



GLOBAL RESEARCH REPORT **MIDDLE EAST**

EXPLORING THE CHANGING LANDSCAPE OF
ARABIAN, PERSIAN AND TURKISH RESEARCH

FEBRUARY 2011

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FOREWORD

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This report has been published by
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ISBN: 1-904431-27-5

As this Global Research Report from Thomson Reuters summarizes, scientific research in the Arabian, Persian and Turkish Middle East lags that of the West. Of course, there are individual scientists from the region who produce world-class research and there are institutions and nations in the Middle East which make significant contributions in certain fields. In fact, the publication and citation indicators described herein show some encouraging trends for the region during the last decade. But naturally one asks, "Why have Arab, Persian and Turkish scientists as a group underperformed compared to their scientific colleagues in the West?"

It is too simplistic to say that there is a singular cause, such as a (false) distinction between faith and reason. From a genetic point of view, Muslims are no different from anyone else. There is surely no ethnic or geographic monopoly on intelligence. Historically, Muslims in Spain, North Africa, and Arabia were at the peak of their civilization when Christian Europe was in the Dark Ages. But what is more important is the modern history of what happened in the Arab, Persian and Turkish world. What happened in the last century? First of all, there was colonization, which installed a class and caste system of the governing elite from or allied with the outside; for example: the British Empire. The result: a huge population of illiterate peasants. Illiteracy reached 50%. For women it was as high as 80%. With this level of illiteracy, when colonization ended after World War II, what did these countries do? They looked first West, then East, to the superpowers for help. And when there was no progress in terms of economic development, after the Cold War, there was only one other place left to look: up. And that search for answers has been exploited by some to politicize faith and religion.

It goes without saying that the developing world should help itself. The Middle East must not think it is incapable of competing with developed nations in science and technology. I have written about this subject and have called for a new education jihad for acquiring useful knowledge. But in addressing the gap in performance, one cannot fail to bear in mind a history that has resulted in large populations of frustrated people who lack real opportunity. Many college graduates today in the Middle East are without jobs. What are their options? All their energy

must not be allowed to be diverted into fanaticism and violence. Unlike the rest of the world – facing a silver wave – the Arab world is facing a youth wave. These young people can achieve great things in science, if they are given a chance.

I see three essential ingredients for progress. First is the building of human resources by eliminating illiteracy, ensuring active participation of women in society, and improving education. Second, there is a need to reform national constitutions to allow freedom of thought, the minimizing of bureaucracy, the development of merit based systems, and the creation of a credible – and enforceable – legal code. Finally, the best way to regain self-confidence is to start centers of excellence in science and technology in each Muslim country to show it can be done, to show that Muslims can indeed compete in today's globalized economy and to instill in the youth the desire for learning. Several new centers of advanced education and research and development in the region represent such efforts. I am encouraging the development of a University of Science and Technology in Egypt with the same goal.

And what can the developed world do? It can partner with Middle Eastern nations to improve their research capabilities. In terms of aid, developed countries should focus assistance. Usually an aid package is distributed among many projects, with a lack of follow-up leading to diffusion of resources so that the aid does not really have significant impact. Real focus can be achieved by establishing what I call partnership-guided aid, with a significant fraction of assistance being directed to programs of excellence using criteria set by the developed nations. There must also be a minimization of politics in aid. The use of an aid program to help specific regimes is a big mistake, in my view. Developed nations can either give money as charity or – and this is better – they can become partners, providing expertise and a follow-up plan.

Such partnerships aimed at improving science and technology in the Arabian, Persian and Turkish Middle East are in the best interests of both the developed and developing worlds since they will significantly contribute to peaceful coexistence and a more civilized and truly global humanity.

Further reading from the work of A Zewail:

"Curiouser and Curiouser: Managing Discovery Making," *Nature*, 468: 347, November 17, 2010 (<http://www.nature.com/news/2010/101117/full/468347a.html>)

"The US Needs a New Soft Era," *The Guardian*, July 11, 2010 (<http://www.guardian.co.uk/commentisfree/cifamerica/2010/jul/11/soft-power-us-middle-east>)

"Science as a Shaper of Global Diplomacy," *Los Angeles Times*, June 27, 2010 (http://www.zewail.caltech.edu/LA_Times.pdf)

"We Arabs Must Wage a New Form of Jihad," *The Independent*, August 24, 2006 (<http://www.independent.co.uk/opinion/commentators/ahmed-zewail-we-arabs-must-wage-a-new-form-of-jihad-413101.html>)

Voyage Through Time: Walks of Life to the Nobel Prize, World Scientific, 2002.

