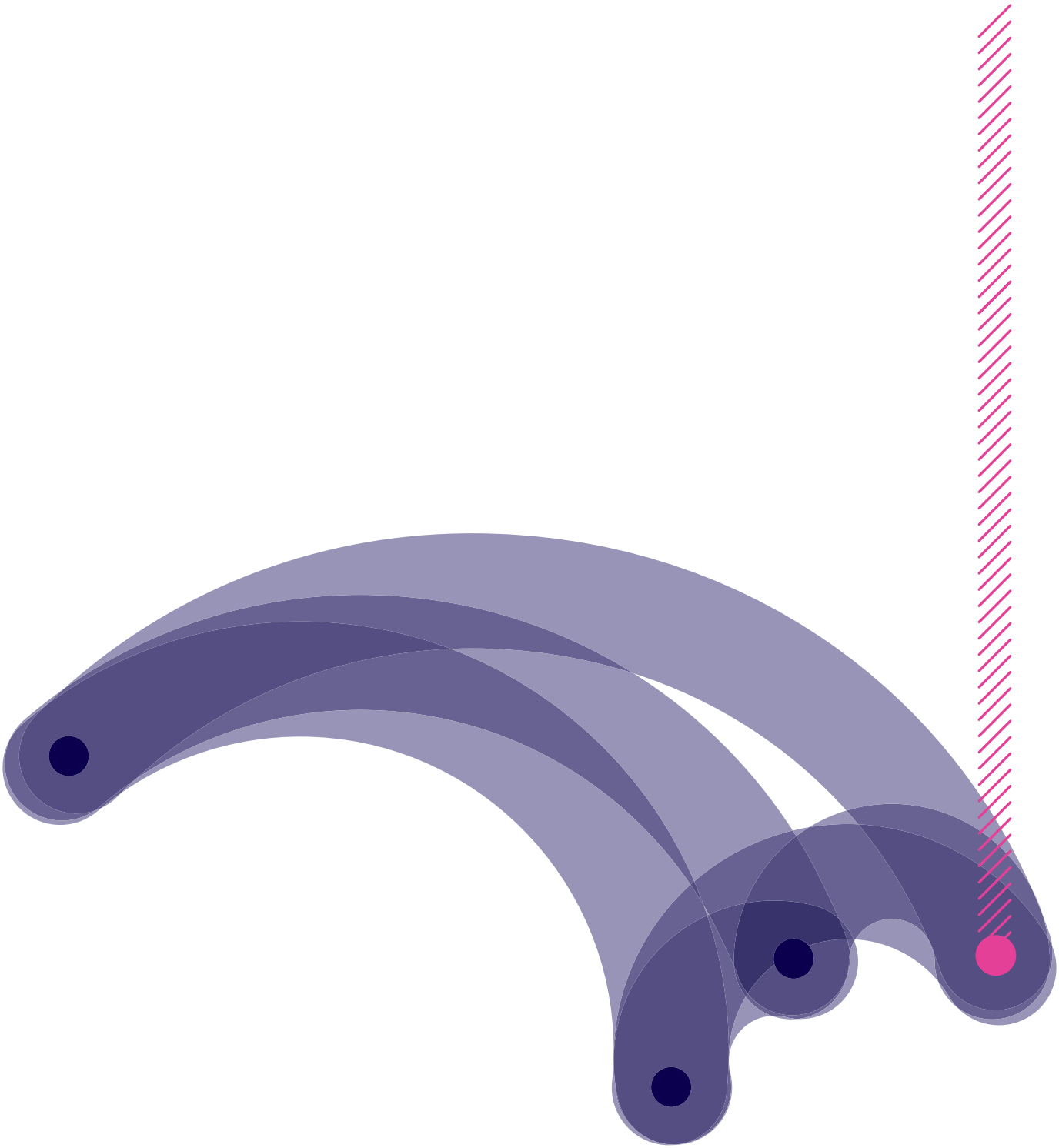
South Korea:
Mass innovation comes of age

Molly Webb

The Atlas of Ideas:
Mapping the new geography of science



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First published in 2007

Series edited by Charles Leadbeater and James Wilsdon

ISBN 1 84180 171 0
Copy edited by Julie Pickard, London
Design by Browns (www.brownsdesign.com)
Printed by The Good News Press

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1 Introduction
The many faces of Korean innovation

Rarely has so much hope been invested in a single scientist. Woo-Suk Hwang symbolised South Korea's ambitions to become a scientific power, and enjoyed a string of breakthroughs in 2005 which seemed to confirm his success. In the spring of that year, *Science* published his paper announcing the creation of patient-specific stem cell lines,[1] a world first. In October, he opened the Seoul World Stem Cell Bank to international fanfare. When he spoke at the BioMedi Symposium in Seoul the following day, bolstered by a who's who of international stem cell research, he was cheered as a celebrity. Hwang's speech dwelled on the desperately ill patients who had found hope in the promise of his treatments, while also appealing to Korean nationalism. 'I put the Korean flag in the middle of western science,'[2] said Hwang, evoking the image of Neil Armstrong planting the US flag on the moon.

I put the Korean flag in the middle of western science.
Woo-Suk Hwang

Some estimate that more than $60 million of public money was invested in his work. Everything he did was designed for optimal media coverage, from a failed attempt to clone a tiger to a cloned dog, Snuppy.[3] In June 2005 the Ministry of Science and Technology (MOST) elevated Hwang to become Korea's first 'Supreme Scientist'.

In little more than a decade, Korea, a country the size of the US state of Indiana with no internationally known pharmaceutical companies and little biotech capability, had catapulted itself to leadership in one of bioscience's most promising fields. Hwang's success sent out a wider message: Asian science could leapfrog the West faster than anyone had dared predict. His advances were the basis for research elsewhere in the world. Researchers in Europe and the US used Hwang's success to argue for more funding to keep pace.

But all too quickly Hwang's success story unravelled. Suspicions were raised over whether Hwang encouraged female researchers to provide eggs for experiments. Worse, Hwang was then accused of faking his results. An inquiry by Seoul National University (SNU), his university, found that the experiments could not be replicated. By late 2005, Korea's superstar scientist was on trial as his personal 'stem cell bubble' burst spectacularly, prompting a mix of bewilderment and denial across Korea. People were slow to accept that Hwang could be a fraud. In March 2006, weeks after the SNU Investigation Committee had confirmed the fraud, 4000 people in Seoul marched in support of the fallen celebrity.

In the wake of 'Hwanggate' it might be tempting to write off Korea as a science power. The idea that a still-developing Asian nation could leapfrog western science seems to have proven far-fetched. Even a superstar scientist couldn't compensate for the structural weaknesses of the system, in which less than 10 per cent of pharmaceutical companies conduct R&D.[4]

But just as too much was invested in Hwang it would be a mistake to write off Korea's potential to become a significant source of science-driven innovation. Korea has achieved miracles in the past 40 years, and it might do the same again.

Table 1 Phases of Korea's growth and major policies

	1960s	1970s	1980s	1990s	2000s
Population (million)	25	32.2	38.1	42.9	48.4
R&D budget as % of GDP		0.39% 0.42%	0.56% 1.52%	1.87% 2.37%	2.39% 2.99%
Development stage (sources of competition)	Imitation or factor-driven stage (cheap labour = 55% of growth)	Internalisation or investment-driven stage (manufacturing capability)		Generation or innovation-driven stage (innovative capability – technology = 55% of growth)	
Major industrial policy direction	Expand export-oriented light industries	Expand export-oriented heavy industries	Expand technology-intensive industries	Promote high-technology innovation, develop information infrastructure, strengthen market-oriented technological innovation, accelerate import liberalisation	Transition to knowledge-based economy. Industrial strength based on restructuring, continued investment, advancement into new markets, upgrading towards higher industrial value chains
Science and Technology (S&T) policy and role of government	Scientific institution-building – MOST/KIST – S&T Promotion Act – five-year economic plan includes S&T	Scientific infrastructure-setting – GRI – Daedeok science town – R&D promotion act – highly qualified personnel	R&D and private lab promotion – NRDP – promoting private research labs – promoting industrial R&D	Leading role in strategic areas – HAN – promoting cooperative R&D – policy coordination – GRI restructuring	New challenges. Head of MOST is made deputy prime minister. OSTI is created to coordinate across departments, promoting indigenous innovation (IPR emphasis)
Macroeconomic policy framework	Prepare legal and institutional bases to support industrialisation	Maximise growth and increase government intervention into the markets	Stabilise macroeconomy and enhance private autonomy and competition	Liberalise trade and FDI and reform financial markets and restructure the economy	Encourage FDI, encourage transparency, FTA with the US and others, Vision 2030 plans
Human resources	Decrease illiteracy	Increase vocational training	Expand higher education system	Develop: – highly skilled human resources in strategic fields – lifelong learning systems	Literacy rates: – 98% (2002) HR innovation, increasing: – market influence – productivity – international
Education policy	Plan education for economic development – improve teaching quality – increase number of college graduates with engineering major – develop medium-skilled HR		Enhance lifelong learning and non-traditional education – government-led, partial market approach – develop highly skilled HR in strategic fields – increase research funds in R&D		Improve quality of education and research: Brain Korea 21 (BK21) encourages R&D research. Phase 1: 1999–2006. Phase 2: 2006–2013, NURI (regional education)

Notes: FDI, foreign direct investment; FTA, free trade agreement; GRI, government research institute; HAN, highly advanced national R&D programmes; HR, human resources; IPR, intellectual property rights; KIST, Korea Institute of Science and Technology; MOST, Ministry of Science and Technology; NRDP, national R&D programmes; NURI, New University for Regional Innovation; OSTI, Office of Science and Technology Innovation; S&T, science and technology; SERI, Samsung Economic Research Institute

Source: Adapted from GR Mitchell, 'Korea's strategy for leadership in research and development', US Department of Commerce, Office of Technology Policy, Jun 1997; Kim, *Imitation to Innovation*, World Bank 2006; *SERI Annual Report*, 2005.

Korea's industrialisation miracle

South Korea emerged from Japanese occupation and a civil war that killed more than one million people, with gross domestic product (GDP) per capita of US$80 in 1960. By 2005, it had become the world's tenth largest economy, with GDP per capita of over $15,000.[5] It achieved this thanks to US support and a combination of hard work and brainpower. South Korea had little else to rely on: partition gave 75 per cent of Korean energy resources to the north.

In the 'imitation phase' of Korean development in the 1960s and 1970s, state-directed industrial policy kicked off Korea's growth.[6] Korean firms were contracted as suppliers to US and Japanese companies. Gradually, these firms internalised and redeveloped technologies from the West to become competitors in their own right. The government facilitated investment in R&D by sharing risk through government research institutes that helped companies to develop key technologies. Korean scientists who returned from the US were enlisted in national projects. The 'internalisation phase' of the early 1980s took a slowdown in the world economy, combined with rising costs, as the prompt for further investment in R&D. Private sector R&D investment increased from 0.21 per cent to 1.17 per cent. Companies such as Samsung started making branded goods in their own right.

Korean analysts have dubbed the 1990s the 'innovation phase',[7] with Korean companies less dependent on foreign designs and intellectual property and more able to explore emerging technologies, for example in mobile communications, on equal footing with US and European competitors. In 1998, the Korean government set out to turn the country into a knowledge economy, committing to doubling investment in R&D and increasing the R&D labour force from 180,000 to 250,000 by 2007 (see table 1).[8]

In short, a country that was on its knees at the start of the 1960s, with few natural resources, a limited higher education system and little or no research, has succeeded through a mixture of brainpower, hard work, state direction of large companies and US support, to become one of the most technologically adept and best-educated societies in the world.

R&D spending was almost 3 per cent of GDP in 2005,[9] about 75 per cent of it from private industry. Public funding for R&D in 2006 was US$8.65 billion, a 15 per cent increase over 2005. Korea is ranked 15th in the world in terms of scientific publications. Between 2000 and 2004, Thomson Scientific indexed 81,057 papers with at least one author in South Korea.[10] Korea has the highest annual growth in patent families – more than 20 per cent[11] – and the highest growth in US patents from 1986 to 2003. More than 50 per cent of the workforce has a degree, but wage levels are about 50 per cent of those in the UK. In many areas, Korean infrastructure for science and its technological capability is world class.

Future plans

Korea also deserves to be taken seriously because it has ambitious plans. The future, not the past, is where Korea's science and technology (S&T) begins. Nearly every government department, university, research institute or company has a vision for the future.

These visions can sometimes appear to be no more than slogans. Korea is used to setting itself ambitious targets without being clear how to reach them. But if Korea delivers only a share of what it has set out to achieve, it will still be a significant force in science and technology.

Ten next-generation growth engines were identified in 2003, designed to drive Korea's 'second leap' to GDP of US$20,000 per capita by 2012. The Ministry of Information and Communications (MIC) 'Ubiquitous Korea' or 'U-Korea' IT839 Strategy is designed to help Korea realise a digital welfare state, at a cost to government and private industry of US$70 billion by 2010. The Korea IT Industry Promotion Agency (KIPA) is promoting open source to turn Korea into an international software 'powerhouse' with 40 per cent of servers running open source operating systems by 2010. The Korea Bio-Vision 2010 aims to push South Korea's biotech ranking from 13th in the world in 2003 to seventh by 2010.[12] Hwang's disgrace has galvanised a renewed effort involving ten ministries to put Korea in the top three counties in biotech by 2015.[13] Government plans are for Korea to have ten cutting-edge nanotechnologies and 12,600 nanotechnology experts by 2010.[14]

Hwang's spectacular failure should not mislead us. Korea has the resources and intention to be a bigger player in S&T innovation. It will also be followed closely as a model by many regions in China.

However, there is still widespread uncertainty about Korea's capacity to deliver on these brave visions and make the transition from state-driven industrial development to ubiquitous knowledge economy. Will the techniques that have got Korea so far now become obstacles?

The evolving Korean model

Korea's evolving innovation system is the product of three linked approaches that sometimes work together but often seem at odds with one another.

The first is *industrial techno-nationalism*. The state development model, working with large conglomerates (the *chaebol*) as the main vehicle, remains a powerful top-down model of development. One of the biggest questions for Korea is how far reform of the 'state-managed, big company' economy will go. One force for the future, particularly in the wake of the economic crisis of 1997, could be reformed, outward-looking and innovative large companies such as Samsung. Yet critics argue that in the last few years, efforts to create a more transparent and competitive economy have slowed. Few other Korean chaebol seem ready to match Samsung's capacity for innovation and internationalisation.

The second is *scientific techno-nationalism*. In the last decade, the techno-nationalist model has been extended to encompass world-class science. This approach emphasises a new generation of scientists and high-tech entrepreneurs as the key figures in this story. Funding for science has expanded dramatically and is set to continue rising. But so are the expectations and pressures on scientists to deliver results. As a result, pressure for reform to Korea's research and university system is likely to mount. More investment in science as the basis for future development will also expose Korea to greater international collaboration and scrutiny. It remains to be seen what kind of science will emerge from this investment. Government is increasing the share of R&D funding put towards basic research to match efforts in more developed economies.[15] But impatience to get results also puts scientists under pressure to deliver results. The Nobel garden at Pohang University of Science and Technology (POSTECH) includes empty podiums for future Nobel prize-winning Korean scientists. Korea desperately wants recognition for its status as a leading source of scientific innovation, but the techno-nationalist model of getting results fast may well be at odds with Korea's ambitions to do world-class science based on long-term research.

The third approach is *ubiquitous innovation*. Korea is one of the most networked, connected and well-educated societies in the world. Mobile telephone penetration is expected to be over 80 per cent in 2008.[16] Phones are beginning to provide not just entertainment but health services. Korea's ubiquitous broadband infrastructure can facilitate mass innovation and creativity: CyWorld, for example, is one of the world's top internet networking sites: a combination of blogs, music and chat where people pay to decorate and personalise their mini home pages. OhMyNews has redefined citizen journalism, providing a multilingual site with millions of readers managed by a team of editors a fraction of the size of a traditional newspaper. President Roh was swept into office by his huge online fan base. Hwang's collaborators first revealed their concerns about his ethics online. Korea has the potential to become a society where aspects of innovation become a mass activity. Its demanding and educated consumers may well drive the creation of new markets in communications, information and services.

This report argues that it is Korea's developing capacity for ubiquitous innovation that may set it apart in future. There are several distinctive components to this:

— The state as partner in (not driver of) innovation. Policy-makers argue increasingly that government must set the framework for innovation rather than direct it.
— Good education. Korean education excels at the basics, especially maths, but also English up to the end of secondary school. This is not matched by the quality of higher education, however. University reforms to reduce reliance on rote learning and improve teaching and research quality will become more pressing.
— A technically literate population. Korea's approach to mobile communication is predicated on connected and capable consumers helping to create lead markets in new applications for technology. Korea will attempt to follow that model in other sectors such as health and biotech.
— Outstanding infrastructure for distributed innovation. In 2005 Korea ranked first among OECD countries in broadband penetration with 25.5 subscribers per 100 inhabitants. Fixed line and mobile phone subscriptions were 1302 for every 1000 people in 2005.[17]
— Chaebol: the modern multinationals. More open, internationalised chaebol such as Samsung Electronics could act as role models for the rest of Korean business.
— Entrepreneurship in emerging areas. New businesses are emerging in areas such as biotech and computer games where the chaebol are not dominant. Small businesses account for 87 per cent of jobs in Korea and a rising share of Korean patents.
— Dynamic younger generation. There are signs of a fresh wave of Korean entrepreneurs in their 30s who have been educated abroad and want to work outside the mainstream structures of the state and the chaebol.
— International collaboration. Koreans are slowly shifting from a developing-country mindset, which takes technology from abroad and sells it back in low-cost products, to a more internationalist perspective that seeks collaboration in setting standards and creating new markets. A prime example is the development of WiBro (portable broadband) being rolled out across the subway system in early 2007, a collaborative project between Intel and several Korean firms.

