Start-ups at the Azadi Innovation Factory in Tehran, established in 2017. Azadi covers an area of 18 500 m^2 and provides employment for 3 500 university graduates and young entrepreneurs. Start-ups cover a range of fields that include architecture and urban living, artificial intelligence, biotechnology, creative content, cybersecurity, fintech and insurance, nanopharmaceuticals and tourism. © Vice-Presidency for Science and Technology of Iran

AT A GLANCE

- Combined with heightened domestic demand, the multiplication of technology incubators and accelerators since 2015 has led to exponential growth in knowledge-based firms and start-ups.
- Between 2014 and 2017, exports of knowledge-based goods grew by a factor of five, before slumping in 2018 following the restoration of US sanctions.
- A series of laws and policies adopted since 2015 have removed barriers to competition and enhanced the financial support system for innovation.
- Market incentives have not managed to boost overall commercial investment in research and development (R&D), however, which dipped from 35% to 28% of domestic expenditure on R&D between 2014 and 2016.
- The 39% unemployment rate among university graduates suggests a pressing need to adapt academic programmes to the needs of the job market.
- Despite attempts to boost domestic manufacturing and employment, the renewable energy sector still contributes less than 1% of the energy mix.

15 · Iran

Shuan Sadreghazi

INTRODUCTION

Five roller-coaster years

The previous *UNESCO Science Report* (Ashtarian, 2015) detailed Iran's plans for gradually weaning its economy off oil resources to accelerate the transition towards a knowledge economy. Events over the intervening years have incited the government to pursue this transition with greater ardour. The most visible expression of this policy is the heightened support for start-ups and other tech-based firms, which has stimulated innovation.

This trend can be divided into two stages. Up until the lifting of sanctions in 2016, the difficulty in accessing foreign technology had stimulated support for endogenous innovation. The government had put in place a number of policy instruments to support innovation, including the pivotal National Innovation Fund[1] (2012) and Nanotechnology Initiative Council (2002). It had also encouraged companies to source their materials from local suppliers as part of what it called the 'resistance economy' (Ashtarian, 2015).

Following the lifting of sanctions by the United Nations, USA and European Union (EU) in early 2016, in keeping with the *Joint Comprehensive Plan of Action*, or nuclear deal, agreed with six major powers[2] the previous year, Iranian scientists and engineers enjoyed greater exposure to foreign state-of-the-art technologies. For instance, the nuclear deal entitled Iran to submit a formal request to participate in a project[3] that may revolutionize energy production, if successful; this project is building an International Thermonuclear Experimental Reactor (ITER) in France. A team from ITER visited Iran in November 2016 to deepen its understanding of Iran's own nuclear fusion-related programmes (Coblentz, 2016).

Heightened exposure to foreign state-of-the-art technologies has added momentum to endogenous creativity. However, scientific interaction with the international community was curtailed in 2018 when the USA withdrew from the nuclear deal, shortly after the International Atomic Energy Agency (IAEA) had certified that Iran was in compliance with the agreement.

US sanctions were immediately restored and subsequently extended. The EU has attempted to preserve the nuclear deal by introducing an Instrument in Support of Trade Exchanges (INSTEX) for companies wishing to do business with Iran.

The re-imposition of sanctions has also penalized Iranian academics and students. In 2018, the international payments–transfer system known as SWIFT disconnected Iranian banks. This means that Iran-based academics and students are unable to pay conference registration fees or order books on international websites. Concerned at the prospect of unwitting violation of the sanctions, many journals and publishers have become reluctant to handle manuscripts signed by Iranian authors or entities (Kokabisagh *et al*., 2019).

Long-established scientific exchanges between Iran and the USA have also dried up since 2017. For example, workshops set up by the US National Academies of Sciences, Engineering and Medicine between 2010 and 2017 to bolster collaboration in fields that included energy and water resource management have been cancelled (Tollefson, 2018).[4]

Despite all the challenges, there is a silver lining. The impact of gruelling sanctions on oil exports has placed the potential of the knowledge economy on the government's radar. This was evident even before the previous batch of sanctions was lifted in 2016; however, government support for local knowledge-based companies and start-ups has moved into higher gear in the past few years, as we shall see later.

A body blow to tech exports

Perhaps the most glaring example of the immediate impact of the re-imposition of US sanctions on science and engineering has been the body blow delivered to Iran's burgeoning export market for medium- and high-tech products (Figure 15.1).

Between 2014 and 2017, exports of knowledge-based goods from Iran's science and technology parks and incubators had grown by a factor of five, before slumping in 2018. This decline in exports is associated with the economic problems encountered by companies and their difficulty in sourcing material and selling products after the re-imposition of sanctions.

The restoration of sanctions in 2018 has motivated companies to use local suppliers of knowledge-based goods and services.

Diversification into knowledge-based fields

The past five years have seen a boom in endogenous innovation. In 2015, Iran launched its first public innovation centres and accelerators to empower start-ups. By 2020, 49 innovation accelerators had been established with private equity and 113 innovation centres had been set up in partnership with science parks and major universities. Technology incubators,[5] meanwhile, have been providing graduate entrepreneurs with co-working spaces and mentoring on campus to help them launch their own start-up.

The government has been encouraging start-ups to diversify into various knowledge-based fields, with emphasis on developing local solutions and addressing the needs of industry. Since 2018, the Vice-Presidency for Science and Technology has published a series of books on global experiences in 20 tech-based fields, to alert entrepreneurs to opportunities for innovation. These fields span waste management, agriculture, water management and drought, air pollution, sports and physical health, digital health, social innovation, energy, tourism, insurance, education and mining.

Meanwhile, some large private companies have been diversifying their investment portfolios. Since 2015, they have established a total of 20 start-ups in such strategic fields as the digital economy, water, energy, lasers and photonics, cognitive sciences, aerospace, software, creative industries, agriculture and transportation. A prime example of this diversification is PersisGen, a specialized accelerator (Box 15.1).

By 2019, Iran had risen through the ranks from 106^{th} (2015) to 61^{st} out of the 129 countries featured in the Global Innovation Index (Figure 15.2).

Local drug production peaks

Iran's research strengths lie in biotechnology and nanotechnology. By 2018, there were 524 active biotech companies in Iran and sales of locally produced nanoproducts had increased twelve-fold in just three years (Figure 15.2). Iran's output in terms of publications on health leapt by 64% between 2012 and 2018, according to the Scopus database.

Local pharmaceutical production has climbed rapidly since 2015. The domestic market was worth US$ 4.5 billion in 2018,[6] with 70% of pharmaceutical companies being locally owned. By 2019, Iran was able to produce 95% of medicines destined for the domestic market, including two-thirds of their active ingredients.[7]

Iran exported pharmaceuticals to 17 countries in 2019, a considerable portion of which went to the EU. EU imports from Iran even peaked in the first half of 2019 at € 18 million, with Germany taking 92% of the stock, according to Eurostat (FDD, 2019). Iran's own imports of European pharmaceuticals amounted to € 320 million in 2019, about the same level as in 2014 (Ghasseminejad and Adesnik, 2019).

