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Estimating investments in General Purpose Technologies

The case of AI Investments in Europe

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Foreword

This report is published in the context of AI Watch, the European Commission knowledge service to monitor the development, uptake and impact of Artificial Intelligence (AI) for Europe, launched in December 2018.

AI has become an area of strategic importance with potential to be a key driver of economic development. AI also has a wide range of potential social implications. As part of its Digital Single Market Strategy, the European Commission put forward in April 2018 a European strategy on AI in its Communication "Artificial Intelligence for Europe" COM(2018)237. The aims of the European AI strategy announced in the communication are:

- To boost the EU's technological and industrial capacity and AI uptake across the economy, both by the private and public sectors
- To prepare for socio-economic changes brought about by AI
- To ensure an appropriate ethical and legal framework.

Subsequently, in December 2018, the European Commission and the Member States published a “Coordinated Plan on Artificial Intelligence”, COM(2018)795, on the development of AI in the EU. The Coordinated Plan mentions the role of AI Watch to monitor its implementation.

AI Watch monitors 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 Member States. AI Watch results and analyses are published on the AI Watch Portal (https://ec.europa.eu/knowledge4policy/ai-watch_en).

From AI Watch in-depth analyses, we will be able to understand better European Union’s areas of strength and areas where investment is needed. AI Watch 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).

This report addresses the following objectives of AI Watch: Providing a methodology and estimates of investments levels in AI in Europe.

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Executive summary

In spite of a large interest in AI, among many open questions around this promising technology, the one concerning the level of investments in AI is particularly disturbing. Various sources provide various figures. This constantly blurs the understanding of the AI-driven revolution among policy makers and business leaders and constraints informed decision making. The current report presents an original and comprehensive methodology to estimate AI investments and applies it to the European economy. It provides estimates of AI investments in Europe in 2018.

The current framework for estimating AI investments in an economy rests on three assumptions: First, it considers AI as a general-purpose technology (GPT). Being a GPT, the economic and innovative potential of AI lies in its capacity to modernise the economy rather than in the strength of the AI producing sector. Consequently, similar to other digital GPTs, to trigger the wave of AI-driven wave of innovation, comprehensive support and funding of AI development and translation of the opportunities offered by AI into new business models and processes is needed. Second, building on the fact that AI is a GPT, the current framework considers among AI investments not only investments in the core technology, but in complementary assets and capabilities such as skills, data, product design and organisational capital. Considering the relevance of the wider focus for an economy-wide uptake of AI, the current framework groups AI-related investments into three target categories: “Talent, skills and life-long learning”, “From the lab to the market” and “Data, technology and infrastructure”. Finally, the framework recognises different roles that the public and private sectors play in the process of AI creation and implementation and provides investment figures of both sectors. Overall, by highlighting the role of different stages, actors and capabilities involved in the AI uptake, the current report attempts to enlarge the perspective on the efforts necessary to roll out AI in an economy.

In 2018, the AI investments in Europe are estimated to be in the range of **7.0-8.4 Billion Euro**. This corresponds to 35-42% of the annual investment target set in the Coordinated Action Plan (EC, 2018b). Current spending in the EU28 is equivalent to 16.3 Euro per capita or 0.04 percent of the EU GDP. For comparison, in 2018, total R&D spending in the EU accounts for 2.11 percent of the EU GDP.

The current framework groups AI-related investments into three target categories. The majority of investments is targeted at labour and human capital covered by “**Talent skills and life-long learning”** target (58%). In this group of expenditures, AI ICT specialists’ compensation represents the largest item. Expenditures on AI-related "**Data, technology and infrastructure**" account for nearly 30% of the total AI investments in the EU with most of investments going into “Computer software and databases”. The smallest stream of funding is directed at the “**From the lab to the market**” target, which includes expenditures on R&D and such intangible capital assets as brand, product design and organisational capital.

Investments in **AI-related intangible assets**, account for 30% of the total expenses or three times more than the expenses on hard infrastructure. There is highly **positive correlation between investments in AI-related tangibles and intangibles**. This points to a large complementarity between different types of investment, which is particularly strong among the "From the lab to the market" and "Data, technology and infrastructure" investment targets. This indicates the importance of investing into tangible and intangible assets to foster successful adoption of AI technologies.

