Europäisches Patentamt
European Patent Office
Office européen des brevets

Patents and the Fourth Industrial Revolution

The global technology trends enabling the data-driven economy
Main findings | December 2020

Executive summary

Purpose of the study

The European Patent Office (EPO) intends this study to guide policymakers, industry and the broader public through a major technology transformation that impacts a wide range of sectors of the economy. Known as the Fourth Industrial Revolution [1] (4IR), this global trend is driven by a constellation of disruptive technologies which together are paving the way to a data-driven economy.

By 2023, it is estimated that more than 29 billion devices will be connected to Internet Protocol networks across the globe, most of which will be creating data in real time. Once combined with other technologies, such as big data, 5G or artificial intelligence, they enable the automation of entire business processes, including repetitive intellectual tasks previously performed by human beings. It is estimated that the cumulative additional GDP contribution of these new digital technologies could amount to EUR 2.2 trillion in the EU alone by 2030, a 14.1% increase from 2017 (European Commission, 2020). Leading innovators in these technologies are already shaping the data-driven economy for the years to come. Meanwhile, others may struggle or even disappear in the wake of 4IR disruptions.

Drawing on the latest information available in published patent documents, the data presented in this study show trends in high-value inventions for which patents have been filed in more than just the inventors' domestic market, by counting international patent families (IPFs [2]). It offers insights into which countries, companies and regional clusters are leading the way in 4IR technologies and thus are best placed to benefit from the data-driven economy in the near future. By highlighting the fields that are gathering momentum and the cross-fertilisation taking place between these fields, this study provides a guide for policy and business decision-makers to direct resources towards value creation in the digital era.

About patents and patent information

Patents are exclusive rights for inventions that are new and inventive. High-quality patents are assets for inventors because they can help attract investment, secure licensing deals and provide market exclusivity. Patents are not secret. In exchange for these exclusive rights, all patent applications are published, revealing the technical details of the inventions in them.

Patent databases therefore contain the latest technical information, much of which cannot be found in any other source, which anyone can use for their own research purposes. The EPO's free Espacenet database contains more than 120 million patent documents from around the world, and comes with a machine translation tool in 32 languages. This patent information provides early indications of technological developments that are bound to transform the economy. It reveals how innovation is driving the Fourth Industrial Revolution.

1 Fourth Industrial Revolution is the term used by Klaus Schwab, founder and Executive Chairman of the World Economic Forum, in his recent book on this subject ("The Fourth Industrial Revolution", 1st edition, New York; Crowne Business, 2017.).

2 Each IPF covers a single invention and includes patent applications filed and published at several patent offices. It is a reliable proxy for inventive activity because it provides a degree of control for patent quality by only representing inventions for which the inventor considers the value sufficient to seek protection internationally. The patent trend data presented in this report refer to numbers of IPFs.