In other ways, Korea still has some way to go if ubiquitous innovation is to be realised. Education remains rigid. Small businesses are overshadowed by the chaebol. The state's power to direct and shape industrial development remains in the background.

Ubiquitious innovation is emerging alongside the other Korean models of innovation, but is not yet dominant. Under industrial techno-nationalism, the main protagonists are the state and the chaebol, backed by a hard-working, largely deferential labour force, absorbing knowledge from the West where needed.

Under scientific techno-nationalism, the main players are scientists and entrepreneurs supported by the state. Dr Hwang was the most extreme case of this reliance on superstar researchers and high-profile programmes to propel Korea into the knowledge age.

Under ubiquitous innovation, the main players are internationally connected Koreans and entrepreneurs working through networks, in a society that combines unprecedented levels of education and connectivity. This mass culture of creativity is already making itself felt in mobile communications and computer gaming but it could soon migrate into other services such as banking and health care.

It is not difficult to see how these models could work together through a mix of state investment in infrastructure, science creating new technologies that are transformed into products by large and small companies, educated and technologically adept consumers quickly adapting new technologies and allowing Korean companies to learn fast about how to apply them.

But these approaches can at times sit in tension. Hwang's fraud was exposed by the younger internet generation, who want the freedom to define their futures, and are open to globalisation. On the Biological Research Information Center (BRIC) online message boards a thread was started by an anonymous author on 5 December 2005 entitled 'the show must go on…' hinting that some of the pictures in one of Hwang's *Science* papers were duplicates. Hundreds of posts examining the paper followed. That online review forced Hwang to agree to a DNA analysis of the stem cell lines. Soon afterwards the paper was withdrawn and SNU started the investigation that led to Hwang's downfall. The more Koreans engage in science, the more international exposure will follow, which will be a challenge to the ethos of techno-nationalism that has driven Korea forward for almost 50 years.

Korea will become a knowledge-driven, innovation society only by at times being painfully at odds with itself, as it learns to navigate the shift from a top-down, techno-nationalist approach to one that is more open, cosmopolitan and unplanned.

A note on methodology

The research for this report was carried out over 18 months by Demos, with the support of an expert steering group. The UK part of the project included a number of research seminars, one of which focused on Korean science and technology.

Five weeks were spent in Korea doing fieldwork. A focus group and over 70 in-depth interviews with policy-makers, scientists and academics were conducted in and around Seoul, Daejeon and Pohang. These interviews were supplemented by attending lectures and conferences, and by informal discussions with many of the people shaping Korea's innovation system.

2 Mapping
The magic numbers

Korea sits between China and Japan, ‘a shrimp between whales’ with a population of 48 million, roughly the same as the number of new millionaires in China. Though we cannot expect that the eye-catching quantities of graduates in China or India will be matched anywhere in the world, especially by Korea, the numbers do tell a story of sometimes surprising and rapid innovation.

This chapter outlines some quantitative measures of innovation in Korea, by looking at the inputs and outputs of the country (see table 2). Inputs include human resources, expenditure on research and development, and foreign direct investment (FDI). Outputs include patents and articles in science and engineering publications.

Table 2 Mapping Korea's innovation system

	Figure	Source
Inputs		
R&D expenditure in 2005	– US$25.03 billion – 24.15 trillion won	MOST (2006)
R&D intensity in 2005 (% of GDP spent on R&D)	– 2.99%	MOST (2006)
Number of industrial R&D centres in 2005	– 12,104	KOITA[18]
Number of R&D personnel in 2003	– 297,060	MOST (2005)
Researchers in R&D per 10,000 people	– 1.8 in 1970 – 16.4 in 1990 – 31.6 in 2003	MOST (2005)
Higher education enrolment rate	– 33.2% in 1990 – 81.3% in 2004	KEDI (2005)[19]
Stock of FDI as % of GDP rise between 1998 and 2004	– 2–9% – 16th most preferred destination for FDI	OECD (2005), WDI S&T indicators (2005)[20]
Broadband DSL internet subscribers (out of 104 countries)	– 1st	WEF 2005[21]

	Figure	Source
Outputs		
Patent applications filed (residents)	– 76,860	WDI (2005)
Patent applications filed (non-residents)	– 126,836	WDI (2005)
Patent commercialisation ratio	– 26.7%	NCST (2005)[22]
Transfer ratio of public research to private sector	– 15.3%	NCST (2005)
Peer-reviewed publications indexed between 2000 and 2004	– 81,057	Thompson ISI (2005)
Global 11-year ranking in peer-reviewed publications (1995–2005)	– 15th	Thompson ISI (2005)

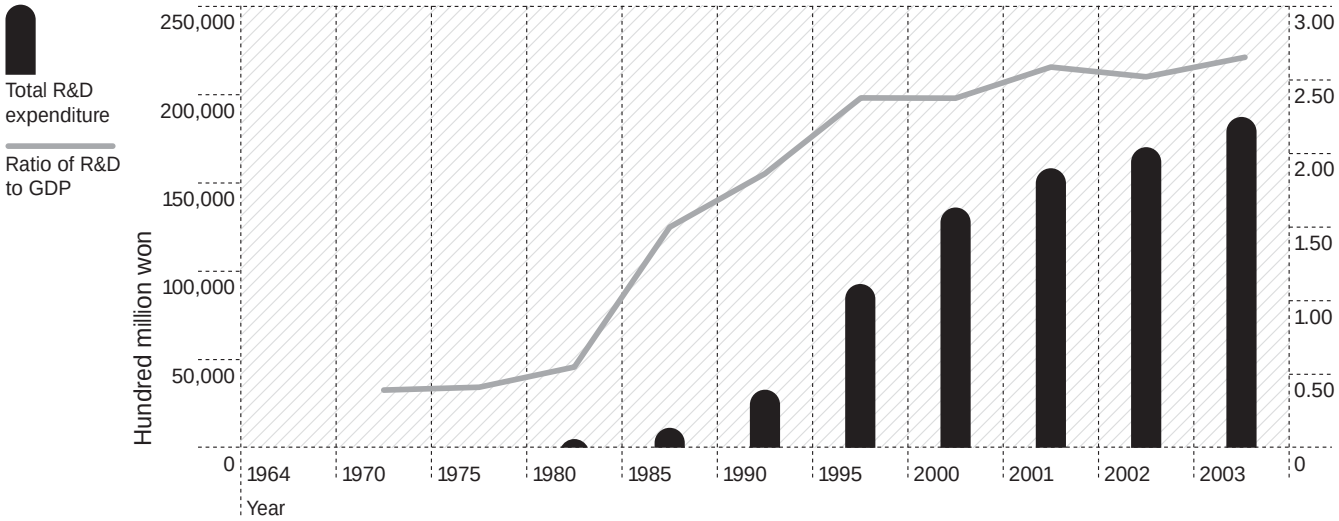
	Figure	Source
Rankings of quality		
Competitiveness ranking out of 25 countries	– 13th in 2005 – 5th in 2010	Deloitte's Competitiveness Index 2005[23]
Innovativeness ranking out of 25 countries	– 15th	Deloitte's Competitiveness Index 2005
Networked readiness index rank (out of 104 countries)	– 24th	WEF and INSEAD 2005[24]
WEF global competitiveness (out of 127 countries)	– 24th	WEF 2006/07
Ease to start a new business (out of 104 countries)	– 44th	WEF 2005[25]
Quality of education system (out of 104 countries)	– 60th	WEF 2005
Quality of math and science education (out of 104 countries)	– 41st	WEF 2005
Transparency (out of 163 countries)	– 42nd	The 2006 Transparency International Corruption Perceptions Index[26]

Inputs

Korean R&D was worth just 0.39 per cent of GDP in 1970, but since 2000, R&D investment has grown from 2 per cent to 3 per cent of GDP. Expansion of R&D will remain a focus for the government as Korea continues to feel the pressures from cheaper manufacturing in China and high-end technology in Japan. Korea has moved from imitation of mature technologies to a more fluid phase of development, but needs investment to stay ahead.

Korea has fallen short of its most ambitious plans in 1989[27] to increase R&D investment to 5 per cent of GDP by 2000. Nevertheless Korea still has the sixth highest rate of R&D investment in the world.[28] A 2006 MOST report showed that South Korean companies, universities and state think tanks together spent 24.15 trillion won (US$25.03 billion) on R&D in 2005, 2.99 per cent of the country's GDP, up 8.9 per cent from 2004 (see figure 1). Secured public funding for 2006 is US$8.65 billion, a 15 per cent increase over 2005.[29] The government plans to increase R&D from 4.8 per cent of total government expenditure in 2003 to 7 per cent by 2007. The budget for key 'new growth' technologies will rise from 28.5 per cent of the total in 2004 to 50 per cent by 2012.[30]

Figure 1 Trend of R&D expenditure and the ratio of R&D to GDP



Source: MOST, 'Status and trend of total R&D expenditure', available at www.most.go.kr/ (accessed 5 Dec 2006).

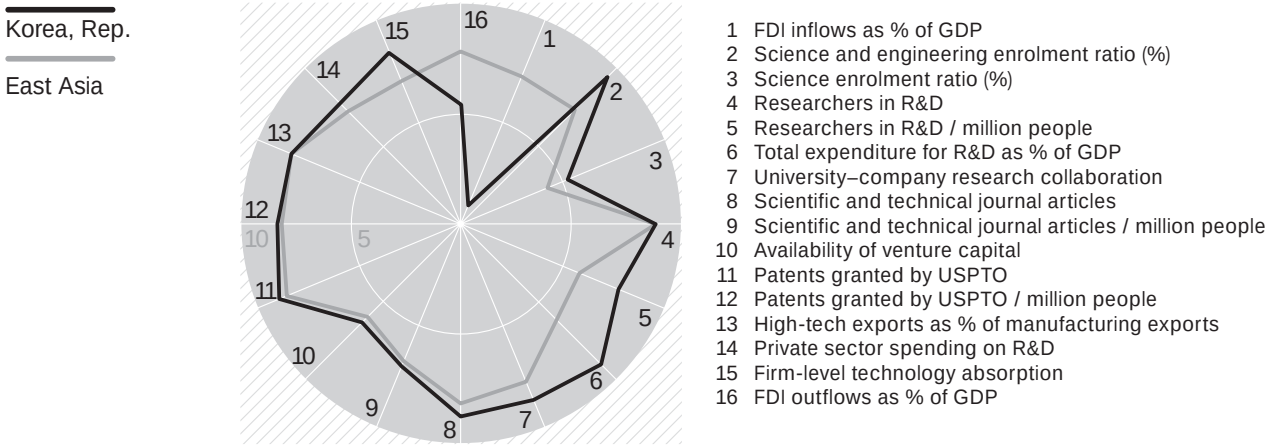
Private industry has caught up with and surpassed the government's R&D spending, now accounting for 75 per cent of total R&D expenditure. In 2006, R&D investment by private industry rose 16 per cent from 2005, after increasing 17 per cent the year before.[31] Several Korean industries put 8 per cent of turnover into R&D[32] as they look for the next growth engines beyond shipbuilding and semi-conductors, in biotech, nanotech and environmental technologies. Korea's multinationals are now shaping the direction of science and technology.

Small companies are also investing more in R&D. In 2006, small and medium-sized enterprises (SMEs) invested 5.7 trillion won, up 22.2 per cent on the previous year, compared with 19.1 trillion won by large companies up 14.8 per cent.[33] The small firms' share of R&D doubled between 1995 and 2001, from 11.4 per cent to 23.6 per cent.[34] SMEs spent 3.58 per cent of sales on R&D in 2004, comparable to their bigger counterparts.[35]

However, over-reliance on private funding can also create vulnerabilities. Basic science may be neglected, especially if private funding is cut in response to recession. A 2006 World Bank report on Korea's knowledge economy notes that if the 1997 crash had lasted any longer, the 14 per cent cut in private R&D it caused could have inflicted long-term damage on the system.[36]

In the past, risk and vulnerability was mitigated by government maintaining a tight rein on business and the economy. However, the Korean research and innovation system today remains closed to outsiders. Though it ranks higher than other east Asian innovation systems on a number of measures, FDI outflows and inflows are the exception (see figure 2).[37] The ratio of foreign sources of funds to total R&D in Korea in 2004 (0.5 per cent) was low compared with countries like France (8 per cent) and the UK (19.4 per cent), which have similar levels of R&D expenditure.[38]

Figure 2 Innovation system variables, South Korea and east Asian nations compared



Source: World Bank, see http://info.worldbank.org/etools/kam/scorecard_adv_param.asp (accessed 6 Dec 2006).

Gradually, the picture is changing. Patents filed in Korea by foreign-owned firms rose to 3.7 per cent of patents filed between 1998 and 2005.[39] Government innovation agencies regard encouraging FDI as vital to develop the quality of research. Yet Korea still ranks next-to-last in a ranking of foreign ownership of domestic inventions.[40] Koreans might argue this means they will reap the benefits of endogenous innovation, rather than foreign investors.

There is little doubting the quality of Korea's hard infrastructure for research: the facilities and the equipment. Korea is one of the few countries in the world with a ministry dedicated to development of information and communications technology (ICT). Korea's broadband infrastructure is ranked number one in the world. But the 'software' on which innovation relies is much weaker. The system is still bedevilled by bureaucracy. Despite reforms since the 1997 economic crisis, public institutions and business culture remains slow to adapt, especially to international collaboration and investment.

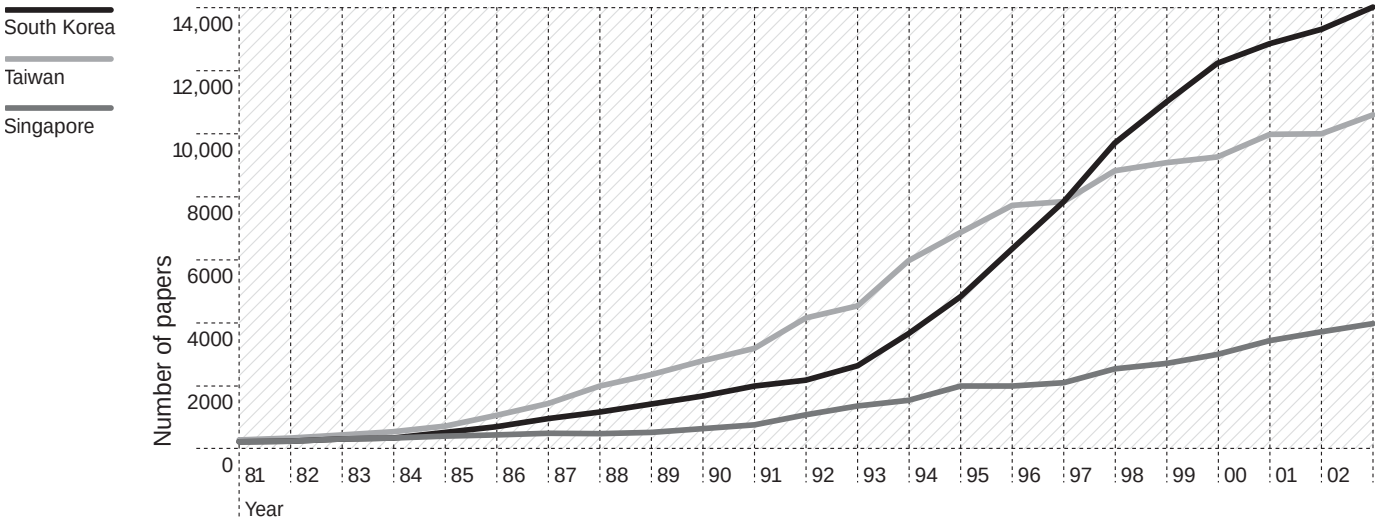
Outputs

Korea's scientific competitiveness seems to be improving markedly. Its science ranking rose four places from 19th to 15th, and technology six places from eighth to second.[41] According to the World Economic Forum, Korea's technology ranking jumped two places to seventh, and overall competitiveness hovers around 24th.[42] On the face of it Korea is producing far more science than it did. Korean scientists are publishing and patenting more frequently. The Science Citation Index (SCI) shows South Korea's publication output increasing dramatically between 1981 and 2003, and the trend is still upwards (see figure 3).[43] Korea's 11-year average ranking (1995–2005) among 147 top performing countries in publications was 15th.[44]

Korean science is strongest in areas such as materials science, chemistry and physics, according to an analysis by Thomson Scientific. In materials research, for example, South Korea's citations-per-paper average was just 1 per cent below the world average.[45]

Yet while Korean scientists publish a lot, their work is not frequently cited by other scientists. In 2005 Korea could not claim a position in the top 20 countries for citations.[46] Injections of cash into the research system have boosted publication outputs, but it will take time for the research ecosystem to grow roots and branches elsewhere.

