

CALL FOR AN INDUSTRIAL-GRADE OVERHAUL

Saudi institutions are making great technological strides, but the country's business community must change its approach to make possible a true innovation culture.

BY NADIA EL-AWADY

The city of Dhahran on Saudi Arabia's east coast owes its existence to oil. Established after the resource was discovered in the region in 1938, Dhahran is home to Saudi Aramco, the world's largest oil producer. The state-owned company employs more than 55,000 Saudis.

But change is coming to the country that oil built. Falling prices have landed Saudi Arabia with a huge budget deficit — nearly US\$100 billion, or 15% of the country's gross domestic product (GDP), in 2015. Deep cuts in public spending have resulted in the reduction of public sector wages and higher education funding (see page S64). Many of the kingdom's leaders believe that the country cannot continue to function at the whim of the global oil market. Among them is Crown Prince Mohammed bin Salman, who in April 2016 announced the Vision 2030 strategy, a plan to diversify the Saudi economy.

While continuing to recognize the oil and gas industry as one of the “essential pillars” of the kingdom's economy, the plan highlights the manufacturing, technology, mining, tourism and leisure industries as promising sectors for investment. “The Saudi addiction to oil has disturbed development of many sectors in past years,” said Prince Mohammed as he introduced Vision 2030. To fund these investments, Saudi Aramco is being disentangled from the government's auspices in readiness for a listing on the stock market that the prince expects to be the “biggest IPO in history.”

The changes aim to maintain Saudi Arabia's position as one of the world's richest economies as measured by GDP per capita, and the country's research institutions see a supporting role for themselves. Saudi Arabian institutions have made among the greatest improvements anywhere in the world in

recent years, and the country has positioned itself as the dominant force in Arab science (page S62). But the kingdom's science, technology and innovation plan, developed by its national science agency, King Abdulaziz City for Science and Technology (KACST) in Riyadh, demands more. As well as calling for increases in peer-reviewed research output, the agency has also set ambitious targets for the number of jobs generated by university start-ups, and the number of patents issued in the country.

A kingdom-wide effort to capitalize on the commercial value of research institutions' academic achievement is underway, and evidence of progress is apparent. For Saudi Arabia's research institutions to fully play their part in the future national economy, the rest of the country must change with them.

PANNING FOR OPPORTUNITY

King Fahd University of Petroleum and Minerals (KFUPM), inside the walls of Saudi Aramco's employee community in Dhahran, seems particularly well placed to contribute to the kingdom's economic diversification.

Established in 1963 as a specialized research university, KFUPM began in 2006 to focus on the commercial value in their academic work. Their vision was to build an environment that would be conducive to the development of new technologies, says Iyad Alzaharnah, the university's director general of innovation and industrial relations. “It's an ecosystem model that links technology to the economy and enables the advancement of individual technologies to the point of commercialization,” he says.

The first step in making their vision a reality was to strengthen the university's intellectual property (IP) portfolio. To increase the number of patent submissions, KFUPM established

an IP management system that allows the university to scan theses and studies for commercial potential before they are published. They also cultivated an innovation culture within the institution, raising awareness of the role of the products of research in a knowledge economy and providing instruction on patenting and technology transfer. They also developed a reward system, through which financial spoils of commercialization are shared with faculty and researchers.

The other important step came in 2006, when KFUPM established a science park called Dhahran Techno Valley. This park is home to all KFUPM's technology transfer, innovation and entrepreneurship efforts. It's also the site of research and development (R&D) centres of 16 multinational corporations, including General Electric, Honeywell and, of course, Saudi Aramco. For Alzaharnah, who complained that “local industries do not invest in R&D”, attracting these businesses to Dhahran was crucial to providing the infrastructure required to support technology entrepreneurship. “Dhahran Techno Valley has become a nucleus for a knowledge economy hub, through which we are now able to start our technology commercialization activities,” says Alzaharnah.