The contribution of the **public sector** is quite substantial and accounts overall to 42% of EU AI investments in 2018. This includes outlays on AI education as well as the adoption of AI by the public sector.

Regarding the **AI investments at the Member States level**, the highest absolute amounts are expensed in the largest countries. France, Germany and the United Kingdom score top three with nearly 50% of the total AI expenditures in the EU. This picture changes substantially when the per capita investments are examined. **Nordic countries and Ireland** are the top scorers, disbursing more than 35 Euro per capita on AI investments. In general, there is a huge variation among the Member States in per capita expenditures, with developing economies spending considerably less than developed ones. Moreover, considerable differences in all expenditure categories exist across the European countries. This reflects structural diversity of their economies and **different levels of AI readiness** of the EU Member States.

1 Introduction

The *Artificial Intelligence for Europe* Communication of the EC sees Artificial Intelligence (AI) as a technology that could boost the European competitiveness (EC, 2018a). The *Coordinated Plan on Artificial Intelligence* outlines how EU Member States could coordinate their strategies, efforts and investments to maximise the benefits of AI for Europe (EC, 2018b). The objective of the AI Watch project, among others, is to monitor the investments by Member States (MSs) targeting AI. The current report lays the foundation for a methodology to estimate investments in AI and applies it to the European economy. It presents an overview of the total AI investments in 2018 related to the development and adoption of AI. This way, the report provides parameters for the discussion related to the direction of support to AI development and application in Europe. The work builds on the initial methodology developed in the PREDICT project in the context of the preparatory work to the EC Communication on *Coordinated Plan on Artificial Intelligence* (EC, 2018b).

Due to the increasing interest in AI among businesses and policy makers, there is a need for evidence of AI take-up and impact. Although there have been many attempts to provide such evidence, they seem to be inconclusive. While some studies claim that both companies that are at the digital frontier and private investors are investing vast amounts of money in AI (MGI, 2017), other are making more modest judgments. A study of AI maturity levels of 500,000 companies concludes that there is a small set of companies adopting AI across the board, and less than 1,500 companies operating in the U.S. are investing anywhere near the space (Naimat, 2016). There are at least two reasons behind this blurred picture. First of all, various definitions of AI are used and most of them are vague and propose an ideal target rather than a measurable research concept (López-Cobo et al., 2019). Second, the available studies look at different sources and/or targets of AI investments. For example, some studies look at the AI technology market and quantify AI investments as the share of expenditures on AI-related technologies in the total expenditures in ICT (IDC, 2017; Orinox, 2017). Other estimations are based on R&D expenditures of large digital firms or the flow of venture capital to AI start-ups (MGI, 2017; OECD, 2018; Science-Business, 2018). It is clear that the choice of AI definition as well as the types of AI-related expenditures that are being taken into account have consequences for the attempts to quantify investments in AI and direct comparison among studies is limited.

The current report takes the view that AI is the most important general-purpose technology (GPT) of our era (Brynjolfsson & McAfee, 2017; Brynjolfsson, Rock, & Syverson, 2018; Trajtenberg, 2018). This means that the economic impact of AI will be reflected by its ability to transform all sectors of the economy, rather than the development and production of AI technology (Lee, 2018). Consequently, to trigger the wave of AI-driven transformation, comprehensive support and funding of AI development and adoption across the economy is needed (Nepelski, 2019). Besides investments in developing AI technologies, successful transition to an AI-driven economy requires investments in complementary, intangible assets including data, skills and organisational capital, which are likely to be 2.7 to 4.1 times bigger than the investments in tangible assets (Brynjolfsson et al., 2018). To take this into account, the current methodology considers a wide set of expenditures on labour and tangible and intangible assets related to AI creation and adoption.