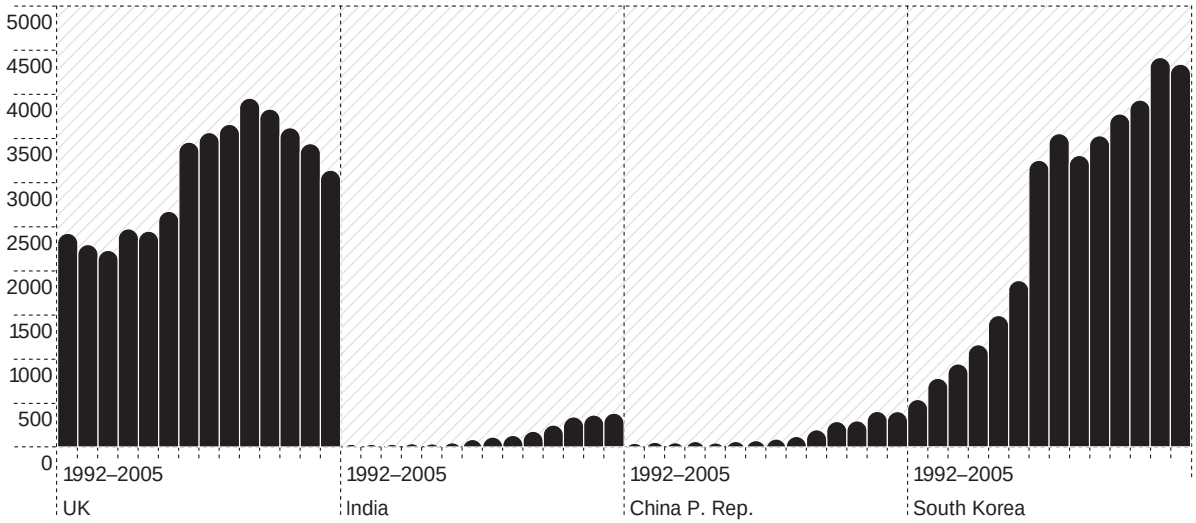
Figure 3 Annual output in science



Source: Thomson Scientific national science indicators

Patenting, especially in areas of manufacturing strength like ICT, is a different story. Led by Samsung Electronics and LG Electronics, Korea files five times as many patents for US dollar of GDP spent on R&D as industrialised European countries.[47] Korea ranks third in the world in ICT measured by patent counts. Korea had the largest increase in patent intensity ratio – number of triadic patent families divided by industry-financed R&D expenditures – in the 1990s[48] and the highest growth in the US patent system from 1986 to 2003[49] (see figure 4).

Figure 4 Growth in US patents* 1992–2005



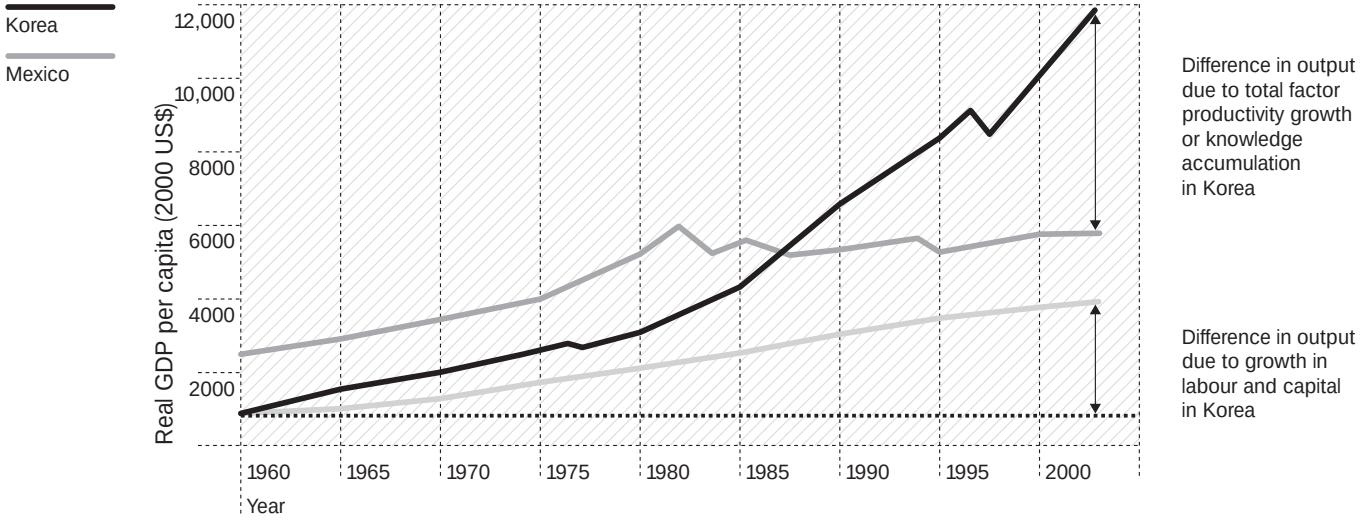
*Patents issued by the US Patent and Trademark Office
Source: US Patent and Trademark Office http://www.uspto.gov/go/taf/cst_utl.htm

The number of patents filed in Europe also increased dramatically in the 1990s, though the overall share of Korea's patents remains low.[50]

Korea now has the third largest patenting office in the world. The current number of patent applications per year is 240,195, almost 500 times the number filed in the first year of the intellectual property (IP) rights system in 1949.[51] IP protection has been a major focus of recent reforms. Revisions to the patent act in January 2006 expanded the novelty standard: patents cannot be granted if the item has been publicly known outside, as well as inside, Korea.[52]

Bibliometrics and patenting measures need to be handled with care. But these figures show that Korea's economic growth is increasingly due to knowledge accumulation rather than labour costs or productivity (see figure 5).[53]

Figure 5 Contribution of knowledge to GDP growth



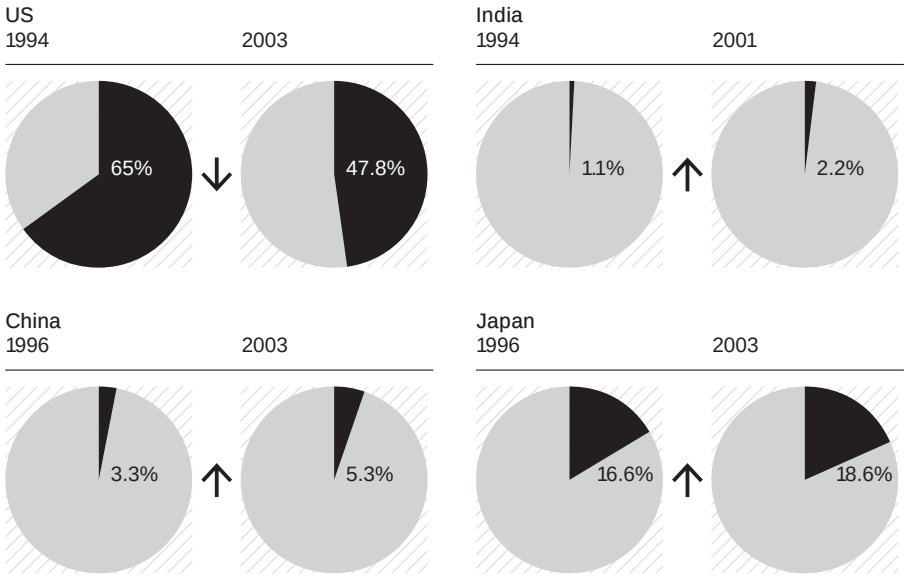
Source: World Bank staff estimates, 'Overview', *Korea as a Knowledge Economy*.

Given where South Korea started in only 1960 it boasts an impressive knowledge scorecard.[54]

Collaboration, both domestically and internationally, is underdeveloped, but improving. From 1987 to 1997, Korea's Advanced Institute of Science and Technology (KAIST) produced the largest number of ICT-related papers, with Seoul National University close behind, mainly from individual authors. However, the share of joint university–public and university–company papers is increasing, amounting to 20 per cent of the total papers published.[55] Smaller firms seem to be more collaborative: cooperation with other firms, universities and research institutes rose from 16.3 per cent of technology developments by SMEs in 1991, to close to 60 per cent at the end of the century.[56]

The share of internationally co-authored papers has stayed constant at about 27–28 per cent over the last decade. Collaboration with countries other than the US is on the increase. According to National Science Foundation data from 1994 to 2003,[57] Korean collaboration with the US as measured by co-authored articles fell from 65 per cent in 1994 to 47 per cent in 2003 (see figure 6).

Figure 6 Korea science and engineering article co-authorships with the US



Source: Science and Engineering Indicators 2006, US National Science Foundation, www.nsf.gov/statistics/seind06/ (accessed 6 Dec 2006).

Yet the data also point to Korea's weakness. Overall levels of scientific publications and patents say little about their quality. Korean inputs – spend on R&D – do not automatically lead to productivity or technological outputs. As we will see in later chapters, the processes by which Korea transitions from a hierarchical and closed system to one that is domestically and internationally networked and open will involve challenging social norms. Korea may be measuring the wrong things.

The Korean system

Whether Korea can maintain its momentum, while also improving quality and extending international collaboration, will depend in large part on how its innovation system is steered by the state.

At first sight the Korean innovation system seems clearly organised. The Ministry of Science and Technology (MOST) focuses on improving fundamental research and the Ministry of Commerce, Industry and Energy (MOCIE), on applied research and industrial technology programmes. The reality is more complex. MOST, for example, funds national R&D programmes that have a strategic focus on fundamental technologies, core infrastructures and applied next-generation technologies. Moreover, 16 other ministries and countless agencies have a role in innovation policy.

One of the most frequent criticisms of the Korean system is not that it is planned but that on the contrary there is too little strategy and too much duplication between competing ministries and plans. In recognition of the risks of confusion MOST has been given an oversight role to make sure resources are used efficiently and agencies collaborate effectively.

The Ministry of Information and Communication (MIC) also plays a critical role. Its objectives include the development of advanced communication network technology, acquisition of indigenous computer technology, and development of communication devices and software technology. Former MIC minister Daeje

Chin went to Stanford, worked at Bell Laboratories, and was the CEO of Samsung before serving the longest of any MIC ministers, a total of three years. President Roh asked him to recreate the MIC as a growth engine for the new economy. Chin developed the U-Korea IT839 Strategy vision, which is credited with ensuring Korea has the most developed IT infrastructure in the world.

Korea is not short of long-term visions that underpin its commitment to science and technology. Alongside five-year economic and science and technology plans, separate foresight exercises set ambitious targets. These have been particularly influential in shaping the development of Korean science.

In the 1980s, for example, more than 800 experts contributed to the 'Long-range plan for science and technology development toward the year 2000'.[58] Three major foresight exercises were conducted after that, one in 1994 to inform the 'G-7' or HAN (Highly Advanced National) R&D projects, and another in 1999 when Korea embarked on an ambitious Vision 2025 strategy involving 200 experts to 'transform the national innovation system from the government-initiated, inward-looking and development-oriented system into a market-driven, diffusion-oriented, globally networked system'.[59] *Vision 2025: Korea's long-term plan for science and technological development* is a blueprint for how Korea should tackle

the paradigm shifts of the twenty-first century; a knowledge-based information society generating wealth from ideas, not materials; attainment of 'unlimited' and free competition between countries; and a new value system focused on personalisation, diversification and improving quality of life.[60]

From 2003 to 2004, the latest national foresight exercise to 2030 attempted to link science and technology to social needs and global challenges.[61] These long-term visions have been complemented by technology roadmaps to align government research programmes with likely market developments in the following ten years. In 2003, Korea designated ten technologies as drivers of economic growth until 2008. From the early 2000s, Korea began investing heavily in developing core technologies through the '21st Century Frontier R&D Programs'. These ten-year projects include IT and materials, but also environmental, bio and nano technologies.

These foresight exercises help to foster consensus about likely technological developments and mobilise public and private resources around key areas. As one senior official put it: 'S&T policy needs to be about selection and concentration. We can't cover everything.' Yet the impressive commitments in these long-term programmes have also attracted scepticism. In 2000, Moo-Young Han, editor-in-chief of the *Korean American Forum* and a professor of physics at Duke University, wrote a scathing critique of the G-7 projects and their new incarnation, the '21st Century Frontier R&D Programs': 'Different name, different policy-makers, the same money, the same old research culture, or the lack of it.'[62] His criticisms echoed familiar themes, namely that research is top-down with MOST at the helm, that duplication is rife and individual creativity stifled. Only recently have these foresight exercises started to engage the Korean public in debates about the direction S&T policy should take. But the government may have no choice but to take a more arms-length approach. In the case of biotechnology, for example, the government lacks the scientific expertise to know how to plan research.[63]

To understand where Korea may be headed on its headlong race from postwar poverty to knowledge economy, we need to look beyond the numbers. We turn first to people, the resource on which Korea is pinning its hopes for the future.

3 People
Skilling up a nation

Top five destination countries for tertiary level Korean students studying abroad in 2004 (total 95,885)

Source: *Global Education Digest 2006*

Professor Robert Laughlin sits in his office on the third floor of an unremarkable building surrounded by quiet administrative efficiency. A white-haired Nobel prize winning physicist, in 2004 he became President of Korea's Advanced Institute of Science and Technology (KAIST) – the first foreigner to occupy the position. His brief was to bring the university into the twenty-first century.

After Japanese occupation and the Korean war, South Korea's greatest resource was its hard-working and increasingly well-educated population. Now science is increasingly used to project national power and potency, and KAIST is at the heart of Korean ambitions.

Just weeks before we met in March 2006, the National Assembly had ratified Laughlin's $97-million 'globalisation package' to fund promising spin-offs, increase foreign faculty by 15 per cent, and require all classes to be taught in English by 2010.

Laughlin's plan provoked a mutiny. Furious professors refused to go along with the reforms. Laughlin's view was that he was caught between a government that wanted reform but had no idea how to pursue it, and a university establishment that would not budge. He describes the government's decision to bring him in as 'an act of desperation' that he says is being repeated across northeast Asia.

It is not the first time that universities have been at the heart of protest over Korea's development. In the 1970s and 1980s, universities provided the base for protest against the Korean dictator Chun Doo Hwan. Today professors in those same universities are protesting against government moves to make Korean universities adopt a more market-oriented, US model for teaching and research.

These debates over the future of Korean universities go to the heart of what kind of innovative society Korea might become. There is an almost unquestioning belief in Korea that science and technology are good for society. President Roh in his inaugural speech declared: 'I will help the rebirth of our country by promoting uninterrupted innovation in science and technology.'[64] But training a skilled labour force to work for rapid industrialisation, within a largely planned economy, is a very different challenge from educating people for innovation. Many in Korea seem unready for what innovation might entail.

More scientists will find themselves pulled in different directions by the unfolding tensions that marked both Dr Hwang and Professor Laughlin's careers. Hwan-suk Kim, who runs the Center for Democracy in Science and Technology (CDST), says that Hwang tapped into a potent mixture of insecurity and ambition in Korea: 'His style was very dangerous. Korea is still a very weak country and has a long way to go to become competitive, and he tapped into this insecurity.' As government pushes universities to deliver more tangible and commercially valuable research, many of their faculty, as Laughlin found, will try to head in the opposite direction.

Yet beneath these battles among the country's scientific elite, another set of possibilities is taking shape: the potential for Korea to spawn mass innovation from a highly educated population.

Training for industrial growth

Education has been central to Korea's rise. At the end of Japanese occupation in 1945, literacy levels were extremely low and only 800 Koreans had graduated from university.[65] Education institutions were moulded to the needs of export-oriented industry, and strong links between firms and vocational high schools enabled a skilled workforce to develop that was loyal to the company.[66] The system today remains highly competitive, and is based mainly on rote memorisation.[67]

Education investment increased from 2.5 per cent of GDP in 1951 to 17 per cent in 1966, and literacy rates began to rise.[68] By 2006, the share of 25–34-year-olds with at least an upper-secondary qualification surpassed 95 per cent, the highest of all OECD countries.[69] Education is a national obsession in Korea. It is common for children to be sent abroad to study English at the age of 10 or 11. Children also work late into the night doing homework and attend crammers to train them for highly competitive exams. Their score dictates what schools they can apply for. At the age of 15, Koreans lead the world in maths and sciences.

Three features of the system stand out. First, the continued reliance on rote learning even when promoting reforms. One high school student we met had just returned from living for five years in Canada with relatives, and was studying for entrance exams, in a rented room, until past midnight every day. She practised for a verbal exam in a way that sounded like rehearsing for a play: the greetings, manner of entering the room and responses are rehearsed by rote even by students who can speak English fluently.

Second, families are prepared to make huge sacrifices for the sake of education and learning English in particular. The preferred choice is still to send students abroad to learn rather than to bring faculty to Korea, although the number of foreign faculty in universities has grown slightly in recent years. Korea's overseas education and training deficit hovered around US$700 million in 2001 and continues to rise.[70] Overall, students are more mobile and, in global terms, the number of Korean students travelling for study is surpassed only by China and Japan. In 2004, 187,683 students went abroad, a 17.4 per cent increase from the year before. Though just over half of students go to the US to study, about 40,000 students study in China, which is seen as a second choice option. 'That's only if they can't get into university in Korea,' one professor told me. In 2004, just 4 per cent of Korean students studied in the UK in spite of the huge interest in English language.[71]

Third, education is a public–private undertaking. Public spending on education remains just below the OECD average, at 4.79 per cent of GDP. Yet private education spending is much higher than any other OECD country at 3.41 per cent.[72] Approximately 85 per cent of four-year universities are private (145 out of 171).[73]

The Korean secondary education system is widely admired for producing well-drilled children who top the league tables for maths and sciences at the age of 15. But that lead gets whittled away quickly, it seems, at the graduate level.

Table 3 Growth in higher education between 1970 and 2004

Year	Number of institutions	Enrolment
1970	142	201,436
1980	343	601,494
1990	270	1,691,681
2000	372	3,363,549
2004	411	3,555,115

Source: Education statistics, Korea Education Development Institute.

Universities have expanded dramatically since the 1980s (see table 3), and are slowly becoming less centrally regulated. The government says it sees its role as setting the framework for universities to develop with guidelines for the percentage of recruits or amount of research. Korea stands out from other countries, especially for those at its level of economic development, for sending high proportions of students into science and engineering: 39.9 per cent or three times as many as the US.[74] Universities with science-related degrees tend to be ranked the highest.[75] More than 80 per cent of Koreans go into higher education but there are significant doubts about its quality. University education tends to be highly departmentalised and rigid. Korea's universities rank low in global terms.