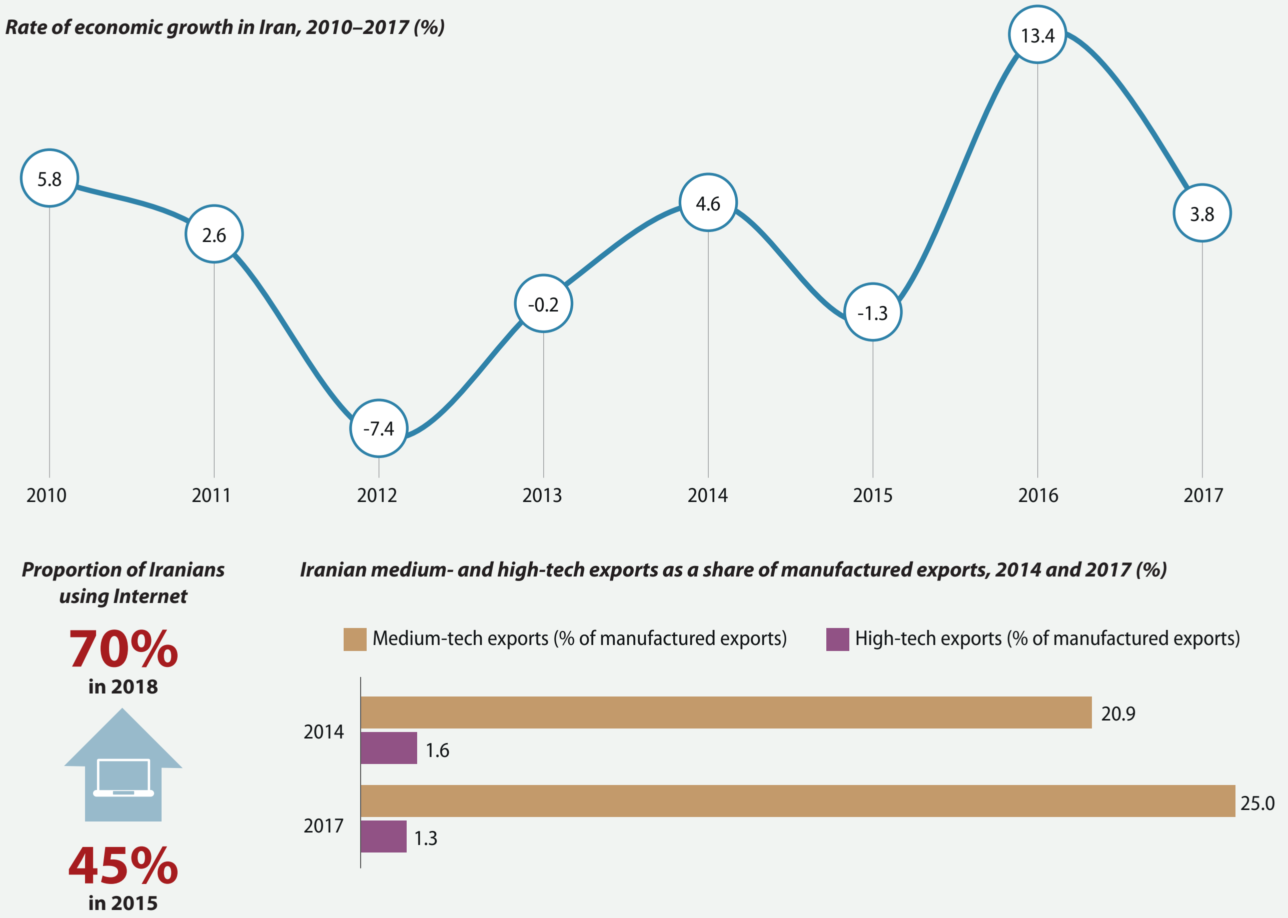
The volume of Iran's pharmaceutical exports had reached US$ 80 million by March 2018 before dropping back to US$ 50 million over the next 12 months (Financial Tribune, 2019).

A short-lived economic rebound

Endogenous innovation has been supported by the economic rebound triggered by the lifting of international sanctions in 2016. Iran posted growth of 13.4% that year and 3.8% the following year, equivalent to about US$ 447.7 billion (Figure 15.1). In the course of the first semester of 2017, recovery extended to the non-oil sector, facilitated by astute monetary and fiscal policies and a boom in the services and construction industries.

According to the Iranian Statistical Centre, the unemployment rate[8] had fallen to 10.6% by March 2020, showing a decline of 1.7% over the previous year, although the rate remained higher for youth and women, at 25.7% and 17.2%, respectively. Four out of ten university graduates are unemployed (39%), up by five percentage points since 2019.

Figure 15.1: **Socio-economic trends in Iran**



Source: World Bank's World Development Indicators (May 2020)

A broad mobilization against Covid-19

In 2020, the economy was ravaged by the Covid-19 outbreak. As Iranians were preparing to celebrate the Persian New Year in mid-March 2020, the number of confirmed cases was approaching the 30 000 mark. Iran has since scaled up its initial response to the crisis and improved co-ordination between government agencies and municipal bodies. In late March, Iranians began repurposing the country's production capacity for the manufacture of domestic personal protection equipment such as masks and hand sanitizer to meet the shortfall.

The National Innovation Fund and Vice-Presidency for Science and Technology also provided support for knowledge-based companies' Covid-19 response. Businesses were offered low-interest loans, for instance. A campaign was also launched called Corona Plus to incite start-ups to find solutions to the challenges posed by Covid-19. Companies were given financial incentives to help them produce medical equipment ranging from disinfectant and protective gear to ventilators and diagnostic kits, or to develop a cure.

Within a few weeks, the number of its Covid-19 testing laboratories had doubled from 22 to around 40. By mid-May, there were almost 120 000 confirmed cases, according to Johns Hopkins Coronavirus Resource Center.

A report by Iran's Parliamentary Research Centre (2020) has estimated that between 2.4 and 6.4 million may lose their jobs, at least temporarily, over Covid-19, 70% of whom lack any insurance cover. The government has been urged to take specific measures for vulnerable lower-income groups.

In addition to its significant impact on sinking oil prices – the government's main source of income – the Covid-19 outbreak has restricted exports of goods to Iran's neighbours. According to the the Central Bank of Iran, more than half of the country's income comes from regional trade channels. Since neighbouring countries closed their borders, Iran's exports have plummeted. In late March 2020, for the first time in six decades, Iran asked for emergency funds from the International Monetary Fund (IMF) to help it handle the situation.[9] The US opposed this request as part of its 'maximum pressure' campaign against Iran.[10]

According to the IMF (2020), GDP shrank by about 5.4% in 2018 and is expected to contract by 8.7% in 2019. The forecasted decline in economic growth would mean that, by the end of 2020, the economy would be 90% of its size just two years earlier, even without the Covid-19 epidemic.

Knowledge-based industries prioritized for support

The government faces the arduous task of cushioning these economic shocks (Hayaty *et al.,* 2018). It will be expected to define effective coping mechanisms for financial services and manufacturing, in particular, since the Iranian economy is characterized by a strong state presence in these sectors.

The government has stepped up efforts to sell its shares in large domestic enterprises, to compensate for the drop in income since sanctions were reimposed in 2018. The budget law for the year beginning on 21 March 2019 forecast revenue of US$ 2.5 billion from privatization.

However, the privatization drive has been encountering some resistance from state-owned companies. There are cases where shares sold on capital markets have been purchased by semi-state-owned entities, or where shares have been transferred to the private sector but not the concomitant responsibility for company management.

Moreover, banks and semi-state-owned enterprises tend to be bureaucratic and to require heavy collateral from start-ups applying for financial support.

The government has made it a priority to cushion the blow of sanctions to its burgeoning knowledge-based industries. For example, since 2018, the National Innovation Fund has been going through a major overhaul; it is evolving from a quasi-banking institution into a regulator and facilitator for financing knowledge-based companies, to help them overcome obstacles in the dominant financial sectors. For instance, the fund is being encouraged to co-ordinate its own programmes with those of other funds for research and technology and with the banking network. The National Innovation Fund is also introducing new investment schemes and streamlining its organizational structure and procedures (NIF, 2019).

For Iranian organizations, obtaining earmarked funds from the state budget does not guarantee that the totality will be

Box 15.1: **PersisGen: Iran's first accelerator for medical biotechnology**

Launched in 2016, PersisGen is a biopharmaceutical company which designs, develops and produces biosimilars, vaccines and plasma-derived products. It also specializes in regenerative medicine throught the use of stem cells.

