The government has decided to respond to [the] increasingly competitive [global] environment by raising its investment in research and development, strengthening the manufacturing sector and developing new creative industries.

Deok Soon Yim and **Jaewon Lee**

Songdo International Business District is a new smart city erected on 600 ha of reclaimed land on Incheon's waterfront, 65 km from Seoul. It is connected to Incheon International Airport by a 12 km-long bridge and forms part of the Incheon Free Economic Zone.
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25 · Republic of Korea

Deok Soon Yim and Jaewon Lee

INTRODUCTION

Time for a new development model

The Republic of Korea[1] has become a benchmark for successful economic development. Between 1970 and 2013, GDP per capita grew from US$ 255 to US$ 25 976, driven by the strong manufacturing and industrial capabilities that turned it into one of Asia's economic 'tigers'. Among the many factors contributing to this success story is the country's commitment to technological progress and to developing an educated, skilled labour force. Today, the Republic of Korea is the only nation to have transformed itself from a major recipient of foreign aid into a major donor.

However, the government recognizes that this remarkable economic growth is no longer sustainable. Global competition with China and Japan is intense, exports are slipping and the global demand for green growth has altered the balance. In addition, a rapidly ageing population and declining birthrates threaten Korea's long-term economic development (Table 25.1). Middle-income households are straining to make ends meet in the face of stagnating wages and there are signs of evident social distress; the Organisation for Economic Co-operation and Development (OECD) reports that the Korean divorce rate has doubled in recent years and that its suicide rate is the highest of any OECD member. The time has come for an alternative development model.

The new priority: a creative economy

Against this backdrop, the government has been trying to set a new path by developing more competitive technologies. Under the Lee Myung-bak administration (2008–2013), the government embarked on a major campaign for 'low carbon technology and green growth,' as we saw in the *UNESCO Science Report 2010*. Lee's government targeted a 5% investment in research and development (R&D) as a percentage of GDP by 2012 and strengthened the ministry responsible for science and technology by transferring responsibility for the budget and co-ordination to the National Science and Technology Council (NSTC).

The current Park Geun-hye administration is emphasizing the 'creative economy,' in an effort to revitalize the manufacturing sector through the emergence of new creative industries.

TRENDS IN STI GOVERNANCE

Science to converge with culture, culture to fuse with industry

In her inaugural address in February 2013, President Park Geun-hye spoke of 'a new era of hope and happiness.' She identified five administrative goals for her government: a creative economy centred on jobs, tailored employment and welfare, creativity-oriented education and cultural enrichment, a safe and united society and strong security measures for sustainable peace on the Korean Peninsula. She offered a new vision for national development, defining it as 'the convergence of science and technology (S&T) with industry, the fusion of culture with industry and the blossoming of creativity in the very border areas that were once permeated by barriers.'

This new vision seeks to transform the country's economic model by deepening its reliance on science, technology and innovation (STI), which have served the country so well in the past. President Park's vision builds on that of her predecessor, who had managed to raise gross domestic expenditure on R&D (GERD) to 4.15% of GDP by 2013, the second-highest level of commitment in the world after Israel (Figure 25.1). This meteoric rise was made possible thanks largely to the strong progression in industrial R&D.

1. The present chapter covers only the Republic of Korea, so references to the abbreviation of 'Korea' designate solely the Republic of Korea.

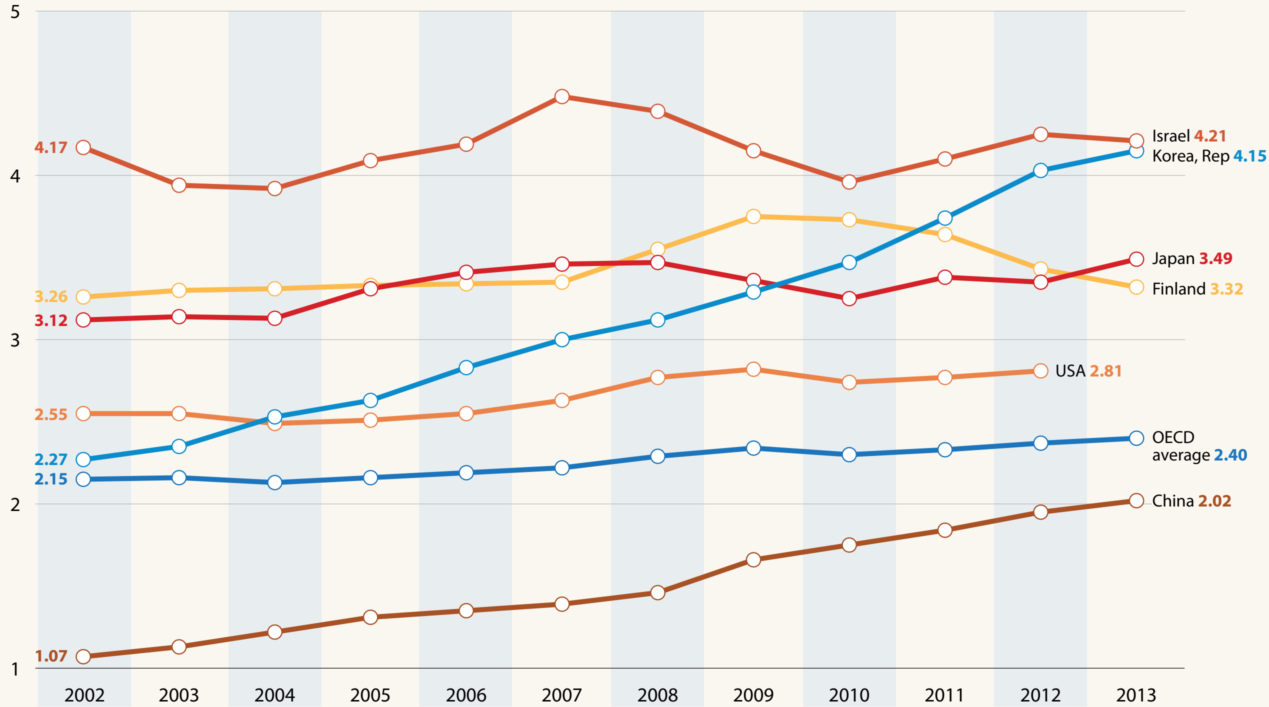
Table 25.1. **Socio-economic trends in the Republic of Korea, 2008–2013**

	2008	2009	2010	2011	2012	2013
Population (thousands)	48 948	49 182	49 410	49 779	50 004	50 219
Population growth rate (%)	0.62	0.62	0.60	0.57	0.55	0.53
GDP (current US$ millions)	1 002 216	901 934	1 094 499	1 202 463	1 222 807	1 304 553
GDP per capita (current US$)	20 474	18 338	22 151	24 155	24 453	25 976
GDP growth rate (%)	2.82	0.70	6.49	3.68	2.29	2.97
Life expectancy at birth (years)	79.8	80.3	80.6	81.0	81.4	–
Inflation, consumer prices (%)	4.67	2.76	2.96	4.00	2.20	1.31
Unemployment rate (% labour force)	3.20	3.60	3.70	3.40	3.20	3.1

Source: World Bank's World Development Indicators, accessed March 2015

Figure 25.1: **Progression in GERD/GDP ratio in Republic of Korea, 2002–2013 (%)**

Other countries and regions are given for comparison



Source: OECD (2015) *Main Science and Technology Indicators*

At the time of fixing the 5% target for the GERD/GDP ratio in 2008, there had been some discordant opinions about the government's strong focus on industrial research and innovation. Some analysts underscored the need to lay greater emphasis on basic research and on upgrading the quality and performance of scientific research, in order to obtain greater global recognition. The previous Lee Myung-bak administration had taken various measures to address these issues, including its *Second Basic Plan for Science and Technology* over 2008–2013 and its Low Carbon, Green Growth policy.