Students must go abroad to attend the best universities in the world, contributing to Korea's own 'brain drain'. Though KAIST and POSTECH ranked first and second according to *AsiaWeek*'s 'Asia's best universities 2000 report',[76] KAIST was 143rd in the world in 2005 (up from 160th in 2004) and POSTECH did not make the top 200.[77] Korea's top universities are all too aware of their low global rankings. Professor Han who heads international collaboration at POSTECH made a special trip to England to discuss the *Times Higher Education Supplement* methodology when the rankings came out in 2005. Professor Han argues that perceptions of Korea lag behind changes in technology: even 20 years ago, POSTECH was on an equal technological footing with the world.

Reforming education: from elite to mass to universal

In response to criticism of the rigidity of basic education and the low quality of higher education, a string of reforms have been launched. The Ministry of Education is promoting the goal of ubiquitous and personalised education, using technology to tailor learning to individual need. In 1999, the government launched the Brain Korea 21 (BK21) project to invest $1.2 billion over seven years to bring Korea towards a 'knowledge-based society' through boosting graduate education, developing an R&D workforce, increasing university–industry collaboration and improving creativity.[78] About 70 per cent of BK21 funding was earmarked for graduate students and postdoctorates, allowing them to concentrate on research. The aim was to 'leap' into the world's top ten in SCI-level publications after 2005. Through the New University for Regional Innovation (NURI) project, $1.4 million has been allocated over five years to 2008 to develop undergraduate education outside the Seoul metropolitan area. The second phase of the BK21 project from 2006 to 2013 will address the issue of quality of research and collaboration between university and industry, especially in rural areas.

Yet many commentators doubt whether the investment will lead to the changes in culture and thinking required. The former president of SNU, Professor Un-Chan Chung, thinks a new vision for Korean innovation is needed: 'The investment-based growth strategy has reached its limits, but a new strategy suited to this era, which we think should be an innovation-based strategy, has not yet fully taken hold.'[79] The goal of his reforms at Korea's most prestigious university was to 'teach students how to cope with the changing world'. In his view, a university should create ideas that could have potentially huge spill-overs, not simply transfer technology to industry. Professor Chung remarked:

The values of openness, disinterestedness, and cooperation will come to be seen as equally important as market principles and global standards… We don't know what the state of the university will be in three or five years. It's not stable.

Professor Laughlin is no longer president of KAIST. In July 2006, after trying to shake KAIST free from state dependence, his contract was not renewed.[80] The old adage 'politics is harder than physics' proved true. His story is also further proof that Korea will not be able to rely on star individuals or quick fixes for systemic problems.

Korea's work culture – characterised by discipline, hard work and determination – propelled the country's industrialisation. Yet the educational institutions that produced such a competent, driven and efficient industrial workforce may well be ill-equipped to create a workforce for an innovative society. Repeated efforts to reform the system – to introduce more personalisation and creativity into basic education; more individual initiative into higher education; better systems for research – have run into repeated opposition and obstacles. Korea wants to become an innovative society but its educational institutions and culture are still heavily slanted towards industrialisation. The tensions between the two will continue to generate conflicts of the kind that derailed Robert Laughlin for years to come.

4 Places
Hubs, Seoul and CyWorld

Tom Collins's enthusiasm cannot hide his exhaustion. Tom is one of 300 staff working at the offices of the Incheon Free Economic Zone (IFEZ) just outside Seoul, created to attract foreign high-tech investment to the self-styled knowledge hub of northeast Asia. Tom, an American, is the only non-Korean on the staff. It is his job, almost single-handedly, to make the zone attractive to foreign investors. After our whistle-stop tour he is due to meet an international education company considering setting up a school in the zone.

The Manhattan of northeast Asia
Incheon Free Economic Zone

Forty miles from Seoul, on the way to Incheon airport, past drab, brown high-rise apartment blocks, there are few signs of what is planned: at the zone's heart will be Songdo, a city with ubiquitous broadband infrastructure due to come to life in 2010. Incheon is self-consciously positioning itself as 'The Manhattan of northeast Asia', an open and cosmopolitan place, more connected to the global economy than to the rest of Korea. A 12.3km latter day Brooklyn Bridge will carry cars to the nearby international airport in just 15 minutes. An area of 209 square kilometres, much of it reclaimed from the sea, will support a population of half a million people, mainly employed in high-tech jobs.

IFEZ stands for the future Korea wants to project to the world: knowledge-based businesses in a cosmopolitan setting, with everyone connected through ubiquitous communications. How IFEZ develops, not just in terms of infrastructure, but also its culture, will determine what kinds of innovation it may produce. IFEZ will be a test bed for how traditional Korean recipes for economic development may combine or clash with its ambitions to become a hub for global innovation.

The US government played little direct role in the growth of Silicon Valley. By contrast, IFEZ is a deliberate creation of central government in part because local government in Korea is so weak. South Korea's dictatorship allowed for no local government. The first time that mayors were publicly elected was 1995. Perhaps it is no surprise that regional development is lagging.

The Ministry of Communications is investing $400 million in Songdo's ubiquitous wireless infrastructure to realise a vision of 'U-life', where everything someone needs, from their house key to their health details, will be on one smart card. The Ministry of Maritime Affairs and Fisheries is building the port infrastructure. Everywhere ministries are heavily involved in the details of what is being planned. The brochures say IFEZ will be cosmopolitan, a place where foreigners and Koreans can mix as equals. Yet there is real doubt about how many foreign companies it will attract. By early 2006 about 45 Korean companies had applied for space in a hundred-acre bio complex. Foreign investors have been harder to find. Tom and his team are scouring the world to attract star researchers with carefully targeted incentives. Yet still culture stands in the way.

'London is international and people feel comfortable there,' Tom explained. 'In the US, there is a sense that "our ethnicity is the world's ethnicity". By contrast, Korea, once dubbed the 'hermit kingdom', is 'very developed technologically, but also very provincial to international visitors'. It is not just culture that's a problem but money as well. Tom explained: 'Korea is a very cash-rich economy at the moment. They don't need the FDI, so how aggressive does the government really want to be in attracting it?'

Clusters

It is conventional wisdom that innovation emerges from tightly knit clusters that bring together sources of knowledge, universities and research centres, with entrepreneurs and venture capitalists. California's Silicon Valley is the prime example of a dynamic cluster which brings together these ingredients through high-velocity labour markets and high levels of immigration. However, Silicon Valley is just one cluster model. Other countries have developed different models. These have tended to be based on a university and its science park, the model that started the Cambridge phenomenon in the UK; deliberate government investment to create technopoles, the approach taken in France; clusters based around larger businesses, the model that emerged along Route 128 around Boston; or clusters based on a dominant city such as Helsinki in Finland. What kinds of clusters will Korea create?

Seoul

Seoul is the centre of gravity of economic, political and cultural activity – the main magnet for talent and research. Seoul Metropolitan Area comprises 11.8 per cent of the nation's territory but its population has increased from 20.8 per cent of the national total in 1960 to 47.9 per cent in 2004 and is forecast to reach 50 per cent by 2011.[81] About 70 per cent of students who ranked in the top 4 per cent in the Scholastic Aptitude Test for entrance to university were enrolled in universities in Seoul. Out of 327,740 admissions places in universities in Korea, 114,908 are in Seoul and nearby areas. Seoul is home to the Korea Institute of Science and Technology, the oldest and most outward-looking government research institute, and the most prestigious university, SNU. Crucially perhaps, Seoul is also home to the new wave of Korean entrepreneurs in digital media and culture. It is Korea at its most cosmopolitan.

Venture capital firms and the stars of the gaming industry congregate in the city's Kangnam district, just south of the river, which teems with young people visiting shops, restaurants and PC bangs, the internet cafés where they congregate to play 'massive multiplayer online role-playing games' (MMORPGs).

47.9%

The percentage of Koreans living in and around Seoul in 2004.

Seoul will remain the main magnet for talent and the main source of innovation in Korea. Seoul's dominance, however, has prompted a string of attempts to create alternative centres for growth and innovation. Since 1995, MOST has created two or three regional research centres in each provincial area to encourage cooperation between universities and small businesses. Science and engineering research centres located in universities are meant to connect research interests to local businesses. The Industrial Research Cluster Support Program, launched in 2002, encourages SMEs to work closely together to find synergies and cooperate in the development of new technologies. The government also supports nine industrial research clusters.

Daedeok science town

By far the most impressive initiative is the Daedeok 'Innopolis'.[82] Daedeok Valley is an integrated industrial belt, which includes a clutch of towns such as Daejeon, and industrial parks in Chungbuk-do Jeollabuk-do. At its heart is Daedeok Innopolis, a mass of publicly funded research complexes covering 6849.5 acres close to Daejeon, more than four times the size of IFEZ.

Built in 1973, Daedeok Innipolis has 56 research institutes, more than 6000 PhD researchers and accounts for 10 per cent of the aggregate research power in Korea. KAIST was relocated to Daedeok in 1989, and Daejeon is also home to the National Central Science Museum, Chungnam University and the newly reopened Expo Science Park.

Daedeok's concentration of scientists and researchers seems very impressive. Yet in other respects the idea of innovation emerging from a state-planned science city cut off from the rest of the economy seems old fashioned. The number of spin-off ventures created in Daedeok grew from 40 in 1995 to 2000 in 2005, with 45 per cent of those in the IT sector and 15 per cent in biotech.[83] But it is far from clear that Daedeok will become a Silicon Valley style centre for innovation or even match the Hsinchu Park in Taiwan that has spawned thousands of semi-conductor companies, many of them now very large.

Several other places, each deploying a different approach to cluster development, could play a role in future Korean innovation.

Pohang

Pohang, located in Gyeongsanbuk province on Korea's east coast, is not a first choice tourist destination, perhaps because it is home to the Pohang Iron and Steel Company (POSCO), founded in 1968 and now the world's second-largest steel producer, producing 28 million tons of steel products each year.

POSCO helped to found POSTECH, Asia's number two science and technology university,[84] which in 1994 received an endowment from POSCO ensuring its future. The alliance between the steel company and the university could yet produce significant innovation.

A case in point is PAL, Pohang Accelerator Laboratory, a national user facility which houses an electron linear accelerator and synchrotron radiation light source.

In Soo Ko, director of the physics department at PAL, explains it got off the ground only by trading with Chinese and Japanese to get the technology required. 'We learned a lot from the Chinese,' he said. Local researchers and companies use the lab. Ko proudly relates that the experiment behind the first *Nature* cover story on Korean research was done at PAL: work in 2003 on Viagra and Alzheimer's by Crystal Genomics and KAIST. Next door, completed in 2006, is one of Korea's five nanotechnology support facilities, the National Center for Nanomaterials Technology (NCNT). The combination of the accelerator and the latest nanotechnology instruments aims to keep them at the cutting edge of materials research.

POSCO is looking for new growth areas, and POSTECH, while maintaining its physics and chemistry strengths, is moving into biotechnology. POSTECH Biotech Center was established in 2000, funded partly by POSCO (40 per cent) and by pharmaceutical companies (60 per cent). Major R&D areas include molecular medicine, biochips and biochemical engineering, plant systems biology, DNA and adenovirus-based preventative vaccines and diabetes treatment research.

Busan

Further south down the coast, Busan, in neighbouring Gyeongsangnam province, is the second-largest city in the country and one of the world's top three ports.

The Busan port, which first opened in 1876, is now being expanded to include 30 new shipping berths by 2011. This will also allow the current port to be redeveloped by 2015 into a multipurpose logistics and commerce centre, incorporating an exhibition and cultural centre, leisure park and international passenger terminal. Busan-Jinhae Free Economic Zone will compete with IFEZ for foreign investment in high-tech manufacturing.

Gwangju

Gwangju Technopark in Gwangju, Korea's sixth largest city, is a prime example of attempts to create a stronger regional innovation system. Founded in 1998, it is one of 13 regional technoparks. Founder James Moon acknowledges that policies 'legislated and implemented from the top are no longer relevant in the era of globalisation' and have 'deepened regional tensions and endangered national cohesion'.[85] Gwangju Technopark houses 18 venture companies and specialises particularly in optical communications, photonics and LED/LD technologies. It is actively seeking to increase its international links.

Regional innovation

Regional innovation committees, to bring together universities, government and business, operate in 116 cities and counties. In addition, at least three complexes run by private companies are home to some of Korea's best R&D. One of these is a semi-conductor cluster in Suwon, a key stop on the railway from Seoul to Busan and home to large parts of Samsung Electronics. An LCD cluster in Paju and the new materials cluster in Pohang are also privately owned.

Wireless clusters and ubiquitous innovation

Cutting across all these attempts to create geographic clusters, however, is Korea's heavy investment in broadband infrastructure, which may prove to be the distinctive ingredient in the Korean approach to innovation. Ubiquitous innovation is central to the branding of Songdo in IFEZ. 'There are really no comparable comprehensive frameworks for ubiquitous computing,' said Anthony Townsend, a research director at the Institute for the Future in Palo Alto, California, and a former Fulbright scholar in Seoul. 'U-city is a uniquely Korean idea.'[86] If all goes well, Songdo's ubiquitous wireless infrastructure should be a world first, piloting new technologies, lifestyles and services.

> Korea can't follow the US football field model; we are in a bowling lane and must aim carefully to avoid the gutters.
> Wonki Min

We will find out in Korea whether broadband networks can provide new non-physical spaces for innovation. By 2008, everywhere in Korea will have mobile access to the internet, even while travelling at speeds of up to 120km/hour thanks to the WiBro service being rolled out by South Korean internet service provider KT and mobile phone operator SK Telecom.

This could also reinvigorate innovation in rural areas. The Information Network Village project run by the Ministry of Government Administration and Home Affairs has invested more than $105 million since 2001 to bring broadband connectivity to 305 villages. Mexico plans to implement its own version soon. Delegations from 65 countries have visited Korea to investigate what is seen as a successful example of bridging the digital divide.

Innovation hub of northeast Asia?

Korea itself wants to become a hub for innovation, closely connected to the Chinese economy. As chairman of the Presidential Committee on Balanced National Development Kyoung-ryung Sung says:

The Korean government is attempting to fundamentally change the national development paradigm so that it can increase national wealth and competitiveness through an open-door policy and innovation-driven developments based on knowledge and technology.[87]

Wonki Min, director of policy coordination at MIC, is both optimistic and honest about Korea's situation: 'Korea is currently in the awkward position of technologically following the EU and Japan, while India and China are just behind us.' Korea still needs a careful strategy, he explained: 'Korea can't follow the US football field model; we are in a bowling lane and must aim carefully to avoid the gutters.'

The vision he sets out is a northeast Asian regional development model involving multinational cooperation:

We have to compete and *collaborate and find win–win solutions. Korea wants to move towards more future-oriented industry. We can no longer rely on cheap labour. Costs here are higher than the Netherlands or Italy.*

However places such as IFEZ and Daejeon will face growing competition from coastal cities in China that are busy creating their own innovation centres. Regional innovation in Korea is relatively weak and venture capital is underdeveloped. Korea's clusters, focused on R&D, often seem cut off from businesses that could exploit their know-how. Korea's clusters seem still to be mainly for Koreans rather than being designed for cosmopolitan innovators. As Wonki Min acknowledged:

We have Russian scientists and we're trying to attract Indians but they don't want to stay here. Chinese people can get huge salaries in China. Support for foreigners here is non-existent. We don't have the edge for attracting foreigners, and we don't want to overpay just to attract them.

A glimpse of the future?

The most potent land in Korea is an uninhabited strip, 155 miles long and 2.5 miles wide, 50 miles north of Seoul. Welcome to the Demilitarized Zone (DMZ), an artefact of the Cold War, which divides North and South Korea. Even in the DMZ there are glimmers of change. The long-abandoned land in the DMZ is home to farmers who grow organic ginseng. A railway station has been built that will open the way for travel between north and south. Tourists are even able to have their passports marked with a dove-decorated DMZ stamp.

The DMZ also nestles alongside some of the most exciting Korean architecture of the last few years. Paju Book City, the centre of Seoul's publishing industry, was a town in crisis in the 1980s. Nearby Heyri was within earshot of the North's propaganda broadcasts. By 2010, more than 400 buildings will have been built in the two towns. The area is attracting the attention of architects and designers worldwide. Ki-Ung Li, the chairman of Paju Book City, says 'the idea was to have a museum-city, a collection of architecture that acts like a living museum'.[88] Paju Book City is an award-wining international experiment in modern living, situated cheek by jowl with a throwback to the Cold War. It is just possible that as Korea develops, both North and South, something surprising and even more creative could emerge from this mix.

5 Business
Venturing beyond the chaebol

Chris Ko is one of many people involved in innovation in Korea who seem caught between the country's past and its ambitions for its future. A senior vice president of the Biolab at Samsung Advanced Institute of Technology (SAIT), Ko was educated in the US, founded and then sold a start-up firm, and in 2000 moved to Korea to work for Samsung.

Korean companies are struggling to attract foreign managers. The next best thing is to bring in a Korean educated abroad. Chris wants to remain open-minded but confides it is not easy to live in Korea as an outsider: 'Samsung is a global company but Korea is not a global nation. Samsung tries to be win–win, but by global standards, we are behind.'

SAIT, the central R&D unit of Samsung Electronics Business Groups, the most profitable arm of Samsung's businesses, is central to the company's hopes to transform itself into a genuinely global force for innovation.

The 1000 researchers at SAIT, which has an annual budget of $300 million, spend 80 per cent of their time on existing business – such as LCDs and semi-conductors – and 20 per cent on disruptive 'next generation' technologies such as biochips and fuel cells. The centre abounds with the trappings of US-style innovation. One meeting room has been renamed 'the dream room'. The BIOCHIP lab announces that those inside should be 'Brave, Innovative, Open-minded, Creative… Pioneers'.

