Japan needs to adopt forward-looking policies ... and to pursue the necessary reforms to adapt to the changing global landscape.

Yasushi Sato and **Tateo Arimoto**

ASIMO is the culmination of two decades of humanoid robotics research by Honda engineers. ASIMO can run, walk on uneven slopes and surfaces, turn smoothly, climb stairs and reach for and grasp objects. ASIMO can also comprehend and respond to simple voice commands. ASIMO has the ability to recognize the face of a select group of individuals. Using its camera eyes, ASIMO can map its environment and register stationary objects. ASIMO can also avoid moving obstacles as it moves through its environment.
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Yasushi Sato and Tateo Arimoto

INTRODUCTION

Two turning points in Japanese politics

Twice, Japan has experienced a political turning point in the past decade. The first came in August 2009, with the electoral defeat of the Liberal Democratic Party (LDP), which had dominated Japanese politics for over half a century. Frustrated by the LDP's failure to shake Japan out of a two decade-long economic slump, Japanese voters placed their hopes in the Democratic Party of Japan (DPJ). Three prime ministers followed in quick succession, none of whom succeeded in rebooting the economy. Twenty-one months after the Great East Japan Earthquake triggered a tsunami and the Fukushima nuclear disaster in March 2011, disillusioned voters returned the LDP to power in the December 2012 general election.

The new prime minister, Shinzo Abe, put in place a set of extraordinarily active fiscal and economic policies which have been dubbed Abenomics. After news emerged that Japan had officially slipped into recession following an increase in taxation on consumption, the prime minister called a snap election in December 2014 to consult the public on whether or not to pursue Abenomics. His party won a landslide victory.

Long-term challenges: an ageing society and economic stagnation

Although Abenomics has helped Japan to recover from recession in the wake of the global financial crisis of 2008, the nation's underlying problems remain. Japan's population peaked in 2008 before embarking on a gradual decline. As the proportion of seniors in the nation's population has surged, Japan has become the world's most aged society, even if the fertility rate did rise somewhat between 2005 and 2013, from 1.26 to 1.43 children per woman. The combination of a sluggish economy and ageing society has necessitated the mobilization of increasingly massive government expenditure, especially for social security. The share of accumulated total government debt in GDP exceeded 200% in 2011 and has since continued to climb (Table 24.1). To help service this debt, the Japanese government raised the tax on consumption from 5% to 8% in April 2014. The Abe cabinet then decided to postpone raising this tax further to 10% until April 2017, citing Japan's weak economic performance.

The current fiscal situation is clearly unsustainable. Whereas government expenditure on social security rose steadily from 2008 to 2013 at an average annual rate of 6.0%, total national revenue barely progressed. In May 2014, the International Monetary Fund (IMF) recommended that Japan raise its consumption tax rate to at least 15%. This figure is still much lower than in most European nations but it would be very difficult to implement the IMF's recommendation in Japan, as most people, especially seniors, would overwhelmingly vote against any party responsible for such a decision. At the same time, the Japanese would also resist any drop in the current level of public service, which is characterized by cost-efficient, hospitable and universal health care, fair and reliable public education and trusted police and judicial systems. Politicians have thus been able to do little to contrary the rapidly widening gap between revenue and expenditure.

Under such extraordinary fiscal pressure, the government has indeed tried hard to streamline public expenditure. The defence budget remained roughly constant from 2008 to 2013, although it was then moderately augmented as attention focused on changing geopolitical circumstances in Asia. Spending on public works was radically cut back by the DPJ administration but increased again after the Great East Japan Earthquake, especially under the Abe administration. The budget for education shrank constantly from 2008 to 2013, with the notable exception of DPJ's flagship policy of making secondary school education free of charge, introduced in 2010. After expanding constantly for years, the budget for the promotion of science and technology (S&T) went into reverse. Although the government still sees S&T as a key driver of innovation and economic growth, the combination of limited revenue and rising expenditure for social security does not bode well for public support of S&T in Japan.

In the private sector, too, investment in research and development (R&D) has dropped since the global financial

Table 24.1: **Socio-economic indicators for Japan, 2008 and 2013**

Year	GDP growth, volume (%)	Population (millions)	Share of population aged 65 years and above (%)	Government debt as a share of GDP (%)*
2008	-1.0	127.3	21.6	171.1
2013	1.5	127.1	25.1	224.2

*General government gross financial liabilities

Source: OECD (2014) *Economic Outlook No.96;* IMF World Economic Outlook database, October 2014; for population data: UN Department of Economic and Social Affairs crisis of 2008, along with capital investment. Instead of investing their resources, firms have been accumulating profits to constitute an internal reserve which now amounts to roughly 70% of Japan's GDP. This is because they increasingly feel the need to be prepared for momentous socio-economic changes, even though these are hardly predictable. A 4.5% reduction in the corporate tax rate in 2012, in response to similar global trends, helped Japanese firms amass their internal reserve, albeit at the expense of raising their employees' salaries. In fact, Japanese firms have consistently cut operational costs over the past 20 years by replacing permanent employees with contractors, in order to compete in the global market. After peaking in 1997, the average salary in the private sector had dropped by 8% by 2008 and by 11.5% by 2013, enlarging income disparities. Moreover, as in many advanced nations, young people increasingly find themselves occupying temporary jobs or working as contractors. This makes it difficult for them to acquire skills and gives them little say in their career paths.

'Japan is back!'

It was in the midst of such fiscal and economic distress that Prime Minister Abe came to office in December 2012. He vowed to make Japan's economic recovery his top priority by overcoming deflation, which had afflicted the Japanese economy for nearly two decades. Soon after his inauguration, he made a speech in February 2013 entitled *Japan is Back,* during a visit to the USA. Abenomics consists of 'three arrows,' namely monetary easing, fiscal stimulus and a growth strategy. Investors the world over were intrigued and began paying special attention to Japan in 2013, resulting in a rise of stock prices by 57% in a year. At the same time, overappeciation of the yen, a phenomenon which had tormented Japanese manufacturers, came to an end. The prime minister even urged the private sector to raise employees' salaries, which it did.

The full effects of Abenomics on the Japanese economy are yet to be seen, however. Although the depreciation of the yen has helped Japan's export industry, the extent to which Japanese firms will bring their factories and R&D centres abroad back to Japan remains unclear. A weaker yen has also raised the price of imported goods and materials, including oil and other natural resources, worsening Japan's trade balance.

It appears that, in the end, Japan's long-term economic health will depend on the third arrow of Abenomics, namely, its growth strategy, the key elements of which include enhancing the social and economic participation of women, fostering medical and other growing industries and promoting science, technology and innovation (STI). Whether these goals are achieved will fundamentally affect the future of Japanese society.

TRENDS IN STI GOVERNANCE

A radical departure from the past

It was the Basic Law on Science and Technology (1995) which first mandated the Japanese government to formulate the *Basic Plan for Science and Technology,* the most fundamental document in this policy area. The *Basic Plan* has since been revised every five years. The *First Basic Plan* (1996) called for a drastic increase in government expenditure on R&D, a wider range of competitive research funds and proper care for research infrastructure. The *Second* and *Third Basic Plan*s specified life sciences, information and communication technologies (ICTs), environment and nanotechnology/ materials science as being the four priority areas for resource allocation, while also emphasizing the importance of basic science. Whereas fostering a competitive research environment and university–industry collaboration continued to be a major policy agenda, communicating science to society gained greater importance. Innovation became a keyword for the first time in the *Third Basic Plan*, published in 2006. A review of implementation of the *Third Basic Plan* by the Council for Science and Technology Policy found growing support for young researchers, a higher proportion of female researchers and greater university–industry collaboration but noted that further efforts were necessary in these areas. The review also emphasized the importance of effective Plan–Do–Check–Act mechanisms.

Just as the Council for Science and Technology Policy was putting the final touches to the *Fourth Basic Plan*, the Great East Japan Earthquake struck on 11 March 2011. The triple catastrophe – the earthquake having triggered a tsunami and the Fukushima nuclear disaster – made a tremendous impact on Japanese society. About 20 000 people died or were reported missing, 400 000 houses and buildings were damaged and properties amounting to hundreds of billions of dollars were destroyed. A wide area encompassing towns and farms had to be evacuated after being contaminated by radioactive materials and six nuclear reactors had to be abandoned; all the remaining reactors were halted across the nation, although a few did temporarily resume operations later. A large-scale plan to save electricity was implemented nationwide over the summer of 2011.

The release of the *Fourth Basic Plan* was postponed until August 2011, in order to take these developments into account. The new *Plan* was a radical departure from its predecessors. It no longer identified priority areas for R&D but rather put forward three key issue areas to be addressed: recovery and reconstruction from the disaster, 'green innovation' and 'life innovation.' The *Plan* also specified other priority issues, such as a safe, affluent and better quality of life for the public, strong industrial competitiveness, Japan's contribution to solving global problems and sustaining the national foundations.

Thus, the *Fourth Basic Plan* made a radical transition from discipline-based to issue-driven STI policy.

In June 2013, just months after the Abe government's pledge to revive the economy rapidly, the government introduced a new type of policy document, the *Comprehensive Strategy on STI*, a combination of a longer-term vision and actions of a one-year duration. The *Comprehensive Strategy* enumerated concrete R&D themes in such fields as energy systems, health, next-generation infrastructure and regional development, while at the same time proposing ways of improving the national innovation system. The plan also identified three key directions for STI policy: 'smartization,[1]' 'systemization' and 'globalization.' In June 2014, the government revised the *Comprehensive Strategy*, specifying the following areas as being important cross-cutting technological fields for realizing the strategy's vision: ICTs, nanotechnology and environmental technology.