The hard work seems to be paying off. KFUPM researchers co-authored 617 natural science articles in 2016, 11 of which appeared in the selection of high-quality journals monitored by the Nature Index. That's enough for fifth place in the index's ranking of Saudi institutions by weighted fractional count (WFC). But in the same year, KFUPM was granted 121 patents — considerably more than any of the research institutions that outperform it academically.

Its 90 US utility patents in 2016 see it ranked

20th out of all the world's universities granted US utility patents that year. Utility patents prevent the copying of the way inventions work and are used, as opposed to design patents, which protect the way they look. For context, the University of Pennsylvania in Philadelphia was granted 92 US utility patents in 2016, but it had 624 articles appearing in Nature Index-monitored journals. The only other Middle Eastern and North African universities to appear in the top 100, as determined by the US-based National Academy of Inventors and the Intellectual Property Owners Association, are Saudi Arabia's King Saud University (36) and Umm Al-Qura University (97), and Israel's Tel Aviv University (43), Technion-Israel Institute of Technology in Haifa (53) and the Hebrew University of Jerusalem (87).

Patenting prowess alone, however, is not a complete measure of commercial success because not everything that is patentable is commercially viable. The numbers of all patents issued to KFUPM worldwide rose from 4 in 2007 to 139 in 2015, but numbers dipped slightly in 2016 — a decline Alzaharnah attributes to a fall in invention disclosure numbers two years earlier as a result of the university introducing stricter quality control measures. “We started reviewing invention disclosures more thoroughly, looking into their market potential and technological readiness,” he says. Faculty embraced the new approach once they grasped its significance, he adds. “They learned to consider commercial potential when they conduct their research and when they write an invention disclosure.” KFUPM is in the process of commercializing about 20 different patents, Alzaharnah says.

SPIN-OFF SUCCESS

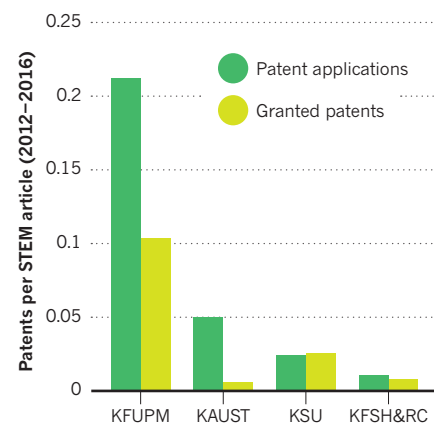
KFUPM takes a variety of approaches to commercializing its technologies. Sometimes, patents are licensed to local or multinational companies. One of its earliest patented technologies, a catalytic cracking process that allows refineries to produce higher yields of petrochemicals from heavy oils, is now the subject of a joint venture between South Korea and Saudi Aramco. It is expected to enter production by the end of the year.

Another important way in which universities seek to commercialize their research is by investing in start-ups. King Abdullah University of Science and Technology (KAUST) in Thuwal is a private research university on Saudi Arabia's western Red Sea coast. Founded in 2009, it is among the world's 20 fastest rising universities in the index, and already Saudi Arabia's leading research institution by WFC (see page S62).

KAUST was granted just 22 patents during the last academic year, small in comparison to the 121 issued to KFUPM in 2016. Considered together with its strong research output, it works out roughly as one patent for every 56 natural science papers published by KAUST authors.

CAPITALIZING ON RESEARCH

KFUPM has by the far the strongest ratio of patents to papers in Saudi Arabia. Between 2012 and 2016 it produced one patent application for every 4.7 STEM articles it published. A granted patent at KFUPM comes along every 9.6 articles. At KAUST, which leads the way in academic terms, 180 papers were published for each patent on average.



This may in part be due to the university's youth; the number of patents granted to KAUST has more than doubled in each of the last three years. But when it comes to supporting start-ups, KAUST appears much stronger. In its first seven years, 29 start-ups have been incorporated at KAUST (compared to just three each at KFUPM and King Faisal Specialist Hospital and Research Centre), and it funds another 40. The KAUST Innovation Fund mainly provides seed funding, though larger sums have been provided to sustain early-stage companies. It also doesn't just focus on home-grown inventions: “The fund invests in KAUST spin-outs, but it also actively looks at international early-stage technology companies,” says Nicola Bettio, the director of the KAUST Innovation Fund.