Samsung Electronics spent $5.44 billion on R&D in 2005, up from $1.88 billion four years ago.[89] Samsung's labs employ more PhDs than government research institutes. Ko explained:

Given we have zero natural resources, Korea can't mimic other innovation models. We need to be a knowledge economy. The role of government should be to provide high-risk infrastructure, good seed technology and job creation. The real innovation happens in the companies. Government should invent and business should re-invent to make it marketable.

He believes the time has come to break decisively with Korea's protectionist, techno-nationalist past to foster a more transparent, outward-looking business culture: 'Has our growth relied on innovation? No, it's relied on personal sacrifice. Lack of openness and transparency is productivity lost.'

People like Chris Ko, working at companies like Samsung, are at the leading edge of change in Korea, promoting a more cosmopolitan business culture open to innovation. SAIT is looking for people who have spent at least 10 per cent of their career abroad and display a personal commitment to innovation.

Even Samsung Electronics, however, cannot entirely escape the tensions of a system that claims to promote free thinking but measures innovation ruthlessly.

The experience of YoungHyun Kim, a researcher in the Telecommunications R&D centre, another of Samsung's 17 research global research centres, exemplifies these tensions. After getting a masters' degree in 2001, YoungHyun Kim went into the optical engineering business of Samsung Electronics and now works in the Fab Lab. Signing on to work at Samsung was not as desirable as going abroad, but allowed him to opt out of military service and stay near his ageing father. YoungHyun Kim spends his days with 1000 other researchers – physicists, electrical engineers and a handful of chemists – delivering research to tight deadlines. Researchers are expected to write one or two patents a year.

Each patent wins a bonus. At times it is almost like working in an innovation factory. YoungHyun Kim's experience shows that even the most global of Korea's chaebol, which prides itself on being open to free thinkers, alert to fluid trends in fast-moving consumer markets, also relies on the ethic of hard work and self-sacrifice that propelled Korea's postwar development. Korea's goals may have changed but many of its managerial recipes remain untouched.

Business expenditure accounts for three-quarters of Korean R&D. So whether Korean businesses can manage home-grown innovation, as opposed to adapting technology developed in the West, will be critical to realising the country's hopes of becoming an innovative nation. And at the heart of that issue is the future of Korea's large companies: its chaebol.

Old habits die hard

The conglomerates or *chaebol* – large, family-owned industrial groupings such as Hyundai, LG, Daewoo and Samsung – laid the foundation for South Korea's development in the 1960s and 1970s by working hand in glove with the government to promote rapid, export-led growth. The government fostered fierce competition between chaebol, and though the overall number of chaebol-affiliated companies grew to 677 in 1994 from 77 in 1974, only a few of the originals survive. Most evolved from small businesses – LG started as a small face cream producer – and grew through rapid learning under effective management in spite of the political turmoil. 'Chaebol have been and will be the dominant factor in Korea's industrialization and globalization.'[90]

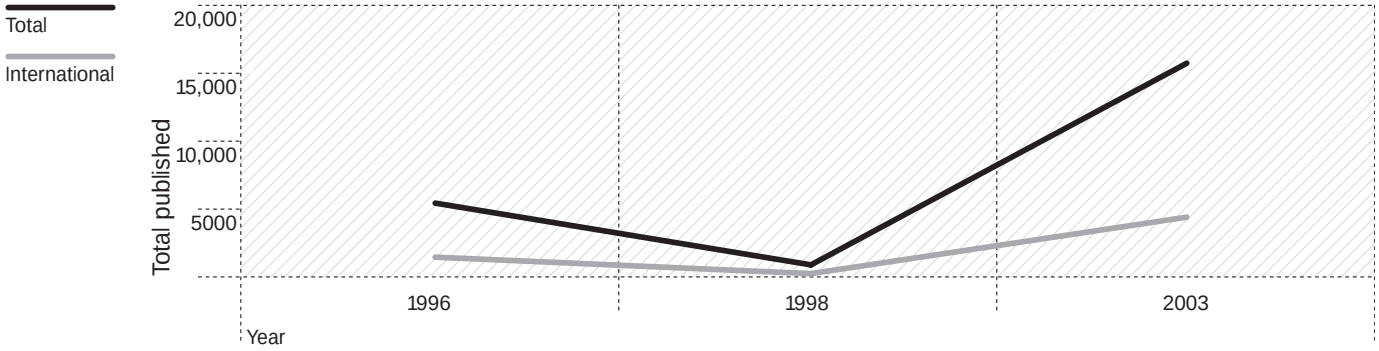
In the early days the chaebol did little R&D. Instead they mainly licensed or copied western technologies to create low-cost products for export. In the late 1970s, following the Technology Development Promotion Act 1972, 'like clockwork, the biggest chaebol all opened R&D laboratories and then smaller enterprises followed suit', says Alice Amsden in *Asia's Next Giant*, her account of Korea's rise.[91] As the chaebol caught up with Japan, technologies like D-RAM and CDMA were developed domestically in the 1980s and 1990s.

The Asian currency crisis of 1997 brought all that to an end. The Korean economy plunged into recession, and society into a state of shock. The current account deficit grew to 3 per cent of GDP, export growth which had been over 30 per cent decreased to 15 per cent, compounded by a slump in world prices for Korea's staple exports – chips, ships and automobiles. Many of Korea's largest companies, once thought too big to fail, were brought to their knees as the stock market plummeted. In exchange for International Monetary Fund (IMF) support to shore up its finances, South Korea was forced to engage in what was seen as fundamental financial and corporate restructuring.

The traditionally family-owned chaebol had to reduce or relinquish family holdings and allow foreign investment, management by boards of trustees and more transparent accounting. Those that survived did so while increasing their investment in innovation. The number of science and engineering papers authored by Korean companies dropped before and during the economic crisis. But both the number of papers and the proportion internationally co-authored rose dramatically afterwards (see figure 7).

Wan-Joo Kim, founder of C-TRI, a small pharmaceutical company, and one of the first researchers who returned from the US to work at the Korea Institute of Science and Technology, described the change: 'Before 1997, we were only imitating. Now it is totally different.'

Figure 7 Korean science and engineering articles



Source: *Science and Engineering Indicators 2006*, US National Science Foundation.

Large Korean companies now routinely invest large sums in R&D, dwarfing spending by their peers in Europe. In 2003, the top ten companies in Korea invested just over 4 per cent of their sales revenue in R&D. The top 20 companies invested slightly less, 3.6 per cent, and the company average of those surveyed by MOST was 2.28 per cent. In the UK, the top companies spend 1.8 per cent of sales on R&D.[92] A third of researchers in Korea's top five companies (Samsung Electronics, LG Electronics, Hyundai Motor Company, POSCO, LG Chemical) have PhDs, rising to 41 per cent in the top ten companies, and 48.4 per cent in the top 20.[93]

Yet the 1997 shock therapy may now be wearing off. There are some signs of old reflexes reappearing. The export-oriented model keeps the Korean economy going: in 2005, exports as percentage of real GDP reached 54.3 per cent.[94] Management scandals continue to be exposed, most recently involving the chairman of Hyundai Motor Company.[95] Small businesses with products or services that cannot compete with the chaebol tend not to survive unless they are aligned with one of the major companies. Lifetime employment is still desirable; takeovers are rare. While government is investing more in small business support, national technology programmes mainly serve the interests of existing businesses. Fear of losing ground to emerging Asian competition puts a premium on supporting Korean champions rather opening them to challenge from domestic competitors.

Samsung, the global chaebol, may be a symbol of what Korean companies could become. Or it could be an exception to the rule.

Outside influence

Unlike China, which has seen a massive inflow of FDI in the last decade, foreign companies were never a significant force in Korea's highly managed economy. Again, since 1997 there have been apparently significant changes. Since joining the OECD in 1996, Korea's restrictive regulations on foreign investment have been reformed. The Foreign Investment Promotion Act of 1998, revised in 1999, opened new sectors to FDI. Overall FDI stocks as a percentage of GDP rose from 2 per cent to 9 per cent between 1998 and 2004, and net inflows reached $8 billion in 2004.[96] FDI rose 103 per cent between 2003 and 2005, pushing Korea's ranking as a destination for FDI up 11 places to 16th in the world.[97]

Foreign companies are being offered attractive incentives to locate in Korea. The 'Act on Designation and Management of Free Economic Zones' 2001 lightens the regulatory environment for foreign companies operating in free economic zones, allowing lower tax rates and looser restrictions on labour. Investors who put more than US$10 million into a high-tech industry or more than US$5 million into R&D facilities can apply for a cash grant.[98] There are tax incentives of up to 100 per cent for a maximum of seven years for international companies planning to invest within Korea. MOST is creating an organisation within the Korea Industrial Technology Association to encourage inward foreign investment in R&D.

Yet these incentives may do little to assuage concerns that many Koreans remain hostile to foreign businesses doing well in Korea. Guy de Jonquieres, Asia business commentator for the *Financial Times*, laments the financial uncertainty facing foreign investors:

Since 2001, the reform drive has ground to a halt. Some observers say it has gone into reverse, enabling Korea's chaebol conglomerates to reassert their stranglehold, stitching up domestic markets and stifling the emergence of new businesses… [and]… Parliament is weak.[99]

Korean youth culture has become cool: the 'hallryu' or 'Korean wave' of soap operas and kimchee has now reached as far afield as California and Mexico. Yet despite growing foreign interest in their country, most Koreans remain cautious:

Koreans are having second thoughts about what many, tellingly, call the 'IMF crisis'. Far from being welcomed for helping to rehabilitate its shattered economy, foreign investors are being demonised by the local press.[100]

A recent Pew Institute survey on global attitudes found that five out of six South Koreans think that Korea should be protected from foreign influence. This inevitably concerns foreign investors 'who wonder if such views are indicative of the type of reception they are likely to receive from government officials, their employees, their suppliers and their customers'.[101]

The small wave

Yet ten years after the 1997 crisis, a few cracks in the chaebol's dominance of the economy are creating space for spin-offs and start-ups to grow. SMEs accounted for 87 per cent of employment in Korea in 2004, 42 per cent of exports and 51 per cent of domestic manufacturing. Between 1997 and 2004, they created 2.16 million jobs. Employment in large companies, by contrast, has declined by 1.22 million in that time.[102] Government support for small business is increasing. In 1996, the central government established the Small and Medium Business Administration (SMBA) which runs its own support initiatives and coordinates those of other ministries. In January 2006, the Ministry of Commerce, Industry and Energy (MOCIE) announced a plan to increase the number of 'leading' SMEs from 10,000 to 30,000 by providing new loans and business guarantees.[103] Under the scheme the Korea Development Bank will increase the amount of funds that can be borrowed by leading SMEs to $2.53 billion.[104]

Biotech

A small but significant share of these new small businesses are in knowledge-intensive areas. There are more than 600 biotech start-ups in Korea, many accredited by the Korean Biotech Venture Association (KOBIOVEN), which helps build networks and capacity.

A prime example is Histostem founded in 2000 by Dr Han Hoon, an immunologist originally working at the Catholic University Medical School. After finding that a patient's liver expressed new DNA following a bone marrow transplant, he suspected that stem cells must be present in bone marrow and also, therefore, in cord blood. He tested this with the approval of the Korean Food and Drug Administration in human patients with some success, though he has been criticised for bringing his discoveries into clinical practice too fast.

Conducting long-term research in highly uncertain areas is plagued with risk, as Dr Han's business partner YS Kye explained:

We have a problem which Hwang exemplifies: government trusted him and it was politically convenient to invest heavily in his work, but there are not enough checks and balances in the system. Regulation must be developed alongside treatments in these new fields.

Dr Han is cautious about the prospects for Korean biotech, which cannot match the funds and skills of multinational pharmaceutical companies. But he believes that medicine inspired by eastern philosophies of prevention will create new opportunities for Korean companies: 'We are in an era where the concept of medicine and treatment is changing to something other than the western drug approach. Cell therapy is a totally new field.' Korean biotech may succeed – and fail – in the riskier, emerging areas where young researchers are not afraid to experiment. These are exactly the areas where ethical issues are likely to arise.

International collaboration will also be vital to Korean biotech. Doo-Hong Park of Mogam Research Institute, a research spin-off of Green Cross, a Korean pharmaceutical company, explained:

Fundamental research is increasing rapidly, but what we lack is experience and capability to translate novel findings into products. This will not happen without international collaboration… We need global partners to help us build this capacity.

Wong argues that SMEs are critical to the emergence of new scientific sectors and more creative 'home-grown' technologies.[105] But this view does not go unchallenged. Sungchul Chung, president of the Science and Technology Policy Institute, which evaluates S&T policies for government, agrees the impact of government is declining but he questions whether this extends to biotech. 'Biotech companies haven't been able to create new industries yet, not in Korea or anywhere in the world. Research still relies on government not private funds.' *Nature Biotechnology* reported in March 2006 that only 200 of the 600 biotech companies created in the 1999–2001 boom are still active, due to a lag in venture funding. But that could be good for competition in the long run. 'That even 200 companies exist is testament to the bold financial commitment of the South Korean government to the life sciences.'[106]

Environmental services

Environmental technology is another booming field. For example, Total E&S, an environmental services company, is a Korean company considering setting up in London, with the help of UK Trade and Investment (UKTI) and Think London. The company started 20 years ago turning landfill gas into electricity and selling it to POSCO and Samsung. The company's president, Hyo-Soon Song, started the company with money his wife lent him. Now he employs 100 people, almost all engineers and chemical engineers:

The environmental business has completely changed from 20 years ago. In the past, it was about making a product. Now, we have to make a product but we must also invest in the future, in preparation for emissions trading.

Between 2004 and 2010, the annual growth rate in Korea's environmental technologies sector is expected to be 14.2 per cent, with the total market exceeding $36 billion by 2010. Several government research institutes, such as the Korea Institute of Energy Research, are supporting clean technologies.

The ubiquitous entrepreneurs

Jimmy Kim was happy to meet us in a Seoul hotel even on a national holiday. Kim is a serial entrepreneur, indebted to the tight network of students and alumni of KAIST, where he went to university after growing up in the US. KAIST bred a lot of Korea's most promising ICT start-ups in the 1990s.

Nexon, the most successful of the KAIST spin-offs, grew from 20 employees to 1000 in just a few years. NCSoft, creator of Lineage, which develops MMORPGs, has a Brighton office with more than 100 employees. Both companies are actively engaged in joint ventures or overseas subsidiaries in China, Japan, the US and the UK. The Korean games market is growing at 10 per cent a year.[107] NHN, the internet company that operates Naver.com, the search engine of choice in South Korea, has kept Google's market share to a mere 2 per cent,[108] partly by pioneering specialised searches linked to games. A day after Kim Jong Il's nuclear test in October 2006, Google announced it was investing US$10 million in an R&D centre in Korea, a recognition that even the world's coolest internet company had something to learn.

Jimmy Kim's software business Innotive is based in Mok-Dong, an area of Seoul known for digital and broadcasting businesses. The building houses floor after floor of software start-ups. In the open-plan office, about 20 designers and programmers are hard at work.

Innotive is developing what Kim describes as the next generation of presentation software, based on technology spun out of the Korean military. He believes it will blow away Microsoft PowerPoint, and is looking to the US for investment from venture capitalists. Innotive is legally a US company: all the R&D is done in Korea but the IP is held in the US. Kim is well connected. His father is president of a Korean university. His KAIST classmates are fellow entrepreneurs. Yet he's exploring a software niche that the more risk-averse chaebol have ignored. People like Jimmy Kim may yet lead a new wave of Korean entrepreneurship based on ubiquitous communications and innovation.

But small, high-growth businesses still face significant difficulties. Being an entrepreneur is a high-risk activity; a solid job with a well-known company is far safer. Though venture firms have increased from 2000 in 1998 to just under 9000 at the end of 2004,[109] business networks are still mainly built through family, university and business associations. It is difficult to escape the reach of the chaebol if you need access to markets or technology. Without such connections, young companies have a difficult time staying afloat.

It is difficult to gauge how far the culture and management of innovation is changing. As Chiasung Lim of Konkuk University observes: 'The Korean innovation system can be summarized in six words: "strong large firms, weak small firms".'[110] Korea's rhetoric and ambitions have changed but old habits linger.

6 Culture
The shy comedian

‘A Japanese journalist recently wrote an article about hallryu. Why is the rest of Asia looking at Korea? Because it’s different from the others – it democratised in the 1980s and there is a lot of variety now. Not just in culture, but in thinking.’

Chong-Su Kim, secretary general of the Council for the Korean Pact on Anti-Corruption and Transparency

Jong Bhak, director of the Korean Bioinformation Center, is a member of Korea's pivotal 'generation 386', named after the Intel 386 processor. He is in his late 30s, went to university in the 1980s, and was born in the 1960s. Bhak grew up in Pusan, and watched his town change dramatically every year as trees gave way to roads, and imported cars to Korean-made cars. The biggest ship ever made was built in Pusan, but Bhak's generation grew up aspiring to be programmers not shipbuilders: as a child he played video games and started programming computers. Seeing such dramatic change around you makes you wonder what is possible, he says. The experiences he had as a child are now being had by ten-year-olds across China. Bhak is one of many who believes Korea's future will be tied to that of China, and a shared Asian model of innovation that the West will eventually have to follow:

Korea doesn't have to work with big pharma in the US or Europe; it can go straight to China where the view of health is totally different. We'll have our own system. The West will follow China as well and there will be huge effects.

If a distinctively Asian model of innovation emerges in the next decade then Korea should – in theory – be at its cutting edge. However, Korea's experience shows that a distinctive approach to innovation will develop only through competition and conflict, as new ways of thinking and working challenge the old order. The Korean political establishment is committed to innovation as a source of the country's economic growth in future. Yet the culture of hard work, deference and consensus that enabled Korea to prosper in the 1960s and 1970s may be, in part at least, an obstacle to innovation in the decades to come. Those seeking to change and so challenge Korean culture and habits – like Robert Laughlin – may find themselves at odds with much of society.

