European Commission

Roadmap for EU – Republic of Korea S&T cooperation

1. THE REPUBLIC OF KOREA AS A PARTNER OF THE EU

Over the past few decades, the Republic of Korea (South Korea) has achieved tremendous economic growth and global integration to become a high-tech industrialised economy. It currently (2018) has a population of 51 million, a GDP of €1332 billion, and a GDP per Capita of €26118. South Korea is the EU's ninth largest export destination, whereas the EU is South Korea's third largest export market. In 2017, EU exports of goods to South Korea amounted to €50 billion and imports of goods from South Korea also totalled €50 billion. South Korean investments in the EU was €19 billion in 2016, whereas EU investments in South Korea was €50 billion, remaining South Korea's biggest Foreign Direct Investor.

The ninth bilateral summit between the EU and South Korea took place on 19 October 2018 in Brussels where leaders reaffirm their strong ties and their commitment to strengthen their strategic partnership. The summit also the occasion to welcome the substantial progress made in the EU-South Korea cooperation in research and innovation and to agree to continue close cooperation on research and innovation in areas such as ICT, nanotechnology, health, climate, energy and mobility, to jointly tackle global challenges, boost competitiveness, foster sustainable growth and job creation.

Since 2010, the EU and South Korea have upgraded their relationship to a Strategic Partnership with relations governed by three key agreements as well as more specific agreements in several fields. The EU-South Korea Framework Agreement (FA, signed in 2010) addresses a wide range of international concerns, including non-proliferation of weapons of mass destruction, human rights, cooperation in the fight against terrorism, energy security, climate change and development assistance. The EU-South Korea Free Trade Agreement (FTA, applied since 2011) aims at integrating the European and South Korean economies, removing barriers to trade between the two partners and providing a successful tool in boosting trade. South Korea is the EU's first partner to have signed agreements in the three key areas of political, trade and security cooperation in EU-led crisis management operations: the FA, the FTA, and the Framework Participation Agreement (FPA, signed in 2014) aimed at facilitating South Korean Participation in EU Common Security and Defense Policy operations.

The Agreement on the Scientific and Technological Cooperation between the EU and South Korea has been in force since 2007. In addition, the Agreement for Cooperation between Euratom and South Korea in the field of fusion energy research has been in force since 2006. Euratom and South Korea are also parties to the ITER International Fusion Energy Organisation (ITER International Agreement is in force since 2007) and are signatories to the Generation IV International Forum (GIF) Charter. Furthermore, South Korea is one of the associated countries of the EUREKA Network and a participant in the Eurostars programme.

The sixth EU-South Korea Joint Scientific and Technological Cooperation Committee meeting held on 20 September 2017 in Brussels was a further testimony of the breadth and dynamism of the partnership that

continues to develop very rapidly and favourably. The successful cooperation on political, economic, security and science & technology affairs reflects the EU's and South Korea's increasing international engagement and shows that they face similar challenges and share many of the same values and concerns. To provide solutions to these challenges, the EU and South Korea are designing comparable policies, instruments and actions. In particular, they are joining forces in a range of strategic focus areas of mutual benefit, and they are improving the framework conditions for their scientists and innovators to work together.

Over the past 20 years, South Korean R&D spending as a share of GDP has doubled to exceed 4.25% in 2016[1]. R&D in South Korea is almost entirely performed and funded by the business sector (more than 75%). Nearly two-thirds of all R&D is directly targeted at developing specific new or improved applications, whereas basic research represents about 20% of total R&D spending.

Intense R&D in South Korea is built upon strong education in natural science and engineering. As a consequence, the share of R&D personnel in total employment has doubled over the past 10 years, with nearly 60% of R&D personnel employed in the business sector.