OVERVIEW • JAMES WILSDON

At Thuwal, on the shores of the Red Sea, a radical experiment is now entering its second year. This is the King Abdullah University of Science and Technology (KAUST), a flagship investment by the Saudi Arabian royal family, which is intended to usher in a fresh era of scientific discovery in the Middle East. With an endowment of around US\$ 20 billion, KAUST by 2020 aims to attract 250 faculty and 2,000 postgraduate students from across the world. And ambition is not KAUST's only distinctive feature. In a country where women's rights are tightly restricted, the campus is co-educational, women are allowed to drive and many choose not to wear the veil. The university's founding principles include a commitment to 'nurture and protect freedom of research' and to 'provide researchers the freedom to be creative and experiment.'ⁱ

In Qatar, at Education City, a 2,500 acre campus on the edge of Doha, seven US universities have opened campuses, including Carnegie Mellon, Weill Cornell Medical College and Texas A&M. Alongside these sits the Qatar Science and Technology Park, which numbers Shell, Rolls Royce and Imperial College among its tenants. Just down the road, the US\$8 billion Sidra Medical and Research Centre will open in 2012. In a country flush with gas revenues, with a population of just under 1 million people, the task of reorienting society towards education and scientific inquiry is substantial. To engage the Qatari public, downtown Doha is dotted with brightly colored billboards urging people to 'Think', 'Create' and 'Dream'.

Abu Dhabi is pursuing a different path: attempting to capitalize on its energy expertise to secure a more sustainable economy. At the core of this strategy is the Masdar Initiative, which will eventually house 50,000 people and 1,500 businesses focused on renewable energy and sustainable technologies.ⁱⁱ Abu Dhabi's leaders argue that such investments are critical if they are to maintain their status in the energy sector, while reducing their long-term dependency on hydrocarbons. And Masdar is attracting powerful partners. Companies like Credit Suisse and Siemens are backing the US\$250 million Masdar Clean Tech Fund. Six leading research institutions, including Imperial College and Columbia University, are part of the Masdar Research Network.ⁱⁱⁱ

These are just three examples of the rapidly changing context for science and innovation in the Middle East. As this timely report

RESEARCH OUTPUT

The Islamic world has a deep history of scholarship and scientific research. It has arguably the oldest institution that might be deemed a multi-faculty university, founded in the 9th century at Fez in Morocco. Libraries in Islamic countries preserved much of classical learning during the European Dark Ages. Islamic scholars in mathematics, astronomy, medicine, and other sciences created a critical platform of knowledge into the Middle Ages.

Against this backdrop, the research investment (R&D spend compared to GDP) and capacity (researcher numbers compared to population) of the 57 member states of the Organisation of the Islamic Conference (OIC) are running at just one-quarter of world averages according to the journal *Nature*^{iv} and the Royal Society of London's recent report.^v

But the Royal Society also pointed to a changing future in its report's title 'A new golden age' because the rate of investment

from Thomson Reuters sets out, there are striking developments across the region, in terms of research policy, investment and outputs. The progress of Turkey and Iran is particularly impressive.

To analyze and make sense of these changes, the Royal Society has teamed up with a consortium of partners (including the Organisation of the Islamic Conference, Qatar Foundation, British Council, Nature and the International Development Research Centre) to produce an Atlas of Islamic-World Science and Innovation, which will be published in 2012 (see <http://royalsociety.org/aiwsi>).

Of course, bricks and mortar are in many ways the simplest part of any scientific investment. The long-term success of initiatives such as KAUST, Education City and Masdar will rest on their capacity to develop a pool of high quality, locally trained graduates and faculty members. Sustained investment in all levels of the education system is required. Primary and secondary schools must be equipped with quality staff able to inspire students to pursue further academic study. Graduates need a vibrant research and entrepreneurial community in which to pursue rewarding careers if they are not to be tempted overseas.

And the Middle East faces particular challenges in spreading the benefits of such flagship investments more widely. In a recent speech at the Royal Society, HRH Princess Sumaya Bint El Hassan of Jordan, commented that "Multilateralism is not a great strength of the Arab World. It is barely a reality. Resource-rich countries spend vast amounts on building a gleaming infrastructure for research and development, but the nurturing of true innovation requires more than dollars....Our resource-rich countries must work with talent-rich, and resource-poor economies for the benefit of all."

So despite the encouraging progress shown in this report, the path to a more innovative Middle East is not without obstacles. By better understanding what is going on within the region, and nurturing collaboration with scientists in Europe, the United States and elsewhere, science can become a force for progress and a platform for building trust. This report is a welcome contribution to that task.

