Web of Science Group

A Clarivate Analytics company

The influence of strategic programmes on Universiti Malaya's research and innovation footprint

A joint report by Clarivate Analytics and Universiti Malaya

In partnership with

UNIVERSITY OF MALAYA

Foreword

"Realise that everything connects to everything else."

Leonardo da Vinci

There are no mistakes, only lessons from the past which future achievements will rise from. Universiti Malaya (UM) has improved its international reputation greatly over the years and in 2019 UM attained the 70th place in the QS World University Rankings. What are the factors that contributed to UM's successes so far?

Answering this question is an indispensable first step toward providing useful insights and guidelines for university-level policy decisions and strategy planning to improve universities' international reputation and global rankings, and for supporting efforts to measure returns on research and innovation investments.

In this report, we investigate UM's specific programmes and related government strategic plans for driving research excellence. In selecting the time periods to compare UM's research and innovation footprint (in terms of its research productivity, quality, impact, performance and collaborations), we deliberately chose three distinct periods over a period of 12 years from 2007 to 2018 to reflect the number of initiatives, for research and innovation development, which have taken place since 2006. A number of universities were appointed research university status, world university rankings were adopted as part of the National Higher Education Strategic Plan, Higher Institution Centres of Excellence (HICoEs) were planned and significantly larger amounts of money were pumped into research with the creation of a myriad of research grant schemes.

In the true spirit of gotong-royong (mutual cooperation), the team from Institute of Research Management & Services (IPPP), Universiti Malaya and Clarivate Analytics, Southeast Asia, worked closely together to ensure high quality and accurate data for grants, grant recipients, global experts involved, scientific and patent information, and robust frameworks were used to analyse and compare UM's Research and Innovation performance over these periods.

The findings in this report serve to prove that when a clear strategic outcome is well supported by appropriate level of funding, dedication and commitment from UM's academics, staff and students, we will be internationally competitive, with academic standards that are on par with the world's top universities. With the evidence at hand, we urge lessons to be drawn from these findings to inform future research agenda, strategies and plans, as this can only solidify UM's leading research and innovation position and contribute significantly to Malaysia's New Economic Model and the coveted developed country status.

Professor Dr. Noorsaadah Abd. Rahman
Deputy Vice-Chancellor
(Research and Innovation)
Universiti Malaya

Lee Inn Beng
Director, Government Strategy
and Engagement (ASEAN)
Clarivate Analytics

Contents

Executive summary

Universities around the world strive for research excellence and aim to rank amongst the top in global university rankings. In this pursuit, many have set very clear objectives and aligned strategies to meet these objectives. One such university is Universiti Malaya.

Malaysia's Higher Education Institutions' (HEIs) research landscape experienced rapid growth during the period of 2007 to 2015. This was spurred by various initiatives from both the government and academic sectors in response to global competition among HEIs to be ranked among world-class universities.

Under the National Higher Education Strategic Plan 2007-2020, formulated in 2007, five Research Universities (RUs) were identified in Malaysia. These are these are Universiti Malaya (UM), Universiti Kebangsaan Malaysia (UKM), Universiti Sains Malaysia (USM), Universiti Putra Malaysia (UPM) and Universiti Teknologi Malaysia (UTM). These research universities are required to focus primarily on research and innovation activities, driven by highly competent academics and competitive international student admissions.

In addition to being a research university, in 2010, Universiti Malaya embarked on the High Impact Research (HIR) Programme initiated by its former Vice-Chancellor, Tan Sri Dr. Ghauth Jasmon with very specific key objectives and strategies. These have clearly helped to achieve great success in improving research impact, reputation and global university ranking position. The HIR Programme began with the university providing RM10 million per year from internal funds to support fundamental research.

In August 2011, the Malaysian Cabinet approved another RM590 million for the programme with a mandate that UM must attain a ranking within the top 100 world university rankings by the year 2016 (University of Malaya High Impact Research Final Report, 2016).

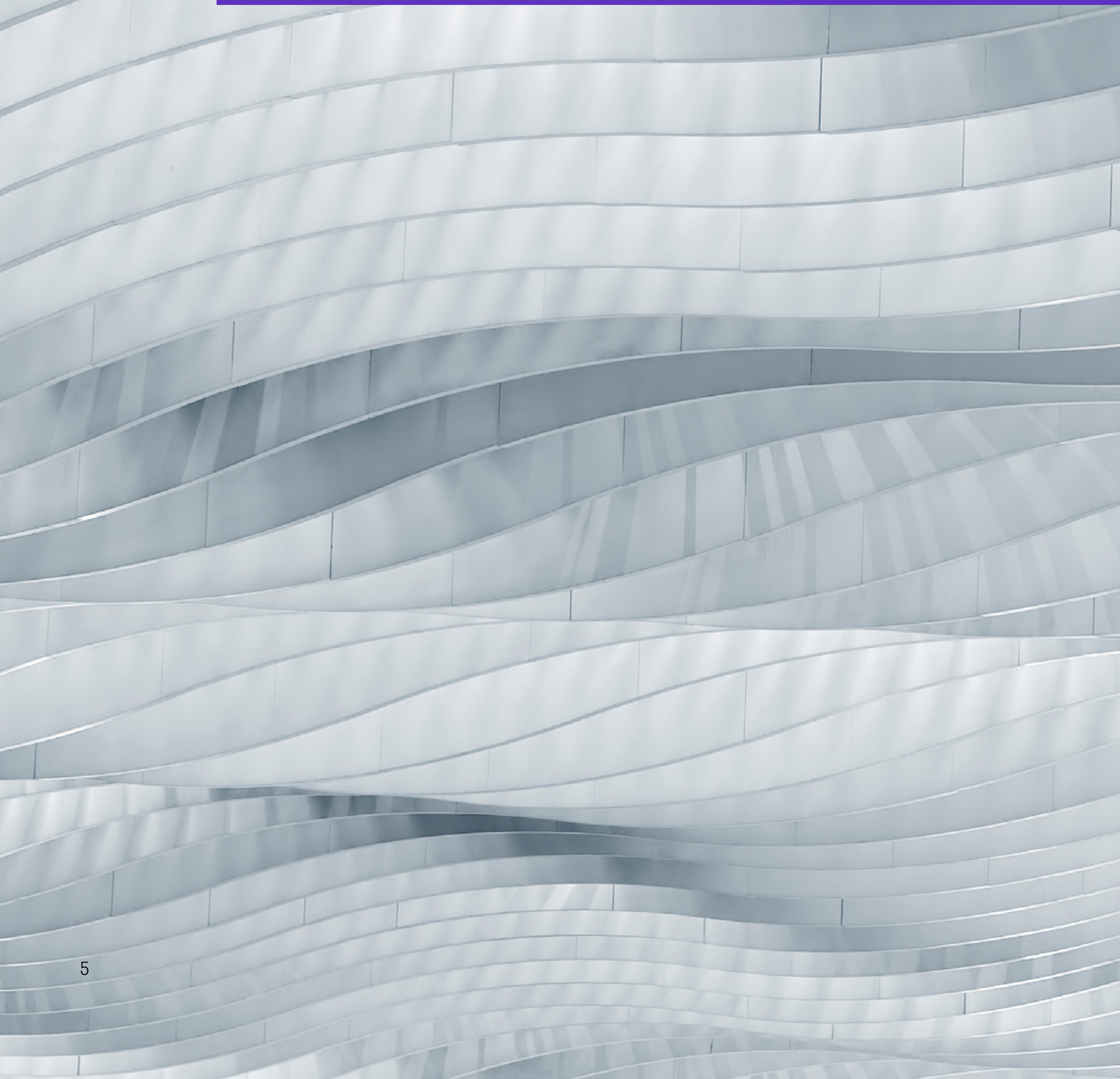
Two of the key objectives of the UM HIR programme were to forge research ties with ivy-league universities through collaborative research with top research icons and aim to publish in Quartile 1 Web of Science™ journals. The vision of the programme was to conduct world-class research in niche areas and elevate the international reputation and world university ranking of the university (University of Malaya High Impact Research Final Report, 2016).

The purpose of this report, jointly published by Clarivate Analytics and Universiti Malaya, is to assess the impact of UM HIR, related university level and government strategic initiatives, and measure the achievements of these programmes. To do so, UM's Research and Innovation Footprint was mapped out using a framework around five aspects – Productivity, Quality, Impact, Performance and Collaborations.

By comparing UM's Research and Innovation Footprint using carefully chosen metrics for each of the five aspects over three distinct time periods of 2007 to 2010, 2011 to 2014, and 2015 to 2018, UM's research and innovation performance can be clearly ascertained. The effectiveness of the UM HIR Programme and other university-level initiatives' contributions towards UM's research impact and performance can be determined while showing a strong path in cause-and-effect these initiatives have in UM's ranking achievement.

The findings from this report can serve as useful insights for university-level policy decisions and strategy planning for improving universities' international reputation and world rankings.

Understanding the report



Methodology

This report uses research and innovation output metrics to evaluate the results of university-level policy programs like the UM HIR Programme. The annual number of Web of Science indexed papers is tracked for the years 2007 to 2018 and further broken down into three periods: Period 1 (2007 to 2010), Period 2 (2011 to 2014) and Period 3 (2015 to 2018).

The report also presents an analysis of patent information from UM as available in Derwent Innovation for the time period of 2007 to 2018 which is then further segmented into the same time periods (Period 1,2 and 3).

In order to create a Research and Innovation Footprint for Universiti Malaya, the framework mentioned below was used for both research and patent insights:

	Research footprint	**Innovation footprint**
Productivity	Total Web of Science Core Collection™ documents	Inventions as measured by Derwent World Patents Index™ (DWPI) Patent Families
Quality	Absolute or Percentage Papers in Quartile 1 (Q1) Journals (Formula: Documents in Q1 journals / Total Web of Science documents * 100)	Derwent Patent Strength Index™ is used as a measure of quality. It is a calculation derived from several factors in its model, including: 1. Frequency of citation referencing the influence of an invention 2. Breadth of geographic filing, correlating to variation in cost and investment in patent protection. 3. Existence and location of granted, issued patent rights, a proxy for validity as well as commitment 4. Technical Breadth of an invention
Impact	Category Normalised Citation Impact (CNCI) and Impact Relative to the World (IR2W)	Commercialised Products or Spin-Off Companies
Performance	High performing research papers measured in terms of top 10% most highly cited documents (% documents in top 10%) Excellent research papers measured in terms of top 1% most highly cited documents (% documents in top 1%)	Commercialised Products or Spin-Off Companies
Collaborations	Percentage of Industry and International Collaborations	International Industry and Academic Collaborations

The Global Institutional Profiling Project (GIPP) research classification schema available in InCites™ is used to analyse and compare UM's research and innovation productivity, quality, impact and performance across six broad research areas. The analysis also examined the level and impact of international collaboration, showing the countries which Universiti Malaya has collaborated most frequently with across three time periods (according to the number of Web of Science-indexed papers listing at least one author affiliation in the given collaborating country).

Impact Profiles
Impact Profiles display the distribution of CNCI values for the research papers published through the three timeframes in the UM HIR Programme (2007 to 2018). Papers are assigned to categories as either uncited, or cited less often than world average (down to half, less than half to one-quarter and so on), or cited more often (up to 2 times, 2-4 times and so on) than world average. The profile is much more informative than a single average value for the whole sample. This was used to assess the UM HIR ICONS that were engaged by UM for the programme by identifying the median and average CNCI of the papers co-authored with these experts (Refer to "Global Research Report on South and East Asia". October 2019, Institute of Scientific Information).

Beam-plots
Beam-plots were used in assessing the performance of a group of papers based on time of publication and percentiles. Each paper's citation count is 'normalised' by the average for journals in their same category and publication year, and that value is converted to a percentile. These were used in the analysis of papers in a specific subject field and also of UM HIR ICONS. (Refer to "Profiles, not metrics", January 2019, Institute of Scientific Information).

Data sources

The data used in this report are drawn primarily from two databases: Web of Science Core Collection™ (including the analytical and benchmarking tool InCites), and Derwent Innovation™.

Web of Science Core Collection™ indexes over 20,000 journals, providing the world's most authoritative compendium of publication and citation figures. Derwent Innovation is a database of patents and patent applications from 60 patent-issuing states and authorities.

