CHAPTER 2

CHANGING INNOVATION DYNAMICS IN THE AGE OF DIGITAL TRANSFORMATION

KEY FIGURES

2 years, 8 months
time it took Skype to reach 100 million users worldwide

5 percentage points
decline in entry rates in digital-intensive sectors compared to 2001

72 %
share of R&D expenditure of the top 250 R&D investors in the world's top 2000

7/10
top companies by market capitalisation are US and Chinese tech giants

What can we learn?

- **Consumer-driven innovations are spreading faster than ever** due to the transition from physical to digital goods combined with strong network effects in the digital age. This is in contrast to the apparent insufficient diffusion of productivity-enhancing technologies across firms.
- **Convergence of the digital and physical worlds is increasing the complexity of innovation** and leading to deep-tech science-driven innovations.
- There is **increasing industry concentration (also for R&I indicators)** and mark-ups over time (in Europe but to a greater extent in North America), not confined to digital-intensive sectors.
- **The dominance of 'tech giants' is not only visible in terms of R&D concentration** and market capitalisation **but also when it comes to some of the key services and infrastructure underpinning digitalisation**, such as search engines, operating systems or cloud infrastructure.
- While R&I investments needed to produce deep-tech innovations can prove costly, **companies that sell digital products can operate under almost 'zero marginal costs'** which can contribute to a greater ability to dominate markets.

What does it mean for policy?

- Promote the **access to data** for innovation in Europe while providing clarity about **principles and regulations** governing privacy and the ethical use of data.
- The increase in concentration has implications for business dynamism, **competition policy, and wealth distribution. Promote competition policies 'fit for the digital age' and measure and assess the impact of the 'digital economy'**.
- With innovation moving at unprecedented speeds, **policymaking also needs to react faster** to the changing contexts. Also, new rules are needed to ensure digital business activities are taxed in a fair and growth-friendly way.
- **Fostering deep-tech, science-based innovations requires a policy mix** that supports frontier research, multidisciplinary teams, R&D labs, innovation and digital hubs, and the availability of capital, notably patient capital.
- Create the right framework conditions for **digital firms in the EU to be able to succeed and compete globally** in the markets providing digital technologies that are underpinning digitalisation.

1. The 5 Cs of the changing dynamics of innovation: celerity, complexity, concentration, costs and consumers

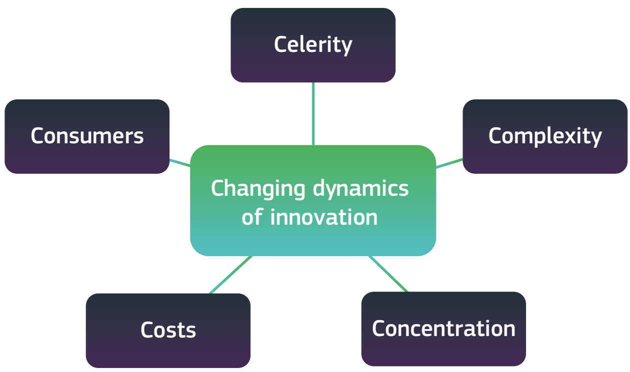
Digitalisation is transforming every aspect of our world. The rise of new technologies, in particular digital technologies and their convergence with the physical world, is affecting millions of workers and companies. New technologies have triggered a global race for investment, talent, knowledge and research. This has several consequences, in particular in terms of industrial policy. Moreover, these new digital technologies have redefined the way in which markets operate and have attracted more attention to high-growth innovative platform-based companies, e.g. the so-called 'tech giants' (Google, Apple, Facebook, Amazon, Microsoft, Baidu, Tencent, Alibaba), a set of global companies which are reaping large economic benefits. The traditional 'innovation pipeline' – research leading to discovery leading to innovation and growth – no longer describes the reality, or not necessarily in those terms.

Furthermore, many innovations in the digital age have enabled companies to operate under a paradigm of close to 'zero marginal cost'. For instance, more and more individuals playing music and using software does not generate additional costs for the company. Innovation has also become more 'consumer-centric' as consumers increasingly look for customised 'solutions' rather than 'products' or 'services'.

At the same time, new technologies are promising large productivity gains although these have yet to materialise. In particular, productivity growth, which largely depends on R&I, is sluggish and continues to hold back more robust growth (see Chapter 3.1 - Productivity puzzle and innovation diffusion).

Hence, in this chapter, we describe in more detail the five main characteristics of the changing dynamics of innovation in the age of digital transformation – celerity, complexity, concentration, costs and consumers - as represented in Figure 2-1.

Figure 2-1 Main characteristics of the 'changing dynamics of innovation'



Source: DG Research and Innovation, Chief Economist - R&I Strategy & Foresight Unit
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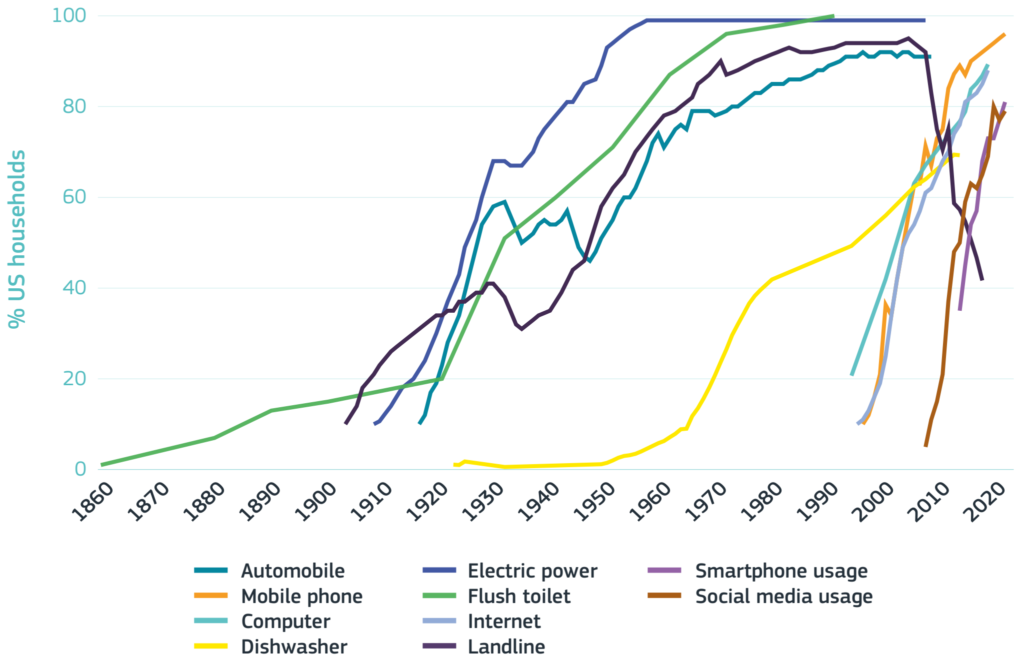
2. Celerity

Technology, and notably consumer-driven innovation, is spreading faster than ever due to the transition from physical to digital goods combined with strong network effects in the age of digital transformation. The pace of change in consumer-driven innovation has accelerated tremendously over time in the era of digitalisation and increasing connectivity. Indeed, innovations are being adopted at a higher rate than in previous decades and centuries. Figure 2-2 shows that it took much longer for potentially all US households to have a flush toilet in their homes, own a car and a dishwasher, or have electricity than to use the internet and even less to use a smartphone or engage in social media channels. The steeper the lines in the graph, the faster the adoption rates for those technologies. However, as noted in Chapter 3.1 - Productivity puzzle and innovation diffusion, a slowdown in innovation diffusion continues to hold back a stronger uptake of innovations across companies and industries, even if business-to-consumer (B2C) innovations have been adopted at faster rates than before, fostered by digitalisation.

Figure 2-2 Technology adoption rates of selected innovations[1] over time, US households, 1860-2019



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Source: DG Research and Innovation, Chief Economist - R&I Strategy & Foresight Unit, adapted from Hannah Ritchie and Max Roser (2019). Data retrieved from: 'https://ourworldindata.org/technology-adoption', based on multiple sources

Note: [1]Technology adoption rates measured as the percentage of households in the United States using a particular technology. The dataset is a compilation of multiple sources to construct a broad overview of the adoption of technology in the United States. The multiple sources of the dataset as well as the definition of the variables are described in Hannah Ritchie and Max Roser (2019).

