


Figure 8 – ThemeScape Map of Scientific Paper Collection; Annotated by Major Themes

Key themes present throughout this collection of papers are illustrated in Figure 8 as a "ThemeScape map" - a visualization method for understanding the common themes and concepts within thousands of documents. Used for market analysis, government intelligence and primarily technology landscapes, the algorithm parses large amounts of text into a topological map of peaks and troughs.
Themes that are commonly shared between documents are represented by mountainous peaks, whereas documents that share little commonality are located within the valleys of the map. The large number of documents in this map means that there are rather few valleys to be found.
The location of an individual document is the vector sum of all the attractions to other documents in the collection based on shared phraseology and the frequency and proximity of these terms.
This map has been manually annotated to summarize the major technology areas within the scientific literature collection. Some technologies will necessarily overlap, and the delineation of one technical area versus another is therefore only approximate. However the map is very useful in describing what topics are common features of global space technology scientific research.
Key themes revealed in this Themescape map focus mainly on satellite navigation, sensor systems, and inertial navigation.

ThemeScape® is a text-mining application that acquires and analyses free text. The algorithms it uses require no application of thesauri or other outside sources of information, and only the free text itself is used by this text-mining tool. The more text the application acquires, the more likely it will be that the output will provide an accurate summary of the major themes present. After analysing the text in multiple documents, it pulls together those documents that share related text and pulls apart those with less related text. The outcome 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 pick out topics of interest. It aggregates word forms that share a common stem, but it does not directly aggregate synonyms. Instead, synonyms may be gathered under a common theme because of the other words that co-occur with those synonyms. Thus, "battery" and "cell" may be clustered together because of the co-occurrence in the same documents of terms like "electrode, rechargeable, electrolyte" and so on. Conversely, "battery" and "cell" may be separated if the map contains a mixture of documents on metals and biology, where the two terms have different meanings. In other words, terms are identified as synonyms only by co-clustering based on common context.

The topographical maps presented by ThemeScape are mathematical solutions built on a random selection of a first document and sequential calculation of the relationships of all the other documents. The orientation of the map is random, and the directions up, down, left, or right have no significance, because the n-dimensional solution might have been presented from any angle. Only the proximity of points within the map has meaning, and co-localized documents are highly likely to share concepts.

In this report there are separate ThemeScape maps covering scholarly papers or patents. The two types of documents are not pooled and analysed together. This is because ThemeScape is context-sensitive, and it would separate patent and literature documents from one another based on the very different formal styles of writing that are reflected in these two types of content. Likewise, if documents in two languages are pooled, it will separate them based on the language, and then each language region will be clustered based on term frequency in that language.

The ThemeScape maps in this report analyse large numbers of documents. The contour lines on the maps diminish in circumference, encircling regions of higher and higher concentration. The density is also shown by the map coloration. White snow-capped peaks represent the highest density, while blue expanses (sea level) indicate low density.

The labels in black on the map are selected by ThemeScape based on term frequency in that map region, and they may have been adjusted by the analyst. The large color-overlay regions enclosed by broken lines have been added by the analyst to identify content at an even higher level of abstraction. The dots on the map represent single documents. Dots are not shown for all the documents, and instead represent a sampling that allows the other features of the map to be discerned. Within the ThemeScape application, the map can be magnified, searched, probed and highlighted to learn more about its contents.

ThemeScape is reliant on statistical methods that are not equivalent to reading by human judges, and in compensation, it analyses millions of documents on a scale of minutes and quickly presents an intuitive, high level summary. It enables and guides further review, and provides a first level overview of very complex datasets.

SPACE TECHNOLOGY SCIENTIFIC LITERATURE SEGMENTATION

Table 1 shows the further segmentation of Space technology topics. Satellite navigation and sensing components appear to be high interest areas. Other areas receive lower levels of research interest.

Technology Segmentation		Total Inventions	Average % Growth or Decline ('09-'14)
1.0 Electronic Navigation	1.01 Radio/Radar Navigation	935	17%
	1.02 Satellite Navigation	3902	18%
2.0 Inertial Navigation	2.0 Inertial Navigation	941	20%
3.0 Celestial Navigation	3.0 Celestial	680	10%
4.0 Navigation System Components	4.01 Sensing Components	3346	20%
	4.02 Hybrization/Augumentation	916	11%
	4.03 Navigation Data Processing	937	9%
5.0 Testing/ Calibration/	5.0 Testing/ Calibration/ Monitoring	2544	14%

Table 1 – Scientific Literature Technology Segmentation

SPACE TECHNOLOGY SCIENTIFIC LITERATURE COLLECTION TECHNOLOGY CATEGORY OVERLAP

The technology categories and that were created to enumerate and describe the space technology landscape were not intended to be mutually exclusive. A single scientific paper can be included in multiple categories or topics.

Figure 9 visualizes the relationship between the technologies categories used in this study. Each number in the diagram shows the number of papers that have content related to both the corresponding row-wise and column-wise segments.

The most correlated segment pairing is satellite navigation with sensing components. Otherwise, mostly smaller sets are generally observed as overlap between the technology segments.

	1.01 Radio/Radar Navigation	1.02 Satellite Navigation	2.0 Inertial Navigation	3.0 Celestial	4.01 Sensing Components	4.02 Hybrization/Augumentation	4.03 Navigation Data Processing	5.0 Testing/ Calibration/ Monitoring
1.01 Radio/Radar Navigation	935	267	44	38	434	27	21	70
1.02 Satellite Navigation		3902	423	99	1167	316	167	509
2.0 Inertial Navigation			941	30	680	40	70	327
3.0 Celestial				680	154	20	37	84
4.01 Sensing Components					3346	214	173	651
4.02 Hybrization/Augumentation						916	44	113
4.03 Navigation Data Processing							937	120
5.0 Testing/ Calibration/ Monitoring								2544

Figure 9 – Number of Scientific Papers per Pair of Technology Segments

SCIENTIFIC PAPER GEOGRAPHIC VOLUME BENCHMARKING

Figure 10 shows the number of scientific papers for ten most prolific countries within the scientific paper collection.
United Sates is the largest source of space technology related peer-reviewed papers, followed by China, Germany, United Kingdom and Canada. It is also interesting to note that the ten most prolific countries contribute to about 70% of output for the scientific paper in the space technology area.

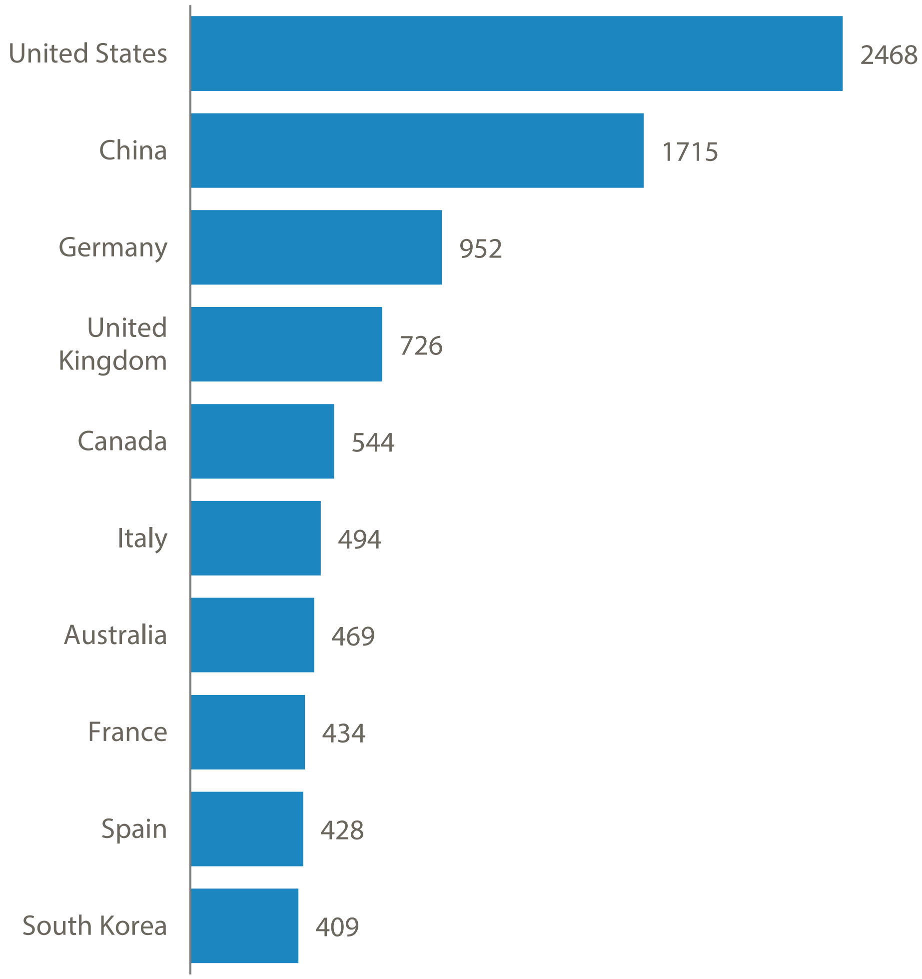


Figure 10 – Number of Scientific Papers per Country; Top 10 Sources

SCIENTIFIC PAPER GEOGRAPHIC ACTIVITY TRENDS

The chart below shows the highest grow rates sources in the scientific literature collection.

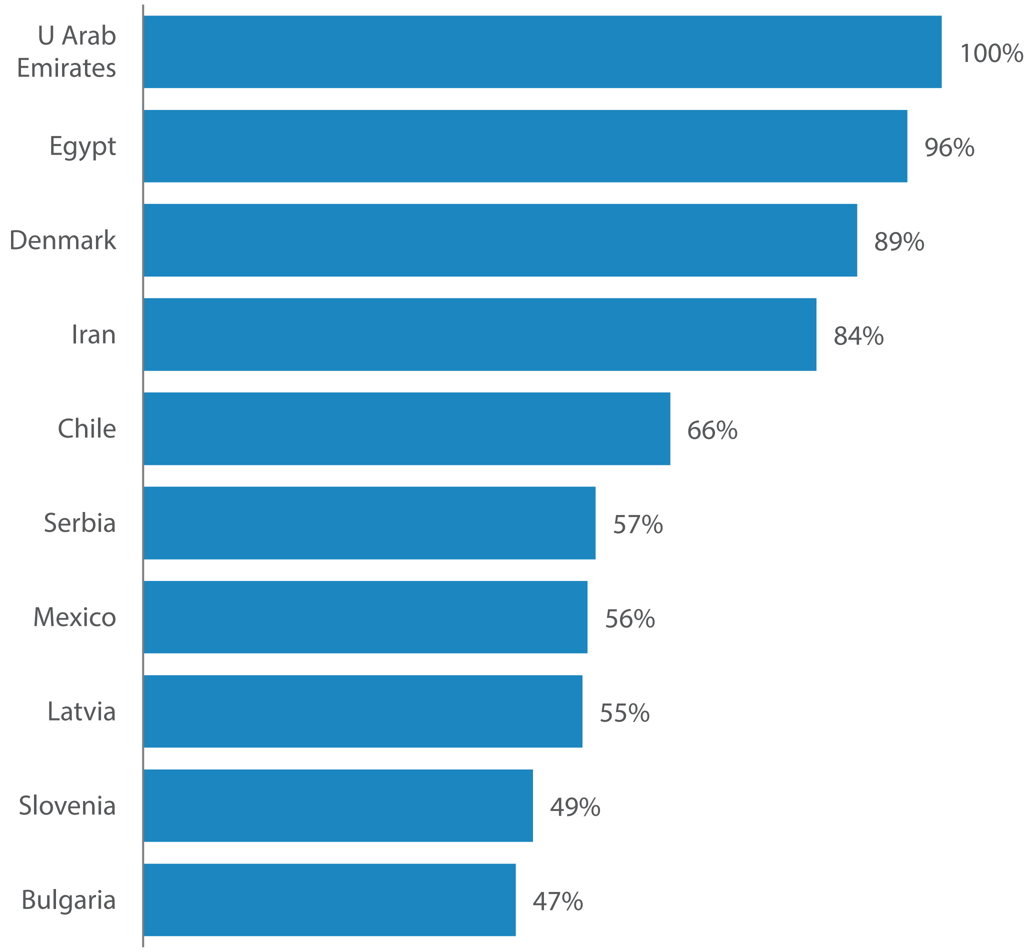


Figure 11 – Highest Growth Rate (%) Geographies in Scientific Publications Output

While scientific literature collection U Arab Emirates, Egypt and Denmark is relatively small, the growth rate of scientific paper published in U Arab Emirates, Egypt and Denmark collection far exceeds that of other countries with high volume of papers.

SCIENTIFIC PAPER GEOGRAPHIC CITATION IMPACT BENCHMARKING

Scientific paper and patent citations are routinely used in technology bibliometrics for assessing the inherent impact and potential quality of research and the downstream technical and scientific relevance of the underlying research.
Figure 12 shows the "Citation Impact", the average citation per paper for all papers in a country's collection (which are having at least 50 publications) and has been sorted by highest citation impact. This shows that output from Israel, Switzerland, Australia, United States and Germany are having the highest impact in the space technology topics.

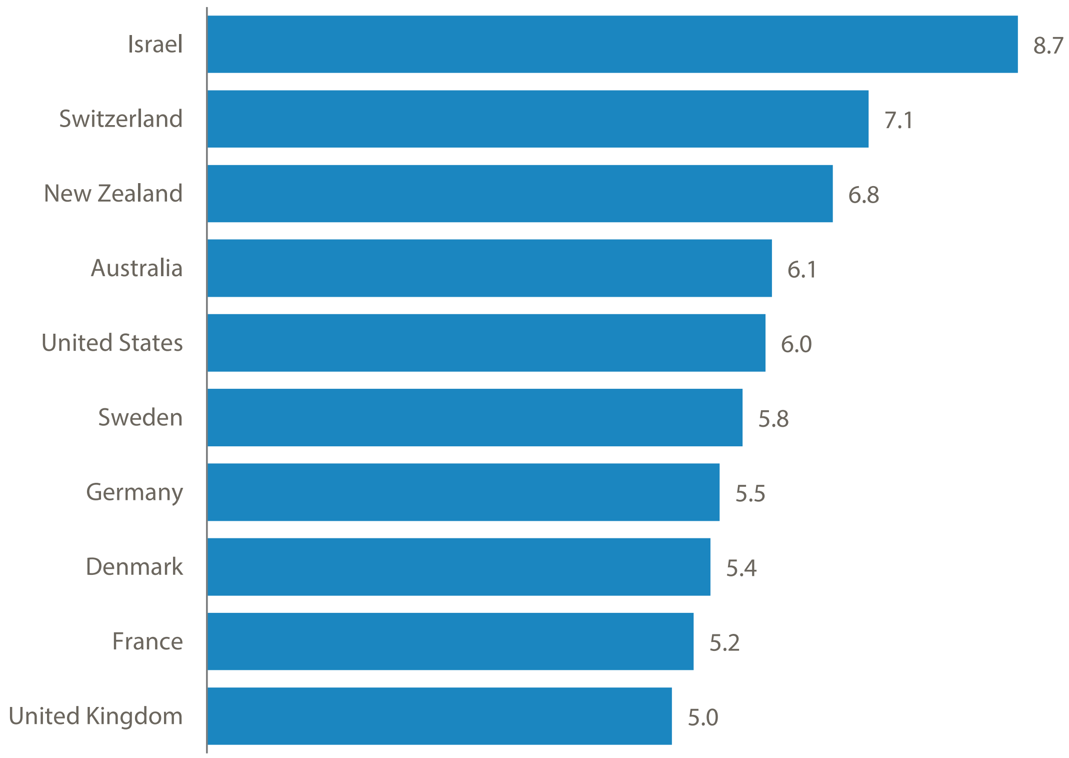


Figure 12 – Highest Citation Impact Geographies of Scientific Publications

Note that the journals included in the project source data (Web of Science) are selected on the basis of both quantitative and qualitative selection criteria, such as editorial quality, peer review robustness and citation impact. Further details of the journal selection process is available from : http://thomsonreuters.com/products_services/science/free/essays/journal_selection_process/

SPACE TECHNOLOGY RESEARCH TOPIC BY GEOGRAPHY

Table 2 shows the split of space technology science and research specialization for top nations. The electronic navigation, navigation system components and testing/calibration/monitoring have been in focus for top nations.

Country of Origin	1.01 Radio/ Radar Navigation	1.02 Satellite Navigation	2.0 Inertial Navigation	3.0 Celestial	4.01 Sensing Components	4.02 Hybrization/ Augumentation	4.03 Navigation Data Processing	5.0 Testing/ Calibration/ Monitoring
United States	30%	16%	19%	30%	24%	27%	28%	30%
China	17%	23%	35%	18%	23%	14%	12%	17%
Germany	10%	8%	3%	10%	8%	12%	13%	10%
United Kingdom	10%	7%	4%	8%	7%	7%	8%	6%
Canada	5%	5%	6%	4%	5%	7%	7%	7%
Italy	6%	6%	2%	6%	4%	4%	5%	5%
Australia	5%	6%	5%	4%	5%	6%	5%	4%
France	5%	4%	3%	6%	4%	3%	4%	3%
Spain	5%	5%	3%	3%	5%	3%	4%	3%
South Korea	3%	4%	6%	2%	5%	5%	4%	5%
Japan	4%	3%	2%	4%	3%	8%	3%	4%
Taiwan	3%	4%	3%	2%	3%	3%	3%	2%
Netherlands	5%	3%	0%	2%	2%	2%	4%	2%
Russia	5%	3%	3%	4%	1%	1%	1%	1%
Switzerland	2%	2%	1%	2%	2%	3%	3%	2%
India	4%	3%	1%	2%	2%	4%	2%	2%
Brazil	1%	2%	0%	0%	1%	1%	1%	1%
Sweden	1%	2%	2%	2%	2%	2%	2%	1%
Poland	2%	2%	1%	0%	1%	1%	1%	1%
Turkey	1%	2%	2%	1%	1%	1%	1%	1%
Austria	2%	1%	0%	1%	1%	1%	1%	1%
Belgium	1%	1%	0%	1%	1%	2%	1%	1%

Table 2 – Specialization by Country; % of Literature Activity in Technical Stream per Country of Origin

SCIENTIFIC PAPER – GLOBAL PROLIFIC ENTITIES

Universities appear to dominate the scientific paper publications in Space technologies. Notably, a large number of Chinese and American universities feature in the top 30 entities publishing scientific literature in this area. Space agencies (NASA and the European Space Agency) appear to be publishing high impact papers, with high citations per paper. Science & Technology Unit, Umm Al Qura University (STU-UQU) has only 1 paper published in this space. Navigation technologies are ever evolving, and STU-UQU may contribute to this technology with more research on navigation technologies.

Entity	Total	Times Cited	Citation per paper
Science & Technology Unit, Umm Al Qura University (STU-UQU)	1	1	1.00
Chinese Academy Of Sciences	239	1440	6.03
University Of California System	210	1684	8.02
Beihang University	202	302	1.50
CNRS	169	1000	5.92
National University Of Defence Technology - China	138	150	1.09
National Aeronautics & Space Administration (Nasa)	122	1436	11.77
University Of Calgary	120	425	3.54
Technical University Of Munich	101	485	4.80
United States Department Of Defense	98	381	3.89
Wuhan University	98	261	2.66
University Of London	93	399	4.29
University Of New South Wales	92	496	5.39
Florida State University System	91	587	6.45
Russian Academy Of Sciences	91	265	2.91
Ohio State University	83	502	6.05
Pennsylvania Commonwealth System Of Higher Education	80	451	5.64
Delft University Of Technology	76	357	4.70
European Space Agency	75	608	8.11
Stanford University	75	440	5.87
Curtin University Of Technology	74	292	3.95
Tsing Hua University	73	194	2.66
University Of Colorado System	73	383	5.25
California Institute Of Technology	71	485	6.83
Shanghai Jiao Tong University	71	148	2.08
University Of Toronto	70	320	4.57
National Cheng Kung University	69	216	3.13
Dept Comp Sci & Engn	68	413	6.07
Max Planck Society	67	695	10.37

Table 3 – Space Technology – Top Global entities for Scientific Literature

SCIENTIFIC LITERATURE OVERVIEW OF GLOBAL PROLIFIC ENTITIES

Table 4 shows the technology profile of the top 30 entities within the scientific literature space of Material Design. Entities appear to be researching most in satellite navigation, and to a lesser extent on sensing components. Most companies are not researching much new Design Methodologies such as modeling, simulation, analysis, and optimization. Science & Technology Unit, Umm al Qura University (STU-UQU) has 1 paper publication pertaining to satellite navigation. While satellite navigation is a prolific research area, radio navigation, inertial navigation, hybridization augmentation, and navigation data processing are also evolving fast (as seen in Figure 5); and can be areas of interest for STU-UQU.