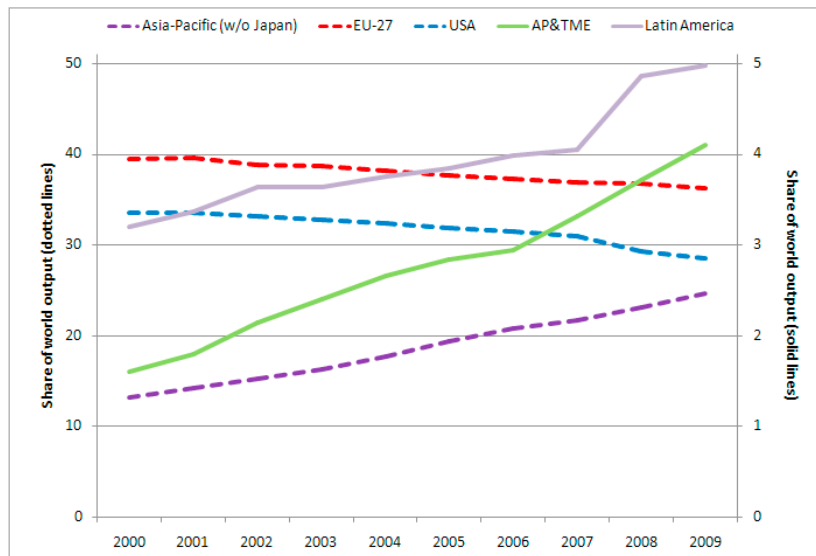
and growth in research in these countries is showing signs of dynamism seen in other countries on which we have reported, such as Brazil^{vi} and China^{vii}. The multi-faceted growth of research in Iran, for example, has been highlighted in annual reports to the UK government on the international comparative performance of the UK research base^{viii}.

In the development of our series of Global Research Reports, it has been our intention for some time to describe the state of the research base in the Islamic world. However, we shared with the Royal Society a problem in defining our scope since 'Islamic countries' are, in fact, global. For this report, because we want to look at national interactions (as we did in our Africa report^{ix}) as well as actions we have chosen to be geographically restrictive.

This Global Research Report covers the Arabian, Persian & Turkish Middle East, whereas the Royal Society reported on a

FIGURE 1

Regional changes in share (%) of world outputs recorded on *Thomson Reuters Web of Knowledge*SM. Note that the left-hand axis for the established regional economies has a scale ten times that for the emerging economies on the right-hand axis.



Source: Thomson Reuters Web of KnowledgeSM

regional AP&TME grouping have increased their share of world output from less than 2% to more than 4% in the last decade. The volume of world output indexed by Thomson Reuters increased from around 760,000 to over 1,160,000 publications in the same period, so the region is taking a growing fraction of an expanding pool.

The region gained on Latin America, which is also expanding rapidly. While much smaller than the Asia-Pacific group (note that Japan, as a mature research economy is excluded from this aggregation), the AP&TME group is actually growing faster – as the diverging lines indicate. Meanwhile, both the EU-27 and the USA^x are losing share (but not volume) against this dynamic competition.

This overview is an informative indicator of research expansion, but is this a pervasive pattern across countries in the region? The 14 nations in this report vary a great deal in size, in wealth (measured as GDP in absolute and relative terms) and in the current development of their higher education and research system. Figure 2 summarizes some of those relativities.

FIGURE 2

Countries in the Arabian, Persian & Turkish Middle East scaled according to their five-year publication output (2005-2009) with an indication of their relative wealth as GDP per capita population



Source: Thomson Reuters Web of KnowledgeSM

much wider network across the OIC that ranges into South America as well as Asia. The 14 countries which are covered here by Thomson Reuters are:

Bahrain, Egypt, Iran, Iraq, Jordan, Kuwait, Lebanon, Oman, Qatar, Saudi Arabia, Syria, Turkey, United Arab Emirates, Yemen

We recognize that definitions of regions will differ and apologize to those who find this unduly restrictive or too broad. Below, we abbreviate the group name to AP&TME.

The countries differ in geographical size, in population and in their economies. They also form an evident global region, which interfaces with the European Union (EU), with Africa, with Russia and its former satellites, and with Asia. They are thus in a good position to benefit from their own potential to grow through their national investments, through the emergence of a regional network and through their collaboration with partners in neighboring regions. This report looks at all these characteristics.