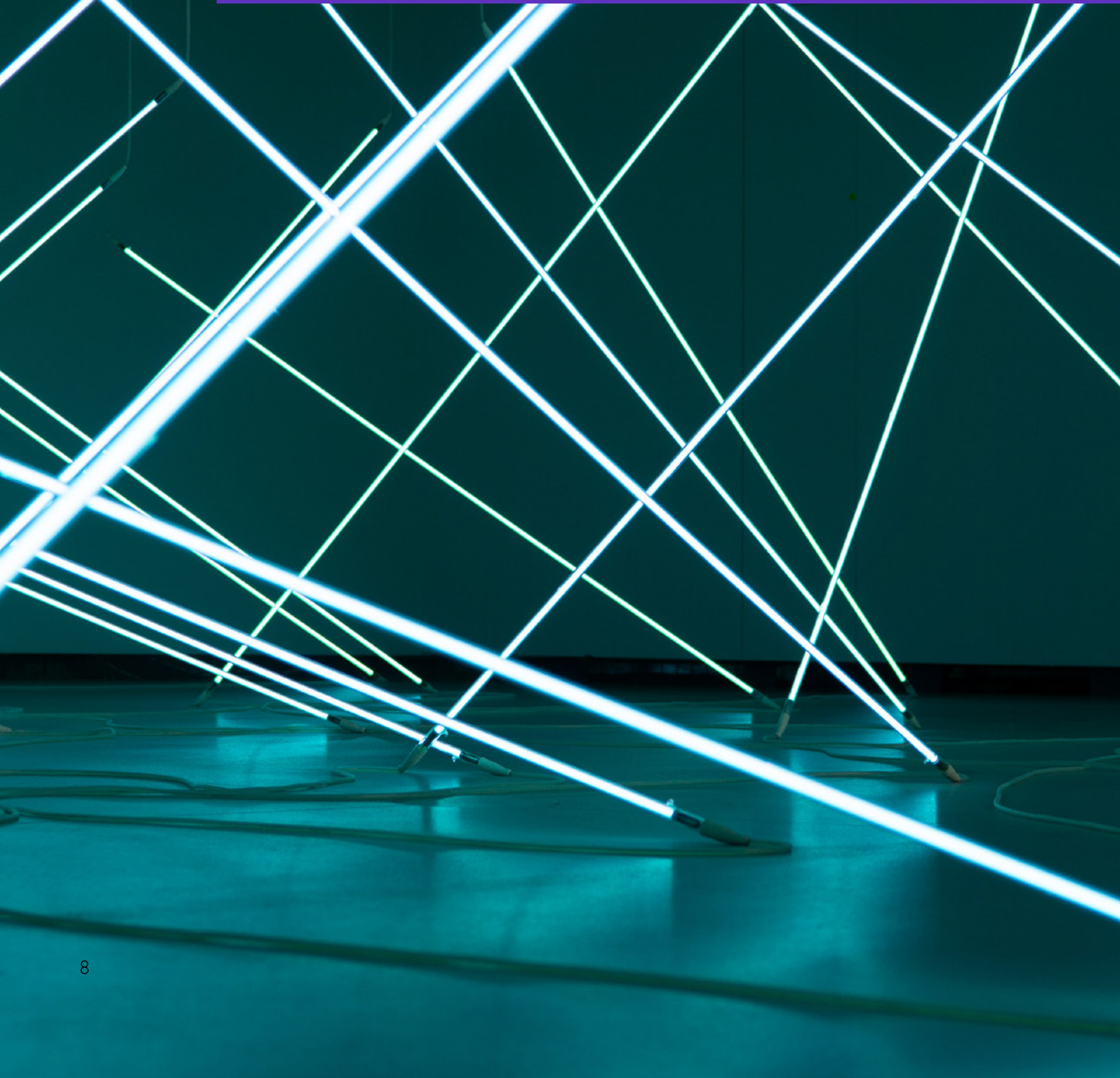
Always in English, and analyzed, re-written and cross-indexed by subject matter experts, DWPI summarizes inventions into what they are, what they are for and why they are needed. The Derwent editorial team process 3.5 million records per year.

The Institute of Research Management and Services (IPPP) in Universiti Malaya is an important provider of the background data that is used to frame the analysis in this report.

Data Type	Source	Notes
Papers, Citations	Web of Science	InCites and Web of Science data were extracted on 2019-07-17. Data from the Web of Science Core Collection (Science Citation Index Expanded, Social Sciences Citation Index, Arts and Humanities Citation Index, Emerging Sources Citation Index, Books and Conference Proceedings Citation Index and covers all document types). All papers from UM have been used in this analysis as the report looks at the overall effects of university-level policy programmes. Where applicable, specific mentions of programmes and its related papers will be attributed accordingly.
Patents	Derwent Innovation	1. For the patents analysis, data from Derwent Innovation, including Derwent World Patents Index (DWPI) and Derwent Patents Citation Index™ (DPCI) was used. In general, patent information used for the analysis is per the data available in Derwent Innovation which may vary from other data sources. 2. Note: Patent applications generally remain unpublished after the earliest priority date for up to 18 months; therefore, the most recent years may have incomplete information and as a result, reflect information as a decline in the innovation output. 3. The data for Malaysia covers only the Malaysian Granted Patents with full text from 2005 – present and bibliographic data from 1953 - present (with gaps). Data is updated in Derwent Innovation every quarter.
UM HIR Grant Recipients	IPPP, Universiti Malaya	Information about topics and areas of research supported under the UM HIR Programme
UM HIR ICONS	IPPP, Universiti Malaya	102 expert researchers from global universities engaged by UM for the UM HIR Programme.
UM HIR Grant Projects and Collaborators	UM HIR Brochure 2014 UM HIR Final Report 2016	https://www.um.edu.my/high-impact-research/download/report

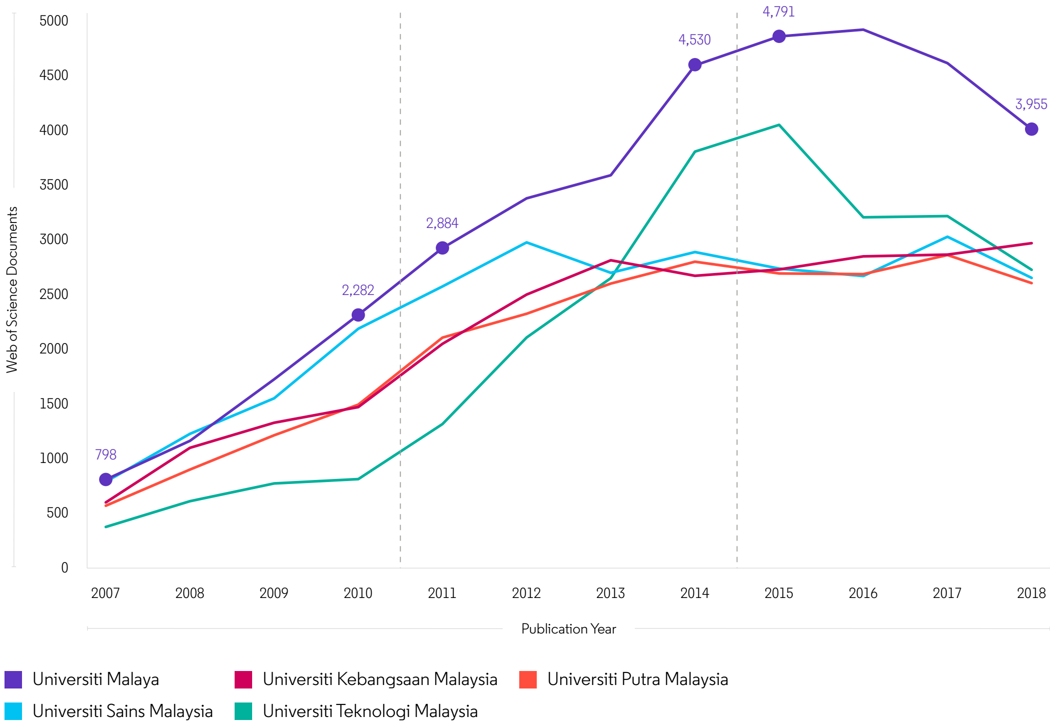
Research and innovation performance

2007–2018



Productivity

Figure 1: Research output 2007–2018



Research output of five Research Universities in Malaysia from year 2007 to 2018 (Source: InCites)

In the year 2007, under the National Higher Education Strategic Plan 2007-2020, four Research Universities (RUs) were identified in Malaysia to drive research and innovation in Higher Education Institutions (HEI). They were tasked to produce creative, innovative and skillful human capital with relevant contributions to offer to the wealth and the wellness of the people. These universities are Universiti Malaya (UM), Universiti Kebangsaan Malaysia (UKM), Universiti Sains Malaysia (USM) and Universiti Putra Malaysia (UPM). Universiti Teknologi Malaysia (UTM) was also recognised as an RU in the year 2010, thus making up a total of five RUs. As part of this plan, more resources and funding have been injected into these RUs from the year 2007, driving a cumulative increase in research output of 632% in Web of Science documents between the years of 2007 to 2010 (See Figure 1).

Under the same National Higher Education Strategic Plan 2007-2020, the Research and Development Critical Agenda Project was created with the aim to increase research and development activities in the HEIs with a focus on increasing revenue from Intellectual Property and Research and Development products that can be commercialised.

The innovation output of these above mentioned five Research Universities (RUs) as measured by the collective volume of inventions witnessed a surge from 90 inventions in the year 2007 to 673 inventions in the year 2010. Universiti Malaya saw a significant increase of 569% in innovation output during this time period. (See Figure 2).

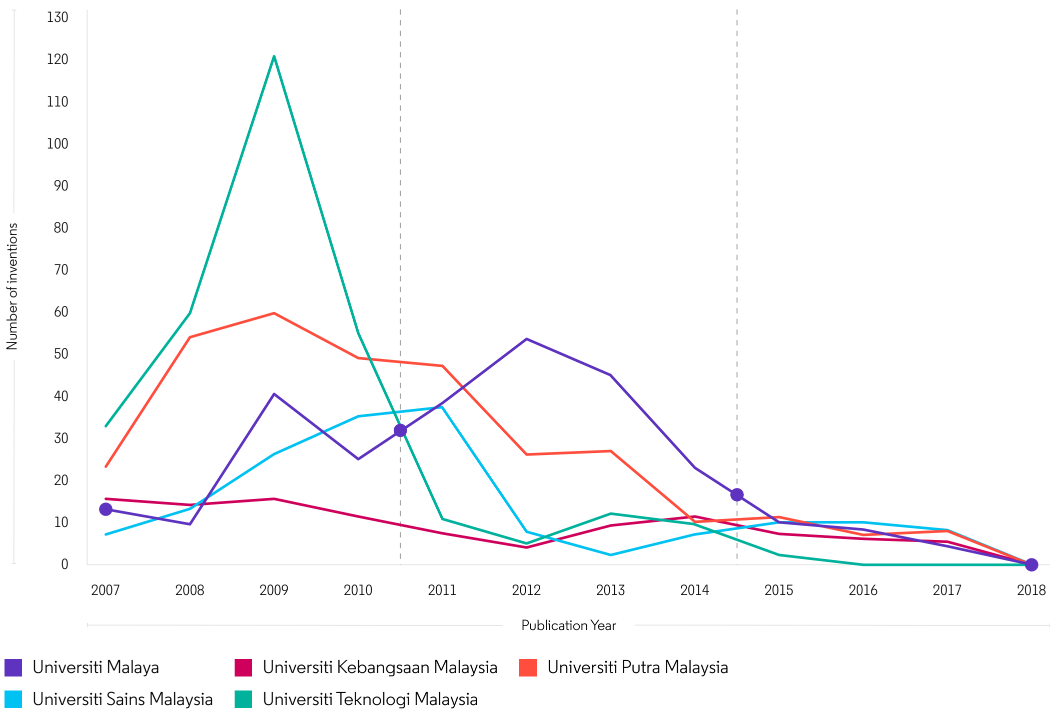
In February 2010, the Universiti Malaya High Impact Research (UM HIR) Programme was initiated. In August 2011, the Ministry of Higher Education Malaysia injected additional funds into the UM HIR Programme to give UM a chance to break into the top 100 world ranked universities by 2016 (University of Malaya High Impact Research Final Report, 2016). This additional support saw UM's research output grow by 1.57 times between the years 2007 and 2010 to the years 2011 and 2014, ultimately producing 4,530 papers in the year 2014 (highest among all the RUs).

During this period, innovation output of Universiti Malaya increased significantly from 38 inventions in the year 2011 to 159 inventions (cumulative) in the year 2014, which was the highest amongst the 5 RUs (See Figure 2).

The increase in innovation output of Universiti Malaya during the time period of 2011 to 2014 could be attributed to an increase in research quality as a result of the Universiti Malaya High Impact Program. In addition, under the National Higher Education Strategic Plan, during the second phase of the Research and Development Critical Agenda Project, more exposure on Intellectual Property was provided to researchers as a move towards increasing commercialization of their R&D products during the years 2011 and 2012, which only further enhanced Universiti Malaya output.

Patent applications generally remain unpublished after the earliest priority date for up to 18 months; therefore, the most recent years may have incomplete information and as a result, reflect information as a decline in the innovation output (in the years between 2015 to 2018).