Entity	1.01 Radio/Radar Navigation	1.02 Satellite Navigation	2.0 Inertial Navigation	3.0 Celestial	4.01 Sensing Components	4.02 Hybrization/Augumentation	4.03 Navigation Data Processing	5.0 Testing/ Calibration/ Monitoring
Science & Technology Unit, Umm Al Qura University (Stu-Uqu)		1						
Chinese Academy Of Sciences	27	159	14	20	71	21	16	41
University Of California System	30	38	16	23	80	18	26	62
Beihang University	18	105	78	26	118	20	11	82
CNRS	18	54	7	25	58	9	14	28
National University Of Defence Technology - China	12	68	52	9	83	11	11	42
National Aeronautics & Space Administration (Nasa)	34	43	2	36	39	6	4	19
University Of Calgary	6	85	20	2	41	5	7	30
Technical University Of Munich	4	53	5	1	17	23	12	22
United States Department Of Defense	19	35	7	16	33	8	7	23
Wuhan University	5	81	8	4	28	12	9	14
University Of London	9	30	4	10	27	9	9	24
University Of New South Wales	2	73	21	1	41	12	2	17
Florida State University System	9	27	6	2	18	10	6	34
Russian Academy Of Sciences	17	40	17	10	20	2	3	6
Ohio State University	11	41	14		25	8	6	36
Pennsylvania Commonwealth System Of Higher Education	4	21	6	4	17	7	16	23
Delft University Of Technology	10	57		1	22	7	3	5
European Space Agency	10	60	2	8	14	2	3	6
Stanford University	10	29	8	7	22	29	6	15
Curtin University Of Technology	4	59	3	3	21	10	4	9
Tsing Hua University	3	47	4	7	26	3	4	13
University Of Colorado System	12	28	4	7	28	6	2	24
California Institute Of Technology	13	24	3	27	23	4	3	10

Table 4 – Scientific literature overview of top Global entities

SCIENTIFIC LITERATURE OVERVIEW OF ASIA PACIFIC PROLIFIC ENTITIES

Entity	Country of Origin	Total	1.01 Radio/Radar Navigation	1.02 Satellite Navigation	2.0 Inertial Navigation	3.0 Celestial	4.01 Sensing Components	4.02 Hybrization/ Augumentation	4.03 Navigation Data Processing	5.0 Testing/ Calibration/ Monitoring
Science & Technology Unit, Umm Al Qura University (STU-UQU)	Saudi Arabia	1		1						
Chinese Academy Of Sciences	China	239	27	##	14	20	71	21	16	41
Beihang University	China	202	18	##	78	26	##	20	11	82
National University Of Defence Technology - China	China	139	12	69	52	9	84	11	11	42
Wuhan University	China	98	5	81	8	4	28	12	9	14
University Of New South Wales	China	92	2	73	21	1	41	12	2	17
Tsing Hua University	China	73	3	47	4	7	26	3	4	13
Shanghai Jiao Tong University	China	71	3	40	8	4	31	5	2	15
National Cheng Kung University	Taiwan	69	4	47	16	2	32	11	12	11
Southeast University - China	China	67	1	33	27	3	40		6	15
Gnss Res Ctr	China	65	1	64	4		19	9	6	9
Southeast Univ	China	65	1	31	26	3	39		6	14
Harbin Engineering University	China	55	1	18	30	2	35	3	1	19
Harbin Institute Of Technology	China	55	3	15	14	13	37	2	6	15
Korea Advanced Institute Of Science & Technology (Kaist	South Korea	54	4	26	5		14	15	3	11
Beijing Univ Aeronaut & Astronaut	China	48	7	18	22	10	30	7	4	26
Univ Tokyo	Japan	46	3	21	6	5	16	11	3	11
Seoul National University	South Korea	44	1	22	6	1	13	4	2	22
Nanjing Univ Aeronaut & Astronaut	China	42	6	17	19	4	31	3	5	16
Shanghai Astron Observ	China	42	6	33		7	13	9	1	7
University Of Tokyo	Japan	42	3	19	5	5	14	10	3	10
Xidian Univ	China	38	8	24	5	5	21	3	2	4
National Taiwan University	Taiwan	37	3	11	4	4	11	5	3	5
Zhejiang University	China	37	2	11	9	3	19	3	5	10
National University Of Singapore	Singapore	35	3	12	4	2	21	10	5	6
Tongji Univ	China	35		31	3	2	8	3		1
Beijing Inst Technol	China	34	4	15	10	2	22	4	3	9

Table 5 – Scientific literature overview of top Asia Pacific entities

MIDDLE EAST & AFRICA – PROLIFIC ENTITIES

Table 6 visualizes the prolific entities in the Middle East and Africa. The list is dominated by Middle Eastern entities, reflecting the trends seen in Table 5 above. Most of the prolific entities in these regions follow the global focus trends on satellite navigation and space components, while not focusing heavily on other technologies.

Entity	Country of Origin	Total	1.01 Radio/Radar Navigation	1.02 Satellite Navigation	2.0 Inertial Navigation	3.0 Celestial	4.01 Sensing Components	4.02 Hybrization/ Augumentation	4.03 Navigation Data Processing	5.0 Testing/ Calibration/ Monitoring
Science & Technology Unit, Umm Al Qura University (STU-UQU)	Saudi Arabia	1		1						
Istanbul Teknik University	Turkey	24	2	13	3	1	14		1	5
Yildiz Teknik University	Turkey	18		16	1	1	1		2	2
American University Of Sharjah	U Arab Emirates	12		12	7		11			4
Iran University Science & Technology	Iran	12		5	1		7	1	1	6
Selcuk University	Turkey	12		8				4		3
University Of Tehran	Iran	11		7	2		4			2
Sharif University Of Technology	Iran	10	1	1	2	2	7	1		4
Ain Shams University	Egypt	9		7	4		7	2		6
Bilkent University	Turkey	9	2	3	3		5		1	
Kn Toosi Univ Technol	Iran	9		7	2		2			2
Univ Cape Town	South Africa	9	1	2					4	2
Boston College	Nigeria	8	2	6		1	2	2		
Cnrs	South Africa	8	1	3			2	1		1
Hacettepe University	Turkey	8		6			1	1	1	1
Isfahan University Of Technology	Iran	8		7				1	1	
Orta Dogu Teknik University	Turkey	8		2	2		4		2	2
Univ Pretoria	South Africa	8	1	3	1	2	6		1	1
Univ Witwatersrand	South Africa	8		1		5	5		1	2
Islamic Azad Univ	Iran	7	1			2	3		2	
National Research Foundation - South Africa	South Africa	7	2	5			1		1	
Royal Military College - Canada	Egypt	7		6	4		7	2		5
Univ Ilorin	Algeria	7		6		1				
Florida State University System	Turkey	6	1	4					2	
Jordan University Of Science & Technology	Jordan	6		4	2		5		1	2
King Abdulaziz Univ	Saudi Arabia	6			1		3	1	2	
Middle E Tech Univ	Turkey	6		1	1		3		2	1
Univ Msila	Algeria	6		6			1	1		2
Afyon Kocatepe University	Turkey	5		4			1			1
King Fahd University Of Petroleum & Minerals	Saudi Arabia	5	1	3			2	1		
Mersin University	Turkey	5				5				

Table 6 – Scientific Literature overview of Middle East & Africa top entities

SCIENTIFIC LITERATURE OVERVIEW OF SAUDI ARABIA PROLIFIC ENTITIES

Entity	Total	1.01 Radio/Radar Navigation	1.02 Satellite Navigation	2.0 Inertial Navigation	3.0 Celestial	4.01 Sensing Components	4.02 Hybrization/ Augumentation	4.03 Navigation Data Processing	5.0 Testing/ Calibration/ Monitoring
Science & Technology Unit, Umm Al Qura University (STU-UQU)	1		1						
King Abdulaziz Univ	6			1		3	1	2	
King Fahd University Of Petroleum & Minerals	5	1	3			2	1		

Table 7 – Scientific literature overview of top Saudi Arabia entities

MIDDLE EAST & AFRICA SPACE TECHNOLOGY SCIENTIFIC LITERATURE TRENDS

This section of the report focuses on the scientific paper collection and the activity and technological trends observed in the Middle East and Africa regions.

MIDDLE EAST & AFRICA – PROLIFIC COUNTRIES

Figure 13 below shows the prolific countries by scientific literature volume in the Middle East & Africa regions. The gray bars indicate Middle East, blue indicates Africa, and green indicates the Kingdom of Saudi Arabia. As seen from the figure, the most prolific countries within these regions are Turkey and Iran, followed by Saudi Arabia, South Africa and Egypt.

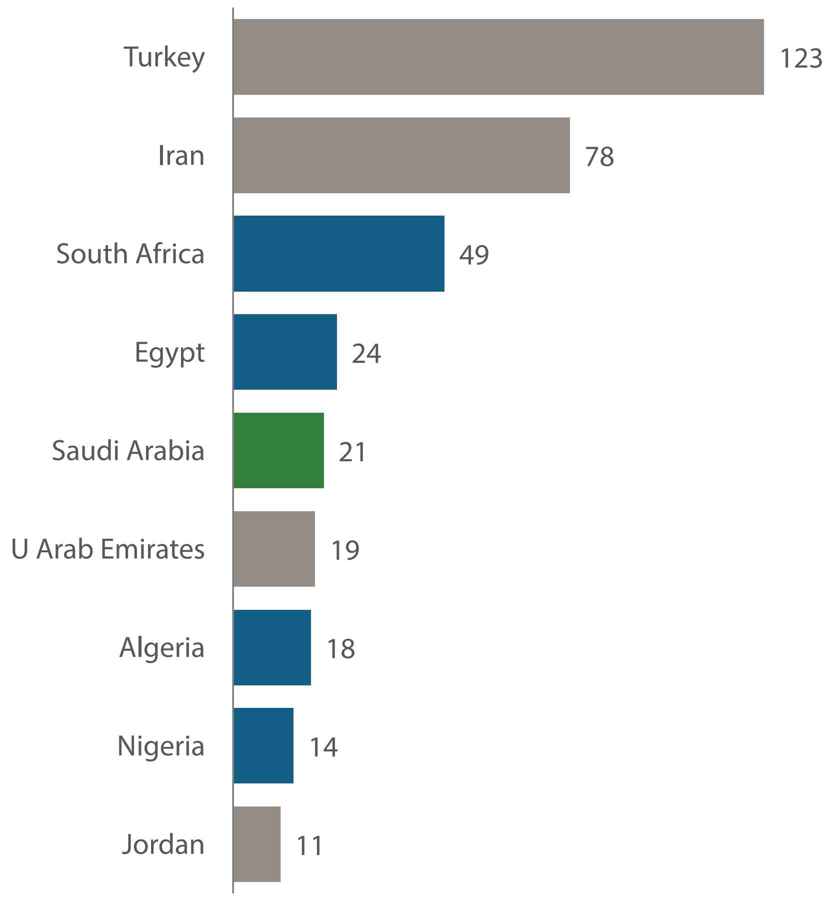


Figure 13 – Middle East & Africa – Prolific countries in scientific literature

A more detailed analysis of the technologies of focus in each of the countries within the Middle East and Africa is presented with reference to Tables 5 and 6. Focus appears to be on satellite navigation, sensing components and testing/calibration/monitoring. Interestingly, most of the countries in these regions have lower focus on inertial navigation, celestial navigation and navigation data processing.

Country of Origin	1.01 Radio/Radar Navigation	1.02 Satellite Navigation	2.0 Inertial Navigation	3.0 Celestial	4.01 Sensing Components	4.02 Hybrization/Augumentation	4.03 Navigation Data Processing	5.0 Testing/ Calibration/ Monitoring
Turkey	11	60	15	8	34	9	9	27
Iran	5	33	9	10	28	4	4	18
South Africa	9	17	2	11	16	3	6	6
Egypt	1	12	5		12	5		9
Saudi Arabia	2	7	1	1	7	2	3	3
U Arab Emirates		13	8	4	13	1	1	4
Algeria	2	12			10	1		3
Nigeria	3	9		3	1	1		
Jordan	1	5	2	1	6		3	2
Kenya	2	6		1	2	1		
Qatar	1	1			4	1		
Ethiopia	3	3		1	3			
Ghana		3						1
Tanzania		2				2		
Tunisia	1	1			2			2
Cameroon	2				1			
Kuwait		1						1
Morocco		2					1	
Uganda	1	2		1				
Azerbaijan					1			
Bahrain		1						
Burkina Faso		1						
Guinea					1			
Madagascar	1	1			1			
Malawi								1
Senegal								1
Sudan		1						
Zambia	1	1			1			
Zimbabwe								1

Table 8 – Middle East & Africa – Prolific countries over technical categories

GLOBAL SPACE TECHNOLOGY PATENT TRENDS

This section of the report focuses on the patent collections produced for the study and the activity and technological trends seen within it. Based on the Thomson Reuters-produced Derwent World Patents Index database, the collection includes both pending patent applications and granted patents published in 47 countries around the world.
A total of approximately 78,000 patented inventions were gathered that are applicable to the various space technology topics of interest to Science & Technology Unit, Umm Al Qura University (STU-UQU). These inventions and their technical nature have been summarized using the ThemeScape software described in the previous section.

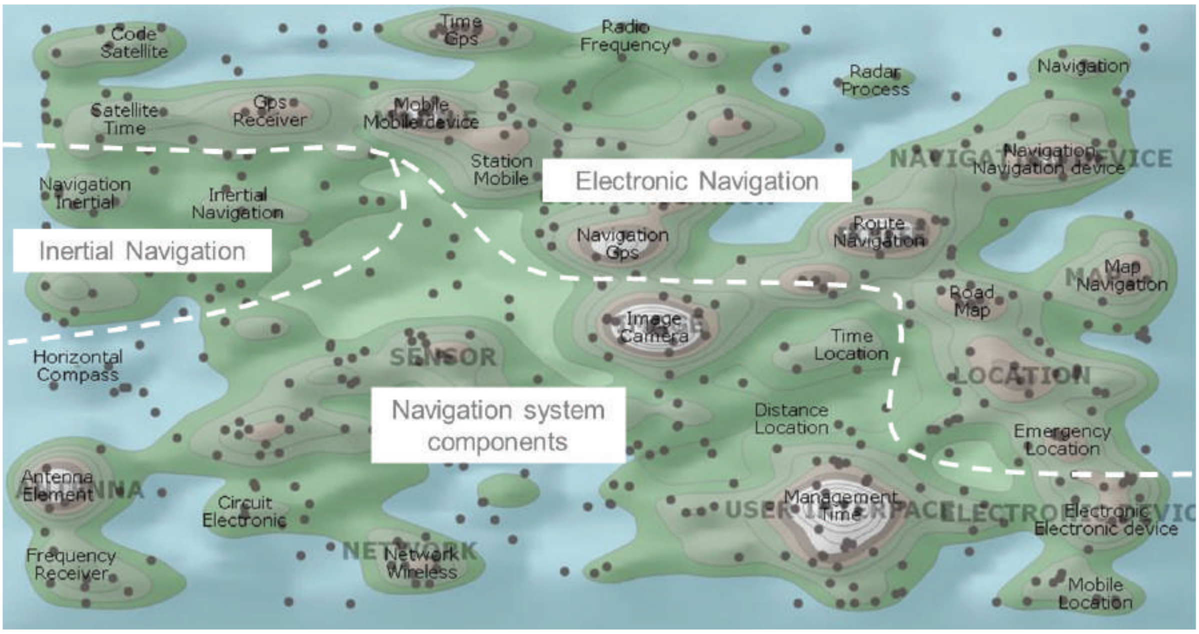


Figure 14 – ThemeScape Map of Patent Collection; Annotated by Major Themes

As previously noted, the ThemeScape map is not designed to provide a detailed accurate view of each patented invention; instead the visual is designed to highlight the common themes shared by hundreds or thousands of patents and patent applications published since 2006.
Some of the key themes revealed in this ThemeScape map include GPS navigation, image sensors and cameras, route navigation and inertial navigation.
This annotation has been provided to guide the reader around the landscape. However, it should be noted that this annotation is only approximate.

SPACE TECHNOLOGY PATENT SEGMENTATION

Table 7 shows the segmentation patents and patent applications in space technology. Much like the non-patent literature, there is significant patenting activity in Satellite navigation. Hybridization/Augmentation appears to be a low activity technology, with no growth or decline – indicating that this area may be a potential white space. Other potential opportunities for patenting include inertial navigation, and testing/calibration/monitoring, both with moderate volumes and low growth rates.

Technology Segmentation		Total Inventions	Average % Growth or Decline (08-13)
1.0 Electronic Navigation	1.01 Radio/Radar Navigation	4960	2%
	1.02 Satellite Navigation	57127	15%
2.0 Inertial Navigation	2.0 Inertial Navigation	4901	9%
3.0 Celestial Navigation	3.0 Celestial	1518	5%
4.0 Navigation System Components	4.01 Sensing Components	10549	8%
	4.02 Hybrization/Augumentation	1154	2%
	4.03 Navigation Data Processing	8816	-7%
5.0 Testing/ Calibration/ Monitoring	5.0 Testing/ Calibration/ Monitoring	6872	6%

Table 9 – Patent Technology Segmentation

SPACE TECHNOLOGY PATENT COLLECTION CATEGORY OVERLAP

The technology categories and that were created to enumerate and describe the space technology landscape were not intended to be mutually exclusive. A single patent family can be included in multiple categories.

Figure 15 visualizes the relationship between select technology segments. Each number in the diagram shows the number of inventions that have content related to both the corresponding row-wise and column-wise segments.

The potential whitespace appears to be hybridization/augmentation with four categories: testing/-calibration/monitoring, radio/radar navigation, satellite navigation and inertial navigation.

	1.01 Radio/Radar Navigation	1.02 Satellite Navigation	2.0 Inertial Navigation	3.0 Celestial	4.01 Sensing Components	4.02 Hybrization/Augumentation	4.03 Navigation Data Processing	5.0 Testing/ Calibration/ Monitoring
1.01 Radio/Radar Navigation	4960	808	395	112	2105	53	381	697
1.02 Satellite Navigation		57127	1144	212	2430	542	1939	1815
2.0 Inertial Navigation			4901	162	2069	483	947	1462
3.0 Celestial				1518	377	21	210	330
4.01 Sensing Components					10549	328	1472	2279
4.02 Hybrization/Augumentation						1154	277	260
4.03 Navigation Data Processing							8816	1697
5.0 Testing/ Calibration/ Monitoring								6872

Figure 15 – Number of Patent Families per Pair of Technology Segments

PATENT ACTIVITY GEOGRAPHIC VOLUME BENCHMARKING

Figure 16 shows the number of patent families or inventions within the patent collection relevant to space technology that can be attributed to each nation . Patenting activity within the space technology topics is led by United States, followed by South Korea, China and Japan. The ten most prolific countries contribute to more than 95% of patent output in the space technology area.

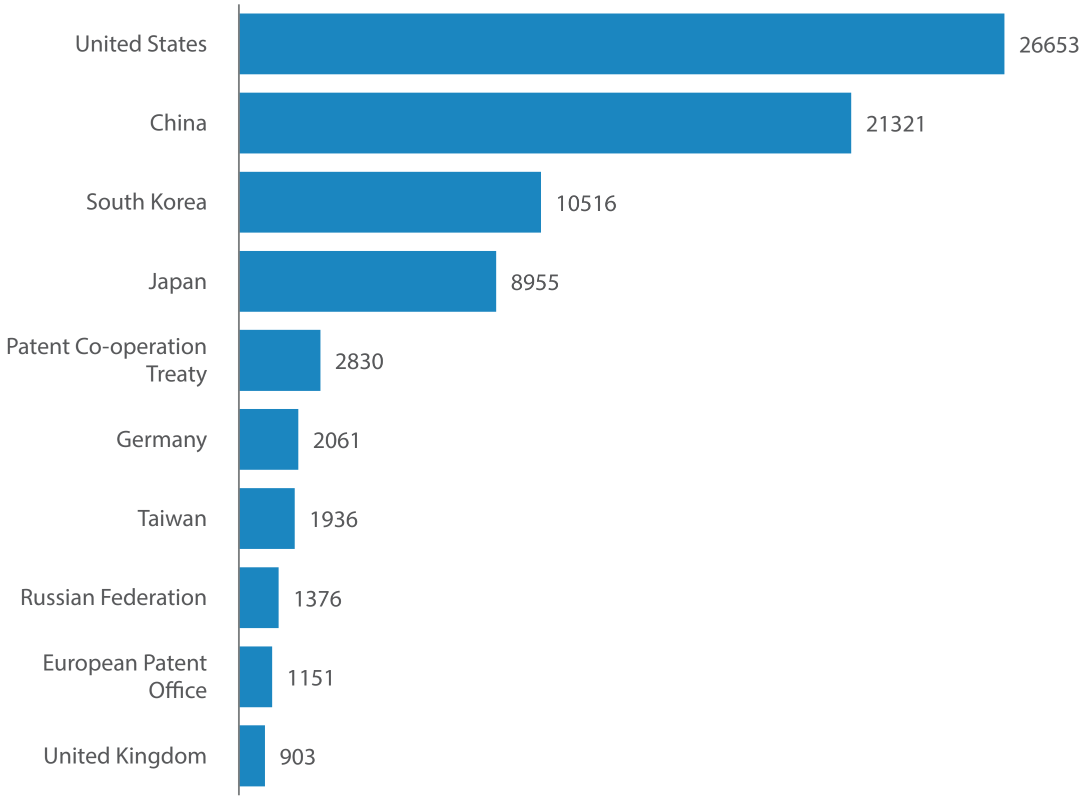


Figure 16 – Number of Patent Families per Country; Top 10 Sources

National attribution of patent activity is primarily performed via the priority filing location of the invention – this is the first filing event that occurs in the international protection of an invention at the various patent offices around the world. Actual geographic location of the inventor or the innovating corporation may vary from the priority filing location. This effect is exhibited primarily by Saudi Arabian entities, few of which file for patents within the Kingdom.

PATENT GEOGRAPHIC ACTIVITY TRENDS

Although overall patent volumes from Brazil, Hungary and Saudi Arabia are low, Figure 17 illustrates the continuing striking growth in the patent portfolio originating from Brazil, Hungary and Saudi Arabia in this field. The figure also illustrates significant growth in Romania.

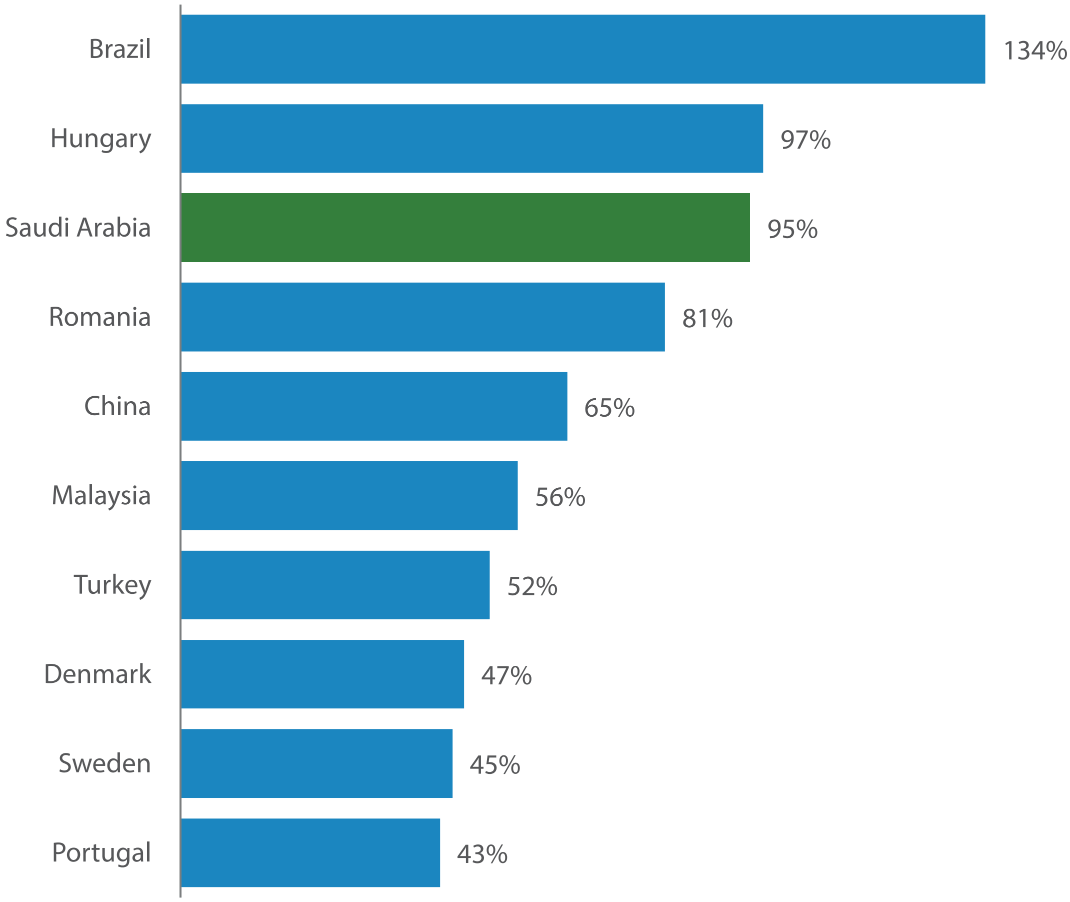


Figure 17 – Highest Growth Rate Geographies in Patent Output

PATENT GEOGRAPHIC CITATION IMPACT BENCHMARKING

Figure 18 details the highest citation impact by nation (with at least 50 patents). Patent citation is a widely utilized measurement of the impact and recognition of an individual patent, and by extension, aggregated groups of patents such as those assigned to a company or associated with the innovation of a nation or region. The measurement is useful as it provides an independent assessment of the quality and impact of the innovation contained within the patent. When aggregated, it provides a method of benchmarking collections of patents for the average impact in comparison to others, e.g. between the two competing entities or between the nations.
Patent citation information within this study is measured via citations to patent family members of the Derwent World Patents Index and from citation events of 26 national patent collections.
On this metric, USA leads with the highest citation impact, followed by Canada, Israel and Finland.