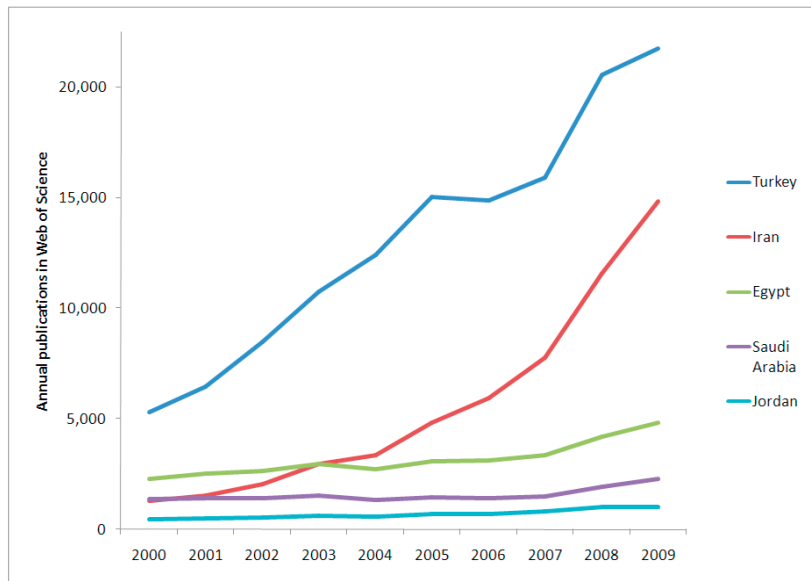
Figure 1 shows that the fourteen countries in our regional AP&TME grouping have increased their share of world output from less than 2% to more than 4% in the last decade. The volume of world output indexed by Thomson Reuters increased from around 760,000 to over 1,160,000 publications in the same period, so the region is taking a growing fraction of an expanding pool.

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FIGURE 3

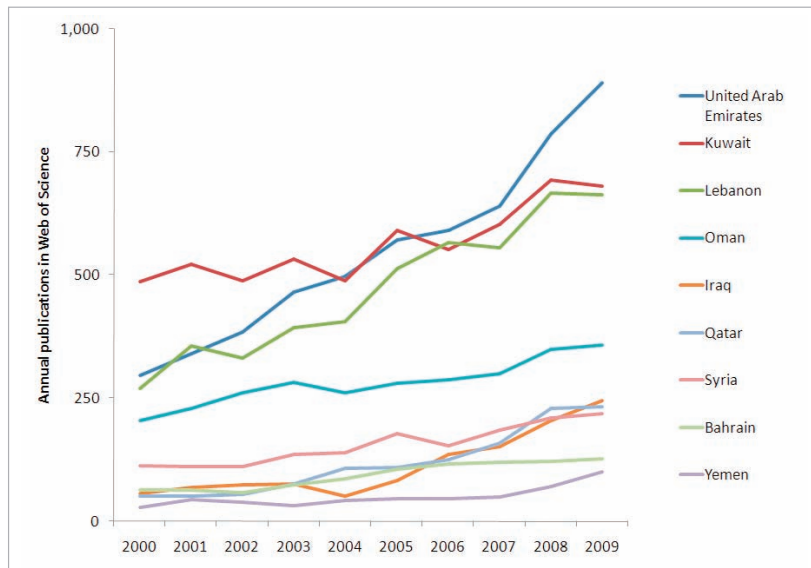
Annual research publication output of the five most prolific countries in the Arabian, Persian & Turkish Middle East. Turkey and Iran, two of the five countries that produce more than 1,000 papers annually, also show a marked annual growth rate. Egypt, Saudi Arabia and Jordan have a substantial output but this is not growing at the same rate as the two leading countries.



Source: Thomson Reuters Web of KnowledgeSM

FIGURE 4

Annual research publication output of nine less prolific nations in the Arabian, Persian & Turkish Middle East. Although current annual output is below 1,000 papers per year for these countries, growth rates are rising. This is particularly noticeable for the United Arab Emirates



Source: Thomson Reuters Web of KnowledgeSM

Turkey produces about half of the region's research articles and reviews, of which medical research makes up its biggest single discipline. Iran produces about one-quarter of regional output, Egypt slightly less than one-eighth, Saudi Arabia about half as much as Egypt and Jordan about half as much again. These five collectively account for more than 90% of total AP&TME research publications. The five nations smallest in research productivity cannot easily be displayed on this diagram: Syria, Qatar, Iraq, Bahrain and Yemen produced about 3,000 publications over the period.

For the purposes of research analysis, the nations assort into two groups. First, five countries produced more than 1,000 papers annually indexed on Thomson Reuters Web of KnowledgeSM over the last few years. Second, there are nine countries with somewhat smaller output. Figures 3 and 4 illustrate the annual production of papers for these two groups for the years 2000 to 2009.

Among the larger producers, Turkey's predominance is strikingly evident, as is its steep rise from just over 5,000 papers in 2000 to nearly 22,000 in 2009. Iran, meanwhile, although starting from a lower point with roughly 1,300 papers in 2000, has displayed a similar trajectory following a notable surge after 2004. By 2009, Iran's output approached 15,000 papers. The rest of the world, as noted above, has been expanding as well. Nonetheless, Turkey's share of world output nearly tripled from 0.7% in 2000 to 1.9% in 2009 while Iran's share grew phenomenally from less than 0.2% to 1.3% over the same decade.