Getting universities to play a more active role in innovation

Any general document related to STI policy in Japan in the past decade has consistently laid heavy emphasis on innovation and university–industry collaboration. A rationale often put forward is that Japan is doing fairly well in scientific research and technological development but is losing ground in terms of value creation and competing on the world stage. Politicians, government officials and industrial leaders all believe that innovation is the key to recovery from Japan's chronic economic stagnation. They also agree that universities should play a more active role in this endeavour.

By 2010, there were already major laws in place to foster university–industry collaboration. The Japanese version of the 'Bayh-Dole provision'[2], which accorded intellectual property rights resulting from publicly funded R&D to research institutes rather than the government, was first codified in a specific act passed in 1999 then made permanent by the Industrial Technology Enhancement Act, amended in 2007. Meanwhile, the Intellectual Property Basic Act had come into effect in 2003, the year that an ambitious reform of tax exemptions for private firms' R&D expenses was introduced, in particular those expenses relating to their collaboration with universities and national R&D institutes. In 2006, the Basic Act on Education was officially amended to expand the mission of universities beyond education and research to making a contribution to society, which implicitly encompassed industrial and regional development.

Numerous programmes were launched within these legal frameworks to foster university–industry collaboration. Some aimed at creating large centres for university–industry research collaboration on varied themes, whereas others supported the creation of university start-ups. There were also programmes to strengthen existing intra-university centres for liaising with industry, supporting university research that responded to specific industrial demands and fostering and deploying co-ordinators at universities. The government also created a series of regional clusters in 2000, although many of these were abolished between 2009 and 2012 after the government decided to terminate innumerable programmes in a hasty effort to cut public spending.

Such a broad range of government support has led to persistent growth in university–industry collaboration in Japan in the past five years. Compared with the preceding five years, however, growth has slowed. In particular, the number of new university start-ups has dropped sharply from a peak of 252 in 2004 to just 52 in 2013 (Table 24.2). In part, this trend reflects the maturation of university–industry relationships in Japan but it may also imply a loss of momentum in public policy initiatives in recent years.

Support for high-risk, high-impact R&D

Nonetheless, the Japanese government remains convinced that promoting innovation through university–industry collaboration is vital for the nation's growth strategy. It has thus recently launched a series of new schemes. In 2012, the government decided to invest in four major universities which would then establish their own funds to invest in new university start-ups jointly with financial institutions, private firms or other partners. When such endeavours yield a profit, part of the profit is returned to the national treasury.

1. Smartization is a term underlying such concepts as 'smart grid' and 'smart city.'

2. The Bayh-Dole Act (officially The Patent and Trademark Law Amendments Act) of 1980 authorized US universities and businesses to commercialize their federally funded inventions.

Table 24.2: **Collaboration between universities and industry in Japan, 2008 and 2013**

Year	Number of joint research projects	Amount of money received by universities in joint research projects (¥ millions)	Number of contract research projects	Amount of money received by universities via contract research projects (¥ millions)	Number of new university start-ups
2008	17 638	43 824	19 201	170 019	90
2013	21 336	51 666	22 212	169 071	52

Note: Here, universities include technical colleges and inter-university research institutes.

Source: UNESCO Institute for Statistics, April 2015

In 2014, a new large programme was launched to support high-risk, high-impact R&D, entitled Impulsing Paradigm Change through disruptive Technologies (ImPACT). This scheme is in many ways similar to that of the US Defense Advanced Research Project Agency. Programme managers have been given considerable discretion and flexibility in assembling teams and directing their efforts.

Another major scheme that got under way in 2014 is the Cross-ministerial Strategic Innovation Promotion (SIP) programme. In order to overcome interministerial barriers, the Council for Science, Technology and Innovation[3] directly administers this programme, promoting all stages of R&D which address key socio-economic challenges for Japan, such as infrastructure management, resilient disaster prevention and agriculture.

These new funding schemes reflect the growing recognition among Japanese policy-makers of the need to finance the entire value chain. The Japanese government is hoping that these new schemes will give rise to groundbreaking innovation that will solve social problems and, at the same time, boost the Japanese economy in the way envisioned by the Abe cabinet.

A boost for renewable energy and clean technology

Historically, Japan has made heavy investments in energy and environmental technology. With few natural resources to speak of, it has launched many national projects since the 1970s to develop both renewable and nuclear energy. Japan had the largest share of solar power generation in the world until the mid-2000s, when it was rapidly overtaken by Germany and China.

After the Great East Japan Earthquake of March 2011, Japan decided to place renewed emphasis on the development and use of renewable energy, particularly since the country's entire network of nuclear reactors was at a standstill by May 2012, with no clear prospect of their starting up again. In July 2012, the government introduced a feed-in tariff, a system which mandates utilities to purchase electricity from renewable energy producers at fixed prices. Relevant deregulation, tax reductions and financial assistance have also encouraged private investment in renewable energy. As a result, the market for solar power has quickly expanded, while the cost of solar electricity has steadily dropped. The share of renewable energy (excluding hydroelectric power) in Japan's total electricity generation rose from 1.0% in 2008 to 2.2% in 2013. It is expected that existing government policies will further enlarge the market for renewable energy.

Japanese industry has been a slow-starter in aeronautics but, since 2003, the Ministry of the Economy, Trade and Industry has been subsidizing an undertaking by Mitsubishi Heavy Industries to develop a jet airliner which it hopes will conquer the global market, thanks to its high fuel efficiency, low environmental impact and minimal noise (Box 24.1).

A disaffection for academic careers

As in many other nations, young Japanese PhD-holders have been finding it difficult to obtain permanent positions in universities or research institutes. The number of doctoral students is on the decline, with many master's students not daring to embark on a seemingly unrewarding career in research.

In response, the Japanese government has taken a series of measures since 2006 to diversify the career paths of young researchers. There have been schemes to promote university–industry exchanges, subsidize internships and develop training programmes to give PhD candidates broader prospects and skills. The government has also promoted curricular reform of doctoral programmes to produce graduates who can more readily adapt to the non-academic environment. In 2011, the Ministry of Education, Culture, Sports, Science and Technology (MEXT) initiated a large-scale Programme for Leading Graduate Schools; this programme has funded the ambitious reform of graduate programmes engaged by universities to stimulate creativity and provide broad-based skills, in order to incubate global leaders in industry, academia and government.

At the same time, the government has taken steps to reform universities' personnel systems. In 2006, the government began subsidizing the introduction of a tenure–track system at university, which had traditionally been absent from Japanese academia. The subsidy was expanded in 2011. The concept of university research administrator (URA) was also officially introduced in 2011. URAs perform a wide range of duties, such as analysing their own institution's strengths, formulating strategies to acquire R&D funding, managing R&D funding, handling issues related to intellectual property rights and maintaining external relations. However, in some universities, URAs are still regarded as being no more than support staff for researchers. It may take some time for the specificity of URAs to be duly recognized in Japanese universities.

Falling student rolls may prompt radical reform

A powerful trend in higher education in recent years has been the emphasis on global human resources, or in other words, people who have no difficulty in working transnationally. Traditionally, the Japanese have been conscious that international interaction is not their strong point, largely due to their poor English. At the turn of the

3. Formerly the Council for Science and Technology Policy, it was strengthened and renamed in 2014.

Box 24.1: The Mitsubishi Regional Jet

The Mitsubishi Regional Jet is the first jet airliner to be designed and produced in Japan. Its official rollout took place on 18 October 2014 and its maiden flight is scheduled for 2015. The first deliveries should follow in 2017. Hundreds of orders have already been received from domestic and foreign airlines.

The jet's main manufacturers are Mitsubishi Heavy Industries and its subsidiary Mitsubishi Aircraft Corporation, established in 2008. Different models of the jet will carry 70–90 passengers with flight ranges of 1 500–3 400 km.

The Japanese aerospace industry has been a slow-starter in aeronautics. Aircraft production was banned in Japan for seven years after the end of the Second World War. After the ban was lifted, research on aerospace technology gradually took off, thanks to the entrepreneurial efforts of a group of researchers at the University of Tokyo and other academic, industrial and government institutions.

Over the following decades, plans to develop and produce aeroplanes were repeatedly thwarted. A semi-public corporation created in 1959 began developing a medium-sized turboprop airliner YS-11 and actually produced 182 airframes before being disbanded and absorbed into Mitsubishi Heavy Industries in 1982 after accumulating losses. Heavily subsidized and controlled by the Ministry of International Trade and Industry (renamed the Ministry of the Economy, Trade and Industry in 2001), the corporation lacked the requisite flexibility to adapt to the changing international market.

Although the ministry consistently strived to promote the Japanese aerospace industry from the 1970s onwards, it was not easy for Japanese manufacturers to realize their plans to develop new aircraft. For a long time, they remained subcontractors to American and European firms. It was only in 2003 that Mitsubishi Heavy Industries began developing a medium-sized jet airliner, a year after the ministry announced that it would subsidize such an undertaking. The original plan was to make a maiden flight by 2007 but this proved overly optimistic.

The initial budget of ¥ 50 billion has since grown to around ¥ 200 billion but, thanks to the tenacious efforts of Mitsubishi and other manufacturers, the Mitsubish Regional Jet boasts high fuel efficiency, a low environmental impact and little noise. Japan's traditional strength in carbon fibre, which has been widely adopted in aeroplanes all over the world, has also been fully incorporated in the jet. Hopefully, these technological merits will have strong consumer appeal in the global market.

