Indirectly, international sanctions have had some benefits for science, technology and innovation in Iran.

Kioomars Ashtarian

Professor Maryam Mirzakhani speaking at the International Congress of Mathematicians in Seoul (Republic of Korea) in 2014, where she was awarded the Field's Medal, the Nobel equivalent for mathematics
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15 · Iran

Kioomars Ashtarian

INTRODUCTION

Sanctions have reshaped public policy in Iran

In the *UNESCO Science Report 2010,* we discussed how high oil receipts had stimulated consumerism but divorced science from socio-economic needs, favouring a science push rather than a technology pull. In more recent years, Iran has been less able to rely on oil receipts, as the embargo has tightened its grip: oil exports shrank by 42% between 2010 and 2012, dropping from 79% to 68% of total exports.

This predicament has reshaped Iranian public policy. The transition from a resource-based economy to a knowledge economy was already programmed in the *Vision 2025* document adopted in 2005. However, it has taken the hardening of sanctions – and a change of government – for policy-makers to make this transition a priority.

Four of the resolutions adopted by the United Nations Security Council since 2006 include progressively tough sanctions. Since 2012, the USA and European Union (EU) have imposed additional restrictions on Iranian oil exports and on enterprises and banks accused of circumventing the sanctions. The embargo is designed to persuade Iran to stop enriching uranium, which can be used for both civilian and military purposes.

Iran has always insisted on the civil nature of its nuclear programme[1] and its compliance with the Nuclear Non-Proliferation Treaty. Civil nuclear science is a source of national pride, in much the same way that Iranians are proud of their prowess in nanotechnology, stem cell technology and satellite technology. There was extensive coverage in the national press when Maryam Mirzakhani (*see photo*) became the first woman and the first Iranian in 2014 to be awarded the Fields Medal, the Nobel equivalent for mathematics.

President Hassan Rouhani took office in 2013 with the intention of dialoguing with the West. He rapidly initiated a new round of negotiations with the contact group, made up of the five permanent members of the United Nations Security Council plus Germany (known as the P5+1). The first concrete sign of a drop in tensions came in November 2013 with the conclusion of an interim arrangement with the P5+1. Shortly thereafter, the EU General Court announced that it would be annulling sanctions against the Central Bank of Iran. Another interim agreement in mid-2014 has allowed oil exports to climb back gradually to 1.65 million barrels per day. A final agreement was signed on 14 July 2015 and rapidly endorsed by the United Nations Security Council, paving the way to the lifting of sanctions.

Iran trades with the East …

Between 2010 and 2012, non-oil exports rose by 12%, as Iran sought to cushion the economic impact of sanctions by limiting cash sales. Iran was able to import gold, for instance, in exchange for exporting goods to other countries. China is one of Iran's biggest customers but owes an estimated US$ 22 billion for oil and gas supplies which cannot be paid due to banking sanctions. In late 2014, China was planning to invest an equivalent sum in electricity and water projects as a way of circumventing the restrictions.

Like China, the Russian Federation is one of Iran's main trading partners.In October 2014, the Iranian agriculture minister met with his Russian counterpart on the sidelines of a Shanghai Cooperation Organization meeting in Moscow to discuss a new trade deal, whereby Iran would export vegetables, protein and horticultural products to the Russian Federation, in exchange for imports of some engineering and technical services, cooking oil and grain products. In September 2014, the Iranian Mehr news agency reported that Iran had signed a US$ 10 billion agreement with Russia for the design and construction of four new thermal[2] power plants, as well as facilities for the transfer of electricity.

The sanctions have caused a distinct shift in Iran's trading partners from West to East. Since 2001, China's exports to Iran have increased almost sixfold. The EU, on the other hand, accounted for almost 50% of Iranian trade in 1990 but, today, represents just 21% of Iranian imports and less than 5% of its exports.

… but conducts science with East and West

Scientific collaboration, on the other hand, has remained largely oriented towards the West. Between 2008 and 2014, the top four partners for scientific co-authorship were, in descending order, the USA, Canada, the UK and Germany (Figure 15.1). In 2012, researchers from Iran began participating in the project to build an International Thermonuclear Experimental Reactor[3] in France by 2018, which is developing nuclear fusion technology. In parallel, Iran is stepping up its collaboration with developing countries. Malaysia is Iran's fifth-closest collaborator in science and India ranks tenth, after Australia, France, Italy and Japan.

This said, just one-quarter of Iranian articles have a foreign co-author. There is a lot of scope for the development of twinning between universities for teaching and research, as well as student exchanges (Hariri and Riahi, 2014). Ties with Malaysia

1. Iran currently has a single nuclear reactor, located in Bouchehr.

2. There are different types of thermal power plant: nuclear, geothermal, coal-driven, biomass-burning, etc.

3. This project is funded by the European Union (*circa* 45% of the budget), China, India, Japan, the Republic of Korea and the USA.

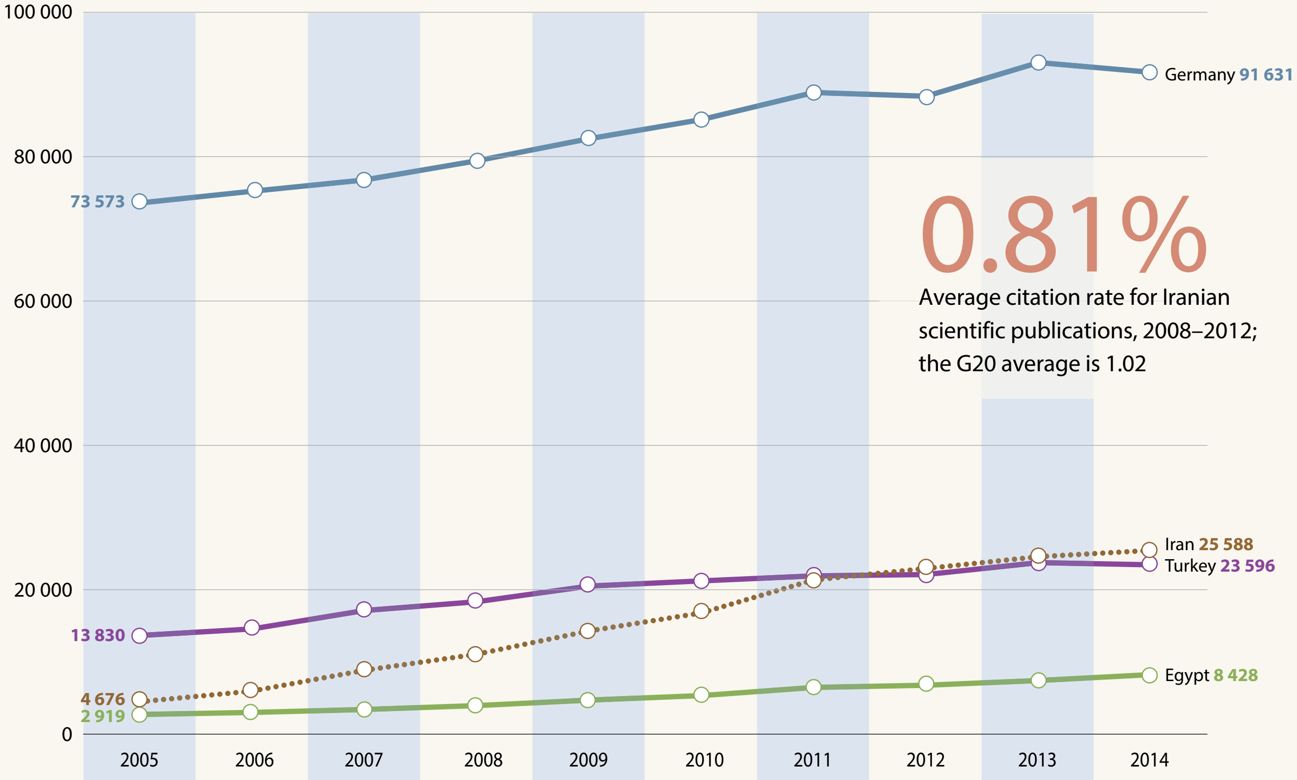
Figure 15.1: **Scientific publication trends in Iran, 2005–2014**

7.4%

Average share of Iranian papers among 10% most cited papers, 2008–2012; the G20 average is 10.2%