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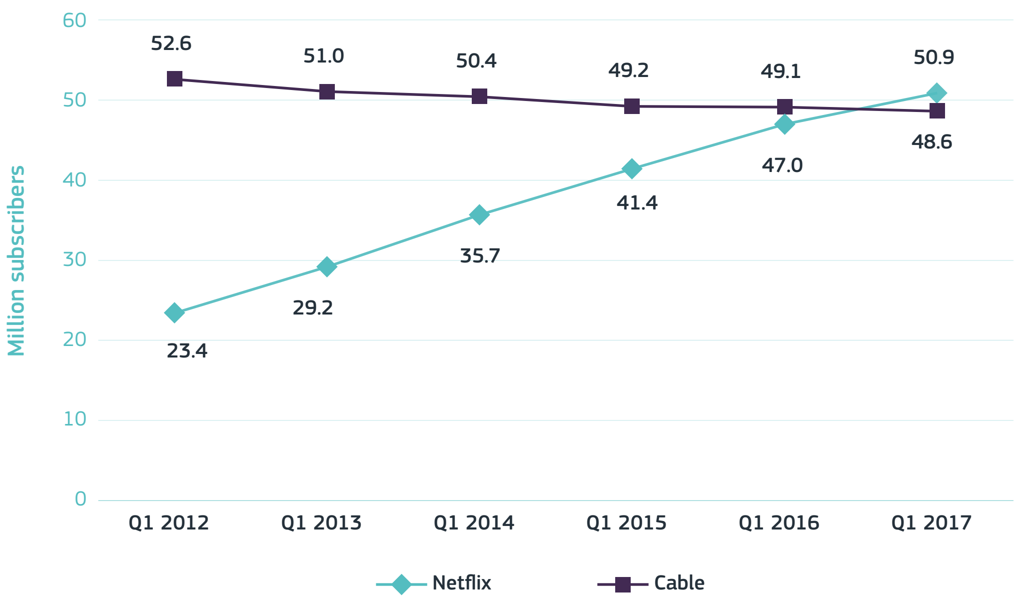
As mentioned by the European Commission (2018a), with innovation changing at an unprecedented speed, what was innovative before becomes non-innovative extremely quickly. For example, mobile phones failed to make the transition to 'smartphones' on time and rapidly lost their market share and relevance. Another example is 'Pay television': it appears that cable TV's subscription base has been in decline, in favour of the almost linear growth of Netflix subscribers (Figure 2-3). Netflix is a subscription-based online streaming platform for movies and TV shows which also produces in-house content. This streaming platform makes use of sophisticated algorithms to generate new content and recommendations according to user preference. It would appear that, since 2017, the number of Netflix subscriptions in the United States has surpassed the number of subscribers to Pay TV. Another example is the decline in the photographic industry from 121 million of shipments worldwide in 2010 to only 19 million in 2018, partly due to the global expansion of smartphones with embedded cameras (Statista, 2019).

Another way to look into the speed of technology adoption is to consider the time it took for new products and services to reach 100 million users since they were launched to the public (Figure 2-4). The telephone was launched in 1878 and it took 75 years for 100 million people to use it since it also relied on the parallel development and expansion of physical infrastructure. This compares to 16 years for the mobile phone, launched in 1979, and 7 years for the internet. In the 2000s, digitalisation spread to the economy quicker than ever, which means that less and less time was needed for new digital products to reach a customer base of 100 million users. For instance, it took just 2 years and 8 months for

Figure 2-3 Number of Netflix subscribers vs. pay-tv subscribers in the United States, in millions, 2012-2017



Source: Statista based on Netflix, Leichtman Research Group
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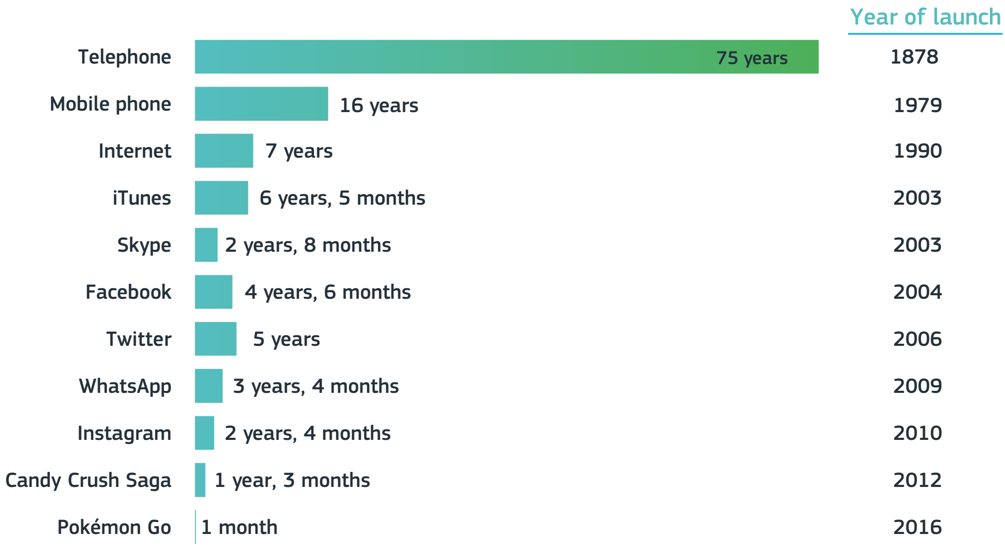
Skype to get 100 million registered users, 2 years and 4 months for Instagram to register 100 million monthly users, and only 1 month for 100 million downloads of Pokémon GO. These examples illustrate how digitalisation has profoundly changed areas such as communication (from the telephone, to the mobile phone, Smartphone, to Skype and WhatsApp) or the entertainment industry (from vinyl, CD-ROMs, iTunes to YouTube and Spotify in the music business, for example).

Figure 2-4 Time for new products and services to reach 100 million users[1], by year of launch



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Source: DG Research and Innovation, Chief Economist - R&I Strategy & Foresight Unit, adapted from BCG (2015) and based on ITU (Telephone and Mobile phone), Scientific American (World Wide Web), Internet Live Stats, Fortune (iTunes), Facebook, Wired (WhatsApp), Techcrunch (Instagram), AppMtr.com (Candy Crush Saga), arinsider.co (Pokemon Go), Searchengineisland (Twitter)

Note: [1]iTunes: number of accounts; Facebook: monthly active users; WhatsApp: active users; Instagram: monthly users; Candy Crush Saga: Facebook users only; Pokemon Go: number of downloads; Twitter: active users; Skype: registered users.

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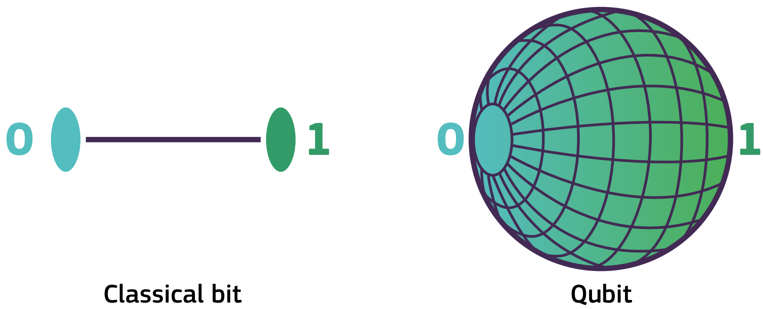
Network effects are also underpinning the speed of these developments, particularly in the digital age. According to Metcalfe's law, 'the effect of a network is proportional to the square of the number of connected users of the system'. Essentially, each new user brings more and more value to the network, which is behind the spectacular growth of social media networks and certain apps.

Quantum computing has the potential to solve highly complex problems in less time than classical computers, which could speed up scientific discoveries and predictions in the future. Unlike classical computers which use 'bits' (i.e. 0 or 1), quantum computers use 'quantum bits' or 'qubits' which allow for the so-called superposition phenomenon, as qubits can take the two values of 0 and 1 simultaneously (Figure 2-5). As a result, qubits enable greater computing power, which could lead to new applications in fields such as big data, cryptography, medicine, weather prediction, and machine learning.

