European Commission

JRC TECHNICAL REPORTS

AI Watch: Estimating AI Investments in the European Union

EUR 31114 EN

EU Science Hub
https://ec.europa.eu/jrc

JRC129174

EUR 31114 EN

PDF ISBN 978-92-76-53433-4 ISSN 1831-9424 doi:10.2760/702029

Luxembourg: Publications Office of the European Union, 2022

How to cite this report: Tatjana Evas, Maikki Sipinen, Martin Ulbrich, Alessandro Dalla Benetta, Maciej Sobolewski and Daniel Nepelski, AI Watch: Estimating AI investments in the European Union, EUR 31088 EN, Publications Office of the European Union, Luxembourg, 2022, ISBN 978-92-76-53433-4, doi:10.2760/702029, JRC129174.

Contents

AI Watch – monitoring the development, uptake and impact of AI for Europe

This report is published in the context of AI Watch, the European Commission's knowledge service to monitor the development, uptake and impact of Artificial Intelligence (AI) for Europe, launched in December 2018. AI Watch monitors the European Union's industrial, technological and research capacity in AI, AI-related policy initiatives in the Member States, uptake and technical developments of AI, and AI impact. AI Watch has a European focus within the global landscape. In the context of AI Watch, the Commission works in coordination with the Member States. AI Watch's results and analyses are published on the AI Watch Portal.

From the in-depth analyses of AI Watch policy makers will be able to understand better the European Union's areas of strength and areas where investment is needed. It will provide an independent assessment of the impacts and benefits of AI on growth, jobs, education, and society. AI Watch is developed by the Joint Research Centre (JRC) of the European Commission in collaboration with the Directorate General for Communications Networks, Content and Technology (DG CONNECT).

Acknowledgements

Data on AI publications provided by Olivier Eulaerts (JRC, Technology Innovation Monitoring) and AI patents and AI university programmes provided by Giuditta De Prato, Montserat López-Cobo and Miguel Vazquez-Prada Baillet (JRC, PREDICT) are gratefully acknowledged.

Authors

Tatjana Evas*, Maikki Sipinen*, Martin Ulbrich*, Alessandro Dalla Benetta**, Maciej Sobolewski** and Daniel Nepelski**

* European Commission, DG CONNECT

** European Commission, DG JRC

Abstract

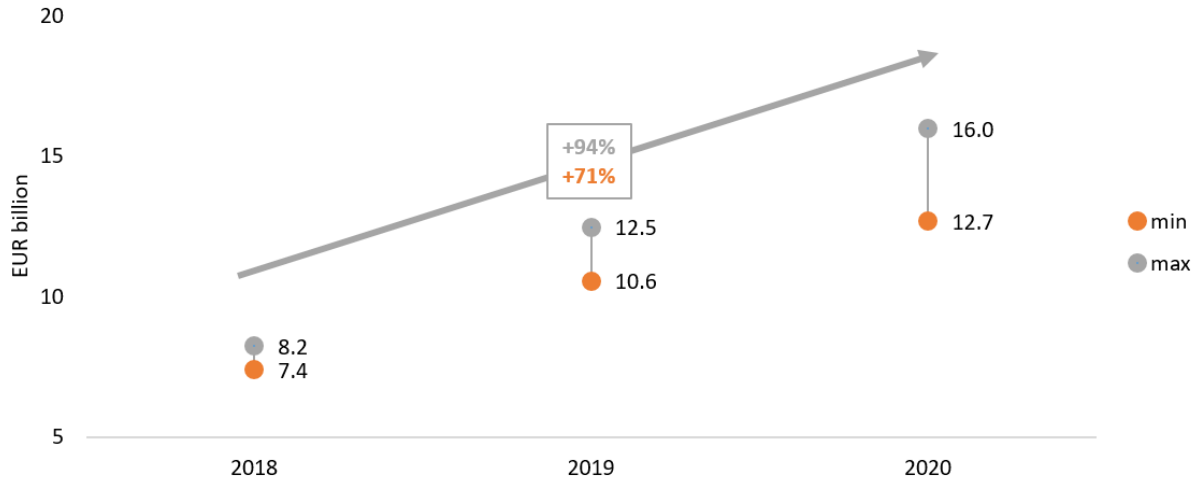
This report provides estimates of AI investments in the EU between 2018 and 2020 and, for selected investments categories, in the UK and the US. It considers AI as a general-purpose technology and, besides direct investments in the development and adoption of AI technologies, also includes investments in complementary assets and capabilities such as skills, data, product design and organisational capital among AI investments. According to current estimates, in 2020 the EU invested EUR 12.7-16 billion in AI. In 2020, due to the COVID19 outbreak, the EU AI investments grew by 20-28%, compared to a growth of 43-51% in 2019.

Executive summary

This report provides estimates of AI investments in the 27 EU Member States between 2018 and 2020 and compares them with the United States and the United Kingdom on selected categories of AI investments. It is part of AI Watch, a project that monitors AI-related developments and provides analyses to support the implementation of the European AI initiatives.

According to estimates, in 2020 the EU invested between **EUR 12.7 billion** and **EUR 16 billion in AI**.[1] In 2020, due to the COVID-19 outbreak, the EU's AI investments grew between 20% and 28%, compared to 43% and 51% in 2019. Total growth between 2018 and 2020 amounts to **71% and 94%** (Figure 1). The EU target is to invest EUR 20 billion per year by 2030 as set in the EC Communication "Artificial Intelligence for Europe".[2] The EU total AI investments in 2020 corresponds to 64-80% of the target, up from 37%-41% in 2018.

Figure 1: Range of EU AI investments, EUR billion and growth rate, 2018–2020



Source: JRC based on EUROSTAT, Spintan and Intan-Invest. Note: For methodological details of the min and max scenario see Annex I.

Most of the EU's AI investments in 2020 were concentrated in labour and human capital, covered by the ***Skills*** investment category (34%). Expenditures on AI-related ***R&D*** account for 30%. AI ***Data and equipment*** and ***Intangible assets*** account for 29% and 7% of total EU AI investments respectively. AI *R&D* and *Computer software and databases* accounted for 60% of the total growth of AI investments in 2020.

The **private** and **public sector** account for 67% and 33% of the EU AI investments respectively. The two sectors also differ in growth levels. While in 2020 the private sector increased its AI investments by 32%, the outlays by the public sector grew by 21%.

Regarding **AI investments at the Member States level**, in 2020 France, Germany, Ireland, Spain and Italy invested over **EUR 1 billion** each. France and Germany, the two leading countries by the volume of AI investments, also increased their AI investments at a rate higher than the average, increasing the gap across the EU. Poland, Romania and Ireland experienced the lowest and Estonia, Malta and Portugal the highest growth of AI investments. In relative terms, on the other hand, Ireland together with the Nordic countries lead the ranking in investment per capita. They spend more than EUR 50 per capita on AI, compared to the EU average of EUR 36 per capita.

In order to assess where Europe stands in terms of AI investments compared to other major economies, the report also makes an attempt to compare the EU AI investments with those in the UK and the US. However, because comparable data for *AI specialists'* and *AI academic teachers' compensation* is not available for the US and the UK, this international comparison is limited to three of the four investment categories used in the estimation of AI investments in the EU (AI-related *Data and equipment*, *R&D* and *Intangible assets*) and excludes the *Skills* category. According to this comparison, **the US spends nearly twice as much as the EU** (and 2.7 times more on a per capita basis) on AI R&D and AI-related complementary assets.

[1] Please see Annex II for description of the methodology for the minimum and maximum scenarios.
[2] European Commission Communication Artificial Intelligence for Europe (COM(2018)237 final).