High spending for low carbon, green growth

The *Second Basic Plan for Science and Technology over 2008–2013* came to be known as the 577 Initiative, in reference to the targets it proposed: the number 5 refers to a 5% GERD/GDP ratio by 2012, the first 7 refers to the government's seven priority areas and the second 7 to the associated policy areas (MEST, 2011). The first target had not quite been achieved by 2012.

Between 2008 and 2011, the government invested KRW 23.72 trillion (US$ 28.1 billion) in the following seven priority areas:

- Advancement of key industries, such as the automobile, shipping and semi-conductor industries (KRW 2.06 trillion);
- Core technology for the development of new industries (KRW 3.47 trillion);
- Knowledge-based service industries (KRW 0.64 trillion);
- State-driven technology, such as space, defence and nuclear power (KRW 9.08 trillion);
- Issue-driven areas such as new diseases and nanodevices (KRW 3.53 trillion);
- Global issues such as renewable energy and climate change (KRW 3.78 trillion);
- Basic and convergent technology, such as intelligent robots and biochips (KRW 1.16 trillion).

The seven policy areas are:

- Nurturing talented students and researchers;
- Promotion of basic research;
- Support for SMEs to foster technological innovation;
- Stronger international co-operation in developing strategic technologies;
- Regional technological innovation;
- A stronger national base for S&T[2]; and
- Dissemination of a science culture.

2. This refers to increasing the number of national R&D facilities and developing a system of co-ordination to operate these facilities efficiently, which includes an online database on S&T, along with efforts to facilitate university–industry co-operation.

The 577 Initiative chalked up some impressive achievements (MEST, 2011):

- An increase in the number of publications recorded in international journals from 33 000 in 2009 to 40 000 in 2012, beyond the target of 35 000;
- An increase in the number of students on scholarships from 46 000 in 2007 to 110 000 in 2011;
- An increase in the number of researchers from 236 000 in 2008 to 289 000 by 2011, equivalent to 59 researchers per 10 000 population – this nevertheless supposes that the target of 100 researchers per 10 000 population will not be reached by 2012;
- A meteoric rise in the World Bank ranking of domestic environments for business creation, from 126th place in 2008 to 24th in 2012;
- An increase in GERD from 3.0% to 4.0% of GDP between 2007 and 2012 (Figure 25.1), driven largely by the business enterprise sector;
- A steep progression in the number of subscribers to the National Science and Technology Information Service, an internet-based platform for S&T statistics, from 17 000 in 2008 to 107 000 in 2010 – the government also introduced more transparent ways of evaluating S&T, including better indicators with more focus on quality control.

Within its Low Carbon, Green Growth policy (2008), the government established the Composite Measure for R&D in Green Technology in 2009. This measure proposes a series of development strategies and investment targets, including that of doubling government investment in green technology to KRW 2 trillion between 2008 and 2012. This target had been surpassed by 2011, when investment reached KRW 2.5 trillion. In all, the government invested KRW 9 trillion (*circa* US$ 10.5 billion) in green technology between 2009 and 2012.

The green growth policy has been institutionalized in the new *Five-Year Plans for Green Growth*, the first of which covered 2009–2013. In order to support both basic research and technological development in green technology, the government introduced its *Plan for National Carbon Dioxide Capture Sequestration* (CCS) in 2010. CCS is a technology for capturing carbon emissions on a large scale, such as those from power plants, and storing the carbon underground in disused mines and the like. The government plans to commercialize CCS technology by 2020. Total investment in green technology by the top 30 private companies amounted to KRW 22.4 trillion (US$ 26.2 billion) between 2011 and 2013.

The government also decided to host the Green Climate Fund in 2012 and supported the establishment of the Global Green Growth Institute[3] in 2010, which works with public and private partners in developing countries and emerging economies to put green growth at the heart of economic planning. The Green Climate Fund is based in the city of Incheon. The fund originated at the global climate talks in Copenhagen (Denmark) in 2009, where it was decided to create a fund endowed with US$ 100 billion per year by 2020 to help developing countries adapt to climate change. In November 2014, 30 countries meeting in Berlin (Germany) pledged[4] the first US$ 9.6 billion.

The government also launched the Green Technology Center Korea in 2013. This government-funded think tank co-ordinates and supports national R&D policies related to green technology, in collaboration with Korean ministries and agencies. The centre also serves as the Republic of Korea's gateway to international co-operation in the design and diffusion of green technology, with a focus on creating a new growth engine for developing countries. The Republic of Korea's partners in this endeavour are the United Nations Development Programme, United Nations Economic and Social Commission for Western Asia and the World Bank.

A blueprint for a creative economy

The *Third Basic Plan for Science and Technology, 2013–2017* came into effect in 2013, the year President Park Geun-hye took office. It serves as a blueprint for Korea's 18 ministries for the years to come. The major feature of this third plan is that it suggests, for the first time, that the government should allocate US$ 109 billion (KRW 92.4 trillion) to R&D over five years as seed money to foster the emergence of a creative economy (MSIP, 2014). This is expected to increase the contribution of R&D to economic growth from 35% to 40%. In addition, this third plan undertakes to raise gross national income per capita to US$ 30 000 and to create 640 000 jobs in science and engineering by 2017 (Table 25.2). These figures demonstrate how the current government plans to use science and technology to foster national growth, although some have questioned whether all of these targets can be reached by 2017.

The *Third Basic Plan* outlines five strategies for reaching these targets (NSTC, 2013) :

- Increase government investment in R&D, support private-sector R&D through tax relief and improve the planning of new research projects;

3. The Global Green Growth Institute was originally conceived by the Lee government as an NGO. It became an international body in 2012 after the signing of agreements with 18 governments. See: http://gggi.org

4. The biggest contributions to the Green Climate Fund were pledged by the USA (US $3 billion), Japan (US$ 1.5 billion), Germany, France and the UK (US$ 1 billion each). Some developing countries made pledges of a more modest nature, including Indonesia, Mexico and Mongolia.

Table 25.2: **The Republic of Korea's R&D targets to 2012 and 2017**

		Unit of measure	Situation as of 2007	Situation as of 2012	Target to 2012 of *Second Basic Plan*	Target to 2017 of *Third Basic Plan*
Financial investment	GERD	In KRW trillions	31.3	59.30^{+1}	–	–
		In current PPP$ billions	40.7	68.9^{+1}	–	–
		Percentage of GDP	3.00	4.15^{+1}	5.00	5.00
	Government-financed R&D expenditure	In KRW trillions	7.8	13.2	92.4 (total over 2012–2017)	
		Percentage of GDP	0.74	0.95^{+1}	1.0	–
	Share of basic research in government R&D budget	Percentage share	25.3	35.2	35.0	40.0
	Share of support for SMEs in government R&D budget	Percentage share	–	12.0^{-2}	–	18.0
	Government investment in green technology	In KRW trillions	1	2	2	–
	Government investment in quality of life	Percentage of government expenditure on R&D	–	15.0	–	20.0
Human capital investment	Researchers (FTE)	Total number	222 000	315 589	490 000^{-1}	–
		Per 10 000 population	47	64	100	–
	PhD-holders in science and engineering	Percentage of total population	–	0.4	–	0.6
	COSTII score	Ranking among 30 OECD countries	–	9th	–	7th
Output	Articles published in Science Citation Index	Total number	29 565	49 374	35 000	–
	Number of patents with international co-applications	Per 1 000 researchers	–	0.39^{-1}	–	0.50
	Technology competitiveness of SMEs	Percentage of total potential	–	74.8^{-1}	–	85.0
	Early-stage entrepreneurial activity	Percentage of enterprise's total activity	–	7.8	–	10.0
	Jobs in science and engineering	Total	–	6 050 000	–	6 690 000
	Gross national income per capita	US$	23 527	25 210	–	30 000
	Contribution of R&D to economic growth	Percentage of GDP	30.4^{-1*}	35.4**	40.0***	40.0****
	Industrial value added per capita	US dollars	–	19 000	–	25 000
	Value of technology exports	US dollars millions	2 178	4 032	–	8 000
	Technology trading	Ratio of technology revenue to expenditure	0.43	0.48	0.70	–

-n/+n = n years before or after reference year.