Figure 2: Innovation output 2007–2018

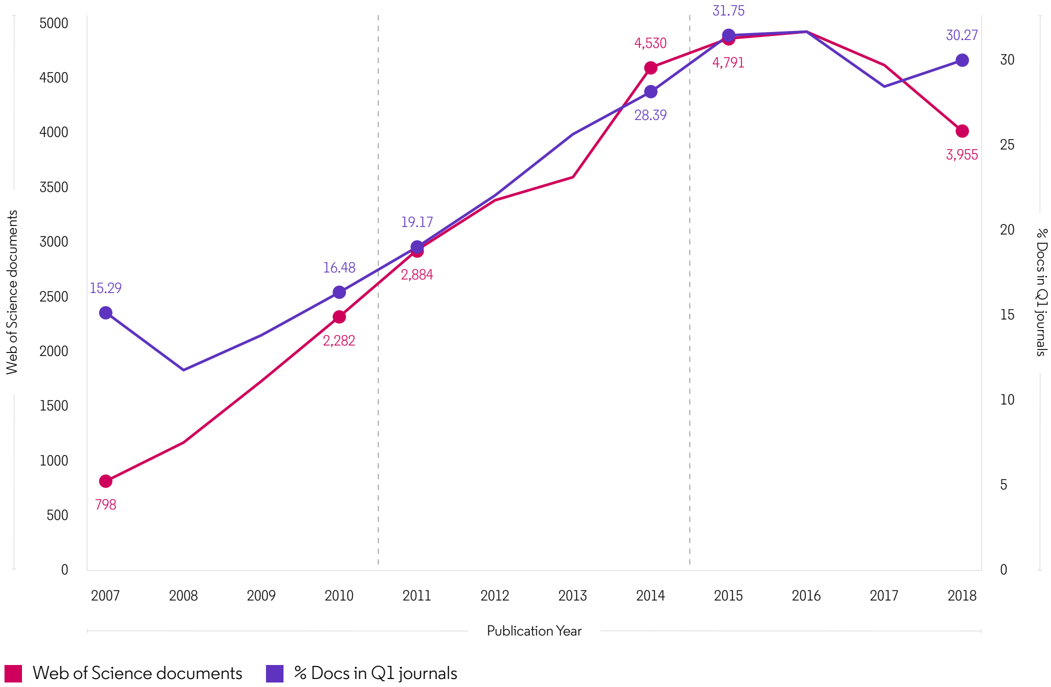


Innovation output of five Research Universities in Malaysia from year 2007 to 2018 (Source: Derwent Innovation)

The UM HIR Programme's end in 2015, followed by the reduction in grants and funding in 2016, saw a steady decline in research productivity (defined by Web of Science documents) for the five RUs. For UM, this translated to a 17% decline from 4,791 documents in the year 2015 to 3,955 documents in the year 2018. Across the three time periods, UM's research output increased by 141% between the period of 2007 to 2010 and the period of 2011 to 2014. The total output for the period of 2015 to 2018 increased by 27% compared to the previous period.

Quality

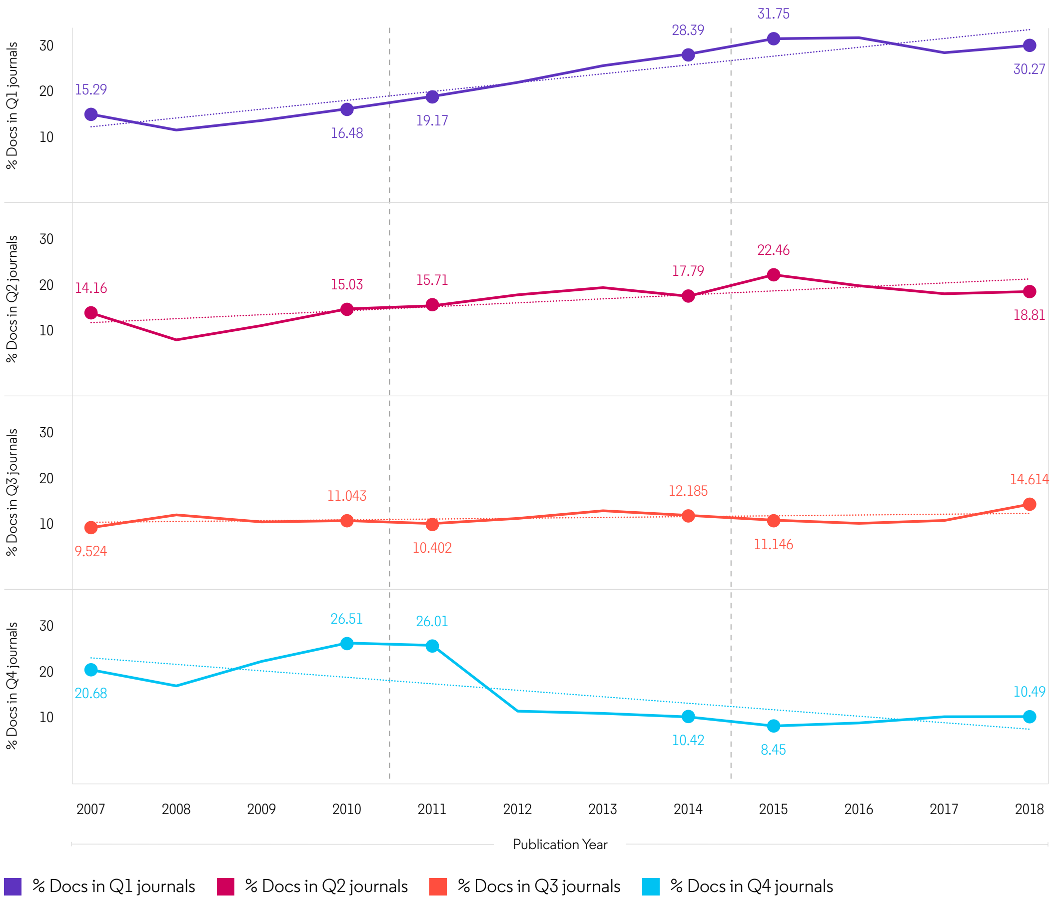
Figure 3: Quality of research output 2007 to 2018 (as represented by % Docs in Q1 journals)



Trend of UM's research output and % of documents published in Q1 journals (Source: InCites)

One of the key objectives for the UM HIR programme was to produce 3,400 top quality papers indexed in the Web of Science Quartile 1 (Q1) journals (University of Malaya High Impact Research Final Report, 2016). This translates to recognising that high quality research output will lead to greater impact and performance of the papers produced. Figure 3 shows the increase in Q1 journals papers and its relationship to the increase in papers over the period of year 2007 to 2018. This new focus is seen in the % of Q1 journals papers (quality) increased from 19.2% in the year 2011 to 28.4% in the year 2014. The total number of Q1 journals papers produced between the year 2011 and 2014 is 3,496 (exceeding UM's target).

Figure 4: Publishing output trend 2007–2018

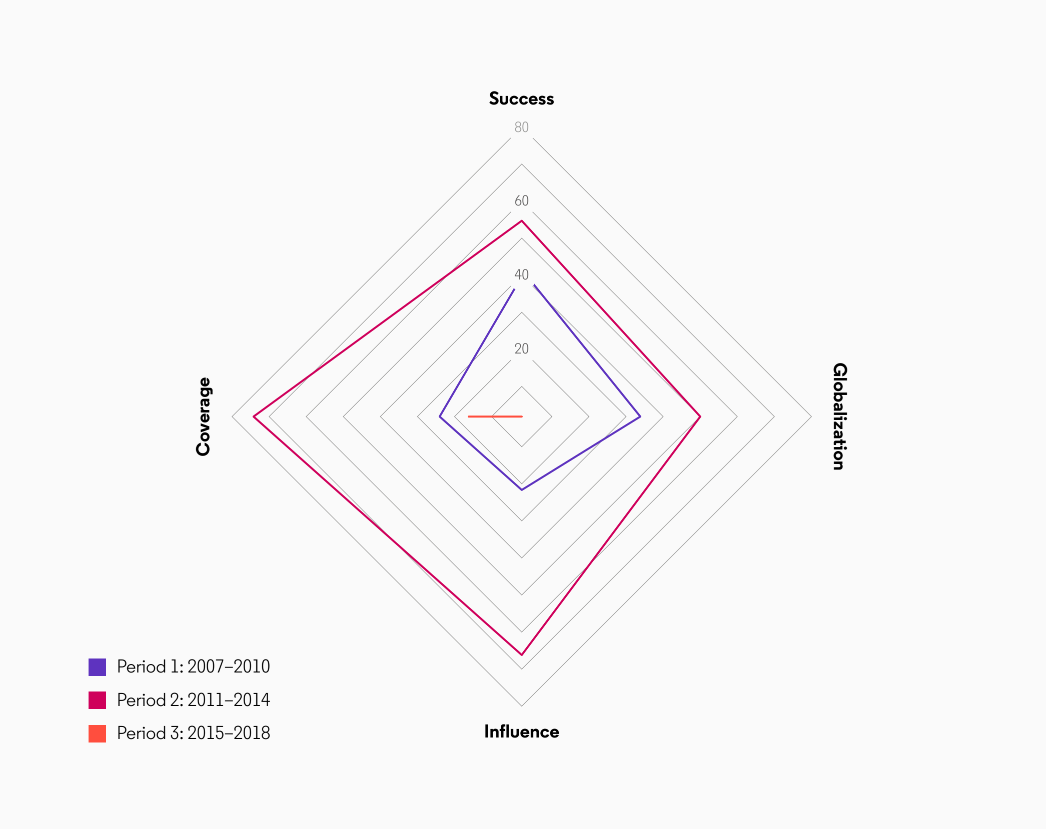


Quality of all research papers published in Journal Impact Factored Journals from Web of Science (Source: InCites)

The change in focus to quality output for UM can be clearly seen in Figure 4 which shows the percentage of papers produced in each Quartile's journals. There is sharp decline in Q4 papers from 26.5% in 2011 to 10.4% in 2014 (See Figure 4). This matches with a corresponding sharp increase in Q1 papers from 19.2% in the year 2011 to 28.4% in the year 2014. UM's research strategy continues to have a strong focus on publishing papers in Q1 journals following the end of the UM HIR Programme although the rate of increase has reduced through the period of 2015 to 2018.

A patent is an important intellectual property and a key measure of innovation. For a patented invention to be valuable, it must be with good quality, have a wide market potential and lay foundations for further developments and refinements. Therefore, in addition to the volume of inventions, measured patent quality via Derwent Strength Index is also essential. The Derwent Strength Index assesses the number of desirable characteristics a single invention has gathered to date. This is then aggregated across technologies and entities to identify trends and importance.

Figure 5: Derwent Strength Index – Innovation indicators 2007–2018



Quality of all research papers published in Journal Impact Factored Journals from Web of Science (Source: InCites)

The key innovation indicators used for the calculation of Derwent Strength Index are as below:

1. **Influence**
   Frequency of citation, referencing impact of the technical invention

2. **Globalisation**
   The breadth of geographic filing, correlating to variation in cost and investment in patent protection

3. **Success**
   Existence and location of granted, issued patent rights, a proxy for validity as well as commitment

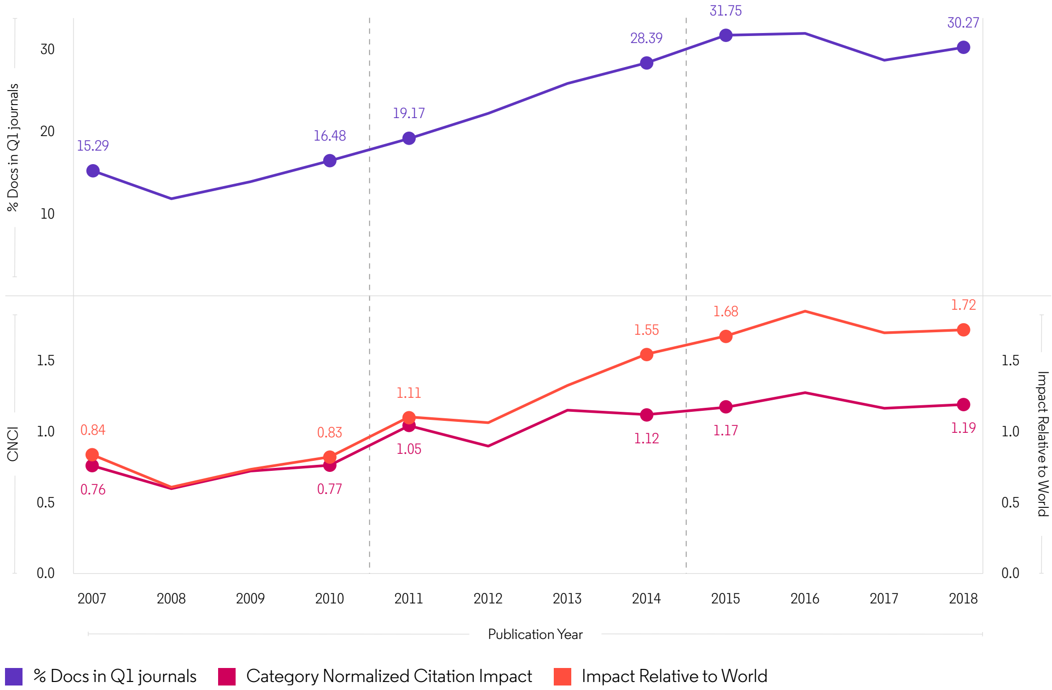
4. **Coverage**
   The invention's technical breadth, correlating to the range of industry

As seen in Figure 5, during the time period of 2011 to 2014, there is an increase in patent quality across all innovation indicators, with huge increases observed in the breadth of technical coverage and influence.

The increase in patent quality reflects the growing focus on conducting strategic research that is aimed at commercialisation and capability of generating intellectual property, thus fulfilling one of the objectives outlined in the Research and Development Critical Agenda Project under the National Higher Education Strategic Plan 2007-2020. The UM HIR Programme was also focused on the need for high quality research. During the time period between 2009 and 2010, the stricter provisions for funding allocation in fundamental research, i.e. selecting research projects with the highest quality; caused UM to begin cultivating high research quality. The downstream impact can be witnessed in the output and quality.