Figure 2-5 Visual representation of the difference between a bit (for classical computers) and a qubit (for quantum computers)



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Source: https://www.austinchronicle.com/screens/2019-04-19/quantum-computing-101-a-beginners-guide-to-the-mind-bending-new-technology/

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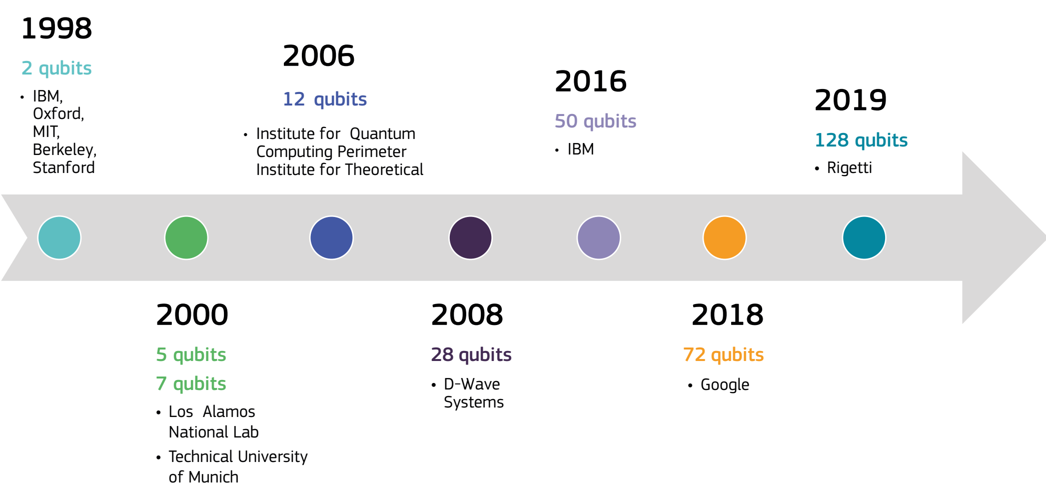
As argued in the MIT Technology Review (2019), the 'immense processing power of quantum computers could ultimately help researchers and companies discover new drugs and materials, create more efficient supply chains, and turbocharge AI'. Some tech giants, such as IBM and Google but also startups like Rigetti, are pushing the frontier forward, resulting in a substantial increase in the number of qubits (and hence computing power) from only 2 in 1998 to 128 in 2019 (Figure 2-6). Thus, advances in quantum computing could further increase the speed of R&I across different scientific fields in the future.

Figure 2-6 Number of qubits achieved by year and organisation, 1998-2019



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Source: DG Research and Innovation, Chief Economist - R&I Strategy & Foresight Unit, adapted from CBInsights and based on http://www.qubitcounter.com/

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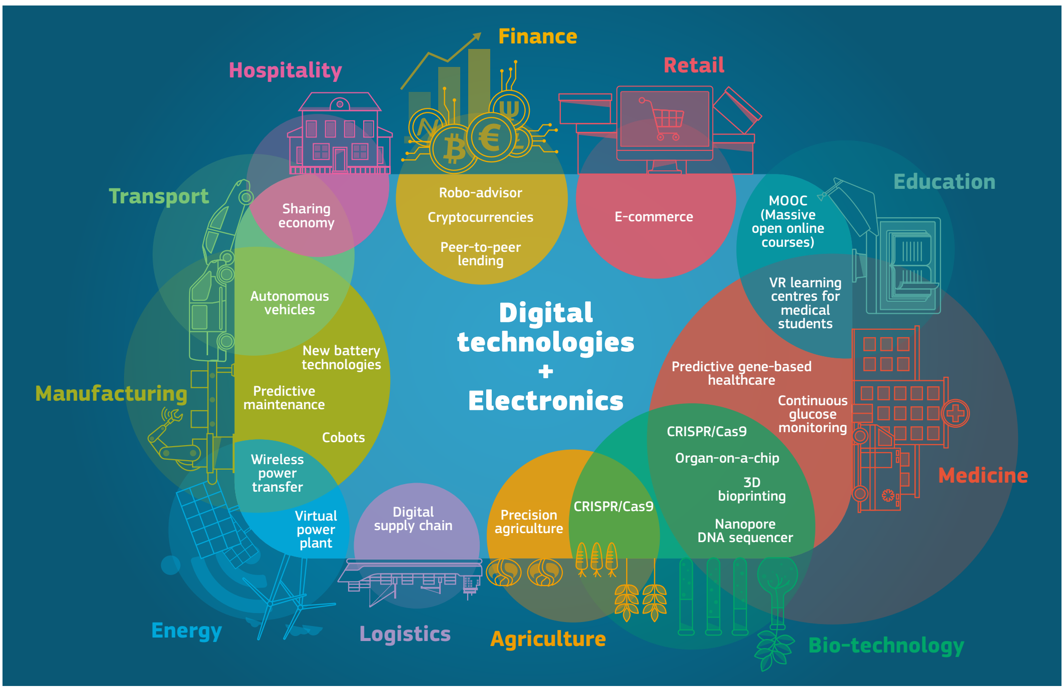
3. Complexity

Convergence of the digital and physical worlds is increasing the complexity of innovation. Innovations are increasingly the result of the convergence between digital technologies and scientific fields leading to 'deep-tech innovations' (Figure 2-7). In other words, this means deeply transformative and increasingly science-based and complex innovations. This includes digital supply chains, precision agriculture, 3D bioprinting, autonomous vehicles, among many others. In order to reap the full benefits of these deep-tech innovations, companies must have in place the right economic competencies, which include an organisational structure that enables the agility and flexibility among teams to master different technologies and new business models, management quality with a strategic vision, staff training, and branding (see Chapter 5.3 - Investment in economic competencies). Moreover, despite having the potential to be deeply transformational, these innovations may take years and sometimes decades to be market ready. As a result, deep-tech, science-driven innovations require 'patient capital' funds that account for the higher uncertainty involved as well as the longer time span to enable them to be tested, improved and hopefully made commercially viable (see Chapter 8 - Framework conditions).

Figure 2-7 **Deep-tech innovation: science-based digitally-enabled innovations**



Source: European Commission, DG Research and Innovation, Chief Economist - R&I Strategy & Foresight Unit
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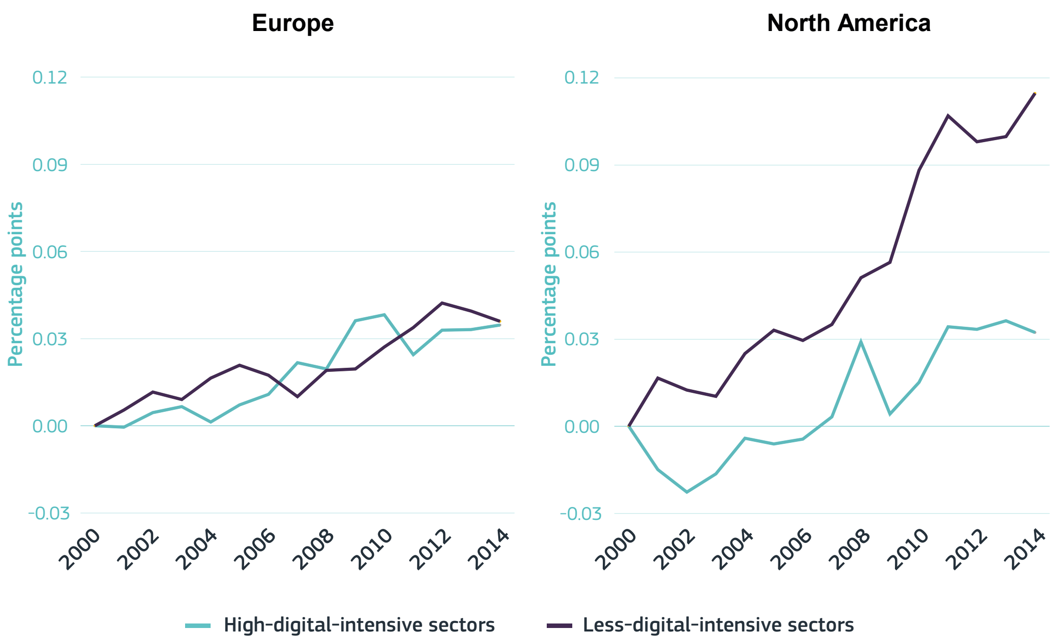
4. Concentration

Industry concentration is a rising phenomenon in North America, and to a less extent in Europe[1]. Bajgar et al. (2019) show that overall sales concentration has been increasing since 2000 in both North America and Europe (Figure 2-8). It is interesting to note that the rising trend in industry concentration in terms of sales is observable in both digital-intensive and other sectors of the economy. In fact, concentration in North America appears more pronounced in sectors other than those with higher digital intensity, even though concentration in the latter appears to have be on the rise since 2007. This could relate to the significant growth in the US in high-tech business dynamism in the early late 1990s and early 2000s (Decker et al., 2016), which was then interrupted. In Europe, differences in concentration in both sectors are not as evident as they are in the United States and Canada.