PersisGen has an accelerator department which is the first of its kind in medical biotechnology in Iran.

The accelerator helps young researchers gain practical skills and establish independent knowledge-based companies. It mentors start-up teams, providing them with technical infrastructure and guidance on prototyping, technology buy-back and investment; it also signs contracts with start-ups for joint product development.

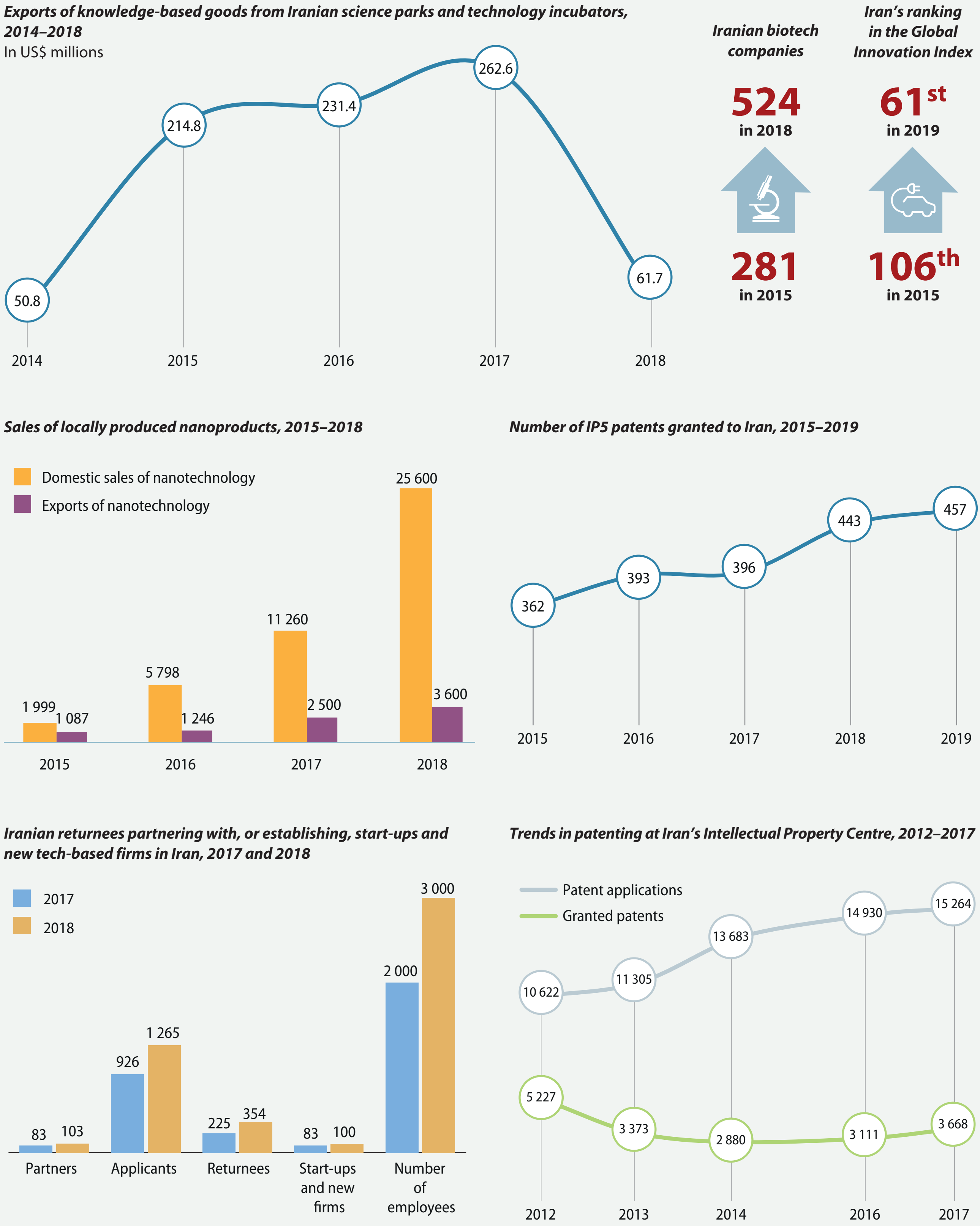
PersisGen is funded entirely through private equity. One of its primary private investors is CinnaGen, a pioneer in Iran's biomedicine industry that was founded in 2003. CinnaGen brings to the table its experience of joint research with the Fraunhofer Institute in Germany.

PersisGen has no foreign shareholders. It is supported by the Vice-Presidency for Science and Technology.

The economic savings for Iran of not having to import medical goods thanks to PersisGen's accelerator are projected to reach US$ 400 million annually by 2025. This forecast should not be unduly affected by the restoration of sanctions, since most of the anticipated production will be destined for the domestic market.

Source: persis.com

Figure 15.2: **Trends in innovation in Iran**



Note: Data are unavailable for 2015.

Note: Technology incubators are called growth centres in Iran. IP5 refers to the US Patent and Trademark Office, European Patent Office, Japanese Patent Office, Korean Intellectual Property Office and State Intellectual Property Office of the People's Republic of China

Source: World Bank's World Development Indicators (May 2020); Iranian Vice-Presidency of Science and Technology's Briefing on Science and Technology; for patents: prepared by Science-Metrix using PatentsView data; Iran Vice-Presidency for Science and Technology (2019); World Intellectual Property Organization; for data from Intellectual Property Centre: Implementation Committee for the National Comprehensive Scientific Map (2019) *Monitoring Report of Science, Technology, Innovation Indicators of the Islamic Republic of Iran*. See (in Persian): https://sccr.ir/Files/7164.pdf effectively transferred to them. By 2020, 87% of the amount destined for the National Innovation Fund had been secured. This fund has played a pivotal role by providing facilities for knowledge-based companies, such as for prototyping, hire-purchase, leasing, working and venture capital, office space, pre-order activities, industrial production plants, issuance of warrants and empowerment programmes.

TRENDS IN SCIENCE GOVERNANCE

A new generation of STI policies

The year 2010 was a turning point for science, technology and innovation (STI) policy in Iran. Up until this point, the emphasis had been on developing higher education and increasing the number of academic publications (1990–2000), followed by support for emerging technologies (2000–2010). The main result of this *first* generation of STI policies was greater academic productivity in emerging technologies, in particular, coupled with the creation of the first science and technology parks.

The founding of the Nanotechnology Initiative Council (2002) was a landmark of this period. These years also saw the adoption of the Competition Act (2007), followed by the establishment of the Competition Council in 2009 to serve as the main pillar of the law's implementation in the marketplace.

The *second* generation of STI policies dates from 2010 when the Vice-Presidency for Science and Technology drafted a bill that was subsequently enacted by parliament as the Law on Support for Knowledge-based Institutions and Companies and Commercialization of Innovation and Inventions (2011). This explicit focus on the knowledge economy was a first for Iran. The National Innovation Fund (2012) was a practical expression of this law. Initally, the aim was to support university spin-offs but this support has gradually expanded to encompass tech-based start-ups and some eligible large enterprises such as CinnaGen or PersisGen, which are privately owned.

The *third* generation of STI policies dates from 2015 when parliament gave another boost to entrepreneurship and innovation through the Law on Removing Barriers to Competitive Production and Enhancing the Financial System. It is this law[11] which led to the first innovation centres and accelerators in 2015.

This law was followed by the *Local Content Requirement Policy* (2016). It introduced a clause requiring international agreements and major national projects to 'include local technology and training.' This clause is now being implemented in national projects.