Strong growth in Iranian publications

Countries with a similar population are given for comparison

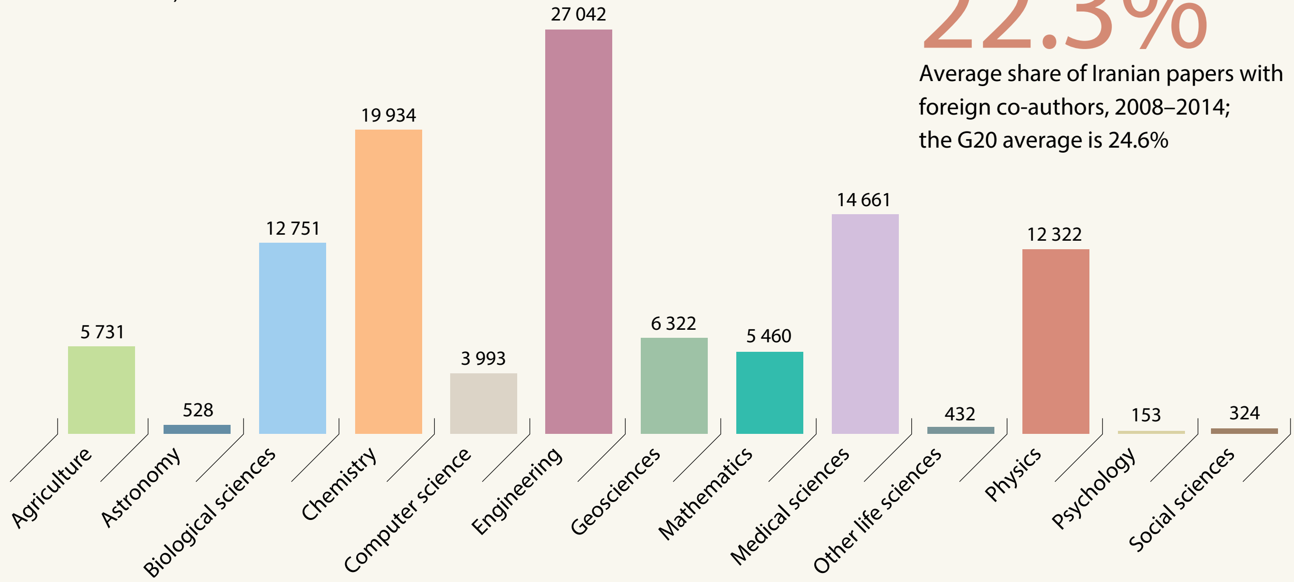


0.81%

Average citation rate for Iranian scientific publications, 2008–2012; the G20 average is 1.02

Iranians now publish most in engineering, followed by chemistry

Cumulative totals, 2008–2014



22.3%

Average share of Iranian papers with foreign co-authors, 2008–2014; the G20 average is 24.6%

Note: Totals exclude unclassified articles

The USA is Iran's top collaborator

Main foreign partners between 2008 and 2014 (number of papers)

	1st collaborator	2nd collaborator	3rd collaborator	4th collaborator	5th collaborator
Iran	USA (6 377)	Canada (3 433)	UK (3 318)	Germany (2 761)	Malaysia (2 402)

Source: Thomson Reuters' Web of Science, Science Citation Index Expanded; data treatment by Science–Metrix are already strong. In 2012, one in seven international students in Malaysia was of Iranian origin (see Figure 26.9). In addition to being one of the rare countries which do not impose visas on Iranians, Malaysia is a Muslim country with a similar level of income. There were about 14 000 foreign students at Iranian universities in 2013, most of whom came from Afghanistan, Iraq, Pakistan, Syria and Turkey. The *Fifth Five-Year Economic Development Plan* has fixed the target of attracting 25 000 foreign students by 2015 (Tehran Times, 2013). In a speech[4] delivered at the University of Tehran in October 2014, President Rouhani recommended establishing an English-language university to attract more foreigners.

Iran is collaborating on international projects via the Organization of Islamic States' Standing Committee on Scientific and Technological Cooperation (COMSTECH). Moreover, in 2008, Iran's Nanotechnology Initiative Council established an Econano network[5] to promote the scientific and industrial development of nanotechnology among members of the Economic Cooperation Organization (see Annex I, p. 736).

Iran hosts several international research centres, including the following established within the past five years under the auspices of the United Nations: the Regional Centre for Science Park and Technology Incubator Development (UNESCO, est. 2010), the International Centre on Nanotechnology for Water Purification (UNIDO, est. 2012) and the Regional Educational and Research Centre for Oceanography for Western Asia (UNESCO, est. 2014).

An economy under pressure

According to Mousavian (2012), the sanctions have slowed Iran's industrial and economic growth, considerably limited foreign investment and triggered national currency devaluation, hyperinflation, declining GDP and, last but not least, a dip in oil and gas production and exports. The sanctions have hit the private sector particularly hard, increasing the costs of finance companies and the credit risk of banks, eroding foreign-exchange reserves and restricting companies' access to foreign assets and export markets. Knowledge-based enterprises have also had limited access to high-quality equipment, research tools, raw materials and technology transfer (Fakhari *et al.,* 2013).

Two other variables have affected Iran's economy: populist policies, which fuelled inflation, and the reform of energy and food subsidies. Some analysts argue[6] that this combination did more harm to the economy than the sanctions and global financial crisis put together (see, for example, Habibi, 2013). They posit that populist policies created an anti-expert discourse, citing President Mahmoud Ahmadinejad's decision to place the Management and Planning Organization under his direct control[7] in 2007. This venerable institution dated from 1948 and was responsible for preparing Iran's medium- and long-term development plans and policies, along with evaluating their implementation.

In January 2010, parliament introduced a reform to remove the energy subsidies which dated from the Iran–Iraq war of the 1980s. These subsidies were costing about 20% of GDP each year and had made Iran one of the most energy-intensive countries in the world. The International Monetary Fund (IMF) has described the reform as 'one of the most courageous moves to reform subsidies in an energy-exporting country' (IMF, 2014).

To cushion the impact on households, the subsidies were replaced by targeted social assistance of the equivalent of about US$ 15 per month that was extended to more than 95% of Iranians. Enterprises were also promised subsidized loans to help them adopt new, energy-saving technologies and credit lines to mitigate the impact of higher energy prices on their production (IMF, 2014). Ultimately, most of these loans have not materialized.[8]

Between 2010 and 2013, inflation climbed from 10.1% to 39.3%, according to the Iranian Statistical Centre. By 2013, the economy had slipped into recession (-5.8%), after growing by 3% in 2011 and 2012. Unemployment remained high but stable, at 13.2% of the the labour force in 2013.

A new team at the economy's bedside

President Rouhani is considered a moderate. Shortly after his election in June 2013, he stated in parliament that 'there must be equal opportunities for women,' before going on to appoint two women vice-presidents and the first woman spokesperson in the Ministry of Foreign Affairs. He has also pledged to expand internet access (26% in 2012). In an interview with NBC News[9] in September 2013, he said that 'we want the people, in their private lives, to be completely free. In today's world, having access to information and the right of free dialogue and the right to think freely is a right of all peoples, including Iranians. The people must have full access to all information worldwide.' In November 2014, he reinstated the Management and Planning Organization.

4. President Rouhani said that 'scientific evolution will be achieved by criticism […] and the expression of different ideas. […] Scientific progress is achieved, if we are related to the world. […] We have to have a relationship with the world, not only in foreign policy but also with regard to the economy, science and technology. […] I think it is necessary to invite foreign professors to come to Iran and our professors to go abroad and even to create an English university to be able to attract foreign students.'

5. See : http://econano.ir

6. See, for example : http://fararu.com/fa/news/213322

7. The Management and Planning Organization was renamed the Presidential Deputy for Strategic Monitoring.

8. The Hi-Tech Development Fund has meanwhile been helping some enterprises to adopt energy-saving technologies. See (in Persian): www.hitechfund.ir

9. See : http://english.al-akhbar.com/node/17069

President Rouhani's domestic priorities are to create an environment more conducive to business and to tackle the acute problems of high unemployment, hyperinflation and inadequate purchasing power: GDP per capita amounted to PPP$ 15 586 (in current prices) in 2012, less than the previous year (PPP$ 16 517).

In 2014, the president instituted two major projects. The first was the *Second Phase of the Subsidy Reform Plan* initiated by his predecessor, which entailed a 30% price rise on petrol. His second major project has been the *Health Overhaul Plan*. This plan reduces the cost of treatment for patients in state-run hospitals from 70% to 5% in rural areas and 10% in urban areas. About 1.4 million patients have been admitted to state-run hospitals since the plan's inception. Some 3 000 specialists have been employed by the ministry to work in vulnerable regions, 1 400 of whom had taken up their positions by the end of 2014. According to Iran's health minister, the plan is not facing any financial problems in its first two years of operation but some health policy experts worry that the government may not be able to pursue this policy for long, owing to the high cost. Six million people have received health insurance since the plan's implementation, according to the health minister, most of them from the poorer echelons of society.

According to the Iranian economic journalist Saeed Leylaz, 'the country's economic condition was not predictable in the past government but the current government has managed to stabilize the economy. This helped make people reluctant to buy dollars for the purpose of saving. The government has also reduced political tensions and refrained from impulsive acts in the economy' (Leylaz, 2014).

Iran's economic outlook is brighter, thanks partly to the resumption of negotiations with the P5+1. The Iranian Central Bank announced growth of 3.7% in 2014, inflation was down to 14.8% and the unemployment rate down to 10.5%. Non-oil exports are growing. Iran nevertheless remains highly dependent on oil. The *Wall Street Journal* estimated that Iran needed a crude oil brent of US$ 140 in 2014 to balance its budget, the year world oil prices tumbled from US$ 115 to US$ 55 between June and December (see Figure 17.2).

Fluctuating global oil prices have spawned fresh challenges. Iran has recently been using new technologies like hydroconversion in its terminals to diversify its oil products. The sharp decline in the price of crude oil since 2014 may prevent the government from investing as much as it would like in research and development (R&D) into advanced oil extraction technologies. An alternative would be for Iran to develop these technologies jointly with Asian oil companies.