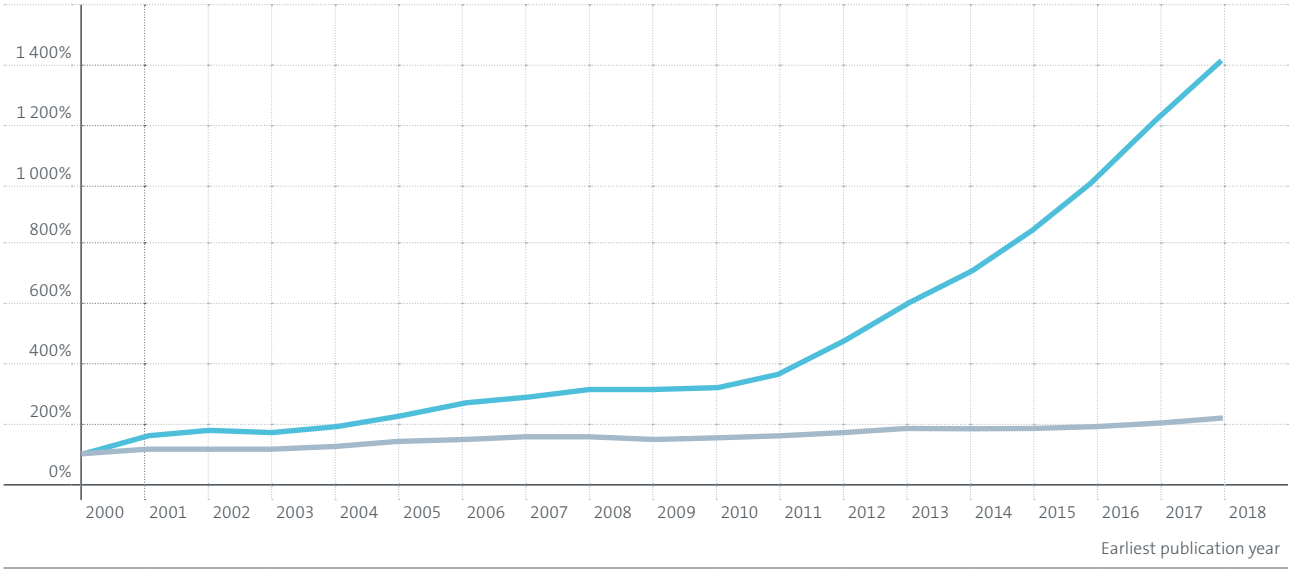
Main findings

Highlight 1: *4IR innovation has dramatically accelerated during the past decade and accounted for more than 10% of global innovation in 2018.*

The pace of global Innovation in 4IR technologies accelerated strongly during the last decade, with an average annual growth rate in patenting close to 20% from 2010 to 2018, compared with 12.8% between 2000 and 2009 (Figure E1). The annual increase in international patent families (IPFs) for 4IR technologies has been nearly five times greater than the growth of IPFs in all fields since 2010 (4.2%). As a result, smart connected objects accounted for more than 11% of all patenting activity worldwide in 2018, with nearly 40 000 new IPFs in 2018 alone.

Figure E1

Global growth of IPFs in 4IR technologies versus all technology fields, 2000-2018