Another milestone has been the Law on the Expansion of Nanotech Utilization 2025 (2017). This law established a ten-year plan for transitioning from the stage of knowledge creation (technology push) to that of market expansion through the diffusion of nanotechnology in local industry and society (demand pull).

Notable in 2019 was the attempt to modernize public procurement procedures to leverage higher levels of local production, through the Law on Maximizing the Use of Local Capacity for Production and Services to address National Needs and Consolidate these Capacities to Enhance Exports.

Iran's judiciary established the Special Council for Dispute Resolution of Knowledge-based Companies and Elites in January 2020. It is based in Pardis Technology Park. A second council has been set up to address the legal problems faced by digital businesses.

For this third generation of STI policies, the Vice-Presidency for Science and Technology has shifted from a *national innovation system* approach, whereby government actors are the focal points of innovation, to developing an *innovation ecosystem* approach, whereby hubs of knowledge-based enterprises and tech-based start-ups are given support and their innovative capacity is linked to addressing national and industrial needs.

Three-step creation of innovation zones

Policies supporting what are called 'innovation zones' in Iran can also be broken down into three stages. The *first* stage entailed measures encouraging the creation of science and technology parks and incubators on university campuses.

By 2018, universities were hosting 45 active science and technology parks and 193 incubators. Pardis Technology Park is the largest. It hosts about 500 companies with a combined total of more than 6 000 employees. Pardis acccounts for 10% of the income and exports from Iran's science and technology parks.

The *second* stage has consisted in creating spaces within large cities where start-ups, investors and other actors of innovation can mingle and network. Abandoned factories have been renovated and rebranded as 'innovation factories' to house this new generation of entrepreneurs.

The first two innovation factories are Azadi and Highway, established in Tehran in 2017 and 2019, respectively, which are branches of the Pardis Technology Park. The start-ups and accelerators at Azadi and Highway are entitled to access facilities at the Pardis Technology Park.

Azadi (see photo, p.x) covers an area of 18 500 m^2 and provides employment for 3 500 university graduates and young entrepreneurs. Start-ups cover a range of fields that include architecture and urban living, artificial intelligence, biotechnology, creative content, cybersecurity, fintech and insurance, nanopharmaceuticals and tourism (The Iran Project, 2019).

The Highway Innovation Factory can accommodate up to 500 employees. It opened with 20 start-ups working in the field of ICTs, medical devices, management, creative content development and agriculture (Tehran Times, 2019).

There are plans to establish another five innovation factories in large cities by 2022.

At the *third* stage of innovation platform creation, academic centres in urban areas are being turned into third-generation universities, also known as entrepreneurial universities. The aim is to bridge the gap with traditional universities and enhance the position of universities within the overall innovation ecosystem (Parliament Research Centre, 2013).

Sharif Innovation Zone is a prominent example of such an approach. By 2017, more than 500 start-ups had been established by students, graduates and faculty of Sharif University of Technology, according to the Platform Towards Developing Entrepreneurship.

A focus on the digital economy

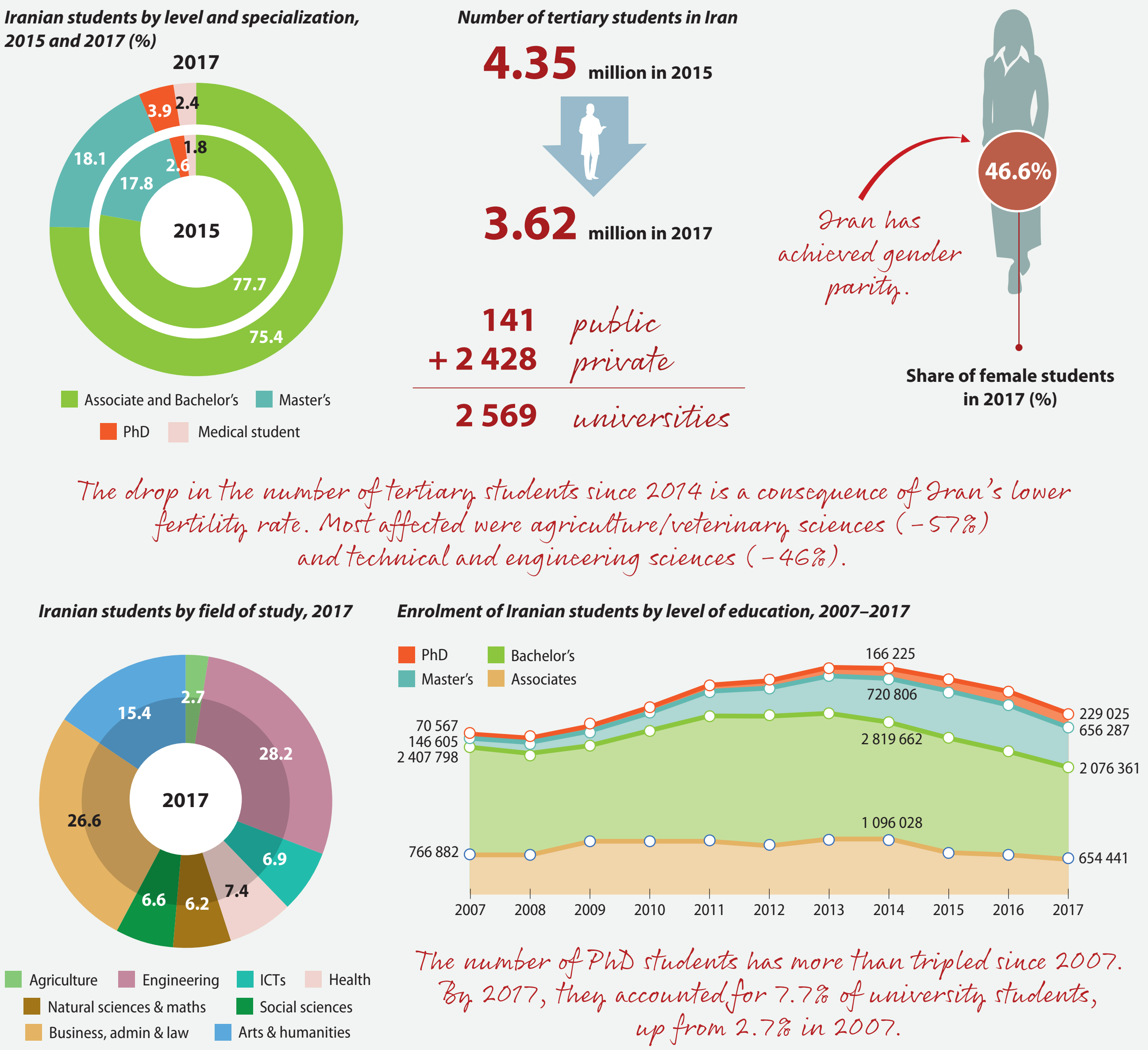
Since 2015, many universities and science parks have organized events to help university graduates develop both technical and soft skills. 'Start-up weekends', 'idea shows' and 'bootcamps' have become common events, with topics ranging from rural entrepreneurship, health, clean air and water to transportation, artificial intelligence, blockchain and cybersecurity. In 2019, the Vice-Presidency for Science and Technology issued an executive directive[12] advising universities to support bootcamps in fields related to the digital economy. Some 23 bootcamps on the digital economy are planned for 2019–2020 for university graduates in digital technologies like artificial intelligence.

The proliferation of these events is a positive sign of support for start-ups from Iran's leadership. However, there are concerns that these events offer little real support beyond awarding prizes and some modest funding. Having a nationwide network of professional mentors in various industries who could interact with start-up teams would help them move on from the gestation phase. Modules for the training of trainers could be developed to guide these mentors.

Sa'di, the famous Persian poet from 7th century, likens an action-less scholar to a honey-less bee. Perhaps Iranian STI policy-makers had this quote in mind when devising policy tools to enhance the impact of the first and second waves of STI policies described above.