TRENDS IN STI GOVERNANCE

Sanctions precipitating shift to a knowledge economy

They say that every cloud has a silver lining. Indirectly, international sanctions have had some benefits for science, technology and innovation (STI):

- *Firstly,* they have accelerated the shift from a resource-based economy to a knowledge economy. There tends to be a weak link between the oil industry and other socio-economic sectors. Companies deprived of oil and gas revenue have shown a propensity to export technical and engineering services to neighbouring countries. According to a report by the Mehr news agency in November 2014 which cited the deputy energy minister for international affairs, Iran currently exports water and technological power services worth over US$ 4 billion to more than 20 countries.[10]
- *Secondly,* the sanctions have helped to reconcile R&D with problem-solving and public interest research, after years of high oil receipts had divorced science from socio-economic preoccupations.
- *Thirdly*, the sanctions have helped small and medium-sized enterprises (SMEs) develop their businesses by erecting barriers to foreign imports and encouraging knowledge-based enterprises to localize production. With unemployment high and Iranians well-educated, they have had no difficulty recruiting trained staff.
- *Fourthly,* by isolating Iranian companies from the outside world, the sanctions have forced them to innovate.
- *Last but not least,* the sanctions have persuaded policy-makers of the need to embrace the knowledge economy.

The government's policy of developing a knowledge economy is reflected in its *Vision 2025* document adopted in 2005, which offers a recipe for turning Iran into the number one economy in the region[11] and one of the top 12 economies in the world by 2025.

Vision 2025 foresees an investment of US$ 3.7 trillion by 2025 to achieve this goal, nearly one-third of which (US$ 1.3 trillion) is to come from foreign sources. Much of this amount is to go towards supporting investment in R&D by knowledge-based firms and the commercialization of research results. A law was passed in 2010 to provide an appropriate funding mechanism, the Innovation and Prosperity Fund, which became effective in 2012 (see p. 394).

10. including Afghanistan, Azerbaijan, Ethiopia, Iraq, Kenya, Oman, Pakistan, Sri Lanka, Syria, Tajikistan and Turkmenistan

11. *Vision 2025* defines this region as encompassing: Afghanistan, Armenia, Azerbaijan, Bahrain, Egypt, Georgia, Iran, Iraq, Israel, Jordan, Kazakhstan, Kuwait, Kyrgyzstan, Lebanon, Oman, Pakistan, Palestine, Qatar, Saudi Arabia, Syria, Tajikistan, Turkey, Turkmenistan, United Arab Emirates, Uzbekistan and Yemen.

Given the persistently low level of foreign direct investment (FDI) – just 0.8% of GDP in 2013 – coupled with Iran's economic woes, several of *Vision 2025's* goals seem unrealistic. A classic example is the target of raising gross domestic expenditure on R&D (GERD) to 4% of GDP by 2025. Other goals seem within reach, such as that of tripling the number of scientific articles to 800 per million population (Table 15.1).

In 2009, the government adopted a *National Master Plan for Science and Education* to 2025 which reiterates the goals of *Vision 2025*. It lays particular stress on developing university research and fostering university–industry ties to promote the commercialization of research results.

A focus on fostering innovation and excellence

The country's successive five-year development plans set out to realize collectively the goals of *Vision 2025*. Adopted by law, these plans also provide the most important institutional basis for STI policy in Iran. The current *Fifth Five-Year Economic Development Plan* covers the period from 2010 to 2015. The chapters relative to higher education and STI policy complement those of the *National Master Plan for Science and Education.*

Under the section on social affairs, the *Fifth Five-Year Economic Development Plan* speaks of developing indicators to measure the quality of the air, food and the environment in general, and undertakes to reduce health-threatening pollution. It also vows to reduce the population's share of health costs to 30% by 2015.

The *Fifth Development Plan* has two main thrusts relative to STI policy. The first is the 'islamization of universities,' which has become a political topic in Iran. The second thrust is to secure second place for Iran in the region in science and technology (S&T) by 2015, which would place it behind Turkey.

The notion of the islamization of universities is open to broad interpretation. The aim seems to be to nationalize scientific knowledge in the humanities and bring it into line with Islamic values, while developing student morals and spirituality. According to Article 15 of the *Plan*, university programmes in the humanities are to be modified as part of this strategy and students are to be taught the virtues of critical thinking, theorization and multidisciplinary studies. A number of research centres are also to be developed in the humanities.

Table 15.1: **Key targets for education and research in Iran to 2025**

	Situation in 2013	Vision 2025 targets
Share of adults with at least a bachelor's degree	–	30%
Share of PhD holders among total students	1.1%$^{-1}$	3.5%
Researchers (FTE) per million population	736^{-3}	3 000
Government researchers (share of total researchers)	33.6%$^{-5}$	10%
Researchers in business enterprise sector (share of total researchers)	15.0%$^{-5}$	40%
Share of researchers employed by universities*	51.5%$^{-5}$	50%
Full-time university professors per million population	1 171	2 000
Scientific articles per million population	239	800
Average citations per publication **	0.61^{-2}	15
Number of Iranian journals with an impact factor of more than 3	–	160
Number of national patents	–	50 000
Number of international patents	–	10 000
Public expenditure on education as a share of GDP	3.7%	7.0%
Public expenditure on higher education as a share of GDP	1.0%$^{-1}$	–
GERD/GDP ratio	0.31%$^{-3}$	4.0%
Share of GERD financed by business enterprise sector	30.9%$^{-5}$	50%
Share of articles among 10% most cited worldwide	7.7%$^{-2}$	–
Number of articles among 10% most cited worldwide	1 270^{-2}	2 250
Number of Iranian universities in top 10% worldwide	0	5

*includes religious centres

**average relative citations; the OECD average in 2011 was 1.16

-n/+n refers to *n* years before reference year

Source: for 2025 targets: Government of Iran (2005) *Vision 2025*; for current situation, Statistical Centre of Iran and UNESCO Institute for Statistics

The following strategies have been devised to secure second place for Iran in S&T in the region:

- a comprehensive system is to be put in place for monitoring, evaluating and ranking institutions of higher education and research institutes. The Ministry of Science, Research and Technology and the Ministry of Health and Medical Education have been entrusted with this task. Researchers will be evaluated on the basis of criteria such as their scientific productivity, their involvement in applied R&D or the problem-solving nature of their work;
- in order to ensure that 50% of academic research is oriented towards socio-economic needs and problem-solving, promotion is to be tied to the orientation of research projects. In addition, mechanisms are to be put in place to enable academics to enrol in further education, take sabbaticals and explore new research opportunities. Research and technology centres are also to be set up on campus and universities are to be encouraged to develop linkages with industry;
- The number of university graduate programmes in applied disciplines is to increase;
- Each university is to be endowed with an academic board that oversees implementation of the academic programme;
- Laboratories in applied science are to be set up and equipped at universities, other educational institutions, in science and technology parks and business incubators by public research institutions and their subsidiaries;
- The GERD/GDP ratio is to increase by 0.5% each year to attain 3% by 2015;
- FDI is to account for 3% of GDP by 2015;
- Scientific ties are to be developed with prestigious international educational and research institutions;
- An integrated monitoring and evaluation system is to be put in place for S&T;
- Major indicators of S&T are to be incorporated in government planning, including the volume of revenue generated by exports of medium-tech and high-tech goods, the share of GDP per capita derived from S&T, the number of patents, the share of FDI in scientific and technological activities, the cost of R&D and the number of knowledge-based companies.

The following priorities focus on technology diffusion and support for knowledge-based companies:

- Priority is to be given in the annual R&D budget of ministries to financing demand-driven research and to supporting the development of private and co-operative SMEs which commercialize knowledge and technology and turn them into export products; the government is to encourage the private sector to set up business incubators and science and technology parks and to encourage foreign parties to invest in technology transfer and R&D, in partnership with domestic companies; foreign investors are also to be encouraged to finance patents; the government is to support the establishment of totally private knowledge-based companies by universities; innovators and leaders in science are to receive targeted financial and intellectual support from the government to support the commercialization of their inventions; the government is to make provisions for the payment of patent application costs at both national and international levels and, lastly, to make arrangements for the commercial release of their product or service (Articles 17 and 18);
- The Ministry of Communications and Information Technology is to develop the necessary infrastructure, such as the installation of fibre optics, to ensure broadband internet access, to enable universities, research bodies and technological institutions to network and share information and data on their respective research projects, intellectual property issues and so on (Article 46);
- A National Development Fund (Articles 80–84) is established to finance efforts to diversify the economy; preserve part of oil and gas rents for future generations; and increase the return on income from accumulated savings; by 2013, the Fund was receiving 26% of oil and gas revenue – the ultimate goal is to reserve 32% of this revenue for the Fund (IMF, 2014);
- New campuses are to be launched in special economic zones by public and private Iranian universities and international leading universities (Article 112);
- Closer ties are to be forged between small, medium-sized and large businesses and, in parallel, industrial clusters are to be set up. Private sector investment is to be encouraged to develop the value chain of downstream industries (petrochemicals, basic metals and non-metallic mineral products), with an emphasis on the establishment of professional industrial estates and the development of closer linkages between industry and science and technology parks to develop capacity for industrial design, procurement, innovation and so on (Article 150).

The pivotal role of the Innovation and Prosperity Fund

The Innovation and Prosperity Fund functions under the Deputy for Science and Technology. It was established in 2012 to support investment in R&D by knowledge-based firms and the commercialization of research results.

According to the Fund's president, Behzad Soltani, 4 600 billion Iranian rials (*circa* US$ 171.4 million) had been allocated to 100 knowledge-based companies by late 2014. Sorena Sattari, Vice-President for Science and Technology, declared[12] on 13 December 2014 that, 'in spite of the difficulties the country is confronting, 8 000 billion rials have been attributed to the Innovation and Prosperity Fund for 2015.'