* average contribution over 1990–2004
** average contribution over 1981–2010
*** average contribution over 2000–2012
**** average contribution over 2013–2017

Note: The Composite Science and Technology Innovation Index (COSTII) was developed by the Korean National Science and Technology Council in 2005. It compares the innovation capacity of 30 OECD countries.

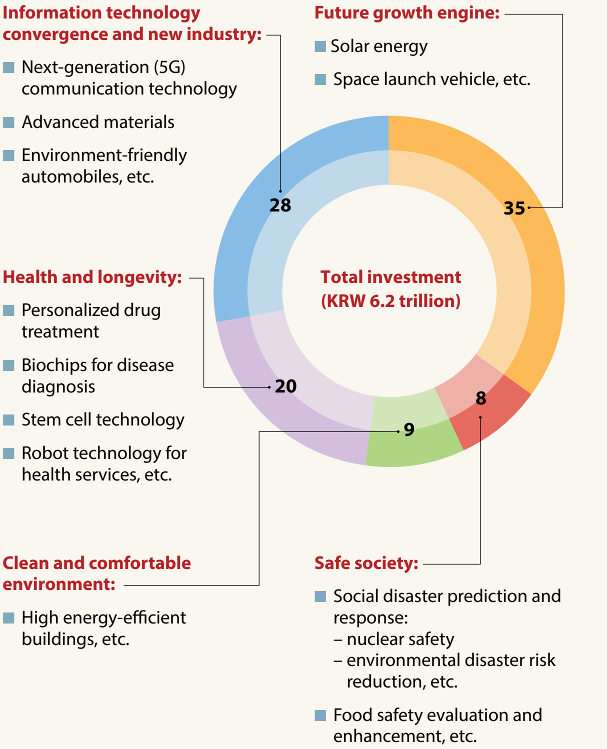
Source: MEST (2008); MSIP (2014b); UNESCO Institute for Statistics; MSIP (2013c)

- Identify five strategic areas for national technological development (Figure 25.2);
- Nurture creative talent by, for example, providing more funding for basic research and inviting 300 eminent foreign scientists to visit and work with national laboratories, etc.;
- Increase support for small and medium-sized enterprises (SMEs) to help them market their research output and technology;
- Create more jobs by enabling 'ecosystems' to support start-ups in science and technology, through funding, consultation services, etc.

Within the five strategic areas mentioned above, a total of 120 strategic technologies have been designated by the government, 30 of which are considered investment priorities over the five years to 2017, by which time the government expects some of these to be technologically feasible. As of mid-2015, the government had not yet announced budgetary targets to 2017. The Ministry of Science, ICTs and Future Planning (MSIP) is in the process of designing a strategic roadmap which will include an implementation plan.

Figure 25.2: **The Republic of Korea's strategic technologies for 2013–2017**

Budget share (%)



Source: NSTC (2013)

A reshuffle of the country's administrative cards

Several government bodies were restructured between 2009 and 2013. In particular, the Park Geun-hye administration established a new Ministry of Science, ICTs and Future Planning (MSIP). MSIP took over responsibility for S&T from the Ministry of Education, Science and Technology (MEST) and recovered some parts of broadcasting and communications from the Korea Communications Commission and some tasks from the Ministry of Knowledge Economy, which was renamed the Ministry of Trade, Industry and Energy.

The National Science and Technology Council (NSTC) was given greater authority in 2011 to meet the demand for greater convergence between science and technology. Its co-ordination function has been reinforced to enable it to prepare the *Basic Plans for Science and Technology* and the *Basic Plans for the Promotion of Regional Science and Technology*, among other documents. The council has also assumed deliberative and legislative power over major plans related to S&T that are suggested by each ministry. It has also recovered responsibility for evaluating national R&D programmes and for fixing the national R&D budget. Moreover, in an effort to streamline co-operation between the government and the private sector, the NSTC is now jointly chaired by the Prime Minister and a person designated by the President from the private sector (NSTC, 2012).

TRENDS IN R&D

The 5% target within reach for 2017

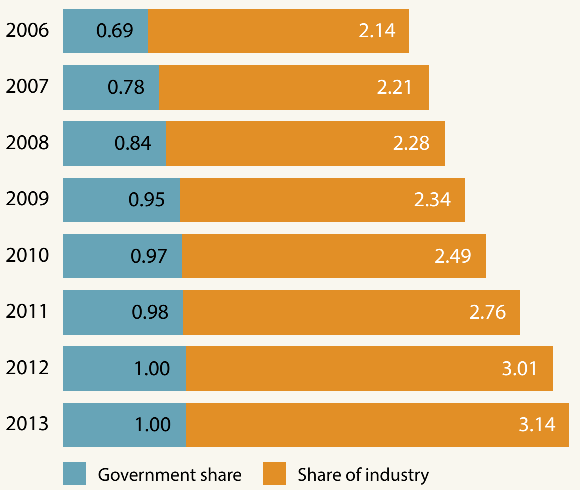
R&D financed by the Government and other national sources has risen almost continually since 1993. By 2008, it was rising by 13.3%[5] per year. The global financial crisis slowed the growth rate somewhat to 11.4% in 2010 and it slipped farther in 2014 to 5.3%. This decline in government funding has been offset by the industrial sector, which funds three-quarters of GERD and managed to increase its own investment in R&D between 2009 and 2013 by an average of 12.4% each year (Figures 25.3–25.5). As a consequence, the GERD/GDP ratio pursued its progression, albeit at a slower pace than that anticipated by the *Second Basic Plan for Science and Technology*. The Republic of Korea may have missed its target of devoting 5% of GDP to GERD by 2012 but the government is determined to see that this target is reached by 2017 (Kim, 2014).

More resources for basic research

Government investment in basic research has changed focus since 2008 by placing greater emphasis on quality. This has also entailed improving the quantity of allocated

5. If other national sources are excluded, government-funded R&D expenditure grew by 12.9% in 2009 and 2010 but only by 2.4% in 2013, according to the UNESCO Institute for Statistics.

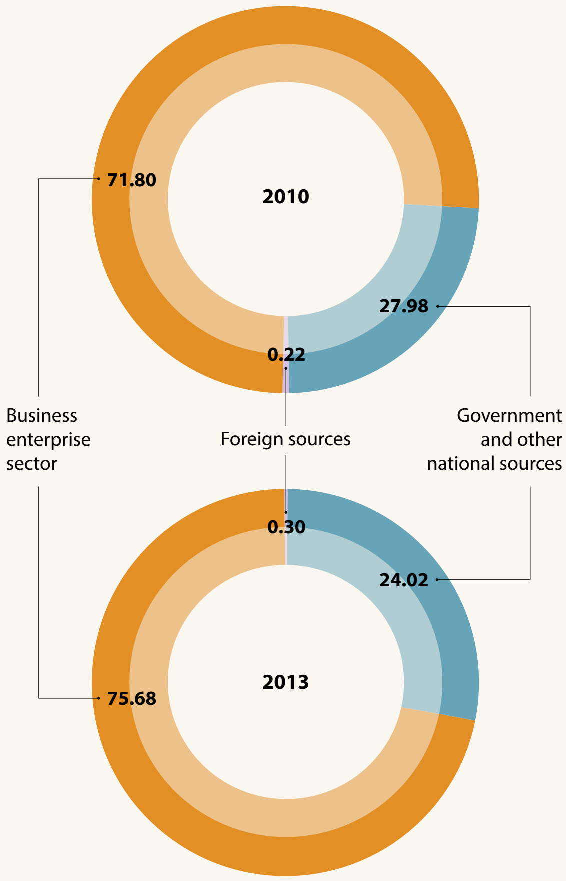
Figure 25.3: **GERD in the Republic of Korea by source of funds and as a share of GDP, 2006–2013** (%)



Note: The government share refers to R&D financed by the government, the higher education sector and other national sources but the contribution of all but the government share is negligible.