The current framework distinguishes also between the sources of funding by breaking down AI investments by two main economic sectors: the private and the public. The attempt is to account for different roles that the two sectors have in the technologically-driven economic progress. Among the main contributions of the public efforts driving the technologically-enabled economic growth is creating markets by providing funding and support at the initial stages of technology creation and diffusion (Mazzucato, 2013, 2016; NIST, 2019). Silicon Valley, the cradle of the digital innovation revolution, is one of the main examples of how the creation of an entire technological domain and economic sector have benefited from public support. The history of AI also shows that the public sector has been intensively supporting the development of technology at its early stages. It provided funding for basic research and education to supply skills necessary for the development and uptake of AI technologies. By taking the lead role in providing patient capital, forming and orchestrating the innovation ecosystems, creating demand for new and untested technological products, the public sector de-risks uncertain R&D activities and bears the costs of necessary failures at the early stages of technology development. Once risks can be assessed, the private sector enters into the picture and assumes further development and commercialisation of technologies (Mazzucato, 2013). Recognising the interplay between the two sectors allows to account for their complementarities in fuelling the AI revolution.

The remaining of the report is structured as follows: Section 2 describes the conceptual framework to estimate AI investments. Section 3 elaborates on the estimation approach and data sources used in the study. Section 4 and 5 present the level of AI investment in the EU and its Member States. Section 6 provides detailed picture of AI investments by source and target for each EU Member State. Section 7 concludes.

2 Framework for estimating AI investments in Europe

The current framework for estimating AI investments in an economy rests on three assumptions:

- **AI is a general-purpose technology** (GPT). Being a GPT, the economic and innovative potential of AI lies in its capacity to modernise the entire economy rather than in the strength of the AI producing sector.
- **The uptake of AI requires complementary investments**. Reaping the benefits of AI does not only require investments in core technology development, but depends on its uptake across the economy. This requires significant investments in complementary assets and capabilities such as skills, software, data and organisational capital.
- **Public and private investments in AI need to co-exist**. The public and private sectors have complementary roles in the process of AI development and diffusion. While the public sector de-risks the AI development at its early stages, private actors assume further development and commercialisation of AI. Balancing the investments of the two sectors is necessary for the AI uptake.

Considering these three observations, the current approach takes a broad view of investments in AI. To account for the nature of AI and AI-enabled innovation, it is proposed that AI investments include:

> *Expenditures on labour and skills as well as tangible and intangible capital assets incurred by public and private organizations to develop and implement AI to (re-)design business processes in order to create new or improve existing products or services.*[1]

The following sections describe each of the three building blocks and their role in defining the framework for estimating AI investments.

2.1 AI as a General Purpose Technology

AI is a generic term that refers to any machine or algorithm that is capable of observing its environment, learning and, based on the knowledge and experience gained, taking intelligent actions and decisions (Craglia et al., 2018). AI is considered as the most important general-purpose technology (GPT) of our era (Brynjolfsson & McAfee, 2017; Trajtenberg, 2018). Similar to such GPTs like electricity or ICT, the impact of AI-based innovations on business and the economy will be reflected not only in their direct contributions but also in their ability to enable and inspire complementary innovations in all sectors of the economy. The main benefits of AI will come from its application across the economy rather than from the development of core technologies (Lee, 2018).

Similar to other digital technologies that are considered as GPTs, to trigger the wave of AI-driven wave of innovation and increase a firm's or a country's competitiveness, comprehensive support and funding of AI development and translation of the opportunities offered by AI into new business models and processes is needed (Nepelski, 2019). This implies addressing the entire innovation value chain starting from initial ideas, basic research, technology development, market commercialisation of AI technologies and covering both AI-producing and AI-using sectors. Besides investments in technology development and deployment, investments in complementary assets such as skills, software, data and organisational capital are critical. The deployment of AI in the business context requires also a set of technical, managerial as well as financial skills and capabilities. In other words, successful transition to an AI-driven economy relies on investments in a range of tangible and intangible assets and capabilities.

The selection of expenditure categories in the framework is guided by the reasoning on the role of technological progress in a sustained, long-run economic growth (Spiezia, 2011; Atkinson, 2018). From the economics perspective, a GPT impacts production process by increasing productivity of production factors. Technologically driven augmentation of labour and capital leads to more output and consequently to GDP growth. In this light, the framework identifies relevant expenditure categories related to both **creation** of AI technology and its **implementation** by producers across all sections of the economy in form of augmented capital and labour inputs.