Egypt and Saudi Arabia display a flatter trajectory for most of the ten-year period. Although both have increased in recent years, and Jordan, too, is trending upwards, it is not immediately apparent from Figure 3 that Jordan has doubled its 2000 output and that these three countries have increased world share by around one-third. With significant investment in higher education and research now forecast, further growth is easy to predict.

Among the smaller-producing countries (Figure 4), the United Arab Emirates earn the distinction of the highest 2009 total, at just below 900 papers, with a notably steep progression in annual production since 2000. Even among the nations in the graph's lower reaches, there are instances of substantial progress in output. Qatar, for example, increased from 51 papers in 2000 to more than 230 in 2009, with Iraq on a similar course. Iraq, Qatar and Yemen more than doubled their – still small – share of world output between 2000 and 2009. These relative changes from a low base are a signal of the huge potential for scientific activity in the region.

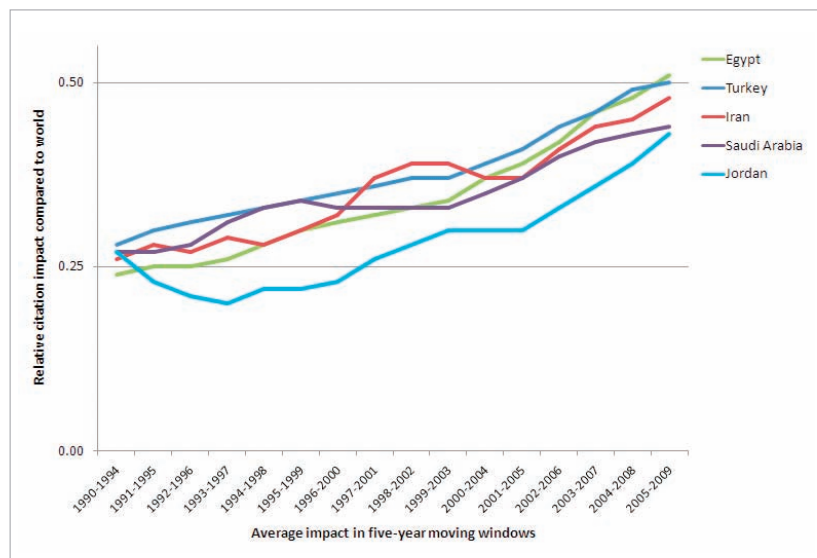
WHAT IS THE IMPACT OF THIS RESEARCH?

Investment in higher education and research builds up a country's knowledge capacity, its ability to use discovery and innovation to create economic wealth, and its potential to realize benefits in health, culture and the quality of life. The increases in output that reflect the growing level of investment will not immediately be translated into world-class research because it will take time to train a new generation of researchers. It will also take time to draw the quality of the new research to the attention of the rest of the world.

That said, we can already begin to see strong signals of improving research impact among the five most productive nations in the region, where there is a reasonable volume of data. In order to get a handle on

FIGURE 5

The Relative Citation Impact of the five most publication-prolific countries in the Arabian, Persian & Turkish Middle East, tracked in five-year overlapping periods since 1990. Although the average citation impact of much of the research in the region remains below world average (which is set at 1.00) it is evident that the impact trend is upwards for all these countries.



Source: Thomson Reuters Web of KnowledgeSM

research ‘excellence’ we have used the frequency with which publications are cited by later works as an index of their impact on the rest of the research community. Citation rates vary by field and citation counts grow by year, so the actual citation count is adjusted (or normalized) for both discipline and year of publication by comparison with a relevant world average, drawn from the same *Thomson Reuters Web of KnowledgeSM* data, to give a Relative Citation Impact index (where world average = 1.00).

The five countries tracked in Figure 5 had a citation impact around just one-quarter of world average citation impact (normalized at 1.00 in these analyses) at the start of the 1990s, whereas by the end of the period of analysis they had risen to around one-half of world average. And note that this is only an *average* impact which will hide a wide variance. The region is producing a growing number of exceptionally highly-cited research publications, as we show below.

WHERE IS THE REGION FOCUSED?

For an overall gauge of research concentration among the 14 countries covered by this report, their collective output in main scientific fields was combined into a single block. Table 1 (below) lists those fields on the basis of the group’s percentage of world output in each field for the years 2005 to 2009, with the left-hand columns, by way of comparison, showing their output and percent share over an earlier five-year period, 2000 to 2004. The right-most column provides a rank number for each discipline (of the 21 main fields covered according to the classification scheme in *Essential Science Indicators*) based on its rate of growth, in number of

papers, between the two five-year periods.