Source: MSIP (2014b)

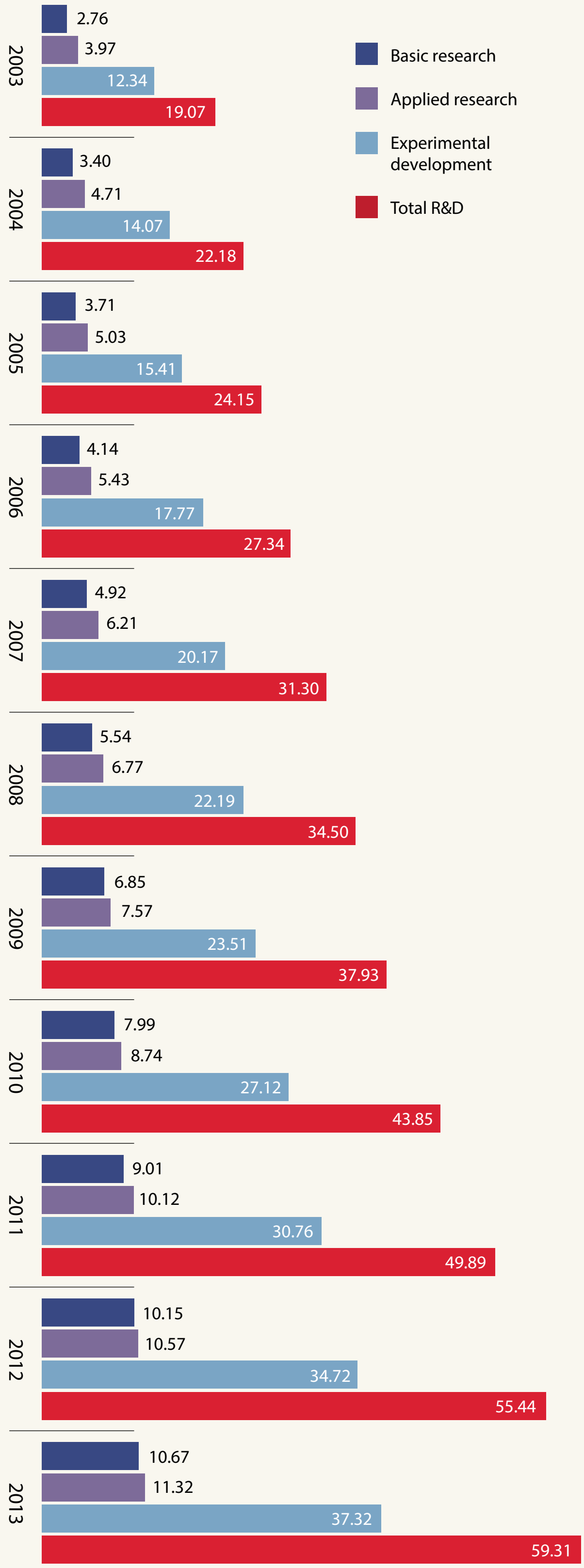
Figure 25.4: **GERD in the Republic of Korea by source of funds, 2010 and 2013** (%)



Source: MSIP (2014b)

Figure 25.5: **GERD in the Republic of Korea by type of research, 2003–2013**

In KRW trillions



Source: MSIP (2014b)

funds. The share of GERD devoted to basic research rose from 15.2% in 2006 to 18.1% in 2009, a share maintained ever since. This was largely thanks to the *Second Basic Research Promotion Plan*, which raised the basic research budget from 25.6% of government spending on R&D (2008) to 35.2% (2012). In parallel, funding allocated to individual basic scientists tripled over the same period from KRW 264 billion to KRW 800 billion (*circa* US$ 936 million) [MSIP, 2014a].

The current government is pursuing this policy. This can be seen in the budget allocated to the International Science Business Belt, currently under construction in the city of Daejeon. This ambitious project was enshrined in the *Basic Plan for an International Science Business Belt,* adopted by the Lee government in 2011. The aim is to correct the impression that the Republic of Korea made the transition from a poor agricultural country to an industrial giant through imitation alone, without developing an endogenous capacity in basic sciences. A National Institute for Basic Science opened on the site in 2011 and a heavy ion accelerator is currently under construction to support basic research and provide linkages to the business world (Box 25.1). Between 2013 and 2014, the Park government doubled the 'business belt's' budget to KRW 210 billion (*circa* US$ 246 million) [Kim, 2014].

The heavy ion accelerator should enable Korean scientists to improve their productivity in physics, which has evolved little since 2008, contrary to biological sciences (Figure 25.6).

Efforts to develop regional autonomy in R&D

The third *National Plan for the Regional Development of Science and Technology 2008–2012* was awarded a much greater share of investment than its two predecessors. The R&D budget for the regions was multiplied by 15 between 2008 and 2013, soaring from KRW 4 689 billion (*circa* US$ 5.9 billion) to KRW 76 194 billion (*circa* US$ 89.2 billion). This budget excludes Seoul and the city of Daejeon, where Daedeok Innopolis is located, the heart of the country's high-tech research community. Much of the funding went on building R&D infrastructure (MSIP, 2013a). This rise should be qualified, however; the share of regional R&D investment in relation to GERD actually remained constant at about 45% of the total over this period. Despite the massive injection of funds, a government evaluation of the third plan's implementation concluded that regional governments remained excessively reliant on central government funding for R&D and that regional R&D remained highly inefficient (MSIP, 2014a). Consequently, the fourth *National Plan for the Regional Development of Science and Technology 2013–2017* has fixed the objective of strengthening regional autonomy and responsibility for R&D. It is reviewing the feasibility of decentralizing inclusive R&D budgets to regional authorities and of improving R&D planning and management capabilities at regional level (MSIP, 2014a).

Industrial production and technology still dominate R&D

Despite the new focus on basic research, 'industrial production and technology' still represented two-thirds of GERD in 2013 (Figure 25.7). Of note is that R&D investment in health and environment rose by more than 40% between 2009 and 2012.

The number of private R&D centres increased by 50% between 2010 and 2012, from 20 863 to 30 589. Since 2004, more than 90% of corporate research institutes have been operated by SMEs and venture companies, although large

Box 25.1: **The Republic of Korea's Silicon Valley**

Moving away from its earlier focus on catch-up technology, the Republic of Korea has invested in a dedicated world-class science and business cluster in and around the city of Daejeon, less than an hour's journey from Seoul in a high-speed train. The International Science Business Belt dates from 2011. It is the country's biggest research complex, home to 18 universities, several science parks and dozens of research centres, both private and public.

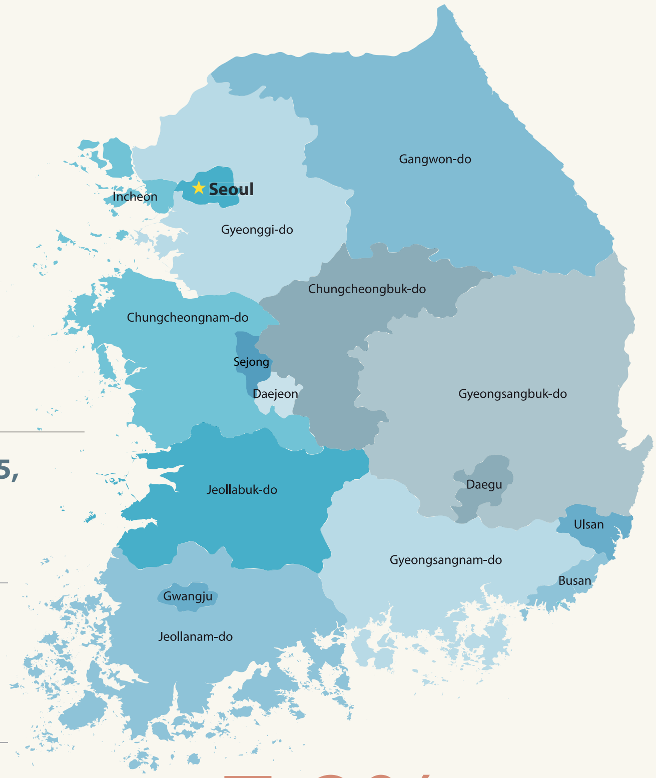
The jewel in the crown will be a heavy ion accelerator, due for completion by 2021. It will form part of the multi-functional research facility now called RAON. Here, researchers will be able to carry out groundbreaking research in basic science and look forward to discovering rare isotopes. RAON will be hosted by the Institute for Basic Science, which is itself under construction. It should open its doors in 2016. The institute plans to attract world-renowned scientists and to cultivate an environment that maximizes the researcher's autonomy; it intends to make its mark among the top 10 world-class research institutes in basic science with a measurable impact on society by 2030.