[1] The current approach to define AI investments takes a broader view of "investments" than the one used in the context of business statistics. It includes intangible asset types that are not commonly considered as "investments" in statistics or accounting. For example, training of employees or business process improvements are accounted as "expenditures". The choice to consider such expenditures as investments in AI is justified by their critical role in the process of AI diffusion.

On the creation side, expenditures on **education** and **skills** enhancement are considered together with expenditures on research and development. On the technology implementation side, selection of relevant expenditure items follows directly from the concept of production function and the role of technological progress in augmentation of production inputs. The economic decisions to adopt artificial intelligence in production will manifest in purchasing AI-augmented inputs. Therefore the framework looks at investments in tangible and intangible **fixed assets** and expenditure on **labour** (Bresnahan, Brynjolfsson, & Hitt, 2002). Given that successful implementation of AI requires reorganisation of a firm around a new technology, design of new organization practices and training of its staff (Brynjolfsson et al., 2018), the framework accounts for expenditures on **organisational capital**, **brand** and **product design** (Corrado, Hulten, & Sichel, 2005, 2009).

2.2 Targets of AI investments

Considering the above discussion on core and complementary assets and capabilities relevant for an economy-wide uptake of AI, the current framework groups AI-related investments into three target categories:

- **Talent, skills and life-long learning**: The most obvious types of investments in AI-related skills include investments in technical skills, which are likely to depend on the level of educational infrastructure in a country. It is assumed that higher expenses on AI education increase the accessibility of AI for enterprises impacting both implementation (via human capital creation) and development of AI technology (via research and development). However, the deployment of AI technologies in business environment requires also specialised managerial competences that allow recognising the opportunity of AI technologies and applying them in all economic sectors. Investments in AI skills should thus include technical as well as relevant business skills. Therefore, this category includes expenditures on AI-related **education programmes**, **compensation of AI ICT specialists** and AI-related **corporate training**.
- **From the lab to the market**: Like any other R&D activities, AI-related R&D comprises creative work undertaken on a systematic basis in order to increase the stock of knowledge and to use it to devise new applications (OECD, 2002). AI R&D activity and expenditures represent an investment in knowledge accumulation and in the development of AI technologies. AI-enabled innovations do not only rely on R&D activities. Like other high-tech business ventures it is a process involving a number of steps, from initial ideas, basic research, technology development, market experimentation through commercialisation. Successful implementation of AI requires reorganisation of a firm around a new technology, design of new organization practices (Brynjolfsson, Hitt, & Yang, 2002). This involves a combination of skills, capabilities and assets necessary to successfully launch a product on the market (Oakey, 2003; Oxtorp, 2014). Therefore, this category includes both expenditures on AI-related **R&D** activities as well as expenditures on AI-related **product design, brand**, **organisational capital** that increase firms' capabilities to translate AI-enabled technological opportunities into new business processes and products.
- **Data, technology and infrastructure**: Data is the foundational resource of AI applications. It is the raw material that needs to be collected, stored, transmitted and analysed and transformed into valuable insights (Braganza, Brooks, Nepelski, Ali, & Moro, 2017). This transformation relies on the available soft- and hardware technology and infrastructure for data collection, storage, networking and processing. The uptake and impact of AI will thus depend on both the availability and accessibility of data as well as on complementary ICT technologies. Consequently, this category contains the investments in AI-related **ICT software** and **hardware**, **telecommunications equipment** and **data**.