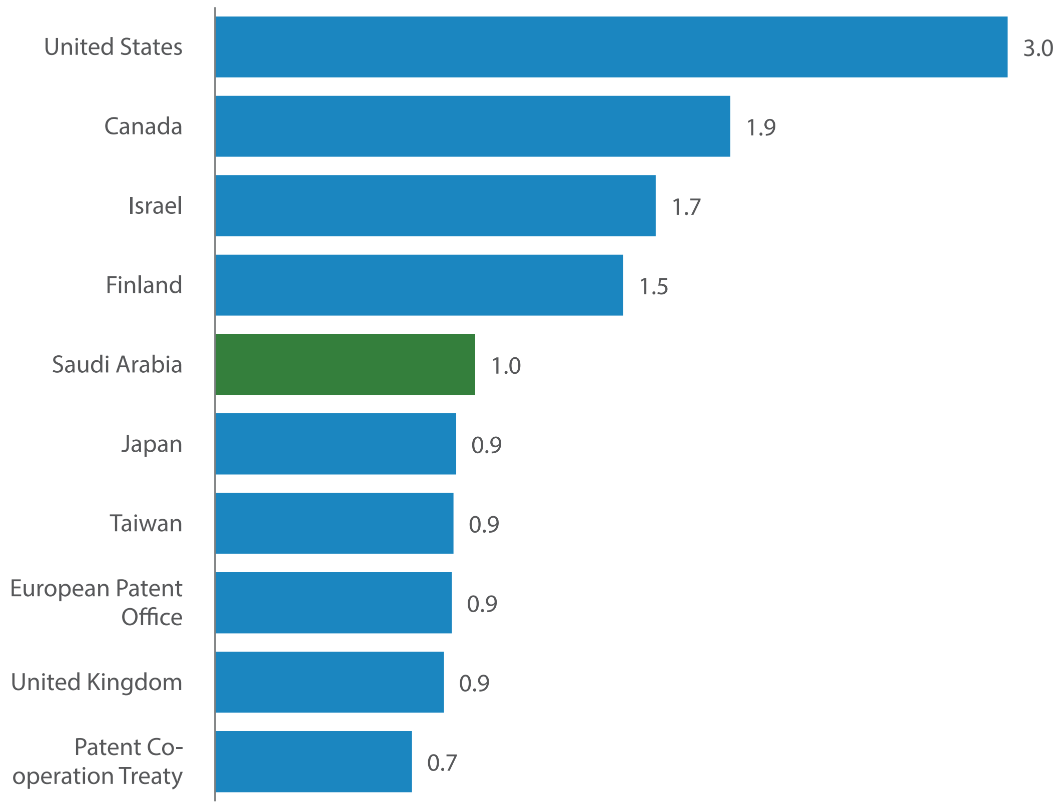


Figure 18 – Highest Citation Impact Geographies of Patents

SPACE TECHNOLOGY RESEARCH TOPIC BY GEOGRAPHY

Table 8 shows the split of space technology science and research specialization for top nations. United States appears to have major focus on satellite navigation and sensing components.

Country of Origin	1.01 Radio/Radar Navigation	1.02 Satellite Navigation	2.0 Inertial Navigation	3.0 Celestial	4.01 Sensing Components	4.02 Hybrization/Augumentation	4.03 Navigation Data Processing	5.0 Testing/Calibration/Monitoring
United States	19%	41%	23%	17%	24%	43%	14%	16%
China	35%	23%	40%	48%	40%	8%	30%	46%
South Korea	8%	16%	6%	4%	8%	6%	12%	9%
Japan	16%	6%	14%	15%	15%	21%	28%	16%
PCT	6%	4%	3%	3%	3%	7%	4%	3%
Germany	5%	2%	3%	3%	3%	6%	5%	3%
Taiwan	0%	3%	1%	0%	1%	2%	2%	1%
Russian Federation	8%	1%	4%	7%	4%	1%	1%	3%
European Patent Office	2%	1%	2%	1%	2%	3%	2%	2%
United Kingdom	1%	1%	1%	1%	1%	1%	1%	1%
France	3%	1%	3%	2%	1%	5%	1%	2%
India	0%	1%	0%	1%	0%	1%	0%	0%
Australia	0%	0%	0%	0%	0%	0%	0%	0%
Italy	0%	0%	1%	0%	0%	0%	0%	0%
Spain	0%	0%	0%	0%	0%	0%	0%	0%
Israel	0%	0%	1%	0%	0%	0%	0%	0%
Canada	0%	0%	0%	0%	0%	0%	0%	0%
Sweden	0%	0%	0%	0%	0%	0%	0%	0%
Brazil	0%	0%	0%	0%	0%	0%	0%	0%
Finland	0%	0%	0%	0%	0%	0%	0%	0%
Netherlands	0%	0%	0%	0%	0%	0%	0%	0%
South Africa	0%	0%	0%	0%	0%	0%	0%	0%
Austria	0%	0%	0%	0%	0%	0%	0%	0%
Saudi Arabia	0%	0%	0%	0%	0%	0%	0%	0%

Table 10 – Specialization by Country; % of Patent Activity Technical in Stream per Country of Origin

PATENT FILINGS – GLOBAL PROLIFIC ENTITIES

The list of prolific entities filing patents includes a mix of consumer electronics manufacturers, automotive/aeronautics companies. Science & Technology Unit, Umm al Qura University (STU-UQU) appears to have no patent filings in Space Technology. While the domain appears to be crowded, there are opportunities for filing patents as discussed previously, in conjunction with Table 9.

Entity	Total	Times Cited	Citation per family
QUALCOMM INC	1827	5163	2.83
SAMSUNG ELECTRONICS CO LTD	1598	2029	1.27
SEIKO EPSON CORP	788	1034	1.31
NOKIA CORP	721	1774	2.46
LG ELECTRONICS INC	695	488	0.70
TOYOTA MOTOR CORP	583	713	1.22
SONY CORP	560	1537	2.74
DENSO CORP	530	877	1.65
APPLE INC	510	2633	5.16
GOOGLE INC	493	835	1.69
MITSUBISHI ELECTRIC CORP	493	311	0.63
IBM CORP	484	1321	2.73
MICROSOFT CORP	480	2367	4.93
STATE GRID CORP CHINA	477	5	0.01
UNIV BEIJING AERONAUTICS & ASTRONAUTICS	445	337	0.76
HONEYWELL INT CORP	424	956	2.25
ETRI	408	278	0.68
RES IN MOTION LTD	399	1228	3.08
AISIN AW CO LTD	395	435	1.10
CLARION CO LTD	392	489	1.25
BOSCH GMBH ROBERT	384	271	0.71
UNIV HARBIN ENG	352	105	0.30
GENERAL MOTORS CORP	349	1383	3.96
HITACHI LTD	334	549	1.64
BROADCOM CORP	325	984	3.03
INTEL CORP	293	580	1.98
PIONEER ELECTRONIC CORP	273	226	0.83
BOEING CO	265	533	2.01
MITAC INT CORP	264	306	1.16
ALPINE KK	263	487	1.85

Table 11 – Space Technology – Top entities for Patents

TECHNOLOGY OVERVIEW OF GLOBAL PROLIFIC ENTITIES

Table 10 shows the technology profile of the top 30 entities within the patent landscape of Space Technology. Satellite navigation is the most patented topic within the landscape, with computing and electronics companies investing heavily in patenting satellite navigation related technologies. Most companies are not investing much in protecting innovations in hybridization/augmentation. Toyota, Mitsubishi, Clarion, Robert Bosch, and Alpine, all of which are active in automotive technologies appear to be focusing majorly on navigation data processing.

Entity	1.01 Radio/Radar Navigation	1.02 Satellite Navigation	2.0 Inertial Navigation	3.0 Celestial	4.01 Sensing	4.02 Components Hybrization/Augumentation	4.03 Navigation Data Processing	5.0 Testing/Calibration/Monitoring
QUALCOMM INC	44	1661	62	22	273	41	81	104
SAMSUNG ELECTRONICS CO LTD	38	1423	32	15	147	11	90	44
SEIKO EPSON CORP	14	271	69	24	238	28	81	201
NOKIA CORP	13	677	3	1	20	15	37	9
LG ELECTRONICS INC	17	550	28	1	34	13	105	27
TOYOTA MOTOR CORP	54	176	54	6	133	27	239	61
SONY CORP	21	426	33	3	33	7	65	41
DENSO CORP	24	106	65	4	111	28	255	77
APPLE INC	10	462	13	2	37	4	18	17
GOOGLE INC	3	452	20	3	24	2	24	7
MITSUBISHI ELECTRIC CORP	63	149	48	28	87	11	176	69
IBM CORP	13	419	4	5	29		36	8
MICROSOFT CORP	5	402	19	10	39	19	26	11
STATE GRID CORP CHINA	7	449	7		13		6	12
UNIV BEIJING AERONAUTICS & ASTRONAUTICS	88	76	176	69	228	6	109	240
HONEYWELL INT CORP	52	225	155	8	173	47	63	84
ETRI	29	346	8	3	24	4	64	32
RES IN MOTION LTD	2	358	12		43	6	16	11
AISIN AW CO LTD	6	42	34	1	38	45	272	41
CLARION CO LTD	2	23	32	3	57	12	185	171
BOSCH GMBH ROBERT	30	132	36	6	79	12	143	27
UNIV HARBIN ENG	79	64	215	16	255	5	71	219
GENERAL MOTORS CORP	16	276	10		29	9	54	32
HITACHI LTD	21	129	17	4	27	6	114	53
BROADCOM CORP	17	308	3	1	16	5	20	22
INTEL CORP	13	269	11	1	13	3	9	9
PIONEER ELECTRONIC CORP	3	69	21		22	9	178	25
BOEING CO	16	192	49	20	52	19	42	42
MITAC INT CORP	8	166	10	3	23	5	97	28
ALPINE KK	11	45	25	3	58	13	144	61

Table 12 – Patent overview of top Global entities

TECHNOLOGY OVERVIEW OF ASIA PACIFIC PROLIFIC ENTITIES

Entity	Country of Origin	Total	1.01 Radio/Radar Navigation	1.02 Satellite Navigation	2.0 Inertial Navigation	3.0 Celestial	4.01 Sensing Components	4.02 Hybrization/Augumentation	4.03 Navigation Data Processing	5.0 Testing/ Calibration/ Monitoring
Science & Technology Unit, Umm Al Qura University (STU	Saudi Arabia	-								
Samsung Electronics Co Ltd	South Korea	1494	36	1334	31	9	144	8	79	35
Seiko Epson Corp	Japan	784	14	267	69	24	238	28	81	201
Lg Electronics Inc	South Korea	637	15	495	28		33	13	104	27
Denso Corp	Japan	504	21	93	63	3	109	27	243	74
State Grid Corp China	China	476	7	448	7		13		6	12
Toyota Motor Corp	Japan	476	48	102	52	6	117	23	217	56
Univ Beijing Aeronautics & Astronautics	China	445	88	76	176	69	228	6	109	240
Hyundai Motor Co Ltd	South Korea	434	15	304	10	1	82	12	104	49
Mitsubishi Electric Corp	Japan	410	61	113	47	27	82	9	136	61
ETRI	South Korea	408	29	346	8	3	24	4	64	32
Aisin Aw Co Ltd	Japan	394	6	41	34	1	38	45	272	41
Clarion Co Ltd	Japan	385	2	23	32	3	57	11	183	167
Univ Harbin Eng	China	352	79	64	215	16	255	5	71	219
Hitachi Ltd	Japan	307	21	114	17	4	24	6	106	52
Panasonic Corp	Japan	301	40	85	32	2	77	6	72	16
Nec Corp	Japan	250	42	158	6	3	10	3	30	21
Sony Corp	Japan	224	14	113	27	3	15	5	52	39
Mitac Int Corp	Taiwan	223	4	129	7	2	19	2	90	26
Alpine Kk	Japan	221	11	28	16	3	50	10	127	48
Univ Southeast	China	206	25	78	75	2	84	5	52	90

Table 13 – Patent overview of top Asia Pacific entities

MIDDLE EAST & AFRICA – PROLIFIC ENTITIES

Table 12 illustrates the top patenting entities in the Middle East and Africa. The space appears to be dominated by smaller, local players, particularly from Saudi Arabia, South Africa and Turkey.

Entity	Country of Origin	Total	1.01 Radio/Radar Navigation	1.02 Satellite Navigation	2.0 Inertial Navigation	4.01 Sensing Components	4.03 Navigation Data Processing	5.0 Testing/Calibration/Monitoring
Sabic	Saudi Arabia	25		24		1		
King Fahd University Of Petroleum & Minerals	Saudi Arabia	10	1	7	1	1		1
Saudi Aramco	Saudi Arabia	6	1	5				
Aselsan Elektronik Sanayi Ve Ticaret As	Turkey	4	1	4	2		1	1
Univ King Abdullah Sci & Technology	Saudi Arabia	4		4				
King Abdulaziz City Sci & Technology (Kacst	Saudi Arabia	3		2		1		
Eskom Holdings Soc Ltd	South Africa	2		2				
General Electric Co	Saudi Arabia	2		1		1		
King Saud University	Saudi Arabia	2		1		1		
Nokia Corp	South Africa	2		2				
9245-2929 Quebec Inc	Saudi Arabia	1		1				
Ael Mining Services Ltd	South Africa	1		1				
African Explosives Ltd	South Africa	1		1				
Andrew Wireless Solutions Africa Pty Ltd	South Africa	1	1			1		
Ant Bilisim Elektronik Ve Enerji Teknolo	Turkey	1		1				
Arcelik Anonim Sirketi	Turkey	1		1				
Ayves Dijital Elektronik Arastirma Gelis	Turkey	1		1				
Azoteq Pty Ltd	South Africa	1		1				
Bulk Mining Explosives Pty Ltd	South Africa	1		1				
Dexrad Pty Ltd	South Africa	1		1				
Discovery Holdings Ltd	South Africa	1		1				
Dnz Telekomuenaokasyon Lojaostaok Aonaza	Turkey	1		1				
E-Kent Teknoloji Ve Odeme Sistemleri	Turkey	1		1				
Ekin Teknoloji Sanayi Ve Ticaret Anonim	Turkey	1		1				
Fideltus Ileri Teknoloji Urunleri Sanayi	Turkey	1		1				
Ford Otomotiv Sanayi Anonim Sirketi	Turkey	1	1	1				
Gps Tracking Solutions Pty Ltd	South Africa	1		1				
Greenbro Pty Ltd	South Africa	1		1				
Gruppo Potente Ltd	Kenya	1		1				
Innfront Connexion Pty Ltd	South Africa	1		1				

Table 14 – Patent Overview of Middle East & Africa entities

TECHNOLOGY OVERVIEW OF SAUDI ARABIA PROLIFIC ENTITIES

Table 12 illustrates the top patenting entities in the Middle East and Africa. The space appears to be dominated by smaller, local players, particularly from Saudi Arabia, South Africa and Turkey.

Entity	Total	1.01 Radio/Radar Navigation	1.02 Satellite Navigation	2.0 Inertial Navigation	4.01 Sensing Components	4.03 Navigation Data Processing	5.0 Testing/ Calibration/ Monitoring
Science & Technology Unit, Umm Al Qura University (STU-UQU)	-						
Sabic	25		24		1		
King Fahd University Of Petroleum & Minerals	10	1	7	1	1		1
Saudi Aramco	6	1	5				
Univ King Abdullah Sci & Technology	4		4				
King Abdulaziz City Sci & Technology (Kacst	3		2		1		
King Saud University	2		1		1		

Table 15 – Patent overview of top Saudi Arabia entities

MIDDLE EAST & AFRICA INFORMATION TECHNOLOGY PATENT TRENDS

This section of the report focuses on the patent collection and the activity and technological trends seen within it – in the Middle East and Africa.

MIDDLE EAST & AFRICA – PROLIFIC COUNTRIES

Patent filing trends appear to be very different from the scientific literature trends. Figure 19 shows that South Africa to be the most popular country for filing patents within the two regions, followed by Saudi Arabia and Turkey. The remaining jurisdictions see only marginal patent filings.

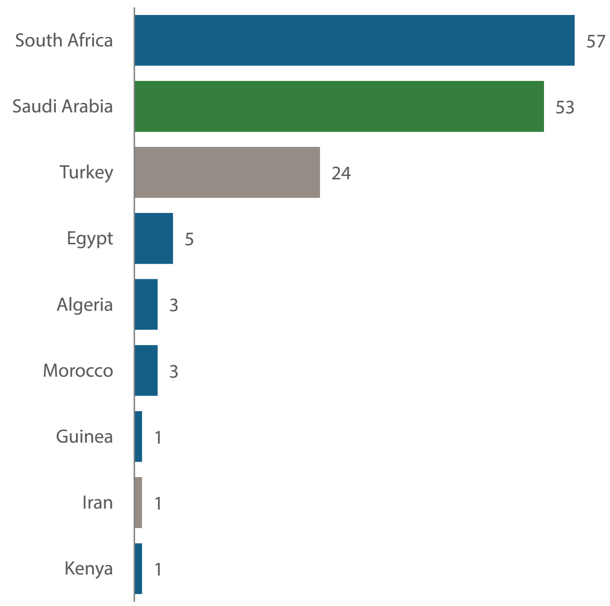


Figure 19 – Middle East & Africa – Prolific countries in patents

Diving deeper, Table 11 shows that South Africa, Saudi Arabia and Turkey to be consistent with the global patent focus on Space Technology.

Country of Origin	1.01 Radio/Radar Navigation	1.02 Satellite Navigation	2.0 Inertial Navigation	3.0 Celestial	4.01 Sensing Components	4.02 Hybrization/Augumentation	4.03 Navigation Data Processing	5.0 Testing/Calibration/Monitoring
South Africa	1	54	1	1	1			1
Saudi Arabia	2	46	1		3			2
Turkey	2	24	3				1	1
Egypt	1	4			1			1
Algeria	1	3			1			
Morocco		3						
Guinea		1						
Iran		1						
Kenya		1						

Table 16 – Middle East & Africa – Prolific countries over technical categories

APPENDIX A – SCIENTIFIC PAPERS TOP AFFILIATIONS

ENTITY-LEVEL DATA TABLES FOR SCIENTIFIC LITERATURE COLLECTION

Table 9 on the following pages shows the top 10 author organizations for each of the technology segments. This information is intended to provide an assessment of the depth and location of the research expertise available in each category.

Technology	Entity	Total
1.01 Radio/Radar Navigation	National Aeronautics & Space Administration (Nasa	34
	University Of California System	30
	Chinese Academy Of Sciences	27
	United States Department Of Defense	19
	Beihang University	18
	Cnrs	18
	Goddard Space Flight Center	18
	Russian Academy Of Sciences	17
	Max Planck Society	17
	Goddard Space Flight Ctr	17
1.02 Satellite Navigation	Chinese Academy Of Sciences	159
	Beihang University	105
	University Of Calgary	85
	Wuhan University	81
	University Of New South Wales	73
	National University Of Defence Technology - China	68
	Gnss Res Ctr	64
	European Space Agency	60
	Curtin University Of Technology	59
	Delft University Of Technology	57
2.0 Inertial Navigation	Beihang University	78
	National University Of Defence Technology - China	52
	Harbin Engineering University	30
	Sch Instrumentat Sci & Optoelect Engn	28
	Southeast University - China	27
	Coll Automat	27
	Southeast Univ	26
	Beijing Univ Aeronaut & Astronaut	22
	Sch Instrument Sci & Engn	22
	University Of New South Wales	21
3.0 Celestial	National Aeronautics & Space Administration (Nasa	36
	California Institute Of Technology	27
	Beihang University	26
	Cnrs	25
	University Of California System	23
	Chinese Academy Of Sciences	20
	Sapienza University Rome	18
	Univ Roma La Sapienza	18
	United States Department Of Defense	16
	Sch Instrumentat Sci & Optoelect Engn	15

Top 10 Entities per Technology Stream
continued

Technology	Entity	Total
4.01 Sensing Components	Beihang University	118
	National University Of Defence Technology - China	83
	University Of California System	80
	Chinese Academy Of Sciences	71
	Cnrs	58
	University Of Calgary	41
	University Of New South Wales	41
	Southeast University - China	40
	National Aeronautics & Space Administration (Nasa	39
	Southeast Univ	39
4.02 Hybrization/Augumentation	Stanford University	29
	Technical University Of Munich	23
	Dept Aeronaut & Astronaut	23
	Chinese Academy Of Sciences	21
	Beihang University	20
	University Of California System	18
	Korea Advanced Institute Of Science & Technology (Kaist	15
	Korea Adv Inst Sci & Technol	15
	Heidelberg Univ	14
	Ruprecht Karl University Heidelberg	14
4.03 Navigation Data Processing	University Of California System	26
	Chinese Academy Of Sciences	16
	Pennsylvania Commonwealth System Of Higher Education (Pcshe	16
	Cnrs	14
	Univ Washington	13
	Technical University Of Munich	12
	National Cheng Kung University	12
	University Of Toronto	12
	Beihang University	11
	National University Of Defence Technology - China	11
5.0 Testing/ Calibration/ Monitoring	Beihang University	82
	University Of California System	62
	National University Of Defence Technology - China	42
	Chinese Academy Of Sciences	41
	Ohio State University	36
	Florida State University System	34
	University Of Calgary	30
	University Of Toronto	29
	Cnrs	28
	Sapienza University Rome	26

Table 17 – Top 10 Paper Publishing Organizations per Technology Segment

APPENDIX B — PATENT STATISTICS AND TABLES

ENTITY-LEVEL DATA TABLES FOR PATENT COLLECTION

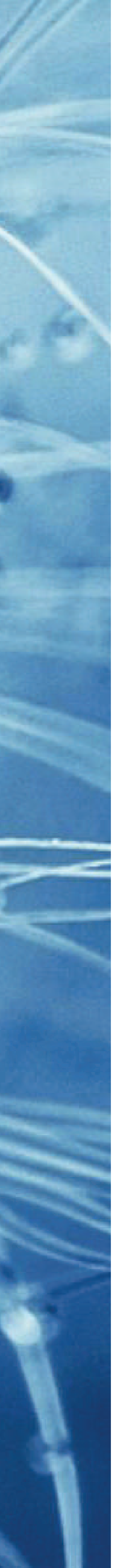
The table 10 below and on the following page shows the top 10 patent applicants or patent assignees for each of the technology segments. This information is intended to provide an assessment of expertise and patent commercialization intent per category.