In order to foster synergies and convergence between basic science and business, high-tech companies and leading enterprises are being invited to group themselves around hubs such as the Korea Basic Science Institute.

The ultimate aim is to build a global city combining science, education, culture and art, where creativity, research and innovation can flourish, as they do in Silicon Valley in the USA or in the cities of Boston (USA), Cambridge (UK) or Munich (Germany).

Source: NTSC (2013), www.isbb.or.kr/index_en.jsp, http://ibs.re.k

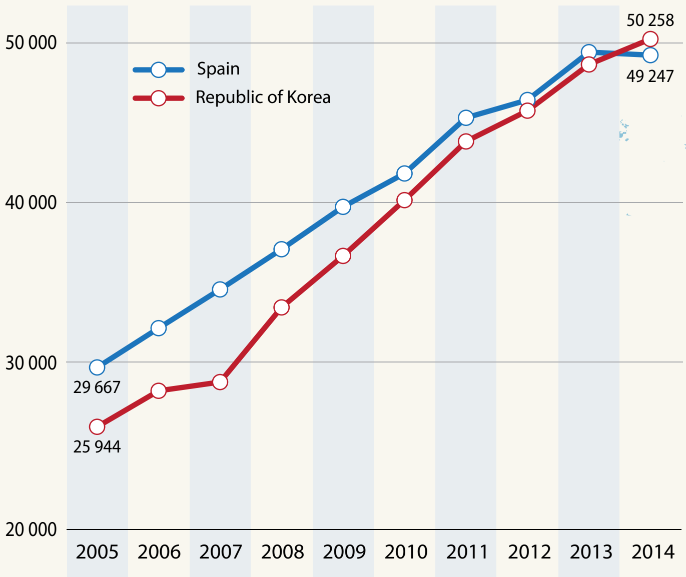
Figure 25.6: **Scientific publication trends in the Republic of Korea, 2005–2014**



0.89

Average citation rate for Korean publications, 2008–2012; the OECD average is 1.08; the G20 average is 1.02

Korean publications have nearly doubled since 2005, overtaking those of similarly populated Spain



7.9%

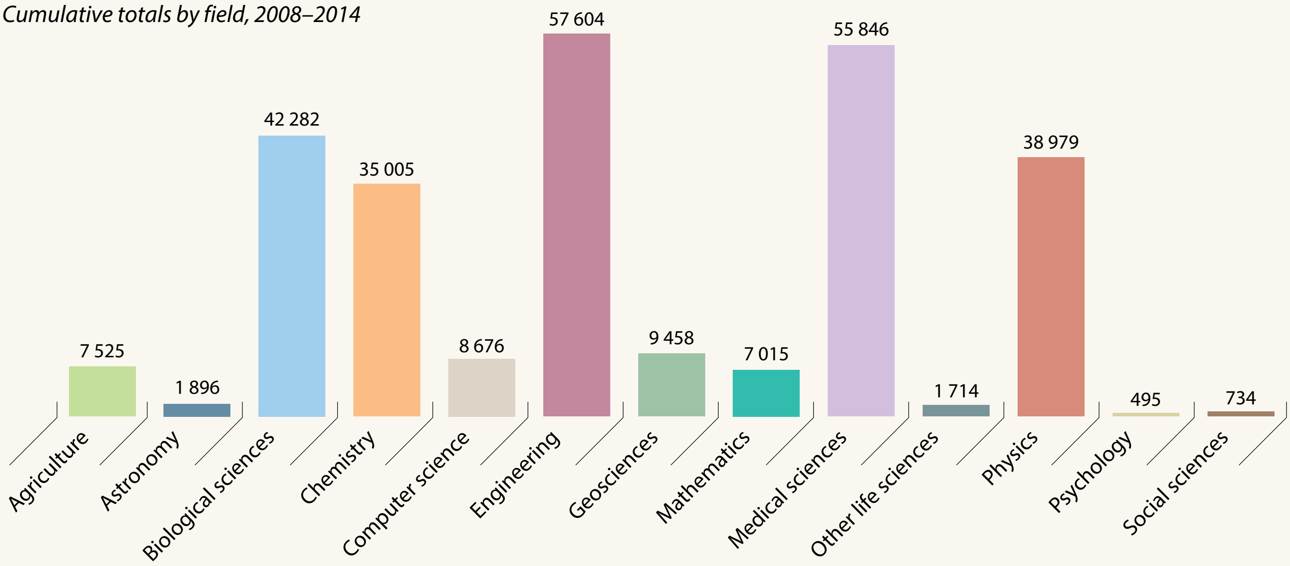
Share of Korean papers among 10% most-cited, 2008–2012; the OECD average is 11.1%; the G20 average is 10.2%

27.6%

Share of Korean papers with foreign co-authors, 2008–2014; the OECD average is 29.4%; the G20 average is 24.6%.

Korean scientists publish most in engineering, physics, chemistry and life sciences

Cumulative totals by field, 2008–2014



The USA remains the Republic of Korea's main partner, followed by Japan and China

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

	1st collaborator	2nd collaborator	3rd collaborator	4th collaborator	5th collaborator
Rep. of Korea	USA (42 004)	Japan (12 108)	China (11 993)	India (6 477)	Germany (6 341)

Source: Thomson Reuters' Web of Science, Science Citation Index Expanded; data treatment by Science–Metrix conglomerates accounted for 71 % of all private investment in R&D in 2009 and 74% in 2012. This shows that just a handful of major companies are the principal investors in Korean R&D, even though SMEs and venture companies play a key role by establishing and operating R&D centres.

Strong growth in domestic and international patents

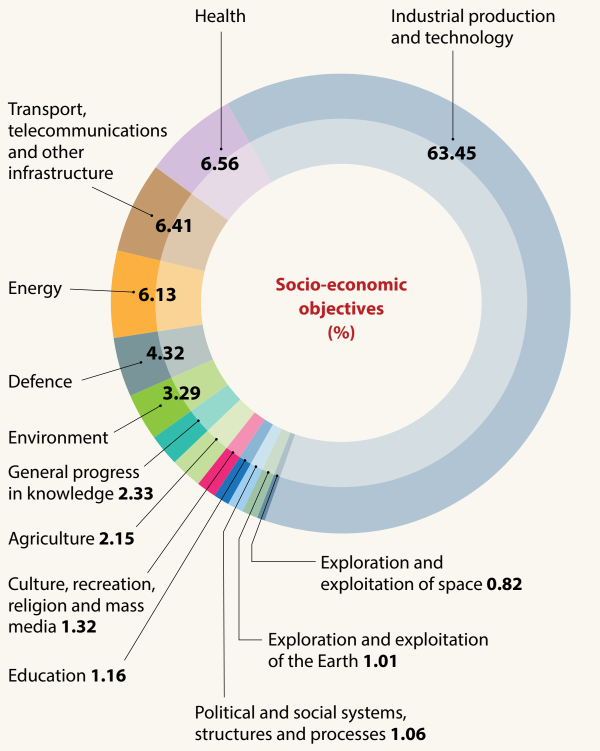
The number of domestic patents registered more than doubled between 2009 and 2013 from 56 732 to 127 330 (KIPO, 2013). This is quite a feat, especially coming as it does in the wake of the global financial crisis. In 2013, Koreans took third place (14 548) for the number of patents registered in the USA, behind Japan (51 919) and Germany (15 498).