2.3 Sources of AI investments

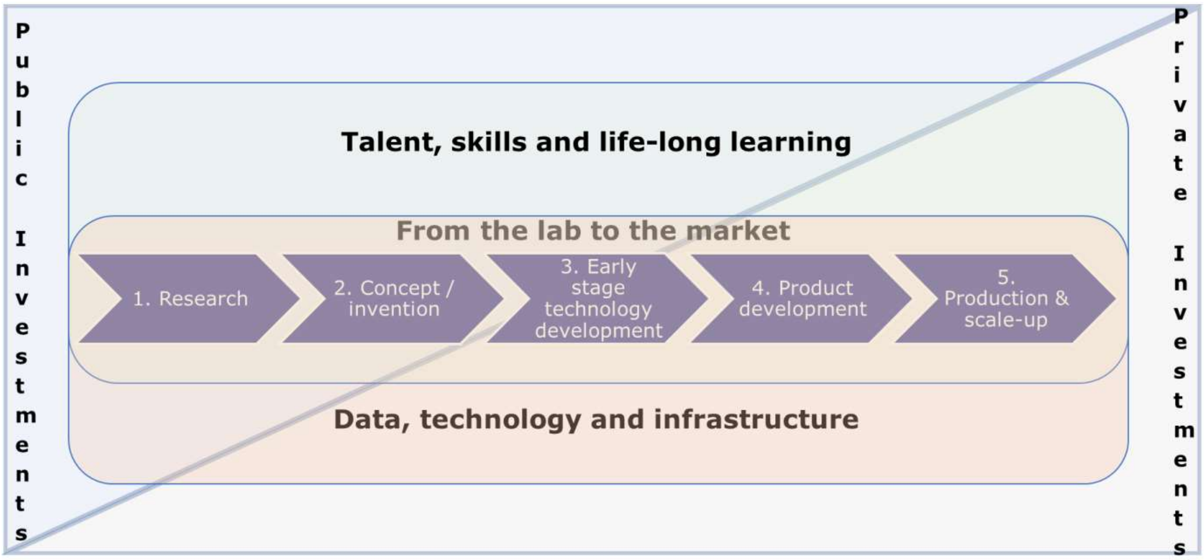
Among the main contributions of public efforts driving the technologically-enabled economic growth is creating markets by providing funding and support at the initial stages of technology creation and diffusion (Mazzucato, 2013, 2016; NIST, 2019). This is clearly the case in the context of AI. The public sector was intensively supporting the development of technology at its early stages. Once the first technological building blocks of AI were laid down and the technology was ready for a take-up, the private sector entered into the picture and assumed further development and commercialisation of technologies.

To account for this "division of labour", the current framework distinguishes between AI investments made by economic agents from market and non-market sectors. This breakdown is operationalised by the use statistical definitions separating **private** from **public investments** to account for different roles that the two sectors have in the technologically-driven economic progress. In operational terms, the framework distinguishes between:

- Private investments made by actors in the market sector: industry, trade, construction, business.[2]
- Public investments made by actors in the non-market sector: public administration, non-market producers in education, human health and social work.[3]

Taking into account the above discussion on AI as a GPT, targets and sources of expenditures and investments in AI creation and adoption, Figure 1 synthesises the proposed framework for estimating AI investments.

Figure 1: Framework for estimating AI investments



Source: JRC based on Auerswald & Branscomb (2003) and Mazzucato (2015).

[2] NACE sections: A-N without real estate, R, S. Organizations from market sector conduct regular for-profit activity.

[3] NACE sections: M72, O, P, Q, R90-92. Non-market sector is composed of organizations which either produce goods or services for free or at non-market prices. In case of human health sector for example the division goes horizontally, separating market-based services from free public services.

3 Estimation methodology and data sources

Estimation of AI investments is carried with a top-down approach and consists of two steps. In the first step the total (economy-wide) levels of expenditures in all relevant categories defined in section 2.2 are collected. In the second step, these expenditures are scaled down with AI-intensity coefficients to reflect amounts that are attributable to AI creation and adoption. The following sections describe the methodology and data sources used in each step and in detail.

3.1 Compiling data on investments

In the first step, the country-level data was compiled on the economy-wide expenditures in the EU in the year 2018 corresponding to the three investment targets: *Talent, skills and life-long learning*, *From the lab to the market* and *Data, technology and infrastructure* (see Section 2.2). According to Table 1, altogether data on ten different investment items were selected. To compile aggregate investment items the following data sources were used: **Eurostat**, **Spintan** and **Intan-Invest**.