The greatest world share for the region in the 2005-to-2009 period is in engineering, with agricultural sciences not far behind. Growth in the latter field has also been pronounced, ranking in the top-five-highest increases in paper output recently. The fields of clinical medicine and chemistry also show comparatively high absolute and relative representation from the group, although growth in these two fields has been more modest. Mathematics, computer science and – especially – microbiology have seen substantial growth since the earlier five-year period. And, although ranking lowest of any of the fields shown here in terms of percent share, the social sciences – a diverse category – have actually evinced the highest growth, albeit from a comparatively low starting point.

From this broad view of collective concentration on the part of all the selected nations, we can sharpen our focus to the five highest-producing nations. An analysis of the fields in which each of the largest producers has contributed to the internationally influential journal literature for the period 2005-2009 reveals some common areas of focus and a few that appear specific to a particular nation.

Overall, Egypt, Jordan, Iran, Turkey, and Saudi Arabia show a common focus in the fields of engineering, agricultural sciences, chemistry, pharmacology, materials science, and mathematics, roughly in that order. But there are many differences in research concentration worth noting. Egypt exhibits a focus in physical sciences, with the exception of its largest share in pharmacology. Iran also emphasizes the physical sciences. Jordan’s largest world share is in environmental sciences and ecology. Saudi Arabia and Turkey contribute the most of the five nations in clinical medicine, but Saudi Arabia’s top field in world share is mathematics, whereas Turkey’s is agricultural sciences.

When one examines highly cited papers – defined as those that rank in the top 1% by citations for their field and year of publication – a related picture appears. Of Iran’s output in mathematics, some 1.7% attained highly cited status for the period 2000-2009. The same figures for Saudi Arabia, Jordan, and Egypt are 1.5%, 1.5%, and 1.0%, respectively. In engineering, 1.5% of Turkey’s output qualified as highly cited, whereas 1.3% of Iran’s did. Among all fields, mathematics and engineering typically ranked first or second in the percentage of highly cited papers for each of the five nations.

Thus, these two fields exhibit both a relative volume focus and high achievement in terms of highly-cited papers. This is consistent with other analyses. In terms of Relative Citation Impact, all five nations exhibit some of their highest scores in mathematics and engineering. In fact, Egypt and Saudi Arabia exceed the world average in citation impact in mathematics, and Turkey does so in engineering.

TABLE 1

Fields of research ranked by global share (% of world output on *Thomson Reuters Web of Knowledge*SM) for 2005-2009 held by the group of 14 nations in the Arabian, Persian & Turkish Middle East. Note that growth rates (the difference between the five-year periods 2000-2004 and 2005-2009) are not dependent on the current world share. The research portfolio is dynamic.

2000-2004		Field	2005-2009		Rank of this field by ...	
Count of papers	Share (%) of world		Count of papers	Share (%) of world	World share	Recent growth
10,811	3.46	Engineering	23,712	5.41	1	9
2,389	3.20	Agricultural Sciences	5,756	5.13	2	5
23,977	2.81	Clinical Medicine	47,201	4.37	3	14
13,288	2.70	Chemistry	25,200	4.07	4	17
4,132	2.31	Materials Science	9,651	3.90	5	7
5,184	2.26	Plant & Animal Science	11,120	3.83	6	11
2,472	3.37	Pharmacology & Toxicology	3,591	3.62	7	21
2,010	1.98	Mathematics	4,986	3.56	8	3
2,191	2.15	Environment/Ecology	4,676	3.24	9	12
1,653	1.61	Computer Science	4,063	2.90	10	4
2,119	1.89	Geosciences	3,967	2.67	11	19
6,171	1.56	Physics	11,852	2.40	12	16
765	1.12	Microbiology	1,928	2.20	13	2
3,055	1.20	Biology & Biochemistry	5,869	2.07	14	15
1,408	1.07	Neuroscience & Behavior	3,046	1.97	15	10
1,088	0.70	Social Sciences	4,399	1.93	16	1

Source: *Thomson Reuters Web of Knowledge*SM

TABLE 2

Global share of research output (% world papers on *Thomson Reuters Web of Knowledge*SM) for the five most research-prolific countries in the Arabian, Persian & Turkish Middle East, analyzing the fields in which they are individually best represented.