Technology	Entity	Total
1.01 Radio/Radar Navigation	Univ Beijing Aeronautics & Astronautics	88
	Univ Harbin Eng	79
	Mitsubishi Electric Corp	63
	Thales Sa	62
	Toyota Motor Corp	54
	Honeywell Int Corp	52
	Toshiba Kk	48
	Qualcomm Inc	44
	Nec Corp	44
	Samsung Electronics Co Ltd	38
1.02 Satellite Navigation	Qualcomm Inc	1661
	Samsung Electronics Co Ltd	1423
	Nokia Corp	677
	Lg Electronics Inc	550
	Apple Inc	462
	Google Inc	452
	State Grid Corp China	449
	Sony Corp	426
	Ibm Corp	419
	Microsoft Corp	402
2.0 Inertial Navigation	Univ Harbin Eng	215
	Univ Beijing Aeronautics & Astronautics	176
	Honeywell Int Corp	155
	Univ Southeast	75
	Seiko Epson Corp	69
	Denso Corp	65
	Qualcomm Inc	62
	Univ Nanjing Aeronautics & Astronautics	56
	Toyota Motor Corp	54
	Boeing Co	49
3.0 Celestial	Univ Beijing Aeronautics & Astronautics	69
	Beijing Control Eng Res Inst	44
	Toray Ind Inc	30
	Mitsubishi Electric Corp	28
	Univ Nanjing Aeronautics & Astronautics	26
	Harbin Inst Technology	25
	Seiko Epson Corp	24
	Beijing Inst Technology	23
	Qualcomm Inc	22
	Univ Beihang	21

Top 10 Entities per Technology Stream
continued

Technology	Entity	Total
4.01 Sensing Components	Qualcomm Inc	273
	Univ Harbin Eng	255
	Seiko Epson Corp	238
	Univ Beijing Aeronautics & Astronautics	228
	Honeywell Int Corp	173
	Samsung Electronics Co Ltd	147
	Toyota Motor Corp	133
	Denso Corp	111
	Mitsubishi Electric Corp	87
	Univ Southeast	84
4.02 Hybrization/Augumentation	Honeywell Int Corp	47
	Aisin Aw Co Ltd	45
	Qualcomm Inc	41
	Denso Corp	28
	Seiko Epson Corp	28
	Toyota Motor Corp	27
	Boeing Co	19
	Microsoft Corp	19
	Thales Sa	16
	Nokia Corp	15
4.03 Navigation Data Processing	Aisin Aw Co Ltd	272
	Denso Corp	255
	Toyota Motor Corp	239
	Clarion Co Ltd	185
	Pioneer Electronic Corp	178
	Mitsubishi Electric Corp	176
	Alpine Kk	144
	Bosch Gmbh Robert	143
	Tomtom Int Bv	123
	Hitachi Ltd	114
5.0 Testing/ Calibration/ Monitoring	Univ Beijing Aeronautics & Astronautics	240
	Univ Harbin Eng	219
	Seiko Epson Corp	201
	Clarion Co Ltd	171
	Xanavi Informatics Kk	118
	Qualcomm Inc	104
	Univ Southeast	90
	Honeywell Int Corp	84
	Denso Corp	77
	Mitsubishi Electric Corp	69

Table 18 – Top 10 Patent Applicants/Owners per Technology Segment



LANDSCAPE OF WATER TECHNOLOGY

SCIENCE & TECHNOLOGY UNIT, UMM AL-QURA UNIVERSITY (STU-UQU)

THOMSON REUTERS IP SERVICES
MAY 2015

Executive Summery

This study has been commissioned by Science & Technology Unit, Umm Al-Qura University (STU-UQU) to evaluate and describe the global scientific research and patent activity within sub-tracks that they have achieved funding for projects in Water Technology. The sub-track in focus is Wastewater Treatment. The study has looked at both scientific papers and patents to form an understanding of the overall scientific and technology landscape.

The scientific papers are sourced from the Web of Science™, a database containing journal articles from approximately 12,500 peer-reviewed journals.

The patent information is sourced from the Derwent World Patents Index™, a database of patents and patent applications from 47 international patent issuing authorities.

Both databases have been selected because they provide a method of defining a unit of science or technology. A single paper defined by the Web of Science is required to have met a minimum threshold of scientific rigor: publication within a journal of repute, peer review sign off, etc. Furthermore, a patent included within DWPI is defined credibly as an attempt to protect a piece of innovation within at least one territory.

Aggregating this information across technologies and countries provides a method of tracking innovation in the field of wastewater treatment. Included in this document are measurements of research and patent quality and direction changes in research and patent activity. It should be noted that in many areas the report utilizes metrics such as average annual percentage growth in scientific and research output to compare activities across technologies and geographies. Such metrics should be treated with care for analyses containing low volumes, as some volatility is expected. Also to be noted is that the global high volume nature of this analysis within Wastewater Treatment technology necessarily entails some level of noise and is not intended to be completely comprehensive. Instead, the analyses enclosed should be treated as a survey of the technology, and the trends and findings interpreted in this manner.

Overall, the fact that the number of patents in this area is about 1.7 times of the number of scientific papers suggests that the practical technical commercialization is more focused than the fundamental research activity.

For STU-UQU, it is interesting to note the patent and scientific literature collections differ with respect to the breakdown in technology segments. The agriculture and municipal/domestic waterwaste sources are comparably addressed in both data sets, however, other industrial wastes including the petrochemical industry waste is majorly addressed in the patent collection as compared to the scientific paper collection. The analysis also suggests that on a global level the primary, secondary and advanced treatment techniques were overly focused as compared to the natural biological treatment technique.

Similarly with regard to average growth rates of these collections (years 2008 - 2013 for patents; years 2009 - 2014 for papers), all of the technology segments in the scientific literature collection and the patent collection have seen a growth over the time period with waterwaste source from other industries as compared to municipal/domestic, agriculture and petrochemical industry waste is in focus. In the patent collection the technology segment which are experiencing growth are primary treatment and wastewater management.

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Introduction to Global Wastewater Treatment Technology

This study presents an analysis of patents and scientific papers that fall within specific topics of water technology which are of interest to Umm Al-Qura University concerning the Wastewater Treatment. The study was commissioned by Umm Al-Qura University as part of a wider program to review the scientific and intellectual property activity in specific topics that they have gained approved funding for projects. Within water technology, they have gained funding approval for 1 project related to Wastewater Treatment specifically in the sub-tracks of Advanced Treatment and protecting Environment. The title of the project is "*Synthesis of Nano Structured Composites and Their Application in Elimination of Methyl Tertiary Butyl Ether (MTBE) From Water*".
A large scale data collation process using globally recognized search processes from Thomson Reuters was undertaken to produce practical and insightful sets of information for analysis regarding the trends, geographies and ultimately the institutions and patent applicants working in the fields of Wastewater Treatment.
As shown in Figure 1, the overall volume of patents in this technology areas filed since 2006 is more than 1.9 times of the volume of scientific papers published since 2008, however in the same time period from year 2008 onwards the scientific papers output is about 64% higher than the patents output.

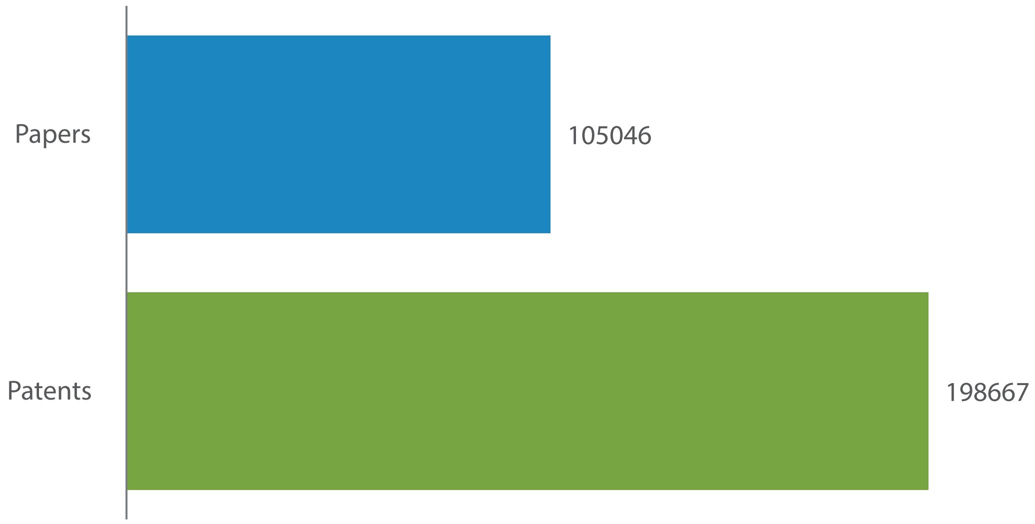

Figure 1 – Scientific paper and patent families in Wastewater Treatment Technology

Additionally, year 2007 onwards patent protection activity related to Wastewater Treatment has gradually increased. The significant drop observed in years 2012-13 is due to the publication lag of 18 months between filing of patent applications and the applications being available for public review (refer to Figure 2, Timeline of Activity). Whereas publications in scientific journals in this areas, which are likely to address more fundamental research in science, during years 2009-14 has continuously increased at an average rate of about 7% year over year. This might suggest that the focus of technology development globally related to Wastewater Treatment is increasingly directed towards fundamental scientific research as well as patenting activity.

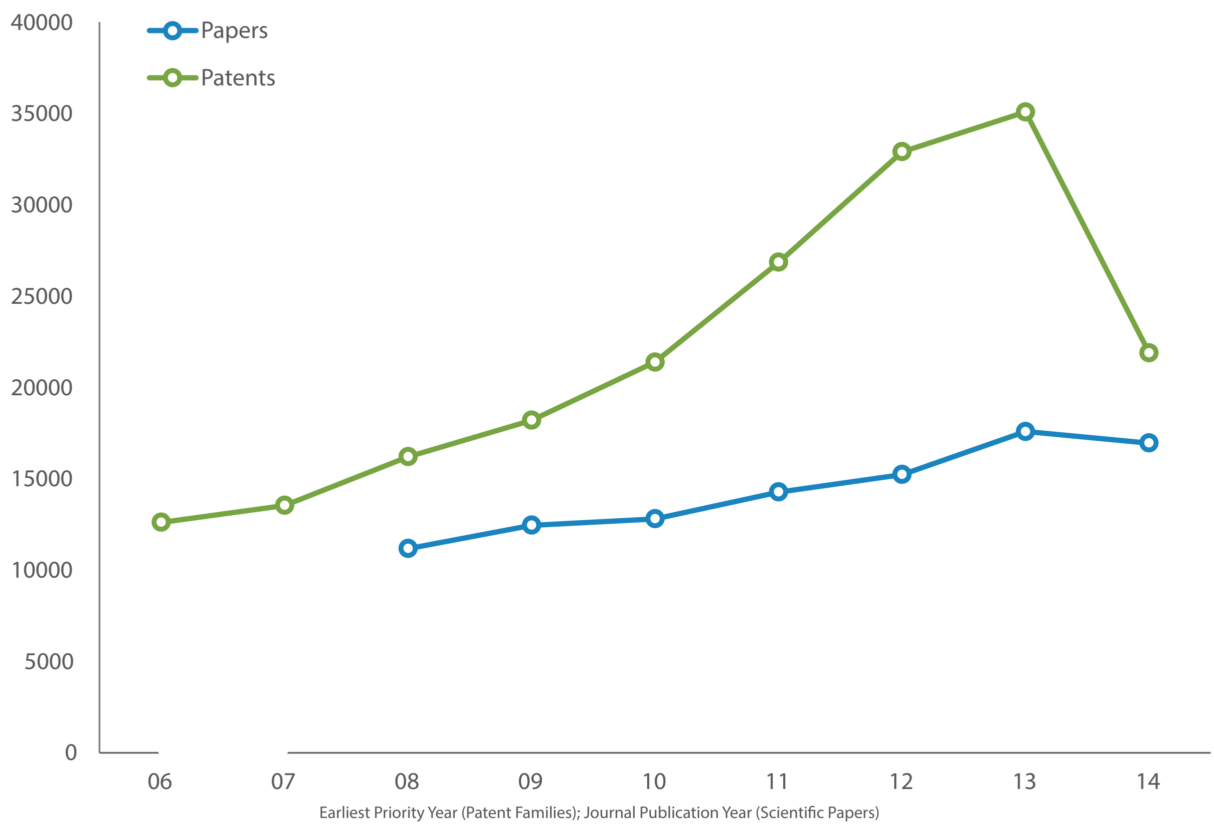

Figure 2 – Timeline of scientific paper and patent family activity

Figures 3 through 5 show three further analyses on each of the data collections (patents, left; papers, right) concerning the nature and high level technology trends occurring within Wastewater Treatment areas.

The patent and scientific literature collections differ with respect to the breakdown in broad technology segments. Four broad level segments within Wastewater Treatment research, which were identified for the purpose of this study, include "Wastewater Sources", "Treatment Techniques", "Wastewater Treatment Plants and Reactors", and "Wastewater Management". Within the Wastewater Sources segment the noticeable sources in both data sets are agriculture and municipal/domestic wastes. However, other industrial wastes including the petrochemical industry waste is majorly addressed in the patent collection as compared to the scientific paper collection. Within Treatment Techniques segment the primary, secondary and advanced treatment techniques were overly focused as compared to the natural biological treatment technique. Apparently Wastewater Management is a least focused segment in both the collections.

Note that the dates used for the collation of the timeline information differ for patent and scientific literature information. Patent Families are measured by the earliest known "priority" or first filing event in the inventions history. Patents are typically retained by patent offices for 18 months or more after filing before they are published. This delay means that the last complete year of information available for patent information is 2012. For scientific papers, the dates used for analyses are the publication dates of the journal containing the paper. These metrics are used throughout the report.

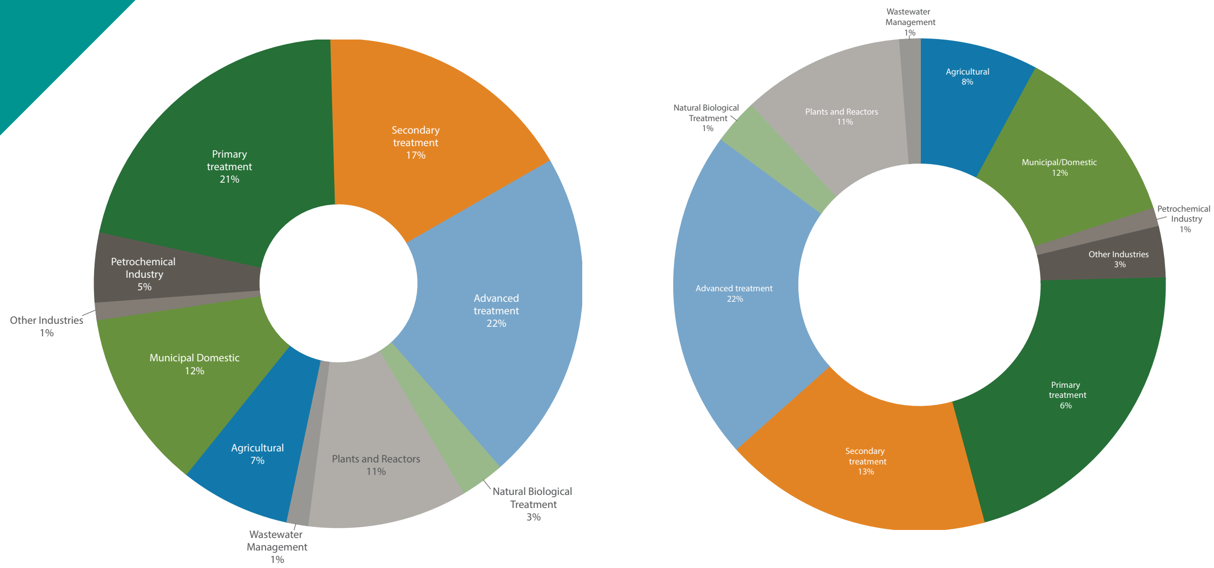

Figure 3 – % of patent (left) and scientific paper (right) collections by Wastewater Treatment Technology topic

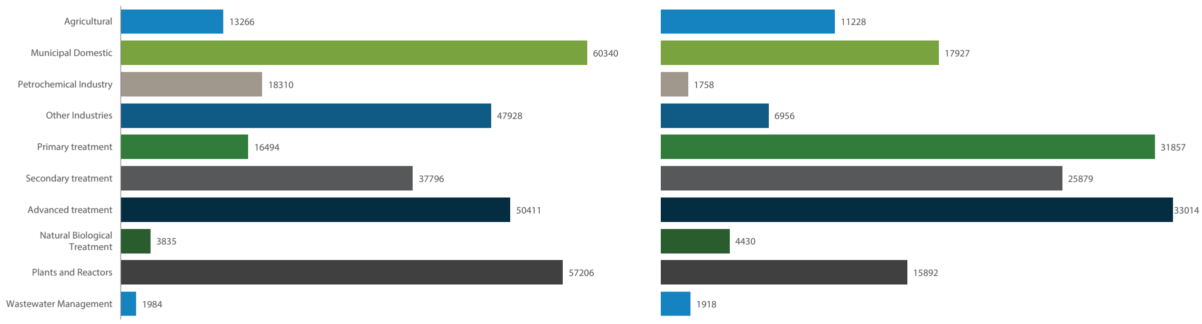

Figure 4 – Number of patents families (left) and scientific papers (right) per Wastewater Treatment Technology topic

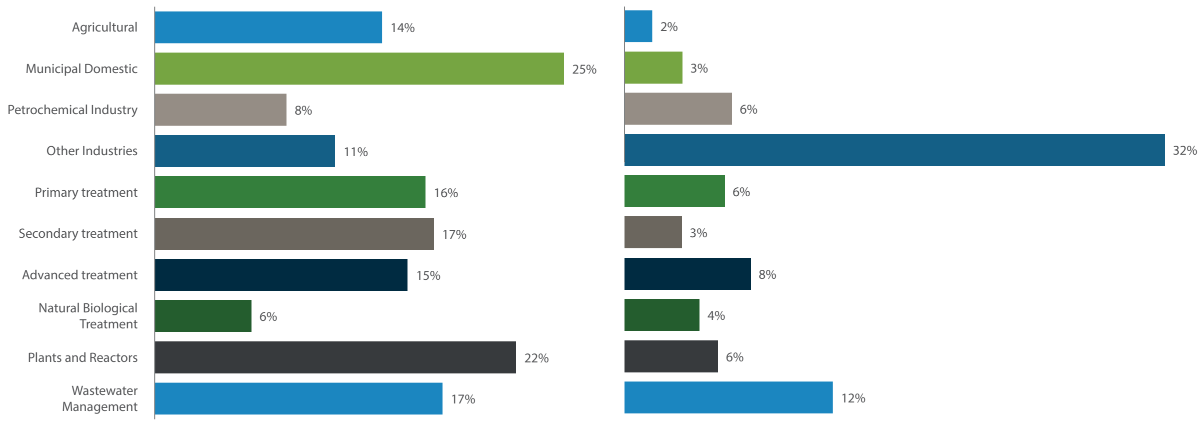

Figure 5 – Average annual % growth or decline in patent family (left) or scientific paper (right)

With regard to average growth rates of these collections (years 2008 - 2013 for patents; years 2009 - 2014 for papers), all of the technology segments in the scientific literature collection and the patent collection have seen a growth over the time period with waterwaste source from other industries as compared to municipal/domestic, agriculture and petrochemical industry waste in focus. In the patent collection the technology segment which are experiencing growth are primary treatment and wastewater management.

Growth trends for scientific literature (Figure 6) since 2008 shows that all the technology segments in Wastewater Treatment are growing with Wastewater Management technology segment leading. Patenting trends since 2006 (Figure 7) shows similar trends with Wastewater Management and Wastewater Treatment Plants and Reactors leading.

Average annual growth or decline is calculated by the average percentage increase or decrease between one year and the next. For example; 5 patents in 2006 followed by 6 patents in 2007 would represent an annual increase of 20%. An increase of 20% in one year, followed by a 10% increase the following year would be represented as a 15% average increase across the two years. This process is followed for 2006 (patents) or 2008 (papers) through to the most recently available year in patent and paper collections, to provide an indicator of the level and direction of recent changes in technology topics.

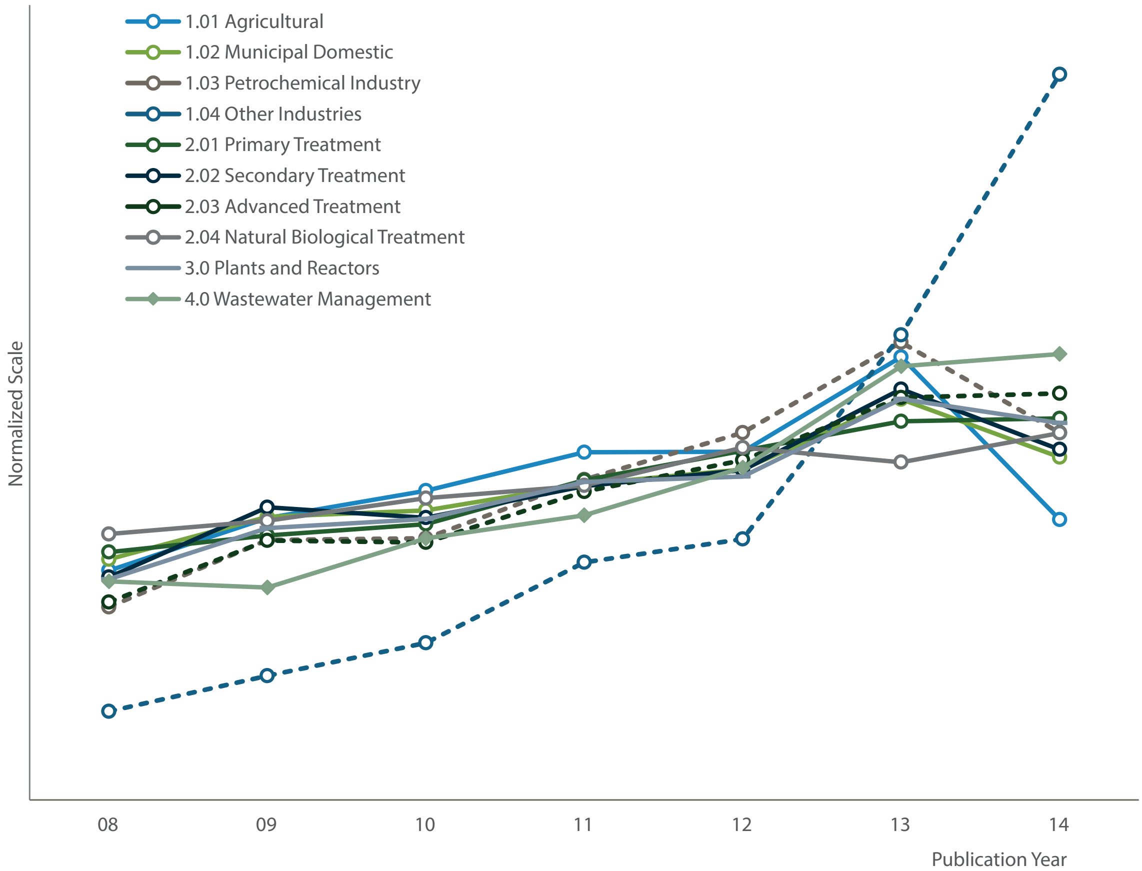

Figure 6 – Normalized timeline of activity for scientific paper collection by Wastewater Treatment Technology topics

The timelines on these charts have been normalised to allow for side by side comparison. Individually, each topic has varying volumes of patent families and scientific papers, however for visualisation purposes, the charts represent the proportion of each topic's activity filed or published in each calendar year.