The Korean spirit

The list of sociocultural factors often cited as crucial to Korea's economic success paints a fairly grim picture of life there. Frequent invasions gave Koreans a tenacity and a 'beat Japan' spirit that remains long after the deprivations of Japanese rule and the Korean War. The 'han' (resentment or grudge) psyche is said to arise from constant feelings of repression in a Confucian society where the individual must defer to father figures or the state. Children are conditioned mentally through long hours of rote learning in the classroom and rigorous testing. People work extremely long hours: in 2002, the average Korean worked 2477 hours, compared with 1821 in the US.[111] The five-day working week became standard only in 2004. Dr Hwang became a national hero partly because he was said to work in his lab until the early hours of the morning. Everyone talks of a 'pali-pali' culture which encourages people to show they are hurrying to complete tasks. It is commonplace to see people jogging to show they are getting into work as fast as possible. The impact on everyday life was conveyed by a 2006 show at one of Korea's leading modern art galleries: a collection of sculpted heads covered in watches. Time is precious; everything must be done fast; every action measured.

That culture propelled rapid industrialisation, in which the task was to produce more, faster, to higher levels of quality. It may be less conducive to aspects of innovation when the task is to explore, question and create. The biggest challenge facing proponents of innovation in Korea is not to provide the hardware of innovation but the cultural software. Many would-be reformers and modernisers in business, universities and government, often people who have spent time working abroad, find themselves caught in the middle of this cultural civil war.

In a cultural no-mans land

Chris Ko at SAIT described it this way: 'Culturally, Koreans are introverted and fear outsiders, but we are forced to be extroverts to make a living. We're like shy comedians who have to get up and perform.' Scientists like Dr Jong Sung Koh, vice president of Drug Discovery at LG Life Sciences, who worked for seven years in California, says he deliberately attempts to mix up the otherwise hierarchical and departmentalised culture in his lab.

> Koreans are forced to be extroverts to make a living. We're like shy comedians who have to get up and perform.
> Chris Ko

Others have found the task of adapting to Korean expectations more troubling. We met Dr Hyang-Sook Yoo when she was directing one of MOST's '21st Century Frontier R&D Programs', looking for genes that are active in stomach and liver cancers common in Asia. She told us her first allegiance was to the scientific process, sparked by reading the *Worm Breeder's Gazette* in the 1950s, the journal that helped found the world's community of molecular biologists. She tried to spend 40 per cent of her time on basic science, unrelated to potential commercial spin-offs. Yoo was no superstar in the mould of Dr Hwang: she coordinated the efforts of 25 principal investigators, each with about 20 researchers. Half way through her grant programme, however, she was under intense pressure to show progress, measured in patents, published papers and potential commercial applications. In May 2006, after an unsatisfactory evaluation from MOST, she was removed from the project, though she remains at the Korea Research Institute for Biotechnology and Bioscience (KRIBB), heading up a collaboration with the Fred Hutchinson Center in the US. Dr Yoo's 11 years as a researcher in the US taught her that good science takes patience, it cannot be rushed. Her Korean funders come from a system that expects measurable results, fast.

Indeed part of the challenge pro-innovation reformers face is that the very understanding of what innovation means is highly culturally specific. Globalisation and democracy will have a powerful influence on the kind of innovation culture that develops in Korea, but both have very specific connotations in Korea.

Open Korea?

The government talks of Korea opening up to global collaboration, but the traditional word for globalisation, *segehwa*, refers to 'reaching another export target, being the best, the biggest and the first in a particular industry or field'.[112] The defensive reaction to a foreigner like Robert Laughlin is not confined to the university sphere. Laughlin found the culture 'nationalistic and ethnocentric'. Rules are rarely written down, he says, so it is often difficult to work out why decisions are taken, especially in a culture of deference towards elders. This lack of transparency, Laughlin concluded, meant that 'by western standards, Korea is a lawless country. Rules are often not written down on purpose.'

More optimistic commentators see some signs that Korean culture could adapt to the demands of internationalisation. Tariq Hussein, author of *The Diamond's Dilemma*,[113] argues that the raw diamond of Korea's potential needs to be cut to polished form. He says of Korea's World Cup team coaches: 'Guus Hiddink (and to a lesser extend Dick Advocaat) were so successful because they balanced the Korean team's collective energy with individual talent.'[114] More young Koreans are going abroad to study and the hallryu wave of Korean popular culture may well stir more international interest in the country. Hussein says Korea is 'dynamic at the edges but not at the centre'.

Chong-Su Kim, secretary general of the Council for the Korean Pact on Anti-Corruption and Transparency (K-PACT), a coalition of government, business and non-government organisations (NGOs) fighting corruption, cites another reason why Korea might be different from other Asian tigers:

A Japanese journalist recently wrote an article about hallryu. Why is the rest of Asia looking at Korea? Because it's different from the others – it democratised in the 1980s and there is a lot of variety now. Not just in culture, but in thinking.

Everyday democracy in Korea

'Koreans came out of a populist movement against a dictator quite recently. You find that people are deeply confused by what democracy is,' a battle-weary Robert Laughlin told us, shortly before leaving for the US. Democracy came to Korea only after years of techno-nationalist development led by the dictator Park Chung Hee, whose goal was to strengthen a country weakened by war, repeated invasion and occupation. Military rule ended on 29 June 1987 when then general Roh Tae Woo gave in to demands for presidential elections and fewer restrictions on human rights. In 1997, Roh Tae Woo, along with another former dictator, was imprisoned, a move seen as consolidating democracy.

Yet the nature of Korean democracy and its role in promoting a more open, innovative culture is deeply disputed. Doh C Shin argues that Korean democracy is an evolutionary, communal project to reduce poverty and alleviate suffering. Shin suggests that 'liberalism and pluralism were grafted onto authoritarian Confucianism and parochial regionalism'[115] leaving a system of highly ordered capitalism. The political system's ultimate goal is to promote well-being, rather than ensure democratic rights.

> Liberalism and pluralism were grafted onto authoritarian Confucianism and parochial regionalism.
> Doh C Shin

Shin's study shows that Koreans tend to value democracy for the kind of economic outcomes it delivers. In Britain, polls suggest that 54 per cent of people regard values such as justice and political freedom as the 'most important' features of society, while just 33 per cent favour economic prosperity and security. In Korea, the percentages are almost reversed, with 64 per cent favouring economic prosperity and 36 per cent political freedom.[116] Shin concludes that most Koreans want a highly managed democracy, based on competent leadership by a minority, rather than a culture of mass political participation. Shin's argument points to the dilemmas Korean leaders will face in the future. Innovation will require a more open, questioning culture, but that may be at odds with most people's desire for orderly, predictable growth.

The emergence, or not, of a more open and transparent democratic culture will have a direct bearing on the funding and governance of science. The Hwang scandal exposed the lack of transparency in science funding: laws were changed to give Hwang extraordinary financial backing. Only now is the government considering reforms, for example, to strengthen the role of review boards of research ethics. As Chong-su Kim, secretary general for K-PACT, remarked: 'The culture has medieval roots. Doctor = father, patient = son. Review boards were weak or not functioning before Hwang.'

New movements

The most important democratic developments, however, may well come from outside government in the growth of NGOs and pressure groups. Contrary to the image of Korea as a passively deferential society, protest is common. A recent study found that one in five Koreans had participated in a protest. Out of that tradition of protest against dictatorship, new social movements are emerging that could have a direct bearing on science and innovation.

In March 2006, Won Soon Park, a leading light of student protests against the dictatorship in the 1970s, launched the Hope Institute, a social innovation think tank. We met Dr Park and his young researchers in Insa-dong, the artistic area of Seoul where the trendy and traditional meet.

After years as a human rights lawyer Dr Park became secretary general of the People's Solidarity for Participatory Democracy (PSPD) in 1995, an NGO that continues to push for accountability and transparency in government and business. In 2002, he founded The Beautiful Foundation and The Beautiful Store, inspired by Oxfam, which today has more than 60 stores in Korea. PSPD also helped provide a home for Hwan-suk Kim and his Center for Democracy in Science and Technology (CDST), which was formed in 1997 to promote citizen participation in science policy-making. Though small, CDST played a prominent role as a critic of Hwang.

The ubiquitous innovation generation

Ubiquitous broadband was seen as a strategic state investment to prevent Korea falling behind in the innovation race:

The early movement toward e-Korea was attributable to the government's resolve that the country would not make the same mistake with the ICT revolution as it had made in the Industrial Revolution in the late 1800s.[117]

Yet this drive for ubiquitous broadband has generated unintended social, cultural and political consequences. It is helping to create a more open, collaborative and questioning culture that is starting to reach deep into the heart of political power.

After Roh Moo-hyun's failed bid for the presidency in 2000 his supporters set up an internet-based fan club, 'Nosamo', to support a second attempt. In 2003, Roh won but was soon impeached because Nosamo was said to have broken campaign laws. On 11 March 2004 an avid supporter of Mr Roh set himself ablaze in front of the National Assembly to protest against the impeachment.[118] The impeachment was not confirmed and Roh remains in office. Nosamo is just one example of the power of mass participation in the world's most wired society.

OhMyNews International also had a big influence on the election, with its extensive reporting.[119] It has just 55 employees, who are supported by more than 38,000 'citizen reporters' – ordinary Koreans who submit articles and opinions on any aspect of current affairs. The success of *OhMyNews* has forced traditional news providers to rethink how they work.[120] While Korea's government wrestles with a strategy to transform the media sector, an entrepreneur has done it for them.[121]

Almost a third of the Korean population uses Cyworld, the Korean online networking site, which boasts about 15 million users who generate 90,000 hits per day. Perhaps 80–90 per cent of Koreans in their 20s have a 'minihompy' (mini homepage), an online space for photo sharing, journalling and networking. It's free to sign up, but there is a cost to decorating a minihompy using 'dotori' or acorns, a micro-payment system developed by mobile services provider SK. It seems students must have a minihompy if they want to participate in university social networks. Some of the more addictive services include a tool to see who has visited your minihompy, gift boxes and wish lists for friends, and the ability to update your site from a mobile phone.

In Korea, computer gamers have the status of rock and sports stars. Instead of going to a film, it is common for young Korean couples to sit side by side in PC bangs playing MMORPGs. SK Telecom has a pro StarCraft team, with a former sports psychologist as their coach. StarCraft's top gamers are celebrities.

There are few signs as yet of this collaborative and participative internet encroaching on the hierarchical world of big business. The World Bank noted in 2003 that although the majority of Koreans were online, they were not using the internet to organise information within businesses as would be expected.[122] However, over time, new business models, services and applications are likely to emerge from Koreans' immersion in social networking and gaming culture. Korea's government may have invested in broadband pipes as the latest stage of industrial development but it is spawning a connected culture, with its own capacity for innovation that the state will struggle to control.

That is not to say the state will not be a player in Korea's digital future. Korea's current position in ICT is the product of a string of long-term plans enacted since the 1980s.[123] Digital Media City, a project initiated by the Seoul Municipal Government, aims to bridge Korea and the world. As the Korean Culture and Content Agency boasts: 'The knowledge-driven service industry is also emerging as the principal axis of the next generation world economy, with the culture content industry at its core.'[124]

It would be unwise to discount Korea's capacity for far-reaching and disruptive innovation based around the internet. Hawoong Jeong, a postdoctoral researcher educated at Seoul National University, joined Albert-Laszlo Barbarasi's physics research group at University of Notre Dame in 1998, and developed a software 'robot' to map the self-organisation of the World Wide Web.[125] Jeong's insights now help to support tools of everyday life, such as Google's search engine. It is not impossible that innovations of similar magnitude might emerge from Koreans working in Korea. The country could yet become a world leader in the next generation of internet services.

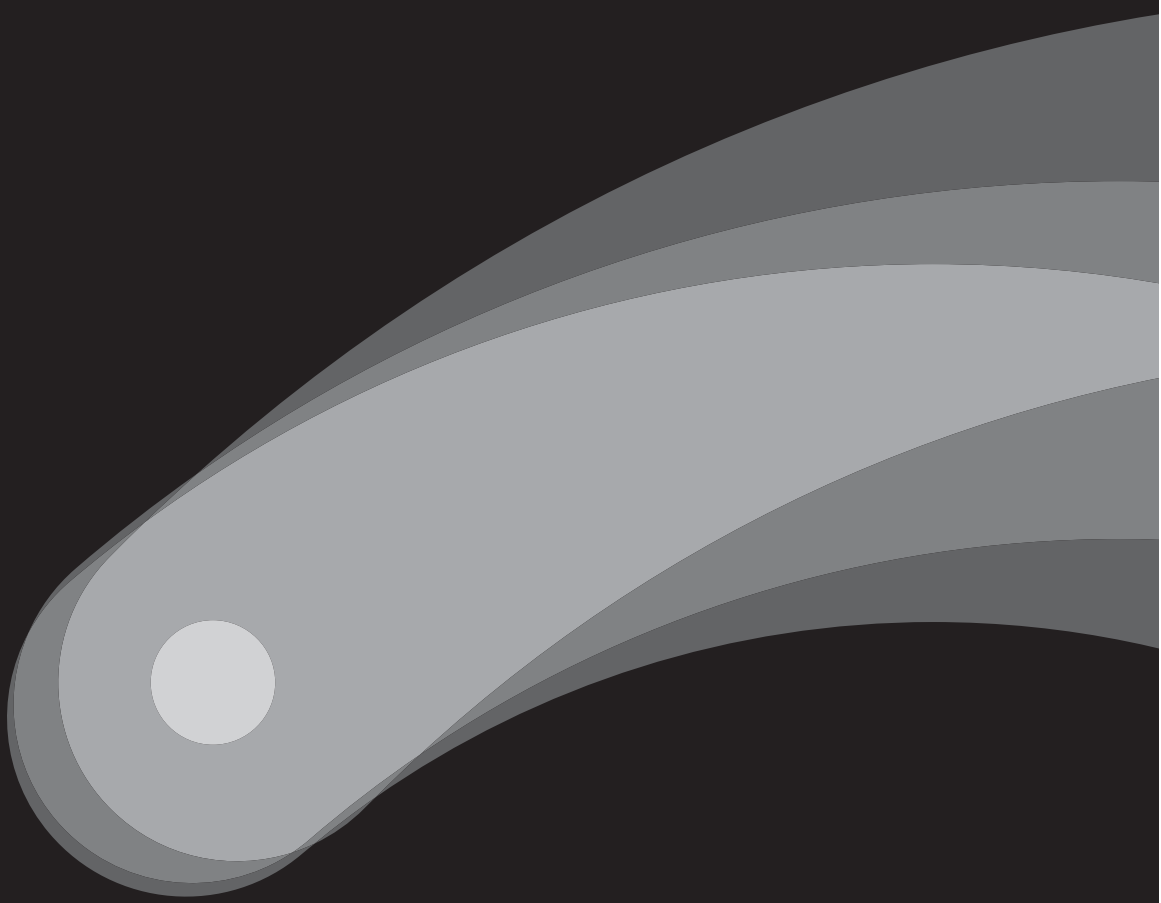
Korea, the shy comedian, is at odds with itself. The traditional hierarchical and deferential culture of hard work and discipline is at odds with the kind of society Korea will need to become to support innovation: more open, cosmopolitan and tolerant of diversity. Innovation thrives on debate and challenge; in Korea debates are often held behind closed doors.

Yet all over Korea there are signs of change, from international footballers to new social movements for open science. Information and connectivity will be powerful tools for a more participative, open and collaborative culture, in turn feeding ubiquitous innovation. Many individuals and institutions will find themselves painfully caught in the middle of these tensions. For every step forward there seems to be at least a half step back.

7 Collaboration

New partnerships for new science

Collaboration is becoming Korea's new conventional wisdom. 'Everyone now believes that Korea needs to be innovative,' says Chaisung Lim, a science and technology studies professor at Konkuk University. 'The desirable model is now joint R&D. Before 1997, everyone said "the Korean way is beautiful". After 1997, the Korea Development Institute said "collaboration is beautiful".'



London's Bermondsey antiques market is an unlikely place to find a little piece of Korea. Yet Korean companies are among the clients of a small design firm called Tangerine, which has 20 staff in London and four in Seoul, working on everything from mobile phones to airline seating. Martin Darbyshire and his Korean business partner have been working with Samsung, LG and a number of smaller Korean businesses for more than 15 years. Often they work for business units on products at late stages of development. Occasionally they do more aspirational work with corporate design centres. Darbyshire is in no doubt: 'Our future in design is working in Asia.'

Over the last 15 years, Darbyshire has learned a few things about collaboration in Korea: 'If you want to work in Korea, you can pretty much ignore the contract.' Time spent on getting a contract right is unproductive, but the lack of a formal contract does not mean the collaboration is open and easy, far from it: 'We aren't empowered the way we would be with a European partner. It's cultural – Korean people don't like to give too much away.'

Aside from the cost of wining and dining (the tradition of imbibing shoju with business associates still holds) there are other things to get used to. Korean companies tend to be stronger in the development of existing products, rather than building the foundations for future capability, although Martin admits it is hard to make judgements because Korean companies guard their IP so jealously. Little has changed in 15 years of collaborative working:

Designers used to have little influence on technology. They'd be told 'here is a circuit board – wrap it'. Now more attention is paid earlier on to human factors. The Korean strategy up to this point has been to throw as much mud against the wall as possible and see what sticks. I remember LG once showing a client 100 handsets in the hopes that they would like a few.

Darbyshire believes more Korean companies will eventually open up to collaboration. Competition to sell telephones and televisions is becoming more intense, with the rise of low-cost competition from China. LG, for example, is starting to talk to customers during the development process. Martin's business partner Don Tae-Lee, who was educated in the UK, has become a senior adviser to Samsung E&C (Engineering and Construction).

Tangerine's experience of collaboration in design and innovation with Korean companies provides some telling lessons.