1. Introduction

The Coordinated Plan on Artificial Intelligence 2021 Review defined the next stage in the joint efforts of the European Commission and Member States to seize the benefits of adopting the latest AI technologies for EU's economy, society and environment, and to create EU global leadership in trustworthy AI.[3] To make the EU's AI vision a reality, the Coordinated Plan on Artificial Intelligence 2021 Review proposed concrete and targeted shared actions, and encouraged mobilising a critical mass of resources to advance the joint priorities. The European Commission together with the Member States and private actors need to: (i) accelerate investments in AI technologies to drive resilient economic and social recovery; (ii) act on AI strategies and programmes to ensure that the EU fully benefits from the first-mover adopter advantages; and (iii) align AI policies to remove fragmentation and address global challenges.

Such aligned European AI policy action can be successful only when it is underpinned by sufficient resources and investment. Further, switching gears from intention to action will require strategic and reinforced monitoring of the development, uptake and impact of AI technologies in the EU. The EU's objective is to gradually increase combined public and private investment in AI to a total of EUR 20 billion per year over the course of this decade.[4] The EU's funding instruments play key role in leveraging additional private and public investment.[5]

This AI Watch report presents estimates of combined public and private AI investments in the EU between 2018 and 2020. The report is based on the latest available data and assesses where the EU stands with respect to the level and dynamics of AI investments. The work on a methodology to estimate AI investments in the EU started in 2019 (Nepelski & Sobolewski, 2020) and has been developed further and updated as new data has become available (Dalla-Benetta, et al., 2021).

Tracking and estimating the combined EU public and private AI investments helps to monitor the progress of implementing the Coordinated Plan on AI, and can provide input to the Plan's future reviews. In addition to ensuring that progress is being made towards the AI investments target, methodology to estimate EU investment in AI can be a blueprint for generating actionable insight on other emerging technologies in the future.

The AI investments estimates presented in this report are available both on the EU level and on the level of individual EU Member States. This allows the Member States' policymakers to utilise them to estimate the volume and direction of their national AI investments. Its components can inform national-level policymaking, for example, as input to monitoring national AI strategy implementation and updating national AI strategies or for comparisons with other countries, setting targets and benchmarking. For the first time, this report includes a section that compares estimates of selected AI investments categories in the US and the UK. It provides a basis for international comparison, as it presents the level of AI investments of the EU with those of the UK and the US for three investment categories: AI-related *Data and equipment*, *R&D* and *Intangible assets*.

Box 1 summarises the key elements of the AI Watch methodology to estimate AI investments.

[3] European Commission Coordinated Plan on Artificial Intelligence 2021 Review (COM(2021)205 final)

[4] European Commission Communication Artificial Intelligence for Europe (COM(2018)237 final).

[5] Funding programmes such as Digital Europe and Horizon Europe provide financial support to research, development and deployment of artificial intelligence in the EU. In addition, the Recovery and Resilience Facility makes available grants and loans to modernise and invest in human-centric, trustworthy, secure and sustainable AI technologies.

Box 1: AI Watch methodology to estimate AI investments

AI Watch takes a comprehensive view towards the resources that are necessary for the development and economy-wide diffusion of AI. The report considers among AI investments expenditures on ***R&D***, ***Skills*** as well as investments in ***Data and equipment*** and ***Intangible assets*** incurred by the **public** and **private** sectors to develop and implement AI, to (re-)design business processes and to create new or improve existing products or services. This approach reflects the fact that AI is a general-purpose technology (GPT), whose potential lies in its capacity to modernise the entire economy. Complementary investments in both tangible and intangible assets are necessary to unlock this potential (Brynjolfsson, Rock, & Syverson, 2018; Corrado, Hulten, & Sichel, 2005).

This report uses a **top-down approach based on national statistics** to estimate AI investments defined and used by AI Watch (Nepelski & Sobolewski, 2020). The approach consists of **two steps**. In the first step, data on the economy-wide levels of expenditures in the individual categories are collected. In the **second step**, these expenditures are weighted with AI-intensity coefficients to reflect amounts that are attributable to AI creation and adoption.

To account for changes in the structure of supply and demand for AI technologies and skills in the economy, **minimum and maximum** AI investments scenarios were computed. The minimum and maximum scenarios take a long- and short-term perspective on the development and diffusion of AI respectively.

For the **European Union**, AI Watch estimates of AI investments rely mainly on publicly available data, e.g. Gross Factor Capital Formation, wages or educational statistics by Eurostat. As a consequence, the results are not directly comparable with many attempts to quantify AI investments that focus on a specific aspect of AI investments that look only at the R&D expenditures of large digital firms or venture capital investments in AI start-ups (MGI, 2017; Science-Business, 2018).

Further methodological details can be found in Annex I and earlier AI Watch reports (Dalla-Benetta, Sobolewski, & Nepelski, 2021; Nepelski & Sobolewski, 2020).

Regarding the **international analysis**, comparable data on AI specialists' compensation and AI academic teachers' compensation is not available for the US. These two investment items of the *Skills* investment category represent 36% of the total EU AI investments in 2020. The comparison of the AI investments in the EU, UK and US relies thus on the available data and covers *R&D*, *Data and equipment* and *Intangible assets* (for further details, please see Annex II). The EU figures (Sections 2 and 3) are thus not directly comparable with the UK and US ones (Section 4).

2. AI investments in the EU

Key facts

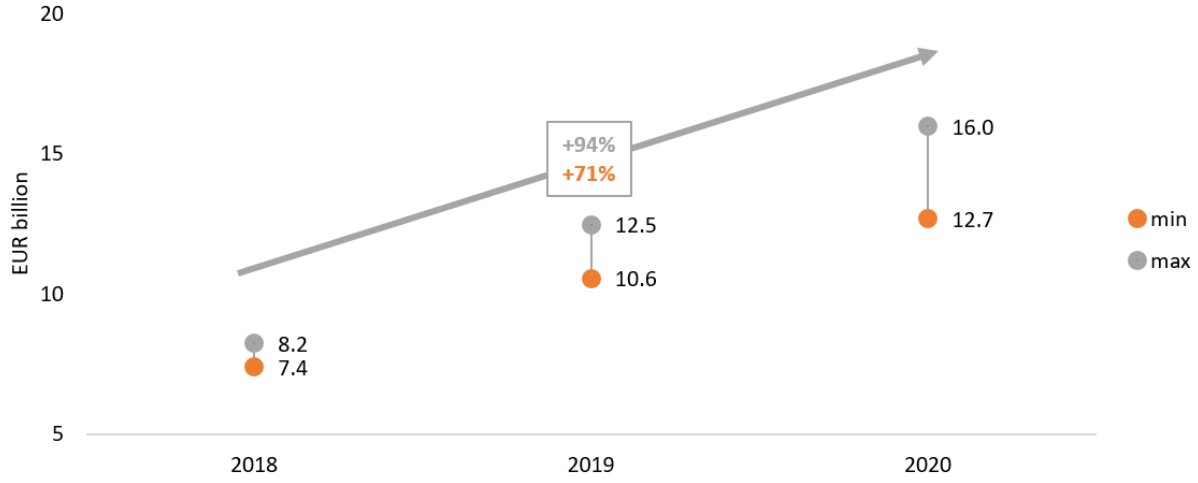
- Between 2018 and 2020, the EU's AI investments increased by approximately 71% and 94% and were in the range of EUR 12.7–16 billion.
- The first COVID-19 year 2020 saw a slower growth of AI investments compared to 2019.
- In 2020, investments in *Skills* (34%) and *R&D* (30%), followed by investments in *Computer software and databases* (29%) and other *Intangible assets* (7%) represent the largest part of AI investments in Europe.
- *R&D* and *Computer software and databases* accounted for 60% of the total growth of AI investments in 2020.
- The private and public sectors account for 67% and 33% of the EU AI investments respectively.
- Between 2019 and 2020, AI investments of the private sector increased considerably more (32%) than those of the public sector (21%), increasing the gap between the two sectors.