Impact and performance

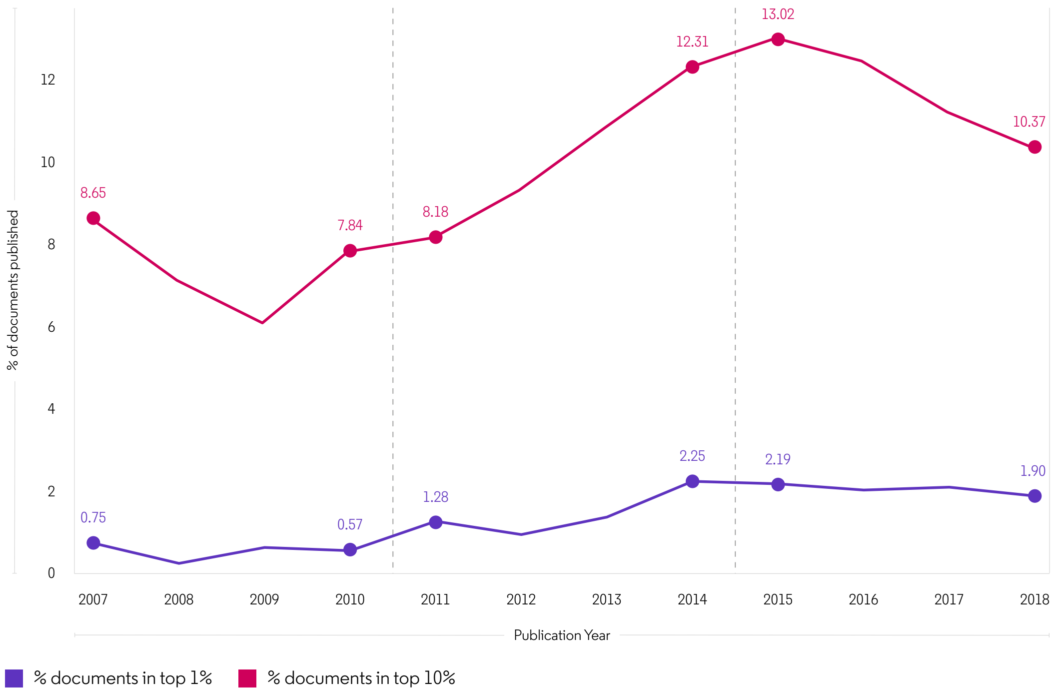
Figure 6: Quality and impact of output



% of documents published in Q1 journals compared with Citation Impact (CNCI and IR2W (Source: InCites)

From the year 2007 to 2010, the increase in quality papers led to a slight improvement in impact from a CNCI of 0.76 in the year 2007 to a CNCI of 0.77 in the year 2010. The great improvements in output of papers from Q1 journals in the period of year 2011 to 2015 propelled UM's impact to above world average from a CNCI of 0.77 in 2010 to a CNCI of 1.12 in 2014. This focus on quality output continued to maintain UM's impact even after UM HIR from 2015 to 2018 (as seen in Figure 6).

Figure 7



Percentage of documents published in the top 1% and 10% of cited documents from year 2007 to 2018 (Source: InCites)

Similarly, the performance of UM's research papers has also improved in terms of the percentage of documents in the top 1% (excellent papers) and top 10% of cited documents (high performing papers). Figure 7 shows that the percentage of documents in the top 10% cited documents increased from 8.2% in the year 2011 to 12.3% in the year 2014. The volume increase for papers in the top 10% and top 1% over the periods was significantly higher from the year 2007 to 2010 (434 papers in top 10%; 33 papers in top 1%) compared to the period from year 2011 to 2014 (1,489 papers in Top 10%; 220 papers in top 1%). This increase provides a stable base of high performing papers and allows for a potential increase in the percentage of excellent papers. After the UM HIR Programme ended, the percentage of documents in the top 10% most cited document has seen a big decline from the peak of 13% in 2015 to 10.4% in 2018. This decline is accompanied with a decline in percentage of documents in the top 1% most cited documents from 2.2% in 2015 to 1.9% in 2018, placing UM in a risky position of declining performance.

During the UM HIR Programme, Universiti Malaya launched many companies to commercialise research and monetise patents. Noteworthy success stories among them are Bio-Apps and UMCH Technology Sdn Bhd (as seen in Table 1).

Bio-Apps

Founded in the year 2012, under the leadership of Professor Dr. Noor Azuan Abu Osman (recipient of HIR-MOHE grant in the year 2011) and Prof Dr. Wan Abu Bakar Wan Abas, Bio-Apps provides high-tech devices for prosthetic and orthotic services. Bio-Apps is supported by a strong patent portfolio. One of the patent publications US20130289743A1 titled Magnetic Coupling Device of a Limb Prosthesis has been cited by organisations such as Chicago Rehabilitation Institute, Korea Workers Compensation and Welfare Service and Otto Bock Healthcare Products. The company generated a revenue of more than RM 2.5 Million in the year 2018. (Source: https://umcic.um.edu.my/success-stories and http://bioapps.com.my/)

UMCH Technology Sdn Bhd.

Founded in the year 2015, under the leadership of Professor Dr. Loo Chu Kiong (recipient of HIR-MOHE grant in the year 2012), UMCH Technology Sdn Bhd. is an incubator company specialising in connected fitness, wellness and healthcare technology solutions. The core product Connected Healthcare Integrated Fitness (CHIEF) is a mobile solution for managing a healthy lifestyle through systematic tracking of user's activities and is well-supported by patents. The company generated around RM 405,856 in 2018, just three years after its inception. UMCH Technology Sdn Bhd. is the recipient of High Impact Programme 2, a national initiative under SME Masterplan 2012-2020, where it receives an end-to-end facilitation including product development, productization, licensing support, regulatory certification, technical and financial assistance. (Source: https://umcic.um.edu.my/success-stories and http://www.umchtech.com/)

Spin-Off Company	About the Organisation	Inventions
BIO-APPS (FOUNDED in YEAR 2012)	Hi-Tech Devices for Prosthetic and Orthotic Services	US20130289743A1|WO2014142643A1 WO2014084720A1| MY167327AWO2015108407A1|WO2014084719A1 MY154289A | MY153828A
UMCH TECHNOLOGY SDN BHD (FOUNDED in YEAR 2015)	Integrated Fitness, Wellness and Healthy Living Solutions	WO2016171542A1

Table 1: Noteworthy examples of spin-off companies from Universiti Malaya during UM HIR Programme (Source: Derwent Innovation)

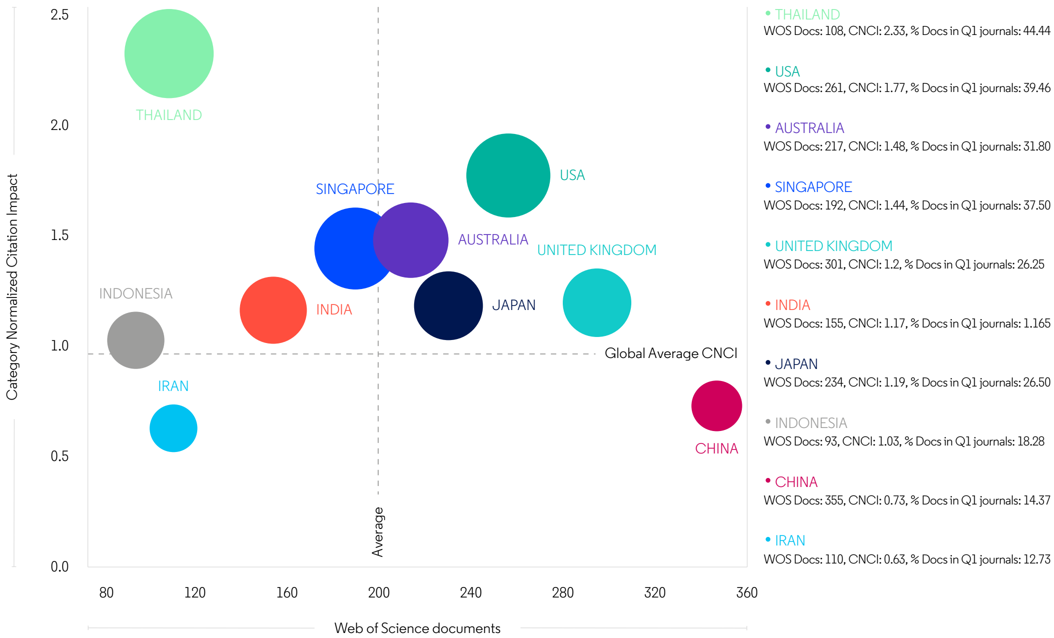
In addition to spin-off companies, during this period, a noteworthy patent publication that received citations from leading global organisations was WO2014112865A1. (as seen in Table 2)

Publication Number	Title	Citing Organizations
WO2014112865A1	A method of producing a unitary pipe having a combination of square and circular cross sections	United States Gypsum | Lockheed Corporation | Valmet Oy

Table 2: Noteworthy example of a patent application from Universiti Malaya during UM HIR Programme (Source: Derwent Innovation)

Collaborations

Figure 8: Collaborating countries 2007–2010

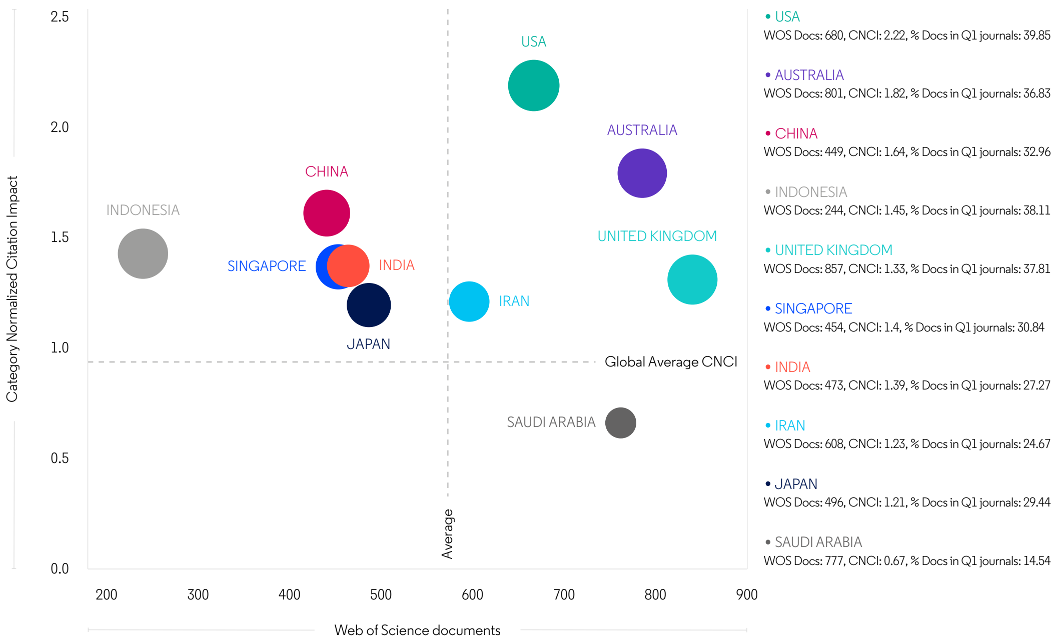


Size of bubble = percentage of documents published in Q1 journals
Top 10 collaborative countries with UM between years 2007 to 2010 (Source: InCites)

The University's research policies had a strong focus on internationalisation and fostering partnerships with Ivy League global universities. The analysis in this section will shed light on the research impact of both international and industry collaborations across the three time periods.

Figures 8, 9 and 10 show the changes in productivity, impact and quality of the international collaborations through the three time periods. The UM HIR Programme saw a lot of collaborations with United States, United Kingdom and Australia and this is evident in figures 9 and 10. (University of Malaya High Impact Research Brochure, 2014). Although the main objective of the UM HIR was to foster collaborative partnerships with Ivy League universities, international collaborations across a few countries showed significant potential for joint success.