Figure 2-8 Concentration in digital-intensive vs. less-digital industries in Europe and North America[(1)], 2000-2014



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Source: Bajgar et al. (2019)
Note: [(1)]The countries for Europe include BE, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IT, LV, NL, NO, PL, PT, SE, SI, and for North America include CA and US. Included industries cover 2-digit manufacturing and non-financial market services. Concentration metrics reflect the share of the top 8 firms in each industry (CR8). The graphs can be interpreted as the cumulated absolute changes in levels of sales concentration for the mean 2-digit sector within each region. For instance, in 2014, the mean European services industry had 4 percentage point higher sales concentration than in 2000.
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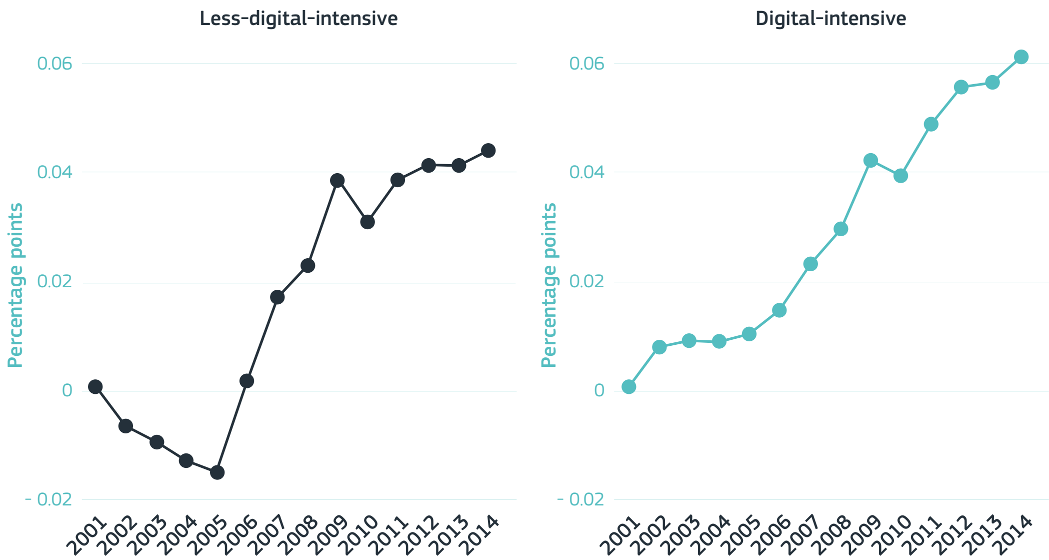
1 In fact, industry concentration in Europe seems more stable (average over the period will be close to zero).

Increasing concentration can also be observed by the rise in average mark-ups over time. Mark-ups in the top digital-intensive sectors are higher and growing faster than in the rest of the economy. As mentioned in De Loecker and Eeckhout (2017), mark-ups are a market power measure for how much higher prices are relative to marginal costs. Calligaris et al. (2018) studied the evolution of mark-ups over time to investigate whether they are on the rise in the age of digital transformation, and whether there are differences between the top 25 % most digital-intensive and the less digital-intensive sectors of the economy. Indeed, Figure 2-9 shows that mark-ups have risen over time in both top-intensive and less-intensive digital sectors, although this increase has been more pronounced in the top digital-intensive sectors (see Chapter 10 - The bottom also matters: policies for productivity catch-up in the digital economy).

Figure 2-9 Mark-up growth over time in digital-intensive vs. less-digital-intensive sectors, 2001-2014



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Source: OECD based on Calligaris, S., C. Criscuolo and L. Marcolin (2018)

Note: This graph fixes the ranking of sectors to the initial period (2001-03), and shows only mark-ups estimated assuming a Cobb-Douglas production function.

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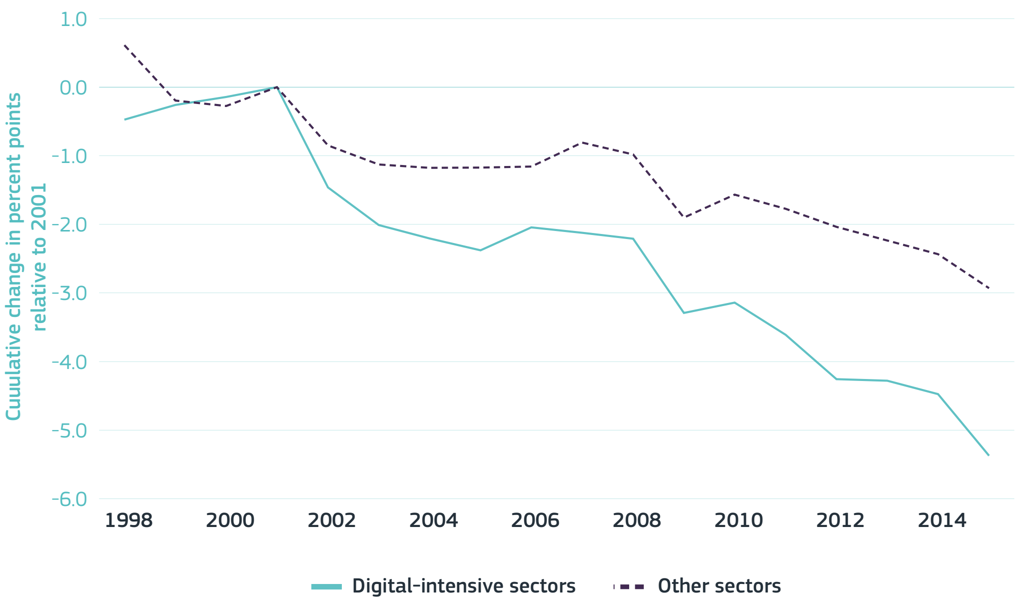
Increasing mark-ups in the top digital-intensive sectors may partly explain the faster decline in entry rates in those sectors. As mentioned in Chapter 3.3 - Business dynamics and its contribution to structural change and productivity growth, business dynamism appears to be on decline, including in Europe. Calligaris et al. (2018) focus on entry rates as a proxy to measure business dynamism in digital-intensive sectors relative to other sectors of the economy. Their analysis shows that the decline in entry rates since 2001 has been more visible in top digital-intensive sectors (Figure 2-10). This suggests that the rise in mark-ups and the concentration of benefits of innovations in a handful of global digital giants may be deterring new firms from entering the most digital-intensive sectors. As a result, the productivity gap between frontier and laggard firms may continue to widen as productivity gains may become concentrated in a small number of firms (see Chapter 3.1 - Productivity puzzle and innovation diffusion).

Figure 2-10 Change in entry rates by sector digital intensity, within-sector trends relative to 2001, 1998-2015



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Source: Calvino and Criscuolo (2019)

Note: The figure reports average within-country-industry trends, based on the year coefficients of regressions within country-sector, with and without interaction with the digital intensity dummy. Digital-intensive sectors are reported with a solid line and other sectors with a dashed line. The dependent variable is entry rates. The baseline year is set to 2001. Each point represents average cumulative changes in percentage points since 2001.

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Over the past decade, technology-related companies companies have climbed up in market capitalisation to dominate the top 10 global companies. Digitalisation has enabled new innovations and business models, and technology and ICT-related companies have mastered the potential of digital transformation to generate new products and services as well as, for example, new sales and marketing strategies. In particular, in 2009, only Microsoft was within the top 10 global companies by market capitalisation, while in 2019, there were seven ICT-related companies – Microsoft, Apple, Amazon, Alphabet, Facebook, Alibaba and Tencent (Figure 2-11). For example, Apple and Alphabet climbed 31 and 18 positions, respectively, compared to the 2009 ranking.

Most of the so-called 'digital' or 'tech' giants benefit from the increasing connectivity of their users which also gives them access to enormous volumes of data in their customer base. For example, Facebook´s revenue model is almost entirely based on Facebook Ads[2] which target users according to certain criteria (e.g. age, gender, nationality). This gives these global companies a competitive advantage. At the same time, data privacy issues should be duly taken into account and regulations should ensure their full compliance. Importantly, in the digital era, there is a **'mismatch' between where value is created and where taxes are paid**. The European Commission (2018c) has proposed new rules to ensure that digital business activities are taxed in a fair and growth-friendly way.

Figure 2-11 Top 10 global companies (1-10) by market capitalisation[(1)], 2019 and 2009

Company	Industry	Country	31 March 2019		31 March 2009		Change in rank between 31 March 2009 and 31 March 2019
			Rank	Market capital-isation (USD bn)	Rank	Market capital-isation (USD bn)	
Microsoft	**Technology**	United States	**1**	905	6	163	+5
Apple	**Technology**	United States	**2**	896	33	94	+31
Amazon.com	**Consumer services**	United States	**3**	875	:	31	-
Alphabet	**Technology**	United States	**4**	817	22	110	+18
Berkshire Hathaway	**Financial**	United States	**5**	494	12	134	+7
Facebook	**Technology**	United States	**6**	476	-	81[(1)]	-
Alibaba	**Consumer services**	China	**7**	472	-	168[(1)]	-
Tencent	**Technology**	China	**8**	438	-	13	-
Johnson & Johnson	**Healthcare**	United States	**9**	372	8	145	+1
Exxon Mobil	**Oil & Gas**	United States	**10**	342	1	337	-9

Source: Bloomberg and PwC analysis, 2019

Note: [(1)]Market capitalisation at IPO date.