Collaboration with Korea is a long-term investment. Not all Korean companies and institutions have the same appetite and capacity for collaboration. For example, Samsung Electronics seems far more open even than other Samsung subsidiaries. Though many Korean companies are extremely cautious, not to say conservative, in their approaches to collaboration, it will become inescapable for more of them, partly for demographic reasons. A decline in the school-age population means the number of first-year students entering university in 2021 will be 34 per cent down on 2003.

The new conventional wisdom

Collaboration is becoming Korea's new conventional wisdom. 'Everyone now believes that Korea needs to be innovative,' says Chaisung Lim, a science and technology studies professor at Konkuk University. 'The desirable model is now joint R&D. Before 1997, everyone said "the Korean way is beautiful". After 1997, the Korea Development Institute said "collaboration is beautiful".'

Professor Han, dean of international affairs at POSTECH, argues collaboration starts at university:

These days the world becomes smaller and smaller… Students need to learn to be leaders and stay competitive with their counterparts in universities overseas. The students are known as 'local boy' if they stay here.

Collaboration is beautiful. Korea Development Institute encouraging joint R&D

Equal partnerships lead to successful collaborations. As Korean science improves it is becoming increasingly possible to create win–win relationships. That is helped by cultural and generational change. Chris Ko at SAIT argues that: 'Collaboration works best on an equal footing with younger people who have a different mindset. They are arrogant but in a positive way.'

Korean science is integrated into the global community. Publishing in foreign S&T journals is always considered better than getting into Korean journals. 'We don't really count the Korean journals because you need exposure worldwide,' says Professor Han. Joint international publishing accounts for just under 30 per cent of Korean publishing.

Korean policy-makers are trying to back collaboration with funds and programmes. About 10 per cent of the '21st Century Frontier R&D Program' budget will be spent on international collaboration.

Publicly funded collaboration

Most public funding for science collaboration goes through the Korea Science and Engineering Foundation (KOSEF). Its budget for international collaboration in 2006 was $1.3 billion, about half coming from MOST and half from its own budget. KOSEF's international programmes began with a Memorandum of Understanding with the US in 1977, quickly followed by an agreement with Japan. Agreements with the Royal Society in 1984, the British Council in 1992 and UK research councils in 1994 are just a few of the memoranda of understanding that KOSEF now has in place with 58 organisations in 37 countries.[126]

KOSEF-funded collaboration falls broadly into three main areas: infrastructure development including exchanges, symposiums and seminars; joint research, with around 100 projects under way; and hosting collaborative research institutes such as the Institute Pasteur. About 13 per cent of KOSEF's international programme budget goes to individuals to pursue personal and professional links. KOSEF officials acknowledge that it is not always easy to justify collaboration based on clear, commercialisable outputs. Reforms are likely to shift the system towards more group-based joint ventures rather than individual exchanges. The Global Research Lab programme started by KOSEF at the beginning of 2006 supports joint projects up to $5 million ($500,000 per year) for three to nine years.

Public–private collaboration

Recent Korean technological advances have relied on cooperation and collaboration to a surprising degree, given the country's reputation for inward-looking protectionism. When Korea decided in 1989 to designate CDMA as a national R&D project, it was going against the dominant standards in the US and Europe. A government-led consortium of private firms and the Electronics and Telecommunications Research Institute (ETRI) chose to develop the core technology through an alliance with the US company Qualcomm. CDMA, now the global standard behind 3G, was rolled out first in Korea in 1996, and since then Korean telecoms companies have continued to drive up mobile phone penetration

rates with the offering of 3G CDMA services, CDMA wireless data services and wireless mobile internet services. Some analysts argue that CDMA is an example of home-grown Korean innovation but Lee and Lim show that international collaboration played a critical role.[127]

1996

The year Korea became the site for the first rollout of CDMA, now the global standard behind 3G.

D-RAM development is another example. Lee and Lim characterise this as 'path-skipping catching-up', where Korean innovators managed to skip parts of the development process through foreign partnership, design and process strategies. Firms were able to buy product designs in the initial stage and then, in collaboration with government research institutes, poured significant resources into the development. The knowledge base of US-educated Koreans was also critical.

In both cases, successful collaboration involved not just transfer of technology but the knowledge of how to apply it, which comes from personal exchanges. If Koreans were bad collaborators neither of these initiatives would have been a success.

WiBro, a wireless broadband internet service based on the WiMAX standard, is an example of a more recent success. Korea splits ownership of IP with Intel. ETRI, Samsung Electronics and LG Electronics were involved in ensuring compatibility with WiMax. Wonki Min, director of policy coordination at MIC, says:

We don't need pure Korean technology – it can be international. WiBro was a collaborative approach from the outset, and that is what made it a success. New standards won't be accepted by others if it's all Korean technology.

Portable internet will be available on the subways in Seoul in early 2007 following successful tests in 2006.

The KAIST–Texas Instruments model

You need a car to get around the huge KAIST campus in Daejeon, home to many of Korea's most impressive efforts at international collaboration. Professor Hwangsoo Lee at KAIST is a mobile communications specialist, who worked on T-DMB, a technology that now allows travellers on Seoul's subway to watch TV on their phones.

But Lee does not work alone. Texas Instruments and his lab have been collaborating for 20 years. On 27 March 2006, they launched a joint venture (JV), the CEO of which is an American, Bill Krenik, to develop future wireless networks: 'We have several problems in mobile in Korea,' says Lee, and the JV is designed to address them. 'We have been focused on basic research. We used a foreign-made chip in T-DMB, so we've decided we need to commercialise some of those critical technologies instead of licensing them from others.'

Lee went to KAIST as an undergraduate and was allowed to waive his military service obligation so that he could go abroad and do a postdoc at Stanford. In 1996 he became a visiting professor at Stanford but came back to work for SK telecomm as the head R&D centre. In three years, he created 20 spin-off companies, many of which now supply SK.

Texas Instruments and KAIST jointly own the IP that emerges from their joint research. Lee plans for T-DMB go beyond broadcasting. 'We're going to do a game phone and a sensor phone, which could calculate CO_2 in the air or the alcohol level in your blood.' Looking five years ahead, he believes internet protocols will dominate communications: 'Almost all networks will be IP-based, we call it AOIP (all over IP).'

The emerging science model

Jo Won Lee, director of The National Program for Tera-level Nanodevices, which is one of the '21st Century Frontier R&D Programs', is working with collaborators from the US, Russia and Japan but not the UK. The reason seems simple:

Financial support in the UK is hard to get. Funding is available only for Commonwealth members. We want to do some collaboration with the UK, and even when we know whom we want to work with, they don't have money. If we tell the Korean government we want to collaborate with the UK, they are willing to support that. But, in the UK, you have to do a lot of proposals to get approval. This is across all areas of science, not just nano.

Yet collaboration with the US is about more than just money. Lee, who was educated at Penn State, explained: 'I know all about the US. Almost 80 per cent of Korean PhDs get them from the US. We don't know very much about the UK. That's why our collaboration is more concentrated in the US.'

Hanjo Lim, a leading photonics researcher, recently sat on the UK Engineering and Physical Sciences Research Council (EPSRC) examining panel for nanotechnologies. He is in the Electrical & Computer Engineering Department of Ajou University and was president of the Korea Nanotechnology Research Society. Yet even he doubts the UK's capacity to engage in collaboration:

The UK programme was very classic and traditional. You need some more speed or variation to adjust to the times. The UK didn't have one centralised programme, but gave funds through chemistry and physics, rather than specifically nano-related projects.

Biotech researchers tell a similar story: the UK is conspicuous for its absence. Take the new Biotech Center at POSTECH as an example. Established in 2000, Sung Ho Ryu, the centre's director, explained: 'Life sciences are the most important area of POSTECH productivity and quality. It's the most high-impact work in Korea.' The centre is already creating international networks but these seem to be mainly with the US. The first researcher sent abroad went to work in a lab at Stanford for six months. That led to a collaborative project and now two more Stanford labs want to exchange researchers. Ryu also hopes to create an adjunct position for Stanford professors.

Even UK success stories in Korea present a mixed picture. Joon Won Park was eager to tell of a successful collaboration started in 2002 between Nottingham University and the POSTECH BioNanotechnology Center created in 2001: 'About four years ago, Saul Tendler from Nottingham University got some money from the UK networking programme to travel to Korea. He visited KAIST, POSTECH and some others and he was most interested in the BioNano Center.'

Together, they developed a new method to combine Park's surface chemistry and Tendler's bio APM tools. In February 2005, they held the first POSTECH–Nottingham Symposium on Bionanoscience.

The partnership seems to be delivering results: Nottingham and POSTECH will split income from IP half and half. The partners have filed a joint patent in the US and jointly authored a paper in *Nature Biotech*. But sustaining collaboration could still prove difficult, according to Park:

First, the money is always a challenge. I usually don't think about embarking on collaboration for under $100,000 per partner. The Nottingham team tried to get funding last year in the UK – to get equipment upgrades and send postdocs, but that failed.

However Park is also sceptical of top-down collaborations, of the kind that ETRI has established with the Cavendish Labs from Cambridge:

I was disappointed by the top-down approach. At the prime ministerial level they agreed to do something and then KOSEF found the best hosting institution. ETRI got an order to write a proposal. Then they have to go visit each other to find out more. Only professors who don't have any funding volunteer. This never works synergistically. Maybe it would work after ten years, but it wouldn't necessarily be guaranteed to succeed.

POSTECH is determined to ramp up its collaborative activities. Its accelerator lab draws researchers from around the world. But Professor Han believes that the exchange of people and ideas is still more important than equipment: 'Maybe we can provide support through the international collaboration department at KOSEF for example, but each researcher has their own connections and this is the way they want to collaborate.' Even the companies that come in, like GE, are through a personal connection. POSTECH President Chan-Mo Park's term will end next year with the completion of an international conference building that will host 50–80 international conferences each year.

The UK as a partner for Korea

The US is overwhelmingly Korea's primary scientific and technological partner. A third of the six million Koreans living abroad are in the US. These social ties make the US a natural place to look for collaboration. A renewed commitment to stem cell research in the wake of the Hwang scandal, for example, involves three Korean-American scientists working in the US. Jong-Deok Kim, who is running international programmes at KOSEF, points out that 'people in their 40s, 50s and 60s got their degrees in the US, so that is a common pattern and difficult to change'. The US Embassy science team in Seoul is small because the networks are self-supporting. Jong-Deok Kim at KOSEF explains: 'Four hundred postdocs go abroad each year through manpower development programmes. Once they've gone abroad, linkages develop naturally.' Estimates vary but it is thought that eight out of ten of these Korean postdocs go to the US.

Four hundred postdocs go abroad each year through manpower development programmes. Once they've gone abroad, linkages develop naturally.
Jong-Deok Kim, KOSEF

Yet some argue that Korea has become over-dependent on the US. There are signs that Korea is searching for new partners in innovation. The Ministry of Science and Technology wants to promote Korea's position in EU framework programmes and within the OECD. Collaboration with other Asian countries, particularly China, is growing slowly. Some are suspicious that Chinese partners may take Korean IP without offering anything in return. Jo Won Lee, head of the National Program for Tera-level Nanodevices, says of his experiences in China: 'We have to be a little careful because they might take our ideas. When some Korean government representatives went to China and wanted to collaborate, China asked them to open our nanoelectronics labs. China is good in nanomaterials and they have huge resources, but they didn't want to open their research to us.'

The proliferation of free-trade agreements within Asia are giving rise to a 'noodle bowl' of agreements which could hinder multilateral agreements.[128] Wonki Min, director of policy coordination at MIC, explained:

In Asia if you look at the size, it's huge, but the countries have very loose ties. There is no collaborative mechanism – members of ASEAN are not very strong. We need to create standards with China and Japan like ETSI, the standards body for Europe. It's time to work together to bring the different legal systems together.

UK collaborative projects tend to be less high profile that those with the US, Germany and France. The Insitut Pasteur, for example, is supported by both the French and Korean governments. The Koreans will fund the institute for ten years to the tune of US$300 million. Opened in 2004, the Institute is already considered a success, with a growing number of patents and papers published, and about half its 80-strong research staff drawn from outside Korea.

Yet Britain could strengthen its position. KOSEF has links with the Royal Academy of Engineering and a number of the UK research councils. Government research institutes have their own links with the UK, such as that between ETRI and the Cavendish Laboratory. Private companies also have good links, such as those between Samsung and Tesco. One high-profile public–private venture between UK-based AMEC and Incheon City will build the new bridge connecting Songdo with Incheon airport.

Recognising how fast it is developing, Korea has long been identified by the UK government as a priority for collaboration. Since 1996, there has been a Joint Korea–UK Commission on Science and Technology, following the S&T Co-operation Agreement signed in 1985. The Korean Academy of Science and Technology (KAST) signed a bilateral agreement with the Royal Society in 1998. Between 2000 and 2004, a UK–Korea high-tech industry forum met five times. And in 2003, a 'Focal Point' programme was established to bring together individuals and universities in each country to lead collaborations in particular areas of science, including nano, bio, space and energy.

According to the latest report from the UK's Global Science and Innovation Forum (GSIF), Korea is stronger on development while the UK is stronger on research.[129] GSIF recommends that the UK uses international collaborative science to improve research and innovation, leverage global influence and meet international development goals. Korean collaboration could contribute to all three of these goals over the long term.

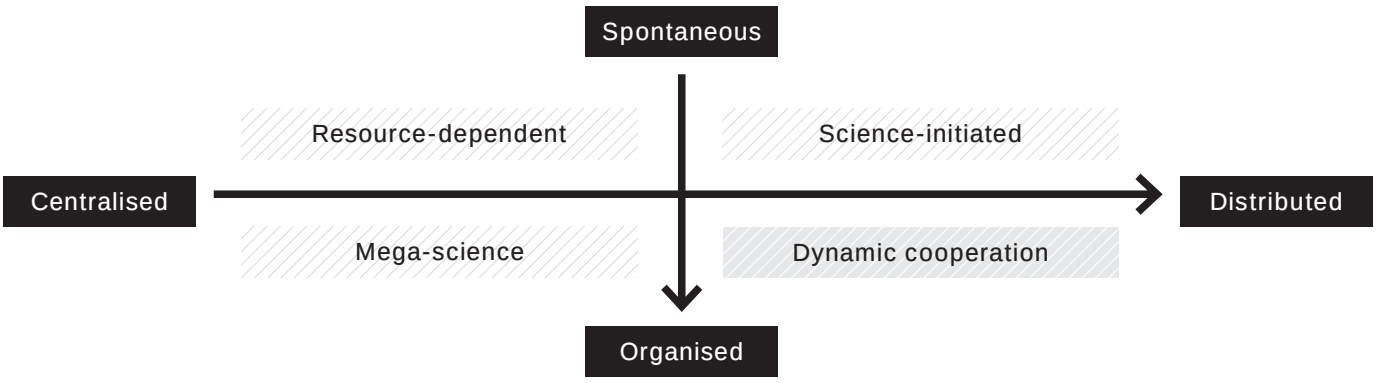
Yet UK collaboration with Korea faces a number of dilemmas. Korean scientists say they would like to work with their British counterparts on a wide range of subjects. Bottom-up networking activities can build up essential relationships between these individual scientists. But often these networks can do little to cement long-term institutional ties or to create shared research projects.

Several of our interviewees mentioned cases in which their British counterparts had found it difficult to follow through on an initial positive contact, or to win long-term funding. Even the Focal Point programme, which extends one-off meetings to three years of networking, suffers from lack of funds. And because government research institutes still choose the scientist contacts who attend, the programme is not open to everyone. 'The whole approach needs more time and effort,' complains Joon Won Park.

The major exception to this bottom-up model is a joint venture between Cambridge University's Cavendish Laboratory and KAIST in the field of nanoelectronics, spintronics and optoelectronics. This was inaugurated in 2004, the same year ETRI signed a memorandum of understanding with Cavendish to start a joint R&D centre in Daejeon. Over the past two years, a number of exchanges and joint workshops have taken place. Professor Peter Littlewood of Cavendish Laboratory is carefully optimistic: 'Our intentions with Korea are unusual. KAIST–Cavendish was driven from the top down, the kind of thing we rarely do. But it's gone a lot better than I thought it would.'

Finding the right recipe for collaboration with Korea will not be simple. More opportunities are opening up for relatively informal, networked exchanges. But these are vulnerable to personnel changes and a shortage of long-term funding. Institutional joint ventures orchestrated top-down run the risk of forcing collaboration for political rather than scientific ends. Collaborating with Korea takes patience and skill. Attitudes in Korea are changing, especially in the most innovative organisations and businesses. As the example of Martin Darbyshire at Tangerine shows, Britain does have skills – in thinking, design and innovation – that Korea needs to complement its ability to develop products rapidly.

Figure 8 Motivating factors for R&D links



Source: Adapted from ET Crawford, T Shinn and S Sorlin (eds), *Denationalizing Science: The contexts of international scientific practice* (Dordrecht, Holland: Kluwer Academic Publishers, 1993), cited in C Wagner et al, *Phase Transition in Korea–US Science and Technology Relations* (RAND Science and Technology, 2003).

The lessons of industrial collaboration are useful, but not necessarily as a template for scientific collaboration going forward. A RAND study on US–Korean collaboration developed a framework for understanding the range of possible interactions, from centralised and organised to distributed and spontaneous (see figure 8).[130] Government tends towards the clarity of organised projects, but scientists are motivated by professional interaction, as we have seen from the early success of the POSTECH–Nottingham collaboration. A model that combines organised and distributed elements, and that mixes the best of the Korean model with the best of the British, could be the key to truly dynamic cooperation.