For instance, the main outcome of the first and second waves of STI policies was a greater number of university graduates (Figure 15.3) and scientific publications (Figure 15.4) but this, alone, did not boost value creation to any significant extent. This is where the policy tools and

Figure 15.3: **Trends in higher education in Iran**



Source: Statistical Centre of Iran, see: www.amar.org.ir; UNESCO Institute for Statistics

Note: Associate level corresponds to the short-cycle diploma in Iran.

programmes of the third wave come in. By emphasizing ecosystem- and platform-building, they are more likely to yield greater value addition – although it is a bit early to say, at this stage.

These policy tools and programmes seek to empower innovative industries and digital industries. One such programme is IranLab, a start-up which organizes exhibitions of advanced, domestic laboratory equipment and materials where creative firms can meet potential customers. So far, there have been six IranLab exhibitions; there is also a permanent online marketplace for interested customers.

Another programme has been offering Market Support for Locally Built Advanced Machinery since 2018, reflecting the importance of this industry for Iran.

So far, more than 400 companies have benefited from this programme, leading to the manufacture of 600 novel products.

Another policy tool focuses on helping knowledge-based companies commercialize their products. Companies are offered supportive financial mechanisms, such as buyer credit, pre-purchase and prototyping credit. Such measures may be cumulated with other supportive regulatory mechanisms for knowledge-based entities, such as tax exemptions, low-interest financial services, exemptions from customs duty and social welfare insurance.

According to the World Bank (2020), Iran ranks 127th out of 190 countries for the ease of doing business but 178th when it comes to starting a business.

Making it easier for digital firms to do business

In 2016, an executive directive was devised to help the growing number of online businesses overcome bureaucratic hurdles. This led to the establishment of the National Union of Online Businesses in 2017, which provides its members with business licenses and other forms of support. This union has also proven useful for tackling certain regulatory barriers and other obstacles encountered by traditional businesses. For instance, in 2020, a parliamentary working group addressed the challenges faced by e-businesses and online services.

In the past five years, Iran's digital ecosystem has seen a boom in online platforms. For example, there are ride-haililng apps (Tapsi and Snapp), online marketplaces (Digikala, Divar), video streaming (Aparat) and an app-based distribution platform (Café Bazaar). Covid-19 has had a silver lining for Iranian online health and well-being start-ups. Since the outbreak, many new health apps have been advertised on billboards.

The growth in supply and demand with regard to online services correlates with the sharp increase in Internet penetration, especially mobile Internet, which has spiked at 70% in 2020, up from 40% in 2015.[13] Two-thirds (65%) of mobile phone connections now have Internet access.[14]

Giving officials a shrewd 'policy acumen'

Another type of complementary programme pursued more actively in the past few years aims to instil policy awareness and acumen in policy-makers to improve decision-making in prioritized areas of science and technology. Such programmes include the:

- national technology foresight programme (2015) for the energy, automotive, health and water sectors;[15]
- R&D surveys conducted biennially since 2015 by the Statistical Centre of Iran to gauge the level of investment by the business, academic, governmental and non-profit sectors;
- *Iran Innovation Survey* (2016), conducted annually by the Vice-Presidency for Science and Technology; and
- National Science and Technology Monitoring System, introduced in 2015 by the Supreme Council for Science, Research and Technology.[16]

SUSTAINABLE DEVELOPMENT AGENDA

High graduate unemployment

The United Nations' *Sustainable Development Report* (2019) ranked Iran 58th overall out of 162 countries, judging that the country was on track[17] to meet its targets for sustainable industrialization, infrastructure development and innovation (SDG9) but falling behind on climate action (SDG13) and on preserving terrestrial biodiversity (SDG15).

Iran ranks third in the Global Innovation Index (2019) for the percentage of the workforce employed in science and engineering. However, it is evident from the high rate of unemployment (39%) among university graduates[18] that more needs to be done to combine university education with career training; this will be a considerable challenge for a country with such a large talent pool (Figure 15.3).

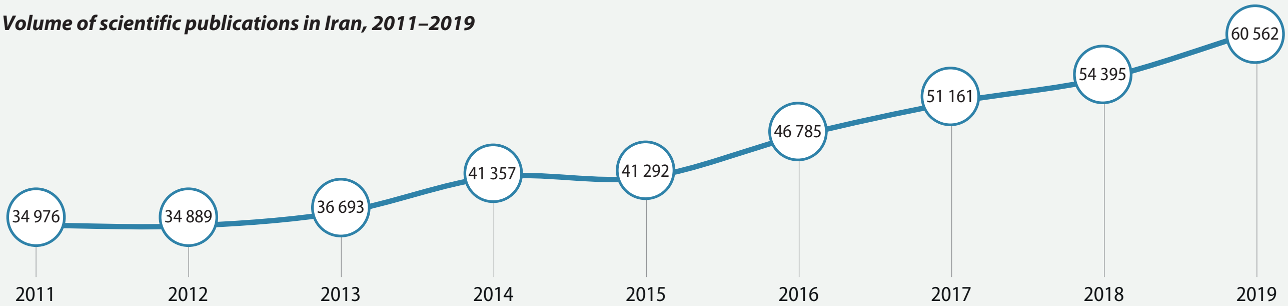
A number of factors explain the extremely high rate of unemployment among graduates. Firstly, there is a lack of statistics and other relevant information on the status of labour supply and demand in various fields of study, making it hard for students to anticipate market needs. This is exacerbated by the lack of co-ordination and communication between organizations and executive agencies in Iran with universities to identify labour market needs.

Universities also tend to rely excessively on purely theoretical education, coupled with weak training in practical and applied fields, especially when it comes to technical, engineering and agricultural disciplines. Universities are also accepting more students in the humanities than the labour market can absorb.

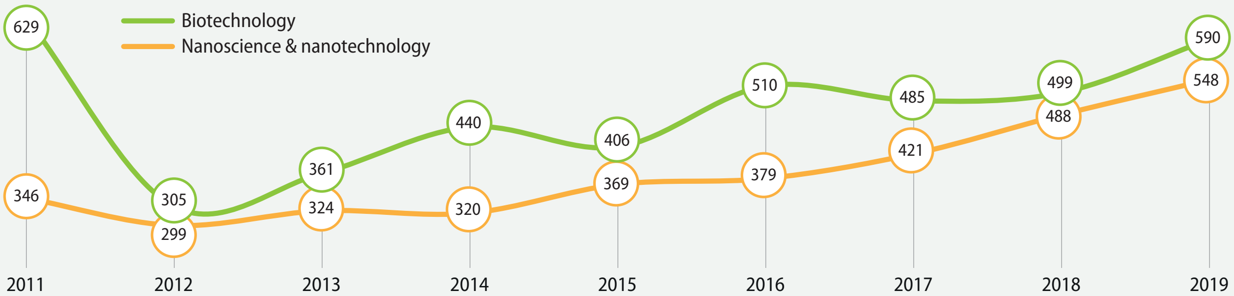
The spread of a culture of credentialism, whereby the obtention of a university degree is considered an end in itself, is not preparing graduates for the harsh realities of the job market. Students are finding that they lack marketable skills or that there are few job opportunities in non-industrial and less developed parts of the country. Upon confronting this reality, many graduates are opting to return to university to pursue a higher degree, in the hope of improving their employability. Habibi (2015) has analysed the phenomenon of graduate surplus and overeducation in Iran, which is also a major issue for other countries in the region.

Figure 15.4: **Trends in scientific publishing in Iran**

Volume of scientific publications in Iran, 2011–2019



Iranian publications in nano- and biotechnology, 2011–2019



Scientific publications per million inhabitants in Iran, 2011, 2015 and 2019

0.94

Average of relative citations for Iran, 2014–2016; the G20 average is 1.02

25%

Share of publications with foreign co-authors in Iran, 2017–2019; the G20 average is 25%

How has output on SDG-related topics evolved since 2012?