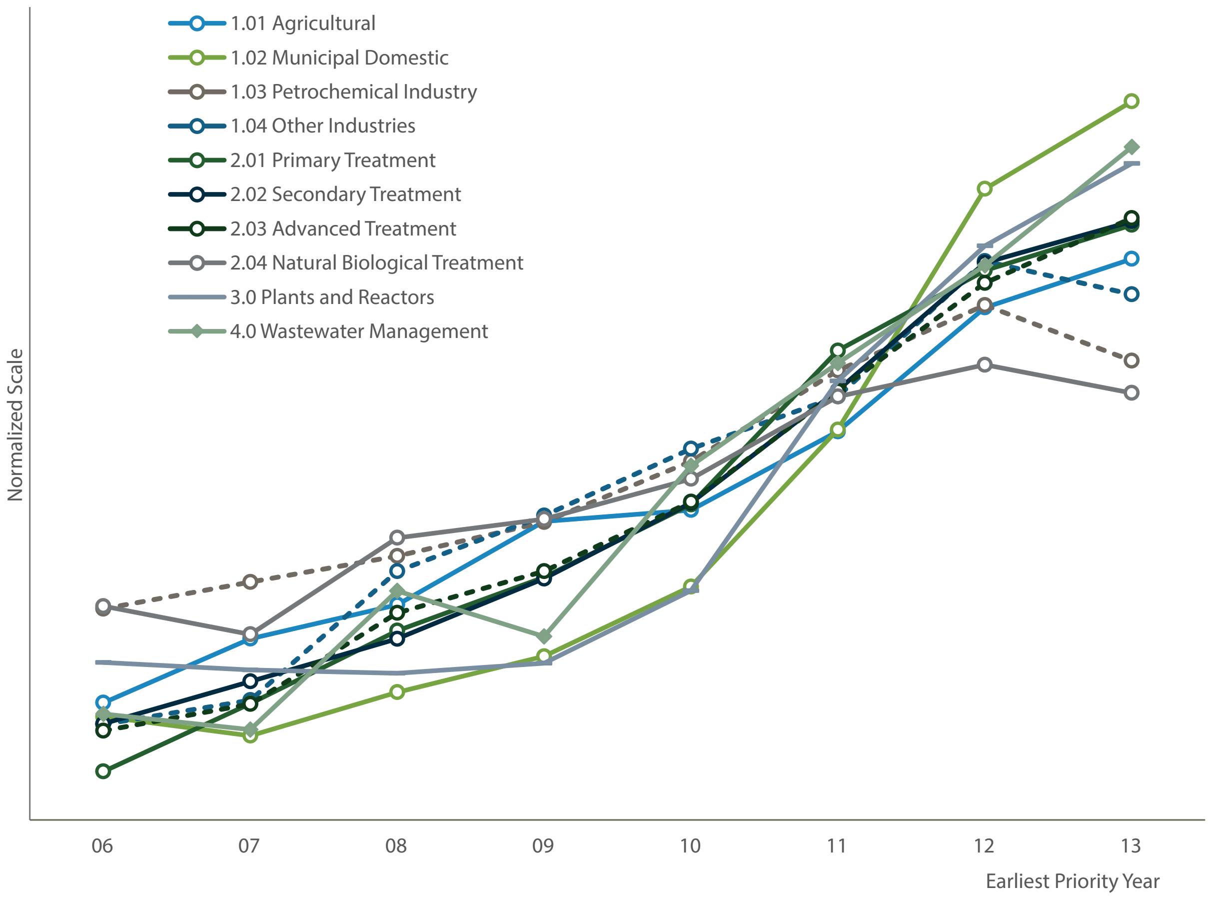

Figure 7 – Normalized timeline of activity for patent family collection by Wastewater Treatment Technology topics

Global Wastewater Treatment Technology Scientific Activity Trend

This section of the report focuses on the scientific paper collection and the activity and technological trends seen within it. Based on the Thomson Reuters-produced Web of Science database, the collection only includes papers published in pre-selected journals of influence.
In total, about 105000 peer reviewed papers were incorporated into the Wastewater Treatment research.

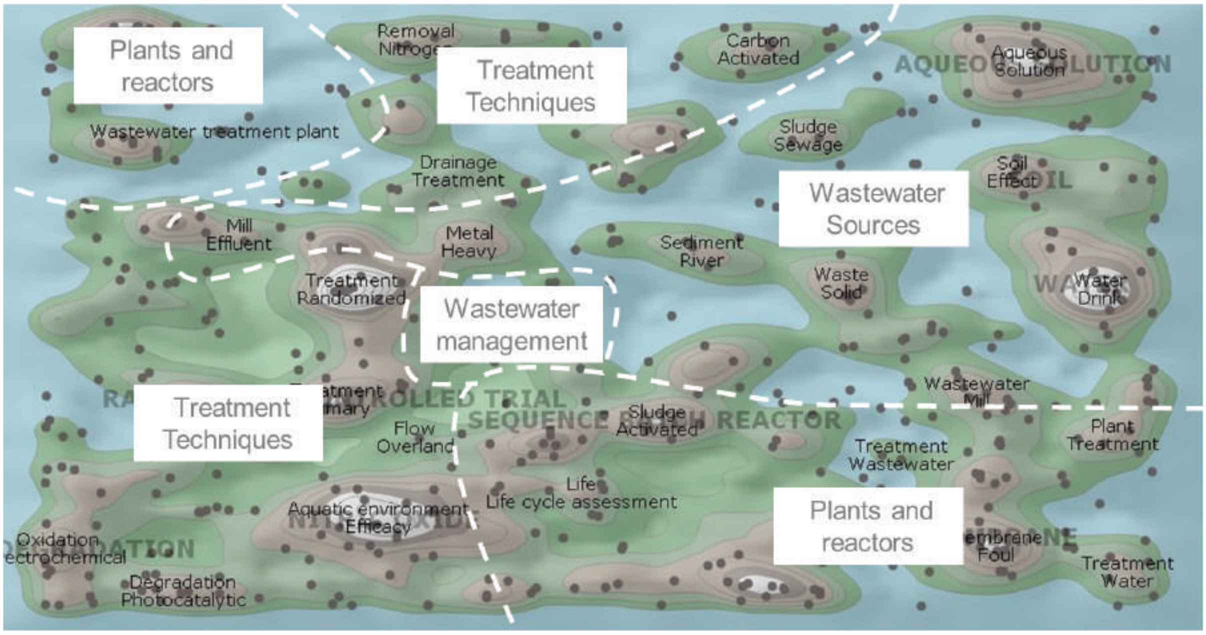

Figure 8 – ThemeScape map of scientific papers on Wastewater Treatment Technology; annotated by major themes

Key themes present throughout this collection of papers are illustrated in Figure 15 as a "ThemeScape map" - a visualization method for understanding the common themes and concepts within thousands of documents. Used for market analysis, government intelligence and primarily technology landscapes, the algorithm parses large amounts of text into a topological map of peaks and troughs.
Themes that are commonly shared between documents are represented by mountainous peaks, whereas documents that share little commonality are located within the valleys of the map. The large number of documents in this map means that there are rather few valleys to be found.
The location of an individual document is the vector sum of all the attractions to other documents in the collection based on shared phraseology and the frequency and proximity of these terms.
This map has been manually annotated to summarize the major technology areas within the scientific literature collection. Some technologies will necessarily overlap, and the delineation of one technical area versus another is therefore only approximate. However the map is very useful in describing what topics are common features of global Wastewater Treatment Research.
Key themes revealed in this Themescape map are aquatic environment efficiency, aqueous solution, treatment randomized and degradation photocatalytic.

ThemeScape® is a text-mining application that acquires and analyses free text. The algorithms it uses require no application of thesauri or other outside sources of information, and only the free text itself is used by this text-mining tool. The more text the application acquires, the more likely it will be that the output will provide an accurate summary of the major themes present. After analysing the text in multiple documents, it pulls together those documents that share related text and pulls apart those with less related text. The outcome 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 pick out topics of interest. It aggregates word forms that share a common stem, but it does not directly aggregate synonyms. Instead, synonyms may be gathered under a common theme because of the other words that co-occur with those synonyms. Thus, "battery" and "cell" may be clustered together because of the co-occurrence in the same documents of terms like "electrode, rechargeable, electrolyte" and so on. Conversely, "battery" and "cell" may be separated if the map contains a mixture of documents on metals and biology, where the two terms have different meanings. In other words, terms are identified as synonyms only by co-clustering based on common context.

The topographical maps presented by ThemeScape are mathematical solutions built on a random selection of a first document and sequential calculation of the relationships of all the other documents. The orientation of the map is random, and the directions up, down, left, or right have no significance, because the n-dimensional solution might have been presented from any angle. Only the proximity of points within the map has meaning, and co-localized documents are highly likely to share concepts.

In this report there are separate ThemeScape maps covering scholarly papers or patents. The two types of documents are not pooled and analysed together. This is because ThemeScape is context-sensitive, and it would separate patent and literature documents from one another based on the very different formal styles of writing that are reflected in these two types of content. Likewise, if documents in two languages are pooled, it will separate them based on the language, and then each language region will be clustered based on term frequency in that language.

The ThemeScape maps in this report analyse large numbers of documents. The contour lines on the maps diminish in circumference, encircling regions of higher and higher concentration. The density is also shown by the map coloration. White snow-capped peaks represent the highest density, while blue expanses (sea level) indicate low density.

The labels in black on the map are selected by ThemeScape based on term frequency in that map region, and they may have been adjusted by the analyst. The large color-overlay regions enclosed by broken lines have been added by the analyst to identify content at an even higher level of abstraction. The dots on the map represent single documents. Dots are not shown for all the documents, and instead represent a sampling that allows the other features of the map to be discerned. Within the ThemeScape application, the map can be magnified, searched, probed and highlighted to learn more about its contents.

ThemeScape is reliant on statistical methods that are not equivalent to reading by human judges, and in compensation, it analyses millions of documents on a scale of minutes and quickly presents an intuitive, high level summary. It enables and guides further review, and provides a first level overview of very complex datasets.

WASTEWATER TREATMENT TECHNOLOGY SCIENTIFIC LITERATURE SEGMENTATION

Table 1 shows the further segmentation of Water treatment technology topics. There appears to be similar amount of interest in primary treatment, secondary treatment and advanced treatment. However, natural biological treatment is still a very small area. Wastewater management is another such area with very little scientific literature, but with relatively high growth rate.

Technology Segmentation		Total Inventions	Average % Growth or Decline ('09-'14)
1.0 Waterwaste Sources	1.01 Agricultural	11228	2%
	1.02 Municipal Domestic	17927	3%
	1.03 Petrochemical Industry	1758	6%
	1.04 Other Industries	6956	32%
2.0 Treatment Techniques	2.01 Primary Treatment	31857	6%
	2.02 Secondary Treatment	25879	3%
	2.03 Advanced Treatment	33014	8%
	2.04 Natural Biological Treatment	4430	4%
3.0 Plants and Reactors	3.0 Plants and Reactors	15892	6%
4.0 Wastewater Management	4.0 Wastewater Management	1918	12%

Table 1 – Scientific literature technology segmentation

WASTEWATER TREATMENT TECHNOLOGY SCIENTIFIC LITERATURE COLLECTION TECHNOLOGY CATEGORY OVERLAP

The technology segments, that were created to enumerate and describe the Wastewater Treatment Research landscape in the areas of Wastewater Sources, Treatment Techniques, Wastewater Treatment Plants and Reactors and Wastewater Management, were not intended to be mutually exclusive. A single scientific paper can be included in multiple categories or segments.

Figure 9 visualizes the relationship between the five broad technology segments used in this study. Each number in the diagram shows the number of papers that have content related to both the corresponding row-wise and column-wise segments.

The most correlated segment pairings are agriculture and municipal/domestic waste with the secondary and advanced treatments using Plants and Reactors.

	1.01 Agricultural	1.02 Municipal/Domestic	1.03 Petrochemical Industry	1.04 Other Industries	2.01 Primary Treatment	2.02 Secondary Treatment	2.03 Advanced Treatment	2.04 Natural Biological Treatment	3.0 Plants And Reactors	4.0 Wastewater Management
1.01 Agricultural	11228	2143	202	720	148	2245	1913	269	1734	341
1.02 Municipal/Domestic		17927	181	902	498	5474	4005	583	5553	629
1.03 Petrochemical Industry			1758	157	50	416	363	52	419	29
1.04 Other Industries				6956	147	1752	1908	188	809	128
2.01 Primary Treatment					31857	817	736	116	484	40
2.02 Secondary Treatment						25879	11731	1476	7133	428
2.03 Advanced Treatment							33014	1052	5217	314
2.04 Natural Biological Treatment								4430	880	81
3.0 Plants And Reactors									15892	569
4.0 Wastewater Management										1918

Figure 9 – Number of scientific papers per pair of technology categories

SCIENTIFIC PAPER GEOGRAPHIC VOLUME BENCHMARKING

Figure 10 shows the number of scientific papers for the ten most prolific countries within the scientific paper collection.
United Sates is the largest source of wastewater treatment-related peer-reviewed papers, followed by China, Spain, United Kingdom, India and Germany. These 10 most prolific countries contribute to about 73% of the scientific publications in the field of wastewater treatment.

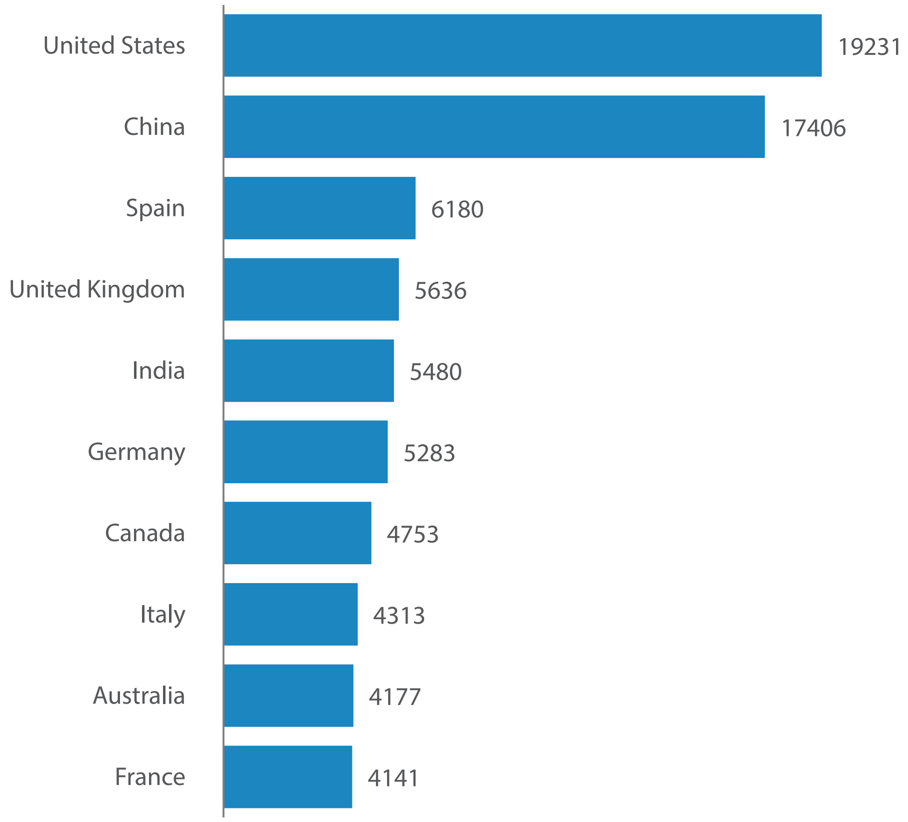

Figure 10 – Number of scientific papers per country; top 10 countries

SCIENTIFIC PAPER GEOGRAPHIC ACTIVITY TRENDS

The chart below shows the highest grow rates sources in the scientific literature collection.

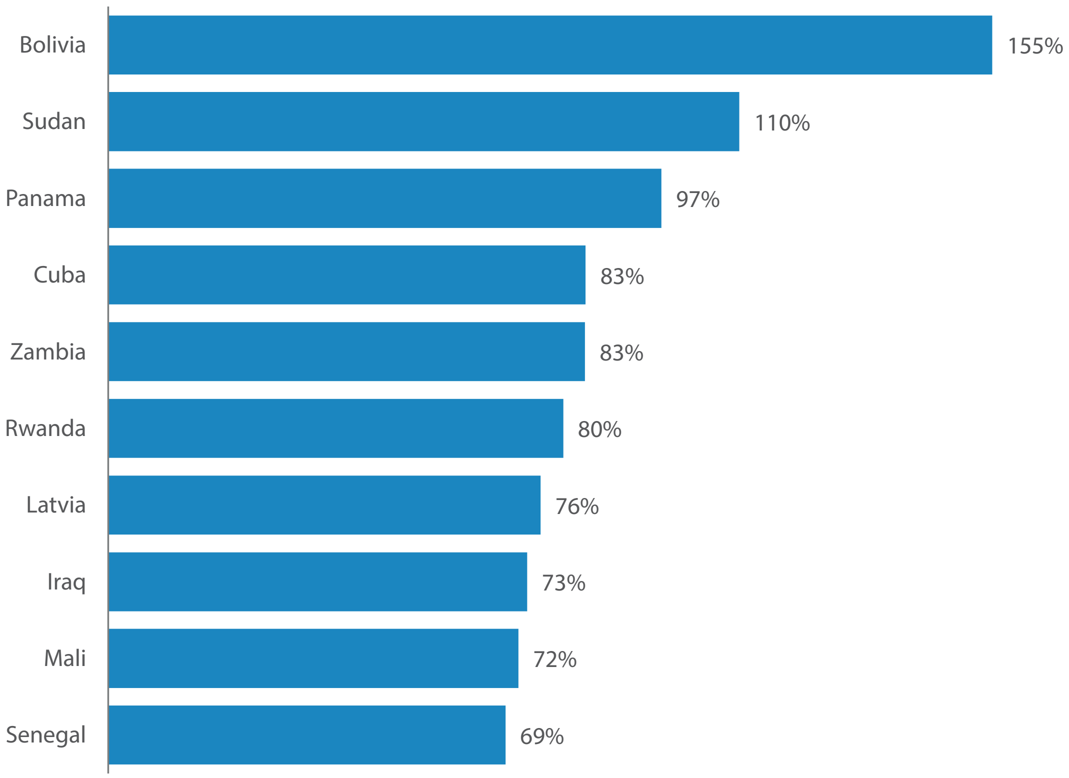

Figure 11 – Highest growth rate geographies in Wastewater Treatment Technology paper output

Figure 11 – Highest growth rate geographies in Wastewater Treatment Technology paper output While the average number of scientific literature publication from Bolivia, Sudan, Panama, Zambia and Rwanda is about 21 and very small relative to the collections of the most prolific countries, the growth rate of Bolivia, Sudan, Panama, Zambia and Rwanda collection far exceeds that of other countries.

SCIENTIFIC PAPER GEOGRAPHIC CITATION IMPACT BENCHMARKING

Scientific paper and patent citations are routinely used in technology bibliometrics for assessing the inherent impact and potential quality of research and the downstream technical and scientific relevance of the underlying research.

Figure 12 shows the "Citation Impact", the average citation per paper for all papers in a country's collection (which are having at least 500 publications) and has been sorted by highest citation impact. This shows that output from Uganda, Switzerland, Austria, Belgium and Singapore are having the highest impact in the field of wastewater treatment.

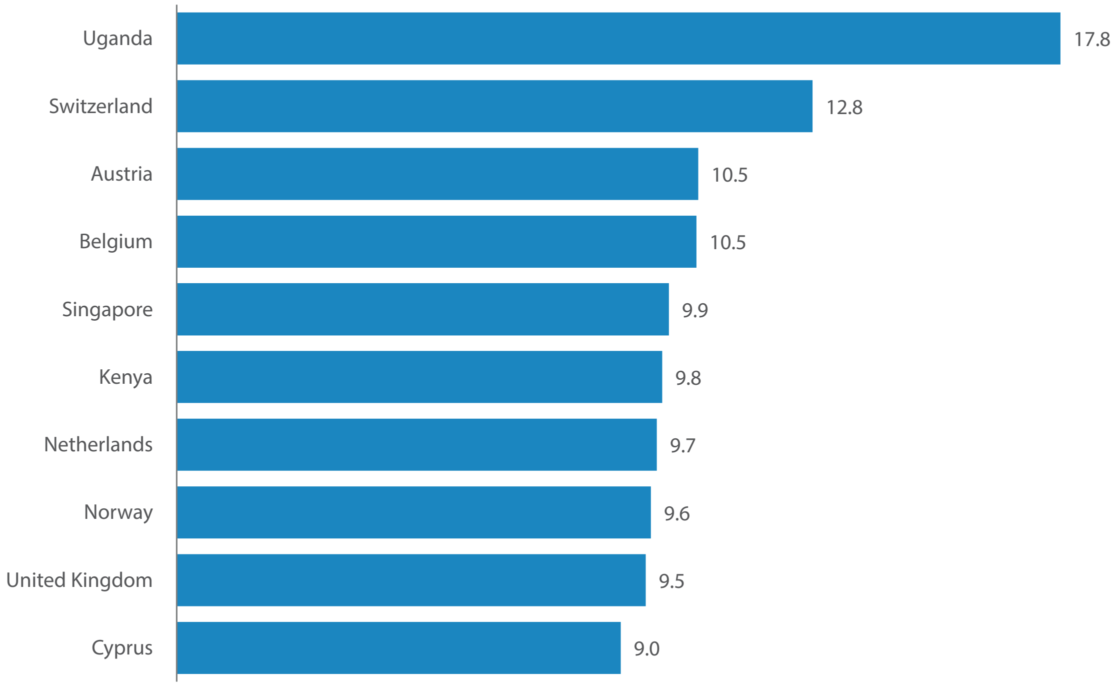

Figure 12 – Highest citation impact geographies of Wastewater Treatment Technology publications

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Note that the journals included in the project source data (Web of Science) are selected on the basis of both quantitative and qualitative selection criteria, such as editorial quality, peer review robustness and citation impact. Further details of the journal selection process is available from : http://thomsonreuters.com/products_services/science/free/essays/journal_selection_process/

WATER TECHNOLOGY RESEARCH TOPIC BY GEOGRAPHY

Table 2 shows the split of Wastewater Treatment Technology science and research specialization for the top nations. The Kingdom of Saudi Arabia appears to have focus on advanced treatment, primary treatment and secondary treatment. Overall, the focus in scientific literature remains fairly evenly spread out over the various Wastewater Treatment Technology topics, across the countries.