8 Prognosis
Ubiquitous knowledge, ubiquitous innovation

Leaving Seoul it is easy to forget how far Korea has come, and how fast. In the 1950s, South Korea was on its knees, illiteracy was rife and university education was limited to a tiny elite. Dotted around this city which gives off a reddish-yellow glow at night are more than 20,000 PC bangs, internet cafés where gamers hang out for hours engaged in digital combat. Online gaming has become a $5 billion dollar industry, conducted over fibre optic cables running beneath the streets and countless wireless data packets coursing through the air.

20,000

The estimated number of 'PC bangs' or internet cafés in and around Seoul.

Korea, long held up as the Asian tiger success story of state-led industrial development, may be about to enter a new age of ubiquitous knowledge and innovation. The IT infrastructure laid down by a government worried about missing the next big thing is fuelling the emergence of a new ultra-connected culture. And the desire to make the most of that platform is taking Korean innovation in unexpected directions.

Witness the birth of the state-sponsored Open Source Software (OSS) movement to reduce reliance on Microsoft. Since the Korean War, development in Korea has been closely aligned with the US. Now Korea sees itself as a challenger. And it is pushing for tri-country collaboration by establishing a China–Japan–Korea forum to promote OSS. In nanotechnology and biotechnology, similar efforts are under way to thrust Korean companies into positions of leadership.

Korea can teach us all something about the future of innovation simply because it is one of the best-connected, best-educated societies in the world. It is at the leading edge of experimenting with ubiquitous, connected, collaborative innovation. This will be far more significant in the long run than the successes and failures of superstar scientists such as the disgraced Dr Hwang.

In the opening chapter of this report, we described the sometimes conflicting faces of Korean science and innovation, as summarised in table 4.

Table 4 Faces of Korean science and innovation

	Industrial techno-nationalism	Scientific techno-nationalism	Ubiquitous innovation
Motivation for innovation	State development	State recognition/ scientific excellence	Quality of life, competitiveness, facing global challenges
Main players	State and chaebol	State and individuals	Networks, individuals, small companies
Qualities or kinds of innovation	Path-driven, market-driven	Technologically informed, practical	Unpredictable, fluid, niche-filling or niche-creating

In chapter 2, we used numbers to tell a story of Korea hurtling to the top of industrial innovation. In chapter 3, we described attempts to reform an elite education system into universal learning for a postindustrial economy. Chapters 4 and 5 surveyed the places and businesses where change is under way. Chapter 6 explored science and innovation in the context of Korea's growth, democratisation and cultural upheaval. Finally, chapter 7 highlighted Korea's commitment to collaboration and the challenges and opportunities that this creates for the UK.

Korean technological visions may be prone to over-ambition. Yet its capabilities should not be discounted. A RAND research team recently identified 56 technology applications that might possibly be developed and implemented by 2020. They ranked Korea as one of the most likely places to lead their development.[131]
Of course, there are uncertainties. A lot may depend on whether anything dramatic happens in North Korea to precipitate a sudden, disruptive and costly integration. That said, South Korea still chooses to look at integration as an opportunity. Dynamic Korea is both a government rallying cry and a description of the social as well as technological innovation that is now under way. Younger generations are adapting Korea's collective orientation to a world that is more open and individualistic. Ultimately, the kind of innovation to emerge from Korea will depend on the interplay between the strengths and weaknesses described below.

Strengths

— *Government support*
Excellent infrastructure has been built over the years of Korea's development, and the government has long-term plans to increase science funding. Excellent broadband and mobile infrastructure will continue to contribute to innovations in communications, lifestyle and health.

— *Private sector driving R&D*
The private sector now accounts for 75 per cent of R&D. Increasingly, business is calling for government to support basic research rather than duplicate their initiatives. There are signs of change among the chaebol and new generation of smaller companies, which are investing in R&D to develop niche competitiveness.

— *Highly educated population*
Koreans have the highest literacy rates in the world, and excellent scientific education. The younger generation is also more global, and wants business degrees, not just engineering degrees. The most talented will be the most mobile, who have 'nationalities but no nationalism'.[132]

— *International links*
Nearly 10 per cent (6.4 million) of all Koreans live abroad and provide good links into other innovation systems.[133] The key for the future will be to translate these into cooperative scientific partnerships. New links must extend beyond the US into broader networks and alliances. Korea's involvement in ITER, the joint international project on nuclear fusion, may suggest a new model.

— *Democratic institutions*
Korea's democracy is young but has developed rapidly and allows for increasing public participation. This, combined with creative use of new technology, supports social innovation as the public pushes for transparency and balanced development.

— *Crisis into opportunity*
Korea's success story is based on competitiveness and technology leapfrogging, pitting firms against one another in a race to succeed. The 1997 economic crisis was a chance to reform. Not only does Korea know how to withstand a crisis, it has shown it can turn a crisis into an opportunity.

Weaknesses

— *Unattractive destination*
Low FDI reflects the difficulties Korea faces in becoming a leading destination for international workers or scientists. Korean culture and media is often nationalistic and conservative. Five out of six Koreans think their country should be protected from foreign influence.

— *Weak links between sectors*
The interface between government, industry and academia remains weak in spite of reform efforts. Business rarely looks to universities or institutes for basic research. In 2003, 97 per cent of corporate research funding went to in-house R&D, with government research institutes performing only 1 per cent and universities 2 per cent.[134]

— *Lack of transparency*
Despite post-1997 reforms, there is still a conservative core that resists transparency. Corruption, collusion between government and big businesses, and poor links between R&D actors are still a problem. All have the same root cause: the low levels of trust in Korean society.

— *Rote learning*
Students are trained, but not in how to lead. But there are now efforts to improve graduate training and encourage students to travel and learn from international scientists who are the best in their fields. Once students and researchers spend some time abroad, they tend to think and work differently.

— *Weak basic research*
Although funding for basic science is growing, the system remains focused on applications and outputs. Korea needs to make the transition from a product focus to broader capacity in science.

— *Over-planning*
Science is often treated like a technological catch-up project, rather than a process. The government has tended to over-promise on what science can deliver, which puts pressure on science and scientists. After Hwang, government should rethink and concentrate instead on creating the space for innovation.

On the train leaving Daejeon, we met a Russian scientist working at the Korea Research Institute of Standards and Science (KRISS). ‘The best research can be done here, better than at home,’ he says. His experience is that there are many foreigners in Daejeon, mostly Chinese, Indians and Russians. ‘Kids come and visit the institute’, he says, ‘and when I go to the science museum, it feels like someday it could be Silicon Valley.’

But even the most cutting-edge centres of innovation in Korea don’t have the feel of Silicon Valley’s entrepreneurial culture. Indeed, Korea’s biggest challenge may be its own eagerness to push innovation. Many politicians and scientists know that what they have observed in Silicon Valley cannot be forced. Yet the Korean state is impatient for change, and worried about the competition from China snapping at its heels. Korea’s biggest danger is that its own impatience to spur innovation, through state-driven direction, may kill it off. Along the way more individuals like Dr Hwang, Professor Laughlin and Dr Yoo will get trapped between the demands of the state and the ethics of science.

What does all this mean for the UK? A ubiquitous innovation system is still emerging in Korea, with pockets of the kind of mobility and openness that may eventually take hold. A new breed of SMEs is growing, especially in the creative industries, gaming and software sectors. Envisaged bio, nano and clean technology applications will require both basic research and commercialisation partnerships. The question for the UK is how it can align itself with these emerging opportunities. We propose five priorities.

1

Unleash mass collaboration

Koreans sometimes ask where are the UK equivalents of the Pasteur or Fraunhofer Institutes? But the most successful collaborations are long term and start with a personal connection. The next wave of Korea–UK collaboration should be modelled less on France and Germany's joint centres, and more on the rich network of Korea–US partnerships.

To capitalise on short-term opportunities where UK and Korean research strengths are well aligned, the UK needs to create one point of entry for collaboration. This could take the form of a targeted initiative through the research councils, enabling UK scientists to match funding where joint opportunities exist. Extended networking through the 'Focal Points' programme is also set to continue. This may yet bring project successes, such as a mooted project between KRIBB and Oxford.

Creative industries in both Korea and the UK are growing faster than other sectors of the economy. UKTI or the Design Council could support wider collaboration through a grant scheme for small creative businesses, to fund fact-finding trips and network-building.

2

Be a magnet for talent

The overwhelming first choice destination for Koreans looking to study abroad is the US. Many Koreans find the UK confusing, or reluctant to back up good ideas with funding. Yet among the strengths of the UK system are its many world-class individual departments, professors or laboratories. Institutional links could be scaled up to allow regular exchanges of talented people, as has worked well in the Nottingham–POSTECH collaboration. Korean researchers already based in the UK should be provided with more support to collaborate with colleagues in Korea. UK universities also need to present a more coordinated approach to Korea that is about long-term research partnerships as well as prospecting for students. Investment in scholarships to the UK should be increased, and top universities in particular should step up their efforts to attract Korean postgraduates in order to increase the number of future Korean science leaders that have close links with the UK. The new scholarship scheme recently announced by the Royal Society is a step in the right direction. It should be developed with Korean researchers in mind.

3

Get our story straight

A number of organisations representing the UK are interested in inward investment, including UKTI, Scottish Enterprise and the regional development agencies. Many scientists and businesses in Korea think of Europe as an opportunity, but are not sure where to look first. The UK is known for its strengths in design and pharmaceuticals, but is considered slow-moving, confusing and difficult to navigate. As a priority, the UK needs to shed its reputation for 'talk and no action'. Too many UK-led missions and networking events lack a clear sense of purpose. We need a more hard-headed and rigorous evaluation of what has and hasn't worked and a greater willingness to back joint projects and smaller-scale experiments.

3 Cont.

How can the UK get better at matching its R&D capabilities to those of Korea? When Korea's new technology roadmap is published, the UK should look carefully at where synergies exist and tailor networking to those areas. Though Korea's strength in pharmaceuticals is behind the UK, it could be an equal partner in ICT, materials science and other emerging areas.

4

Build the knowledge banks

Korea may not be a country on the scale of China and India, but the UK still needs to understand more about what is going on, particularly in regions outside Seoul. The knowledge gained from numerous scoping trips and networking activities is not collected centrally, so effort is duplicated, and wheels are endlessly reinvented. The Foreign and Commonwealth Office is ideally positioned to gather information through its science and innovation network, but these specialists need more time 'pounding the pavements', creating links with Korean organisations, and less time organising scoping visits for UK visitors. Other European countries combine their fact-finding trips into larger, less frequent delegations of 50 or 100 people. This can generate more interest from prospective collaborators, and is a model that the UK should consider adopting.

Building on Korea's passion for online interaction, UK scientists could also showcase themselves and build networks through social software tools, such as a new website called 'Nature Network London', being created by *Nature* to showcase London as a science city. 'Think of it as MySpace for scientists,' says Sara Abdulla, director of the initiative.

5

Lead global science towards global goals

New models for multinational, multidisciplinary collaboration could place the UK alongside Korea at the centre of global research networks. Korea has already been involved with ITER and open source standard setting with China and Japan. The UK should promote joint initiatives in areas of science that are clear international priorities (eg clean energy), which would create an opportunity for partnerships with Korea that also connect to global goals.

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3 S Hong, 'Replication, scientific fraud, and STS', prepared for the EASTS Conference on Dr Hwang's Controversy in Korea, Taipei, Taiwan, on 4 Aug 2006.
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5 Estimates vary: GDP per capita topped $22,000 in 2006 according to the CIA *World Factbook*, $17,908 in 2003 according to World Economic Forum (WEF), and gross national income (GNI) per capita was $15,830 in 2005 according to the World Development Indicators (WDI), see http://devdata.worldbank.org/data-query/ (accessed 6 Dec 2006).
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The Atlas of Ideas Korea fieldwork began with a trip to Seoul in October 2005, and continued in February and March 2006. Thanks to our partners in Seoul, First Secretaries of Science and Innovation Jim Thomson and Mark Tomlinson and their team, Youngsun Soh, Kyejin Chay and especially Hyeyoung Kim for her help in the research process. Thanks to Ok-Soon Kim and the rest of the UKTI team, and Ian Simm and his team at the British Council and Howard Jang, Scottish Development International. Thanks to Jim and Angela for making me feel welcome and Julia Lee for her support and unique perspective.

Special thanks to Ambassador Warwick Morris, who put his support behind the project and generously invited me along to events at his home in early March 2006, as did Guy Warrington and Karen Malia. Many thanks to Won Soon Park, Yukyung Kim-Cho, Eun Jin Choi, Jehong Lui and others at the Hope Institute for providing invaluable insights into Korean culture.

Many thanks to all the people who openly shared their experiences and expertise in Korean science and innovation, including Hyun Seung Yang, Hyang-Sook Yoo, Sungchul Chung, Un-Chan Chung, Robert Laughlin, Hwan-suk Kim, Charles Lho, Chiasung Lim, Chris Ko, Jong Bhak, Joon Won Park, Jung Sung Koh, Helen Kim, Tariq Hussein, Jimmy Kim, John David Kim, YoungHun Kim, Jae-young Son, Phil Burton, Brendan Barker, and the excellent team at Somerset Palace Residence.

Thanks to Paul Lawrence for skyping and being so supportive. Thanks to Jack Stilgoe and Alison Harvie, who had to handle not a few scheduling and operational glitches.

Finally, a big thanks to the Atlas team: Charlie Leadbeater, James Wilsdon, Kirsten Bound, Paul Miller and Anna Maybank, for all their brilliant work.

As ever, all errors remain my own.

Molly Webb
January 2007

65 List of organisations interviewed

- Bionanotech Research Center, Daejeon
- British Council, Seoul
- Center for Democracy in Science and Technology (CDST), Seoul
- Center for Functional Analysis of the Human Genome, Daejeon
- Chem-Tech Research Inc (C-TRI), Suwon
- Electronics and Telecommunications Research Institute, Daejeon
- Green Cross Corp., Yongin
- Gwangju TechnoPark, Gwangju
- Histostem (Seoul Cord Blood Bank), Seoul
- Hope Institute, Seoul
- Incheon Free Economic Zone (IFEZ), Incheon
- Innotive, Seoul
- Institut Pasteur Korea, Seoul
- Intel, Seoul
- International Crisis Group, Seoul
- KAIST, Department of Biological Sciences, Daejeon
- KAIST, Department of Electrical Engineering and Computer Science, Daejeon
- KAIST, Humanoid Robot Research Center, Daejeon
- KAIST, Research Affairs, Daejeon
- Kookmin University, Seoul
- Korea Biotech Venture Association (KOBIOVEN), Seoul
- Korea Institute of Energy Research (KIER), PEM Fuel Cell Research Development, Daejeon
- Korea Institute of Evaluation and Planning (ITEP), Seoul
- Korea Institute of Machinery and Materials (KIMM), Daejeon
- Korea Institute of Science and Technology (KIST), Strategic Planning and International Cooperation, Seoul
- Korea Institute of Science and Technology Evaluation and Planning (KISTEP) Division of Management, Seoul
- Korea Institute of Science and Technology Information (KISTI), Seoul
- Korea IT Promotion Agency (KIPA), Policy Development and Open Source Promotion, Seoul
- Korea Nanotechnology Research Society (KONTRES), Seoul
- Korea National Assembly, Seoul
- Korea National Nanotechnology Fabrication Center, Daejeon
- Korea Research Institute of Chemical Technology (KRICT), Daejeon
- Korea Research Institute of Standards and Science (KRISS), Daejeon
- Korea Science and Engineering Foundation (KOSEF), Daejeon
- Korea Science Foundation, Seoul
- Korean Pact on Anti-Corruption and Transparency (K-PACT), Seoul
- Korean Research Institute of Bioscience and Biotechnology (KRIBB), Daejeon
- LG Life Sciences, Daejeon
- Ministry of Commerce, Industry and Energy (MOCIE), Seoul
- Ministry of Education and Human Resources Development, University Innovation Office, Seoul
- Ministry of Information and Communications Policy Bureau (MIC), Seoul
- Ministry of Science and Technology (MOST), Overall Planning Division, Europe and Oceania Cooperation Division, Seoul
- Mogam Research Institute, Yongin
- National Genome Information Center, Daejeon
- Office of Science, Technology and Innovation (OSTI), Seoul
- OhMyNews, Seoul
- Ovum, Seoul
- People's Solidarity for Participatory Democracy (PSPD), Seoul
- POSTECH, BioNanotechnology Center, Pohang
- POSTECH, Biotech Center, Pohang
- POSTECH, Planning and International Affairs, Pohang
- POSTECH, Pohang Accelerator Laboratory (PAL), Pohang
- Samsung Advanced Institute of Technology, Yongin
- Samsung Economic Research Institute (SERI) Center for Global Cooperation, Seoul
- Samsung, Global Strategy Group, Seoul
- Samsung, Telecommunications R&D Center, Suwon
- School of Business Konkuk University, Seoul
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- Scottish Development Agency, Seoul
- Seoul National University (SNU) Physics Department, Seoul
- Seoul National University (SNU) President's Office, Seoul
- The *Financial Times*, Seoul
- The Korea Independent Commission Against Corruption (KICAC), Seoul
- The National Program for Tera-level Nanodevices, Seoul
- Think London, Seoul
- Total E&S Co Ltd, Seoul
- UK Trade and Investment, Seoul
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We are very grateful to our partners for their generous support for this project.

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This pamphlet forms part of The Atlas of Ideas, an 18-month study of science and innovation in Asia, with a focus on opportunities for collaboration with the UK and Europe. The project is funded by the UK government and a consortium of public and private sector partners.

The second phase of The Atlas of Ideas begins in April 2007. As well as deepening our analysis of innovation in Asia, this will explore countries including South Africa and Brazil, and examine cross-cutting themes such as scientific diasporas, low-carbon innovation and science in the Islamic world. To find out more, or to download the other project reports, visit www.atlasofideas.org

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ISBN 1 84180 171 0
Price £10

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