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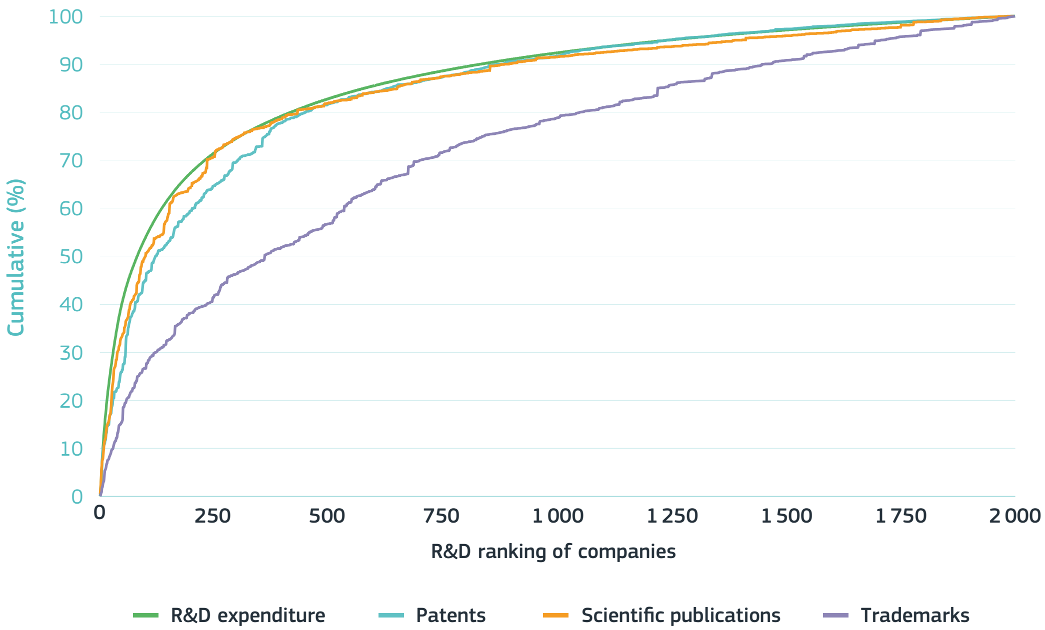
2 https://www.visualcapitalist.com/how-tech-giants-make-billions/

Concentration can also be observed when it comes to scientific publications and innovation outputs by the top R&D investors. Dernist et al. (2019) looked into the top 2 000 R&D investors worldwide. Having linked this information to data on publications, patents and trademarks, the authors found that the top 250 R&D investors alone actually account for around 72 % of total R&D expenditure, 71 % of publications, 65 % of patents and 42 % of registered trademarks among the top corporate R&D sample (Figure 2-12). When extending the analysis to the top 2 000 corporate R&D investors, the authors concluded that this group of companies was responsible for almost two thirds of patents filed at the largest intellectual property (IP) offices worldwide, for example.

Figure 2-12 R&D investment, publications and IP bundle of the world's top 2 000 R&D investors, 2014-2016(1)



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Source: Dernist et al. (2019) based on Joint Research Center-OECD, COR&DIP© database v.2., 2019

Note: (1)Data relate to companies in the top 2 000 corporate R&D sample, ranked by R&D investment in 2016. The IP bundle refers to the number of patents and trademarks filed in 2014-16, and owned by the top R&D companies, and the number of scientific articles are those published by authors affiliated in the top R&D companies during the same time-period, using fractional counts. See Box 2-1 for further details on the coverage.

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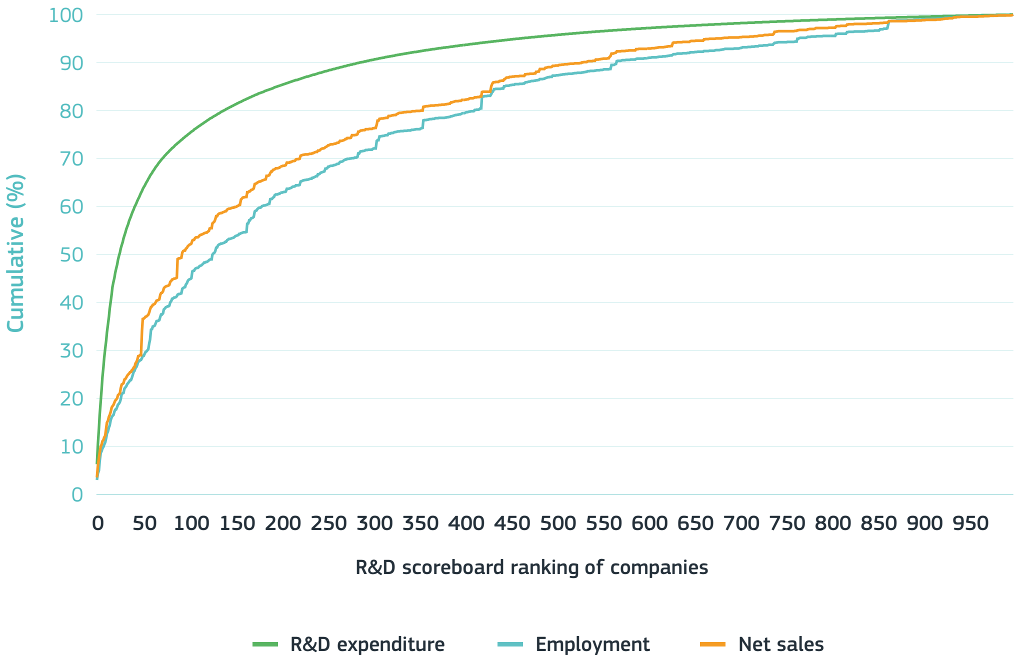
The concentration of R&D activities as well as sales and employment is a phenomenon that is also evident in Europe. When looking to the top 1 000 R&D investors in the EU, an unequal distribution of R&D expenditure among companies (Figure 2-13) can be observed. The same uneven picture applies to sales and employment, albeit less pronounced than R&D investments. For example, the top 25 R&D investors in the EU account for half of the group's R&D expenditure.

Figure 2-13 R&D investments, employment and net sales of the top EU28 1 000 R&D investors, 2019



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Source: DG Research and Innovation, Chief Economist - R&I Strategy & Foresight Unit, based on EU Industrial R&D Investment Scoreboard 2019

Note: Data refers to the top 1 000 R&D investors in the EU. There are a few missing values for companies regarding employment and net sales.

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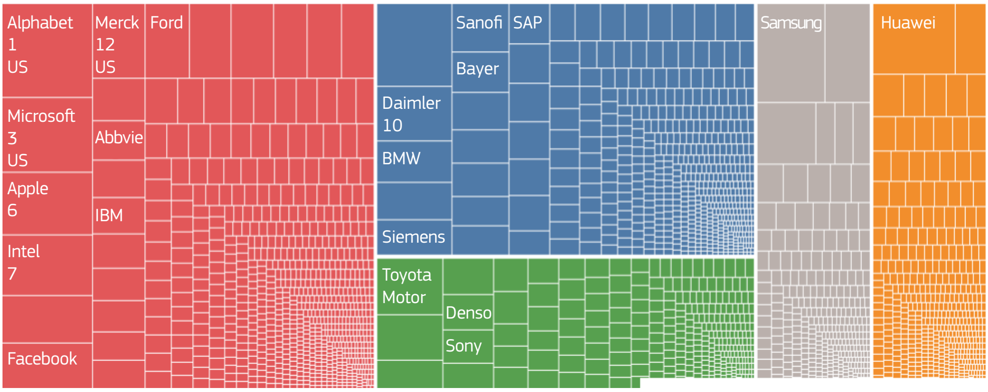
The rising concentration of R&D investments among a relatively small number of players is also visible at the global level. According to European Commission (2018), the top 2 500 R&D investors account for 90 % of the world's business-funded R&D. Moreover, just a few companies account for a significant share of all R&D expenditure (Figure 2-14) in each region.