Figure 9: Collaborating countries Year 2011–2014

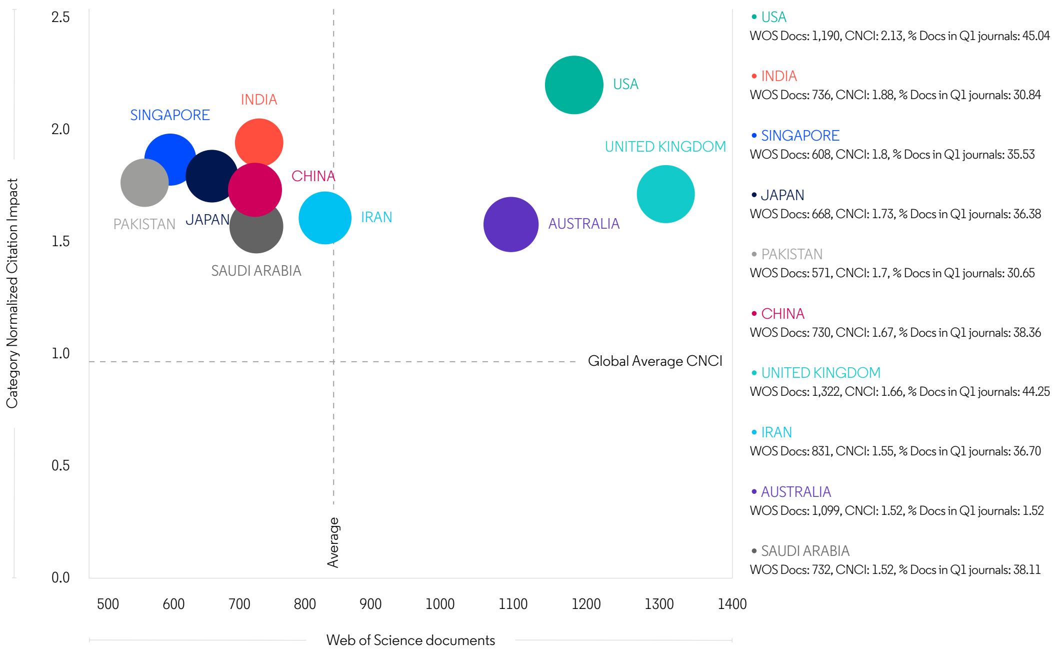


Size of bubble = percentage of documents published in Q1 journals
Top 10 collaborative countries with UM between years 2011 to 2014 (Source: InCites)

Apart from this, research collaboration with the United States produced great improvements in productivity from 261 Web of Science documents during the period of 2007 to 2010, to 680 Web of Science documents during the period of 2011 to 2014. Research impact for these collaborations also increased from a CNCI of 1.77 (year 2007 to 2010) to a CNCI of 2.2 (year 2011 to 2014). Some notable collaborations are with Harvard University and Yale University. UM had no research collaborations with Harvard during the period of 2007 to 2010 but had 39 collaborative papers during the year 2011 to 2014 which produced an average CNCI of 1.82. Between the years 2007 to 2010, UM and Yale University only had eight collaborative papers and this increased to 29 papers with an average CNCI of 1.93 during the year 2011 to 2014. Not only was UM HIR's main objective met, the collaboration with Ivy League universities reaped rewards.

Research impact for these collaborations also increased from a CNCI of 1.77 (year 2007 to 2010) to a CNCI of 2.2 (year 2011 to 2014). This result clearly shows that the objective of collaborating with Ivy League universities was a huge success.

Figure 10: Collaborating countries Year 2015–2018



Size of bubble = percentage of documents published in Q1 journals
Top 10 collaborative countries with UM between years 2015 to 2018 (Source: InCites)

China was a top collaborator for UM in terms of productivity at a volume of 355 Web of Science documents in the period between 2007 to 2010. Productivity of this collaboration increased by 26% from 355 in the initial period (2007 to 2010) to 449 in the following period of 2011 to 2014. Research impact through collaborations with China also improved significantly from a CNCI of 0.73 (2007 to 2010) to 1.64 (2011 to 2014), making this partnership third highest in impact during the years between 2011 to 2014. This strong collaboration continued on until the years 2015 to 2018.

Another country collaborator of interest is Saudi Arabia with a sudden entry to the top 10 list during the period of 2011 to 2014.

Comparing across this period and the next (2015 to 2018), productivity maintained at a similar level of over 700 documents while the CNCI increased from 0.67 (2011 to 2014) to 1.51 (2015 to 2018). The increase in quality from 14.5% (Years 2011 to 2014) to 38.1% of documents published in Q1 journals also pointed towards a potential for this partnership.

In terms of the overall trend in volume of international and industry collaborations, there was an increase in international collaborations from 39.9% in year 2010 to 45.1% in year 2014 with a decline in industry collaborations from 1% in 2010 to 0.6% in year 2014 (see Figure 11).

Figure 11: Collaboration trends from 2007 to 2018

Trend of UM's international and industry collaboration for research from year 2007 to 2018 (Source: InCities)

However, the National Higher Education Action Plan Phase 2 has helped to direct efforts towards commercialisation which helped UM see some success in this aspect. In June 2011, Universiti Malaya entered into a collaboration agreement with Aurigene Discovery Technologies Limited, a wholly owned subsidiary of Dr. Reddy's Laboratories Limited, a specialized biotechnology company engaged in discovery and early clinical development of novel and best-in-class therapies to treat cancer and inflammatory diseases. The agreement included development of three drug discovery projects, training of university students at the facilities of Aurigene Discovery Technologies Limited and joint research and publications, and industrial PhD programs. As a result of this collaboration, Universiti Malaya co-owns two U.S. granted patents (US9630932B2 and US9353107B2) with Aurigene Discovery Technologies Limited.

The University launched a strategic plan in 2016 to create a vibrant research and innovation ecosystem and be the most preferred global research partner in Malaysia (UM Strategic Plan of 2016-2020, 2018). This explains the increase in collaborations during the period of 2015 to 2018 as seen in Figure 11.

With the existing high quality and impact research stemming from the UM HIR program and UM Strategic Plan, UM is well placed to leverage the strategic collaborations with international universities and industry to drive high value innovations. This will greatly support the government's current focus on research that leads to greater economical and societal impact.

One such example is the work of Dr. Wei Ru Wong (recipient of the HIR Grant in 2013), whose research on dengue detection with the University of Ottawa was featured in reputable high impact journals and media including *Nature, Science,* and *Laser Focus World*. In 2016, Dr. Wong filed for a patent publication (WO2018090125A1) on *"Long-Range Surface Plasmon-Polariton Biosensor"*. In the same year, this research project on dengue biosensor was awarded a funding worth close to RM two million for commercialization. In 2017, she became the co-winner for the Malaysia Toray Science Foundation (MTSF) Science and Technology Award as a recognition to the excellence in her work. (Source: https://umexpert.um.edu.my/weiru.html)

An analysis of six broad research areas

The various initiatives from UM and the Ministry provided research funding to different subject areas in the university. In this section, we will use the UM HIR Grant distribution as a yardstick to frame the research and innovation footprint of the broad research areas. We adopted the six broad research areas in the Global Institutional Profiling Project (GIPP) schema in InCites as this categorisation has strong similarities to how the UM HIR grants were allocated in UM. This research area schema is used in the methodology for the Times Higher Education World University Rankings.

Table 3 below shows the number of UM HIR funded projects for each subject field and is used to give an estimation to the proportion of grants given to each area.

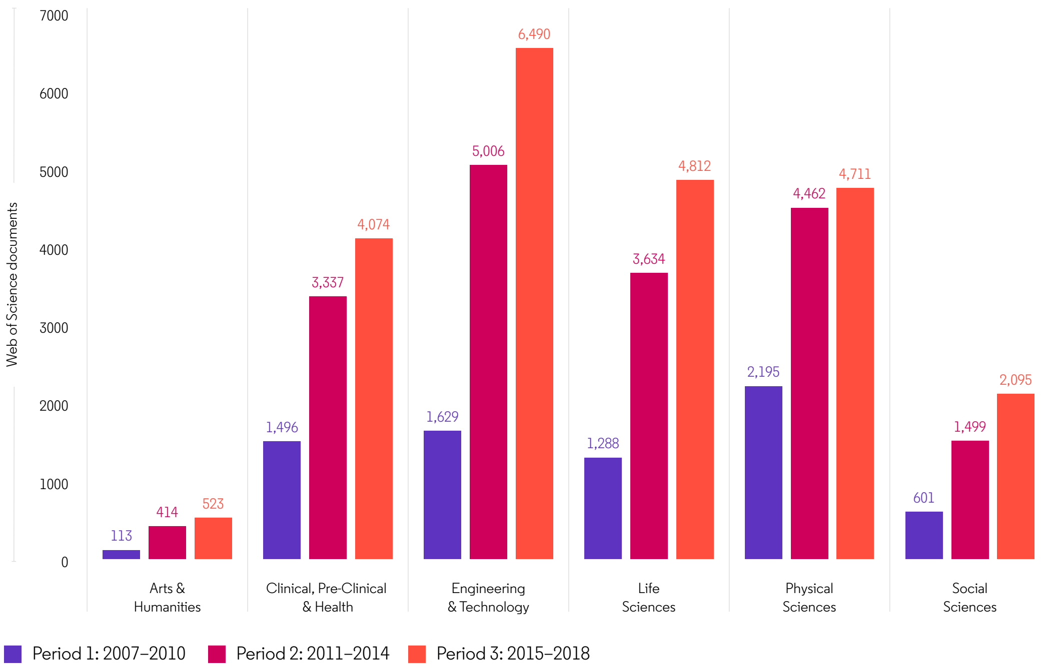
Field from UM data	Proportion of projects granted	Corresponding GIPP area
Medicine and Dentistry	34%	Clinical, Pre-Clinical & Health
Engineering	30%	Engineering and Technology
Science	8%	Life Sciences and Physical Sciences
Computer Science and IT	7%	Engineering and Technology
Arts and Social Science	5%	Arts and Humanities and Social Sciences
Others[1]	16%	All of the above

Table 3: Research areas in the UM HIR Programme and the corresponding proportion of projects. (Source: IPPP)

1. These projects were granted via the Chancellery and the subject areas these fall into are spread across all 6 of the GIPP research areas.

Productivity

Figure 12: Trend of growth across research areas

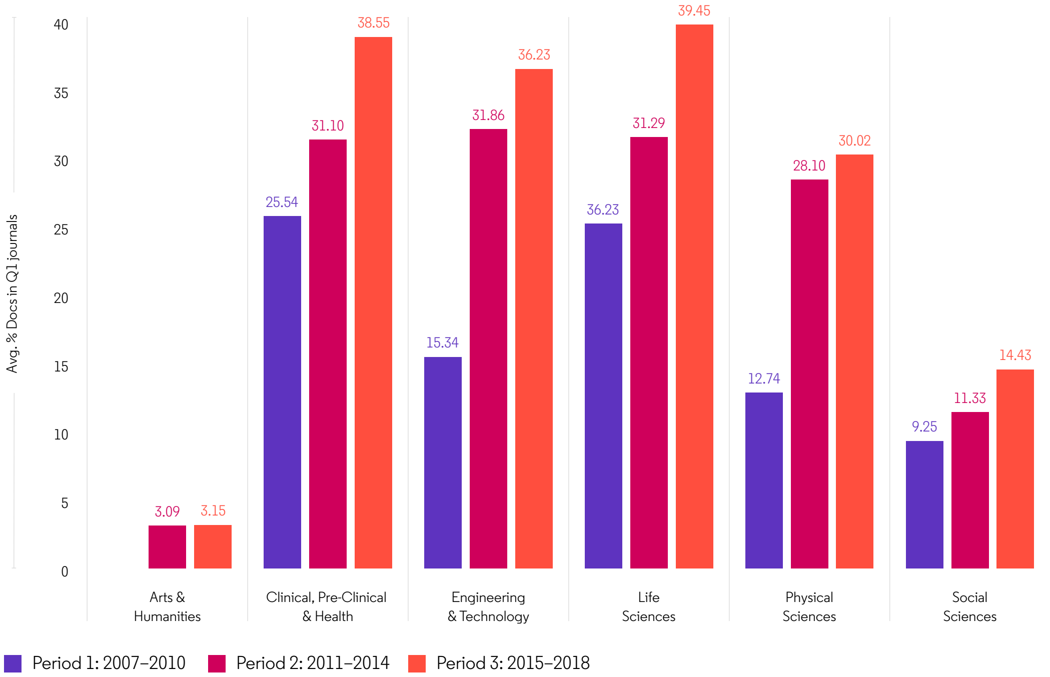


Trend of productivity across six GIPP research areas (Source: InCites)

A look at the overall Web of Science output of each GIPP research area shows that the investments from the various university-level policy programmes like the UM HIR grants has led to an overall increase in productivity across all areas during the UM HIR period of 2011 to 2014 (refer to Figure 10). The sharp increase of documents published in Engineering and Technology (207% increase from the period of 2007 to 2010, to the period of 2011 to 2014) and Clinical Medicine (123% increase) aligns closely with the respective number of funded projects too. However, Physical Science (103% increase) and Life Sciences (182% increase) had extremely high growth in productivity during the same two periods even though only 8% of projects were granted in these areas.

Quality

Figure 13: Trend of % documents in Q1 journals growth across research areas

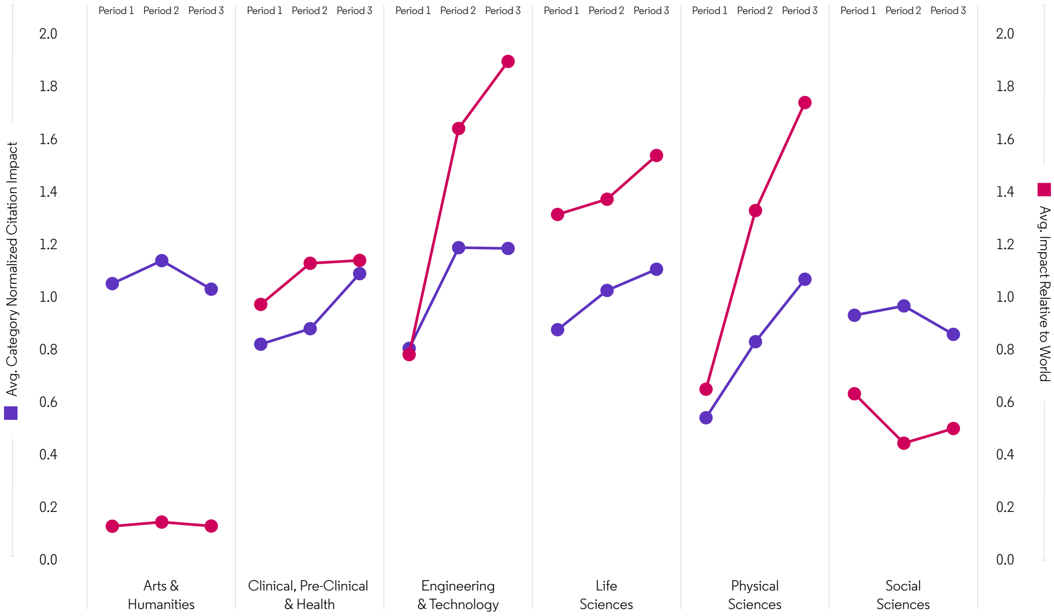


Trend of quality publications in Q1 journals across the six GIPP research areas (Source: InCites)

Physical Sciences saw the sharpest increase (121%) in quality papers in Q1 journals from 12.7% during the period of 2007 to 2010, to 28.1% during the period of 2011 to 2014. Engineering and Technology came in second at 108% increase in quality papers in Q1 journals from 15.3% during the period of 2007 to 2010, to 31.9% during the period of 2011 to 2014. Clinical Medicine also has an increase in quality papers in Q1 journals from 25.5% during the period of 2007 to 2010, to 31.1% during the period of 2011 to 2014. (Refer to Figure 13).