2.1. The level and growth of EU AI investments

Figure 2 presents the evolution of AI investments between 2018 and 2020 in the EU. Overall, between 2018 and 2020, investments increased by approximately 71% and 94% and were in the range of EUR 12.7–16 billion.[6] This corresponds to 63–80% of the EUR 20 billion annual investment target.[7] Maintaining similar level of growth, by 2025 the AI investments will surpass EUR 30 billion.

Compared to 2019, the EU's AI investments increased by EUR 2.1–3.5 billion or between 20% and 28%. This year-over-year growth of AI investments in 2020 was considerably lower than in 2019. Between 2018 and 2019 the figure grew between 43% and 51%. The COVID-19 outbreak was declared a pandemic by the World Health Organisation in March 2020. The slower growth of AI investments in 2020 is most likely a result of the COVID-19 crisis.

Figure 2: Range of EU AI investments EUR billion and growth rate, 2018–2020



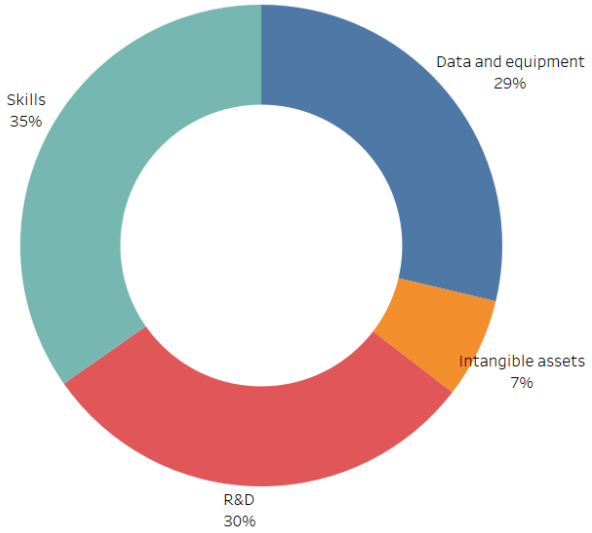
Source: JRC based on EUROSTAT, Spintan and Intan-Invest. Note: For methodological details of the min and max scenario see Annex I.

Figure 3 presents the composition of expenditures by AI investments category. In 2020, the *Skills* investment category accounted for the majority of AI investments in Europe (34%). Expenditures on AI-related *R&D* represent 30% of the total AI investments in the EU. *Data and equipment* and *Intangible assets* account for 29% and 7% of the total EU AI investments respectively.

[6] The *min* and *max* scenarios are computed using patent- and publications-based coefficients using averages of 2000 and 2018, and 2010 and 2018 respectively. As patent and publications coefficients under the *max* scenario are larger, the implied AI estimates are larger as well. For further details see Figure 13 in Annex I.

[7] European Commission Communication on Artificial Intelligence for Europe (COM(2018)237 final).

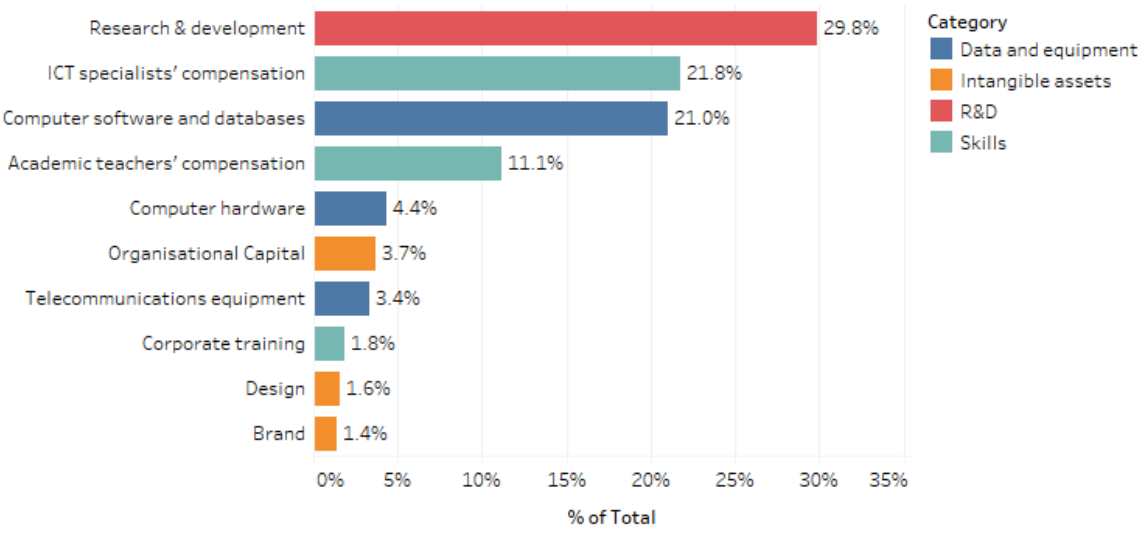
Figure 3: EU AI investments by investment category, 2020



Source: JRC based on EUROSTAT, Spintan and Intan-Invest data. Note: Figure presents estimates for the maximum scenario (see Annex I).

According to Figure 4, with nearly 30%, *R&D* represents the largest investment item of AI investments. ICT specialists' compensation and Computer software and databases account for approximately 21% of the EU AI investments each. Investments in *Intangible assets*, including Brand, Design and Organisational Capital account for nearly 7% of the total investments.

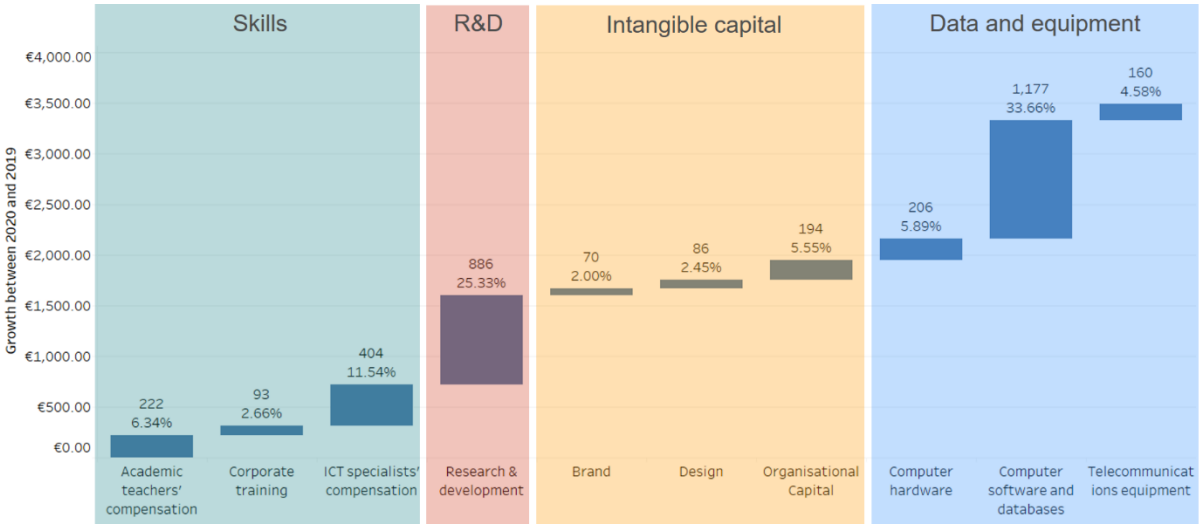
Figure 4: EU AI investments by investment item, 2020



Source: JRC based on EUROSTAT, Spintan and Intan-Invest. Note: Figure presents estimates for the maximum scenario (see Annex I).