When it comes to AI science and innovation, the weight of the world´s top corporate R&D investors also appears to be higher than in other companies, as measured by publications, patents and trademarks. As mentioned in Chapter 7 - R&I enabling artificial intelligence, in recent years there has been a boom both in AI publications and patenting activity. In this context, the global 2 000 corporate R&D investors seem more active than other players in producing AI scientific publications and patenting and generating trademarks for their innovations (Figure 2-15). This indicates that the development of AI R&I may also become increasingly concentrated.

Figure 2-14 World top 2 500 R&D investors by region, 2018/2019



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Source: European Commission, 2019 EU Industrial R&D Investment Scoreboard

Note: US companies are represented in red, EU28 companies in blue, Japanese companies in green, Chinese companies in orange, and the Rest of the world in grey.

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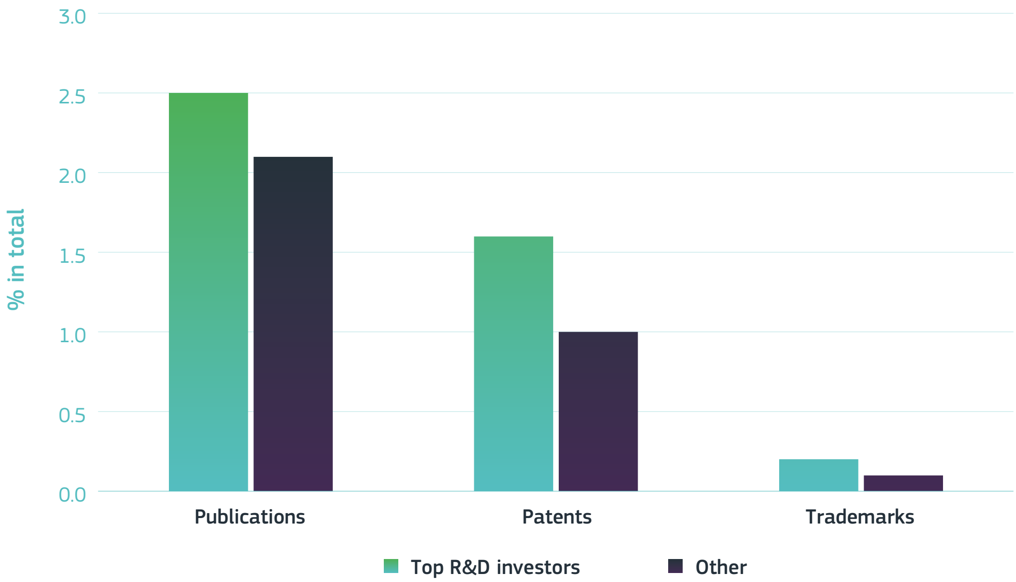
Figure 2-15 AI-related patents, trademarks and publications of top R&D investors relative to other actors(1), 2014-2016



Science, research and innovation performance of the EU 2020

Source: Dernist et al. (2019) based on Joint Research Center-OECD, COR&DIP© database v.2., 2019

Note: (1)Share in total patents, trademarks and publications, top R&D investors and other actors.

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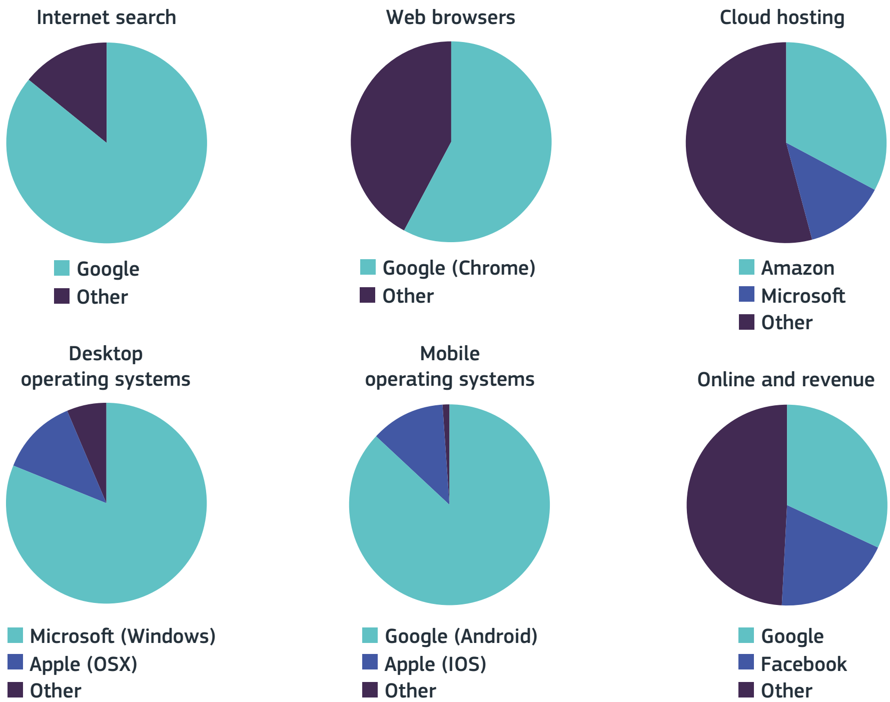
The dominance of US tech giants is not only visible in terms of R&D investments but also when it comes to some of the pillars underpinning digitalisation, such as search engines, operating systems and cloud infrastructure. Figure 2-16 shows that just a few companies – Google, Amazon, Microsoft, Apple and Facebook – account for very large shares in different digital markets, notably internet search, web browsers, cloud hosting, desktop and mobile operating systems, and online advertising revenues. For example, Google is the clear leading search engine with a market share close to 90%[3]. Amazon alone is the top cloud infrastructure provider with 33% market share worldwide. Van Reenen (2018) argues that the 'growth of platform competition in digital markets has led to the dominance by a small number of firms such as internet search (Google), operating systems for cell phones (Apple, Android), ride-sharing (Uber), home sharing (Airbnb)'. Moreover, the author[4] highlights that the mechanism of competing on platforms means that, for example, in the case of Google, online searches will give the company increasingly larger amounts of data which will optimise their algorithms. As a result, this will attract more users to the platform and hence generate further advertising revenues. Moreover, the ownership and control of users´ data for advertising or improving the quality of products has led to considerable concerns over data privacy as well as market power.

Figure 2-16 Global market shares by company - internet search, web browsers, cloud hosting, desktop operating systems, mobile operating systems and online advertising revenue, 2017



Science, research and innovation performance of the EU 2020

Source: https://mitsloan.mit.edu/ideas-made-to-matter/will-regulating-big-tech-stifle-innovation (September 2018), based on Synergy Research, CNBC, Statista

Stat. link: https://ec.europa.eu/info/sites/info/files/srip/2020/parti/chapter2/figure-2-16.xlsx

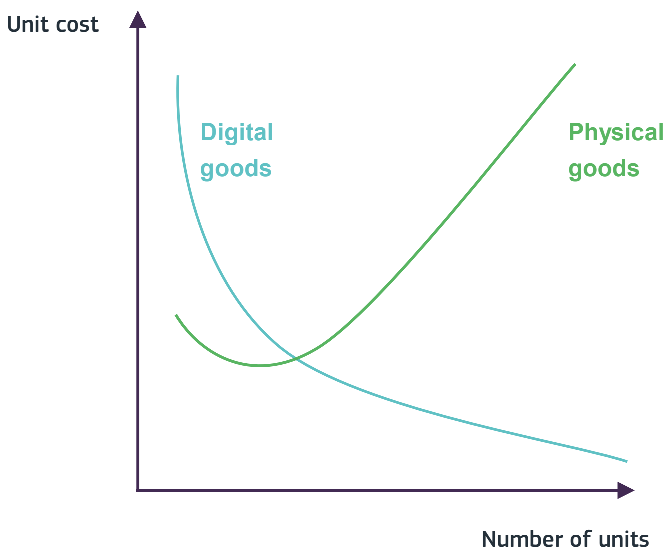
3 https://www.statista.com/statistics/216573/worldwide-market-share-of-search-engines/

4 https://mitsloan.mit.edu/ideas-made-to-matter/will-regulating-big-tech-stifle-innovation

5. Costs

While the R&D investments required to produce deep-tech innovations can prove costly, companies that sell digital products can manage to operate under close to 'zero marginal costs', as a result of the diminishing importance of tangible capital in the era of digital transformation. Digital products and services (e.g. smartphone apps) have the inherent economic properties of non-rivalry – i.e. many users can use them simultaneously without restricting the access of others to the same digital good – and of being infinitely expandable (Eurofound, 2018) which means they can be used an infinite number of times and at no cost. In other words, the marginal cost for digital goods declines indefinitely[5] (Figure 2-17). Indeed, the biggest transformation created by digitalisation concerns the 'move from atoms to bytes'[6]. While 'physical innovations' such as the landline telephone rely on inputs for their production based on atoms (e.g. physical infrastructure, raw materials, human capital) which follow the laws of physics, in the digital age, bytes allow a digital good to be produced at close-to-zero marginal cost since there is almost zero cost for reproduction and communication (Guellec and Paunov, 2018). Therefore, digital companies do not have the same needs for physical infrastructure and tangible capital as other industries. In fact, they often benefit from IT platforms, software systems and tools, cloud storage capacity, etc. which tend to be more inexpensive than other types of tangible assets.