Impact

Figure 14: Trend of impact across research areas



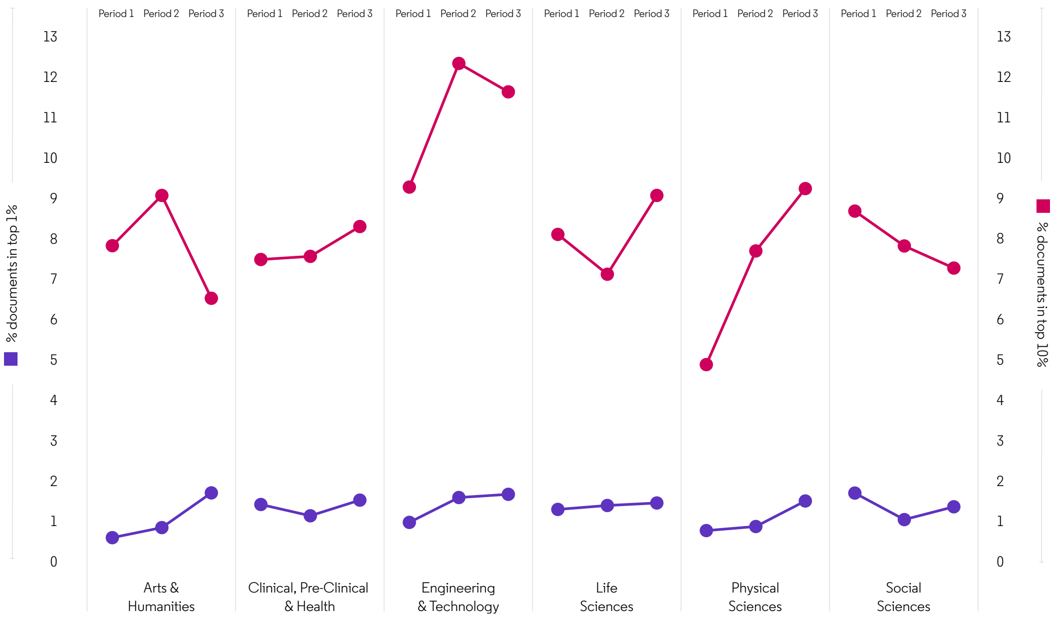
Trend of research impact (CNCI and IR2W) across the six GIPP research areas (Source: InCites)

As a result of the significant improvements in the percentage of papers published in Q1 journals from the period between 2007 to 2010 and the period between year 2011 to 2014 in all six research areas (see Figure 13), research impact (as measured by CNCI and IR2W) in these areas also improved (refer to Figure 14). Engineering and Technology improved from a CNCI of 0.82 (Year 2007 to 2010) to 1.22 (Year 2011 to 2014) and Life Sciences improved from a CNCI of 0.9 (Year 2007 to 2010) to 1.05 (Year 2011 to 2014), both areas exceeding the world average CNCI of 1.0. Physical Sciences also showed a marked increase in CNCI from 0.52 to 0.81 during the same two time periods.

This impact growth is sustained after the year 2014 for Physical Sciences and Life Sciences but impact remained relatively unchanged for Engineering and Technology (even though there was still a great increase in output of 29.6% through the same period).

Performance

Figure 15: Trend of performance across research areas



Trend of research performance (%documents in top 10% and top 1% of cited documents) across 6 GIPP research areas (Source: InCites)

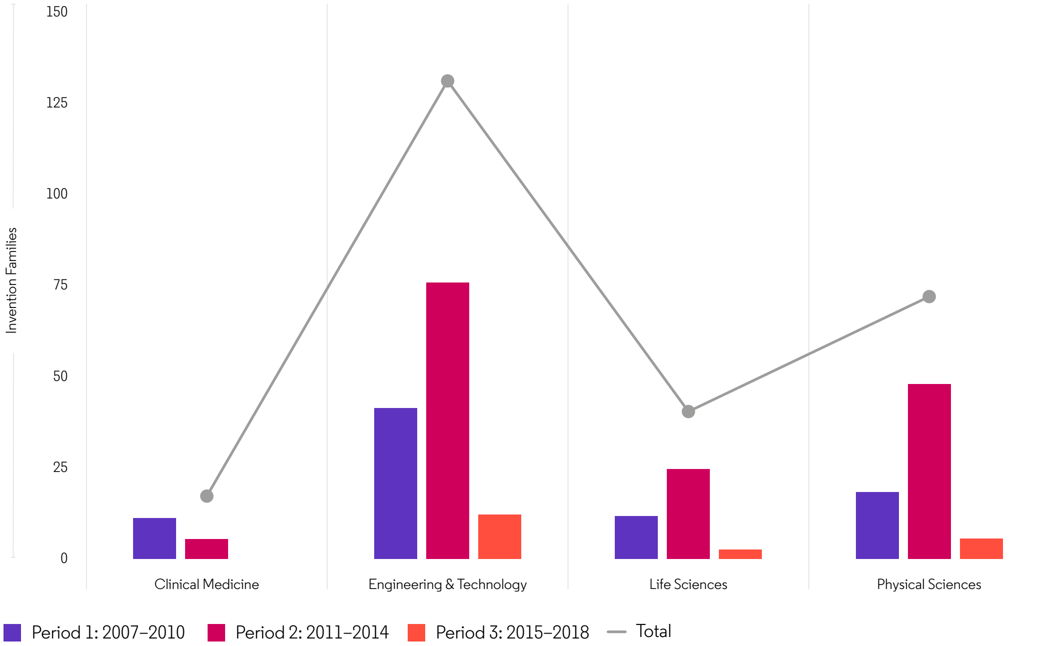
The performance of Engineering and Technology improved greatly from 9.5% of papers performing in the top 10% of citations in their field during the period of 2007 to 2010, to 12.8% of papers during the period of year 2011 to 2014 (see Figure 15). Physical Sciences also showed sharp increases from 4.7% during the years 2007 to 2010, to 7.8% during the years 2011 to 2014. Life Sciences, on the other hand, had a reduction in the percentage of papers performing in the top 10% of their field from 8.2% (Year 2007 to 2010) to 7.1% (Year 2011 to 2015).

During the period between 2015 to 2018, Engineering and Technology had a slight decrease in performance for papers in top 10% from 12.8% (Year 2011 to 2014) to 12% (Year 2015 to 2018). Physical Sciences and Life Sciences both saw around a 2% improvement over the same two time periods.

The increase in quality papers in Q1 journals across all research areas clearly contributes towards improvement of research performance by driving upwards momentum of the number of papers in the top 10% and top 1% most cited documents (refer to Figures 13 and 15). Two research areas of interest would be Life Sciences and Physical Sciences as these areas had less granted projects compared to the other areas but still managed to see improvements in productivity, quality, impact and performance.

Among the six GIPP subject areas, innovation output is applicable for four scientific subject areas, namely, Clinical, Pre-Clinical and Health, Engineering and Technology, Life Sciences and Physical Sciences

Figure 16: Innovation output across research areas (2007–2018)



Innovation output across 4 research areas for Universiti Malaya from year 2007 to 2018 (Source: Derwent Innovation)

Among these four GIPP subject areas, Engineering and Technology contributed the highest (50%) of the innovation output during the time period (2007 to 2018).

Between 2011 to 2014, innovation output for three out of the four GIPP subject areas reached their peaks of innovation output.

A closer look at Engineering and Technology research output

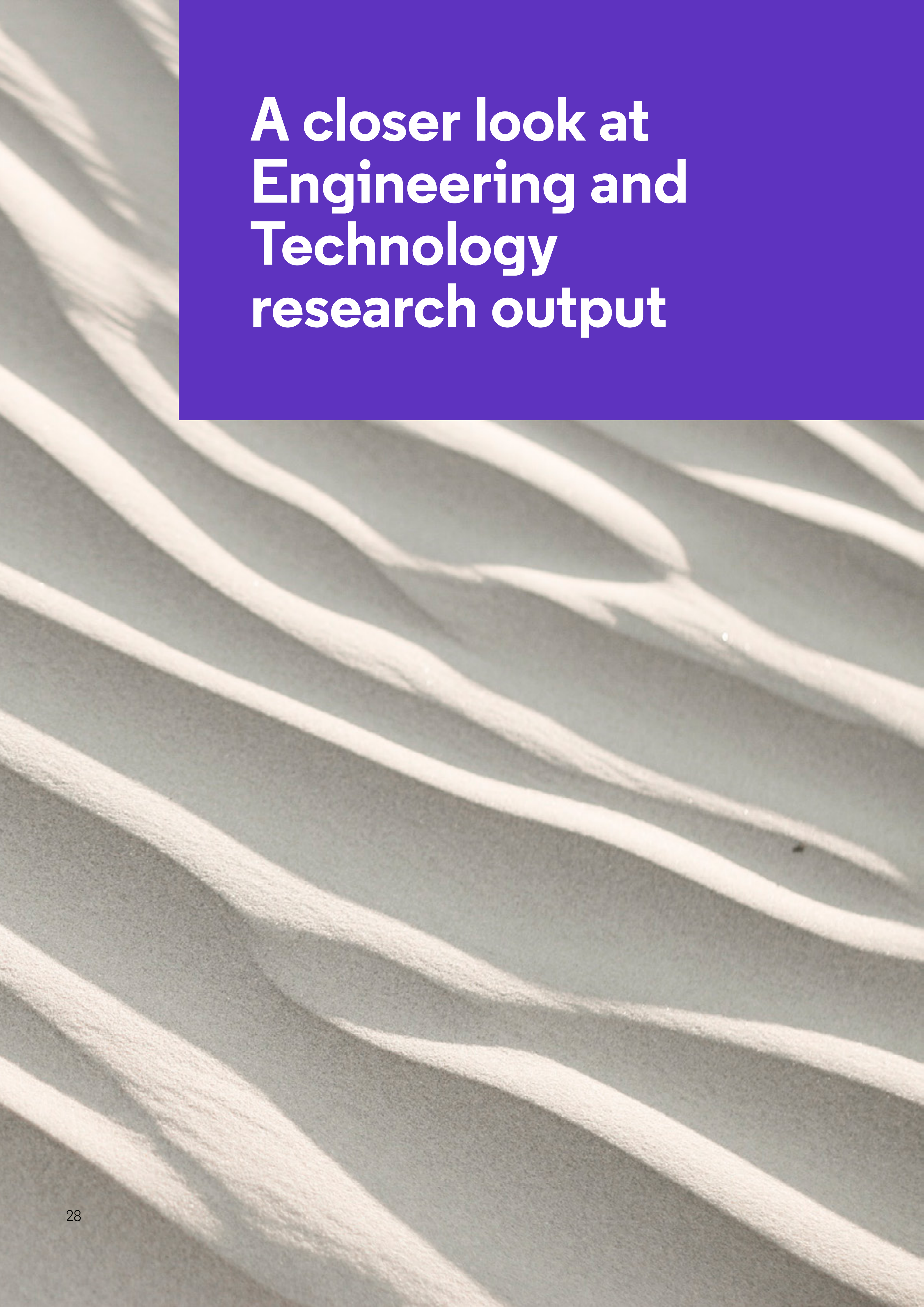
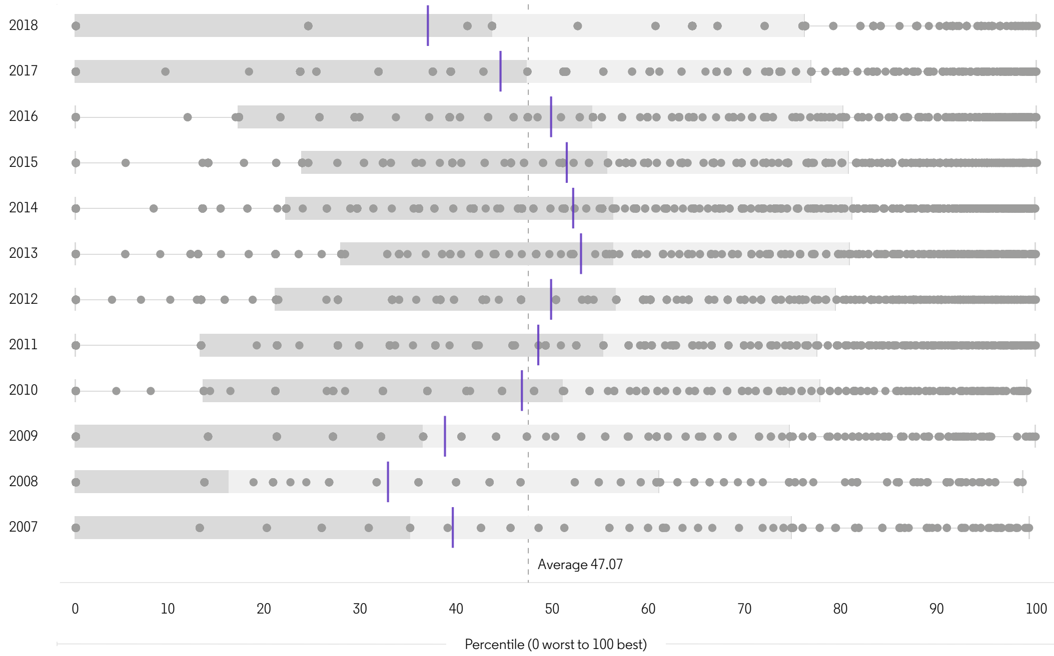


Figure 17: All Engineering and Technology papers from UM (Year 2007–2018)



Beam-plot of engineering and technology papers over time (Y-axis)
and their corresponding citation performance percentile in field (X-axis) (Source: InCites)

As one of the highest contributors in terms of Web of Science papers published between the year 2011 to 2018, Engineering and Technology is chosen for further analysis in this section over the three time periods. A total of 13,129 papers from Engineering and Technology with no more than 100 authors were published during the year 2007 to 2018.