Turkey		Iran		Egypt		Saudi Arabia		Jordan	
Field	Percent	Field	Percent	Field	Percent	Field	Percent	Field	Percent
Agriculture	2.87	Engineering	1.71	Pharmacy	0.71	Mathematics	0.32	Environment	0.16
Medicine	2.84	Chemistry	1.68	Materials Sciences	0.66	Engineering	0.31	Engineering	0.15
Engineering	2.22	Materials Sciences	1.19	Chemistry	0.64	Medicine	0.26	Agriculture	0.15
Plant & Animal Sciences	2.17	Agriculture	1.19	Engineering	0.57	Pharmacy	0.22	Mathematics	0.13
Environment	1.82	Mathematics	1.16	Agriculture	0.48	Materials Sciences	0.19	Pharmacy	0.12
Materials Sciences	1.67	Pharmacy	1.05	Physics	0.40	Geosciences	0.16	Chemistry	0.11
Chemistry	1.34	Plant & Animal Sciences	0.93	Microbiology	0.35	Chemistry	0.15	Computer Sciences	0.11
Mathematics	1.30	Computer Sciences	0.79	Geosciences	0.34	Computer Sciences	0.15	Geosciences	0.10
Pharmacy	1.29	Physics	0.76	Plant & Animal Sciences	0.32	Physics	0.14	Plant & Animal Sciences	0.09
Neurosciences	1.25	Medicine	0.60	Mathematics	0.31	Microbiology	0.13	Medicine	0.07
All fields	1.70	All fields	0.87	All fields	0.36	All fields	0.17	All fields	0.08

Source: *Thomson Reuters Web of Knowledge*SM

Of Iran's output in all fields, 0.48% is highly cited. If we compare that to the definition of highly cited papers as the global top 1%, then we see Iran produces about half of what would be expected for parity. Similar figures for the other nations are: Turkey 0.37%, Jordan 0.28%, Egypt 0.26%, and Saudi Arabia at 0.25%.

COLLABORATION

The expanding network of research collaboration has become a predominant feature of the global research base, as we have noted in previous Global Research Reports. Nations increasingly draw on one another's expertise and share costs and resources by working together, enabling the rapid sharing and exploitation of new knowledge.

An analysis of interactions between nations in the Arabian, Persian & Turkish Middle East reveals a lower level of collaboration than is generally true elsewhere. Some nations, such as Egypt, Jordan and Saudi Arabia are relatively frequent research collaborators with around 40% of their domestic output having one or more co-authors from another country and, usually, another country in the region is among the more frequent partners.

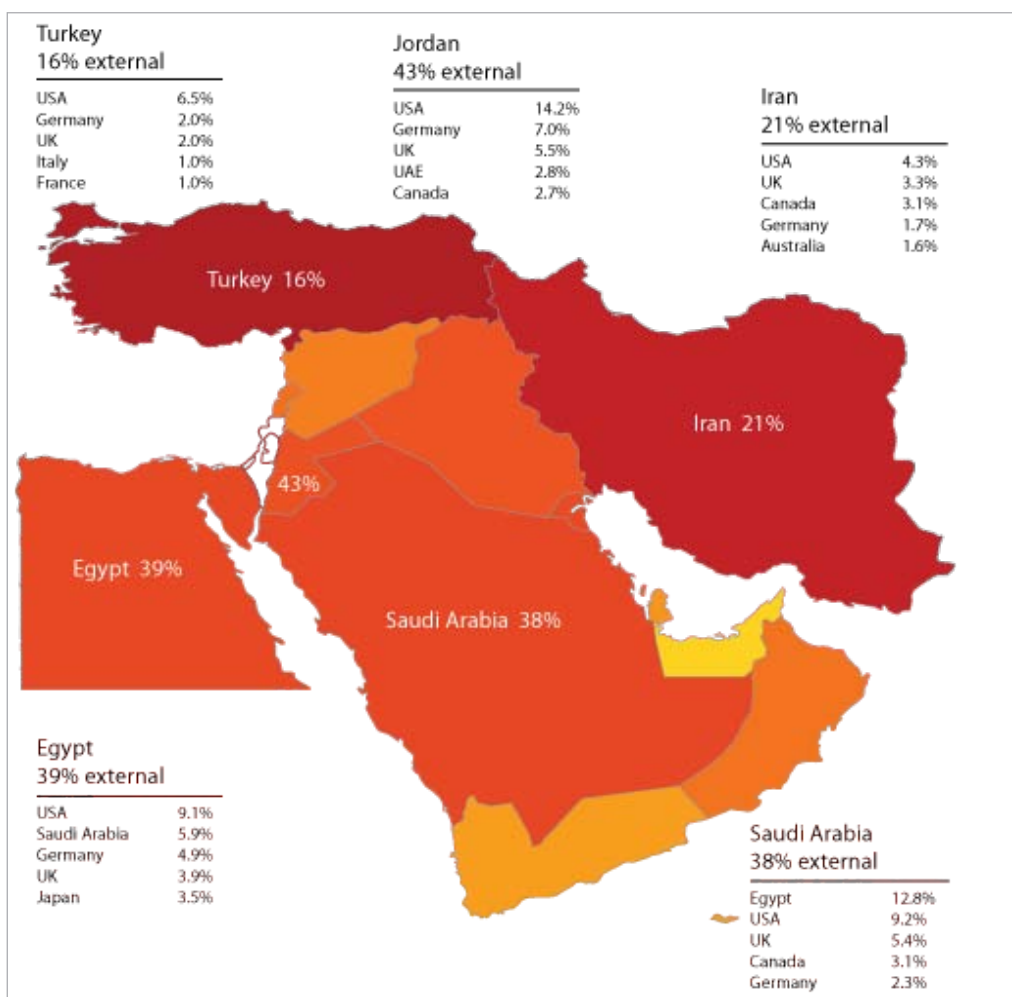
Iran and Turkey have much lower levels of collaboration than do Jordan, Egypt, and Saudi Arabia, while Syria, Yemen, Oman and Qatar have particularly low levels of research linkage to other countries. This suggests that much potential remains to expand collaborative partnerships, which would further enhance the current growth trends and might also be an effective mechanism in enabling the less research intensive areas of the region to develop in partnership with more mature neighbors.