The Innovation and Prosperity Fund is the primary policy instrument for ensuring the implementation of Articles 17 and 18 of the *Fifth Five-Year Economic Development Plan:*

- National organizations wishing to conduct problem-solving research may apply for the allocation of facilities and partnering to the Secretariat of the Working Group for the Assessment and Identification of Knowledge-based Companies and Institutions and Supervision of Project Implementation.
- Universities wishing to set up fully private companies may also apply to the fund; as of December 2014, public and private universities from four Iranian provinces had applied to establish knowledge-based companies in special economic zones (Article 112): Tehran, Isfahan, Yazd and Mashhad. These applications are still under review, according to the Supreme Council of Science, Research and Technology.
- The fund also supports SMEs by offering tax incentives and paying partial costs of commercializing knowledge and technology; it also covers part of the interest on bank loans contracted for the purchase of equipment, the setting up of production lines, testing and marketing, etc.;
- The fund also offers financial support to private companies wishing to set up business incubators and science and technology parks then facilitates the establishment of these centres through such measures as the provision of rent-free premises and tax incentives.

The fund is also intended to encourage foreign parties to invest in technology transfer and R&D but this ambition has been somewhat thwarted by the international sanctions; foreign companies may still invest in patents, however.

Innovators and leaders in science receive intellectual and financial support from the National Elites Foundation, which was set up[13] in 1984. In December 2013, a new department was created within the foundation, called the Deputy of International affairs. It aims to harness the talent of non-resident Iranians to improve domestic capacity in S&T and take advantage of the experience of the diaspora. The foundation tailors its services to four different groups: Iranian PhD graduates from the world's top universities; Iranian professors teaching in the world's top universities; Iranian experts and managers heading the world's top scientific centres and companies in technological fields and, lastly, non-resident Iranian investors and entrepreneurs who have succeeded in technological fields. The eligibility criteria were revised in 2014 to include groups as well as individuals and research expertise and experience as well as academic performance. The selection of elites has also been delegated to the universities. Additional incentive measures have been introduced, such as grants for research visits to top universities abroad and research grants from day one of a faculty member's career.

12. See (in Persian): www.nsfund.ir/news

13. See: http://en.bmn.ir

Enter the 'economy of resistance'

On 19 February 2014, the Supreme Leader Ayatollah Ali Khamenei introduced, by decree, what he termed Iran's 'economy of resistance.' This economic plan outlines strategies for making Iran more resilient to sanctions and other external shocks. It essentially reasserts the goals of *Vision 2025*, which is why some key provisions will sound familiar.

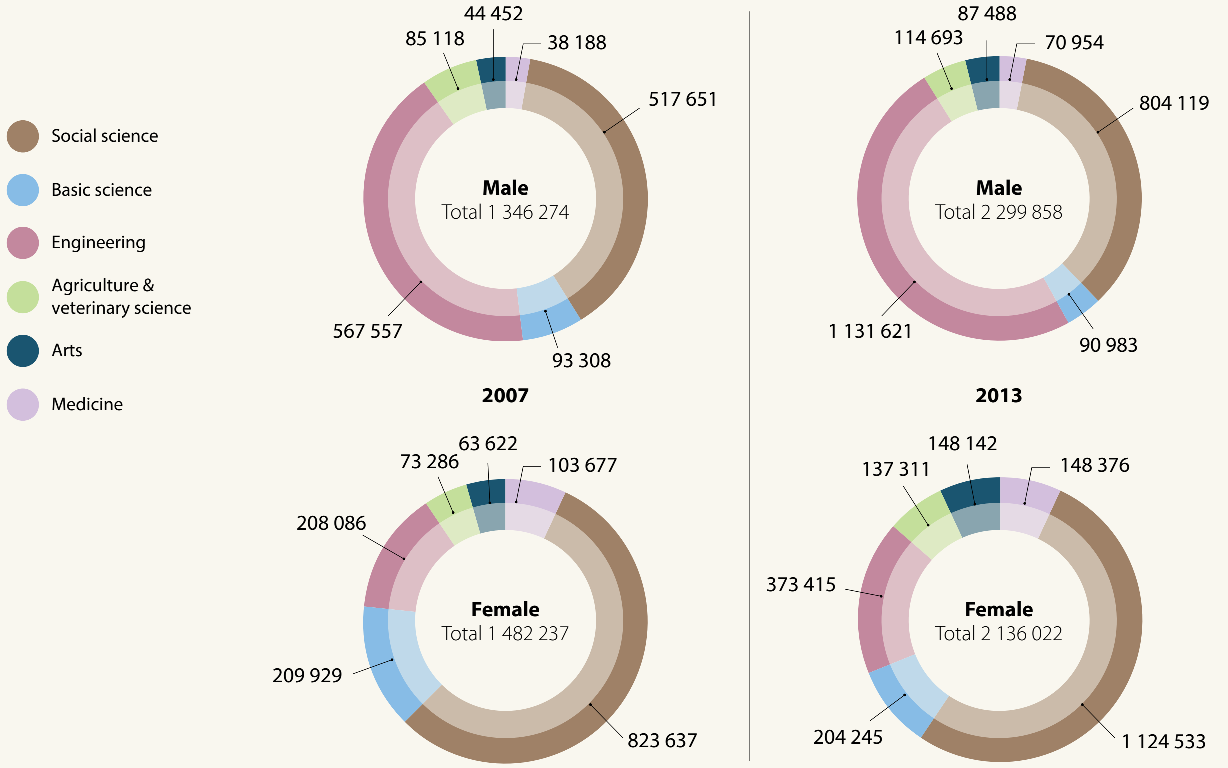
Coming when it did, some analysts see the economy of resistance as an endorsement of the new government's comprehensive economic reform, after the previous administration's relative indifference towards *Vision 2025* caused it to veer off course. For Khajehpour (2014a), a managing partner at Atieh, a group of strategic consulting firms based in Tehran, Iran 'has all the resources that an economy would need to play a much more significant role on the international stage. The missing links are in the areas of responsible and accountable policy-making, legal transparency and modern institutions.'

Key provisions of the 'economy of resistance' include (Khajehpour (2014a):

- promoting a knowledge-based economy through the drafting and implementation of a comprehensive scientific plan for the country and the promotion of innovation, the ultimate goal being to become the top knowledge-based economy in the region;
- utilizing the reform of subsidies to optimize energy consumption in the country, increase employment and domestic production and promote social justice;
- promoting domestic production and consumption, especially in strategic products and services, to reduce dependence on imports, while improving the quality of domestic production;
- providing food and medicine security;
- promoting exportable goods and services through legal and administrative reform, while promoting FDI for export purposes;

Figure 15.2: **Students enrolled in Iranian universities, 2007 and 2013**

Both public and private universities



Source: Iranian Statistical Centre (2014) *Statistical Yearbook*

Figure 15.3: **PhD graduates in Iran by field of study and gender, 2007 and 2012**

Source: UNESCO Institute for Statistics

- increasing the economy's resistance through regional and international economic collaboration, especially with neighbours but also through diplomacy;
- increasing oil and gas value-added exports;
- implementing reforms to rationalize government costs, increase tax revenues and reduce dependency on oil and gas export revenue;
- increasing the share of the National Development Fund from oil and gas export revenues;
- increasing transparency in financial matters and avoiding activities that pave the way for corruption.

TRENDS IN HUMAN RESOURCES AND R&D

Strong growth in students but no rise in R&D intensity

Between 2005 and 2010, policy-makers focused on increasing the number of academic researchers, in line with *Vision 2025.* To this end, the government raised its commitment to higher education to 1% of GDP in 2006 and has since maintained this level, even as public expenditure on education overall has slipped from 5.1% (2006) to 3.7% (2013) of GDP.

The result has been a steep rise in tertiary enrolment. Between 2007 and 2013, student rolls swelled from 2.8 million to 4.4 million in the country's public and private universities (Figure 15.2). There were more women students than men in 2007 but their proportion has since dropped back slightly to 48%. Some 45% of students were enrolled in private universities in 2011 (UIS, 2014).

Enrolment has progressed in most fields, with the exception of natural sciences where it has remained stable. The most popular fields are social sciences (1.9 million students) and engineering (1.5 million). There are more than 1 million men studying engineering and more than 1 million women studying social sciences. Women also make up two-thirds of medical students.

The number of PhD graduates has progressed at a similar pace (Figure 15.3). Natural sciences and engineering have proved increasingly popular among both sexes, even if engineering remains a male-dominated field. In 2012, women made up one-third of PhD graduates, being drawn primarily to health (40% of PhD students), natural sciences (39%), agriculture (33%) and humanities and arts (31%). According to the UNESCO Institute for Statistics, 38% of master's and PhD students were studying S&T fields in 2011 (UIS, 2014).

Although data are not readily available on the number of PhD graduates choosing to stay on as faculty, the relatively modest level of GERD would suggest that academic research suffers from inadequate funding. A study by Jowkar *et al*. (2011) analysed the impact of 80 300 Iranian articles published between 2000 and 2009 in Thomson Reuter's Science Citation Index Expanded; it found that about 12.5% of these publications were funded and that the citation rate of funded publications was higher in almost all subject fields. The greatest share of funded publications came from universities subordinate to the Ministry of Science, Research and Technology.