Figure 17 is a beam-plot of all these research papers over time with their corresponding citation performance percentile rank in the subject area. This gives a snapshot of the performance of these papers over the three time periods in this report. Between 2007 to 2010, the average percentile of the papers published during those years were mostly below the 50th percentile. Papers published between the year 2011 to 2014 saw an improvement in percentile performance where the average percentiles over those years were mostly above the 50th percentile (more papers were performing in the top 50% of all papers in the subject category). Papers published between 2015 to 2018 saw a decrease in their performance with the 2017 and 2018 average percentiles at levels below 50 again.

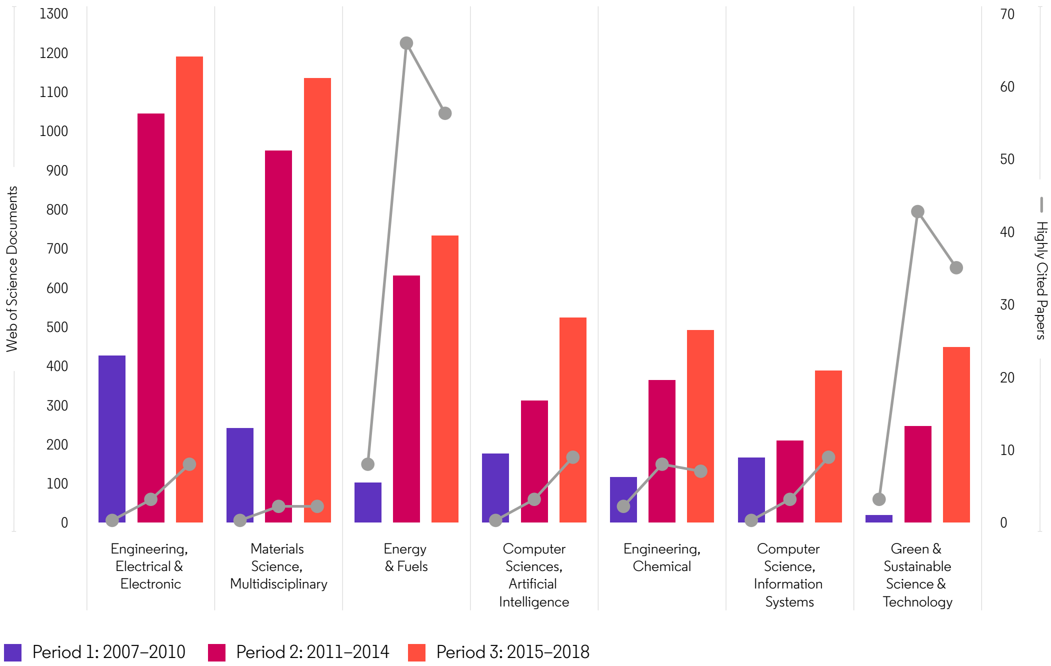
The innovation output for Engineering and Technology saw an 81% increase from the time period of year 2007 to 2010, to the time period of year 2011 to 2014 which can be attributed to the focus on driving high quality strategic research aligned with the National Higher Education Strategic Plan 2007 - 2020 and the UM HIR Programme.

	Engineering, electrical and electronic	Materials science, multidisciplinary	Energy and fuels	Engineering, chemical	Computer science, artificial intelligence	Green and sustainable science and technology	Computer science, information systems
Web of Science documents	2,313	2,159	1,411	883	864	719	616
% of documents in Q1 Journals	15.82	18.48	54.15	40.66	23.50	39.78	16.72
Highly Cited Papers	11	4	126	15	12	80	12
Category Normalized Citation Impact	1.12	1.02	1.33	1.05	1.08	1.43	1.59
Impact Relative to World	0.55	0.73	2.42	1.36	0.64	2.89	0.64
% documents in top 1%	1.21	0.65	0.78	0.68	1.04	1.39	3.41
% documents in top 10%	9.99	8.48	15.59	12.46	12.04	16.83	12.66
% International Collaborations	46.30	41.55	52.66	50.85	52.55	51.04	52.11
% Industry Collaborations	1.21	0.32	0.64	0.91	0.23	0.28	0.32

Table 4: Sub-fields in Engineering and Technology and corresponding Research Footprint from year 2011 to 2018 (Source: InCites)

Table 4 shows sub-fields of Engineering and Technology and their corresponding Research Footprint from year 2011 to 2018. Although Energy and Fuels ranks number three in terms of productivity (Web of Science documents) at 1,411, it is doing very well in quality (54% published in quality Q1 journals) and impact (1.33 CNCI). The performance of the output from this field also has promise with 16.1% of documents in the top 10%. The global visibility of Energy and Fuels is also the highest with 51.5% in international collaborations.

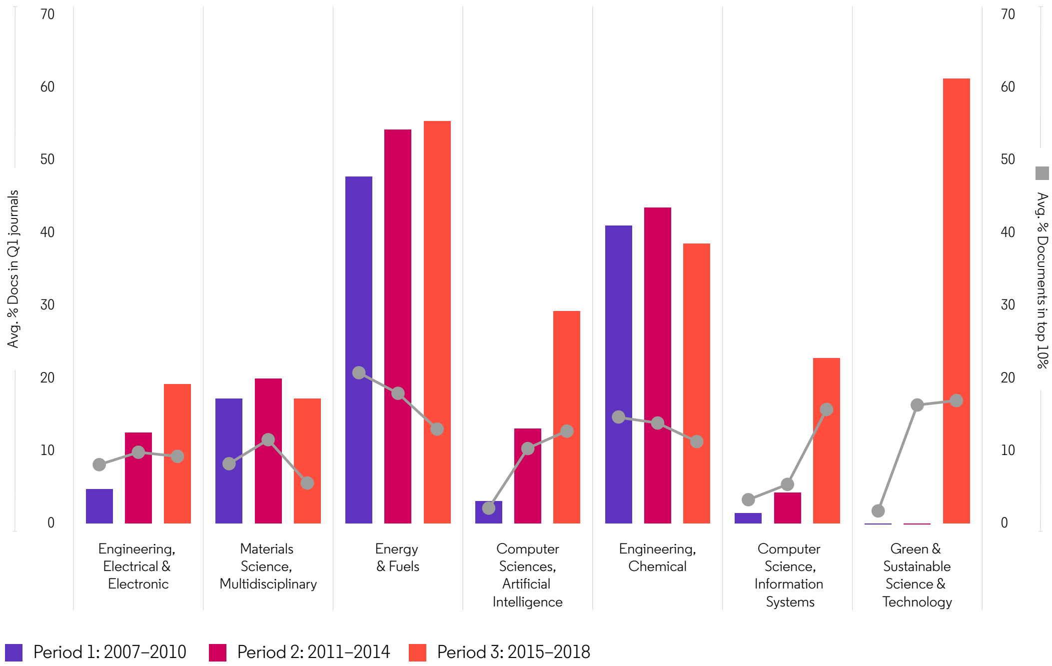
Figure 18: Trend of productivity growth across sub-fields



Productivity trend of sub-fields across three time periods (Source: InCItes)

Figures 18 and 19 show the productivity, quality and performance trend of the sub-fields. Green and Sustainable Science and Technology had the highest increase (1175%) in productivity from 20 papers during 2007 to 2010, to 255 papers during 2015 to 2018 (See Figure 19). Energy and Fuels had the second highest increase (528%) in productivity from 104 papers during 2007 to 2010, to 653 papers during 2015 to 2018. The decline in percentage of documents in the top 10% from 2011 to 2018 (as seen in Figure 19) could be something that needs to be addressed.

Figure 19: Trend of quality and performance across sub-fields



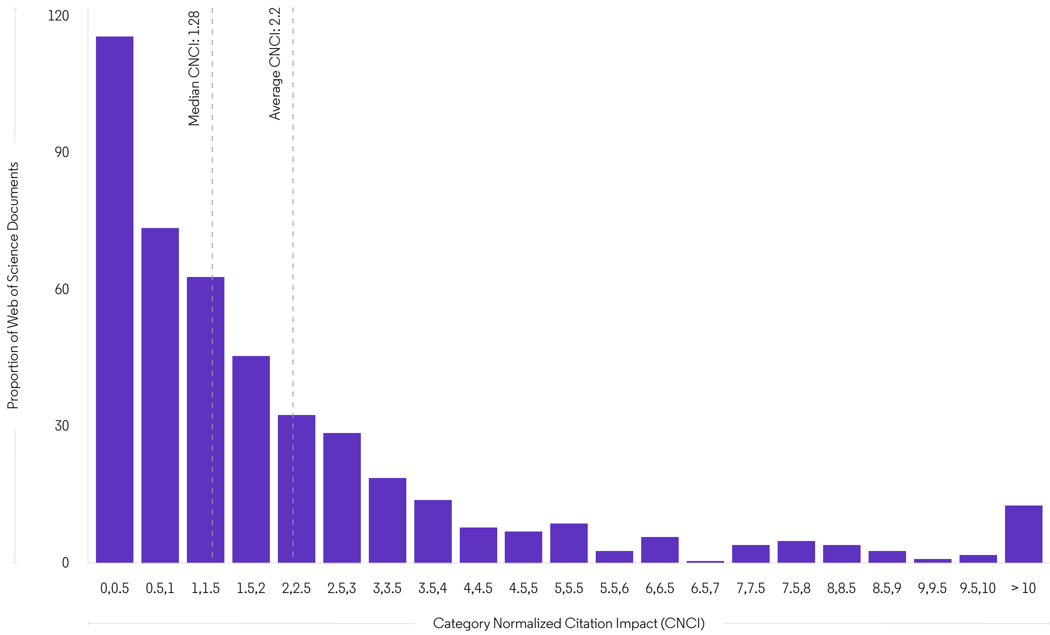
Quality and performance of Engineering and Technology sub-fields (Source: InCites)

In terms of quality and performance, two sub-fields show signs of concern after the UM HIR period. Materials Science and Chemical Engineering both had a decline in their percentages of papers in Q1 journals and top 10 percent (See Figure 19). Materials Science has a decline in % of documents in Q1 journals from 19.9% (Year 2011 to 2014) to 17.1% (Year 2015 to 2018), and reduction in % of documents performing in top 10% from 11.6% (Year 2011 to 2014) to 5.6% (Year 2015 to 2018). Chemical Engineering had its quality of documents reduced from 43.4% (2011 to 2014) to 38.5% (2015 to 2018) in Q1 journals, and this led to a subsequent decline in the performance of documents from 13.9% (Year 2011 to 2014) to 11.3% (Year 2015 to 2018) in the top 10% of the field.

Universiti Malaya HIR ICONs and their partnership with UM

In order to foster closer collaborations and build relationships with top universities, UM appointed world-renowned scientists (HIR ICONS) from around the world to collaborate with UM researchers in their respective projects. The support of these icons serves as a means for them to share their expertise with UM academic staff, thus helping to enhance the research reputation of UM through such international connections. These individuals were foreign faculty affiliated to top universities world-wide. This section of the report looks at the impact and overall performance of papers co-authored with UM HIR ICONs. A sample group of 102 ICONS was used for this analysis.