The country also recorded a rise within triadic patent families – an aggregate of registrations with patent offices in Europe, Japan and the USA – even though the ratio per billion KRW of research budget slipped (Figure 25.8). This didn't prevent Korean inventors from ranking fourth in 2012.

Technology trade has doubled

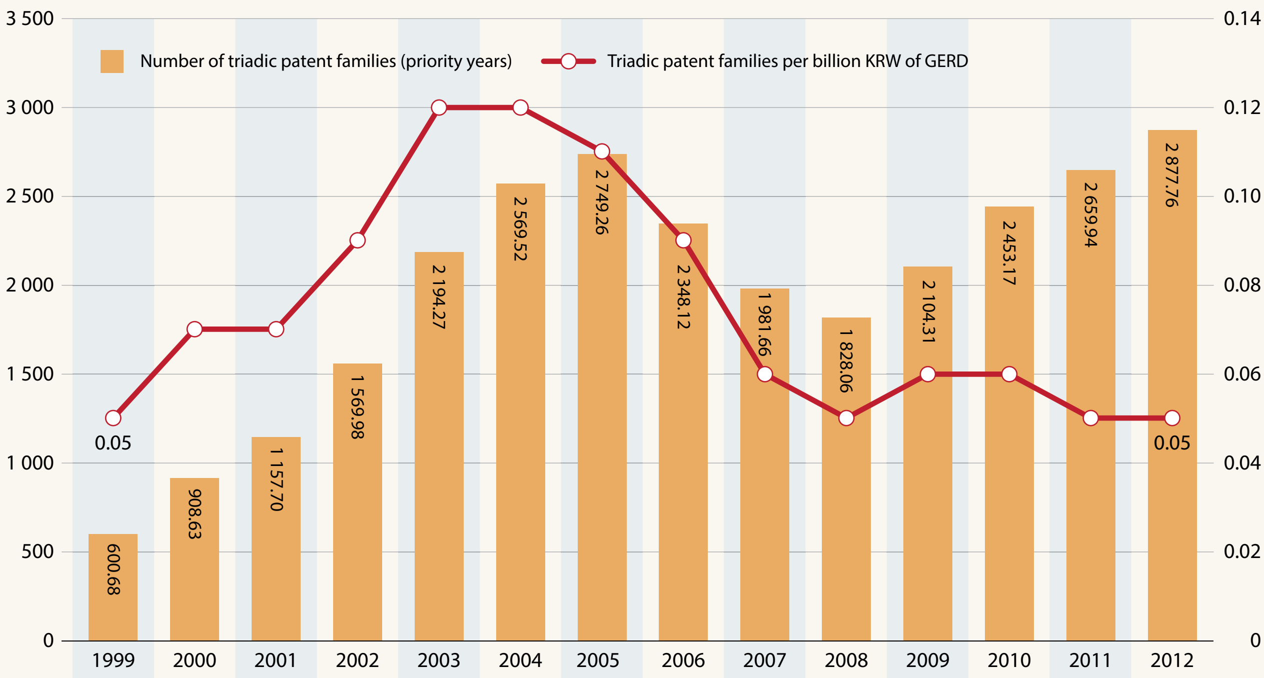
The volume of technology trade doubled between 2008 and 2012 from US$ 8.2 billion to US$ 16.4 billion. The trade balance, which can be calculated as a ratio of technology exports to technology imports, improved from 0.45 in 2008 to 0.48 in 2012 (MSIP, 2013b). Although this increasing volume of technology trade implies that the country is actively engaging in global innovation, it continues to record a large deficit in the global technology marketplace that it is striving to remedy.

Figure 25.7: **GERD in the Republic of Korea by socio-economic objective, 2013** (%)



Source: MSIP (2014b)

Figure 25.8: **Triadic patent family registrations in the Republic of Korea, 1999–2012**



Source: MSIP (2014b)

The volume of Korean high-tech exports (US$ 143 billion) is comparable to that of Singapore (US$ 141 billion) and higher than that of Japan (US$ 110 billion). Six out of ten high-tech exports fall into the category of electronics and telecommunications; exports in this sector even increased from US$ 66.8 billion in 2008 to US$ 87.6 billion by 2013.

Most countries experienced a dip in high-tech exports in 2009 after the global financial crisis hit but, whereas the Republic of Korea and Singapore rapidly recovered, the volume of high-tech exports stagnated in Japan and has not yet recovered in the USA, where high-tech exports earned US$ 237 billion in 2008 but just US$ 164 billion five years later.

Great strides in technological competitiveness

In 2014, the Republic of Korea ranked 6th for scientific competitiveness and 8th for technological competitiveness, according to the Institute of Management Development, based in Switzerland. The rankings for both science and technology have improved hugely since the turn of the century but it is in technological competitiveness that Korea has made the biggest strides in the past five years. The country is particularly efficient in communication technologies. For example, it ranked 14th in 2014 for mobile telecommunication costs per minute, compared with 33rd a year earlier. Other indicators surveyed remained sluggish, however. For example, in terms of technological co-operation among corporations, Korea it ranked 39th, whereas its rank on cybersecurity issues was downgraded from 38th to 58th over the same period. This correlates with the drop in scientific productivity in computer sciences observed in recent years.

TRENDS IN HUMAN RESOURCES

Korea now ranks sixth for the number of researchers

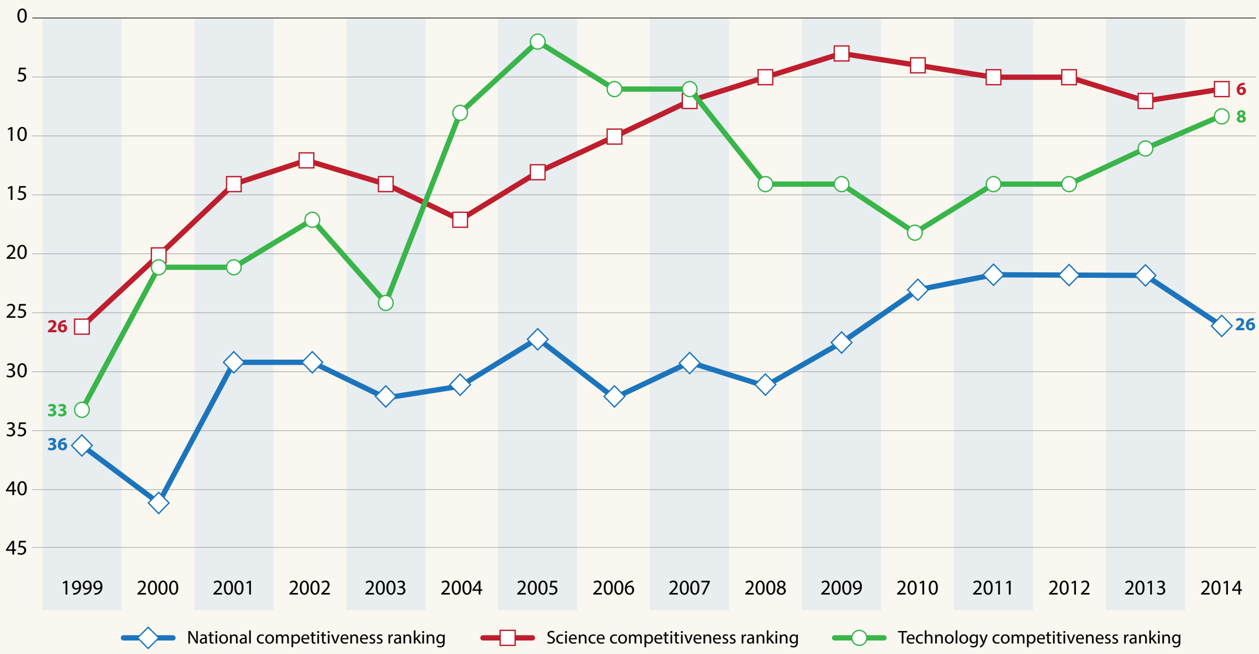
The number of full-time equivalent (FTE) researchers grew steeply between 2008 and 2013 from 236 137 to 321 842 (Figure 25.10). As a result, the Republic of Korea now ranks sixth for this indicator after China, the USA, Japan, the Russian Federation and Germany. More importantly, the Republic of Korea has more researchers per million population than any of these countries: 6 533 in 2013. In terms of researcher density, it is surpassed only by Israel and some Scandinavian countries. Moreover, thanks to the steady rise in the country's GERD/GDP ratio, the investment available to each researcher has managed to keep pace with the burgeoning numbers of personnel, even climbing slightly from PPP$ 186 000 to PPP$ 214 000 between 2008 and 2013 (Figure 25.10).

