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EPO press release

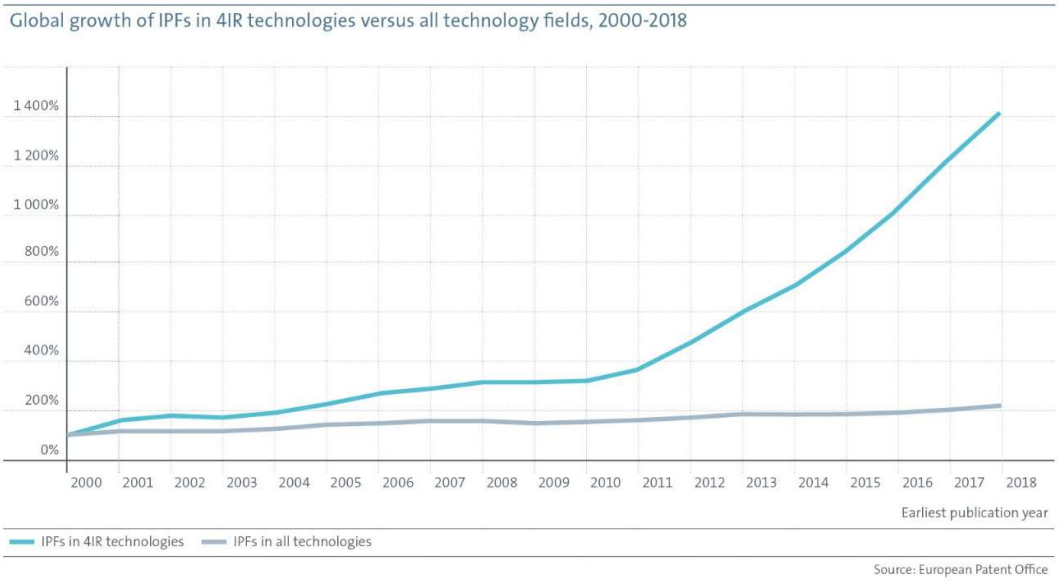
Innovation in smart connected objects accelerating fast worldwide, new patent data shows

- EPO study reveals that technologies of the fourth industrial revolution (4IR) accounted for more than 10% of all patenting activity worldwide in 2018
- Global growth of 4IR patents nearly five times faster than average
- US is world leader; strong growth from China and South Korea; Europe losing ground
- Within Europe, Germany, UK and France account for largest shares of 4IR innovation, but several smaller economies performing better
- Top 20 regional clusters responsible for well over half of all patenting activity, with 13 largest clusters all located in Asia or US

Munich, 10 December 2020 – A study published today by the European Patent Office (EPO) shows that innovation in fourth industrial revolution (4IR) technologies has accelerated significantly worldwide. Between 2010 and 2018, global patent filings for these technologies, which concern smart connected objects and span the Internet of Things, big data, 5G, and artificial intelligence (AI), grew at an average annual rate of almost 20% – nearly five times faster than the average of all technology fields.

The study, entitled *Patents and the Fourth Industrial Revolution – the global technology trends enabling the data-driven economy*, looks at all international patent families (IPFs) related to 4IR worldwide between 2000 and 2018. Each of these represents a high-value invention for which patent applications have been filed at two or more patent offices globally. The study finds that nearly 40 000 new IPFs were filed for these technologies in 2018 alone. This means they accounted for more than 10% of all patenting activity worldwide that year.

"Constellations of smart connected devices, faster wireless internet, big data and AI are transforming the global economy and having a profound impact across many sectors, from manufacturing to healthcare to transport," said EPO President António Campinos. "What we are seeing is not just an acceleration of the development of information and communications technology – it is a major shift towards a fully data-driven economy. While Europe is not growing as fast as other regions, our strength lies in the diversity of our innovation ecosystem, the strong performance of some of our smaller countries with their high levels of specialisation, and some innovative regional clusters."