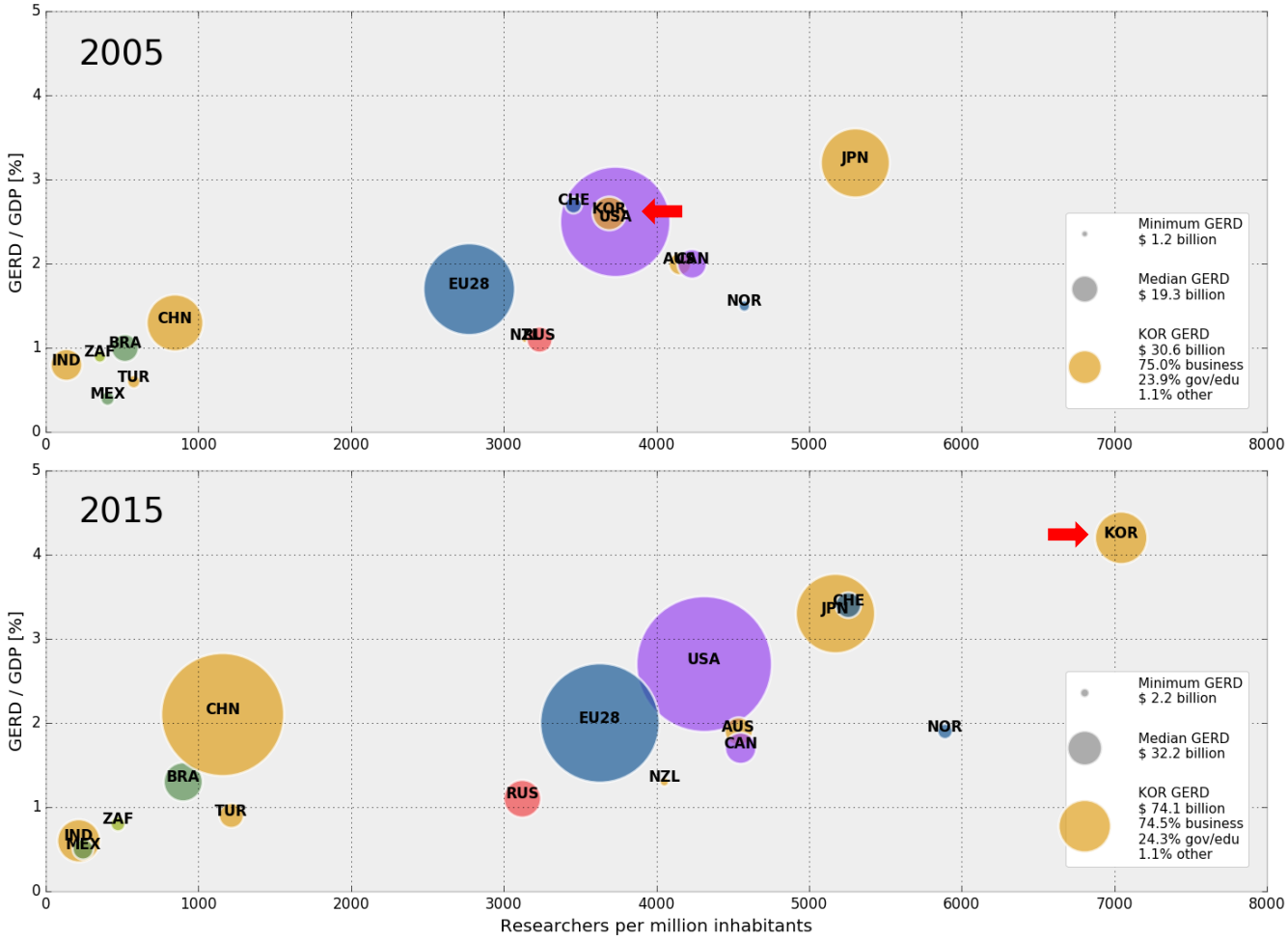
South Korea has one of the lowest rates of business R&D funded by firms or institutions from abroad. Most business R&D is internally funded, with 6% of direct funding received from government. In addition, South Korean firms receive the equivalent of 8% of total business R&D through tax incentives.