Figure 2-17 The evolution towards 'zero marginal costs' for digital goods



Science, research and innovation performance of the EU 2020

Source: DG Research and Innovation, Chief Economist - R&I Strategy & Foresight Unit, based on Essays, UK. (2018) and Rifkin (2014)
Stat. link: https://ec.europa.eu/info/sites/info/files/srip/2020/parti/chapter2/figure-2-17.xlsx

5 See, for example: https://praxtime.com/2013/01/06/digital-economics-the-zero-marginal-cost-economy/ and https://www.goodreads.com/book/show/18594514-the-zero-marginal-cost-society

6 https://www.weforum.org/agenda/2018/06/how-long-does-it-take-to-hit-50-million-users

6. Consumers

Network effects can also play an important role in fostering the use and uptake of digital technologies, even though there is the risk of 'consumer lock-in'. In the case of social networks (but also other digital products such as online platforms or certain software tools), the higher the scale of users in the networks the greater the consumer value from that interconnectedness. However, consumers may be 'locked in' to such products or services as the cost associated with changing provider is too high since their network is established through a different provider. For instance, Microsoft's strong position in terms of office operating systems means that a network of people are using the same systems to work and collaborate in a compatible way. For this reason, the incentives to change to a different operating system provider are low considering the cost of learning and setting new harmonised standards for sharing information and communicating.

Business model innovation contributes to capturing greater value from new goods and services. In particular, various digital business models have emerged to benefit from the new opportunities brought by the digital age. As mentioned in Baden-Fuller and Haefliger (2013), 'business models mediate the link between technology and firm performance'. Box 2-1 summarises the different approaches to business model innovation, especially in the digital age.

BOX 2-1 Business model innovation: capturing value

Companies increasingly compete not only on the products and services they sell but also in terms of the underlying business model. In fact, business model innovation can be a true disruptor in many markets and an important differentiator when there is a high degree of competition.

For example, in clothing retail there are many established brands, including strong European multinationals such as the United Colors of Benetton (Italy) or H&M (Sweden), with successful business models. In this context, the business model of ZARA (Spain) enabled the company to differentiate itself from its competitors. For example, instead of outsourcing most of its production to Asia, it also has production units in Spain and Portugal. Moreover, the company has collections which change on a weekly basis rather than the longer design cycles of its competitors[7].

Another example is that of Skype in the telecommunications sector. Skype was created by Niklas Zennström (Sweden) and Janus Friis (Danish), in cooperation with Ahti Heinla, Priit Kasesalu, and Jaan Tallinn (Estonia). While calls and, in particular, international calls can be expensive, Skype used the VoIP – Voice over Internet Protocol – technology to allow users to communicate over the internet by voice, for free if you subscribe to the free version. Moreover, it relies mainly on software development, thereby reducing the need for physical infrastructure.

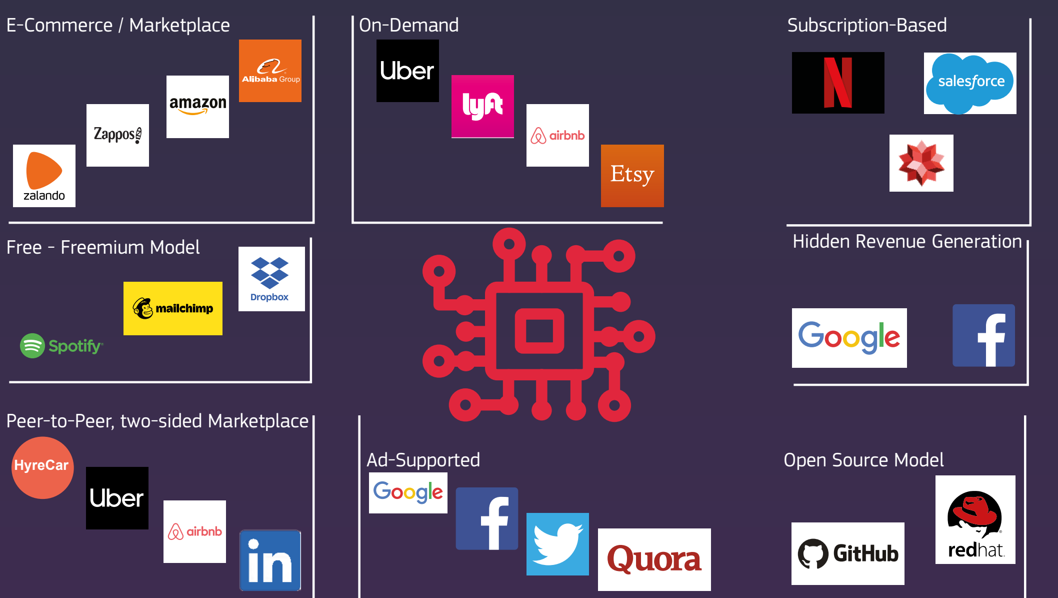
7 https://www.slideshare.net/jindrichweiss/55-business-models-to-revolutionize-your-business-by-michaela-csik

In the era of digitalisation, companies operating in the digital space are adopting different business model strategies. Figure 2-18 simplifies the different approaches being used.

These include, in a nutshell:

- **E-commerce/marketplace**: an online platform connecting buyers and sellers.
- **On-demand**: aggregate niche-service providers on a platform providing a user-friendly experience, running mainly on mobile apps.
- **Subscription-based**: the access implies the payment of a fee with a certain regularity, typically every month or every year.
- **Freemium**: a basic version of the service is offered alongside a premium (paid) version.
- **Peer-to-peer**: individuals directly transact with each other with little or even no intermediation from others.
- **Ad-supported**: mainly based on advertising as the source of revenue.
- **Open source**: involves not only the owners of the project but also the community.

Figure 2-18 Mapping of digital business models and examples of companies

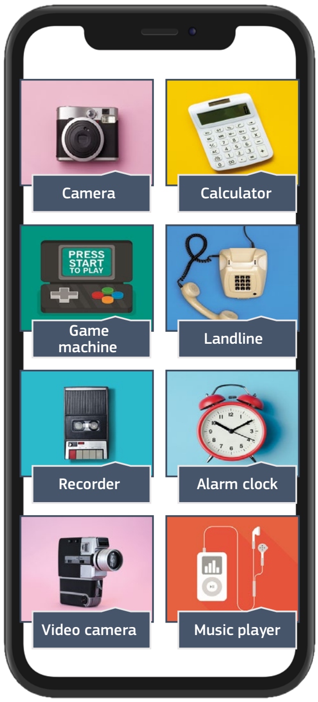


Source: https://fourweekmba.com/digital-business-models/

Stat. link: https://ec.europa.eu/info/sites/info/files/srip/2020/parti/chapter2/figure-2-18.xlsx

The widespread use of smartphones and other tech gadgets has underpinned the creation of the 'digital consumer', enabling free digital goods in a single device and making many physical (and paid) goods obsolete. Since the creation of the smartphone in 2007, apps and other digital tools and services have boomed. Moreover, as noted by Brynjolfsson and Collis (2019), today, smartphones provide for free many of the functions of physical paid goods, such as the alarm clock, calculator, game machine, landline, recorder, video camera, or a music player, as represented in Figure 2-19.