Between 2019 and 2020, the volume of AI investments increased by EUR 3.5 billion. Figure 5 presents the contribution of different investment items to this growth. The top three items contributing the most to the increase in AI investments in 2020 were investments in Computer software and databases (EUR 1.2 billion or 33.7% of the total increase), *R&D* (EUR 886 million) and ICT specialists' compensation (EUR 404 million). Expenditures on Corporate training, Design and Brand contributed less than 3% each to the growth of the EU's AI investments.

Figure 5: EU AI investments change between 2019 and 2020 by investment item, EUR million and % of total

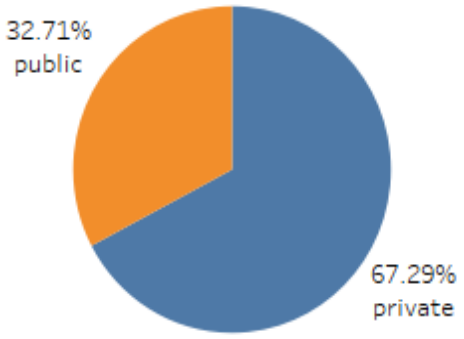


Source: JRC based on EUROSTAT, Spintan and Intan-Invest. Note: Figure presents estimates for the maximum scenario (see Annex I).

2.2. AI investments in the public and private sectors in the EU

In 2020, the private sector invested over EUR 10.7 billion in the development and adoption of AI. According to Figure 6, this represents 67% of the EU's AI investments. The public sector accounted for the remaining 33% or EUR 5.2 billion.

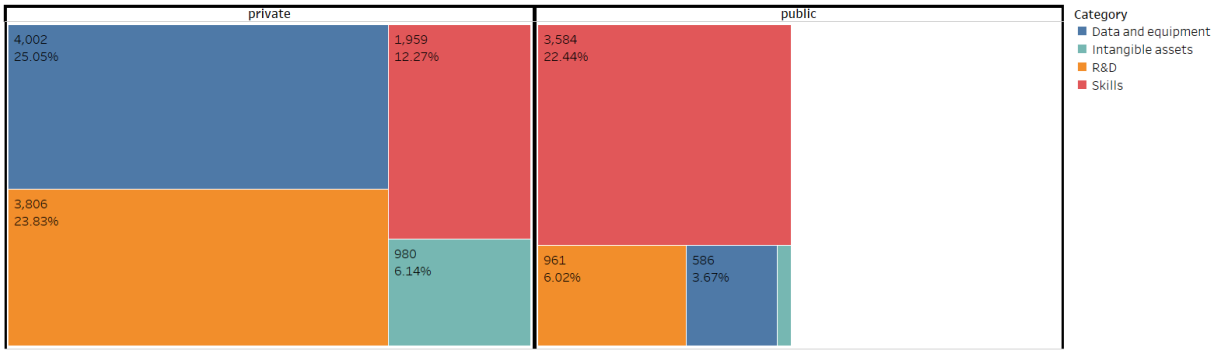
Figure 6: Distribution of EU AI investments by sector, 2020



Source: JRC based on EUROSTAT, Spintan and Intan-Invest. Note: Figure presents estimates for the maximum scenario (see Annex I).

Figure 7 presents a detailed breakdown of the allocation of AI investments by each sector by different categories and their contribution to the total. The *Skills* investment category has the largest share of investments made by the public sector. Overall, it accounts for over EUR 3.6 billion or 22% of the total AI investments in Europe. The remaining main categories of AI investments of the public sector are *R&D* (EUR 1 billion) and *Data and equipment* (EUR 0.6 billion). These two items account for nearly 10% of total EU AI investments. Considering the private sector, the three main investment categories include *Data and equipment* (EUR 4 billion), *R&D* (EUR 3.8 billion) and *Skills* (EUR 2 billion).

Figure 7: EU AI investments by category and sector, EUR million and % of total, 2020

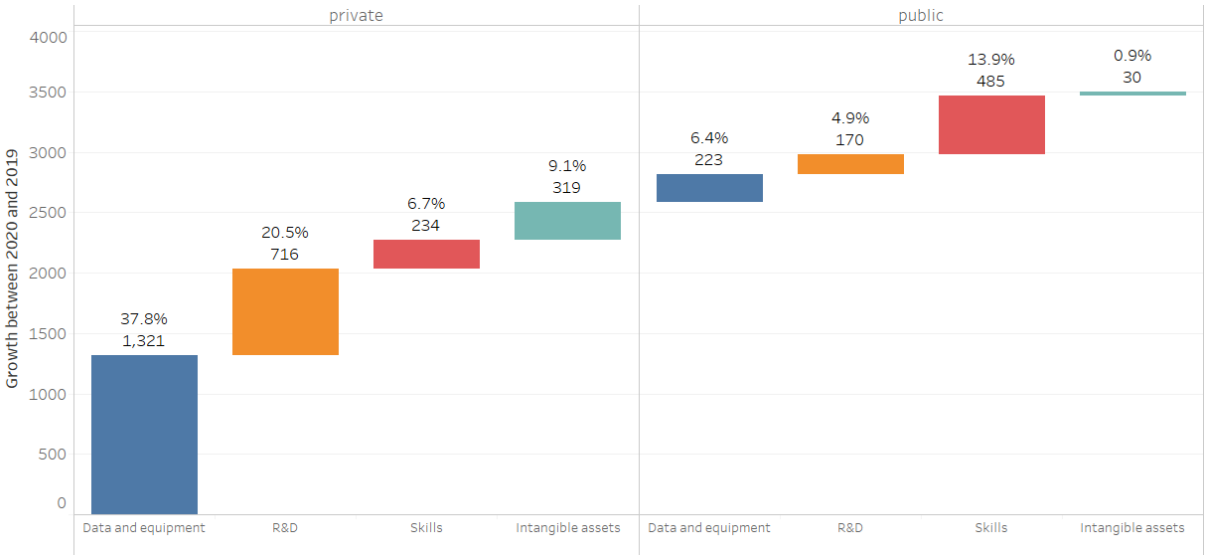


Source: JRC based on EUROSTAT, Spintan and Intan-Invest. Note: Figure presents estimates for the maximum scenario (see Annex I).

Between 2019 and 2020, the AI investments of the private sector increased by EUR 2.6 billion or 32%. In the same period, the public sector increased its AI investments by EUR 0.9 billion or 21%. Figure 8 breaks down the growth of AI investments by the sector of origin and investment category. The EUR 3.5 billion increase in AI investments was mainly driven by the increase of the investments in *Data and equipment* and *R&D* of the private sector and expenditures on *Skills* of the public sector. The growth in these three investment categories account for over 70% of the total increase in the EU's AI investments in 2020.

The higher growth of AI investments in the private sector than in the public sector led to an increase of its relevance for the total level of AI investments. While in 2018 and 2019 the private sector accounted for 63% and 65% of the total EU AI investments (Dalla-Benetta, et al., 2021), in 2020, its share in the total reached 67%.

Figure 8: EU AI investments change between 2019 and 2020 by sector and investment category, EUR million and % of total change



Source: JRC based on EUROSTAT, Spintan and Intan-Invest. Note: Figure presents estimates for the maximum scenario (see Annex I).