South Korea has relatively low domestic and global linkages. Its output of scientific publications reflects a relatively modest public research effort within the broader innovation system. A key weakness of its science and research system, reducing the impact of its scientific research, is its low level of international collaboration, as measured by co-authorships, co-inventions, and collaboration among innovative companies.

32% of tertiary graduates in South Korea are in natural sciences and engineering disciplines. Main research strengths compared to the EU, as indicated by field-weighted citation impact of academic publications, are in chemical engineering (catalysis, bioengineering), materials science (biomaterials, metals and alloys), engineering (building and construction, mechanics of materials), renewable energy, surfaces/interfaces and physical and theoretical chemistry (see Figure 3 in Annex). Data on PCT patent applications based on OECD classification notably show that South Korea specialises more than EU28 on ICT and nanotechnology related patents (see Figure 4 in Annex).

[1] 'OECD Science, Technology and Industry Scoreboard 2018'

Figure 1: Expenditures in Research & Development and researchers per million inhabitants



Note: GERD in current PPP; Top chart: Data for CHE from 2004. Bottom chart: Data on researchers per million inhabitants for BRA from 2014, for CAN from 2014, for MEX from 2013 and for AUS from 2010.
Source: DG RTD - International Cooperation
Data: UIS, OECD, EUROSTAT; extraction date: 11/10/2018

South Korea's R&D investment has placed the country at the frontier of cutting-edge technologies. For technologies related to the Internet of Things, big data, quantum computing and telecommunications, South Korea accounts for 14.1% of the patent families filed at the world's largest patent offices in 2010-12 (up from 4.8% in 2005-07). For advanced materials and nanotechnologies South Korea's share stands at 21%, up from 13%. And for health-related technologies, South Korean firms and researchers file 6% of patent families, up from 3.5%[2].

South Korea is also set to become a major world nuclear energy player and a country exporting nuclear power plant and nuclear technology. In fission, R&D is supporting national competitiveness and technology exports. In

[2] 'OECD Science, Technology and Industry Scoreboard 2015'

fusion, South Korea is active in ITER activities and has built, with international help, the most recent and large world tokamak, KSTAR. Furthermore, discussion has been launched with Euratom on the principles of establishing a network of international facilities in which KSTAR and the European JET, Asdex-UG, Tore Supra together with other international fusion facilities can increase support to ITER.

2. STATE OF PLAY OF EU-REPUBLIC OF KOREA S&T COOPERATION

2.1. On-going FP7 and Horizon 2020 cooperation

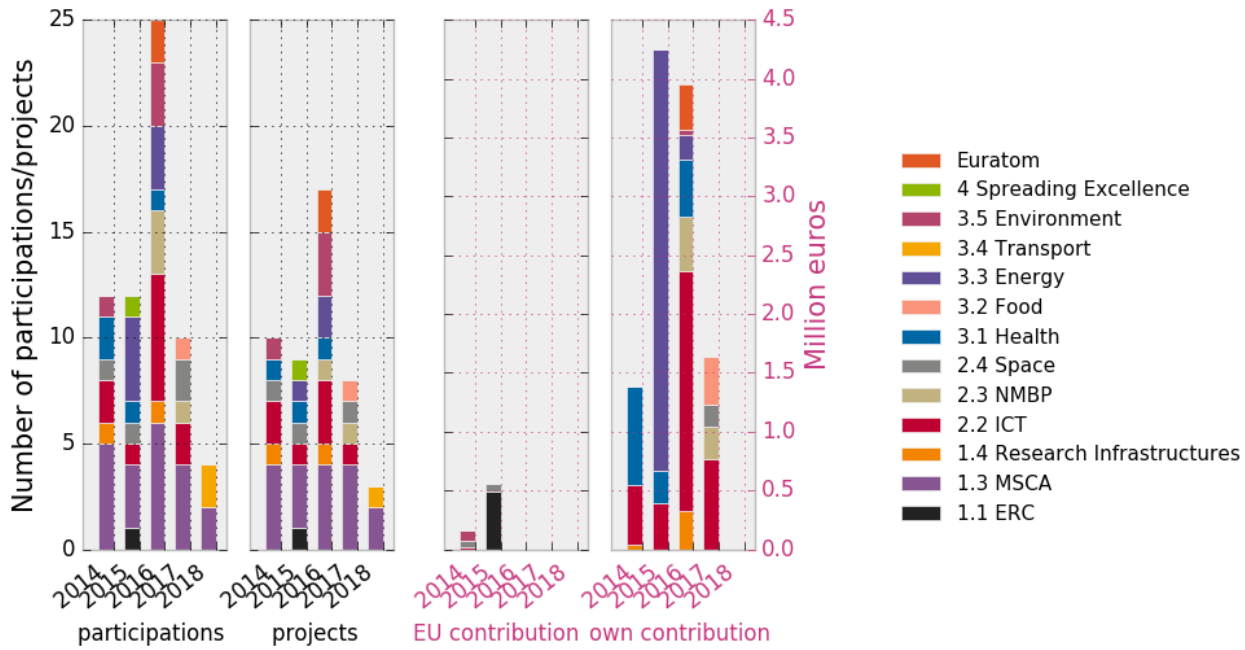
In FP7 collaborative projects, there were 67 participations of entities from South Korea. They took part in 54 projects that had a total budget of €284 million. Most of the projects were in the areas of ICT, Health, Nanotechnologies, Materials and Production technologies, Environment, and Euratom.