Figure 2-19 How the smartphone enabled free digital goods in a single device, and substituted paid goods



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Source: DG Research and Innovation, Chief Economist - R&I Strategy & Foresight Unit, adapted from Brynjolfsson and Collis (2019)

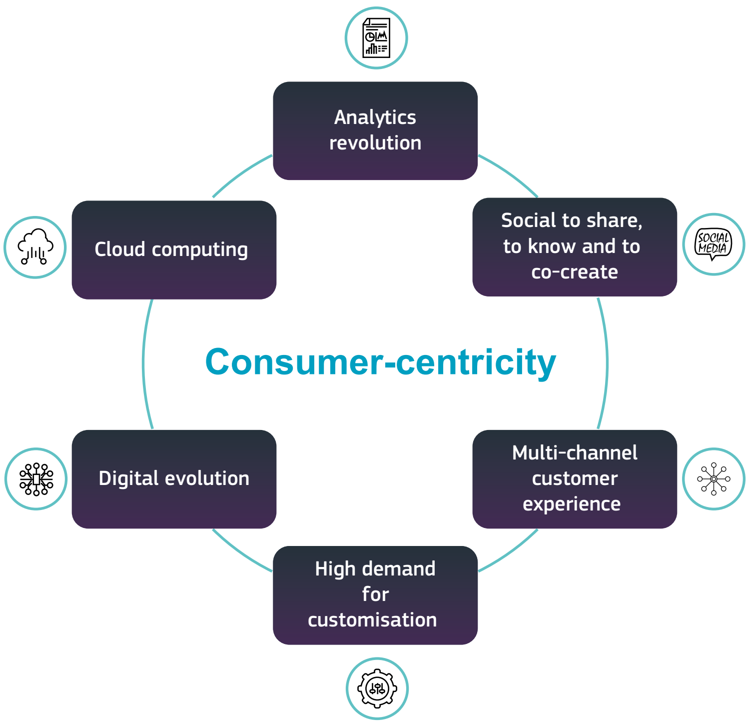
Note: Images extracted under the licence with stock.adobe.com: © samrit, #201880065; © Dariia Chernenko, #282607942; © chinnarach, #275830884; © patrick, #141611205; © Matt, #308036749; © moreiraalison, #288587446; © dark322, #311919896; © khagani_m, #229130888; © mix3r, #162491327.

Stat. link: https://ec.europa.eu/info/sites/info/files/srip/2020/parti/chapter2/figure-2-19.xlsx

Moreover, e-commerce is on the rise (OECD, 2019) since the cost of digital payments has also declined. As a result, the physical and digital worlds are becoming more and more interconnected, leading to faster and first-hand innovations consumers can choose from. In addition, tech gadgets such as the smartphone and tablet, allied to widespread internet use also mean that consumers are able to access to a lot of information, including in real-time.

Thus, innovation is becoming increasingly customer-centric. In other words, consumers are no longer mere users of new technologies but are actually driving innovations. As they are more informed than ever, companies face even greater pressure, including trying to anticipate future needs. Another growing practice is to have customers' involvement and feedback early in the process of creating a new product or service so that companies can customise the new solutions to the exact needs of the consumer and hence differentiate from their main competitors to secure a higher market share. Figure 2-20 presents an overview of the main trends driving consumer-centric behaviour. These include the big data analytics revolution, extensive social networks and interconnectedness, multi-channel customer experience, a strong demand for almost tailored-made and personalised products and services, and the rise of cloud computing, although there are certainly other factors behind this trend.

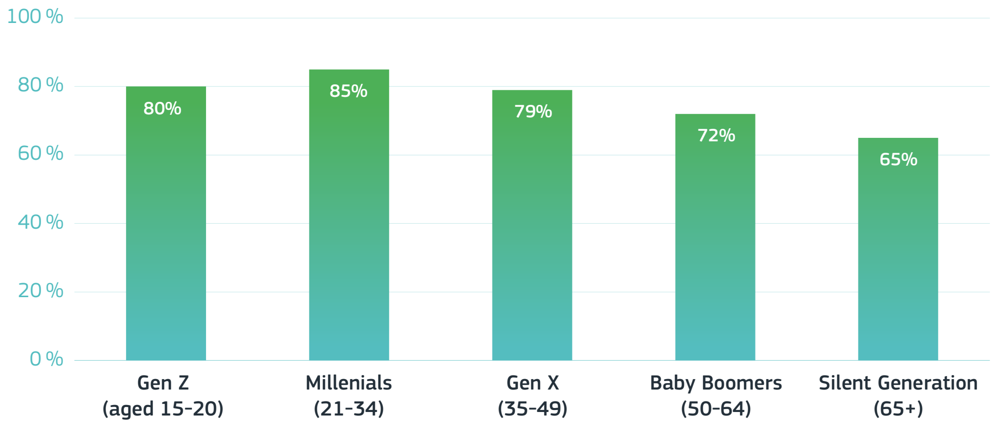
Figure 2-20 Visual representation of the trends shaping consumer-centric behaviour



Source: DG Research and Innovation, Chief Economist - R&I Strategy & Foresight Unit, adapted from Accenture
https://insuranceblog.accenture.com/the-customer-centric-insurer-how-digital-is-creating-a-more-uncertain-competitive-landscape
Stat. link: https://ec.europa.eu/info/sites/info/files/srip/2020/parti/chapter2/figure-2-20.xlsx

Consumers are also increasingly putting pressure on companies to become more environmentally friendly, with millennials leading this push for change in organisations. Overall, it seems that all generations are demanding companies take tougher action to become more environmentally sustainable. In particular, it is the younger generations (Gen Z and Millenials) who seem to be the most concerned about making this change (Figure 2-21). As noted in Wade et al. (2019), 'sustainability and digitization have developed more or less independently of each other, but it's time for these two worlds to merge'. The authors call for the **rise of "corporate digital responsibility" that encompasses social, economic, technological, and environmental aspects**.[8]

Figure 2-21 Percentage of respondents who said that it is 'extremely' or 'very' important that companies implement programmes to improve the environment, by generation



Source: The Conference Board® Global Consumer Confidence Survey, conducted in collaboration with Nielsen Q2 2017
Stat. link: https://ec.europa.eu/info/sites/info/files/srip/2020/parti/chapter2/figure-2-21.xlsx

8 https://sloanreview.mit.edu/article/corporate-responsibility-in-the-digital-era/?utm_source=twitter&utm_medium=social&utm_campaign=sm-direct

7. Conclusions

Digitalisation has deeply transformed our economies and societies. In the digital age, the adoption of technologies is happening at an unprecedented speed due to the rise of digital innovations combined with strong network effects. In this context, **fostering the uptake and diffusion of digital skills, competences and practices** across individuals, companies, regions and countries is paramount. At the EU level, the expected Updated Skills Agenda for Europe, and the Digital Skills and Jobs Coalition, aim to tackle the digital skills gap. Furthermore, policies must be faster to react to the changing contexts.

Moreover, digital technologies such as artificial intelligence are increasingly merging with the physical world across a wide range of sectors, leading to a new wave of 'deep-tech innovation' that has intrinsically different 'needs' to other types of innovation. In particular, **deep-tech innovation is very science-based, multidisciplinary and capital-intensive**. The risk associated with these innovations is also very high as they may take some time to be market-ready (if ever), although the private and social returns from a commercially viable and disruptive product may also be extremely high. As a result, these innovations require 'patient capital', multidisciplinary teams, R&D labs, and well-connected innovation hubs, among other factors. Within Horizon Europe, the European Council will support breakthrough, deep-tech innovators.

Industry concentration is also on the rise, although the phenomenon is more prevalent in North America than in Europe. Similarly, **increasing concentration is also visible in terms of R&D investments and outputs such as sales**, whereby most of the benefits are concentrated in a small group of 'superstar' firms. Furthermore, some of the technologies underpinning digitalisation, such as cloud infrastructure, appear to be concentrated in a few US tech giants. This calls, for instance, for competition policies that are 'fit for the digital age'.

Access to data is also increasingly seen as a competitive advantage to thrive in the digital era and gain market shares, especially at a time when innovation is more and more 'customer-centric' and enabling product differentiation. However, access to data should be in line with principles and regulations regarding privacy and the ethical use of data. In the EU, the General Data Protection Regulation (GDPR) provides guidance on the fair use of data. Moreover, the European Data Strategy will make more data available for use in the economy and society, while keeping those who generate the data in control. It will ensure that European rules, in particular privacy and data protection, as well as competition law, are fully respected. The EU will create a single market for data where €4-6 billion will be invested in total in common European data spaces and a European federation of cloud infrastructure and services[9].

Measuring the digital economy to understand its impacts is key. For instance, new studies argue that the digital economy has been underestimated in traditional measures such as gross domestic product, or that consumers' welfare linked to digital innovations is also not being duly accounted for[10]. **In a global and digital economy, international tax rules need to be rethought** as they 'do not capture business models that can make profit from digital services in a country without being physically present', nor do they account for the new ways in which profits are created including 'the role that users play in generating value for digital companies'.[11]

9 For more information please visit https://ec.europa.eu/digital-single-market/en/content/european-digital-strategy
10 See for instance Brynjolfsson and Collis (2019), 'How Should We Measure the Digital Economy?'.
11 https://ec.europa.eu/taxation_customs/business/company-tax/fair-taxation-digital-economy_en

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