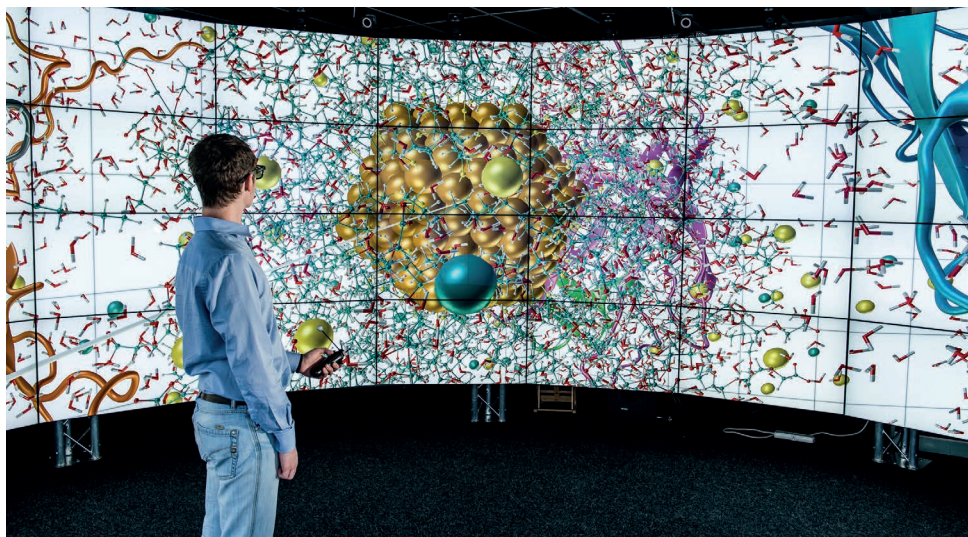
Amongst the companies KAUST has supported is Visual Experience, a virtual reality

start-up launched in 2015 with \$150,000 seed funding provided by the university. “Visual Experience started with the idea to bring the holy sites of Saudi Arabia closer to people that cannot afford to travel there,” explains co-founder Peter Rautek, a KAUST researcher specializing in augmented and virtual reality. He and his team brought 360-degree panoramic video of the holy city of Mecca straight to mobile phone screens for the first time, and have since begun selling virtual reality content to Saudi business customers, as well as developing an innovative folding version of Google's popular Cardboard virtual reality viewer. The company was named by *Forbes Middle East* as one of the most promising Saudi start-ups in 2016. “We are developing partnerships in Europe and the US to sell our mobile virtual reality viewer to a larger market,” Rautek says.

Another KAUST-supported start-up to be named by *Forbes Middle East* in 2016 is NOMADD Desert Solar Solutions. Founded in 2012, it produces an automated system for cleaning solar panels without water, invaluable in water-scarce Saudi Arabia where, according to the company, dust storms can reduce the energy yield from solar farms by 60%. NOMADD has been supported by KAUST from the start — the university hosts it on its research park, has provided entrepreneurial training, and in June 2016, NOMADD secured \$1 million from the KAUST Innovation Fund.

Other Saudi Arabian universities are also viewing start-ups as vehicles for commercializing their research. The investment arm of KSU in Riyadh, for instance, touts an investment portfolio of 10 companies, based both locally and abroad, working in the areas of health-care, information technology, and renewable energy. And King Faisal Specialist Hospital & Research Center (KFSH&RC), also based in Riyadh, has three spinoffs to its name.

One of those came less than a year ago, when KFSH&RC used its expertise in genetic



Visualization of molecules at KAUST's NexCave VR facility.

testing to launch a next-generation sequencing (NGS) lab able to diagnose hereditary and metabolic diseases. The centre's geneticists are experienced in interpreting genetic variants, especially those related to the kingdom's highly consanguineous population, explains KFUSH&RC geneticist, Fowzan Alkuraya. The team has built a database of pathogenic and benign variants from the local population, and are experienced in preparing accessible reports for clinicians.