Up to October 2018, under Horizon 2020, there are 42 South Korean participations in collaborative actions, 20 participations in Marie Sklodowska-Curie Actions (MSCA) and 1 participation in a European Research Council (ERC) grant, with ICT and energy as the most active areas of cooperation. The success rate of South Korean applicants is 24.6% (as compared to 15.8% overall).

Horizon 2020 participation so far is mainly in the areas of ICT, health, energy, climate action, and satellite navigation. For example, there are two South Korean participants in the €25 million TBVAC2020 project that aims to innovate and diversify the current tuberculosis vaccine and biomarker pipeline while at the same time applying portfolio management using gating and priority setting criteria to select as early as possible the most promising tuberculosis vaccine candidates, and accelerate their development. Another example: three organisations from South Korea participate in the €25 million DESTRESS project that aims to create enhanced geothermal systems reservoirs with sufficient permeability, fracture orientation and spacing for economic use of underground heat.

The EC's Joint Research Centre cooperates with South Korean institutions mainly in the fields of health, measurement science, energy and transport, construction standards, nuclear safety and security. In particular, there is a longstanding cooperation on reference measurement methods, materials and measurement data; evaluation and scientific validation of alternative testing methods for regulatory safety assessment of chemicals; and nuclear data measurements.

Figure 2: Participation of the Republic of Korea in Horizon 2020



Note: Participations of beneficiaries, third-parties and partner-organisations.
Source: DG Research and Innovation - International Cooperation
Data: CORDA (JRC, EIT and art.185 not included); extraction date: 15/10/2018

2.2. Current framework conditions for EU-REPUBLIC OF KOREA S&T cooperation

The EU-South Korea Free Trade Agreement is creating new opportunities for market access not only in goods but also in services and investments. It includes provisions in areas such as competition policy, government procurement, intellectual property rights, transparency in regulation and sustainable development. In particular, the procurement chapter expands procurement opportunities to public works concessions and Built-Operate-Transfer contracts not yet covered by the Government Procurement Agreement commitments, and the IPR chapter includes provisions on copyright, designs and geographical indications and well as enforcement of IPRs based on the EU's internal rules in the enforcement directive.

In spite of the government-level agreement setting positive framework conditions, some practical issues in R&I cooperation still remain to be improved. These are illustrated by the low real access for South Korean-based European entities to South Korean research and innovation programmes, and the lack of penetration to public procurement of R&D services and innovative solutions. Today, only very few European companies undertake R&D activities in South Korea, whereas there are growing opportunities for cooperation, both in research and in innovation.

To support the participation of entities established in South Korea in Horizon 2020 projects, the South Korean government regularly co-funds such participation. The mechanism covers all thematic areas of Horizon 2020.