Source: compiled by authors

century, however, virtually all businesses were finding it increasingly difficult to operate within Japan's closed market. In response, MEXT initiated a major project in 2012 for the Promotion of Global Human Resource Development, which was expanded in 2014 into the Top Global University Project. These projects provided universities with generous subsidies to produce specialists who would feel comfortable working transnationally. Such government projects aside, Japanese universities are themselves making it a priority to educate students in today's global context and to enrol international students. By 2013, 15.5% of all graduate students (255 386) were of foreign origin (39 641). The great majority (88%) of international graduates[4] were Asian (34 840), including 22 701 from China and 2 853 from the Republic of Korea.

Arguably the most fundamental challenge facing Japanese universities is the shrinking 18 year-old population. Since peaking at 2 049 471 in 1992, the number of 18 year-olds has almost halved to 1 180 838 (2014). The number of university entrants has nevertheless risen, owing to the surge in the proportion of young Japanese attending university: 26.4% in 1992 and 51.5% in 2014 (Figure 24.1). However, most stakeholders see signs of saturation; they share the view that a radical reform of the nation's university system is imminent.

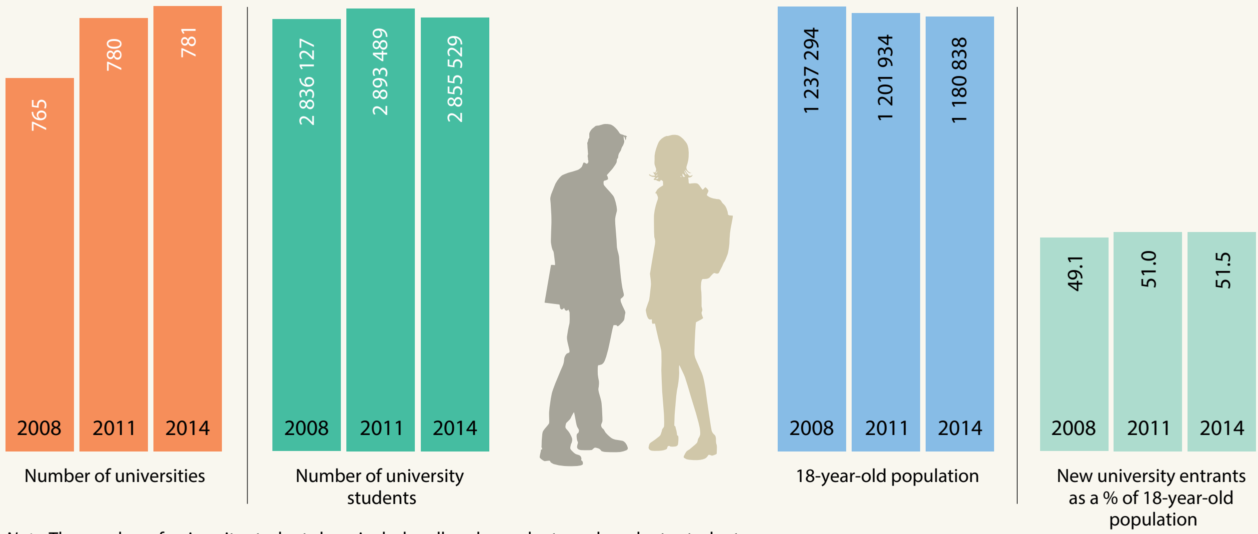
The number of universities in Japan had climbed steadily until recently. As of 2014, there were 86 national universities, 92 other public universities and 603 private universities. This total (781) is quite large by international standards. About half of private universities are now unable to fill their quota, suggesting that a massive consolidation and merger may take place in the near future.

An historic reform which stratifies universities

A government-led structural reform of national universities is already under way. Ever since these were semi-privatized in 2004 and renamed national university corporations, their regular government funding has been cut by roughly 1% each year. National universities were expected to help themselves by obtaining more research grants, more private-sector funding and more donations. Not all of them have managed to adapt well to this new environment, however;

4. Others came from Viet Nam (1 333) and Malaysia (685). Among non-Asian students, 1 959 were European, 872 African, 747 from the Middle East, 649 from Latin America (649) and 424 from North America.

Figure 24.1: **Number of universities and university students in Japan, 2008, 2011 and 2014**



Note: The number of university students here includes all undergraduate and graduate students.

Source: MEXT (2014b, 2014c)

only a handful have remained healthy, the others having suffered from shrinking funding. In light of this situation, the government has been urging universities since 2012 to initiate reforms and to redefine their own missions to make the most of their unique strengths. As an incentive, the government is providing universities willing to engage in reform with a range of subsidies.

The universities' efforts alone have not sufficed, however. In November 2013, MEXT announced the *National University Reform Plan*, in which the ministry suggested that each national university choose one of three directions; it could become a world-class centre for education and research, a national centre for education and research or a core centre for regional revitalization. In July 2014, MEXT made it clear that funding for national universities would also be reformed; under the new scheme, three types of universities would be evaluated according to different criteria and funding options. This is an epoch-making decision because all national universities in Japan have had the same institutional status up until now. From now on, they will be officially stratified.

Publicly funded R&D institutions are also under reform. Previously, institutions such as the Japan Aerospace Exploration Agency, Japan International Cooperation Agency and Urban Renaissance Agency fell under the same category of independent administrative agencies. In June 2014, a bill was passed which attributes a separate status of national R&D agency to 31 out of 98 agencies. National R&D agencies will be evaluated on a relatively long-term basis (every 5–7 years), compared to other agencies (mostly 3–5 years), to maximize their R&D performance.

Although the Institute of Physical and Chemical Research (RIKEN) and the National Institute of Advanced Industrial Science and Technology (AIST) are currently catalogued as independent administrative agencies, the government was intending to make them special national R&D agencies, a status which would have given them considerable latitude in introducing unique evaluation systems and entitled them to pay exceptionally high salaries to outstanding researchers. The plan has been put on hold, however, following a highly publicized case of misconduct by a RIKEN researcher which shall be evoked again below.

Creating spaces where scientists and the public can meet

In 2001, the second *Basic Plan for Science and Technology* recognized the increasing interdependence between science and society. It underlined the need to strengthen bidirectional communication between science and society, urging researchers in social sciences and humanities to play their part. Since then, a great variety of programmes related to science communication, science cafés, science outreach, science literacy and risk communication have been launched. Graduate programmes in science communication and science journalism have been introduced in several universities and the number of science communicators has clearly increased. Since 2006, the Japan Science and Technology Agency has been holding an annual festival called Science Agora to provide a place for scientists and the general public to meet. Science Agora's mandate was expanded in 2014 to include debate on critical social issues related to science and technology.

Scientific advice has come to the fore since the triple catastrophe

The importance of maintaining a dialogue between scientists and policy-makers has been recognized more recently. The issue of scientific advice came to the fore after the Great East Japan Earthquake of March 2011. There was a widespread perception that the government was unable to mobilize scientific knowledge to cope with the triple catastrophe. A series of symposia were held to discuss the role of scientific advice in policy-making and the idea was tabled of appointing science advisors to the prime minister and other ministers, although this idea has not materialized yet. Meanwhile, the Science Council of Japan (the Japanese Academy of Sciences) revised its Code of Conduct for Scientists in January 2013, adding a new section on scientific advice. A stronger commitment to this issue on the part of policy-makers will be necessary for Japan to participate actively in the rapidly evolving international discussion on this topic.

In 2011, the government launched a programme called Science for RE-designing Science, Technology and Innovation Policy (SciREX). The purpose is to establish a system which reflects scientific evidence[5] more robustly in STI policy. The SciREX programme supports several research and education centres within universities, issues grants to researchers in relevant fields, and promote the construction of the relevant evidence base. The many researchers in social sciences and humanities involved in this programme are training specialists in this new field and publishing their findings on such themes as science-based innovation, STI and economic growth, policy-making processes, the social implication of S&T and the evaluation of R&D.

While SciREX is mainly concerned with evidence-based STI policy, science and technology can also inform other policy fields, such as environmental policy and health policy ('science for policy,' as opposed to 'policy for science'). In these fields, policy-makers rely heavily on advice put forward by scientists in various formats because solid policy-making is impossible without specialized knowledge of relevant phenomena.

Despite the obvious virtues of scientific advice for policy-making, the relationship between the two is not always straightforward. Scientific advice can reflect uncertainties and scientists may express divergent opinions. Scientific advisors may be affected by a conflict of interest, or subject to pressure from policy-makers. For their part, policy-makers may select scientific advisors arbitrarily or interpret scientific advice in biased ways. The question of scientific advice has thus become an important topic for discussion in many Western nations and international bodies like the OECD.

5. understood as encompassing not only information and knowledge from natural sciences but also from economics, political science and other social sciences, as well as humanities

Research misconduct has undermined public trust

Research integrity is at the heart of public trust in science. In Japan, the number of publicized cases of research misconduct increased markedly during the 2000s, in parallel with shrinking regular funding for universities and the growth in competitive grants. In 2006, the government and the Science Council of Japan respectively established guidelines on research misconduct but these have not reversed the trend. Since 2010, there has been a spate of reported cases of large-scale research misconduct and misuse of research funds.

In 2014, an extremely serious and highly conspicuous case of research misconduct was exposed in Japan. On 28 January, a 30-year old female researcher and her senior colleagues held a sensational press conference at which they announced that their papers on the creation of Stimulus-Triggered Acquisition of Pluripotent (STAP) cells were being published in *Nature* the next day. This stunning scientific breakthrough received extensive media coverage and the young researcher became a star overnight. Soon after, however, questions were raised in cyberspace about indications of manipulated figures and plagiarized texts in the papers. Her employer, RIKEN, subsequently confirmed her misconduct on 1 April. Although she resisted for a long time and never publicly admitted her misdeeds, she did resign from RIKEN after the institute's investigative committee conclusively rejected the validity of the papers on 26 December, asserting that the STAP cells were in fact another well-known type of pluripotent cell known as embryonic stem cells.