Even though one-third of GERD came from the business sector[14] in 2008, this contribution remains too small to nurture innovation effectively – it represents just 0.08% of GDP. GERD even dropped between 2008 and 2010 from 0.75% to 0.31% of GDP. In this context, the target identified in the *Fifth Five-Year Development Plan* (2010–2015) of devoting 3% of GDP to R&D by 2015 looks elusive, to say the least.

According to the UNESCO Institute for Statistics, the number of full-time equivalent (FTE) researchers rose from 711 to 736 per million inhabitants between 2009 and 2010. This corresponds to an increase of more than 2 000 researchers, from 52 256 to 54 813.

Businesses are performing more R&D than before

In 2008, half of researchers were employed in academia (51.5%), one-third in the government sector (33.6%) and just under one in seven in the business enterprise sector (15.0%).

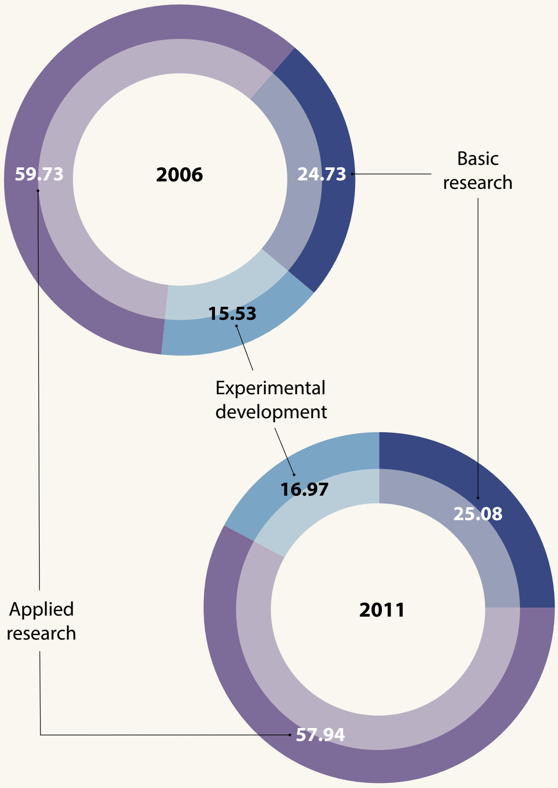
Between 2006 and 2011, the number of firms declaring R&D activities more than doubled, however, from 30 935 to 64 642. Once more recent data become available, we may find that the business enterprise sector has been hiring more researchers than before. So far, there has been little change in the focus of industrial R&D, with firms still conducting mainly applied research (Figure 15.4).

More articles but few technological spin-offs

One priority of STI policy in recent years has been to encourage scientists to publish in international journals. Again, this is in line with *Vision 2025*. As we have seen, the share of internationally co-authored articles has remained relatively stable since 2002. The volume of scientific articles has augmented considerably, on the other hand, even quadrupling by 2013 (Figure 15.1). Iranian scientists now publish widely in international journals in engineering and chemistry, as well as in life sciences and physics. Contributing to this trend is the fact that PhD programmes in Iran now require students to have publications in the Web of Science. Women contribute only about 13% of articles, with a focus on chemistry, medical sciences and social sciences, according to Davarpanah and Moghadam (2012).

14. Data are unavailable for a more recent breakdown by sector.

Figure 15.4: **Focus of Iranian firms by type of research, 2006 and 2011 (%)**



Source: Iranian Statistical Centre

This productivity gain has had little effect on the production of technology, however. In nanotechnology, for instance, Iranian scientists and engineers were only granted four patents by the European Patent Office between 2008 and 2012. The lack of technological output results mainly from three shortcomings in the innovation cycle. The first among these shortcomings is the failure to co-ordinate executive and legal power structures to strengthen intellectual property protection and the wider national innovation system, despite this being a key policy objective for over a decade now. In the *Third Five-Year Development Plan, 2000–2004,* the co-ordination of all scientific activities was entrusted to the Ministry of Science, Research and Technology, to avoid overlap with other ministries (health, energy, agriculture, etc.). The post of Presidential Deputy for Science and Technology[15] was likewise created in 2005 to centralize the budget and planning of all S&T activities. Little has been done since, however, to improve co-ordination between administrative bodies in the executive branch and judiciary.

The past few years have witnessed persistent inattention to problem-solving in decision-making and little effort to improve the country's inadequate system of intellectual property protection. These two shortcomings do more to weaken the national innovation system than either the lack of available venture capital or the international sanctions.

Why the persistent inattention to problem-solving, despite a plethora of documents? This is because public policy in Iran combines strategic planning with poetic idealism. Official policy documents are a mixture of declarations of intent and copious recommendations – even though, when everything is a priority, nothing is. A more complex and detailed alternative is required, a planning model that does not elaborate recommendations until the issues and related policy questions have first been clearly defined and the legal context analysed, a model which comprises an implementation plan and a rigorous monitoring and evaluation system.

PRIORITY AREAS FOR R&D

Most high-tech companies are state-owned

Some 37 industries trade shares on the Tehran Stock Market. These industries include the petrochemical, automotive, mining, steel, iron, copper, agriculture and telecommunications industries, a unique situation in the Middle East.

Most of the companies developing high technology in Iran are state-owned. The Industrial Development and Renovation Organization (IDRO) controls about 290 of them. IDRO has also set up special purpose companies in each high-tech sector[16] to co-ordinate investment and business development. In 2010, IDRO set up a capital fund to finance the intermediary stages of product- and technology-based business development.

Some 80% of state-owned firms are due to be privatized over the ten years to 2014, further to an amendment to Article 44 of the Constitution in 2004. In May 2014, Tasnim News Agency quoted Abdollah Pouri Hosseini, the head of the Iran Privatization Organization, as saying that Iran would be privatizing 186 state-run companies in the new year (beginning 21 March 2014 in Iran). Twenty-seven of these companies have a market value each in excess of US$ 400 million, he said. Several key industries remain largely state-owned, however, including the automotive and pharmaceutical industries (Boxes 15.1 and 15.2).

Iran's R&D priorities are reflected in their share of government outlay (Table 15.2). In basic and applied science, the priority fields

15. In Iran, each vice-president has several deputies. Under the Vice-President for Science and Technology, for instance, there is a Deputy for Science and Technology, a Deputy for Management Development and Resources and a Deputy for International Affairs and Technological Exchange.

16. These entities are the Life Science Development Company, Information Technology Development Centre, Iran InfoTech Development Company and the Emad Semiconductor Company.

are dense matter, stem cells and molecular medicine, energy recycling and conversion, renewable energies, cryptography and coding. The priority technological industries are aerospace, ICTs, nuclear technology, nanotechnology and microtechnologies, oil and gas, biotechnology and environmental technologies.

In aerospace, Iran manufactures aeroplanes, helicopters and drones. It is currently developing its first wide-body plane[17] to improve seating capacity, as the country only has about nine aircraft per million population. The industry plans to shift its focus from 59-seaters to planes that can seat 90–120 passengers, as long as it can import the relevant technical knowledge.

Meanwhile, the Iranian Space Agency has built a number of small satellites that are launched into low-Earth orbit using a locally produced carrier rocket called Safir. In February 2012, Safir transported its biggest satellite yet, weighing 50 kg (Mistry and Gopalaswamy, 2012).

17. After purchasing the production license for the An-140 from Ukraine in 2000, Iran built its first Iran-140 commercial passenger plane in 2003.

A growing role in biotechnology and stem cell research

Research in biotechnology has been overseen by the Iranian Biotechnology Society since 1997. Iran maintains three important health research[18] facilities. Two of these, the Pasteur Institute and the National Research Centre for Genetic Engineering and Biotechnology, study human pathologies. The third, the Razi Institute for Serum and Vaccines, studies both human and animal diseases. The Razi and Pasteur Institutes have been developing and producing vaccines for humans and livestock since the 1920s. In agricultural biotechnology, researchers are hoping to improve crop resistance to pests and disease. The Persian Type Culture Collection is a subordinate of the Biotechnology Research Centre in Tehran, which falls under the umbrella of the Iranian Research Organization for Science and Technology (IROST); it provides services to both private industry and academia.

18. See: www.nti.org/country-profiles/iran/biological

Box 15.1: **Automobiles dominate Iranian industry**

After oil and gas, the automotive industry is Iran's biggest, accounting for about 10% of GDP and employing about 4% of the labour force. There was a boom in local car manufacturing between 2000 and 2013, driven by high import duties and a growing middle class. In July 2013, sanctions imposed by the USA prevented Iranian companies from importing the vehicle parts upon which domestic cars rely; this caused Iran to cede its place to Turkey as the region's top vehicle manufacturer.

The Iranian car market is dominated by Iran Khodro (IKCO) and SAIPA, which are subsidiaries of the state-owned Industrial Development and Renovation Organization. SAIPA (standing for *Société anonyme iranienne de production automobile)* was founded in 1966 to assemble French Citroën cars under license for the Iranian market. IKCO was founded in 1962 and, like SAIPA, assembles European and Asian cars under license, as well as its own brands.

In 2008 and 2009, the government spent over US$ 3 billion on developing infrastructure to enable vehicles to run on compressed natural gas. The aim was to reduce costly petrol imports due to an insufficient refining capacity in Iran. With the world's biggest natural gas reserves after the Russian Federation, Iran rapidly became the world leader for the number of vehicles running on natural gas: by 2014, there were over 3.7 million on the road.

In 2010, the government reduced its participation in both companies to about 20% but the deals were annulled the same year by the Iranian Privatization Organization.