The two sides have agreed on early exchange of programme information to enable provision of such co-funding and to allow for monitoring of the cooperation intensity, as well as to continue to support efforts of multipliers, notably National Contact Points, for facilitating access to information and partnering of R&I stakeholders. Moreover, both sides have agreed to jointly promote the organisation of R&I Days and other matchmaking events to facilitate partnering with both academia and industry.

Schemes for researchers' mobility are important cooperation arrangements. The Implementing Arrangement for South Korean researchers to join the teams of European Research Council Principal Investigators is progressing well with several calls and successful visits already undertaken. So far, 109 scientists from South Korea have been selected for visiting ERC project teams during 2013-2017, and 1776 ERC grantees have expressed their intention to receive a South Korean scientist, demonstrating a very high level of interest in scientific cooperation with South Korea. Mobility of researchers is also promoted through the EU's Marie Skłodowska-Curie Research Fellowship Programme with hundreds of exchanges already taking place, and further joint efforts are undertaken to promote the participation of South Korean researchers and research institutes in this programme.

3. PRIORITIES FOR THE FUTURE IN S&T COOPERATION

3.1. Areas of future S&T cooperation agreed at latest Joint Committee

Both the EU and South Korea reaffirmed commitments to strongly encourage EU-ROK cooperation on a range of topics of common interest and mutual benefit:

- In the area of enabling and industrial technologies, ongoing projects from the EU-ROK first joint call in ICT are progressing well notably with demonstrations foreseen at the PyeongChang Olympic Games and potential to leverage the research for common positions in the context of global standardisation. A second EU-ROK joint call is planned on the challenges of 5G technologies and systems demonstrations and trials and of combining Cloud, Internet of Things and Artificial Intelligence technologies.

- The meeting confirmed acceleration of clean energy innovation through the Mission Innovation initiative as a shared commitment. Specific challenges to be addressed by projects under the next Horizon 2020 work programme notably include renewable energy sources, heating and cooling in buildings, energy systems, smart cities, energy consumers, and carbon capture utilisation and storage.

- As both sides have substantial research in the area, EU-ROK cooperation is also set to be encouraged in advanced nanoelectronics technologies developments. Strong encouragement of EU-ROK cooperation on nanosafety is also scheduled as both sides are already actively involved in a number of multilateral platforms on these issues. Furthermore, the EU side welcomed the intention of ROK to participate in the EU Observatory for Nanomaterials.

- Both sides expressed the need to continue addressing diseases at global level mainly through multi-lateral initiatives such as in the areas of infectious diseases, rare diseases and antimicrobial resistance. Very good progress was registered in the context of the initiative for Global Research Collaboration for Infectious

Disease Preparedness, GloPID-R, and the ROK side stated the wish to join also the Joint Programming Initiative on Antimicrobial Resistance, JPIAMR.

- Development of applications for the Global Navigation Satellite System was confirmed as a common priority where international cooperation is likely to add value and increase impact.

In nuclear energy research, a bilateral Work Program has been adopted with consolidation and extension of collaborative activities, specific cooperation between the South Korean KSTAR and the European JET programmes, joint exploitation of fusion facilities for risk mitigation in ITER delays, discussion on principles of an international networking of facilities in support to ITER, and potential South Korean participation in specific Broader Approach activities.

The European Commission's Joint Research Centre collaborates with South Korean institutions on seismic testing techniques for infrastructures, R&D and standardisation in construction.

3.2. Potential further areas of future S&T cooperation proposed at latest Joint Committee, through SFIC, or by thematic services

At the latest Joint Committee:

- The two sides agreed to encourage cooperation on R&D and demonstrations under the Automated Road Transport topics to test the performance and safety of innovative highly automated driving systems and on human centred design of automated vehicles.

- Both sides pledged to encourage cooperation between European and Korean research centres on innovation for disaster-resilient societies including new solutions drawing on a range of technologies adapted to the needs of first responders.