The saga was closely followed by the Japanese population; it seriously undermined public perception of the validity of science in Japan. The case also spurred a wider round of public debate on S&T policy in general. For example, after questions were raised about the young researcher's doctoral thesis, her alma mater, Waseda University, carried out an investigation and decided to cancel her degree with a one-year suspension to give her time to make the necessary corrections. In parallel, the university began investigating other theses originating from her former department. Aside from the problem of quality assurance of degrees, many other issues came to the fore, such as the intense competition among researchers and institutions and the inadequate training of young researchers. In response to this serious, highly publicized case, MEXT revised its guidelines on research misconduct in 2014. These guidelines alone will not suffice, however, to solve the underlying problems.

TRENDS IN R&D

Low government spending on R&D

Japan's gross domestic expenditure on R&D (GERD) had grown consistently until 2007, before plunging suddenly by nearly 10% in the aftermath of the US subprime crisis. Only in 2013 did GERD rebound, mainly due to the recovery of the global economy (Table 24.3). Japan's GERD is closely linked to the nation's GDP, so the drop in GDP in recent years has allowed Japan's GERD/GDP ratio to remain high by international standards.

Government expenditure on R&D increased over the same period but appearances can be deceptive. Japan's R&D budget fluctuates each year owing to the irregular, yet frequent approval of supplementary budgets, especially in the wake of the Great East Japan Earthquake. If we look at the long-term trend, Japan's stagnating government R&D expenditure reflects the extremely tight fiscal situation. By any measurement, though, the ratio of government spending on R&D to GDP has remained low by international standards; the *Fourth Basic Plan* (2011) fixes the target of raising this ratio to 1% or more of GDP by 2015. The *Plan* contains a second ambitious target, that of raising GERD to 4% of GDP by 2020.

The overall structure of Japan's government R&D expenditure has gradually changed. As we said earlier, regular funding of national universities has declined consistently for more than a decade by roughly 1% a year. In parallel, the amount of competitive grants and project funding have increased. In particular, there has been a proliferation recently of multi-purpose, large-scale grants that do not target individual researchers but rather the universities themselves; these grants are not destined purely to fund university research and/or education *per se;* they also mandate universities to conduct systemic reforms, such as the revision of curricula, introduction of tenure–track systems, diversification of researchers' career paths, promotion of female researchers, internationalization of educational and research activities and moves to improve university governance.

As many universities are now in serious want of funding, they spend an extraordinary amount of time and effort applying for these large institutional grants. There is growing recognition, however, of the side-effects of spending so much time on applications, administration and project evaluation: a heavy burden on both academic and administrative staff; short-cycle evaluations can discourage research and education from longer-term viewpoints and; it is often hard to maintain project activities, teams and infrastructure once the projects end. How to strike the best balance between regular and project funding is thus becoming an important policy issue in Japan.

The most remarkable trend in industrial spending on R&D has been the substantial cutback in ICTs (Figure 24.2). Even the Nippon Telegraph and Telephone Corporation, which had historically played a key role as a formerly public organization, was forced to trim its R&D spending. Most other industries maintained more or less the same level of R&D expenditure between 2008 and 2013. Car manufacturers coped relatively well, for instance, Toyota even coming out on top for global car sales between 2012 and 2014. Hardest hit after the global recession of 2008–2009 were Japanese electric manufacturers, including major players such as Panasonic, Sony and NEC, which cut back their R&D spending drastically in the face of severe financial difficulties; compared with manufacturers in other fields, their recovery has been slow and unsteady. It remains to be seen whether the economic stimuli introduced through Abenomics since 2013 will reverse this trend.

Cutbacks in industry have affected research staff

The number of researchers in Japan grew steadily until 2009, when private enterprises began cutting back their research[6] spending. By 2013, there were 892 406 researchers in Japan (by head count), according to the OECD, which translated into 660 489 full-time equivalents (FTE). Despite the drop since 2009, the number of researchers per 10 000 inhabitants remains among the highest in the world (Figure 24.3).

6. Some enterprises stopped hiring, others laid off staff or re-assigned them to non-research positions.

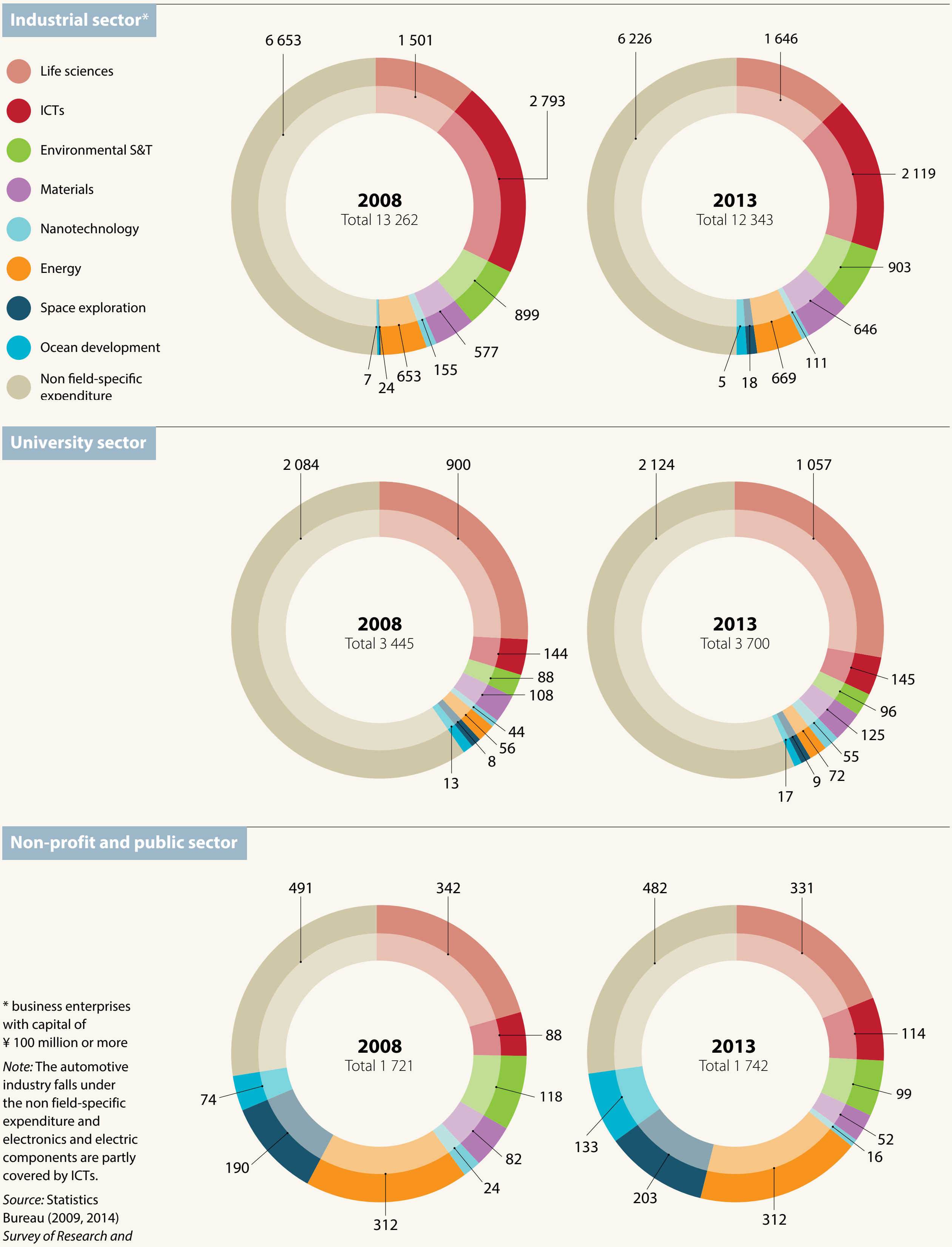
Table 24.3: **Trends in Japanese GERD, 2008–2013**

Year	GERD (¥ billion)	GERD/GDP ratio (%)	Government expenditure on R&D (GOVERD) (¥ billion)	GOVERD/GDP ratio (%)	GOVERD plus higher education expenditure on R&D/ GDP ratio (%)
2008	17 377	3.47	1 447	0.29	0.69
2009	15 818	3.36	1 458	0.31	0.76
2010	15 696	3.25	1 417	0.29	0.71
2011	15 945	3.38	1 335	0.28	0.73
2012	15 884	3.35	1 369	0.29	0.74
2013	16 680	3.49	1 529	0.32	0.79

Source: UNESCO Institute for Statistics, April 2015

Figure 24.2: **R&D expenditure in Japan by field, 2008 and 2013**

In ¥ billions



* business enterprises with capital of ¥ 100 million or more

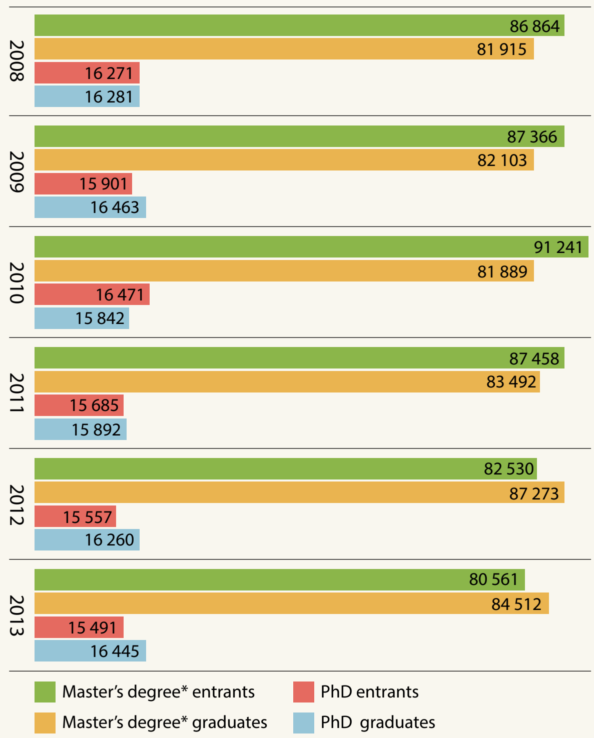
Note: The automotive industry falls under the non field-specific expenditure and electronics and electric components are partly covered by ICTs.