Iran published twice as much as expected, relative to global averages, on the topics of smart-grid technology, human resistance to antibiotics, desalination and national integrated water resource management.

The volume of output was also above average for hydropower, wind-turbine technologies and sustainable chemical waste management.

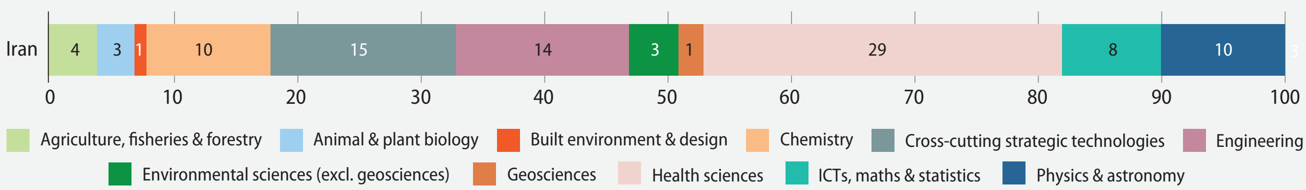
For many of these topics, the number of publications nearly doubled between 2012–2015 and 2016–2019. For example, this was the case for publications on smart-grid technology (from 1 136 to 2 158) and human resistance to antibiotics (from 592 to 1 045).

Output surged for the energy-related fields of greater battery efficiency (from 248 to 635), geothermal energy (from 76 to 171), photovoltaics (from 664 to 1 331) and biofuels and biomass (from 420 to 1 034).

Although output on radioactive waste management remains low, it doubled from 24 (2012–2015) to 53 (2016–2019) publications.

For details, see chapter 2

Scientific publications in Iran by broad field of science, 2017–2019 (%)



Iran's top five partners for scientific co-authorship, 2017–2019 (number of publications)

	1st collaborator	2nd collaborator	3rd collaborator	4th collaborator	5th collaborator
Iran	USA (9 833)	Canada (4 578)	UK (3 859)	Australia (3 673)	Italy (3 586)

The USA is Iran's primary scientific partner.

Source: Scopus (excluding Arts, Humanities and Social Sciences); data treatment by Science-Metrix

Domestic research spending stagnating

In 2017, Iran devoted 0.83% of GDP to gross domestic expenditure on research and development (GERD,[19] Figure 15.5). The National Research Institute for Science Policy had fixed an ambitious target for this indicator of 3% of GDP by the end of the *Fifth National Development Plan* (2011–2017) and 4% of GDP by the end of the *Sixth National Development Plan* in 2021 (Ashtarian, 2015).[20]

The inability to raise the GERD/GDP ratio is considered a major shortcoming of the *Fifth National Development Plan*. This trend is apparently due to the combined effect of an inadequate allocation of state budgets earmarked for research and the lack of interest in the private sector in augmenting its own financial investment in R&D. The plan had foreseen that public–private partnerships with a 50/50 share of investment would fuel demand-driven R&D.

Industrial R&D fell from 35% to 28% of GERD between 2014 and 2016. Visibly, market incentives have not proven strong enough to boost commercial investment in R&D.

The mere 2% increase in the 2020–2021 national budget for research centres and university research institutes makes achieving domestic spending targets any time soon even less likely.

One achievement of the *Fifth National Development Plan* is to have increased the number of research programmes, including joint research projects between Iranian and foreign research institutes. For instance, in November 2019, Iran's Vice-President for Science and Technology travelled to China with 70 knowledge-based Iranian companies to identify Chinese business partners.

A decline in local patenting

The number of patent applications submitted to Iran's Intellectual Property Centre has progressed, even if the number of patents issued locally shows a decline. Conversely, Iranian inventors are obtaining more patents than before from international patent offices (Figure 15.2).

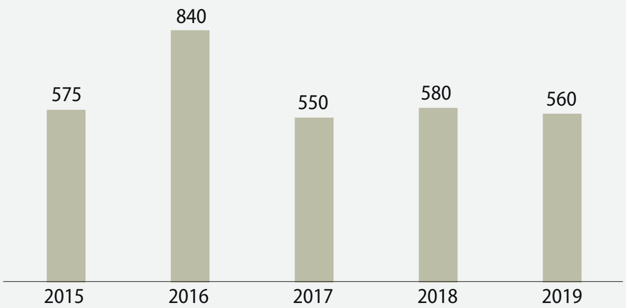
According to the Global Innovation Index, Iran is one of the top three countries for the rate of improvement in innovation. Its most noted accomplishments relate to the quality of infrastructure, particularly as concerns the deployment of information and communication technologies (ICTs) to deliver public services. There have also been improvements reported in expenditure on education, state funding per pupil, patent applications, high-tech imports and exports of ICT services that include software development, telecommunications, film, radio and television recording and broadcasting (WIPO, 2019).

Continued growth in those indicators is, to some extent, the result of co-operation among relevant bodies in collecting

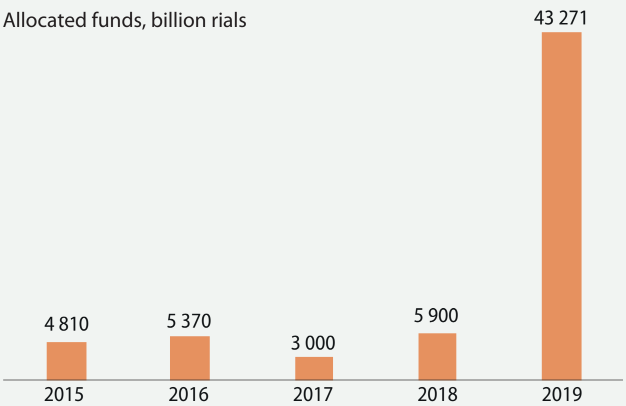
Figure 15.5: **Trends in research expenditure in Iran**

National Innovation Fund support for knowledge-based projects, 2015–2019

Number of projects



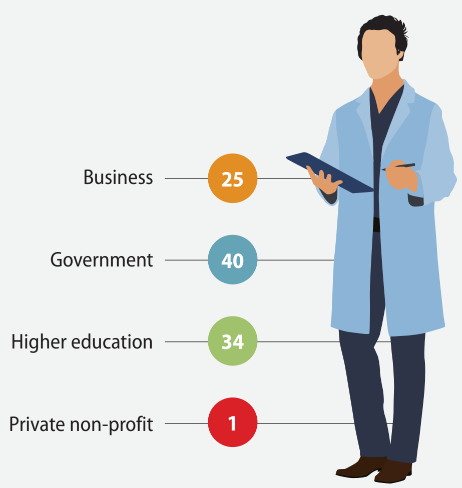
Allocated funds, billion rials



0.83%
GERD/GDP ratio, 2017

PPP$95 790
GERD per researcher (FTE, constant 2005 values), 2017

GERD performed by sector in Iran, 2017 (%)



Banks and credit institutions lent 137.6 trillion rials (ca US$ 850 million) to 1 108 knowledge-based companies in 2019, a 74.5% rise over 2018.

Note: The Vice-Presidency's Office for Science and Technology considers that GERD may be closer to 1% of GDP, based on the report produced by the Iranian Statistical Office (2019). *Report on Executive Bylaw for STI Evaluation and Monitoring.*

Source: NIF (2019); Central Bank of Iran; for GERD: UNESCO Institute for Statistics

Chapter 15

and surveying data and publishing it internationally. This trend continued in 2019, in line with the *Comprehensive Scientific Plan* (2011) and the stance of the *Resistance Economy Council* within the Plan and Budget Organization.