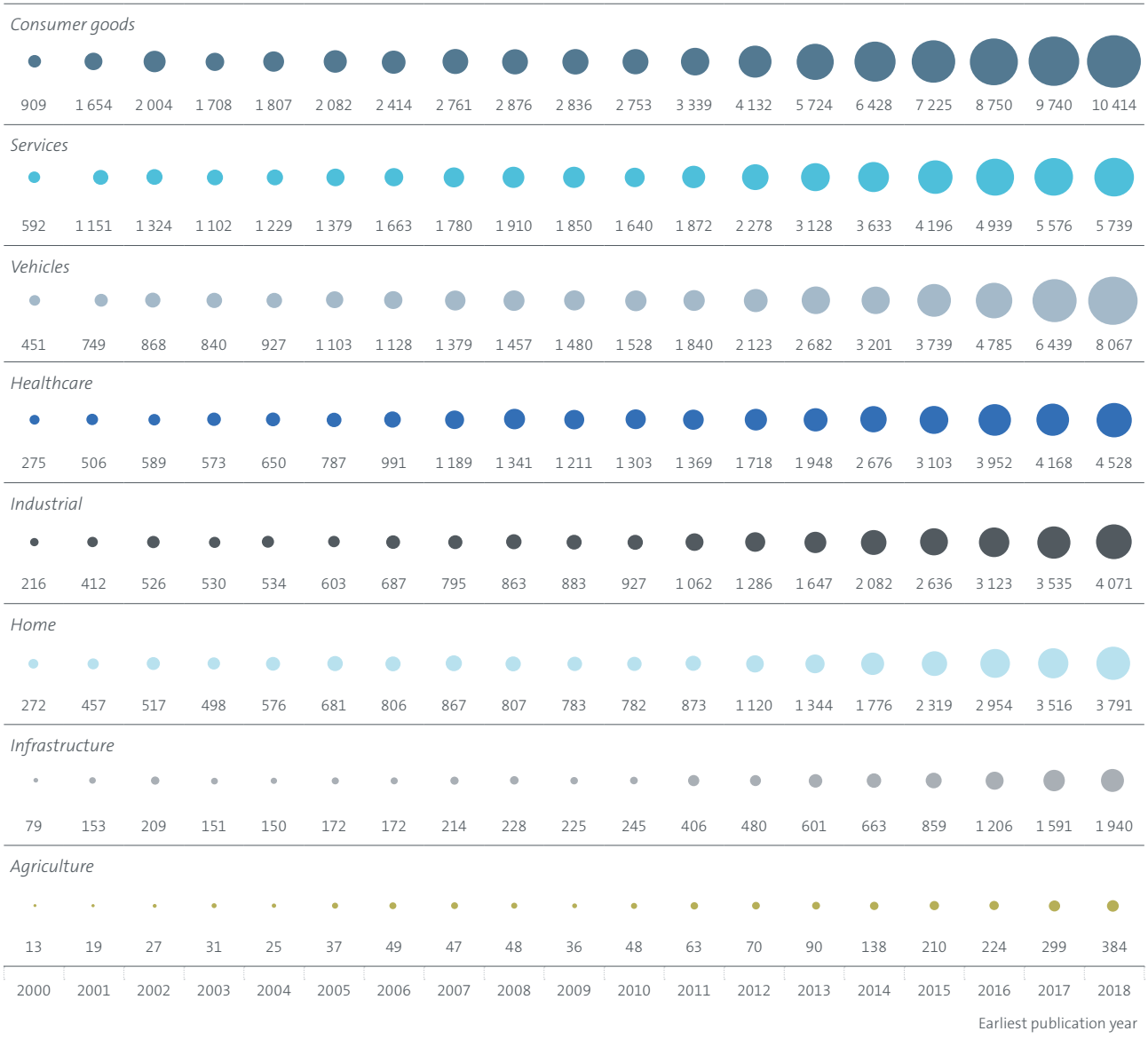


Source: European Patent Office

Similar growth trends are observed in all categories of 4IR technology fields, along with an increasing convergence between those fields. The rise of patenting activities has been especially impressive in connectivity and data management, with up to 14 000 and 11 500 IPFs respectively posted in these two fields in 2018 alone, and annual growth rate of 26.7% and 22.5% respectively between 2010 and 2018. A large variety of application domains have likewise been impacted by 4IR innovation over the same period, from smart industry, agriculture, and infrastructure to smart services (Figure E2). Among them, smart consumer goods (e.g. wearables, entertainment, toys, textiles) generated more than 10 000 IPFs in 2018 alone.