Source: Statistics Bureau (2009, 2014) *Survey of Research and Development*

Figure 24.3: **Number of researchers (HC) in Japan, 2008 and 2013**

Source: Statistics Bureau (2009, 2014) *Survey of Research and Development*

Figure 24.4: **Trends in master's and PhD programmes in Japan, 2008–2013**



* includes professional degree courses

Source: MEXT (2013, 2014c) *Statistical Abstract of Education, Science and Culture*

The number of master's students grew steadily until 2010 when the curve inversed (Figure 24.4). The rise can largely be attributed to the financial crisis from 2008 onwards, when graduates fresh out of university enrolled in graduate schools after giving up hope of finding a job. The drop in enrolment in a master's degree can be partly explained by the growing disappointment in law schools, which were first instituted in 2004 to train a mass of lawyers with diverse backgrounds but have actually produced a mass of jobless lawyers. It might also reflect university students' general scepticism as to the utility of the master's degree. Many master's students also appear to be discouraged from postgraduate study by the prospect of an uncertain career path. The number of new PhD students has also been dropping since peaking at 18 232 in 2003.

Research: more feminine and more international

One in seven Japanese researchers was a woman in 2013 (14.6%). Although this is an improvement on 2008 (13.0%), Japan still has the lowest proportion of women researchers of any member of the Organisation for Economic Co-operation and Development (OECD). The Japanese government is determined to improve this ratio. The *Third* (2006) *and Fourth* (2011) *Basic Plans for Science and Technology* both fixed a goal of a 25% ratio of women: 20% of all researchers in science, 15% in engineering and 30% in agriculture, medicine, dental and pharmaceutical research (Figure 24.5). These percentages are based on the current share of doctoral students in these fields. In 2006, a fellowship scheme was launched for women researchers returning to work after maternity leave. Moreover, given that the ratio of female researchers has been embedded in the assessment criteria of various institutional reviews, many universities now explicitly favour the recruitment of women researchers. As the Abe cabinet strongly advocates a greater social participation by women, it is quite likely that the rise in female researchers will accelerate.

The number of foreign researchers is also gradually rising. In the university sector, there were 5 875 foreign full-time teaching staff (or 3.5% of the total) in 2008, compared to 7 075 (4.0%) in 2013. Since this ratio remains fairly low, the government has been taking measures to internationalize Japanese universities. The selection criteria for most large university grants now take into account the proportion of foreigners and women among teaching staff and researchers.

Scientific productivity a casualty of multitasking

Japan's world share of scientific publications peaked in the late 1990s and has been sliding ever since. The nation was still producing 7.9% of the world's scientific papers in 2007, according to the Web of Science, but its share had receded to

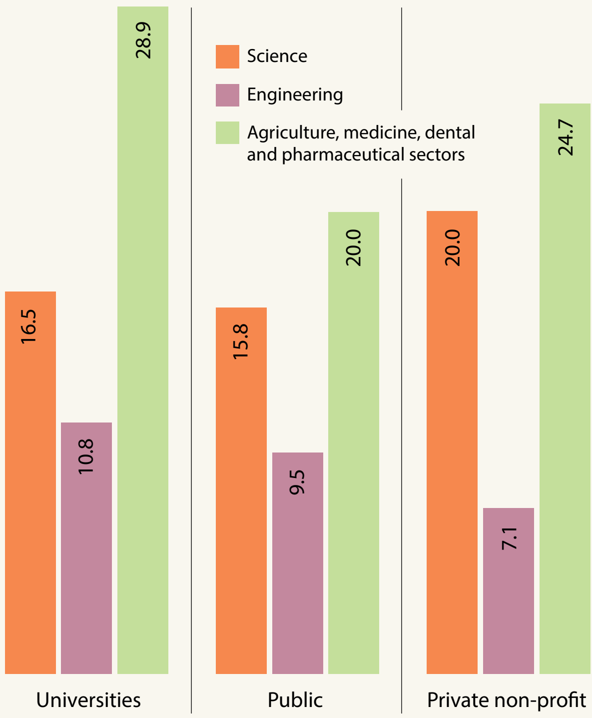
5.8% by 2014. Although this is partly due to China's continuing growth, Japan's poor performance is extraordinary: the world produced 31.6% more papers in 2014 than in 2007 but Japan's production declined by 3.5% over the same period.

One explanation may lie in the meagre growth in Japanese university spending on R&D over the same period, just 1.3% in constant prices, according to the UNESCO Institute for Statistics. The shrinking amount of university researchers' time reserved for research may also be to blame. As we have seen, there has been a modest increase in the number of university researchers in Japan in recent years but the use of their time has changed considerably: each researcher spent an average of 1 142 hours on research in 2008 but only 900 hours in 2013 (Figure 24.6). This worrying 21% drop can be partly accounted for by the decrease in the average number of hours worked by university researchers, which were cut back from 2 920 to 2 573 over the same period. What is certain is that the time allocated to research has been curtailed far more sharply than the time devoted to teaching and other activities; researchers face an array of unavoidable tasks these days: preparing classes in English as well as in Japanese, writing syllabi for all their classes, mentoring students beyond the academic setting, recruiting prospective students, setting up highly diversified and complicated enrollment processes, adapting to increasingly stringent environmental, safety and security requirements, etc..

The decline in publications by Japanese researchers might also be related to changes in the nature of public R&D funding. More and more grants to individual researchers as well as universities are becoming innovation-oriented, and just writing academic papers is no longer regarded as adequate. Whereas innovation-oriented R&D activities also lead to academic papers, Japanese researchers' effort is now possibly less concentrated on producing papers *per se*. At the same time, there are indications that decrease in private R&D funding has brought about a drop of publications by researchers in the private sector.

The downward trend in Japan's publication record is visible in all fields of science (Figure 24.7). Even in chemistry, materials science and physics, fields where Japan used to have a certain presence, its world share has dropped considerably. This is somewhat ironic, considering that a growing number of Japanese scientists have been internationally recognized in recent years for their truly outstanding work. Since the beginning of the century, 15 Japanese scientists (two of whom have become US citizens) have received Nobel prizes (Box 24.2). In point of fact, most of their achievements were made decades ago. This begs the question of whether Japan still retains the institutional and cultural environment that gives rise to such creative work. In the current climate, it will be a real challenge to realize the *Fourth Basic Plan's* target of positioning 100 institutions among the world's top 50 for the citation of research papers in specific fields by 2015.

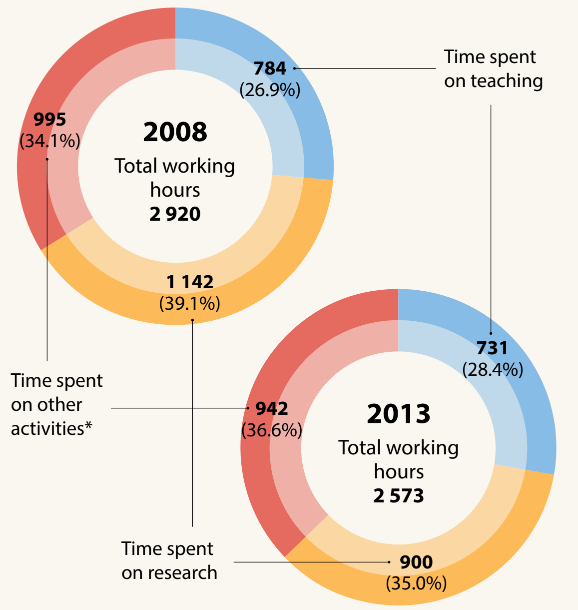
Figure 24.5: **Share of female researchers in Japan by sector and employer, 2013 (%)**



Note: Data are unavailable for the business enterprise sector.

Source: Statistics Bureau (2014) Survey of Research and Development.