Investments in **computer hardware**; **computer software and databases** and **telecommunications equipment** and **research and development** were taken from the **Eurostat**'s data on gross fixed capital formation (GFCF) provided in national accounts. Additional Eurostat tables were utilized for compilation of expenditure on **ICT specialists'** and **academic teachers' compensation**. Purchases of the remaining intangible assets, i.e. **organisational capital**, **brand**, **corporate training** and **design**, were taken from the **Spintan** and **Intan-Invest** databases. These two databases were developed within the SPINTANT and INNODRIVE research projects, funded by the European Commission. Their objective was to create harmonized frameworks for measuring intangible investments that are not covered in national accounts. Spintan database covers expenditures on intangible assets by non-market producers and Intan-invest by market sector. Both databases use several elementary categories of intangible assets out of which a subset is used for the compilation of data in step one of the estimation procedure. Regarding the geographic coverage, Spintan covers 21 and Intan-invest 19 EU Member States. The most recent data is available for year 2015. The methodology of compiling data is described in Corrado, Jäger, & Jona-Lasinio (2016) and Corrado, Haskel, Jona-Lasinio, & Iommi (2016).

Out of the ten expenditure items listed in Table 1, eight categories correspond to the exact variables available in the source tables. The two remaining expenditure items, **Academic teachers' compensation** and **ICT specialists' compensation** involved some additional computations.

Estimation of the **Academic teachers' compensation** was carried in the following way: First, compensation of teachers (with active teaching responsibilities) for 2016 was taken from the Eurostat's data on expenditure on tertiary education (educ_uoe_fini01). This expenditure covers all types of institutions that deliver educational services, hence no breakdown to public and private sectors was possible. Fixed assets purchased by educational institutions, such as machinery and research equipment, were not taken into consideration because they are counted as investments included in other investment types.

Regarding **ICT specialists' compensation**, no information on the labour costs of this group is available. Hence, it was estimated using a number of datasets. First, based on the data from national accounts published by the Eurostat on number of hours worked and number of workers (nama_10_a64_e) the average annual number of hours per worker was compiled separately for the private and public sector. As a next step, from the earnings survey (earn_ses_hourly), the premium on hourly earnings of professionals over median earnings was computed for each sector. Next, actual labour cost levels, including compensation of employees plus taxes, was taken from labour cost survey and index (lc_lci_lev). Finally, the ratio of professionals employed in the public and public sector was compiled from the labour force survey using employment by sectors (lfsa_esegn2). With all these elements a median annual labour cost of a professional employed in the private and public sector was calculated. With this cost estimate per worker, the total compensation of ICT specialists with tertiary education was obtained based on the statistics on employed ICT specialists by educational attainment level (isoc_sks_itspe). The estimated figures for ICT specialists' compensation at both the EU28 and the Member States level are presented in Table 40 in Annex 1.

Disaggregation of the Eurostat data to the **public** and **private sector** is based on the share of public administration, defence, education, human health and social work activities (NACE sections OPQ) in total economy and was established based on the table nama_10_nfa_fl. The share of the public sector spending on national account assets is slightly underestimated. The three NACE divisions: M72 (scientific research and development) and R90-92 (entertainment, museums and gambling) were classified entirely to the private sector although in reality they contain a mixture of market and non-market entities. The separation of the public and public sector had to follow entire NACE sections because data on individual assets is not available on the level of NACE divisions.

Table 1: Investment targets, items and data sources

Investment targets	Investment item	Data source
Talent, skills and life-long learning	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)
From the lab to the market	Organisational capital	Intan-invest (private sector) Spintan (public sector)
	Brand	
	Design	
	Research & development	Eurostat: National Accounts GFCF (nama_10_an6; nama_10_nfa_fl)
Data, technology and infrastructure	Computer hardware	
	Computer software and databases	
	Telecommunications equipment	

Source: JRC.

The final figures of all investment items were computed for the 28 EU MSs. However, the original data sources were not complete. For example, the Eurostat GFCF database does not include data for Croatia. In other data sources, numerous different gaps in the data exist for various countries. The most common problem is missing figures for one or two most recent years. A more serious issue relates to the unavailability of data for selected elementary assets. For confidentiality reasons, some statistical offices publish only data on aggregated categories.