3. AI investments in the EU Member States

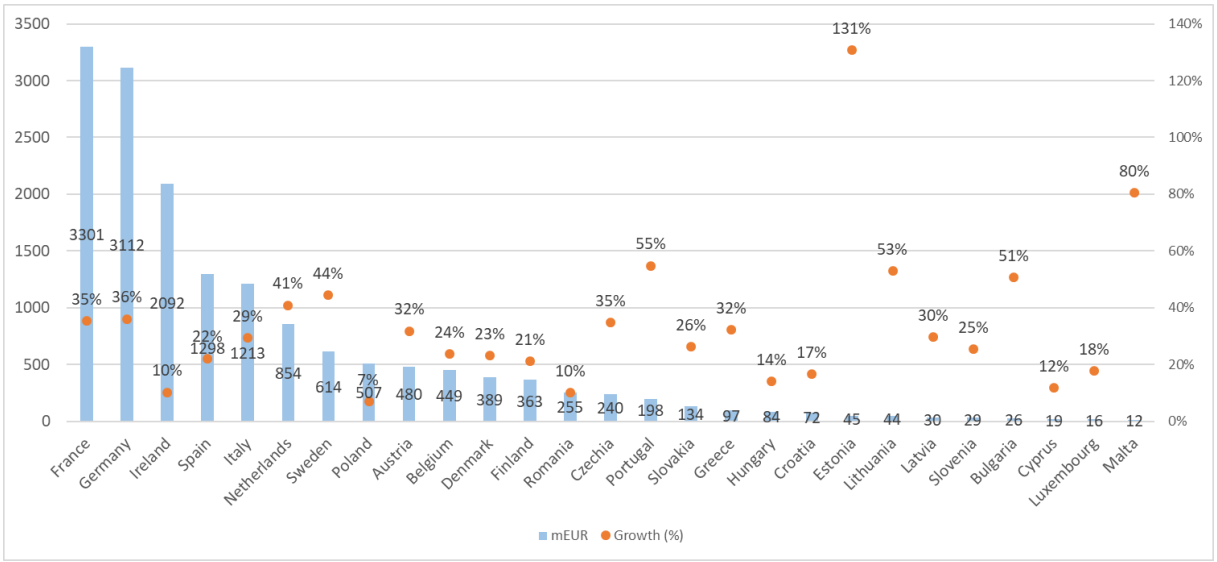
Key facts

- AI investments in France, Germany, Ireland, Spain and Italy have surpassed EUR 1 billion per year.
- The two leading countries, France and Germany, increased their AI investments at a rate higher than the average, thus increasing the gap across the EU Member States.
- Ireland together with the Nordic countries lead the ranking in investment per capita. They spend more than EUR 50 per capita on AI compared to the EU average of EUR 36.
- In 2020, Estonia, Malta and Portugal had the highest growth of AI investments, while Poland, Romania and Ireland experienced the lowest growth.

Turning the attention to the AI investments at the country level, Figure 9 presents the 2020 amount of AI investments and their growth rate between 2019 and 2020 by country. The two largest European economies, France and Germany, spent over EUR 3 billion on AI each. These two countries account for over 40% of the total AI expenditures in the EU. With slightly over EUR 2 billion, Ireland comes in third in the ranking.[8] Spain and Italy are the remaining EU countries with AI investments surpassing EUR 1 billion per year.

As indicated in Figure 2, the level of AI investments between 2019 and 2020 grew at an average rate of 20–28%. However, this figure varies greatly from country to country. According to Figure 9, with 131%, Estonia recorded the highest increase in AI investments. In 2020, Poland (7%), Romania and Ireland (10%) recorded the lowest increase in AI investments. It must be noted, that in 2019 AI investments in Ireland grew by 208% (Dalla-Benetta, et al., 2021) and, although at a considerably smaller rate, they continued to grow in 2020. Although there is a slightly negative correlation between the absolute level of AI investments and their growth, the two leading countries, France and Germany, increased AI spending at a rate higher than the average. At the same time, many smaller countries had lower rates of growth than the EU average. This indicates that the AI gap across the EU is increasing.

Figure 9: 2020 AI investments by country (EUR million) and growth between 2019 and 2020



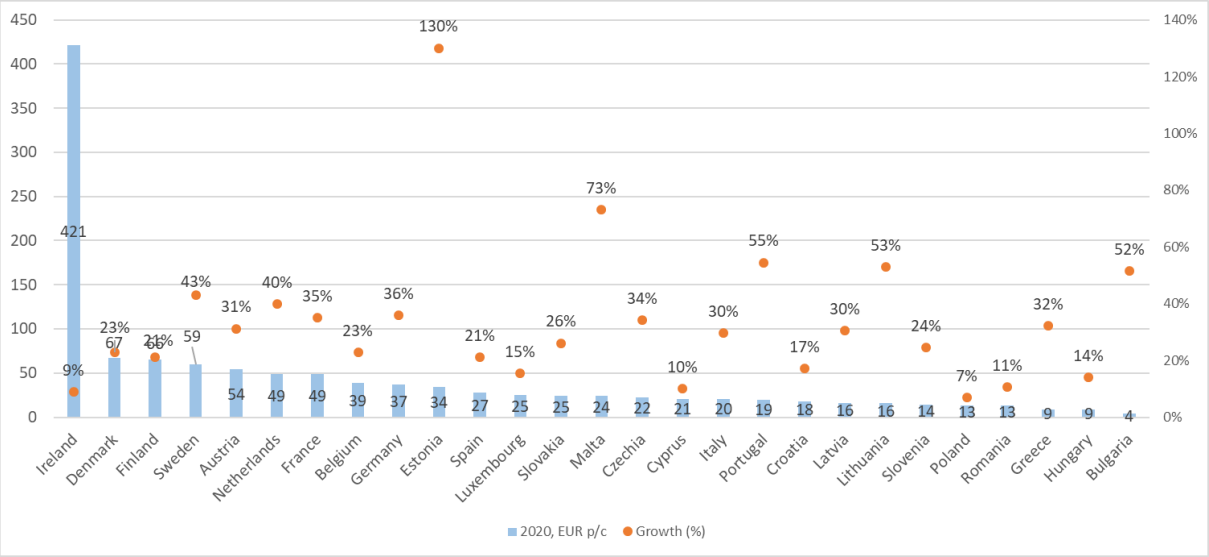
Source: JRC based on EUROSTAT, Spintan and Intan-Invest. Note: max scenario (see Annex I).

When the per capita investments are examined (see Figure 10), Ireland together with the Nordic countries lead the ranking, spending more than EUR 50 per capita on AI. In comparison, the EU average AI investments per capita in 2020 were at the level of EUR 36. In general there is a large variation among the Member States in

[8] In Ireland, the large volumes and growth rates of investments in investment categories used to estimate AI investments, e.g. R&D expenditures or investments in intangibles, were noted in the previous AI Watch report (Dalla-Benetta, A., Sobolewski, M., & Nepelski, D. (2021). AI Watch: European Union AI investments 2020 *JRC Technical Reports*: JRC.) This is related to the relocation of sales proceeds or assets by multinationals to their Irish subsidiaries. See, for example, Montornès, J., & Khder, M.-B. (2021). The impact of multinationals' transfers on Irish GDP.

per capita expenditures, with developing economies spending considerably less than developed ones. This applies also to the level of growth of AI investments per capita, which ranges between 7% (Poland) and 130% (Estonia).

Figure 10: AI investments per capita by country (EUR) in 2020 and growth between 2019 and 2020



Source: JRC based on EUROSTAT, Spintan and Intan-Invest. Note: max scenario (see Annex I).