IKCO is the biggest car manufacturer in the Middle East. In 2012, it announced that it would henceforth be reinvesting at least 3% of company sales revenue in R&D.

For years, Iranian carmakers have used nanotechnology to increase customer satisfaction and safety by providing such comforts as anti-stain dashboards, hydrophobic glass planes and anti-scratch paint. In 2011, the Nanotechnology Initiative Council announced plans to export to Lebanon a series of 'home-made' nano-based engine oils manufactured by the Pishgaman–Nano-Aria Company (PNACO); these nano-based oils reduce engine erosion, fuel consumption and engine temperature. In 2009, researchers at Isfahan University of Technology developed a strong but light nanosteel as resistant to corrosion as stainless steel for use in road vehicles but also potentially in aircraft, solar panels and other products.

The sanctions imposed in 2013 hit exports particularly hard, which had doubled to about 50 000 cars between 2011 and 2012. This prompted IKCO to announce plans in October 2013 to begin selling 10 000 cars a year to the Russian Federation. Traditional export markets include Syria, Iraq, Algeria, Egypt, Sudan, Venezuela, Pakistan, Cameroon, Ghana, Senegal and Azerbaijan. In 2014, French car-makers Peugeot and Renault resumed their traditional business with Iran.

Source: http://irannano.org; Rezaian (2013); Press TV (2012)

Table 15.2: **Government outlay for R&D in Iran by major agency, 2011**

	R&D centre	Budget (million rials)
Deputy for Science and Technology		1 484 125
Supports the following R&D centres	Nanotechnology Initiative Council	482 459
	Centre for the Development of Knowledge-Based Companies	110 000
	Biotechnology Research Centre	100 686
	Centre for the Development of Drugs and Traditional Medicine	90 000
	Centre for Stem Cell Research	75 000
	Centre for New Energy Development	65 000
	Centre for ICT Development and Microelectronics	60 000
	Centre for Cognitive Science	56 274
	Centre for Water, Drought, Erosion and Environmental Management	50 000
	Centre for Software Technologies	10 000
Ministry of Science, Research and Technology		1 356 166
	Iranian Space Agency	85 346
	Iranian Research Organization for Science and Technology	357 617
Ministry of Defence		683 157
Ministry of Health and Medical Training		656 152
Ministry of Industry		–
	Industrial Development and Renovation Organization	536 980
	Iranian Fisheries Research Organization	280 069
	Iran Aviation Industries Organization	156 620
Ministry of Energy		38 950
	Atomic Energy Organization	169 564
	Research Institute of the Petroleum Industry	480 000
	Renewable Energy Organization (SUNA)	12 000
Ministry of Information and Communication Technology		440 000
Ministry of Agriculture		86 104
Other		33 147 411
	95 universities and 72 institutions affiliated to the Ministry of Science, Research and Technology	
	84 universities and 16 institutions affiliated to the Ministry of Health and Medical Training	
	22 universities and institutions affiliated to the Ministry of Defence	
	32 science and technology parks	
	184 institutions affiliated to the Ministries of Industry and Agriculture	
	23 institutions affiliated to the Presidency	
	63 other organizations	
Total		**41 069 680**

Note: The three following centres were established in 2014 under the Deputy for Science and Technology: the Centre for Oil, Gas and Coal Research; Centre for the Optimization of Energy and the Environment; and the Centre for Knowledge-based Marine Companies. The budget for each ministry does not cover the universities and other institutions associated with it.

Source: www.isti.ir; compiled by author with input from the National Research Institute for Science Policy

Box 15.2: The ups and downs of Iran's pharmaceutical industry

There are currently 96 local manufacturers in Iran which produce some 30 billion units of medicine worth about US$ 2 billion per year. Local production covers about 92% of the Iranian market but does not include high-quality drugs needed for the specific treatment of diabetes, cancer, etc. These drugs need to be imported, at a cost of about US$ 1.5 billion. As the market volume represents US$ 3.5 billion, this means that 43% of demand is met through imports.

Of the 96 local companies, about 30 control 85% of the market. The biggest four players are Daroupakhsh, Jaberebne Hayyan, Tehran Shimi and Farabi, in descending order. These four companies alone account for more than 20% of the market. Local manufacturers still rely on outdated production lines, making the cost of pharmaceutical manufacturing relatively high in Iran and thus expensive for consumers.

Foreign pharmaceutical companies in Iran usually operate either directly through their branch offices or through dealerships with Iranian pharmaceutical companies authorized to sell their products.

In Iran, per capita expenditure on medicine stood at US$ 46 in 2011. The pharmaceutical industry has a profit margin of about 14%. This is three times the profit margin of the Iranian automotive industry. Most pharmaceutical companies are state-owned or quasi-governmental entities, although some are listed on the Tehran Stock Exchange. The private sector's share of the market only amounts to about 30%. Pharmaceutical companies export drugs to about 30 countries, for a market value of US$ 100 million per year.

Under the Ministry of Health and Medical Education, it is the Department of Foods and Drugs which is directly responsible for supervising pharmaceutical companies. The government tends to make all strategic decisions and monitors standards, quality and the payment of subsidies to recipient companies.

In recent years, there has been a growing emphasis on local production and exports to regional markets. Export destinations include Afghanistan, Iraq, Yemen, the United Arab Emirates and Ukraine.

Although the pharmaceutical sector is not included in the sanctions regime – even US pharmaceutical companies can easily apply for licenses from the US Treasury's Office of Foreign Assets Control to export goods to Iran – it is severely undermined by the blanket banking sanctions. Iranian importers complain that Western banks have been declining to enter into transactions related to pharmaceutical imports into Iran. In fact, it is the banking and insurance sanctions which have been the main irritant for all Iranian businesses.

Some Western companies have also reduced their business dealings with Iranian pharmaceutical companies out of fear of contravening the sanctions. This is limiting imports of high-tech machinery, equipment and medicine, including essential drugs for diseases such as cancer, diabetes and multiple sclerosis. Imports from US and European drug-makers were down by 30% in 2012, forcing Iranian companies to import drugs of a lower standard from Asia. The shortage has also pushed up prices, as substitution is not an option in the highly patented world of pharmaceuticals, putting many drugs beyond the reach of the average Iranian. The sanctions also leave Iran short of the hard currency needed to pay for Western drugs.

Source: Khajehpour (2014b); Namazi (2013)

Iranian scientists publish less in agricultural sciences than in medical sciences, although the number of articles has progressed considerably in both fields since 2005. Iran is a growing destination for medical tourism in the Middle East. The Royan Institute, for instance, is a beacon for infertile couples (Box 15.3).

Iran has become a hub for nanotech

Nanotech research has taken off in Iran since the Nanotechnology Initiative Council (NIC)[19] was founded in 2002 (Figure 15.5). NIC's budget increased considerably between 2008 and 2011, from 138 million to 361 million rials; NIC received a lesser endowment in 2012 (251 million rials) but this has since rebounded to 350 million rials (2013).

NIC is tasked with determining the general policies for the development of nanotechnology in Iran and with co-ordinating their implementation. It provides facilities, creates markets and strives to help the private sector develop relevant R&D activities.

There are several nanotechnology research centres in Iran:

- the Nanotechnology Research Centre at Sharif University (est. 2005), which established Iran's first doctoral programme in nanoscience and nanotechnology;
- the Nanotechnology Research Centre at Mashhad University of Medical Sciences within the Mashhad Bu Ali Research Institute (est. 2009);

19. See: www.irannano.org

Box 15.3: **The Royan Institute: from infertility treatments to stem cell research**

The Royan Institute was founded by Dr Saeid Kazemi Ashtiani in 1991 as a public non-profit research institute for reproductive biomedicine and infertility treatments. It publishes the *Cell Journal* and the *Iranian Journal of Fertility and Sterility,* both of which are indexed in Thomson Reuters' Web of Science. The institute has its own annual prize, the Royan International Research Award.

The Royan Institute is administered by the Jihad Daneshgahi (*jihad* here means sacred effort in a scientific domain), which itself comes under the supervision of the Council of the Cultural Revolution. The institute is officially non-governmental but is, in fact, part of the higher education system and thus government-funded.

In 1998, the institute was approved by the Ministry of Health as a cell-based research centre. Today, it employs 46 scientists and 186 laboratory technicians in three separate institutes: the Royan Institute for Stem Cell Biology and Technology; the Royan Institute for Reproductive Biomedicine; and the Royan Institute for Animal Biotechnology.

One of the institute's first achievements was the birth of a child conceived using *in vitro* fertilization techniques in 1993. A decade later, the institute set up a stem cell research department. In 2003, it developed human embryonic cell lines for the first time. In 2004, researchers succeeded in obtaining insulin-producing cells from human embryonic stem cells. Adult stem cells have been used to treat corneal injuries (to the eye) and myocardial infarctions (heart attacks) in humans.

In 2011, the Royan Institute set up a Stem Cell Bank and a cell-therapy pre-hospital. A year later, the first healthy child was born after being treated for beta-thalassemia, a disease caused by a defect in the gene responsible for producing haemoglobin, an iron-rich protein contained in red blood cells. About 5% of the world's population are healthy carriers of a gene for haemoglobin disorders but these are most common in Asia, the Middle East and the Mediterranean Basin.

Among other achievements, one could cite the birth of the first cloned sheep in Iran in 2006 and that of the first cloned goat in 2009.