Figure E2

Global growth of IPFs in application domains, 2000-2018



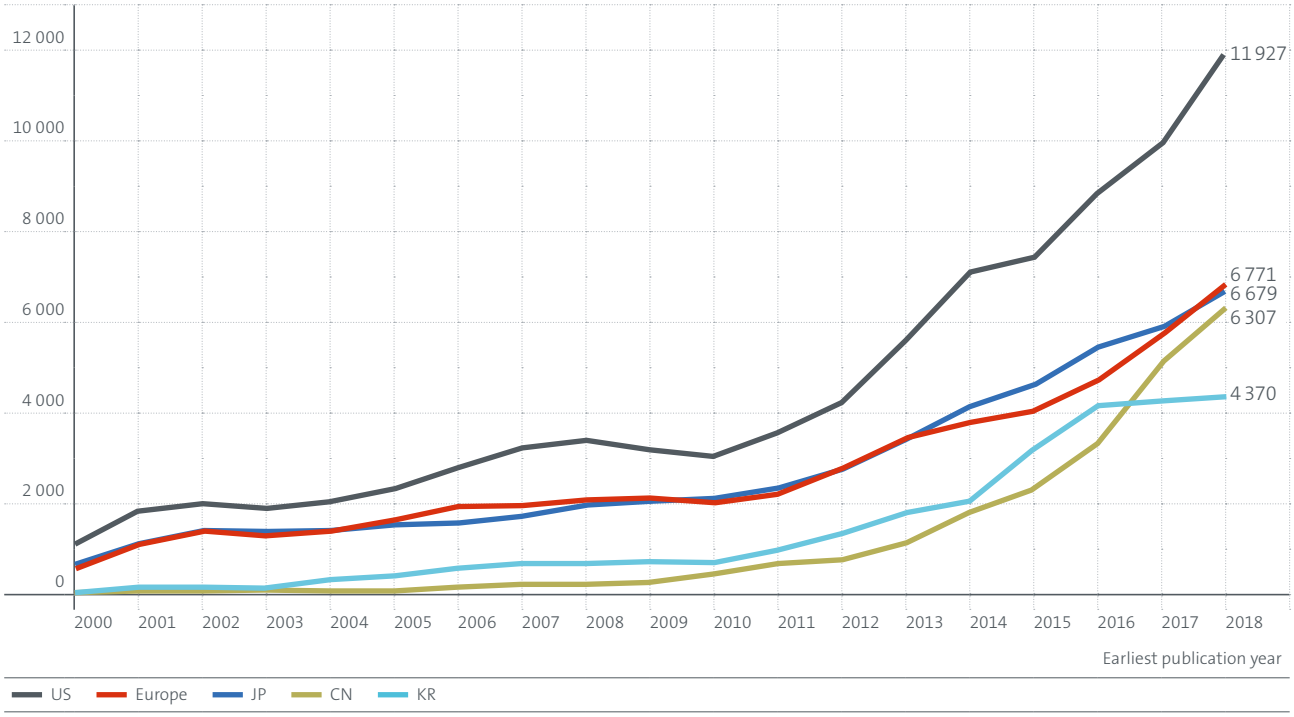
Source: European Patent Office

Highlight 2: *The US remains the world leader in 4IR technology, despite the fast growth of 4IR innovation in Korea and China. Europe*[3] *is losing ground to other global 4IR innovation centres, despite the remarkable performance of small countries such as Sweden and Switzerland.*

The US is by far the most innovative world region in 4IR technologies, with about one third of all the IPFs between 2000 and 2010 (Figure E3) and a strong presence in all technology sectors of 4IR. The US further reinforced this lead after 2010, due to a faster growth of 4IR IPFs (+18.5% annually on average) than in Europe and Japan. Europe and Japan each account for about one fifth of all IPFs in 4IR since 2000. The Republic of Korea and the People's Republic of China account for another 10% each, with a stronger specialisation in the core technology fields of IT hardware, software and connectivity. However, they started from very low levels in the late 2000s and their innovative activities have increased very fast since then (25.2% and 39.3% respectively per year on average).