4. AI investments in the EU, UK and US

Key facts

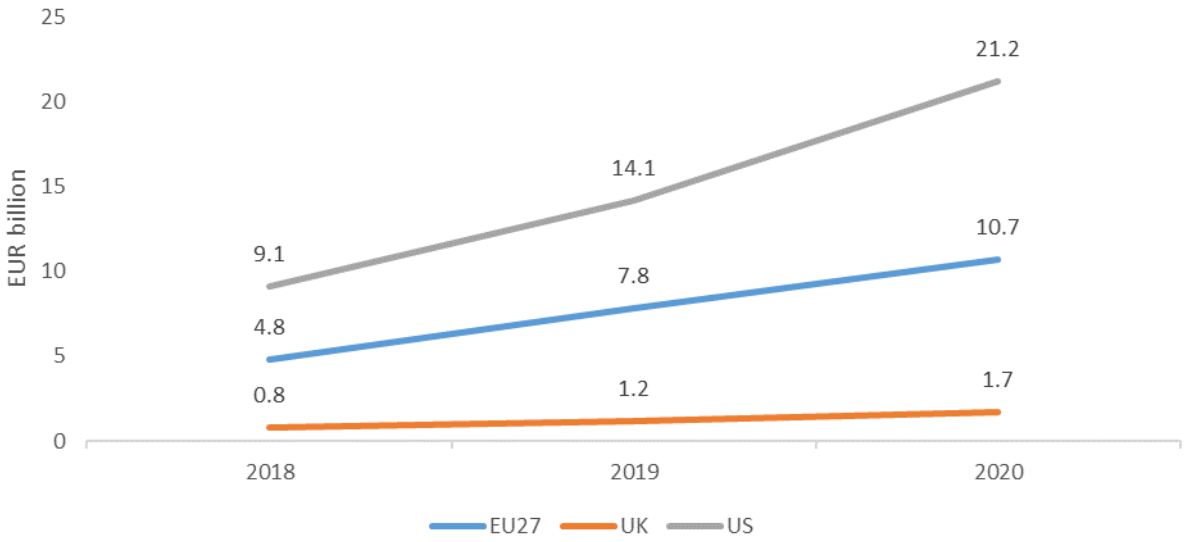
- In 2020, the US invested twice as much in AI as the EU.
- The EU and the US have similar structures of investments with the private sector accounting for over 80% of AI investments.
- In the UK, in 2020, the growth of AI investments was higher than 2019, while the EU and the US reported smaller growth rates.
- Among the three regions, during the COVID-19 crisis the level of growth of AI investments was the least resilient in the EU.

4.1. AI investments in the EU, the UK and the US

Regarding the international analysis, comparable data on AI specialists' compensation and AI academic teachers' compensation is not available for the US. The comparison of the AI investments in the EU, UK and US relies thus on the available data and covers *R&D*, *Data and equipment* and *Intangible assets* and excludes the Skills investment category.[9] Considering the selected investments categories, Figure 11 presents the evolution of AI investments between 2018 and 2020 in the EU, the UK and the US. In 2020, the overall level of AI investments for the EU is estimated to be approximately EUR 10.7 billion. In comparison, the US and the UK invested EUR 21.2 and EUR 1.7 billion respectively.

In the EU and the US, the growth of AI investments in the COVID-19 year was lower than in the preceding year. However, the level of decrease was not equal. In 2019, the EU saw a 64% increase in AI investments, and in 2020 investments grew by only 37%. In contrast, in the US, the figure was 55% and 50% in 2019 and 2020 respectively. In contrast, in 2020, AI investments in the UK grew at a higher rate (46%) than in 2019 (40%). In other words, among the three regions, the AI investments in the EU were the least resilient to the COVID-19 crisis.

Figure 11: Estimates of AI investments in the EU, UK and US, 2018–2020, EUR billion



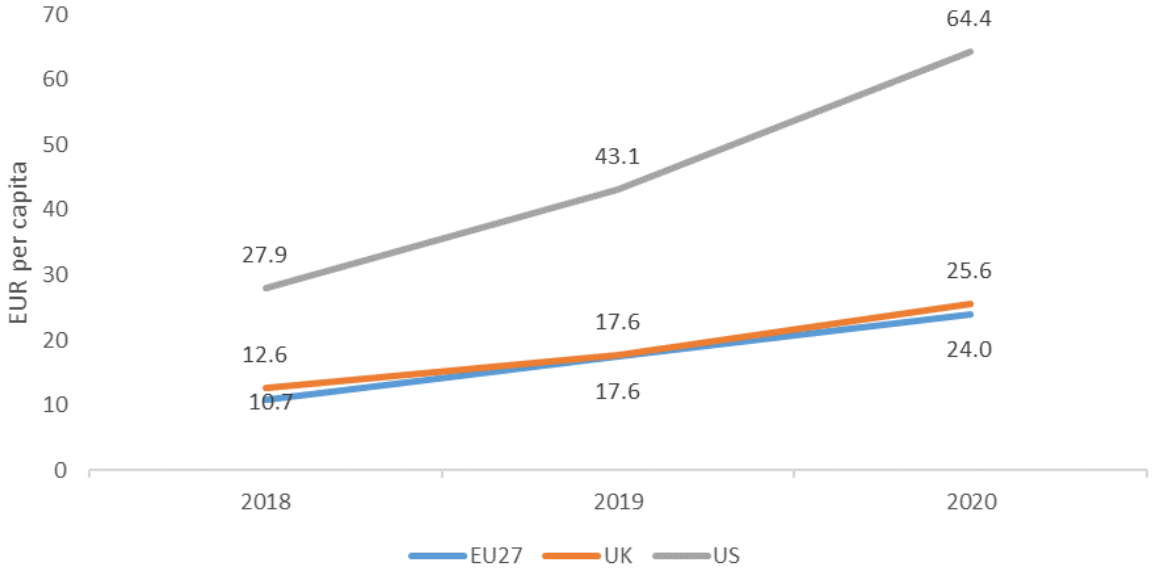
Source: JRC based on EUROSTAT, UK and US Statistical Offices, Spintan and Intan-Invest. Note: Includes estimates according to the maximum scenario. For methodological details of the min and max scenario see Annex I.

Regarding AI investments per capita, Figure 12 shows that the US is well ahead the EU and the UK. While the EU and UK have AI investments at the level of approx. EUR 25 per capita, the US spends nearly EUR 65 per

[9] As explained in Box 1, due to the lack of comparable data for the US on AI-related *Skills*, the figures presented in this section are not directly comparable with the EU figures presented in Sections 2 and 3.

capita. Similar to the overall level of AI investments, the UK seems to have been the country with the most resilience to the COVID-19 crisis. In 2020, its year-over-year growth rate was 45% compared to 39% in 2019. In contrast, in the EU, the figured dropped from 63% to 36%, and in the US from 54% to 49%.

Figure 12: Estimates of AI investments per capita in the EU, UK and US, 2018–2020, EUR



Source: JRC based on EUROSTAT, UK and US Statistical Offices, Spintan and Intan-Invest. Note: Includes estimates according to the maximum scenario. For methodological details of the min and max scenario see Annex I.

4.2. AI investments in the EU, the UK and the US by sector and category

Table 1 breaks down AI investments in the EU, UK and US by sector of origin and investment category. The EU and the US have a very similar structure of AI investments with respect to the sector of origin. In the EU and the US the private sector accounts for 84% and 83% of the total AI investments respectively. The remaining 16% and 17% originate from the public sector. The contribution of the UK public sector is significantly higher than in the other two regions and accounts for 77% of the total AI investments in this country.