Figure 24.6: **Breakdown of working hours of Japanese university researchers, 2008 and 2013**



* Time spent on university administration, services to society such as clinical activities, etc

Source: MEXT (2009, 2014d) *Survey on FTE data for Researchers in Higher Education Institutions*

Figure 24.7: **Scientific publication trends in Japan, 2005–2014**

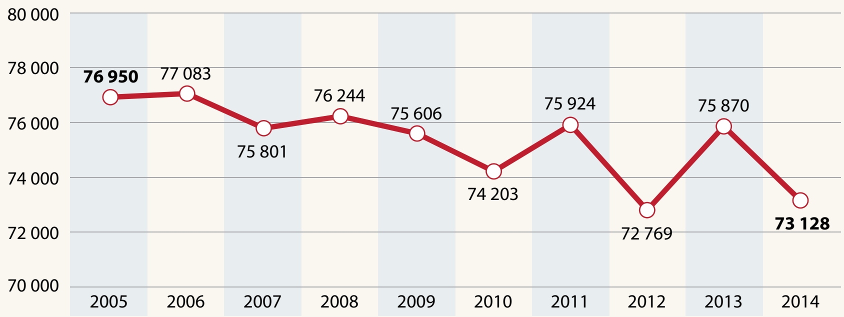
The number of Japanese publications has declined since 2005

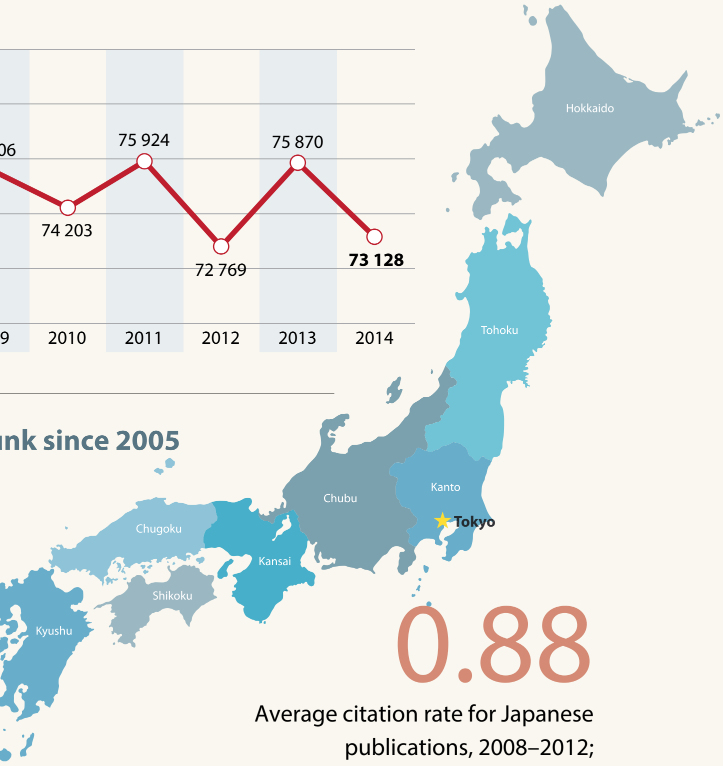
606

Publications per million inhabitants in 2005

576

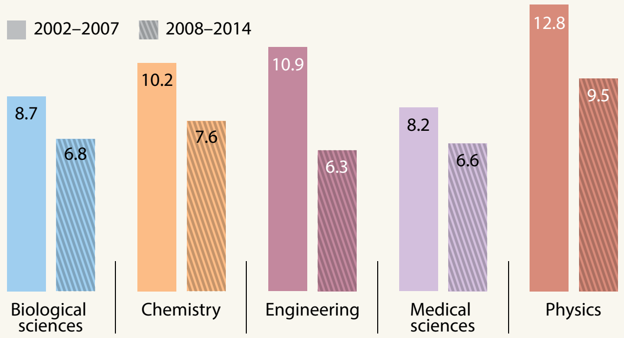
Publications per million inhabitants in 2014





Japan's world share of scientific publications has shrunk since 2005

World share of Japanese articles by field (%)



0.88

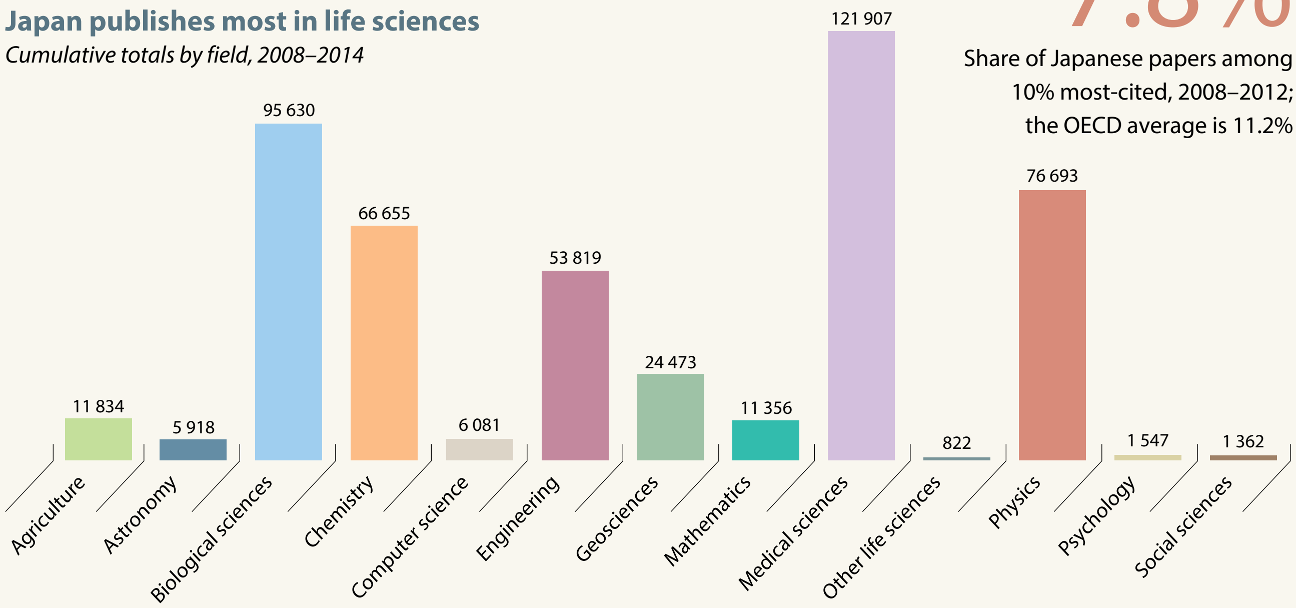
Average citation rate for Japanese publications, 2008–2012; the OECD average is 1.08

7.8%

Share of Japanese papers among 10% most-cited, 2008–2012; the OECD average is 11.2%

Japan publishes most in life sciences

Cumulative totals by field, 2008–2014



Note: Excludes 45 647 unclassified articles

27.1%

Share of Japanese papers with foreign co-authors, 2008–2014; the OECD average is 29.0%

Japan's top partners are the USA and China

Main foreign partners, 2008–2014 (number of papers)

	1st collaborator	2nd collaborator	3rd collaborator	4th collaborator	5th collaborator
Japan	USA (50 506)	China (26 053)	Germany (15 943)	UK (14 796)	Korea, Rep. (12 108)

Source: Thomson Reuters' Web of Science, Science Citation Index Expanded; data treatment by Science–Metrix, November 2014; for Japan's world share of publications: NISTEP (2009, 2014) *Indicators of Science and Technology*

Box 24.2: **Why the increase in Japanese Nobel laureates since 2000?**

Every year, Japanese people excitedly await the announcement from Sweden of the year's Nobel laureates. If Japanese scientists are named, great celebration by the media and the public follows.

Between 1901 and 1999, the public would have had to be extremely patient: just five Japanese scientists received the prestigious award over this entire period. Since 2000, on the other hand, 16 Japanese scientists have been distinguished, including two who have become US citizens.

This does not necessarily mean that the research environment in Japan has improved overnight, since much of the laureates' work was done before the 1980s. However, public and private R&D funding did make a difference in some cases. The work of Shinya Yamanaka, for example, received ample funding in the 2000s from the Japan Society for the Promotion of Science and the Japan Science and Technology Agency. Yamanaka was recompensed (Nobel Prize for Physiology or Medicine, 2012) for his discovery of induced pluripotent stem cells. As for Shuji Nakamura (Nobel Prize for Physics, 2014), he invented efficient blue light-emitting diodes (LED) in the 1990s, thanks to the generous support of his company, Nichia Corporation.

What other factors could explain the increase in Japanese Nobel laureates? It would appear that the focus of the prize has changed. Although the selection process is not disclosed, the social impact of research seems to have been carrying more weight in recent years. All eight Nobel prizes awarded to Japanese scientists since 2010 are for discoveries which have had a demonstrable impact on society, even though three Japanese physicists (Yoichiro Nambu, Toshihide Maskawa and Makoto Kobayashi) received the prize in 2008 for their purely theoretical work in particle physics.

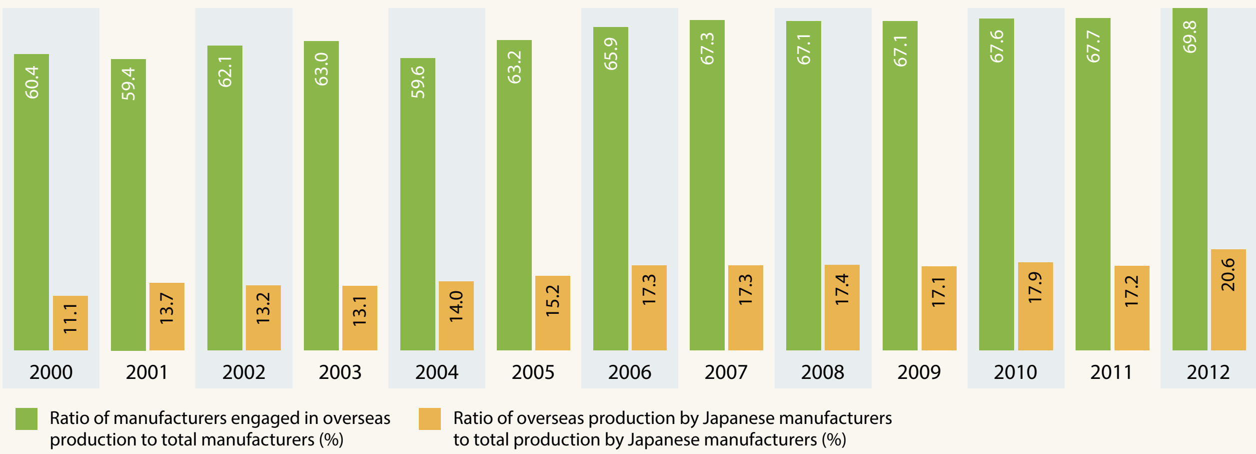
If the Nobel Prize Committee is indeed giving greater recognition to the social impact of research, this could well be a reflection of the changing mindset of the global academic community. The *Declaration on Science and the Use of Scientific Knowledge* and *Science Agenda: Framework for Action* from the World Conference on Science in 1999 may well be the harbinger of this change. Organized in Budapest (Hungary) by UNESCO and the International Council for Science, the World Conference on Science produced documents which explicitly stressed the importance of 'science in society and science for society,' as well as 'science for knowledge.'