The Royan Institute established the Cord Blood Bank in Iran in 2005. In November 2008, the Bank announced that US$ 2.5 billion would be invested in stem cell research over the next five years and that stem cell research centres would be opened in all major cities.

Source: www.royaninstitute.org; PressTV (2008)

- the Medical Nanotechnology and Tissue Engineering Research Centre at the Shahid Beheshti University of Medical Sciences;
- the Nanotechnology Research Centre at Jondi Sapoor University (est. 2010); and
- the Zanjan Pharmaceutical Nanotechnology Research Centre at Zanjan University of Medical Sciences (est. 2012).

Iran's nanotechnology programme is characterized by the following features (Ghazinoory *et al*., 2012):

- policy-making is a top-down process led by the government;
- the programme is futuristic (forward-looking);
- it relies heavily on promotional efforts to stimulate an interest in nanotechnology among policy-makers, experts and the general public, including an annual Nanotechnology Festival in Tehran; the NIC has created a Nano Club[20] for school students and a Nano Olympiad;
- it places emphasis on making all the links in the value chain;
- it makes wide usage of financial support as an incentive;
- it is supply-based, as opposed to needs-based, and relies on Iran's domestic capabilities.

In nanotech, quantity still outstrips quality

One of NIC's missions has been to hoist Iran among the top 15 countries in this field. It has succeeded admirably, as Iran ranked seventh worldwide by 2014 for the volume of papers related to nanotechnology (Figure 15.5). Iran has also progressed rapidly for the number of papers per million inhabitants. In the past decade, 143 nanotech companies have been established in eight industries.

Despite this feat, the average citation rate has dropped since 2009 and few patents are being granted to inventors, as yet. Moreover, the number registered with the European Patent Office and US Patents and Trademark Office dropped from 27 to 12 between 2012 and 2013 after steady growth since 2008.

20. See: nanoclub.ir

Table 15.3: **Growth in Iran's science and technology parks, 2010–2013**

	2010	2011	2012	2013
Number of science and technology parks	28	31	33	33
Number of business incubators	98	113	131	146
Patents generated by science and technology parks	310	321	340	360
Knowledge-based companies established in science and technology parks	2 169	2 518	3 000	3 400
Research personnel working in science and technology parks	16 139	16 542	19 000	22 000

Source: author, based on communication with Ministry of Science, Research and Technology, 2014

A growing network of parks and incubators

Since 2010, five science and technology parks have been set up, along with 48 business incubators (Table 15.3). Whereas some parks specialize, others group a wide spectrum of companies. For instance, the Persian Gulf Science and Technology Park (also known as the Knowledge Village) was set up in 2008; it nurtures companies in all of the following fields: information, communication and electronic technology; nanotechnology; biotechnology; oil, gas and petrochemical; maritime industry; agriculture and the date palm industry; fishing industry and aquatic species; and the food industry.

A survey of about 40 firms established in science and technology parks in Iran's East Azarbaijan Province in 2010 found a correlation between the level of investment in R&D and the extent of innovation; it also revealed that, the longer SMEs had been established in the park, the more innovative they were. On the other hand, the most dynamic firms were not necessarily those with the greatest number of researchers (Fazlzadeh and Moshiri, 2010).

CONCLUSION

Science *can* grow under an embargo

We claimed in the *UNESCO Science Report 2010* that Iranian STI policy was characterized by a science push rather than a technology pull. Today, we could say that STI policy is characterized by a sanctions push rather than a science pull. The increasingly tough sanctions regime since 2011 has oriented the Iranian economy towards the domestic market. By erecting barriers to foreign imports, the sanctions have encouraged knowledge-based enterprises to localize production.

Iran reacted to the sanctions in 2014 by adopting an 'economy of resistance' – a term encompassing both economic policy and STI policy. Policy-makers are being challenged to look beyond extractive industries to the country's human capital for wealth creation, now that they have come to realize that Iran's future lies in the transition to a knowledge economy.

Iranian education policy used to focus on Iran's strength in basic sciences. This focus, together with other factors like the petrodollars windfall, had divorced science from socio-economic needs, as we saw in the *UNESCO Science Report 2010*. The deteriorating economic situation, coupled with a surge in the number of graduate students and the difficulties they encounter in finding work, has created a fertile terrain for a greater focus on applied sciences and technology. In this context, the government's limited budget is being directed towards supporting small innovative businesses, business incubators and science and technology parks, the type of enterprises which employ graduates. In parallel, the Ministry of Science, Research and Technology plans to develop more interdisciplinary university courses and a Master of Business Administration degree, in order to make university curricula more responsive to socio-economic needs.

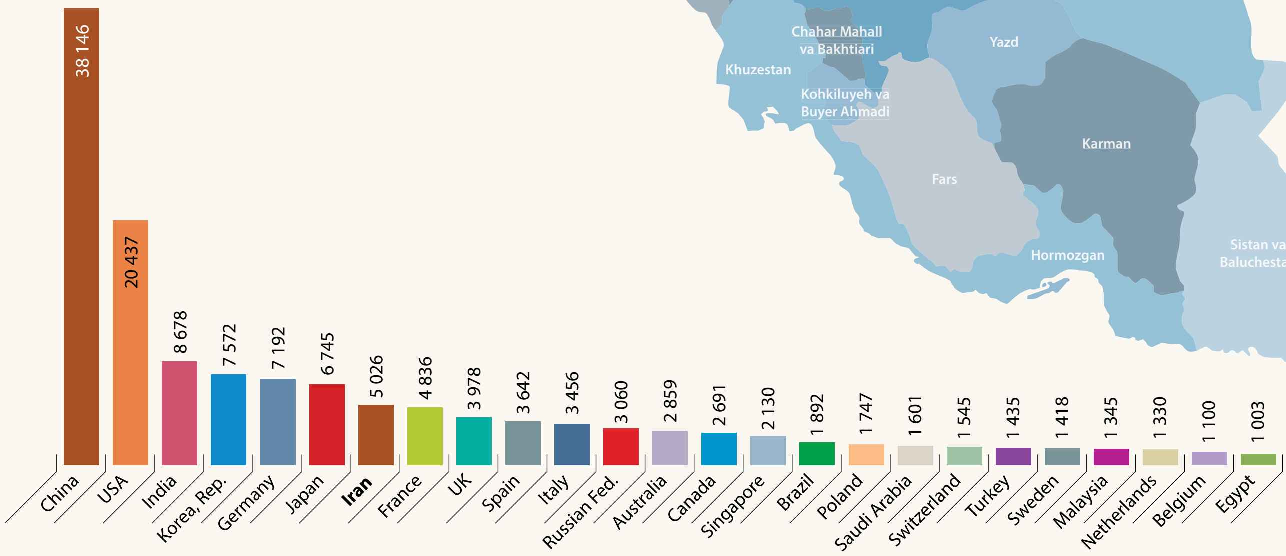
The sanctions have had one unanticipated, yet welcome effect. With the state no longer able to rely on petrodollars to oil the wheels of a sprawling administration, the government has embarked upon reform to reduce institutional costs, introduce a more disciplined budgeting system and improve science governance.

Iran's experience offers a unique perspective. More than any other factor, the growing importance of STI policy in Iran is a consequence of the tougher international sanctions. Science *can* grow under an embargo. This realization offers hope for a brighter future in Iran.

Figure 15.5: **Trends in nanotechnology in Iran**

Iran is now ranked seventh worldwide for the number of nanotech-related papers

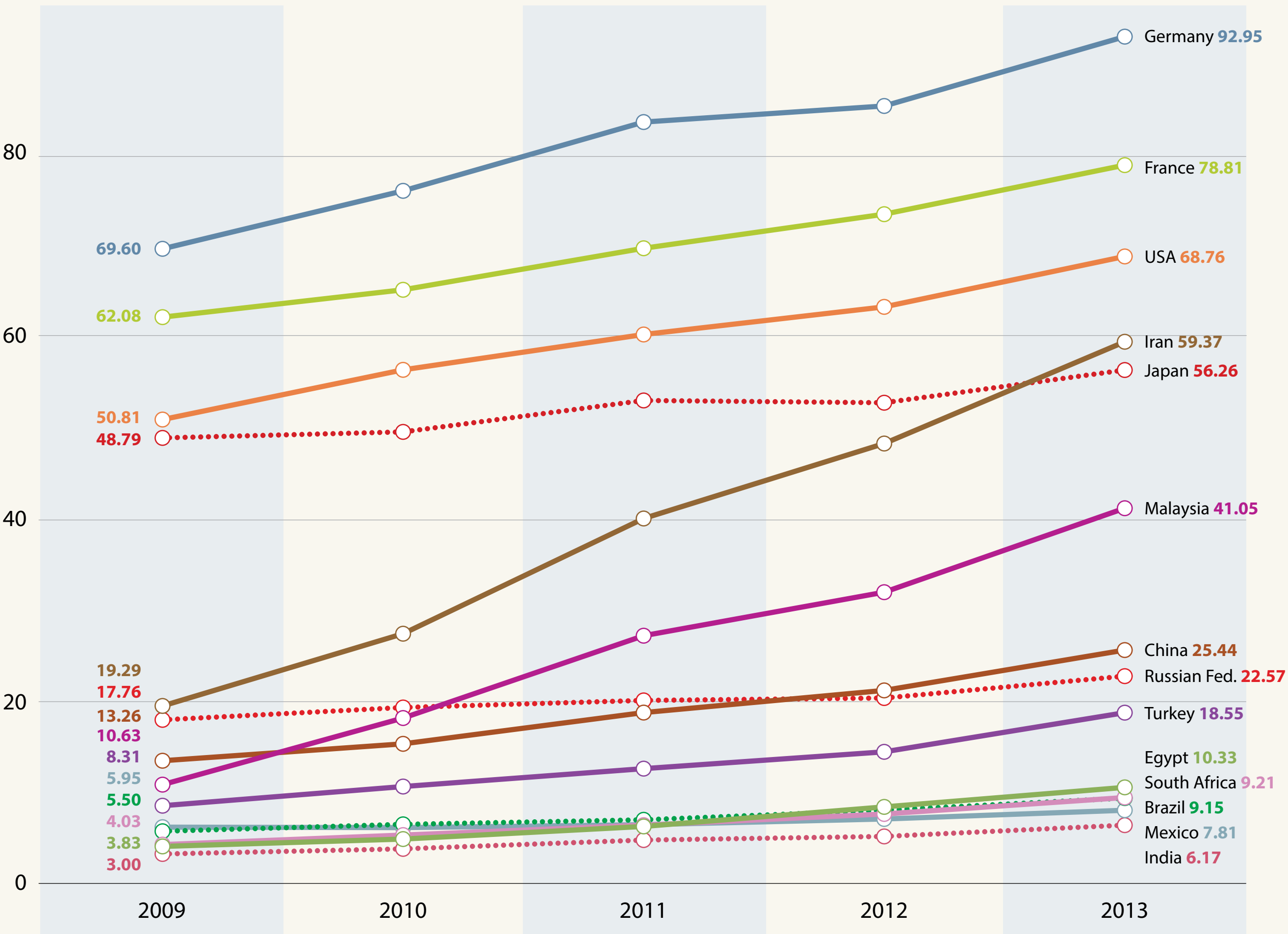
Top 25 for volume of nanotechnology-related papers, 2014