Table 1: AI investments by sector and category in the EU, UK and US, EUR million and %, 2020

		Region					
		EU		UK		US	
Sector	**Category**	mEUR	% of total	mEUR	% of total	mEUR	% of total
Private	Data and equipment	4001.7	37.3%	669.9	39.0%	8473.4	39.9%
	Intangible assets	980.0	9.1%	300.4	17.5%	1837.9	8.7%
	R&D	3806.0	35.5%	318.4	18.6%	6801.2	32.0%
	Skills	226.4	2.1%	39.6	2.3%	522.1	2.5%
Subtotal: private		**9014.2**	**84%**	**1328.3**	**77%**	**17634.5**	**83%**
Public	Data and equipment	586.1	5.5%	129.1	7.5%	1056.9	5.0%
	Intangible assets	93.2	0.9%	25.1	1.5%	219.7	1.0%
	R&D	961.4	9.0%	184.4	10.7%	2218.6	10.5%
	Skills	60.8	0.6%	49.4	2.9%	92.2	0.4%
Subtotal: public		**1701.6**	**16%**	**388.0**	**23%**	**3587.4**	**17%**
Total		**10715.8**	**100%**	**1716.3**	**100%**	**21221.9**	**100%**

Source: JRC based on EUROSTAT, UK and US Statistical Offices, Spintan and Intan-Invest. Note: Note: Includes estimates according to the maximum scenario. For methodological details of the min and max scenario see Annex I.

Looking at the contribution of the individual investment categories to the total level of AI investments, we can observe that the EU and the US have a very similar investment structure. For example, *Data and equipment* investments of the private sector in the EU account for 37.3% and in the US for 39.9% of the total AI investments. Similarly, *R&D* investments of the private sector in the EU account for 35.5% and in the US for 32% of the total AI investments.

The overall lower share of the private sector in the total AI investments in the UK is mainly a result of the fact that it spends less on *R&D* (18.6% of the total amount) than its counterparts in the EU and the US. At the same time, however, in relative terms, the UK private sector spends double the amount on AI-related *Intangible assets* (17.5% of the total amount) that the EU (9.1%) or the US (8.7%) private sector.

5. Concluding remarks

The study is a continuation of providing estimates of AI investments in the EU and, with this edition, in selected global economies. Considering the relevance and dynamics of AI investments across the countries under consideration, further measuring remains critical for informed policymaking with respect to this new technology.

Drawing on the latest available data, this report presents estimates of AI investments in Europe between 2018 and 2020, applying the methodology outlined in the first AI Watch report on estimating AI investments (Nepelski & Sobolewski, 2020) and subsequently applied (Dalla-Benetta, et al., 2021). Compared to the previous editions on estimating AI investments in Europe, the report contrasts the level of AI investments of the EU with those of the UK and the US for three investment categories: AI-related *Data and equipment*, *R&D* and *Intangible assets*.

Emphasis on developing an approach to estimating and tracking AI investments is a key component in the effort to reinforce monitoring of the development, uptake and impact of AI technologies in the EU. For example, Eurostat has started to gather data on the adoption of AI technologies in European industry.[10] Similarly, AI Watch's AI Index combines different indicators and provides a fuller picture of ongoing developments around AI.[11]

[10] https://ec.europa.eu/eurostat/web/products-eurostat-news/-/ddn-20210413-1
[11] https://ai-watch.ec.europa.eu/ai-watch-index-2021_en

Annex I: Methodology to estimate AI investments

This is the third AI Watch report presenting estimates of AI investments in the EU. It uses the methodology to estimate AI investments defined in the first AI Watch report on AI investments (Nepelski & Sobolewski, 2020) and later in the 2020 report (Dalla-Benetta, et al., 2021). Drawing on the latest available data, it revisits the 2018 and 2019 estimates and adds AI investments estimates for 2020. Below, the key methodological steps are recalled.

AI investments estimation is carried out with a top-down approach and consists of two steps. In the first step, data on the economy-wide levels of expenditures in all relevant categories are collected. In the second step, these expenditures are weighted with AI-intensity coefficients to reflect amounts that are attributable to AI creation and adoption.

1) Step one: Economy-wide levels of investments

In the first step, country-level data is compiled on economy-wide expenditures in the EU corresponding to the four investment categories: *Skills*, *R&D* and *Data and equipment* and *Intangible assets.* The four categories include ten different investment items. Table 2 presents the investment categories, items and data sources used. The final dataset consists of 532 data points per year corresponding to country-item-sector combinations.

Table 2: Investment categories, items and data sources

Investment categories	Investment item	Data source
Skills	ICT specialists' compensation	Eurostat: ICT statistics (isoc_sks_itspe) / National Accounts (nama_10_a64_e) / Wages (earn_ses_hourly; lc_lci_lev; lfsa_esegn2) / Educational statistics (educ_uoe_grad02)
	Academic teachers' compensation	Eurostat: Educational statistics (educ_uoe_fini01, educ_uoe_perp02)
	Corporate training	Intan-invest (private sector)
Intangible assets	Organisational capital	Intan-invest (private sector) Spintan (public sector)
	Brand	
	Design	
R&D	Research & development	Eurostat: National Accounts GFCF (nama_10_an6; nama_10_nfa_fl)
Data and equipment	Computer hardware	
	Computer software and databases	
	Telecommunications equipment	

Source: JRC AI Watch.

2) Step two: AI intensity coefficients

In the second step, for each type of aggregated expenditures collected in the first step, a corresponding share of AI was estimated. To obtain the AI share of investments, all economy-wide expenditure items from step one are weighted by the respective AI intensity coefficients, which can take values of between 0% and 100%.

Table 3 provides the correspondence between expenditure items and AI intensity coefficients and their definitions. Except for *R&D*, each aggregate expenditure item has been treated with exactly one coefficient as indicated in the last column of Table 3. In comparison to the previous method of estimating AI-related *R&D* investments, both patent- and publication-based AI intensity coefficients are used. The final amount of AI-related *R&D* investments is an average of both estimates. The rationale behind this is that many AI technologies are not patentable and scientific publications serve as a better proxy of R&D activities in AI.

Table 4 provides definitions of the AI intensity coefficients together with the data source and description of methodologies that were used to compute them. In addition, the time coverage of the data used is provided. Basic descriptive statistics of the coefficients are given in Table 5.

Table 3: Investment items and corresponding AI intensity coefficients

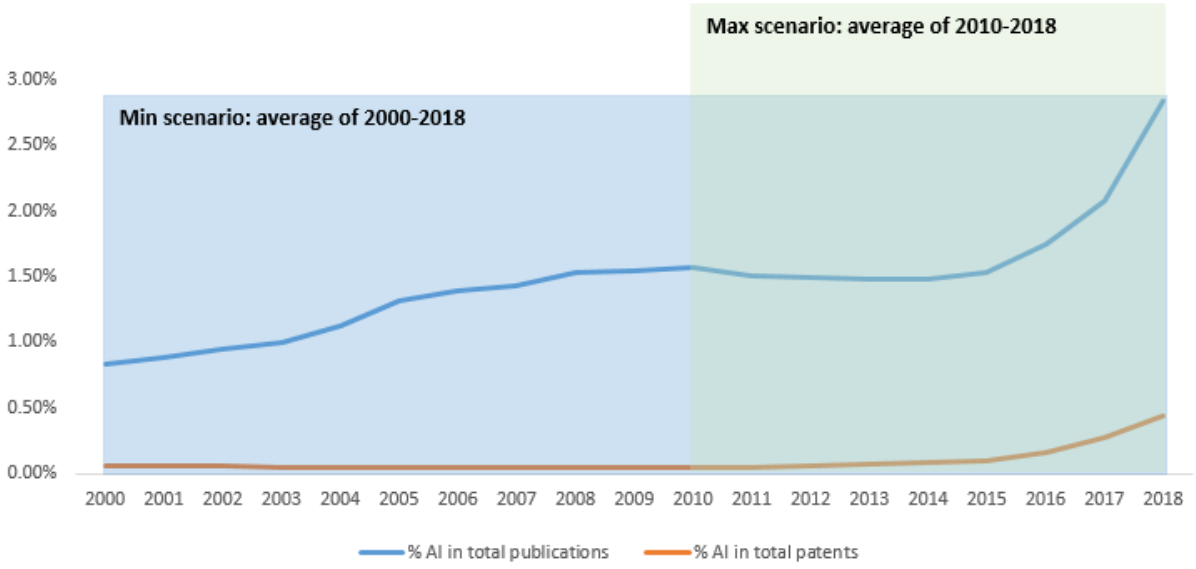
Investment categories	Investment item	AI intensity coefficient applied
Skills	ICT specialists' compensation	% of AI ICT specialists in country's total number of ICT specialists
	Academic teachers' compensation	% of AI university programmes in country's total programmes
	Corporate training	% of AI patents in total number of patents worldwide
Intangible assets	Organisational capital	
	Brand	
	Design	
R&D	Research & development	% of AI patents in country's total number of patents AND % of AI publications in country's total number of publications
Data and equipment	Computer hardware	% of AI patents in total number of ICT patents worldwide
	Computer software and databases	
	Telecommunications equipment	

Source: JRC AI Watch.