Source: compiled by authors

Patents: aiming for quality over quantity

The number of patent applications to the Japan Patent Office (JPO) has been declining since 2001. Many factors seem to have contributed to this phenomenon. In the past decade, many firms have refrained from applying for large quantities of patents, instead focusing their efforts on obtaining high-quality patents. This is partly because of the steep rise in examination fees charged by the JPO since 2004. After the global crisis in particular, Japanese firms could no longer afford to spend as much as before on patent applications. They have also come to lay more emphasis on applying to foreign patent offices, reducing the relative importance of domestic patents. In addition, years of an overappreciated yen and a shrinking Japanese market have spurred many firms to move their R&D and manufacturing centres abroad; as a result, they now feel less inclined to file many of their patents in Japan (Figure 24.8).

Figure 24.8: **Overseas production by Japanese manufacturers, 2000-2012**



Source: Cabinet Office (2008–2013) *Annual Survey of Corporate Behaviour*

Table 24.4: **Patent activities in Japan, 2008 and 2013**

	Patent applications	Granted patents	Examination time (months)	PCT international applications
2008	391 002	159 961	29	28 027
2013	328 436	260 046	11	43 075

PCT = Patent Cooperation Treaty

Source: Japan Patent Office (2013, 2014) *Annual Report of Patent Administration*

The JPO had actually intended for the number of patent applications in Japan to drop, in order to solve the chronic problem of long waiting times for patent applications to be examined. The first Intellectual Property Promotion Programme had been established in 2004 to reduce the waiting time from 26 months to 11 months by 2013. JPO encouraged private firms to select only their best candidates for patent application; it also raised the number of patent examiners by 50%, mainly through massive hiring of fixed-term officials, and at the same time improved their productivity. In the end, JPO achieved its goal just in time (Table 24.4).

There may be another explanation for the decrease in patent applications: this could be a symptom of Japan's weakening innovative capabilities. Since patent statistics reflect so many different factors, their validity as an indicator of R&D seems less evident than it once did. In today's ever-more globalized world, the very meaning of the national patent system is changing.

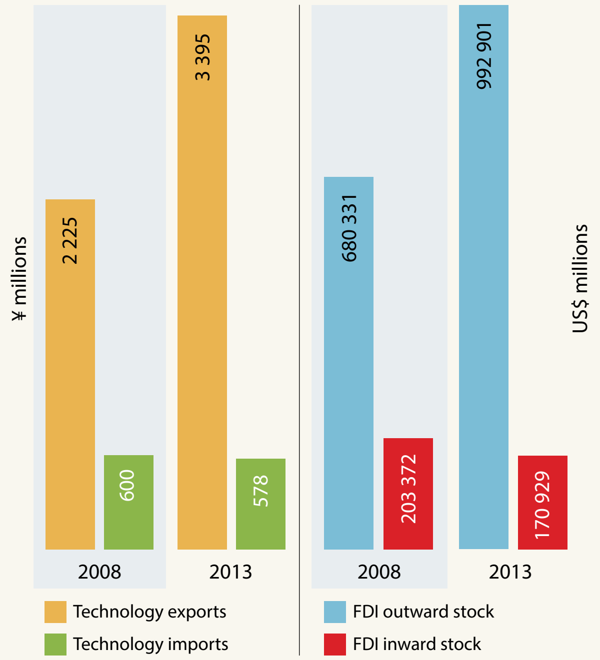
TRENDS IN GLOBAL ENGAGEMENT

Strong on technology but less competitive than before

In recent years, Japan's economic relationship with the world has fundamentally changed. In 2011, the country recorded a trade deficit for the first time since 1980. This was partly due to a decrease in exports, combined with a rise in oil and natural gas imports following the 2011 triple catastrophe in the Tohoku area and the subsequent halting of nuclear power plants. The trade deficit did not turn out to be a temporary phenomenon, however. It has become chronic, fuelled by the weak competitiveness of Japanese manufacturers in the global market, the transfer of their factories overseas and high prices for oil and other natural commodities. Even though Japan's current account is still in the black, its industrial fabric is definitely less competitive than it used to be.

That is not to say that Japan's technological strength has waned. For example, technology exports grew by more than 53% between 2008 and 2013, whereas technology imports remained roughly constant over the same period. Japan's outward FDI stocks swelled by 46%, even as inward FDI stocks shrank by 16%. Japan has thus been increasingly active in transferring technology and investing abroad. The fact that FDI inflows remain low in comparison with other nations has

Figure 24.9: **Japan's technology trade and FDI stock, 2008 and 2013**



Source: Statistics Bureau (2014); UNCTAD (2009, 2014) *World Investment Report*

become a source of concern, however, for it means that Japan is failing to attract foreign investors and introduce foreign business resources. The Japanese government regards FDI inflows as being generally beneficial because they create jobs and boost productivity, while at the same time promoting open innovation and revitalizing the regional economy, which has long suffered from depopulation and ageing.

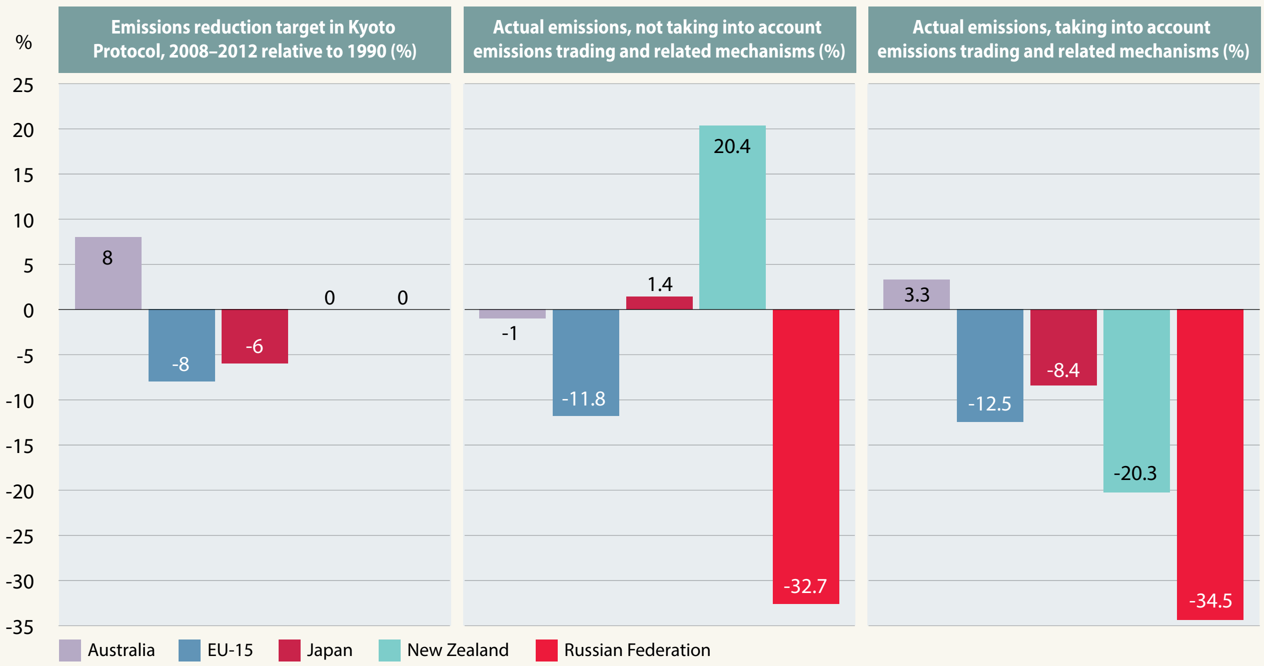
Incentives to attract FDI

The Japanese government has recently taken steps to stimulate FDI inflows (Figure 24.9). A law enacted in November 2012 provides incentives for global corporations to relocate their R&D centres and Asian branches to Japan, such as a reduction in corporate tax and other privileges. Just months later, in June 2013, the Abe Cabinet's *Japan Revitalization Strategy: Japan is Back*, fixed the target of doubling FDI inflows by 2020. To this end, the government designated six National Strategic Special Zones that are expected to become international centres for business and innovation through deregulation. Behind these measures is a sense of crisis that Japan might be losing its attractiveness as a business destination relative to other Asian nations.