Note: The total for China does not include Chinese Taipei, which recorded 3 139 papers in this database in 2014.

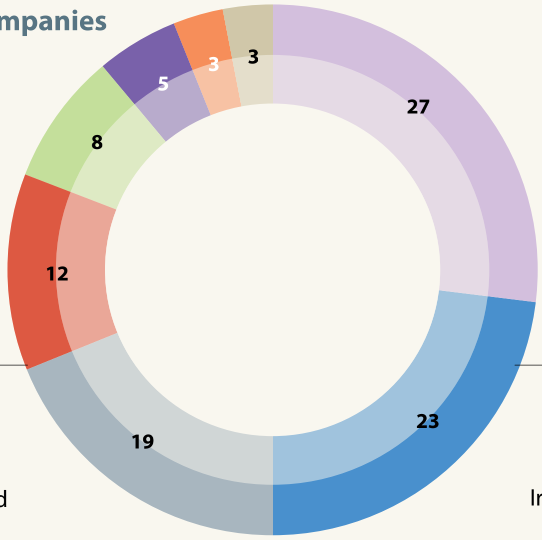
Iran performs well for the number of nanoarticles per million inhabitants

Other countries are given for comparison



The 143 Iranian nanotech companies are active in eight industries

Percentage share



568

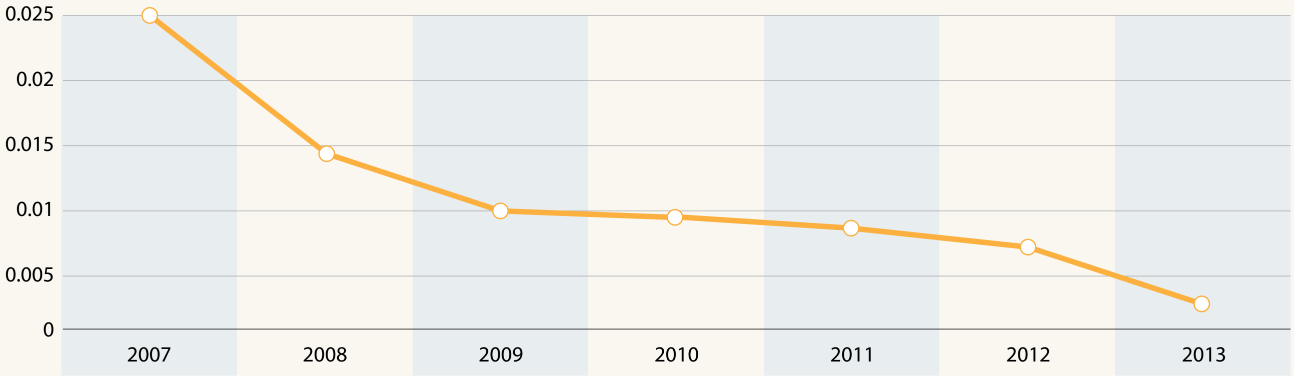
Iranian researchers worked in the field of nanotechnology in 2003

20 966

Iranian researchers worked in the field of nanotechnology in 2013

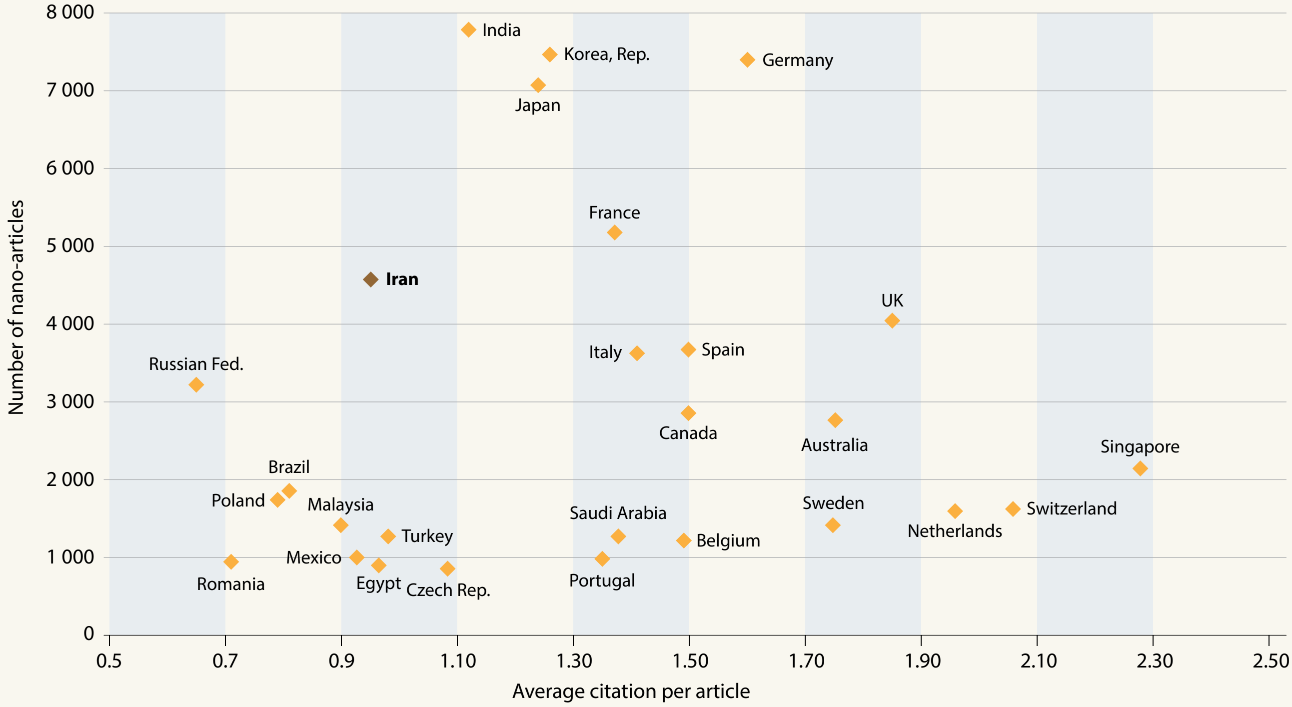
Patents are not keeping pace with growth in publications…

Number of nanotech patents from Iran registered by EPO and USPTO per 100 scientific articles



… and quality does not yet match quantity in Iran

Average citations of Iranian nanotech articles, in comparison with those of other leading countries, 2013



Source: statnano.com (January 2015), based on data from Thomson Reuters' Web of Science, Science Citation Index Expanded, and records from European Patent Office and US Patents and Trademark Office

KEY TARGETS FOR IRAN

- Raise the GERD/GDP ratio to 3% by 2015 and to 4% by 2025;
- Carry business expenditure on R&D to 50% of GERD by 2025;
- Raise the share of researchers employed by the business enterprise sector to 40% by 2025;
- Increase the number of full-time university professors per million population from 1 171 in 2013 to 2 000 in 2025;
- Raise FDI to 3% of GDP by 2015;
- Privatize 80% of state-owned firms between 2004 and 2014;
- Publish 800 scientific articles in international journals per million population by 2025, compared to 239 in 2013.

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Kioomars Ashtarian (b. 1963: Iran) holds a PhD in Technological and Public Policy from Laval University in Canada and is an Associate Professor at the Faculty of Law and Political Science of the University of Tehran. He is former Director-General of the Public Sector at the Management and Planning Organization of the Islamic Republic of Iran (2003–2004) and former Dean of News Faculty, the Iranian News Agency (2002–2003). Currently, he occupies the post of Secretary in the Cabinet Office for Social Affairs and E-Government.

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