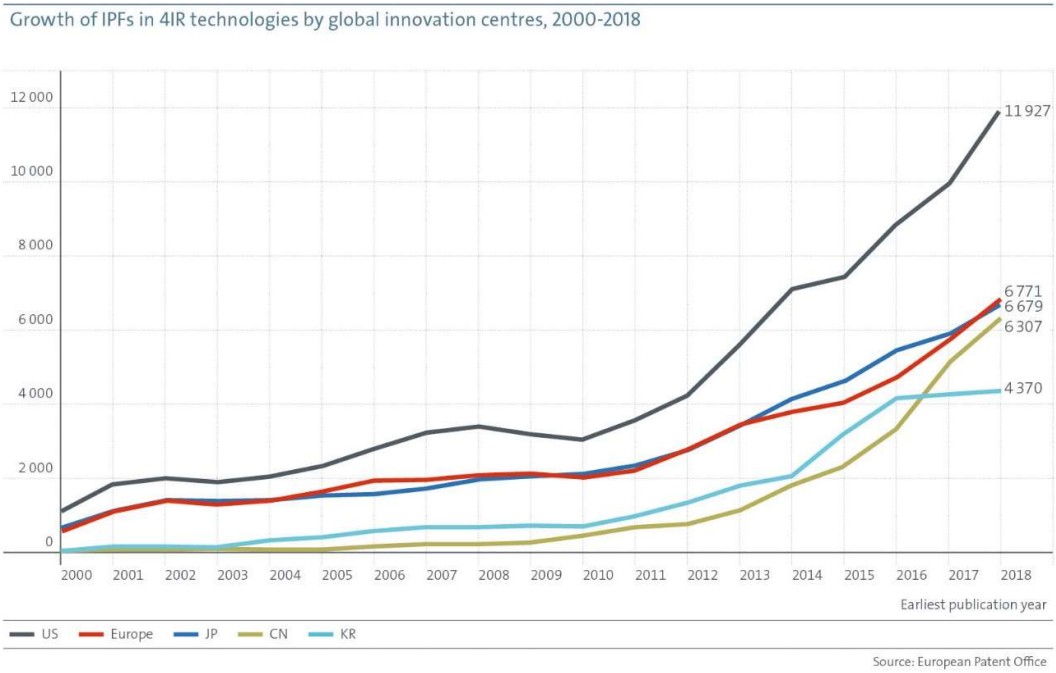


In terms of technology fields, the study finds that innovation has risen most sharply in the areas of connectivity and data management. With nearly 14 000 IPFs in 2018 and annual growth of 26.7% since 2010, connectivity, which covers protocols, short and long range communication, is the largest of all the 4IR technology fields analysed. This impressive rise has been largely driven by the development of 5G, which will support the massive deployment of 4IR technologies. Data management, which encompasses all technologies aiming at exploiting data, from their creation, processing and analysis to feedback execution, has posted average annual growth of 22.5% since 2010, and in 2018 accounted for more than 11 000 IPFs.

A large variety of application domains have likewise been impacted by 4IR innovation over the same period, ranging from consumer goods to services, vehicles, healthcare and industry. The largest application domain, smart consumer goods (e.g. wearables, entertainment, toys, textiles), generated more than 10 000 IPFs in 2018 alone (see Figure: *Global growth of IPFs in application domains, 2000-2018*).

US in the lead, Europe growing but losing ground

Looking at the geographical origin of 4IR innovation, the study confirms that the US remains the world leader, accounting for around a third of all inventions between 2000 and 2018, compared with Europe and Japan with about one fifth each. The US has even reinforced its lead in patents filed globally since 2010, growing annually on average by 18.5%, which is faster than both Europe and Japan (average annual growth rates of 15.5% and 15.8% over the same period). Starting from very low levels in the late 2000s, the innovative activity of China and South Korea has increased at a very high rate (posting annual average growth of 39.3% and 25.2% respectively from 2010 until 2018).



Both the rapid emergence of China and South Korea and the steep development of patent applications from other regions has caused Europe to lose ground to other global 4IR innovation centres.

Looking inside Europe, Germany alone produced 29% of all 4IR patents generated by European companies and inventors between 2000 and 2018 – more than twice the contribution of the United Kingdom (14.3%) and France (12.5%). However, the average growth of 4IR innovation in these three countries between 2010 and 2018 has been well below the world average (of 19.7%). By contrast, the fastest growing European countries were Sweden (+22.6%) and Switzerland (+19.6%), which posted increases in IPFs from 2010 to 2018 that equalled or even exceeded the global average. Several smaller countries, notably Sweden (10.1% of all European IPFs since 2000), the Netherlands (7.7%), Finland (6.9%) and Switzerland (3.5%) are significant contributors to 4IR innovation in Europe. Furthermore, Finland and Sweden are European champions with respect to IPFs per million inhabitants (651 and 524 respectively over the period 2000-2018), which is comparable to that of South Korea (525).

Top applicant ranking highlights rise of South Korea and China

The top 10 applicants in the period 2010-2018 accounted for nearly a quarter of all IPFs for 4IR technologies. The list is headed by South Korean companies Samsung and LG, and also includes four US companies, two European companies and one from each of Japan and China. A comparison with the ranking for the period 2000 to 2009 shows that the top European and Japanese applicants have lost ground to their US, South Korean and Chinese counterparts since 2010.