Country of Origin	1.01 Agricultural	1.02 Municipal Domestic	1.03 Petrochemical Industry	1.04 Other Industries	2.01 Primary Treatment	2.02 Secondary Treatment	2.03 Advanced Treatment	2.04 Natural Biological Treatment	3.0 Plants and Reactors	4.0 Wastewater Management
United States	12%	15%	1%	4%	42%	20%	20%	5%	12%	2%
China	8%	16%	1%	6%	17%	36%	47%	3%	15%	1%
Spain	12%	20%	2%	9%	24%	27%	33%	4%	26%	2%
United Kingdom	9%	17%	1%	4%	49%	17%	17%	5%	9%	2%
India	14%	12%	2%	11%	20%	22%	45%	3%	11%	1%
Germany	8%	17%	1%	4%	48%	16%	18%	4%	16%	2%
Canada	9%	22%	2%	7%	33%	24%	25%	4%	18%	2%
Italy	10%	16%	2%	7%	47%	17%	19%	4%	15%	3%
Australia	12%	18%	1%	7%	32%	29%	29%	5%	16%	3%
France	9%	17%	1%	5%	33%	24%	28%	5%	16%	2%
Japan	7%	19%	1%	4%	37%	22%	28%	3%	14%	1%
Brazil	14%	17%	3%	6%	28%	20%	26%	9%	17%	2%
South Korea	5%	17%	1%	5%	32%	26%	39%	3%	15%	1%
Turkey	11%	15%	2%	10%	26%	24%	38%	3%	13%	2%
Iran	13%	11%	4%	8%	14%	23%	52%	3%	11%	1%
Netherlands	9%	15%	1%	4%	49%	22%	19%	5%	12%	3%
Taiwan	6%	16%	1%	6%	25%	29%	39%	4%	16%	1%
Poland	7%	27%	2%	7%	22%	32%	33%	5%	22%	3%
Sweden	9%	19%	1%	6%	43%	24%	19%	3%	20%	3%
Switzerland	8%	22%	1%	3%	40%	20%	20%	5%	20%	3%
Belgium	9%	16%	1%	4%	38%	24%	25%	7%	18%	3%
Malaysia	12%	11%	5%	15%	15%	29%	49%	3%	11%	1%
Portugal	9%	16%	1%	13%	21%	26%	36%	8%	23%	3%
Greece	15%	23%	1%	10%	26%	25%	32%	4%	20%	4%
Mexico	18%	17%	2%	9%	15%	30%	43%	4%	16%	2%
Denmark	13%	20%	2%	3%	40%	29%	21%	4%	20%	4%
South Africa	14%	22%	1%	10%	23%	24%	30%	4%	18%	3%
Egypt	18%	13%	2%	8%	25%	20%	43%	1%	12%	1%
Israel	27%	20%	1%	3%	29%	25%	25%	4%	16%	3%
Singapore	5%	16%	1%	3%	21%	35%	49%	4%	13%	1%
Pakistan	26%	13%	1%	12%	17%	20%	37%	4%	12%	2%
Thailand	13%	14%	2%	10%	20%	33%	35%	3%	15%	3%
Saudi Arabia	12%	14%	3%	11%	20%	22%	49%	2%	12%	1%
Romania	8%	14%	2%	11%	13%	24%	47%	7%	19%	2%
Finland	8%	18%	2%	13%	37%	21%	26%	4%	16%	1%
Tunisia	19%	15%	3%	17%	11%	25%	43%	6%	15%	2%

Table 2 – Wastewater Treatment Technology specialization by country; % of literature activity per technical stream

SCIENTIFIC PAPER - PROLIFIC GLOBAL ENTITIES

Universities appear to dominate the scientific paper publications in wastewater technologies. Notably, a large number of Chinese universities feature in the top 30 entities publishing scientific literature in this area. Science & Technology Unit, Umm al Qura University (STU-UQU) has 18 papers published in this space. However, the citation per paper is relatively low, as compared to other entities within the top 30. University of California, University of Queensland, Harvard University, and University of Barcelona, all appear to have highly relevant scientific literature publications, with a high number of citations for their scientific papers. This indicates that these entities may be involved in more fundamental research on wastewater treatment.

Entity	Total	Times Cited	Citation per paper
Science & Technology Unit, Umm Al Qura University (STU-UQU)	18	28	1.56
Chinese Acad Sci	2557	18840	7.37
Univ California	1613	16797	10.41
Tongji Univ	876	5300	6.05
Harbin Inst Technol	867	5028	5.80
Tsinghua Univ	716	4135	5.78
Zhejiang Univ	714	4099	5.74
Univ Sao Paulo	711	4136	5.82
Univ Queensland	636	8402	13.21
Islamic Azad Univ	561	2366	4.22
Indian Inst Technol	552	6364	11.53
Csic	538	6247	11.61
Shandong Univ	495	2332	4.71
Delft Univ Technol	491	4450	9.06
Univ Ghent	487	4837	9.93
Natl Taiwan Univ	468	3123	6.67
Harvard Univ	466	6487	13.92
Peking Univ	464	3857	8.31
Nanjing Univ	458	3555	7.76
Univ Toronto	446	4383	9.83
Univ Florida	423	2974	7.03
Univ Barcelona	412	5515	13.39
Univ Alberta	397	3237	8.15
Shanghai Jiao Tong Univ	394	2478	6.29
Nanyang Technol Univ	373	4378	11.74
Natl Univ Singapore	370	3076	8.31
Us Epa	367	3794	10.34
Univ Washington	366	3189	8.71
Seoul Natl Univ	364	2161	5.94
Usda Ars	357	2605	7.30
Univ Porto	355	3256	9.17

Table 3 – Wastewater Treatment Technology – Top entities for scientific literature

SCIENTIFIC LITERATURE OVERVIEW OF TOP GLOBAL ENTITIES

Table 4 shows the technology profile of the top 30 entities within the scientific literature space of wastewater technology. It is interesting to note that most entities focus either on primary treatment, or on secondary and advanced treatment, but not both. Few entities have put equal emphasis on the two technology areas. Science & Technology Unit, Umm al Qura University (STU-UQU) has 18 publications across plants and reactors, primary treatment, secondary treatment, advanced treatment, pertaining to agricultural waste water, and municipal/domestic waste water. As noted above in connection with Table 1, natural/biological treatment, and wastewater management appear to be relatively less researched, even by the top entities.

Entity	1.01 Agricultural	1.02 Municipal Domestic	1.03 Petrochemical Industry	1.04 Other Industries	2.01 Primary Treatment	2.02 Secondary Treatment	2.03 Advanced Treatment	2.04 Natural Biological Treatment	3.0 Plants and Reactors	4.0 Wastewater Management
Science & Technology Unit, Umm Al Qura University (STU-UQU)	3	3		1	3	3	7		4	
Chinese Acad Sci	413	503	37	171	172	962	1079	136	486	22
Univ California	241	252	9	51	724	302	274	81	176	38
Tongji Univ	33	222	3	24	47	455	513	37	204	8
Harbin Inst Technol	18	172	13	38	43	515	546	42	195	4
Tsinghua Univ	35	203	14	36	54	332	396	34	188	10
Zhejiang Univ	57	119	18	29	124	254	337	23	107	6
Univ Sao Paulo	68	133	11	48	216	174	197	38	142	6
Univ Queensland	44	128	7	36	146	270	258	32	159	34
Islamic Azad Univ	82	36	22	44	56	128	320	10	54	4
Indian Inst Technol	75	90	13	62	42	189	298	30	77	3
Csic	109	122	16	78	93	129	122	35	134	10
Shandong Univ	20	49	5	17	80	249	269	15	40	
Delft Univ Technol	34	125	14	28	49	248	232	42	137	22
Univ Ghent	52	97	13	26	83	183	192	31	146	15
Natl Taiwan Univ	44	83	10	24	83	201	168	21	90	3
Harvard Univ	20	39	3	3	379	9	25	2	8	3
Peking Univ	29	71	6	21	97	164	196	11	73	8
Nanjing Univ	28	79	9	26	32	158	263	23	96	9
Univ Toronto	5	41	2	14	313	42	56	6	34	1
Univ Florida	107	64	5	12	117	107	81	29	53	8
Univ Barcelona	35	80	3	24	97	129	180	13	113	6
Univ Alberta	20	76	42	30	128	99	114	10	48	5
Shanghai Jiao Tong Univ	21	54	3	12	117	103	179	10	56	2
Nanyang Technol Univ	18	57	3	10	31	183	215	10	50	2
Natl Univ Singapore	16	56	6	14	76	107	192	16	51	6
Us Epa	46	109	2	20	23	135	118	25	104	17
Univ Washington	14	42		3	253	38	43	8	25	4
Seoul Natl Univ	26	48	4	6	167	67	98	6	40	2
Usda Ars	198	51	5	7	27	63	39	59	58	8
Univ Porto	27	50	7	23	63	87	174	12	97	4

Table 4 – Scientific literature overview of top global entities

SCIENTIFIC LITERATURE OVERVIEW OF TOP ASIA PACIFIC ENTITIES

Entity	Country of Origin	Total	1.01 Agricultural	1.02 Municipal Domestic	1.03 Petrochemical Industry	1.04 Other Industries	2.01 Primary Treatment	2.02 Secondary Treatment	2.03 Advanced Treatment	2.04 Natural Biological Treatment	3.0 Plants and Reactors	4.0 Wastewater Management
Science & Technology Unit, Umm Al Qura University (STU-UQU)	Saudi Arabia	18	3	3		1	3	3	7		4	
Chinese Acad Sci	China	2557	413	503	37	171	172	962	1079	136	486	22
Tongji Univ	China	876	33	222	3	24	47	455	513	37	204	8
Harbin Inst Technol	China	867	18	172	13	38	43	515	546	42	195	4
Tsinghua Univ	China	716	35	203	14	36	54	332	396	34	188	10
Zhejiang Univ	China	714	57	119	18	29	124	254	337	23	107	6
Indian Inst Technol	India	552	75	90	13	62	42	189	298	30	77	3
Shandong Univ	China	495	20	49	5	17	80	249	269	15	40	
Natl Taiwan Univ	Taiwan	468	44	83	10	24	83	201	168	21	90	3
Peking Univ	China	464	29	71	6	21	97	164	196	11	73	8
Nanjing Univ	China	458	28	79	9	26	32	158	263	23	96	9
Shanghai Jiao Tong Univ	China	394	21	54	3	12	117	103	179	10	56	2
Nanyang Technol Univ	Singapore	373	18	57	3	10	31	183	215	10	50	2
Natl Univ Singapore	Singapore	370	16	56	6	14	76	107	192	16	51	6
Seoul Natl Univ	South Korea	364	26	48	4	6	167	67	98	6	40	2
Sun Yat Sen Univ	China	341	16	61	1	12	135	97	118	7	37	2
Dalian Univ Technol	China	335	6	38	7	22	16	165	210	9	58	1
Univ Sains Malaysia	Malaysia	332	36	37	13	21	30	104	220	8	27	2
Univ Tokyo	Japan	324	27	64	11	7	80	114	107	5	77	11
S China Univ Technol	China	295	21	26	12	33	18	119	157	9	65	2
Fudan Univ	China	293	9	36	3	7	118	76	110	11	30	

Table 5 – Scientific literature overview of top Asia Pacific entities

SCIENTIFIC LITERATURE OVERVIEW OF TOP MIDDLE EAST & AFRICA ENTITIES

Table 6 visualizes the prolific entities in the Middle East and Africa. The list is dominated by Middle Eastern entities, reflecting the trends seen in Table 5 above. Most of the prolific entities in these regions follow the global focus trends on primary treatment, secondary treatment and advanced treatment, while not focusing heavily on other technologies. Notable exceptions include the Islamic Azad University, with a substantial focus on agriculture.

Entity	Country of Origin	Total	1.01 Agricultural	1.02 Municipal Domestic	1.03 Petrochemical Industry	1.04 Other Industries	2.01 Primary Treatment	2.02 Secondary Treatment	2.03 Advanced Treatment	2.04 Natural Biological Treatment	3.0 Plants and Reactors	4.0 Wastewater Management
Science & Technology Unit, Umm Al Qura University (STU-UQU)	Saudi Arabia	18	3	3		1	3	3	7		4	
Islamic Azad Univ	Iran	561	82	36	22	44	56	128	320	10	54	4
Istanbul Tech Univ	Turkey	293	11	76	4	27	14	177	157	25	73	12
Univ Tehran	Iran	287	42	52	20	28	35	93	105	20	45	5
King Saud Univ	Saudi Arabia	242	39	35	9	16	70	45	86	6	32	1
Univ Tehran Med Sci	Iran	239	14	28	6	5	78	62	98	6	42	3
Tarbiat Modares Univ	Iran	194	22	21	2	23	17	56	106	12	23	1
King Abdulaziz Univ	Saudi Arabia	168	19	19	1	31	11	28	95	1	23	2
Ege Univ	Turkey	156	31	16	4	16	35	20	67	6	15	1
Istanbul Univ	Turkey	152	7	24	1	14	55	22	55	5	17	5
Univ Kwazulu Natal	South Africa	131	17	18	2	6	35	21	39	7	21	4
Univ Alexandria	Egypt	129	25	16	5	11	23	30	76		9	
King Fahd Univ Petr & Minerals	Saudi Arabia	127	12	8	6	9	9	22	99	1	8	
Dokuz Eylul Univ	Turkey	126	8	16	16	14	23	54	35	7	30	4
Ataturk Univ	Turkey	121	15	13		15	26	23	59	1	7	
Hacettepe Univ	Turkey	121	2	5		10	63	14	36		10	
Univ Johannesburg	South Africa	121	8	17	1	14	2	51	84	3	23	2
Razi Univ	Iran	112	17	8	19	10	5	31	66	4	20	1
Univ Tabriz	Iran	109	3	5	3	7	6	32	83	3	4	2
Amirkabir Univ Technol	Iran	107	8	5	1	17	7	20	74	4	8	1
Cairo Univ	Egypt	107	12	5	1	6	53	14	26	1	10	1
Middle E Tech Univ	Turkey	106	8	26		18	11	35	48	3	32	4
Selcuk Univ	Turkey	104	7	18	2	7	25	20	45	4	15	
King Abdullah Univ Sci & Technol	Saudi Arabia	103	6	24	3	11	13	52	50	9	18	2
Suleyman Demirel Univ	Turkey	102	28	10	3	11	19	20	34	4	15	1
Gebze Inst Technol	Turkey	101	4	9		6	1	43	77		8	
Univ Cape Town	South Africa	99	10	27		12	34	25	16		9	4
Erciyes Univ	Turkey	97	5	11	1	12	34	23	30	3	9	2
Univ Pretoria	South Africa	97	17	27	3	17	24	19	15	5	16	3
Univ Witwatersrand	South Africa	97	8	18		10	24	21	31	4	13	2
Uludag Univ	Turkey	96	29	16		15	21	20	42	3	13	

Table 6 – Scientific literature overview of top Middle East & Africa entities

SCIENTIFIC LITERATURE OVERVIEW OF TOP SAUDI ARABIA ENTITIES

Entities	Total	1.01 Agricultural	1.02 Municipal/Domestic	1.03 Petrochemical Industry	1.04 Other Industries	2.01 Primary Treatment	2.02 Secondary Treatment	2.03 Advanced Treatment	2.04 Natural Biological Treatment	3.0 Plants And Reactors	4.0 Wastewater Management
Science & Technology Unit, Umm Al Qura University (STU-UQU)	18	3	3		1	3	3	7		4	
King Saud Univ	242	39	35	9	16	70	45	86	6	32	1
King Abdulaziz Univ	168	19	19	1	31	11	28	95	1	23	2
King Fahd Univ Petr & Minerals	127	12	8	6	9	9	22	99	1	8	
King Abdullah Univ Sci & Technol	103	6	24	3	11	13	52	50	9	18	2
King Abdulaziz Univ Sci & Technol	23	2	4		2	3	8	14	2	2	1
King Abdulaziz City Sci & Technol	18	4		1	2	1		12		1	
Science & Technology Unit, Umm Al Qura University	18	3	3		1	3	3	7		4	
Taif Univ	15	4			3	5	3	5			
Taibah Univ	11	2	2		2	1	4	5		1	
Jazan Univ	10	1	1		1	5	1	3			
King Faisal Univ	10	3	1		1	3	4	5			
King Faisal Specialist Hosp & Res Ctr	9					9					
King Khalid Univ	8	1	1	1	1	2	1	2			1
Aljouf Univ	7	3	2	1	1	2	2	1		2	
Najran Univ	7				1		1	7			
Qassim Univ	7	2	4			3		1		4	
Salman Bin Abdulaziz Univ	6	1	2			2	1	1		1	
Yanbu Ind Coll	6					1	3	3			
Alfaisal Univ	5					3	1	2			
Mutah Univ	5					1		4			
King Fahad Med City	4					4					
Saudi Aramco	4		1	1				2			
Schlumberger Water Serv	4	2	2				1			1	1
Univ Dammam	4		1		1	2		1			
King Saud Bin Abdulaziz Univ Hlth Sci	3					3					
Minist Hlth	3					2		1			
Northern Borders Univ	3			1	2	1					
Royal Commiss Jubail & Yanbu	3	2	2					2		2	
Univ Hail	3				2	1	1	1			
Al Imam Muhammad Ibn Saud Univ	2							2			

Table 7 – Scientific literature overview of top Saudi Arabia entities

MIDDLE EAST & AFRICA WASTEWATER TREATMENT SCIENTIFIC LITERATURE TRENDS

This section of the report focuses on the scientific paper collection and the activity and technological trends observed in the Middle East and Africa regions.

MIDDLE EAST & AFRICA –PROLIFIC COUNTRIES

Figure 13 below shows the prolific countries by scientific literature volume in the Middle East & Africa regions. The gray bars indicate Middle East, blue indicates Africa, and green indicates the Kingdom of Saudi Arabia. As seen from the figure, the most prolific countries within these regions are Turkey and Iran, followed by South Africa, Egypt and Saudi Arabia.

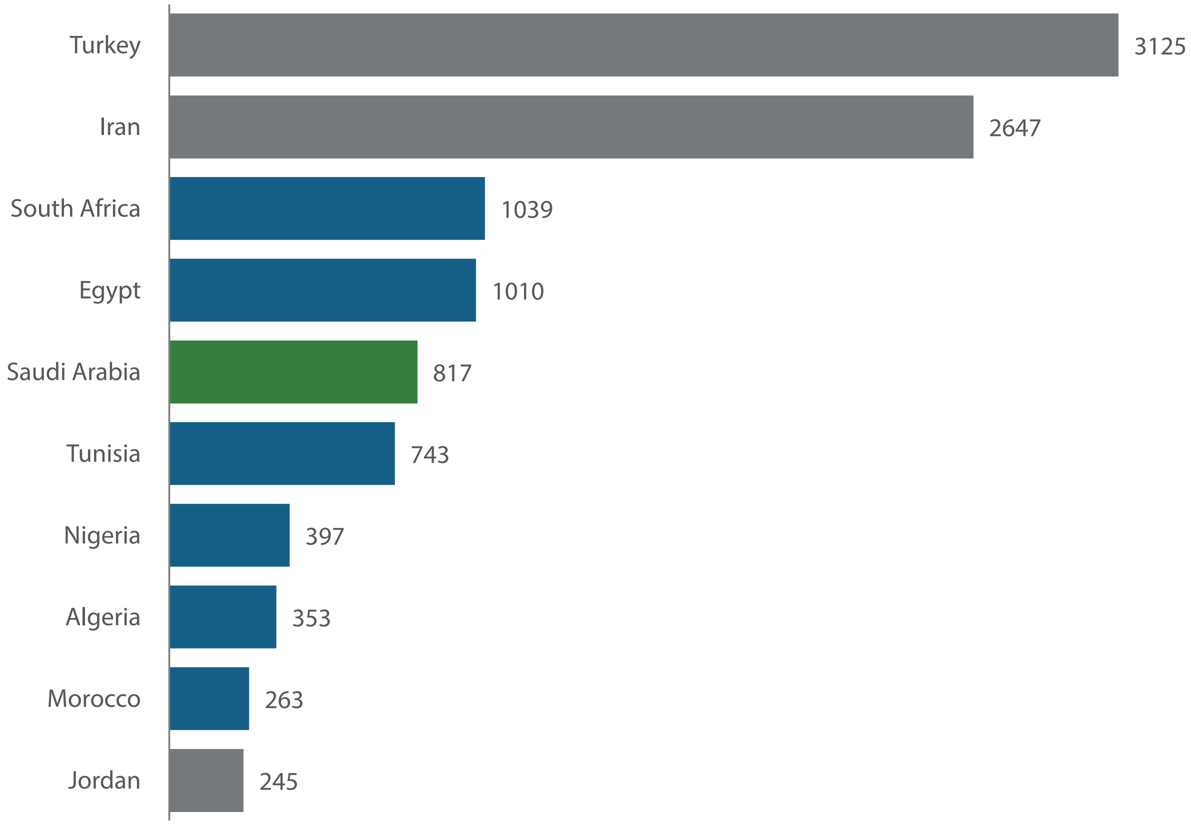

Figure 13 – Middle East & Africa – Prolific countries in scientific literature

A more detailed analysis of the technologies of focus in each of the countries within the Middle East and Africa is presented with reference to Tables 5 and 6. Focus appears to be on agriculture, municipal, Primary treatment, secondary treatment and advanced treatment. Also notable is the interest in agriculture, municipal and petrochemical industry in these countries. Interestingly, most of the countries in these regions have lower focus on natural biological treatment, plants and reactors and wastewater management.

Country of Origin	1.01 Agricultural	1.02 Municipal Domestic	1.03 Petrochemical Industry	1.04 Other Industries	2.01 Primary Treatment	2.02 Secondary Treatment	2.03 Advanced Treatment	2.04 Natural Biological Treatment	3.0 Plants and Reactors	4.0 Wastewater Management
Turkey	351	482	65	318	828	753	1172	96	410	52
Iran	339	284	114	201	368	610	1366	88	285	26
South Africa	144	231	12	106	237	248	314	38	190	30
Egypt	185	135	25	81	250	205	432	14	125	15
Saudi Arabia	101	113	24	88	162	181	398	19	99	7
Tunisia	140	111	26	126	83	188	323	42	112	18
Nigeria	87	70	11	40	106	69	95	17	33	6
Algeria	29	22	6	25	28	121	245	6	36	2
Morocco	44	36	13	40	45	67	116	15	25	7
Jordan	72	57	8	19	29	64	93	11	55	10
U Arab Emirates	15	30	18	11	29	44	80	3	27	7
Iraq	11	19	4	17	12	51	79	5	17	
Kenya	20	42		2	35	28	24	8	9	2
Ethiopia	29	18		4	42	9	18	8	7	6
Uganda	18	21		2	50	22	21	4	6	4
Oman	24	22	4	4	15	29	37	3	15	5
Ghana	40	27	3	9	17	15	18	8	8	4
Kuwait	9	23	8	3	20	29	11		14	5
Tanzania	22	18		4	30	17	10	9	4	1
Lebanon	9	18	3	7	17	22	21	3	13	4
Qatar	6	12	5	15	10	10	32		8	2
Cameroon	9	17	1	3	15	13	23	3	3	3
Syria	22	3	2	1	12	9	13	1	4	3
Zimbabwe	15	14		3	15	2	9	3	5	
Burkina Faso	9	10		3	15	5	6	11	3	1
Malawi	3	9			18	7	8	2	8	
Senegal	10	5	1	1	11	5	3	1	2	1
Cote Ivoire	3	7			6	10	8	2	5	2
Botswana	3	5			6	7	3		2	1
Sudan	2	1		1	15	4		3	2	
Bahrain	3	6		1	9	3	6		5	1
Zambia	3	6			10		1			1
Rwanda	6	2		1	6	5	5		4	2

Table 8 – Middle East & Africa – Prolific countries over technical categories

GLOBAL WASTEWATER TREATMENT TECHNOLOGY PATENT TRENDS

This section of the report focuses on the patent collections produced for the study and the activity and technological trends seen within it. Based on the Thomson Reuters-produced Derwent World Patents Index database, the collection includes both pending patent applications and granted patents published in 47 countries around the world.
A total of approximately 1,98000 patented inventions were gathered that are applicable to the various wastewater treatment technology segments of interest to Umm Al-Qura University. These inventions and their technical nature have been summarized using the ThemeScape software described in the previous section.