The government is taking a three-pronged approach to improving the quality of scientific output. Firstly, it is gearing support towards the high end of the scale by identifying and supporting top-ranked scientists: 75 in 2017 and 77 in 2019.

Secondly, it is encouraging the diaspora to invest in Iran. So far, more than 1 400 Iranian professionals abroad have joined various local projects and initiatives. The diaspora has also launched more than 100 start-ups employing more than 3 000 skilled staff.

Thirdly, the government is helping Iranian inventors to apply for international patents to give them a greater chance of commercializing their invention.

Air pollution a downside of industrialization

According to the World Health Organization (WHO), Iran performs best in the Middle East for seven SDG indicators, including the vaccination rate and maternal health. Life expectancy at birth in 2016 was 75 years for men and 77 years for women.

The country performs well for the provision of water and sanitation and with regard to public policy on malaria and HIV but seems to underperform when it comes to air pollution.

Air pollution is one of the most visible downsides of Iran's efforts to industrialize and join global production chains. Each winter, periodic peaks in poor air quality cause schools (and sometimes universities) to close in Tehran and other large cities.

WHO recommends a concentration of airborne particulate matter of 2.5 µg/m^3. In 2018, Iran had an average concentration of 25 µg/m^3, with Tehran being the world's 23rd most-polluted capital city (26.1 µg/m^3) [IQAir, 2018]. On a more positive note, along with India, Iran has the greatest number of real-time air quality monitors in South Asia.

In 2016, Iran ranked 105th (out of 178 nations) on Yale University's (USA) Environmental Performance Index. Two years later, Iran had moved up 25 places in this index.

National plans contain measures for environmental protection, such as Act 190 on Green Management of the *Fifth National Development Plan* (2011–2017). However, the enforcement of environmental regulations remains a challenge (Tahbaz, 2016; Nabavi, 2018).

Being able to call upon foreign expertise, in accordance with multilateral environmental agreements, can also make a difference. For instance, a 2017 law stipulates that endangered wetlands must be restored, in line with Iran's obligations under the Ramsar Convention (Box 15.2). In 2018, for the fifth year in a row, Japan funded the ongoing restoration of a major wetland in northwest Iran, Lake Urmia. The United Nations Development Programme is partnering with the Iranian Department of the Environment for this initiative, via a project that is involving local communities in sustainable agriculture and biodiversity conservation.[21]

Greater ambitions for renewable energy

The majority of Iran's power plants are driven by fossil fuels, primarily natural gas (Figure 15.6).

In Iran's 20-year *Vision 2025* (2005) document, also known as *Iran 2025* (*Iran 1404* in the Persian calendar), the government was mandated to increase the share of renewable energy to 1.8% of the energy mix (about 20 000 MW), with hydropower being the designated priority.

However, Article 50 of the *Sixth National Development Plan* (2017–2021) is more ambitious; it aims to increase the share of plants powered by renewable energy to 5% by 2021.

This means that, by 2021, around 4 GW out of the current capacity of 85 GW should come from renewable sources. As of February 2020, 120 solar and wind power plants were in operation across Iran but these were producing a mere 800 MW of electricity, or just under 1% of the energy mix. Construction of other solar and wind power plants is ongoing

Box 15.2: **Stricter laws in Iran for environmental protection**

In January 2017, parliament approved bills mandating the administration to ensure the implementation of strategic environmental assessments and environmental impact assessments, within the framework of the *Sixth National Development Plan* (2017–2021).

The law tasks the administration with monitoring waste management projects on beaches, marine environments, forests and plains. 'Green' management methods are to be introduced by the public administration and external organizations in Iran.

The law prohibits any exploitation of forests for commercial and industrial purposes after current contracts expire in 2020. The administration must allocate a budget to cover the cost of shifting from logging to importing wood products.

The law calls for setting up wastewater treatment plants and conducting water reclamation projects, as well as managing industrial and household wastewater. By 2021, at least 20% of waste is to be disposed of each year in an environmentally friendly way.

The law also stipulates that 20% of endangered wetlands must be restored by 2021, particularly those listed under the Ramsar Convention.

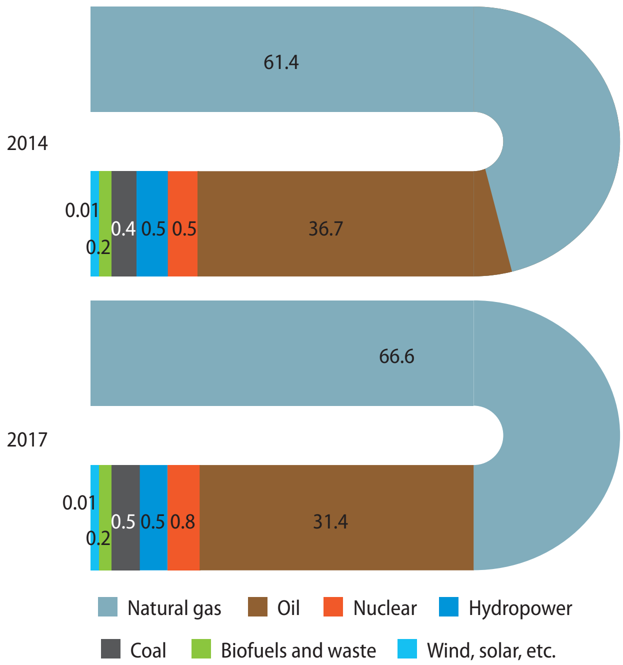
Medicinal herb-farming is also to be developed over 250 000 hectares by 2021.

A comprehensive plan is to be drawn up by 2018 to cope with sand and dust storms.

Some 10% of gas-powered motorcycles are to be replaced each year with electric ones.

Source: Tehran Times (2017)

Figure 15.6: **Breakdown of Iran's primary energy supply by source, 2014 and 2017 (%)**



Note: Values are not drawn to scale.

Source: International Energy Agency; epi.envirocenter.yale.edu

to supply the national power grid with an extra 362 MW of renewable energy, according to the Ministry of Energy.[22]

The main legal framework for developing, operating and selling renewable power is laid out in Article 61 of the Law on Modification of Energy Consumption Patterns, adopted in 2016, and the *Sixth National Development Plan* (2017).[23]

The Ministry of Energy has a dedicated renewable energy arm called the Renewable Energy and Energy Efficiency Organization (SATBA). SATBA is in charge of issuing licences for the establishment of renewable energy facilities; it also acts as the offtaker for the guaranteed purchase of the electricity generated by such facilites.

In 2015, the Ministry of Energy extended the duration of the guaranteed-purchase contracts from five to 20 years to spur investment. The Renewable Energy Organization of Iran (SUNA) then announced plans, in May 2016, to raise the amount of guaranteed prices for electricity generated at plants built with local skills and equipment, in an attempt to boost domestic manufacturing and employment in this sector (Kalehsar, 2019).

Moreover, according to a law approved by the government cabinet in 2016, which makes reference to Article 138 of the *Constitution*, all ministeries, government institutions and public non-governmental organizations, banks and municipalities are mandated to source 20% of their electricity consumption from renewable sources.

In addition, the Supreme Energy Council passed a law in 2018 on the Creation of a Market for Environmental and Energy Optimization. This law introduced incentives for consumers in the form of energy-saving certificates.

In the national budget for 2020–2021, there is a clause supporting the establishment of knowledge-based companies in the field of clean energy, in collaboration with eligible foreign firms.

The *Sixth National Development Plan* has also paid special attention to facilitating investment by foreign firms. In 2017, Iran signed two large contracts for the construction of solar power plants. The first involved the state-owned Amin Energy Developers and Norway's Saga Energy and would have produced a solar power plant capable of generating up to 2 GW of energy by 2022, at a cost of € 2.5 billon. The second concerned the British investor in renewable energy projects, Quercus, at a cost of € 500 million. However, by the end of 2018, the re-imposition of US sanctions had forced both companies to withdraw from these projects (Tsanova, 2018).