- Last year both the EU and the South Korea ratified the Paris Agreement to undertake ambitious efforts to produce solutions that contribute to mitigate and adapt to climate change. This includes common action in areas such as decarbonisation, climate services, and cryosphere research where international cooperation is encouraged on both sides.

In fission, co-operation could continue under the calls of the Euratom Programme, and future nuclear energy systems will continue to be addressed (including within the Framework Agreement for International Collaboration on R&D of Generation IV Nuclear Energy Systems). In fusion, South Korea and Euratom have roadmaps for the Demonstration Power Station developments; these are also part of the South Korean Fusion Development Plan (2007-36). South Korea might be involved in the European fusion programme and EUROfusion programme, including through consolidation of cooperation between JET and KSTAR tokamaks.

ANNEX:

HORIZON 2020 WORK PROGRAMME 2018-20 TOPICS EXPLICITLY ENCOURAGING COOPERATION WITH THE REPUBLIC OF KOREA

	Topic identifier	Topic title
2018	DT-ART-01-2018 (closed)	Testing, validation and certification procedures for highly automated driving functions under various traffic scenarios based on pilot test data
	DT-ART-02-2018 (closed)	Support for networking activities and impact assessment for road automation
	EUK-01-2018 (closed)	Cloud, IoT and AI technologies
	EUK-02-2018 (closed)	5G
	INFRAIA-01-2018-2019	Integrating Activities for Advanced Communities
	NMBP-13-2018 (closed)	Risk Governance of nanotechnology (RIA)
	NMBP-14-2018 (closed)	Nanoinformatics: from materials models to predictive toxicology and ecotoxicology (RIA)
	SC1-HCC-03-2018 (closed)	Support to further development of international cooperation in digital transformation of health and care
	LC-SC3-RES-4-2018 (closed)	Renewable energy system integrated at the building scale
	LC-SC3-RES-5-2018 (closed)	Increased performance of technologies for local heating and cooling solutions
	LC-SC3-CC-1-2018-2019-2020	Social Sciences and Humanities (SSH) aspects of the Clean-Energy Transition
	CE-SC3-NZE-2-2018 (closed)	Conversion of captured CO2
	LC-SC3-ES-3-2018-2020	Integrated local energy systems (energy islands)
	SU-DRS02-2018-2019-2020	Technologies for first responders
2019	DT-ART-03-2019	Human centred design for the new driver role in highly automated vehicles
	DT-ART-04-2019	Developing and testing shared, connected and cooperative automated vehicle

2019		fleets in urban areas for the mobility of all
	LC-MG-1-10-2019	Logistics solutions that deal with requirements of the 'on demand economy' and for shared-connected and low-emission logistics operations
	ICT-06-2019	Unconventional Nanoelectronics
	LC-SC3-NZE-5-2019-2020	Low carbon industrial production using CCUS
	LC-CLA-07-2019	The changing cryosphere: uncertainties, risks and opportunities
	NMBP-15-2019	Safe by design, from science to regulation: metrics and main sectors (RIA)
	SPACE-EGNSS-4-2019	Awareness Raising and capacity building
	DT-SPACE-06-EO-2019	International Cooperation Copernicus – Designing EO downstream applications with international partners
	SU-SPACE-22-SEC-2019	Space weather
	LC-SC3-RES-1-2019-2020	Developing the next generation of renewable energy technologies
	LC-SC3-RES-29-2019	Converting Sunlight to storable chemical energy
	LC-SC3-ES-6-2019	Research on advanced tools and technological development

Figure 3: Republic of Korea – Top scientific areas compared to EU28 in terms of citation impact of publications