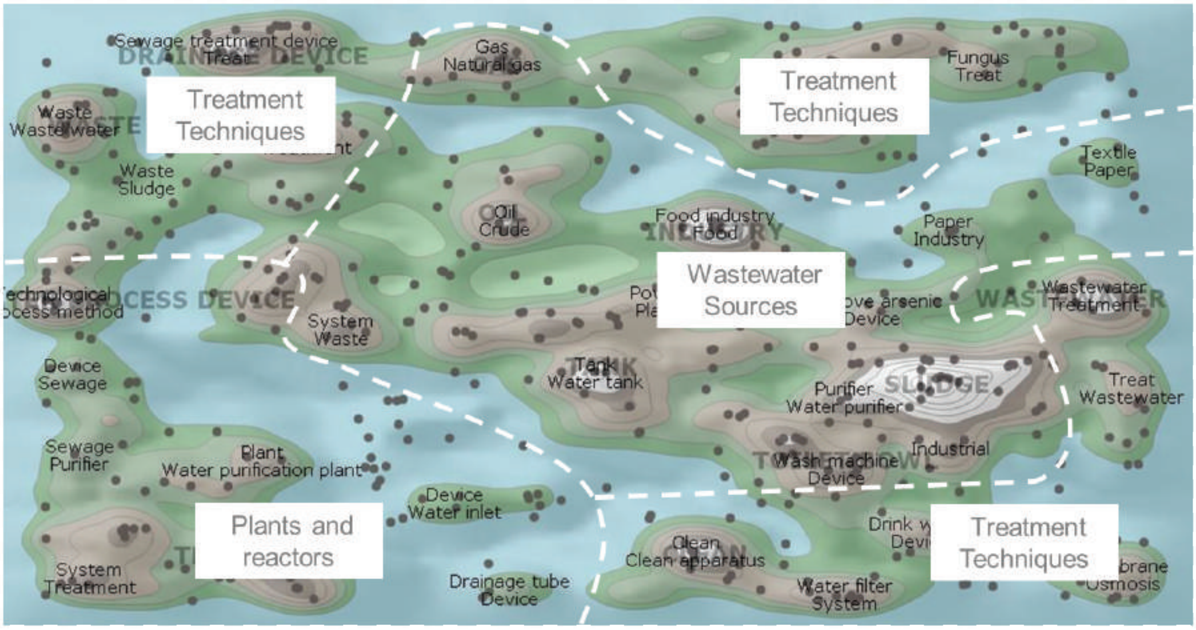

Figure 14 – ThemeScape map of patent collections on Wastewater Treatment Technology; annotated by major themes

As previously noted, the ThemeScape map is not designed to provide a detailed accurate view of each patented invention; instead the visual is designed to highlight the common themes shared by hundreds or thousands of patents and patent applications published since 2006.
Some of the key themes revealed in this ThemeScape are water purifier, waste water treatment and sewage treatment device.
This annotation has been provided to guide the reader around the landscape. However, it should be noted that this annotation is only approximate.

WASTEWATER TREATMENT TECHNOLOGY PATENT SEGMENTATION

Table 7 shows the further segmentation of Wastewater Treatment Technology topics in the patent collection. Highest amount of patenting activity revolves around advanced treatment and plants and reactors, and technologies suited to municipal domestic waste handling. Similar to the literature collection, natural biological treatment is still a very small area, indicating a very niche area. This is a potential white space, with fairly high growth – indicating opportunities for patenting in this area. Wastewater management is another such low patenting activity, high growth white space area – with a good scope for patenting.

Technology Segmentation		Total Inventions	Average % Growth or Decline (08-13)
1.0 Waterwaste Sources	Agricultural	13266	14%
	Municipal Domestic	60340	25%
	Petrochemical Industry	18310	8%
	Other Industries	47928	11%
2.0 Treatment Techniques	Primary treatment	16494	16%
	Secondary treatment	37796	17%
	Advanced treatment	50411	15%
	Natural Biological Treatment	3835	6%
3.0 Plants and Reactors	Plants and Reactors	57206	22%
4.0 Wastewater Management	Wastewater Management	1984	17%

Table 9 – Patent collection technology segmentation

WASTEWATER TREATMENT TECHNOLOGY PATENT COLLECTION CATEGORY OVERLAP

The technology segments, that were created to enumerate and describe the Wastewater Treatment Research landscape in the areas of Wastewater Sources, Treatment Techniques, Wastewater Treatment Plants and Reactors and Wastewater Management, were not intended to be mutually exclusive. A single patent family can be included in multiple categories.

Figure 15 visualizes the relationship between select technology segments. Each number in the diagram shows the number of inventions that have content related to both the corresponding row-wise and column-wise segments.

The most correlated segment pairings are agriculture and municipal/domestic waste with the secondary and advanced treatments using Plants and Reactors.

	1.01 Agricultural	1.02 Municipal Domestic	1.03 Petrochemical Industry	1.04 Other Industries	2.01 Primary treatment	2.02 Secondary treatment	2.03 Advanced treatment	2.04 Natural Biological Treatment	3.0 Plants and reactors	4.0 Wastewater management
1.01 Agricultural	13266	2713	1167	3185	677	1702	2044	233	2199	100
1.02 Municipal/Domestic		60340	3010	9524	6217	9714	8677	1225	12636	909
1.03 Petrochemical Industry			18310	6497	1214	2317	2653	306	3107	93
1.04 Other Industries				47928	3044	7905	9304	997	7332	380
2.01 Primary Treatment					16494	5478	5069	617	3596	170
2.02 Secondary Treatment						37796	13249	2095	10395	346
2.03 Advanced Treatment							50411	1469	11245	298
2.04 Natural Biological Treatment								3835	1532	44
3.0 Plants And Reactors									57206	394
4.0 Wastewater Management										1984

Figure 15 – Number of patent families per pair of technology categories

PATENT ACTIVITY GEOGRAPHIC VOLUME BENCHMARKING

Figure 16 shows the number of patent families or inventions within the Wastewater Treatment Research landscape in the areas of Wastewater Sources, Treatment Techniques, Wastewater Treatment Plants and Reactors and Wastewater Management patent collection that can be attributed to each nation . Patenting activity within the Wastewater Treatment Research landscape is lead by China, followed by Japan, South Korea and United States. About 60% of the patenting activity is originating from China and about 97% of the patenting activity is originating from the top 10 countries.

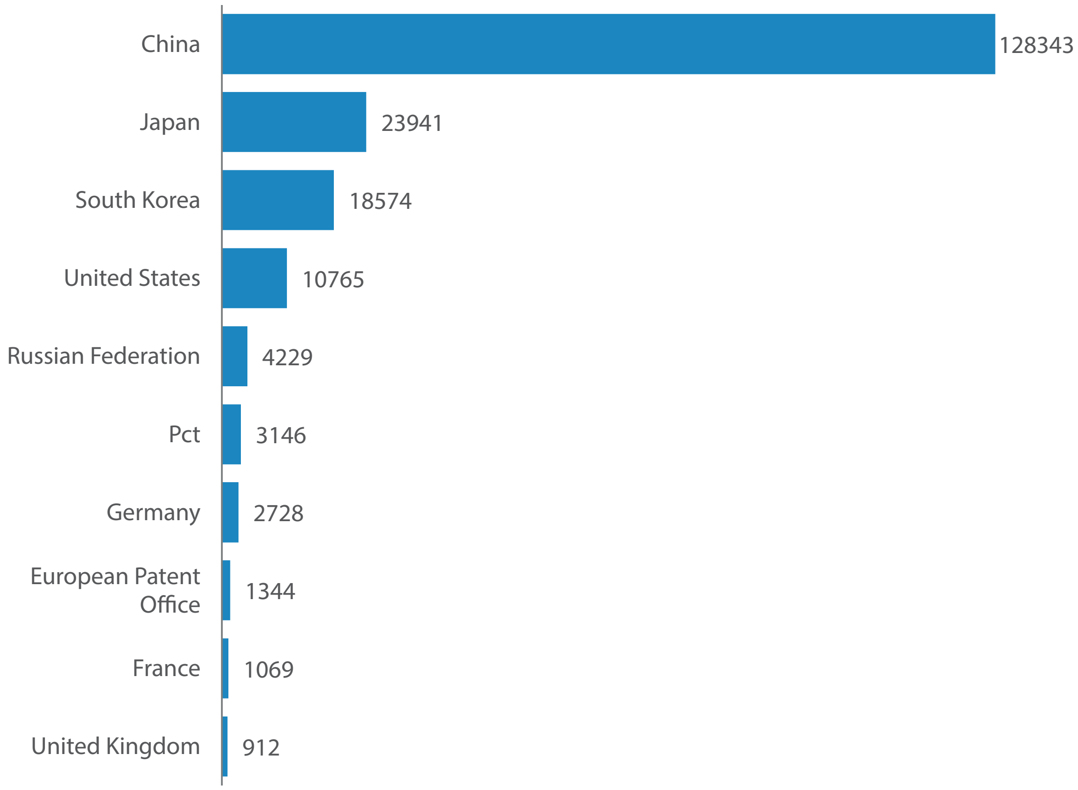

Figure 16 – Number of patent families per country; top 10 countries

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National attribution of patent activity is primarily performed via the priority filing location of the invention – this is the first filing event that occurs in the international protection of an invention at the various patent offices around the world. Actual geographic location of the inventor or the innovating corporation may vary from the priority filing location. This effect is exhibited primarily by Saudi Arabian entities, few of which file for patents within the Kingdom.

PATENT GEOGRAPHIC ACTIVITY TRENDS

Although an average number of patent filings from Belgium, Hungary and Portugal is about 39 which very small as compared to the patenting activity in the most prolific countries, the growth rate of patenting activity in Belgium, Hungary and Portugal exceeds that of most prolific countries and other countries. Out of most prolific countries China also has a high growth rate of patent output.

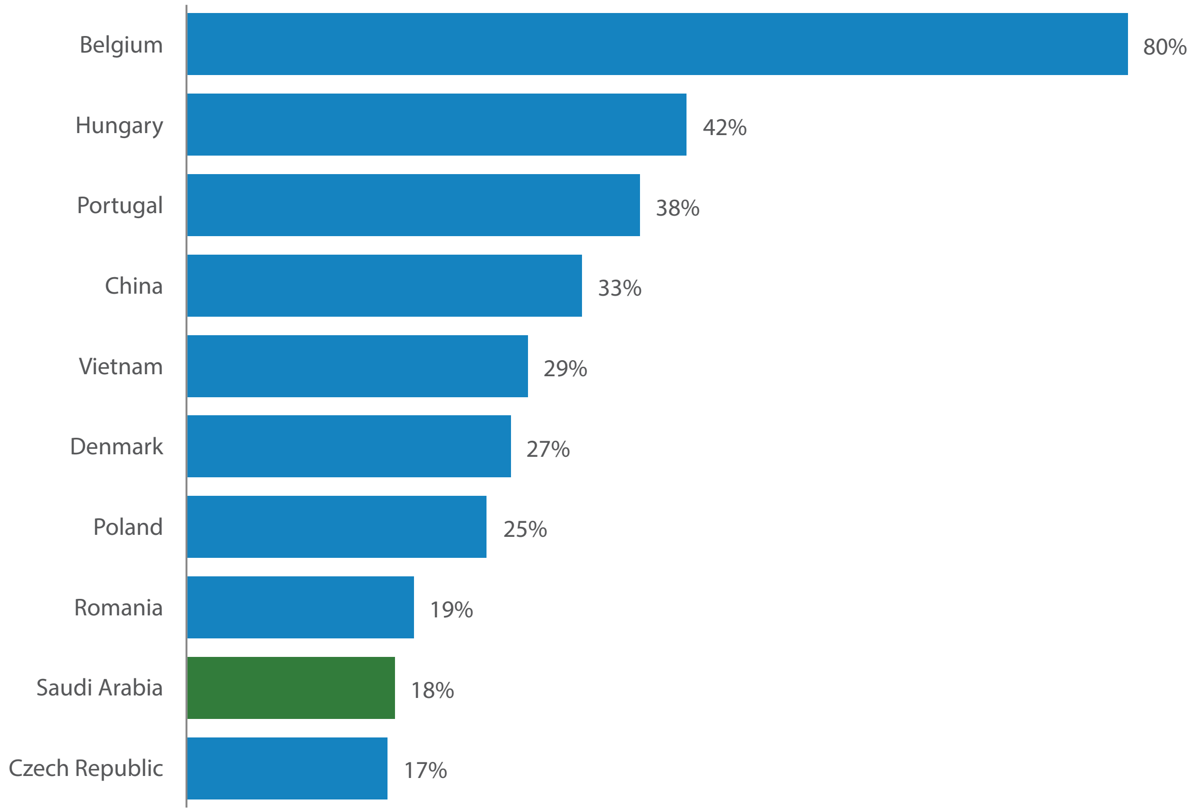

Figure 17 – Highest growth rate geographies in Wastewater Treatment Technology patent output

PATENT GEOGRAPHIC CITATION IMPACT BENCHMARKING

Figure 18 details the highest citation impact by nation (with at least 50 patents). Patent citation is a widely utilized measurement of the impact and recognition of an individual patent, and by extension, aggregated groups of patents such as those assigned to a company or associated with the innovation of a nation or region. The measurement is useful as it provides an independent assessment of the quality and impact of the innovation contained within the patent. When aggregated, it provides a method of benchmarking collections of patents for the average impact in comparison to others, e.g.: between two competing entities or between nations.

Patent citation information within this study is measured via citations to patent family members of the Derwent World Patents Index and from citation events of 26 national patent collections.

On this metric, Norway leads with the highest citation impact, followed by United States, and Switzerland.

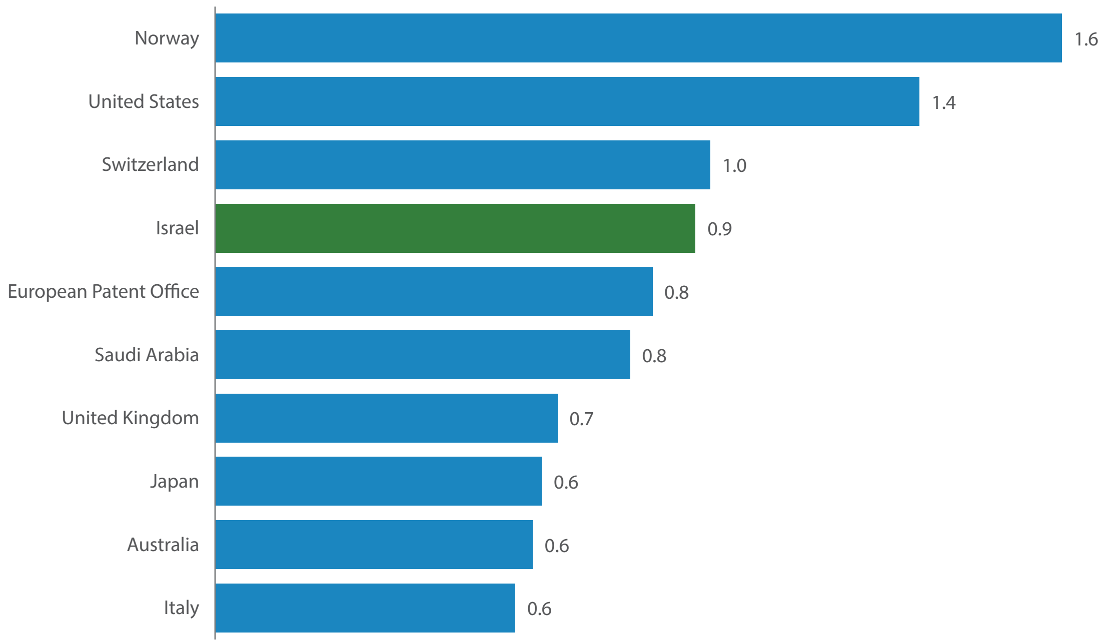

Figure 18 – Highest citation impact geographies of Wastewater Treatment Technology patents

WASTEWATER TREATMENT TECHNOLOGY RESEARCH TOPIC BY GEOGRAPHY

Table 8 shows the split of Wastewater Treatment Technology science and research specialization for the top nations. In most countries, focus appears to be high in plants and reactors and municipal technologies. All other areas see very little focus in the top jurisdictions. Kingdom of Saudi Arabia has 138 patents, focused on a variety of technologies, with highest focus on petrochemical industry, advanced treatment, and plants and reactors.

Country of Origin	1.01 Agricultural	1.02 Municipal Domestic	1.03 Petrochemical Industry	1.04 Other Industries	2.01 Primary Treatment	2.02 Secondary Treatment	2.03 Advanced Treatment	2.04 Natural Biological Treatment	3.0 Plants and Reactors	4.0 Wastewater Management
China	6%	32%	7%	24%	10%	21%	27%	2%	20%	1%
Japan	5%	25%	11%	20%	4%	15%	23%	3%	56%	1%
South Korea	6%	33%	7%	15%	8%	16%	22%	1%	54%	1%
United States	14%	24%	28%	29%	8%	16%	25%	2%	31%	2%
Russian Federation	8%	19%	11%	60%	3%	10%	13%	2%	14%	0%
Pct	7%	26%	22%	25%	8%	18%	28%	4%	40%	1%
Germany	5%	35%	11%	23%	5%	12%	23%	2%	36%	1%
European Patent Office	9%	24%	25%	31%	4%	13%	26%	2%	29%	1%
France	11%	27%	18%	38%	4%	15%	22%	3%	31%	0%
United Kingdom	12%	30%	22%	24%	6%	11%	21%	1%	39%	2%
India	12%	21%	18%	32%	6%	21%	28%	2%	31%	1%
Taiwan	7%	22%	3%	14%	5%	15%	22%	2%	47%	1%
Australia	22%	28%	21%	26%	9%	15%	20%	2%	29%	4%
Italy	14%	28%	19%	43%	5%	11%	19%	2%	38%	0%
Brazil	17%	19%	25%	29%	8%	16%	11%	3%	20%	1%
Spain	16%	22%	8%	32%	5%	13%	19%	2%	35%	0%
Canada	16%	26%	33%	18%	12%	20%	8%	3%	20%	1%
Poland	9%	51%	8%	20%	6%	18%	11%	5%	24%	1%
Mexico	17%	22%	11%	37%	9%	27%	25%	1%	33%	1%
Netherlands	16%	26%	12%	31%	5%	11%	24%	2%	29%	2%
Sweden	9%	34%	18%	30%	7%	10%	15%	3%	33%	0%
Finland	13%	24%	15%	43%	5%	19%	20%	2%	40%	2%
Saudi Arabia	9%	13%	49%	29%	12%	9%	26%	3%	26%	1%
Austria	2%	31%	13%	25%	6%	26%	14%	4%	26%	2%
Romania	14%	22%	16%	27%	1%	15%	21%	1%	33%	0%
Denmark	8%	27%	20%	22%	1%	23%	22%	3%	34%	3%
Norway	10%	21%	39%	26%	5%	16%	10%	3%	47%	1%
South Africa	12%	34%	16%	41%	2%	12%	21%	0%	22%	1%
Czech Republic	6%	35%	17%	15%	6%	23%	24%	2%	37%	2%
Switzerland	11%	26%	14%	18%	5%	16%	19%	3%	26%	1%
Indonesia	11%	10%	13%	35%	6%	32%	24%	8%	32%	3%
Singapore	13%	25%	14%	25%	8%	30%	29%	6%	40%	2%

Table 10 – Wastewater treatment Technology specialization by country; % of patent activity per technical stream

PATENT FILINGS - PROLIFIC GLOBAL ENTITIES

The list of prolific entities filing patents includes a number of universities, particularly from China – indicating that the Chinese innovation is driven by patenting activity from the universities. Science & Technology Unit, Umm al Qura University (STU-UQU) appears to have no patent filings in the wastewater treatment space. While the space appears to be crowded, there are opportunities for filing patents as discussed previously, in conjunction with Table 7.

Entity	Total	Times Cited	Citation per Family
CHINA PETROCHEMICAL CORP	1083	169	0.16
UNIV ZHEJIANG	928	386	0.42
PANASONIC CORP	851	538	0.63
TOSHIBA KK	763	517	0.68
KURITA WATER IND LTD	761	538	0.71
HITACHI LTD	682	523	0.77
UNIV TONGJI	634	241	0.38
UNIV NANJING	587	294	0.50
HARBIN INST TECHNOLOGY	580	176	0.30
UNIV BEIJING TECHNOLOGY	567	156	0.28
UNIV SOUTH CHINA TECHNOLOGY	500	278	0.56
UNIV CHANGZHOU	466	14	0.03
UNIV QINGHUA	452	198	0.44
PETROCHINA CO LTD	402	53	0.13
UNIV JIANGNAN	394	135	0.34
TORAY IND INC	384	364	0.95
UNIV SHANDONG	375	119	0.32
UNIV CHONGQING	362	129	0.36
ORGANO CORP	338	420	1.24
MIURA KOGYO KK	335	219	0.65
MITSUBISHI JUKOGYO KK	334	240	0.72
UNIV SHANGHAI JIAOTONG	334	111	0.33
UNIV DONGHUA	330	131	0.40
UNIV TIANJIN	322	71	0.22
WOONG JIN COWAY CO LTD	313	121	0.39
UNIV JIANGSU	308	26	0.08
METAWATER KK	289	210	0.73
LG ELECTRONICS INC	285	58	0.20
UNIV JINAN	273	47	0.17
TOTO LTD	271	109	0.40

Table 11 – Wastewater Treatment Technology – Top entities for patents

PATENT OVERVIEW OF TOP GLOBAL ENTITIES

Table 10 shows the technology profile of the top 30 entities within the patent landscape of wastewater treatment. A number of companies, such as, Panasonic, Toshiba, Hitachi and China Petrochemical are patenting heavily in the plants and reactors technology, as compared to other areas. The universities within the top 30 entities are patenting technology mainly in the water treatment technologies – i.e. secondary treatment, and advanced treatment. Natural/Biological treatment, and wastewater management, as seen in conjunction with table 5, appears to be white spaces with even the top entities not patenting heavily in these areas.