CONCLUSION

An effective coping mechanism

The reinstatement of sanctions following US withdrawal from the nuclear deal has hit the economy hard. However, there is also a sense of *déjà vu*. Iranians had already lived under sanctions for years.

In 2014, the country had developed a coping mechanism it dubbed the 'resistance economy,' to wean itself off its hard-hit oil-rent economy by seeking local solutions for those industries that could no longer count on imports of foreign materials and technologies.

Combined with heightened domestic demand, the multiplication of technology incubators and accelerators since 2015 has led to exponential growth in knowledge-based firms and start-ups. This proliferation of self-reliant businesses seems to have driven a form of dynamic decentralization that contrasts with the more inert top-down approach to central planning to which Iranians have become accustomed.

Despite the pain inflicted by sanctions, higher domestic demand for innovation and the desertion of the Iranian marketplace by foreign technology providers has created a potential opportunity for knowledge-based firms to climb higher in the value chain and gain a bigger market share. The brief respite between 2016 and 2018 when sanctions were lifted has also fostered endogenous innovation by giving companies access to foreign state-of-the-art technologies.

The next stage: better management and co-ordination

Building on this momentum will now require a shift in the mindset and skill-set of Iranian knowledge-based firms. They should also beware of the introspection trap. Regardless of the situation with regard to sanctions, finding new avenues for exports in uncharted waters should be perceived as an opportunity to reduce exposure to country- and region-specific risks through more diversified foreign markets.

Once tech-based firms have reached an appropriate level of maturity and competence, the introduction of incentives for them to enter global markets could be one solution for reducing their reliance on the insulated domestic market (Farnoodi *et al.,* 2020).

Although the vitality of the innovation ecosystem is plain to see, there is a need to add more 'substance' to it by laying greater emphasis on output and impact, rather than solely on input and one-off events like the Start-up Weekends that have become a common occurrence.

Many technology incubators and accelerators seem to have adopted the kind of management style that is a legacy of the public sector. This suggests that more attention should be paid to management training in these tech-based environments. Executive and on-the-job training for knowledge-based firms and start-up mentors would be helpful, especially for those incubators and accelerators situated outside large cities or which are not affiliated with prominent academic centres.

In cases where innovation centres are semi-privately owned or have close government ties, an 'ambidextrous set-up' could be employed to reduce the bureaucratic hurdles that these young teams encounter when fulfilling their administrative obligations. This would give young inventors the breathing space to give full rein to their creativity.

Prospects for the digital economy look promising, especially if investment is channelled into emerging technologies such as artificial intelligence, the Internet of Things and blockchain.

The diffusion of Industry 4.0 technologies in mature industries such as the automotive, oil and gas and petrochemical industries should also favour their integration in the knowledge economy.

The Innovation Paradox

Despite notable achievements in specific knowledge-based fields, Iran still faces the Innovation Paradox. In other words, it faces the challenge of turning knowledge into value at the industrial level and ensuring that this knowledge trickles down through society as a whole (Hamidi Motlagh *et al*., 2019).

Addressing this paradox calls for, *inter alia*, facilitating closer ties between the supply and demand side of the innovation system, such as by empowering innovation intermediaries who understand the needs of industry and are able to access networks across the value chain and by upgrading what are known as 'bridging institutions' to ensure that their reach extends beyond the ephemeral benefits of conferences, events and seminars.

Arguably one of the most notable institutional achievements of the past five years has been the overhaul of the National Innovation Fund. The fund has developed new financial tools like venture capital to nurture the knowledge economy, which is to be commended. However, more attention should be paid to promoting investment options that go beyond the provision of loans and facilities.

The remaining loopholes in the institutional chain of the funding system for the knowledge economy can be plugged by supporting intermediary institutions, credit institutions, developing venture capital megafunds and by establishing a knowledge economy bank.

A need for more effective career training

In higher education, meanwhile, the number of master's and PhD graduates has grown but there is a pressing need to revise academic programmes with an eye to developing the requisite skills for the job market. This is particularly vital for a country like Iran that has a large young population – one in four Iranians were under 15 years of age in 2019, according to the Iranian Statistical Centre – and a high share (39%) of unemployment among university graduates.

More needs to be done to move away from the culture of credentialism, whereby students perceive a university degree as an end in itself, with little regard for whether it will give them marketable skills. Universities need to combine their classic curricular programmes with effective career training and exposure to industry through more dynamic and engaging internship programmes, technical and vocational training at tertiary level and other means (Heshmati and Dibaji, 2019).

As demonstrated in the preceding pages, Iran has no shortage of policies and mandates pertaining to science, technology and innovation. Some might even say that the country has produced too much of a good thing. The challenge will be how to implement these policies effectively without becoming bogged down in red tape. Iran's innovation ecosystem has made sterling progress in the past five years. A little more synergy and coherence among the actors of this ecosystem would help it progress to the next level of maturity.

KEY TARGETS FOR IRAN

Iran plans to:

- raise the of plants powered by renewable energy to 5% by 2021;
- increase expenditure on R&D to 4% of GDP by 2021.

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ENDNOTES

1 This was referred to as the Innovation and Prosperity Fund by Ashtarian (2015).
2 The six powers are China, France, Germany, the Russian Federation, UK and USA.
3 The ITER project involves the European Union, China, India, Japan, Republic of Korea, Russian Federation and USA.
4 Sanction-related travel restrictions have also affected non-Iranian scholars planning to attend scientific workshops and conferences in Iran.
5 Technology incubators are called growth centres in Iran.
6 In the present chapter, data for a specific year cover the 12-month period from March to March.
7 See: https://www.tasnimnews.com/en/news/2019/02/04/1939260/iran-producing-95-of-needed-pharmaceuticals-president-says
8 The Iranian Statistical Centre uses a methodology which estimates the number of people with jobs by counting one hour of work per week as employment.
9 See: https://time.com/5804706/iran-coronavirus/
10 See: https://www.nytimes.com/reuters/2020/04/22/world/middleeast/22reuters-health-coronavirus-iran-eu.html
11 A number of articles in this law are important for STI, including that supporting company patent registration and copyright protection (clause #4), that supporting investment in R&D by industrial and production units; (clause #31); that expanding the manufacture of knowledge-based products (clause #43); and that increasing the endowment for specialized research and technology funds (clause #44).
12 In Iran, directives are not compelling, since they have no mandatory clauses.
13 See: *The Global State of Digital 2020*: https://datareportal.com/reports/digital-2020-iran
14 ibid.
15 See: http://iranforesight.ir
16 See: www.atf.gov.ir/en
17 As of 2020, Iran had not yet submitted any voluntary national review on its progress in implementing *The 2030 Agenda for Sustainable Development*.
18 Graduates make up 15.6% of the unemployed in the general population but 39% of the graduate population.
19 The previous *UNESCO Science Report* (Ashtarian, 2015) cited a GERD/GDP ratio of 0.31 in 2010; this ratio is now considered to have been underestimated, owing to the limited number of firms surveyed at the time and the absence of data from some large universities and enterprises.
20 The *Fifth National Development Plan* was extended for a year to 2017, so overlaps with the start of the *Sixth National Development Plan* covering 2017–2021 (1396–1400 in the Persian calendar).
21 See: https://www.ir.undp.org/content/iran/en/home/presscenter/articles/2018/05/06/press-release-government-of-japan-renews-commitment-to-restoring-lake-urmia-for-the-fifth-year-in-a-row.html
22 See (in Persian): http://news.moe.gov.ir/News-List/51682
23 See: https://www.lexology.com/gtdt/tool/workareas/report/renewable-energy/chapter/iran