Fortunately, there is currently a fertile environment for business. A drastic depreciation of the yen in recent few years has induced many Japanese manufacturers to bring their factories back to Japan, thereby steadily generating jobs. Lower oil prices and corporate tax rates have also fostered this 're-shoring' trend among Japanese firms. Although it is uncertain how long these

Figure 24.10: **Japan's progress towards targets under the Kyoto Protocol, 2012**

Other countries are given for comparison



Source: Greenhouse Gas Inventory Office of Japan, National Institute for Environmental Studies

favourable conditions will last, there are signs that Japanese corporations are also re-evaluating the unique strengths of the business environment in Japan, which include social stability, reliable production infrastructure and a capable labour force.

A commitment to international targets

While aiming for competitiveness, Japan has also been deeply committed to the international agenda for sustainable development. Under the *Kyoto Protocol* of 1997, Japan agreed to reduce its greenhouse gas emissions by 6% over 2008–2012 relative to 1990. Taking into account emissions trading and related mechanisms, Japan has reached this target (Figure 24.10). Ironically, the economic damage caused by the global financial crisis helped Japan to attain this feat. Japan has been reluctant to participate in any new scheme, however, as long as major emitters such as China, the USA and India do not have any substantial duty[7]. In fact, Japanese firms were dissatisfied with the *Kyoto Protocol* because they perceived Japan as already being a low-emitter by the 1990s and felt it would be more difficult for the country to achieve a similar goal than for other countries.

More recently, Japan has eagerly taken part in emerging global frameworks for sustainability. Japan has been an active participant of the Belmont Forum, an association of funding agencies supporting research on earth's environmental changes, ever since its inception in 2009. It has also been one of the drivers behind an ambitious scheme beginning in 2015, Future Earth. This scheme incorporates several global research frameworks for global environmental change and is expected to last for ten years. Japan also hosted the 10th Conference of the Parties to the Convention on Biological Diversity in October 2010. The *Nagoya Protocol* adopted by this conference provides a legal framework for the fair, equitable sharing of benefits arising from the utilization of genetic resources. The conference also adopted 20 *Aichi Biodiversity Targets* for the global community to 2015 and 2020. In accordance with these international agreements, the Japanese government revised its own *National Strategy for Biodiversity* in 2012, specifying detailed targets, action plans and indicators for evaluation[8].

Japan's proactive stance on global engagement is founded on its vision of science diplomacy. Japan considers that its participation in co-operative programmes in science and technology strengthens its diplomatic relations and is therefore in the national interest. In 2008, MEXT and the Ministry of Foreign Affairs launched a joint programme for a Science and Technology Research Partnership for Sustainable Development (SATREPS) with developing countries; collaborative research projects tackle problems in such areas as environment, energy, natural disasters and infectious diseases.

7. China and India did not have specific targets under the *Kyoto Protocol* and the USA was not a signatory.

8. Japan's legal framework in this field consists of the Basic Act on Biodiversity (2008) and the Act on Promotion of Regional Co-operation for Biodiversity (2010).

CONCLUSION

A need for forward-looking policies and a new mindset

Japan has experienced some stark trends since 2010: public and private funding of R&D have barely evolved, fewer students are entering doctoral programmes and the number of scientific publications is declining. These trends have been shaped by the current macro-socioeconomic context: an ageing population, demographic decline, sluggish economic growth and a burgeoning national debt burden.

Over the same period, science and technology in Japan have also been deeply affected by a national tragedy, the Great East Japan Earthquake of 2011. Other milestones will also go down in history: LDP's return to power in December 2012, heralding the launch of Abenomics, and the STAP cells controversy in 2014, which has shaken the scientific establishment and public trust in science.

Recent events and macro-trends have spawned fundamental challenges for the academic, government and industrial sectors. For the academic sector, university reform has clearly been a central challenge for some time. The ongoing reform is a multifaceted exercise involving the consolidation and merger of universities in the face of a declining young population, greater internationalization and the promotion of female researchers, enhanced collaboration with industry, development of a healthy research environment and better career prospects for young researchers. An overarching goal will be to improve the mediocre visibility of Japanese universities in the global landscape. Perhaps hardest of all, Japanese universities will be expected to carry out this array of reforms on a shrinking regular budget. This will demand a highly cost-effective use of public funding for universities; it will be important for the government to work in concert with the academic and industrial sectors to devise the most efficient use of the public purse in funding universities.

In April 2016, the *Fifth Basic Plan for Science and Technology* will become operational simultaneously with the start of the third six-year planning period for national universities. On this occasion, the ongoing reform of the university sector and its funding systems will need to move into higher gear, if it is to improve research productivity and diversify and internationalize university education. The academic community, in turn, will need to share its vision of the university of the future and strengthen internal governance mechanisms.

A major additional challenge for the academic community – and the government – will be to restore public confidence. Official statistics show that the triple catastrophe of 2011 has shaken the public's trust not only in nuclear technology but also in science and technology, in general. Moreover, just as public confidence was recovering, the STAP cells scandal broke. The academic community and the government should not content themselves with taking steps to prevent misconduct in research; they should also re-examine systemic aspects of the problem, such as the excessive concentration of R&D funds in a handful of institutions or laboratories, the vertiginous drop in regular funding and permanent research positions and evaluations of researchers based on short-term performance.

The academic community in Japan will also have to live up to the growing expectations of society. In addition to producing excellent research output, universities will be required to turn out high-quality graduates who can exercise leadership in today's speedy, globalized world fraught with uncertainty. Japanese universities will also be expected to collaborate keenly with industry to create social and economic benefits at the local, national, regional and global levels. In this respect, the role of public R&D institutes such as RIKEN and AIST will be particularly important because they can serve as arenas where academic, industrial and other stakeholders can readily interact. Also offering potential for innovation is the new Japan Agency for Medical Research and Development, established in April 2015 on the model of the US National Institutes of Health to realize Prime Minister Abe's vision of a vehicle to promote the Japanese medical industry.

The industrial sector in Japan has its own share of challenges. By 2014, Abenomics and other factors, including the recovery of foreign economies, had helped major Japanese firms recover from the global crisis but their financial health remains heavily dependent on relatively strong share prices. The effects of the past few years on investor confidence are still visible in the reluctance of Japanese firms to raise R&D spending or staff salaries and in their aversion to the necessary risk-taking to launch a new cycle of growth. Such a stance will not ensure the long-term health of the Japanese economy, since the positive effects of Abenomics cannot last forever.

One possible direction for Japanese industry would be for it to devise macrostrategies around a set of basic concepts suggested by the Japanese government in its *Comprehensive Strategy for STI*: 'smartization', 'systemization' and 'globalization'. It has become difficult for Japanese manufacturers to compete in the global market as far as the production of stand-alone commodities is concerned. However, Japanese industry can use its technological strength to satisfy global demand with system-oriented, network-based innovation supported by ICTs. In such fields as health care, urban development, mobility, energy, agriculture and disaster prevention, there are great opportunities worldwide for innovative firms to supply highly integrated, service-oriented systems. What Japanese industry needs is to combine its traditional strengths with a future-oriented vision. Such an approach could be applied to preparing for the 2020 Olympic/Paralympic Games in Tokyo; to that end, the Japanese government is now promoting STI via grants and other programmes in a broad range of fields, including environment, infrastructure, mobility, ICTs and robotics, using such keywords as 'sustainable,' 'safe and secure,' 'friendly to senior and challenged people,' 'hospitable' and 'exciting.'

Another possibility for Japan will be to promote creative industries in such areas as digital contents, online services, tourism and Japanese cuisine. The Ministry of Economy, Trade and Industry (METI) has been promoting the Cool Japan Initiative for several years now, which culminated in the establishment of the Cool Japan Fund Inc. by law in November 2013 to help Japan's creative industries spread their wings abroad. Such endeavours could be more tightly integrated into Japan's overall STI policy.

Almost a quarter of a century has passed since the Japanese economy entered the doldrums in the early 1990s. During this prolonged economic slump, each of the industrial, academic and governmental sectors in Japan has undergone reforms. Many electric, steel and pharmaceutical firms were merged and restructured, as were financial institutions; national universities and national research institutes were semi-privatized; and government ministries went through a comprehensive reorganization. These reforms have surely strengthened the foundation for R&D in Japan's industrial, academic and government sectors. What is needed now is for Japan to have confidence in its national innovation system. It needs to adopt forward-looking policies and arm itself with the courage to pursue the necessary reforms to adapt to the changing global landscape.

KEY TARGETS FOR JAPAN

- Raise the GERD/GDP ratio to 4% or more by 2020;
- Raise government expenditure on R&D to 1% of GDP or more by 2015;
- Position 100 institutions among the world's top 50 in specific fields for the citation of research papers by 2015;
- Raise the share of women occupying high-level posts in both the public and private sectors to 30% by 2020;
- Raise the proportion of women researchers by 2015 to 20% in science, 15% in engineering and 30% in agriculture, medicine, dental and pharmaceutical research;
- Attract 300 000 international students to Japan by 2020;
- Double the amount of FDI inflows (US$ 171 billion in 2013) by 2020.

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Yasushi Sato (b. 1972: Japan) is a Fellow at the Centre for Research and Development Strategy of the Japan Science and Technology Agency. He was previously Assistant Professor at the National Graduate Institute for Policy Studies in Tokyo. Dr Sato obtained his PhD in History and the Sociology of Science in 2005 from the University of Pennsylvania (USA).

Tateo Arimoto (b. 1948: Japan) is Director of the Science, Technology and Innovation Policy Programme at the National Graduate Institute for Policy Studies in Tokyo, where he has been a professor since 2012. He is also Principal Fellow of the Centre for Research and Development Strategy at the Japan Science and Technology Agency. Former Director-General of Science and Technology Policy Bureau of the Ministry of Education and Science, he obtained his master's degree in Physical Chemistry from the University of Kyoto in 1974.