Figure E3

Growth of IPFs in 4IR technologies by global innovation centres, 2000-2018



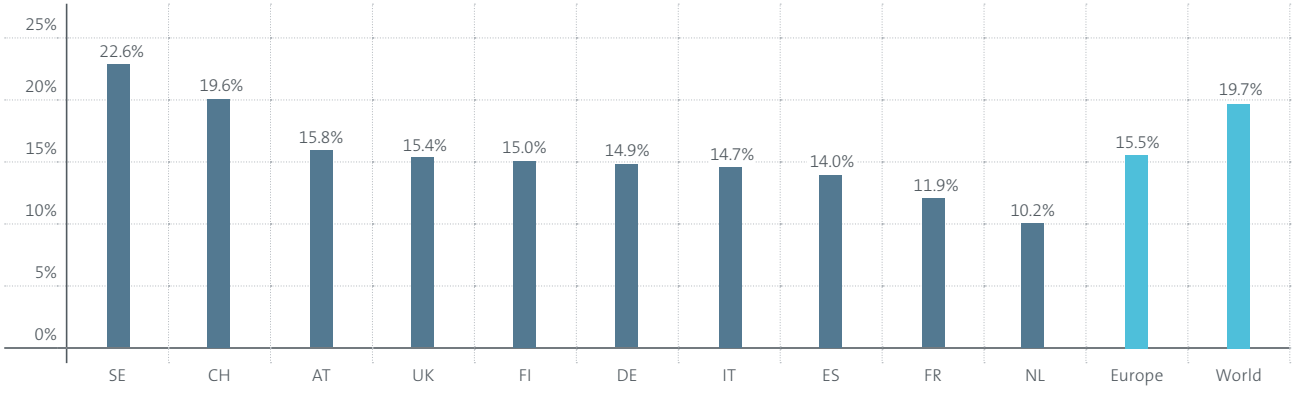
Source: European Patent Office

3 Europe is defined as comprising all 38 member states of the European Patent Organisation.

Germany alone produced 29% of all the IPFs generated in Europe between 2000 and 2018 - more than twice the contribution of the United Kingdom and France, each with 10% of European IPFs. However, the average growth of 4IR innovation in these countries in the past decade has been well below the world average (19.7%). The performance of smaller European countries is all the more remarkable in this context. With 651 and 524 IPFs respectively per million inhabitants over the period 2000-2018, Finland and Sweden show a productivity in 4IR innovation that is comparable to that of Korea (525). From 2010 to 2018, Sweden and Switzerland also posted a growth of IPRs that equals or even exceeds the global average over this period.

Figure E4

Average annual growth of IPFs for 4IR technologies in leading European countries, 2010-2018



Source: European Patent Office

Highlight 3: *The dynamism of national industry champions and regional clusters in 4IR technologies explains the domination of the US and the rise of Korea and China in the 4IR innovation landscape. By contrast, the relative weight of the top European and Japanese 4IR applicants has diminished since 2010, while the main 4IR clusters in Europe and Japan have experienced slower growth in their innovative activities.*

The top 10 applicants in the period 2010-2018 together account for 23.8% of all international patent families (IPFs) for 4IR technologies, up from 18.5% in the period 2000-2009. They feature four US companies, two Korean companies and two European companies, while Japan and China are represented by one company each. Korean companies Samsung and LG dominate the ranking, with 5.2% and 2.9% respectively of all IPFs and similar specialisation in IT hardware, power supply, and smart goods and services. The entry of Chinese company Huawei in the top 10 after 2010 illustrates the fast rise of 4IR innovation in China in recent years. By contrast, top European and Japanese applicants have lost ground to their US and Asian counterparts during the same period.

Table E1

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%	

Innovative activities are often geographically concentrated into regional clusters, typically in large urban agglomerations with an ecosystem of R&D-performing institutions around leading companies. The top 20 4IR clusters identified in the study constitute the main engines of their respective countries' performance in 4IR innovation and are jointly responsible for more than half (56.3%) of all IPFs in the period 2010-2018. Their ranking (Table E2) is topped by thirteen Asian and US clusters, followed by seven clusters located in Europe and the Middle East, all with different leading companies and 4IR specialisation profiles.

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, Korean and Chinese clusters in the top 10 showed impressive annual growth rates of around 20% between 2010 and 2018, and even 30% for the region of Beijing. By contrast, top clusters in Europe and Japan have experienced a more limited average annual growth, of 8% to 16%, during the same period. In comparison with the very large global clusters observed in other parts of the world, innovation activities in Europe also appear to be distributed between smaller regional clusters located across its different countries.

Table E2

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%

The full report is available for download at:
epo.org/trends-4IR

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