3) Minimum and maximum range of AI investments

To partially account for changes in the structure of supply and demand for AI technologies and skills in the economy, minimum and maximum AI investments scenarios were computed. As illustrated by Figure 13, in the *min* scenario, to take a long-term perspective of the AI impact on the economy, patent- and publications-based coefficients based on the period between 2000 and 2018 were used (see Table 4). The *max* scenario relies on patent- and publications-based coefficients computed for the period between 2010 and 2018 that is assumed to reflect the most recent developments in the field of AI and its diffusion in the economy.

Figure 13: AI intensity coefficients and their minimum and maximum scenario ranges



Source: JRC based on PATSTAT and SCOPUS data.

According to Table 5, the first two intensity coefficients, *the share of AI patents in total number of patents worldwide* and *the share of AI patents in total number of ICT patents worldwide*, have the same value for all countries, i.e. 0.2% and 1.31% respectively. The remaining four, i.e. *the share of AI ICT specialists in country's total number of ICT specialists*, *the share of AI patents in country's total number of patents, the share of AI publications in country's total number of publications* and *the share of AI university programmes in country's total programmes*, take individual values for each country. According to Table 5, *the share of AI ICT specialists in country's total number of ICT specialists* ranges between 0% and 4.54% and has an average of 1.05%. *The share of AI patents in country's total number of patents* takes values between 0.62% and 4.95% and *the share of AI university programmes in country's total programmes* is between 0% and 7.55%. It must be mentioned that, in most cases, the value zero is a result of unavailable data for an individual country. As patent and publications coefficients under the *max* scenario are larger, the implied AI estimates are larger as well.

Table 4: AI intensity coefficients, time coverage and data sources

AI intensity coefficient applied	Coefficient definition	Time coverage and data source	Compilation method
% of AI patents in total number of ICT patents worldwide	Number of AI patent applications over total ICT patent applications worldwide.	Min. scenario: 2000–2018; Max. scenario: 2010–2018; PATSTAT by European Patent Office	Text matching on dictionary with AI terms with patent titles and descriptions (De Prato et al. 2019)
% of AI patents in total number of patents worldwide	Number of all AI patent over total number of patent applications worldwide.		
% of AI patents in country's total number of patents	Number of all AI patent applications over total number of patent applications with innovators based in a country.		
% of AI publications in total number of publications	Number of all AI publications over total number of publications in a country.	Min. scenario: 2000–2018; Max. scenario: 2010–2018; Scopus	
% AI ICT specialists in country's total number of ICT specialists	Number of AI ICT specialists, approximated by the number of AI ICT graduates in the years 2015–2017, over total number of ICT specialists in a given country.	2020; StudyPortals and (Lopez-Cobo et al., 2019) 2016–2018; Eurostat educational statistics	
% of AI university programmes in country's total programmes	Number of specialised AI programs over all university programs available in a given country.	2020; StudyPortals and (Lopez-Cobo et al., 2019)	

Source: JRC AI Watch.

Table 5: Descriptive statistics of AI intensity coefficients in the maximum scenario

Statistic	% of AI patents in total number of patents worldwide	% of AI patents in total number of ICT patents worldwide	% AI ICT specialists in country's total number of ICT specialists	% of AI patents in country's total number of patents	% of AI university programmes in country's total programmes
Min	0.2%	1.31%	0.00%	0.62%	0.00%
Max	0.2%	1.31%	4.54%	4.95%	7.55%
Average	0.2%	1.31%	1.05%	1.36%	2.70%

Source: JRC AI Watch.

Annex II: Comparing AI investments in the EU, UK and US

Comparable data on AI specialists' and AI academic teachers' compensation is not available for the US. These two investment items represent 36% of the total EU AI investments in 2020 (see Table 6). As a results, the analysis in Section 4 compares the available data and covers all other investment items. The figures used in the international comparison are thus not directly comparable with the EU figures in Sections 2 and 3 of this report.

Table 6: Composition of AI investments in the EU and availability of data for the US

Investment category	Investment item	% of total AI Investments in the EU	Available for the US
Skills	AI specialists' compensation	24%	No
	AI academic teachers' compensation	12%	
	Corporate training	2%	Yes
Intangible assets	Brand	2%	
	Organisational Capital	4%	
	Design	2%	
R&D	R&D	22%	
Data and equipment	Computer hardware	5%	
	Computer software and databases	23%	
	Telecommunications equipment	4%	

Source: JRC AI Watch.

References

Brynjolfsson, E., Rock, D., & Syverson, C. (2018). *The productivity J-curve: how intangibles complement general purpose technologies*: Cambridge, MA: National Bureau of Economic Research.

Corrado, C., Hulten, C., & Sichel, D. (2005). Measuring Capital and Technology: An Expanded Framework *Measuring Capital in the New Economy* (pp. 11-46): National Bureau of Economic Research, Inc.

Dalla-Benetta, A., Sobolewski, M., & Nepelski, D. (2021). AI Watch: European Union AI investments 2020 *JRC Technical Reports*: JRC.

MGI. (2017). Artificial intelligence: The next digital frontier?

Nepelski, D., & Sobolewski, M. (2020). Estimating investments in General Purpose Technologies: The case of AI Investments in Europe *JRC Technical Reports*: JRC.

Science-Business. (2018). Money flowing into European AI companies, *Science Business*. Retrieved from https://sciencebusiness.net/news-byte/money-flowing-european-ai-companies

List of figures

List of tables

GETTING IN TOUCH WITH THE EU

In person

All over the European Union there are hundreds of Europe Direct information centres. You can find the address of the centre nearest you at: https://europa.eu/european-union/contact_en

On the phone or by email

Europe Direct is a service that answers your questions about the European Union. You can contact this service:

- by freephone: 00 800 6 7 8 9 10 11 (certain operators may charge for these calls),

- at the following standard number: +32 22999696, or

- by electronic mail via: https://europa.eu/european-union/contact_en

FINDING INFORMATION ABOUT THE EU

Online

Information about the European Union in all the official languages of the EU is available on the Europa website at: https://europa.eu/european-union/index_en

EU publications

You can download or order free and priced EU publications from EU Bookshop at: https://publications.europa.eu/en/publications. Multiple copies of free publications may be obtained by contacting Europe Direct or your local information centre (see https://europa.eu/european-union/contact_en).

KJ-NA-31114-EN-N

The European Commission's science and knowledge service

Joint Research Centre

JRC Mission

As the science and knowledge service of the European Commission, the Joint Research Centre's mission is to support EU policies with independent evidence throughout the whole policy cycle.

EU Science Hub

ec.europa.eu/jrc

@EU_ScienceHub

EU Science Hub - Joint Research Centre

EU Science, Research and Innovation

EU Science Hub

Publications Office of the European Union

doi:10.2760/702029

ISBN 978-92-76-53433-4