	Scientific Area	Share in world output	Share of international co-publications	Citation Impact Difference with EU28	8-year trend
High publication output	Chemical Engineering: Catalysis	3,9%	37%	+0.44	↑
	Materials Science: Biomaterials	5,0%	33%	+0.4	–
	Engineering: Building and Construction	2,9%	29%	+0.33	–
	Materials Science: Metals and Alloys	4,9%	26%	+0.27	↑
	Energy: Renewable Energy, Sustainability and the Environment	4,1%	27%	+0.19	↑
	Materials Science: General Materials Science	5,5%	29%	+0.19	↑
	Engineering: Mechanics of Materials	4,3%	33%	+0.18	↑
	Physics and Astronomy: Surfaces and Interfaces	5,1%	26%	+0.17	↑
	Chemistry: Physical and Theoretical Chemistry	2,7%	37%	+0.17	↑
	Chemical Engineering: Bioengineering	8,1%	25%	+0.16	↑
Low publication output	Pharmacology, Toxicology and Pharmaceutics: Miscellaneous	1,9%	10%	+1.07	–
	Nursing: Emergency Nursing	1,2%	17%	+1.06	–
	Business, Management and Accounting: Management Information Systems	1,6%	58%	+0.93	–
	Social Sciences: Library and Information Sciences	1,4%	39%	+0.87	↑
	Social Sciences: Law	0,6%	37%	+0.62	↑
	Chemical Engineering: Process Chemistry and Technology	3,8%	24%	+0.58	↑
	Decision Sciences: Information Systems and Management	1,5%	50%	+0.58	↑
	Biochemistry, Genetics and Molecular Biology: Miscellaneous	6,8%	11%	+0.5	–
	Engineering: Miscellaneous	3,3%	35%	+0.44	↑
	Chemical Engineering: Filtration and Separation	4,6%	39%	+0.43	↑

Source: DG Research and Innovation – International Cooperation
Data: Elsevier SciVal; extraction date: 6/8/2017; publications' window: 2011-2013; citations' window: 3 years
Note: These tables show scientific areas in which the country's academic publications have a higher citation impact than EU28, and whether this difference has decreased, increased or remained the same in the past 8 years. They are grouped in two tables. The top table focuses on areas with high share of publications in the country's total output of publications and the bottom table on those with low share of publications. Scientific areas are based on Elsevier 'All Science Journal Classification'. For each area, the country's share in the world output of publications and the share of international co-publications are also shown.

Figure 4: Republic of Korea – Specialisation compared to EU28 in selected technologies based on PCT patents

	Technology	2014 PCT patents	2014 PCT patents of EU28	2014 Specialisation compared to EU28	8-year trend
OECD classification	ICT	6.009	14.579	1,62	–
	Nanotechnology	48	137	1,38	↑
	Medical technology	891	3.879	0,90	↑
	Pharmaceuticals	548	2.524	0,85	↑
	Biotechnology	567	2.745	0,81	↑
	Selected environment-related technologies	678	3.663	0,73	↑
WIPO classification	IT methods for management	442	425	3,78	↑
	Telecommunications	566	749	2,75	↓
	Audio-visual technology	526	761	2,51	↓
	Digital communication	1.813	2.700	2,44	↑
	Semiconductors	518	820	2,30	↓
	Computer technology	926	1.762	1,91	↑
	Furniture, games	319	952	1,22	↓
	Other consumer goods	403	1.238	1,18	↓
	Optics	309	959	1,17	↓
	Electrical machinery, apparatus, energy	990	3.101	1,16	↑
	Macromolecular chemistry, polymers	261	870	1,09	↑
	Micro-structural and nano-technology	23	86	0,97	↓
	Food chemistry	128	484	0,96	↓

Source: DG Research and Innovation – International Cooperation
Data: OECD (top table) WIPO (bottom table); extraction date: 6/8/2017
Note: The top table shows the relative specialisation of the 2014 PCT patent output of the country with respect to EU28, calculated as (# of patents of country in technology X / # of patents of country in all technologies) / (# of patents of EU28 in technology X / # of patents of EU28 in all technologies). It also shows whether the relative specialisation has increased, decreased or remained the same in the past 8 years. The selected technologies are classified based on the OECD database. The bottom table shows the same information for the top-13 technologies with the highest specialisation index with respect to EU28 - this time the technology classification is based on the WIPO database. Both tables also show the country's and EU28 total number of PCT patents under each technology in 2014.