"Our expertise in variant identification is something I've always seen as a huge business opportunity," says Alkuraya. In the past, sequencing had to be done outside the country: "there wasn't a single NGS lab in the region," he says. Alkuraya and his colleagues convinced the business investment arm of KFUSH&RC to enter the NGS market by investing in their knowhow and variant information. The lab has sequenced more than 2,000 samples in its first year, with many institutions in the region making use of the new lab, says Alkuraya.

KFUSH&RC has bolstered its technology transfer activities, developing a comprehensive framework of policies for intellectual property management and commercialization, says Khalid Abu Khabar, deputy executive director of KFUSH&RC's research centre. Among these policies are generous arrangements for the sharing of revenues from patent licenses and related activities. "This should lead to increased patent filing activities and direct scientists' thoughts to the importance of innovation," says Abu Khabar.

UNDERSTANDING THE CHALLENGES

Despite the momentum provided by the countrywide push to mobilise knowledge to support the economy, establishing KFUSH&RC's start-ups was slow, says Abu Khabar. Launching spin-off companies in Saudi Arabia has also proven tough for KFUPM: "We are weak in the area of start-ups," Alzaharnah concedes.

A major difficulty is finding entrepreneurs willing to invest the time and effort to turn a promising research project into a commercial venture. The problem is neatly illustrated by a novel water desalination system that KFUPM researchers have developed in collaboration with the Massachusetts Institute of Technology (MIT) in Cambridge. Rather than trying to commercialize the technology (an energy-efficient version of humidification-dehumidification system) in Saudi Arabia, it has been licensed to a start-up in the US for purifying water produced from unconventional oil resources, such as rock (oil shale) and sand (oil sands). "When the results started appearing, the ecosystem here was not ready," says Alzaharnah. "The entrepreneurs were ready from the MIT side, the venture money was there in Boston, the engineering infrastructure was there," he says. "Now we are working on a project to customize this technology and bring it back to Saudi Arabia."

"THE KINGDOM'S INDUSTRIES NEED TO BE GIVEN STRONGER INCENTIVES."

The lack of an existing culture of innovation within Saudi Arabia may now be the country's biggest challenge. The Global Innovation Index (GII), a co-publication of the Cornell SC Johnson School of Business, INSEAD business school, and the World Intellectual Property Organization, ranked Saudi Arabia's innovation capabilities 55th out of 127 world economies in 2017. The kingdom outperforms the

average for high-income countries in terms of the quality of its local universities, says Rafael Reynoso, lead researcher of the GII. It also ranks highly for the state of its cluster developments, such as KFUPM's Dhahran Techno Valley. Overall, however, the report finds Saudi Arabia's innovation is below that expected based on its level of development.

The kingdom's industries need to be given stronger incentives to invest in R&D, Alzaharnah says. "If Saudi Arabia wants to advance the size of its economy and its impact," he says, "then Saudi industries must spend more on R&D."

Attracting the investors required to get technology start-ups off the ground can be difficult. Business leaders surveyed by the World Economic Forum in 2016 said access to financing was one of the biggest obstacles to doing business in the country, alongside restrictive labour regulations and an inadequately educated workforce.

Alzaharnah believes a Saudi venture capital industry is crucial. "We need to understand how venture capital and angel investment industries were created in Boston and in California," he says. He advocates the example set by the US, developing a regulatory and financial system that encourages the growth of venture capital and angel investment industries "that invest in soft assets in science and technology rather than in real estate."

Saudi Arabia's plan to diversify its economy and reduce its reliance on oil hinges on whether these cultural changes can be achieved. Some Saudi institutions are competing with the very best in the world by some measures of technology transfer, and promising start-ups leave no doubt that there is marketable research going on. But these institutions cannot transform the country operating in a vacuum. An entrepreneurial spirit may not be easy to teach, but if Saudi Arabia's transition is to be successful, it needs to find one. ■



Filming at Mecca for a 360 degree video to be streamed.



Genetics researchers at the research center at King Faisal Specialist Hospital.