Comparison of top 10 applicants between 2000-2009 and 2010-2018

Ranking 2000-2009			Ranking 2010-2018			
	Company	Share		Company	Share	Change
1	SAMSUNG ELECTRONICS [KR]	2.8%	1	SAMSUNG ELECTRONICS [KR]	5.2%	=
2	SONY [JP]	2.6%	2	LG [KR]	2.9%	+
3	PANASONIC [JP]	2.1%	3	QUALCOMM [US]	2.7%	+
4	SIEMENS [DE]	1.8%	4	SONY[JP]	2.4%	-
5	NOKIA [FI]	1.8%	5	HUAWEI [CN]	2.1%	+
6	PHILIPS [NL]	1.7%	6	INTEL [US]	2.0%	+
7	APPLE [US]	1.5%	7	MICROSOFT [US]	1.8%	+
8	MICROSOFT [US]	1.5%	8	ERICSSON [SE]	1.7%	+
9	CANON [JP]	1.4%	9	NOKIA [FI]	1.5%	-
10	HITACHI [JP]	1.3%	10	APPLE [US]	1.5%	-
	Total 2000-2009	18.5%		Total 2010-2018	23.8%	

4IR innovation concentrated in regional clusters

The patent data in the study also shows that innovation is concentrated in certain regional clusters of innovation around the world, typically in large urban agglomerations with an ecosystem of high-performing R&D institutions around leading companies. The top 20 4IR clusters constitute the main sources of 4IR innovation in their countries and are jointly responsible for well over half (56.3%) of all IPFs in the period 2010-2018. The regional ranking is topped by 13 Asian and US clusters, followed by seven clusters located in Europe and the Middle East, all with different leading companies and 4IR specialisation profiles (see Figure: *Top global 4IR clusters in Europe and the Middle East*).

The two main 4IR clusters (Seoul and Tokyo) each account for nearly 10% of IPFs worldwide, and the third one, San José (Silicon Valley), for another 6.8%. All US, South Korean and Chinese clusters in the top 10 grew strongly between 2010 and 2018, with the region of Beijing achieving the highest increase (at 30% per year). By contrast, top clusters in Europe and Japan have experienced lower average annual growth. In comparison with the very large global clusters observed elsewhere, innovation activities in Europe also appear to be distributed between smaller regional clusters.

Top 20 global 4IR clusters

Global ranking	Cluster	Country	Share 4IR (2010-2018)	Average growth rate (2010-2018)
1	Seoul	KR	9.9%	22.7%
2	Tokyo	JP	9.8%	10.3%
3	San José	US	6.8%	21.1%
4	Osaka	JP	4.0%	9.1%
5	Shenzhen	CN	3.1%	20.6%
6	San Diego	US	2.9%	20.2%
7	Seattle	US	2.4%	21.5%
8	Beijing	CN	2.3%	30.5%
9	New York	US	2.0%	13.8%
10	Detroit	US	1.5%	25.8%
11	Taipei City	TW	1.4%	16.5%
12	Boston	US	1.4%	12.2%
13	Los Angeles	US	1.3%	13.7%
14	Tel Aviv	IL	1.2%	15.4%
15	Eindhoven	BE/DE/NL	1.2%	8.9%
16	London	GB	1.1%	12.9%
17	Munich	DE	1.1%	16.1%
18	Stockholm	SE	1.0%	15.2%
19	Paris	FR	1.0%	8.5%
20	Stuttgart	DE	0.9%	11.4%

Further information

Read the full study and executive summary at: epo.org/trends-4IR

Notes to the editor

- This study will be presented by the EPO's Chief Economist on 17 December 2020 at a virtual conference entitled *The role of patents in an AI driven world*. (17/18 December 2020). Find out more and register (free of charge) for this event.
- Read more about the Fourth Industrial Revolution.
- For more statistics, visit the EPO's Patent Index 2019.

About the study

This is the second study published by the EPO on patents and the fourth industrial revolution, following the publication of a report in December 2017 focussing on European patents. The current study takes a global perspective and is based on the concept of international patent families (IPFs). It looks at all IPFs filed by companies and inventors around the world from 2000 to 2018 across over 350 distinct technology fields. The study also pinpoints the major clusters for particular 4IR competences in the US, Europe, Japan, South Korea and China, and includes four case studies highlighting a range of inventions related to the fourth industrial revolution.

About international patent families

The patent analysis in this report is based on international patent families (IPFs). Each IPF represents a unique invention and includes patent applications filed and published in at least two countries or filed with and published by a regional patent office, as well as published international patent applications. IPFs represent inventions deemed important enough by the inventor to seek protection internationally, and only a relatively small percentage of applications meet this threshold. They can thus be used as a sound basis for comparing

international innovation activities, as they reduce the biases that may arise when comparing patent applications across different national patent offices.

About the EPO

With 6 600 staff, the European Patent Office (EPO) is one of the largest public service institutions in Europe. Headquartered in Munich with offices in Berlin, Brussels, The Hague and Vienna, the EPO was founded with the aim of strengthening co-operation on patents in Europe. Through the EPO's centralised patent granting procedure, inventors are able to obtain high-quality patent protection in up to 44 countries, covering a market of some 700 million people. The EPO is also the world's leading authority in patent information and patent searching.

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