Entity	1.01 Agricultural	1.02 Municipal Domestic	1.03 Petrochemical Industry	1.04 Other Industries	2.01 Primary Treatment	2.02 Secondary Treatment	2.03 Advanced Treatment	2.04 Natural Biological Treatment	3.0 Plants and Reactors	4.0 Wastewater Management
CHINA PETROCHEMICAL CORP	15	298	306	385	148	363	301	39	136	6
UNIV ZHEJIANG	72	131	90	276	56	251	397	22	67	8
PANASONIC CORP	13	185	74	106	15	56	138	23	632	4
TOSHIBA KK	18	267	103	185	47	119	179	22	500	40
KURITA WATER IND LTD	5	131	58	215	38	243	256	134	490	2
HITACHI LTD	9	247	67	124	37	167	159	46	480	24
UNIV TONGJI	25	173	16	203	90	196	272	31	47	8
UNIV NANJING	26	114	23	184	72	225	303	23	54	8
HARBIN INST TECHNOLOGY	12	136	25	129	38	305	308	29	48	4
UNIV BEIJING TECHNOLOGY	3	309	10	84	33	225	291	41	86	7
UNIV SOUTH CHINA TECHNOLOGY	20	101	42	159	51	163	173	26	54	6
UNIV CHANGZHOU	25	204	35	140	47	168	223	12	33	1
UNIV QINGHUA	22	96	43	144	56	121	177	16	39	9
PETROCHINA CO LTD	10	148	152	63	79	84	55	5	56	6
UNIV JIANGNAN	25	62	26	133	26	103	140	11	30	3
TORAY IND INC	15	114	57	174	26	95	165	37	180	1
UNIV SHANDONG	10	113	26	101	39	121	121	7	43	1
UNIV CHONGQING	15	124	25	103	41	122	129	14	48	7
ORGANO CORP		30	23	100	5	71	178	40	222	
MIURA KOGYO KK	2	35	7	75	7	11	156	4	230	
MITSUBISHI JUKOGYO KK	5	57	93	32	13	29	72	6	225	3
UNIV SHANGHAI JIAOTONG	28	60	36	77	30	96	140	13	28	3
UNIV DONGHUA	5	40	16	138	24	107	112	7	9	4
UNIV TIANJIN	14	58	29	82	26	91	138	8	27	2
WOONG JIN COWAY CO LTD	2	46	4	14	3	41	114	1	224	
UNIV JIANGSU	35	84	21	56	20	61	126	2	24	2
METAWATER KK	8	191	27	73	11	72	78	19	155	5
LG ELECTRONICS INC		103	3	9	10	19	30	1	181	2
UNIV JINAN	13	70	19	77	22	84	92	14	38	1
TOTO LTD	3	41	16	11	4	3	52		192	

Table 12 – Patent overview of top global entities

PATENT OVERVIEW OF TOP ASIA PACIFIC ENTITIES

Entity	Country of Origin	Total	1.01 Agricultural	1.02 Municipal Domestic	1.03 Petrochemical Industry	1.04 Other Industries	2.01 Primary treatment	2.02 Secondary treatment	2.03 Advanced treatment	2.04 Natural Biological Treatment	3.0 Plants and reactors	4.0 Wastewater management
Science & Technology Unit - Umm Al Qura University (STU-UQU)	Saudi Arabia	-										
China Petrochemical Corp	China	1083	15	298	306	385	148	363	301	39	136	6
Univ Zhejiang	China	926	72	131	90	275	55	251	396	22	67	8
Panasonic Corp	Japan	849	13	185	74	105	15	56	137	23	632	4
Toshiba Kk	Japan	756	18	264	101	182	46	119	179	22	496	40
Kurita Water Ind Ltd	Japan	753	4	129	58	214	38	238	253	130	483	2
Hitachi Ltd	Japan	659	8	242	59	119	36	164	154	44	466	24
Univ Tongji	China	631	25	171	16	201	90	195	271	31	47	8
Univ Nanjing	China	586	26	114	23	184	72	224	302	23	54	8
Harbin Inst Technology	China	580	12	136	25	129	38	305	308	29	48	4
Univ Beijing Technology	China	567	3	309	10	84	33	225	291	41	86	7
Univ South China Technology	China	500	20	101	42	159	51	163	173	26	54	6
Univ Changzhou	China	466	25	204	35	140	47	168	223	12	33	1
Univ Qinghua	China	451	22	95	43	143	55	120	176	16	39	9
Petrochina Co Ltd	China	401	10	147	152	63	78	84	55	5	56	6
Univ Jiangnan	China	394	25	62	26	133	26	103	140	11	30	3
Toray Ind Inc	Japan	381	15	113	56	171	25	95	162	37	180	1
Univ Shandong	China	375	10	113	26	101	39	121	121	7	43	1
Univ Chongqing	China	362	15	124	25	103	41	122	129	14	48	7
Organo Corp	Japan	336		30	23	99	5	71	177	40	222	
Univ Shanghai Jiaotong	China	334	28	60	36	77	30	96	140	13	28	3

Table 13 – Patent overview of top Asia Pacific entities

PATENT OVERVIEW OF TOP MIDDLE EAST & AFRICA ENTITIES

Table 12 illustrates the top patenting entities in the Middle East and Africa. The space appears to be dominated by smaller, local players, particularly from the Kingdom of Saudi Arabia (KSA), Turkey, and South Africa.

Entity	Country of Origin	Total	1.01 Agricultural	1.02 Municipal Domestic	1.03 Petrochemical Industry	1.04 Other Industries	2.01 Primary treatment	2.02 Secondary treatment	2.03 Advanced treatment	2.04 Natural Biological Treatment	3.0 Plants and reactors	4.0 Wastewater management
SAUDI ARAMCO	Saudi Arabia	45	1	2	34	11	5	5	2	3	17	
KING ABDULAZIZ CITY FOR SCIENCE AND TECHNOLOGY	Saudi Arabia	32	6	9	9	11	9	1	15		7	1
KING FAHD UNIVERSITY OF PETROLEUM AND MINERALS	Saudi Arabia	18	3	2	12			1	4		1	
SABIC	Saudi Arabia	18			9	2		2	7		4	
ARCELIK ANONIM SIRKETI	Turkey	11				1			7		4	
KING ABDULLAH UNIVERSITY OF SCIENCE AND TECHNOLOGY	Saudi Arabia	7	1	1	1	5	1	1	1		2	
COUNCIL SCI & IND RES SOUTH AFRICA	South Africa	6		2		1		1	2		1	
KING SAUD UNIVERSITY	Saudi Arabia	4		2	1	3			1		1	
SALINE WATER CONVERSION CORPORATION	Saudi Arabia	4				1			1	1	2	
SASOL TECHNOLOGY PTY LTD	South Africa	4	1	1	2		1					
SIEMENS IND INC	Saudi Arabia	4	1	1	4	1	3	2	1	2	4	
UNIV STELLENBOSCH	South Africa	4	1					1	3		2	
SASAKURA KK	Saudi Arabia	3							1	1	2	
UNIV TSHWANE TECHNOLOGY	South Africa	3		2		2	1	1	1			
UNIV WITWATERSRAND JOHANNESBURG	South Africa	3			3			1			1	
WATER RE-USE PROMOTION CENT	Saudi Arabia	3							1	1	2	
ZH JINZO MIZU SOKUSHIN CENT	Saudi Arabia	3							1	1	2	
BMB MECCA CO	Saudi Arabia	2						1	1		2	
BURCON NUTRASCIENCE MB CORP	Saudi Arabia	2							2			
CHINA BLUECHEMICAL LTD	Saudi Arabia	2				2						
CHINA NAT OFFSHORE OIL CORP	Saudi Arabia	2				2						
HSE HITIT SOLAR ENERJI AS	Turkey	2				2						
MASSACHUSETTS INST TECHNOLOGY	Saudi Arabia	2	1		2							
SASOL TECHNOLOGY	South Africa	2		1	1		1					
SENUR ELEK MOTORLARI SAN VE TIC AS	Turkey	2		2								
SINO-ARAB CHEM FERTILIZER CO LTD	Saudi Arabia	2				2						
TERRAMARK MARKENCREATION GMBH	Saudi Arabia	2		1	1	1			1			
UNIV CAPE TOWN	South Africa	2	1		1	1						
UNIV FREE STATE	South Africa	2		1	1	1						
UNIV WESTERN CAPE	South Africa	2							2		2	

Table 14 – Patent overview of top Middle East & Africa entities

PATENT OVERVIEW OF TOP SAUDI ARABIA ENTITIES

Entity	Total	1.01 Agricultural	1.02 Municipal Domestic	1.03 Petrochemical Industry	1.04 Other Industries	2.01 Primary treatment	2.02 Secondary treatment	2.03 Advanced treatment	2.04 Natural Biological Treatment	3.0 Plants and reactors	4.0 Wastewater management
Science & Technology Unit - Umm Al Qura University (STU-UQU)	-										
SAUDI ARAMCO	45	1	2	34	11	5	5	2	3	17	
KING ABDULAZIZ CITY FOR SCIENCE AND TECHNOLOGY	32	6	9	9	11	9	1	15		7	1
KING FAHD UNIVERSITY OF PETROLEUM AND MINERALS	18	3	2	12			1	4		1	
SABIC	18			9	2		2	7		4	
KING ABDULLAH UNIVERSITY OF SCIENCE AND TECHNOLOGY	7	1	1	1	5	1	1	1		2	
KING SAUD UNIVERSITY	4		2	1	3			1		1	
SALINE WATER CONVERSION CORPORATION	4				1			1	1	2	
WATER RE-USE PROMOTION CENT	3							1	1	2	
SINO-ARAB CHEM FERTILIZER CO LTD	2				2						
Bio Nano Consulting	1			1							

Table 15 – Patent overview of top Saudi Arabia entities

MIDDLE EAST & AFRICA WASTEWATER TREATMENT PATENT TRENDS

This section of the report focuses on the patent collection and the activity and technological trends seen within it – in the Middle East and Africa.

MIDDLE EAST & AFRICA – PROLIFIC COUNTRIES

Patent filing trends appear to be very different from the scientific literature trends. Figure 19 shows that Saudi Arabia to be the most popular country for filing patents within the two regions, followed by South Africa and Turkey. The remaining jurisdictions see only marginal patent filings.

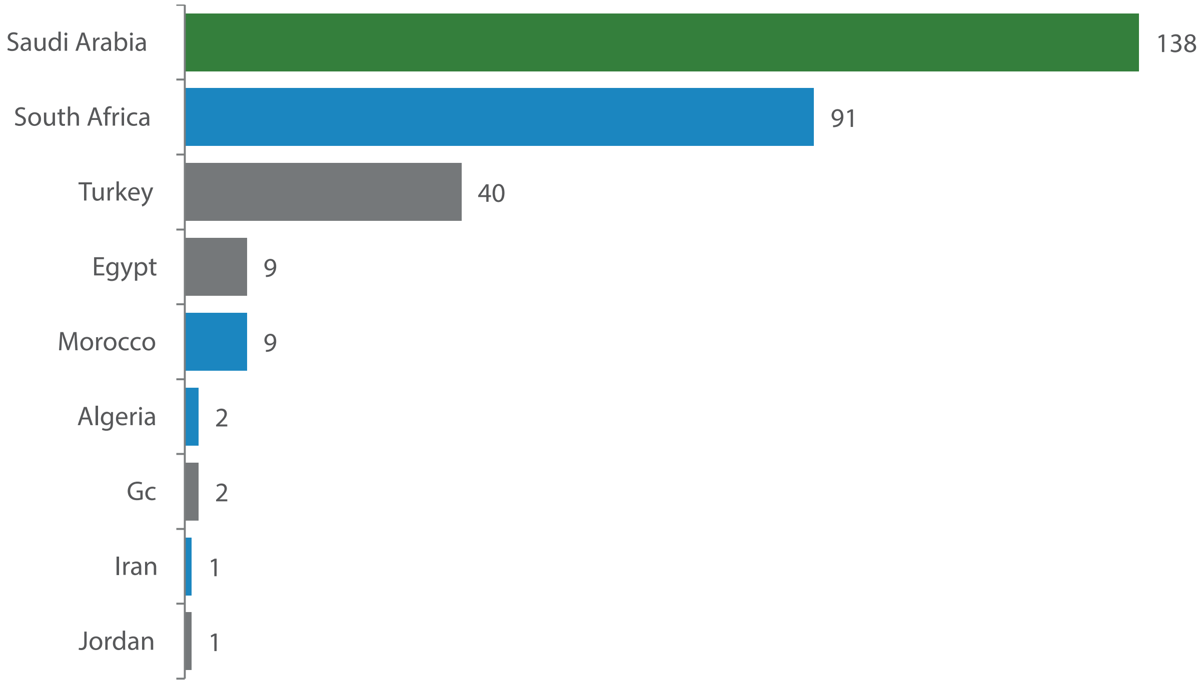

Figure 19 – Middle East & Africa – Prolific countries in patents

Diving deeper, Table 11 shows that Saudi Arabia to be consistent with the global patent focus on Wastewater Treatment Technology.

Country of Origin	1.01 Agricultural	1.02 Municipal Domestic	1.03 Petrochemical Industry	1.04 Other Industries	2.01 Primary Treatment	2.02 Secondary Treatment	2.03 Advanced Treatment	2.04 Natural Biological Treatment	3.0 Plants and Reactors	4.0 Wastewater Management
Saudi Arabia	13	18	68	40	16	12	36	4	36	1
South Africa	11	31	15	37	2	11	19		20	1
Turkey	5	6	3	7	3	3	10		17	
Egypt	3	1	2	4		1	2		1	
Morocco	2	5	1	7	1	1	2		1	
Algeria	1	1		1					2	
Gc			1			2	1		1	
Iran								1		
Jordan						1	1		1	
Tunisia	1									

Table 16 – Middle East & Africa – Prolific countries over technical categories

APPENDIX A – SCIENTIFIC PAPERS TOP AFFILIATIONS

ENTITY-LEVEL DATA TABLES FOR SCIENTIFIC LITERATURE COLLECTION

Table 13 on the following pages shows the top 10 author organizations for each of the technology segments. This information is intended to provide an assessment of the depth and location of the research expertise available in each category.

Technology	Entity	Total
1.01 Agricultural	Chinese Acad Sci	413
	USDA ARS	334
	University of California System	166
	Consejo Superior de Investigaciones Cientificas (CSIC)	109
	Univ Florida	107
	China Agr Univ	91
	Islamic Azad Univ	82
	Indian Institute of Technology (IIT)	75
	Univ Nacl Autonoma Mexico	74
	Agr & Agri Food Canada	70
1.02 Municipal/Domestic	Chinese Acad Sci	503
	Tongji Univ	222
	Tsinghua Univ	203
	Harbin Inst Technol	172
	Univ Sao Paulo	133
	Univ Queensland	128
	Delft Univ Technol	125
	Consejo Superior de Investigaciones Cientificas (CSIC)	122
	Environm Canada	120
	Zhejiang Univ	119
1.03 Petrochemical Industry	Univ Alberta	42
	Chinese Acad Sci	37
	Islamic Azad Univ	22
	Univ Tehran	20
	Razi Univ	19
	Zhejiang Univ	18
	Univ Fed Rio De Janeiro	18
	Consejo Superior de Investigaciones Cientificas (CSIC)	16
	Univ Putra Malaysia	16
	China Univ Petr	16
1.04 Other Industries	Chinese Acad Sci	171
	Consejo Superior de Investigaciones Cientificas (CSIC)	78
	Indian Institute of Technology (IIT)	62
	Univ Sao Paulo	48
	Council of Scientific & Industrial Research (CSIR) - India	46
	Islamic Azad Univ	44
	Monash Univ	41
	Univ Aveiro	40
	Univ Granada	39
	Univ Malaya	39

Technology	Entity	Total
2.01 Primary Treatment	University of California System	450
	Harvard Univ	379
	Univ Toronto	313
	Univ Washington	253
	Univ Pittsburgh	231
	Duke Univ	229
	Mayo Clin	224
	Univ Sao Paulo	216
	Univ Sydney	207
	Univ Penn	202
2.02 Secondary Treatment	Chinese Acad Sci	962
	Harbin Inst Technol	515
	Tongji Univ	455
	Tsinghua Univ	332
	Univ Queensland	270
	Zhejiang Univ	254
	Shandong Univ	249
	Delft Univ Technol	248
	Natl Taiwan Univ	201
	Indian Inst Technol	189
2.03 Advanced Treatment	Chinese Acad Sci	1079
	Harbin Inst Technol	546
	Tongji Univ	513
	Tsinghua Univ	396
	Zhejiang Univ	337
	Islamic Azad Univ	320
	Indian Inst Technol	298
	Shandong Univ	269
	Nanjing Univ	263
	Univ Queensland	258
2.04 Natural Biological Treatment	Chinese Acad Sci	136
	United States Department of Agriculture (USDA)	59
	Us Geol Survey	52
	Harbin Inst Technol	42
	Delft Univ Technol	42
	Univ Sao Paulo	38
	Tongji Univ	37
	Univ Sci & Technol China	36
	Consejo Superior de Investigaciones Cientificas (CSIC)	35
	Tsinghua Univ	34
3.0 Plants and Reactors	Chinese Acad Sci	486
	Tongji Univ	204
	Harbin Inst Technol	195
	Tsinghua Univ	188
	Univ Girona	174
	Univ Queensland	159
	Univ Ghent	146
	Univ Sao Paulo	142
	Delft Univ Technol	137
	Consejo Superior de Investigaciones Cientificas (CSIC)	134
4.0 Wastewater management	Univ Queensland	34
	Univ Girona	24
	Chinese Acad Sci	22
	Delft Univ Technol	22
	Swiss Federal Institute of Aquatic Science & Technology (EAWAG	22
	Us Epa	17
	Univ Ghent	15
	Commonwealth Scientific & Industrial Research Organisation (CSIRO	15
	Tech Univ Denmark	14
	Univ Laval	14

Table 17 – Top 10 paper publishing organizations per technology segment

APPENDIX B — PATENT STATISTICS AND TABLES

ENTITY-LEVEL DATA TABLES FOR PATENT COLLECTION

The Table 18 below and on the following page shows the top 10 patent applicants or patent assignees for each of the technology segments. This information is intended to provide an assessment of expertise and patent commercialization intent per category.

Technology	Entity	Total
1.01 Agricultural	UNIV ZHEJIANG	72
	UNIV NANKAI	64
	UNIV CHINA AGRIC	38
	UNIV JIANGSU	35
	JIANGSU AGRIC SCI INST	31
	UNIV SICHUAN AGRIC	29
	UNIV HUNAN AGRIC	29
	UNIV SHANGHAI JIAOTONG	28
	UNIV NANJING AGRIC	28
	TIANJIN BINHAI INT FLOWERS TECHNOLOGY PA	28
1.02 Municipal Domestic	UNIV BEIJING TECHNOLOGY	309
	CHINA PETROCHEMICAL CORP	298
	TOSHIBA KK	267
	HITACHI LTD	247
	UNIV CHANGZHOU	204
	METAWATER KK	191
	PANASONIC CORP	185
	UNIV TONGJI	173
	PETROCHINA CO LTD	148
	HARBIN INST TECHNOLOGY	136
1.03 Petrochemical Industry	CHINA PETROCHEMICAL CORP	306
	PETROCHINA CO LTD	152
	GENERAL ELECTRIC CO	109
	TOSHIBA KK	103
	MITSUBISHI JUKOGYO KK	93
	UNIV ZHEJIANG	90
	CHINA NAT OFFSHORE OIL CORP	76
	PANASONIC CORP	74
	HITACHI LTD	67
	KURITA WATER IND LTD	58
1.04 Other Industries	CHINA PETROCHEMICAL CORP	385
	UNIV ZHEJIANG	276
	KURITA WATER IND LTD	215
	UNIV TONGJI	203
	TOSHIBA KK	185
	UNIV NANJING	184
	TORAY IND INC	174
	UNIV SOUTH CHINA TECHNOLOGY	159
	UNIV QINGHUA	144
	UNIV CHANGZHOU	140

Technology	Entity	Total
2.01 Primary treatment	CHINA PETROCHEMICAL CORP	148
	UNIV TONGJI	90
	PETROCHINA CO LTD	79
	UNIV NANJING	72
	UNIV ZHEJIANG	56
	UNIV QINGHUA	56
	UNIV SOUTH CHINA TECHNOLOGY	51
	TOSHIBA KK	47
	UNIV CHANGZHOU	47
	UNIV CHONGQING	41
2.02 Secondary treatment	CHINA PETROCHEMICAL CORP	363
	HARBIN INST TECHNOLOGY	305
	UNIV ZHEJIANG	251
	KURITA WATER IND LTD	243
	UNIV NANJING	225
	UNIV BEIJING TECHNOLOGY	225
	UNIV TONGJI	196
	UNIV CHANGZHOU	168
	HITACHI LTD	167
	UNIV SOUTH CHINA TECHNOLOGY	163
2.03 Advanced treatment	UNIV ZHEJIANG	397
	HARBIN INST TECHNOLOGY	308
	UNIV NANJING	303
	CHINA PETROCHEMICAL CORP	301
	UNIV BEIJING TECHNOLOGY	291
	UNIV TONGJI	272
	KURITA WATER IND LTD	256
	UNIV CHANGZHOU	223
	TOSHIBA KK	179
	ORGANO CORP	178
2.04 Natural Biological Treatment	KURITA WATER IND LTD	134
	HITACHI LTD	46
	SHINKO PANTEC CO LTD	46
	UNIV BEIJING TECHNOLOGY	41
	ORGANO CORP	40
	CHINA PETROCHEMICAL CORP	39
	TORAY IND INC	37
	UNIV TONGJI	31
	HARBIN INST TECHNOLOGY	29
	UNIV SOUTH CHINA TECHNOLOGY	26
3.0 Plants and reactors	PANASONIC CORP	632
	TOSHIBA KK	500
	KURITA WATER IND LTD	490
	HITACHI LTD	480
	MITSUBISHI JUKOGYO KK	408
	MIURA KOGYO KK	230
	WOONG JIN COWAY CO LTD	224
	ORGANO CORP	222
	SHARP KK	218
	TOTO LTD	192
4.0 Wastewater management	TOSHIBA KK	40
	HITACHI LTD	24
	SUZHOU WANTAI VACUUM FURNACE INST CO LTD	17
	KOREA INST CONSTR TECHNOLOGY	10
	UNIV QINGHUA	9
	SUZHOU COOBOS FLUID TECHNOLOGY CO LTD	9
	SUZHOU MEISHENG ENVIRONMENTAL PROTECTION	9
	MITSUBISHI CORP	8
	UNIV ZHEJIANG	8
	UNIV NANJING	8

Table 18 – Top 10 Patent applicants/owners per technology segment

وحدة العلوم والتقنية
Science & Technology Unit