In the region, as appears to be true almost universally, the most frequent collaborative partner in research is the USA. An important exception is the link between Saudi Arabia and Egypt. For Saudi Arabia, Egypt is clearly the most frequent partner while for Egypt (as we noted in our Report on Africa) Saudi Arabia is a key partner ahead of all but the USA.

While Jordan is the most collaborative nation, Egypt appears to hold a pivotal role in linking within the region as well as into Europe, North Africa and to the USA and Japan. For all nations, the UK and Germany are also frequent partners, reflecting both the attractiveness of their domestic research quality and their substantial capacity for internationally collaborative research partnerships.

FIGURE 6

Top collaborating partners for the five most prolific research publishing nations in the Arabian, Persian & Turkish Middle East. Color intensity reflects research output volume, with deeper colors corresponding to greater output. The numbers in each country refer to the percentage of national output that has an international co-author. Note that the figure of 43%, near the centre of the map, refers to Jordan (table at top of map).



Source: Thomson Reuters Web of KnowledgeSM

SUMMARY

Historically, the Islamic world is widely recognized as having contributed signally to the foundation of much of the world's understanding of science. However, the region has featured less prominently during the modern era. The data reported here show a region where research still lags significantly on its European and Asian neighbors but which is also showing a powerful – though patchy – resurgence.

Ahmed Zewail identified three essential ingredients that would address the gap in performance for the Middle East, and he placed the development of human capital as the first of these. The research environment, strongly promoted through universities free to pursue their own programs of thought and innovation, is critical to this. James Wilsdon drew attention to some of the portfolio of exciting developments that are now translating this ambition into reality. The resources that the region can deploy are enormous and the potential for achievement and innovation is vast.

The analysis in this report presents a complex picture, and the contrasts are very marked. There is very rapid growth for some nations, notably Turkey and Iran, but there are still very low levels of research activity and output elsewhere in the region. That means that the possibility of a regional network of collaborative endeavor is unrealized, because there is simply insufficient capacity in some countries to engage even locally. Levels of collaboration are, for most of the region, well below those that are now being seen in Europe and Asia. So, there is much still to be put in place.

Ahmed Zewail also talked of partnerships as a route to development – not only regional partnerships but links to the rest of the world. The good news is that this need not be about diffuse aid – an issue of concern – because the rest of the world should be able to identify emerging centers of excellence. For Iran, 1.7% of its publications in mathematics were ranked in the global 1% most highly-cited: well above global average. For Turkey, 1.5% of its engineering output met the same criterion. Although national average citation impact may lag behind world averages, there is a growing volume of excellence that will undoubtedly enable further growth of high-quality capacity.

Agriculture, plant & animal sciences and environmental science are increasingly well represented. Cutting-edge biotechnology is less evident, but the growth of the well-resourced new institutions will surely mean that these fields too will soon be seen to build research capacity in the region.

It is difficult, and perhaps unnecessary, to provide any simple summary of the current state of the research environment across the Arabian, Persian & Turkish Middle East. Institutional growth and development will surely transform the emerging strengths of the last decade into a new reality. It is essential that this should not only deliver top-end research but also create more robust educational and social transformation through human resource capacity. How widespread that change becomes and how it translates into different research fields will be an interesting narrative to follow. Given the rich human capacity and available resources of the Arabian, Persian & Turkish Middle East, as well as the clear evidence of improvement for Turkey and Iran presented here, one may hope to see further advances in science and technology for the region in the future.

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