Women remain a minority in Korean science

In 2008, only one in six researchers (15.6%) was a woman. The situation has improved somewhat since (18.2% in 2013) but the Republic of Korea still lags far behind the beacons for this indicator, Central Asia and Latin America, where about 45% of researchers are women, even if it performs better than Japan (14.6% in 2013). When it comes to remuneration, there is a yawning gap between men and women researchers in the Republic of Korea (39%), the widest of any OECD country. Japan has the next-biggest gap in remuneration (29%).

The government is cognizant of the problem. In 2011, it introduced a *Second Basic Plan for Women Scientists and*

Figure 25.9: **Changes in Republic of Korea's competitiveness ranking in science and technology, 1999–2014**

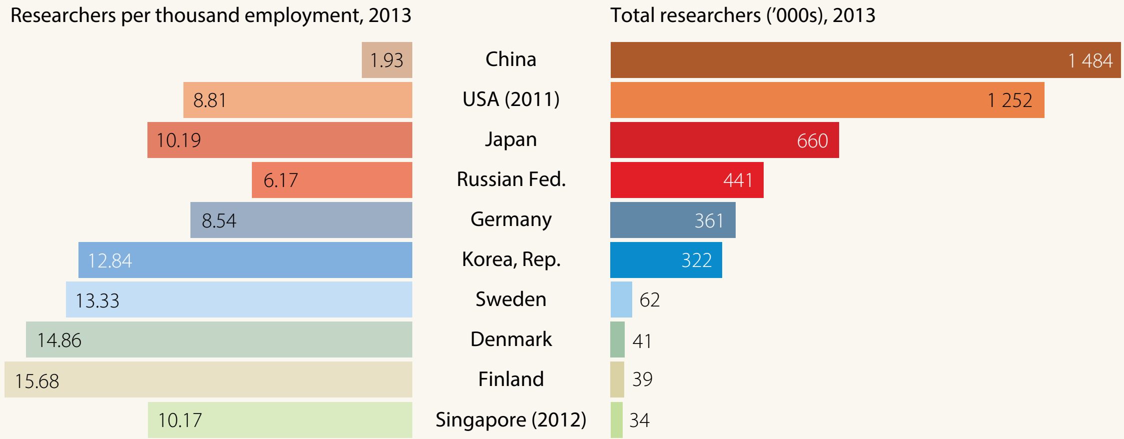


Source: IMD (2014) *World Competitiveness Yearbook*. Institute of Management Development: Lausanne (Switzerland)

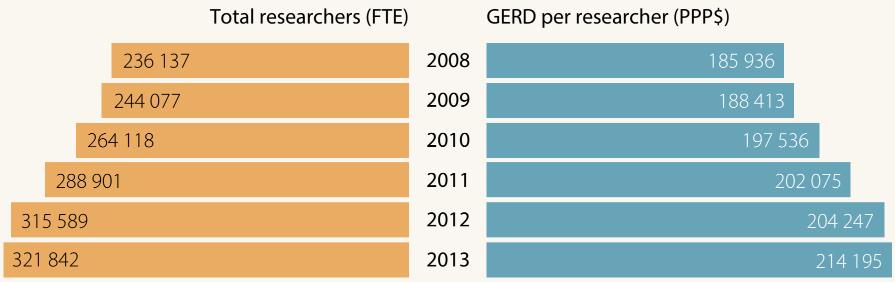
Figure 25.10: **Trends among Korean researchers (FTE), 2008–2013**

The Republic of Korea has one of the world's greatest researcher intensities

Other countries are given for comparison



The budget per researcher has risen since 2008



Source: OECD (2015) *Main Science and Technology Indicators*

Engineers (2009–2013), which outlines measures for fostering career development and making the working environment more women-friendly. In 2011, centres for women in science and technology lodged within several universities merged to form the Centre for Women in Science, Engineering and Technology (WISET). WISET develops policies to mainstream women in science, engineering and technology. The centre held a Gendered Innovation Forum in March 2014 to bring Korean experts together with science attachés from embassies in Seoul. The centre is also hosting the next Gender Summit in Seoul in late 2015. The first gender summits have been held in Europe and the USA since 2011. This will be the first such event in Asia.

Measures to nurture creative talents

The Korean government has come to realize that developing national capabilities for innovation will require nurturing creativity among the young (MSIP, 2013b). To this end, it has outlined several strategies for the 'renaissance of the natural sciences and engineering'. Ministries have jointly introduced 'measures to nurture creative talents', in order to attenuate the focus on academic backgrounds and promote a new culture whereby people encourage and respect the creativity of individuals. One example of these measures is the Da Vinci Project being experimented in selected primary and secondary schools to develop a new type of class which encourages students to exercise their imagination and which revitalizes hands-on research and experience-based education.

The government is also promoting the Open Academy Project with the Korea Advanced Institute of Science and Technology and other universities to establish an online platform where students can study and enter into discussion with professors. There are plans to make online courses accessible to anyone with an interest in studying and to link these courses to an academic credit banking system to ensure that the credits obtained by students enrolled in these online courses are recognized.

The *Second Basic Plan for Nurturing Human Resources in Science and Engineering* (2011–2015) aims to foster human resources in science and technology by focusing on the development of creativity, the scope of which is to be expanded to include elementary and secondary education. The government is promoting education for science, technology, engineering, arts and mathematics (STEAM) to promote the convergence of these fields and help students grasp economic and social challenges in the future. Brain Korea 21 plus has been implemented within the scope of the plan (Box 25.2). The government has also expanded its financial support to young researchers: the number of projects qualifying for government support rose from 178 (KRW 10.8 billion) in 2013 to 570 (KRW 28.7 billion) in 2014.

Based on the *Medium-and Long-term Supply and Demand Forecast for Human Resources in Science and Technology* (2013–2022), the country will face an excess of 197 000 graduates and 36 000 postgraduates with a master's degree by 2022, whereas there will be shortage of 12 000 PhD-holders.

As industry needs a greater number of employees with training in science and technology than in the past, policy measures will need to correct this misalignment. For example, the government plans to conduct a foresight exercise with a focus on human resource needs in emerging technologies to make up for the projected shortfall in these fields.

A creative economy town

The Creative Economy Town[6] is one example of a series of offline and online platforms set up by the Park government to allow individuals to share and commercialize their ideas. Professionals from relevant fields act as mentors, providing legal advice on intellectual property rights and other issues and connecting budding innovators with companies which have the potential to market their ideas.

A second example is the Innovation Center for the Creative Economy. This government centre is located in Daejeon and Daegu and serves as a business incubator.

These initiatives are not without controversy, however, as some feel that the government is intervening too much. The main question hinges on whether entrepreneurship can be better fostered with government support or by leaving entrepreneurs to fend for themselves in the marketplace.

A survey conducted by the Korea Federation of Small and Medium-Sized Enterprises in 2014 revealed that the federation's members judged the level of entrepreneurship in the Republic of Korea to be quite low.[7] It is still too early at this point to analyse whether or not the government's efforts have succeeded in fostering innovation.