Figure 20: Impact distribution of ICON co-authored papers

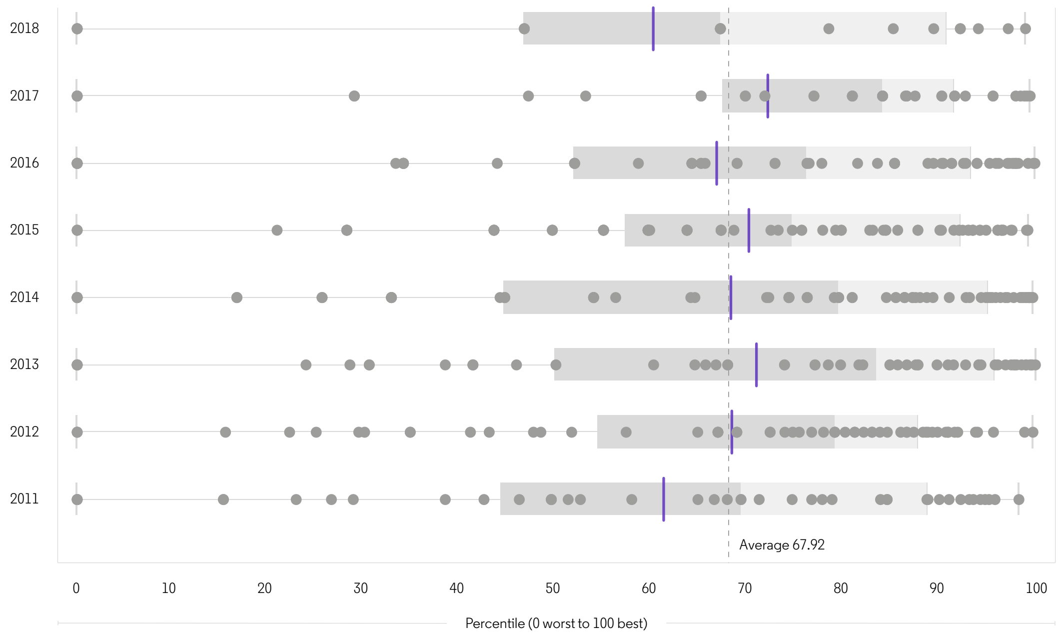


Citation impact distribution on ICON Co-authored papers from year 2011 to 2019 (Source: InCites)

Out of the 102 ICONs, 43 of them contributed to 459 papers (with a maximum author list of 100) published from 2011 to 2019. The presence of continued partnership past the end of the UM HIR programme shows that these ICONS have helped researchers in UM forge lasting research collaboration. It also meets one of the key objectives of UM HIR in building ties with Ivy League universities and many other top universities worldwide.

Figure 20 shows the citation impact profile of the documents co-authored with UM HIR ICONS. There is a good proportion of papers with citation impact above 1.0 (269 papers out of 459). The median CNCI of all these papers is 1.28 and the average CNCI is 2.2 (world average=1.0), indicating that these papers have performed more than 2 times higher than the world average.

Figure 21: Citation Performance of ICON Co-authored papers by year



Beam-plot of the data from Figure 21 showing the citation performance of the papers in percentile within their fields (Source: InCites)

For the periods between 2011 to 2014 and 2015 to 2018, papers co-authored with the UM HIR ICONs have improved strength from performing in the 60th average percentile of citations in its category (during the period of year 2011 to 2014) to a peak of around 72nd average percentile of citations in its category (see Figure 21).

Key findings

Universiti Malaya saw its global university ranking improve from 133rd place in the year 2015 to 70th place in the most recent Quacquarelli Symonds (QS) World University Rankings 2019-2020.

Through the analysis, the report has shed light on the key factors, through programmes like the UM HIR Programme and the National Higher Education Strategic Plan, that can help to propel universities in research and innovation excellence. These factors include:

01

Quality research output is the fuel for research performance. One of the key objectives of the UM HIR is to focus research and publication efforts on increasing the number of papers in Quartile 1 (Q1) quality journals indexed in the Web of Science. Publishing in these top-quality journals gives these quality research papers the potential to be read by the international research community.

UM saw the greatest increase in output of Q1 journals papers in the period from 2011 to 2015 which helped UM's volume of papers performing in the Top 10% of their field see a 243% increase and those in the top 1% of their field see a 566% increase from the period of 2007 to 2010 to the period of 2011 to 2015.

02

Having a strong performing base of research can give universities the power they need for impact. The marked increase in output of Q1 journal papers in the period from 2011 to 2015 helped UM's research impact (as measured by Category Normalized Citation Index CNCI) surpass the world average of 1.0 from a CNCI of 0.77 in the 2010 to a CNCI of 1.12 in the year 2014.

03

Strategic and strong research collaboration through academic and industry networks is key to driving research impact. The collaborations forged by UM during the period of 2011 to 2014 have led to a 363% increase in productivity in the top three collaborated countries (United Kingdom, United States of America, Australia) from the period between 2007 to 2010 to the period between 2015 to 2018. The rates of production in quality Q1 journals papers in these countries also increased over the same timeframes leading to significant improvements in their research impact.

Apart from country and industry level collaborations, partnering with elite and influential researchers from Ivy League universities have not only helped UM improve its research impact and performance, but also built lasting impactful relationships that extend past the initial programme. These partnerships serve as a good foundation for capacity building within the university and improves international visibility of the research from UM.

04

Proportionate amount of investment is needed to drive research and innovation excellence. According to the report *Global Research Report – South and Southeast Asia* published by the Institute for Scientific Information (ISI) in 2019, development of human capital and research environment are two key areas where funding and investments need to take place in order to achieve research and innovation success. The UM HIR Programme is a clear example of how these significant investments have been put in place for successful outcomes. Without enough investments, the successful outcomes of the programme could not have been met.

Glossary of terms and references

Category normalized citation impact (CNCI) is a valuable and unbiased indicator of impact irrespective of age, subject focus and document type. CNCI value of 1 represents performance at par with the global average, values above 1 are considered above world average and values below 1 are considered below world average.

Citations
During examination of patent applications for validity, patent office examiners reference previous patent applications that are relevant – known as the "prior art". These references or citations are exceptionally useful in identifying impactful innovation, as inventions that gather significant citation over time correlate to importance.

Within the report, citation information is used to identify particularly close patent applicants or technology: these analyses rely on a particular type of examiner reference – those that in the examiner's view would invalidate the patent application they are reviewing.

Citation levels are also used, via a frequency calculation, as one factor in the Derwent Strength Index.

Documents in JIF journals
Documents published in a journal found in Journal Citation Reports in a given year.

Documents in Q1 – Q4 journals
Number of documents that appear in a journal in a particular Journal Impact Factor Quartile in a given year.

Highly cited papers
The Highly Cited Papers indicator shows the volume of papers that are classified as highly cited in the Clarivate Analytics solution solution Essential Science Indicators™ (ESI). Highly Cited Papers in ESI are the top 1% in each of the 22 subject areas represented in the Web of Science, per year. They are based on the most recent 10 years of publications. Highly Cited Papers are considered to be indicators of scientific excellence and top performance and can be used to benchmark research performance against field baselines worldwide.

Impact relative to the world (IR2W)
The indicator is the citation impact of the set of publications as a ratio of world average. This indicator can be applied at the institutional, national, and international level. It shows the impact of the research in relation to the impact of the global research and is an indicator of relative research performance. The world average is always equal to one. If the numerical value of the Impact Relative to World exceeds one, then the assessed entity is performing above the world average. If it is less than one, then it is performing below the world average.

Percentile in subject area
The percentile of a publication is determined by creating a citation frequency distribution for all the publications in the same year, subject category and of the same document type (arranging the papers in descending order of citation count) and determining the percentage of papers at each level of citation, i.e., the percentage of papers cited more often than the paper of interest. A percentile indicates how a paper has performed relative to others in its field, year, and document type and is therefore a normalized indicator.

Percentage of documents in top 1% and top 10%
The percentage of documents in top 1% and top 10% indicator is the top 1% and 10% percent most cited documents in a given subject category, year and publication type divided by the total number of documents in a given set of documents, displayed as a percentage. A higher value is considered to be higher performance.

Patent
A patent is a right, and usually a set of rights in multiple legal jurisdictions, that provides for a time limited period of exclusive use (typically 20 years) of the technologies described in the patent specification. In return, the applicant of the patent must fully disclose how to use, make or build their invention.

For a patent to be valid (noting some variation depending on jurisdiction) it must be novel (not previously disclosed or in use), must not be obvious to someone with average skill in the technology and must have a real-world use.

It should be noted that there are different varieties – shorter term “utility models”, design patents etc.

Patent rights usually must be maintained via periodic payment of a fee, otherwise the right will lapse.

Dates (patent)
Patent rights, in their various jurisdictions, have many dates associated with them – the date of filing of the first registration (known as the priority filing), the date of publication of an application, the date of publication of a granted, issued patent etc.

For consistency, all dates in the report use the earliest “priority” year (the first date) of the patent family / group of patent rights surrounding the same invention. However, a restriction exists – patent applications generally remain unpublished after this date by up to 18 months; therefore the most recent years may have incomplete information.

Derwent strength index
The Derwent Strength Index assesses the number of desirable characteristics a single invention has gathered so far to date. This is then aggregated across technologies and entities to identify trends and importance. The Strength calculation uses several factors in its model, including:

1. Frequency of citation, referencing impactful of the technical invention

2. The breadth of geographic filing, correlating to variation in cost and investment in patent protection

3. Existence and location of granted, issued patent rights, a proxy for validity as well as commitment

4. The invention’s technical breadth, correlating to the range of industry which the invention maps on In addition, the Strength Index also models the value of inventions over time as well as weighting for factors that accrue over time, e.g. existence granted patent rights

Document counts (patent)
Patented ideas are registered locally within individual legal jurisdictions to provide local protection rights, e.g. US patent rights, Swiss, British, Japanese etc. However, each of these duplicate related filing events surround a single invention or idea, measurement of which would provide a distorted output.

For the purposes of decision support and consistency, all analyses in the report use a single definition of "unit of innovation" – the Derwent World Patents Index patent family. This is synonymous with "invention".

As the landscape is designed to measure innovation activity, and not simply IP rights, all analytics in the report (unless directly mentioned) include both pending applications, granted patents; as well as abandoned or lapsed applications and granted patents.

Grant/allowance
Most patent applications do not issue as granted patents. The rate of issuance, or allowance rate is determined by a number of factors: applicable patent law within each legal jurisdiction for patent validity e.g. the novelty level of the invention within each application, whether it is considered obvious to someone of average skill in that technology, whether it has a real world use as well as other statutory or judicial restrictions.

In addition, applicants regularly do not pursue their patent application to granted status, as it may be uneconomic, or the purpose of the application was not to acquire a granted patent but to prevent others from doing so.

References and background reading
Secretariat Of High Impact Research Universiti Malaya. (2016). University Of Malaya High Impact Research Final Report August 2011-June 2016. https://www.um.edu.my/high-impact-research

Adams J, Pendlebury D, Rogers G, Szomszor M. (2019). Global Research Report – South and Southeast Asia

Adams J, McVeigh M, Pendlebury D, Szomszor M. (2019). Profiles not metrics

Johari, ZK. (2015) 'Budget 2016 makes many sector cuts, education badly hit', Malaysiakini (https://www.malaysiakini.com/news/319638)

Malaysia Ministry of Education. National Higher Education Strategic Plan (PSPTN) 2007-2020 UM Strategic Plan of 2016-2020. Universiti Malaya. (https://ppsg.um.edu.my/strategic-planning)

Reference sites
University of Malaya Centre of Innovation & Commercialization (UMCIC). https://umcic.um.edu.my/success-stories

BioApps Sdn Bhd. http://bioapps.com.my/

UMCH Technology Sdn. Bhd. http://www.umchtech.com/

Aurigene Discovery Technologies. http://www.aurigene.com/

Data extraction dates
Web of Science/InCites data on 17 July 2019.

Derwent Innovation data on 1 August 2019.

Scientific literature researcher:
Ms Dju-Lyn Chng
Solution Consultant
Web of Science Group

Patent researcher:
Ms Ridhma Dhar
Solution Consultant
Derwent Group

Consulting researcher:
Dr. Tan Hsiao Wei
Head of Research Management
Policy & Strategy Unit
Universiti Malaya

Mr. Lee Inn Beng
Director of Government and Strategic Engagements
Clarivate Analytics

Special thanks:

Ms. Claris Liew
Account Manager, Academic
Web of Science Group

Dr. Anthony Dona
Solution Consultant ANZ
Web of Science Group

Ms. Geeho Liu
Director, Solution Consulting
Clarivate Analytics

About the Web of Science Group

The *Web of Science Group*, a Clarivate Analytics company, organizes the world's research information to enable academia, corporations, publishers and governments to accelerate the pace of research. It is powered by the *Web of Science* – the world's largest publisher-neutral citation index and research intelligence platform. Its many well-known brands also include *Converis*, *EndNote*, *Kopernio*, *Publons*, *ScholarOne* and the *Institute for Scientific Information (ISI)*. The 'university' of the Web of Science Group, ISI maintains the knowledge corpus upon which the index and related information and analytical content and services are built; it disseminates that knowledge externally through events, conferences and publications and it carries out research to sustain, extend and improve the knowledge base. For more information, please visit webofsciencegroup.com.

Contact our experts today:

+1 215 386 0100 (U.S.)
+44 (0) 20 7433 4000 (Europe)
+65 6775 5088 (Singapore)
+81 3 4589 3100 (Tokyo)
+86 10 5760 1200 (Beijing)
+61 2 8587 7636 (Sydney)

webofsciencegroup.com