A more systemic approach to co-operation

Korean scientists have been participating in international projects and exchanges for years. Some 118 scientists collaborated with the European Organization for Nuclear Research (CERN) in 2013, for instance. The Republic of Korea is also a partner in the project which is currently building an International Thermonuclear Experimental Reactor in France and invested around KRW 278 billion in this project from 2012 to 2014. The government also contributed KRW 20 million (*circa* US$ 23 000) to support the participation of more than 40 individual Korean researchers in the European Union's Seventh Framework Programme for Research and Technological Development from 2007–2013 (MSIP, 2012).

6. https://www.creativekorea.or.kr

7. http://economy.hankooki.com/lpage/industry/201410/e20141028102131120170.htm

Box 25.2: **Brain Korea 21 Plus: the sequel**

The *UNESCO Science Report 2010* followed the fortunes of the Brain Korea project, which had been renewed in 2006 for another six years. Within this project, universities and graduate schools wishing to qualify for government funding were obliged to organize themselves into research consortia. The aim was to encourage world-class research.

This approach seems to have worked, for the performance and output of both participating graduates and faculties effectively improved. For example, the number of articles produced by university staff and graduates increased between 2006 and 2013 from 9 486 to 16 428. Importantly, the impact factor per article also progressed: from 2.08 in 2006 to 2.97 in 2012 (NSTC, 2013).

Encouraged by this success, the project was extended for another six years in 2013, under the name of Brain Korea 21 Plus. In its first year, the project received an allocation of KRW 252 billion (*circa* US$ 295 million).

Whereas the initial project focused on increasing the quantity of R&D performed, Brain Korea 21 Plus is focusing on improving the quality of both teaching and research at local universities, along with their ability to manage projects. By 2019, the project hopes to have enrolled a great deal more students in accredited master's and PhD programmes than in the past, in order to nurture some of the talent that will be needed to develop a more creative economy.

Source: https://bkplus.nrf.re.kr

The government is also encouraging Korean collaboration with world-class laboratories through a home-grown scheme, the Global Research Laboratory Programme, which was launched in 2006. Each year, the Ministry of Science, ICTs and Future Planning and the National Research Foundation invite Korean research institutions to answer their call for project proposals. These proposals may concern basic sciences or technological fields, as long as the research topic necessitates collaboration with laboratories abroad. Successful joint projects may be awarded annual funding of KRW 500 million (*circa* US$ 585 000) for up to six years. The number of Global Research Laboratory projects has increased from 7 in 2006 to 48 in 2013 (MSIP, 2014a).

The current government is particularly keen to see the private sector develop core technologies by investing in foreign companies. The *National Plan for International Co-operation in Science, Technology and ICTs* (2014) sets out to do just that. A key element of the plan is the establishment of the Korea Innovation Centre, which will play a supporting role for Korean researchers and entrepreneurs eager to invest abroad while attempting to woo foreign investors to Korean shores (Box 25.3).

Some forms of international assistance also incorporate science and technology, such as the Techno Peace Corps programme, which funds postdoctoral students. Another example is the project being implemented by the government in Viet Nam to establish the Viet Nam–Korea Institute of Science and Technology. The government also plans to establish 'centres for appropriate science and technology' in developing countries, in order to provide post-management of projects, including consultancies and education; for example, the government has established an innovative Water Centre (iWc) in Cambodia to boost Cambodian R&D oriented towards providing a clean water supply and serve as a base for the Republic of Korea's international assistance in science and technology. The government's overall budget for this type of international assistance is expected to increase from KRW 8.2 billion in 2009 to KRW 28.1 billion (*circa* US$ 32.9 million) in 2015 (Kim, 2011).

CONCLUSION

A new orientation towards entrepreneurship and creativity

The Republic of Korea has come through the global financial crisis since 2008 remarkably unscathed. However, this should not mask the fact that the country has outgrown its catch-up model. China and Japan are competing with Korean technology in global markets and exports are slipping as global demand evolves towards green growth.

The government has decided to respond to this increasingly competitive global market by raising its investment in R&D, strengthening the manufacturing sector and developing new creative industries. The country's investment in R&D has already risen quite substantially but there is now some doubt as to whether this has produced the desired result. It may be that investment in R&D has reached a point where marginal growth in the performance of R&D is close to zero. The Republic of Korea thus now needs to optimize the management of its national innovation system to take full advantage of this rising investment.

Without a corresponding restructuring of industry and its accompanying innovation system, the injection of R&D funding

Box 25.3: The Korea Innovation Centre

Established in May 2014 as part of the new 'creative economy,' the Korea Innovation Centre promotes Korean exports and the internationalization of national researchers.

It also incites venture companies and SMEs to enter the world market. In order to encourage networking and common platforms for co-operation, it is opening up offices in the European Union (Brussels), the USA (Silicon Valley and Washington, DC), China and the Russian Federation, as well as at home.

The Korea Innovation Centre is operated jointly by the National Research Foundation, which provides the secretariat, and the National Information Technology Industry Promotion Agency. Its mission is aligned with the five strategies designated under the 2014 *National Plan for International Co-operation in Science, Technology and ICTs:*

- Establish systemic linkages to support international co-operation and overseas business;
- Enhance support for SMEs to launch overseas ventures;
- Strengthen innovation capacities by developing world-class human resources in STI;
- Strengthen international co-operation and partnerships in science, technology and ICTs;
- Create more efficient management systems to respond to international demand.

Source: www.msip.go.kr

may not be able to produce better output. As posited by the theory of innovation systems, the total productivity of a national innovation system is a key factor for change but it is also quite difficult to transform the national innovation system, as it tends to be an 'ecosystem' that is most concerned with linking the various actors through relationships and processes.

The country is now striving to become more entrepreneurial and creative, a process that will entail changing the very structure of the economy. Up until now, it has relied on large conglomerates such as Hyundai (vehicles) and Samsung and LG (electronics) to drive growth and export earnings. In 2012, these conglomerates still represented three-quarters of private investment in R&D – an even higher share than three years previously (KISTEP, 2013). The challenge will be for the country to produce its own high-tech start-ups and to foster a creative culture in SMEs. Another challenge will be to turn the regions into hubs for creative industries by providing the right financial infrastructure and management to improve their autonomy.

KEY TARGETS FOR THE REPUBLIC OF KOREA

- Raise GERD from 4.03% to 5.0% of GDP between 2012 and 2017;
- Ensure that SMEs achieve 85% of their potential technological competitiveness by 2017, compared to 75% in 2011;
- Raise support for SMEs from 12% of the government R&D budget in 2012 to 18% by 2017;
- Raise the share of basic research in the government budget from 32% in 2012 to 40% by 2017;
- Raise the share of government investment in improving the quality of life through R&D from 15% in 2012 to 20% in 2017;
- Increase the number of jobs in S&T from 6.05 million to 6.69 million by 2017;
- Increase the share of early-stage entrepreneurial activity in enterprises from 7.8% in 2012 to 10% in 2017;
- Increase the number of PhD-holders from 0.4% to 0.6% of the population between 2012 and 2017;
- Raise industrial added value per capita from US$ 19 000 in 2012 to US$ 25 000 by 2017;
- Commercialize the technology for carbon dioxide capture sequestration by 2020;
- Double the value of technology exports from US$ 4 032 million to US$ 8 000 million between 2012 and 2017.

In sum, the government's agenda for a creative economy reflects a growing consensus that the country's future growth and prosperity will depend on its ability to become a global leader in developing and commercializing innovative new products, services and business models.

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Deok Soon Yim (b. 1963: Republic of Korea) holds a PhD in Business Studies from the Graduate School of Chung-Ang University in Seoul. He is a Senior Research Fellow at the Science and Technology Policy Institute in Sejong. His research interests include science and technology parks, regional innovation clusters and the globalization of R&D. He was a consultant for the Korean government on the initiative for Daedeok Science Town, which later expanded to become Daedeok Innopolis.

Jaewon Lee (b. 1984: Republic of Korea) is a researcher at the Science and Technology Policy Institute (STEPI) in Sejong. Prior to joining STEPI in 2014, he undertook research at the Stockholm International Peace Research Institute through a grant from the Korean Foundation. He holds a Master's in International Studies from the Graduate School of International Studies at Seoul National University.