In order to address the issue of **missing data**, the following procedures were applied:

- **Lack of data for particular countries**. This problem was encountered in the Eurostat's table on GFCF (missing data for Croatia) as well as in the Spintan and Intan-Invest databases (7 and 9 Member States missing respectively). In the first case the structure of assets for Croatia was assumed to be an arithmetic average of structures for Greece and Slovenia. In the latter cases the structures of intangible assets missing in the Spintan and Intan-Invest databases were established based on the results of factor and cluster analysis of gross fixed capital formation assets. In other words, countries with the largest proximity of their GFCF structures to the missing data Member States were taken in each case.
- **Lack of data for some disaggregated assets**. This problem concerned only the Eurostat's GFCF data. For example, in case of Germany and Poland, expenditure on ICT equipment (composed of two elementary assets: computer hardware and telecommunications equipment) is not reported separately but only as a part of a broader category of assets (machinery and equipment). For the purpose of data compilation the implied expenditures on these elementary assets were separated based on their weighted shares in Austria and Sweden (for Germany) and in Czechia and Hungary (for Poland). In all cases the implied breakdown of assets is consistent with the system of four identities which aggregate elementary assets into broader groups.
- **Lack of data for most recent years**. This type of issues were very common but also the most straightforward to fix. For example at the time of compilation (September 2019) the data on GFCF

for 2018 was available only for six Member States. Seven Member States had the most recent data reported for 2016 and thirteen Member States for 2017. The missing data points were extrapolated based on the structure of expenditures from the last available year.

The final dataset consists of 532 data points corresponding to country-item-sector combinations. The values of all expenditure items, aggregated to the EU28 level are given in Table 2. The breakdown of expenditures at the Member States level is provided in Annex 1 in Table 37, Table 38 and Table 39.

According to Table 2, the aggregate value of expenditures in the entire EU28 economy, across all three targets and corresponding ten items amount to almost 2 trillion euro in 2018. This figure is equivalent to 12.3% of the EU GDP or 3.8 KEUR per capita. The top three expenditure items in 2018 were ICT specialists' compensation, research and development and organisational capital. Table 2 gives also some idea about the heterogeneity of investments across the EU Member States. For example the ratio of R&D capital investment to GDP ranged from 0.3% for Romania to 8.3% for Ireland. Considerable differences in all expenditure categories can be observed across the EU Member States indicating structural diversity of their economies.

Table 2: The value of investment items at the EU28 level in 2018 (current prices).

Investment item	total [BEUR]	per capita [EUR]			as a share of GDP [%]		
	value [EU28]	value [EU28]	min [MS]	max [MS]	value [EU28]	min [MS]	max [MS]
Computer hardware	68.9	134	7	737	0.4%	0.1%	1.2%
Computer software and databases	256.2	500	59	1,511	1.6%	0.3%	3.3%
Telecommunications equipment	61.6	120	8	391	0.4%	0.1%	1.1%
Organisational capital	335.6	655	68	1,469	2.1%	0.7%	3.6%
Brand	115.7	226	3	923	0.7%	0.0%	1.2%
Corporate training	157.4	307	3	721	1.0%	0.0%	4.0%
Design	140.2	274	6	795	0.9%	0.1%	1.7%
Research & development	338.1	660	52	5,578	2.1%	0.3%	8.3%
ICT specialists' compensation	394.9	771	139	1,987	2.5%	0.9%	4.1%
Academic teachers' compensation	79.4	155	40	487	0.5%	0.2%	0.9%
Total	**1,948.0**	**3,802**	**541**	**10,810**	**12.3%**	**5.2%**	**17.5%**

Source: JRC, based on Eurostat, Intan-Invest and Spintan databases. The EU28 population and GDP levels for 2018 taken for calculation are respectively: 512.38 million people and 15,857 billion EUR. The min [MS] and max [MS] values correspond to the lowest and highest scores across the Member States.

3.2 Estimating the AI shares of investments

In the second step, for each type of aggregated expenditures collected in the first step (see Section 3.1), a corresponding share of AI was estimated. To obtain the AI share of investments, all economy-wide expenditure items from step one, with an exception of ICT specialists' compensation, were multiplied by the respective AI intensity coefficients. Table 3 provides the correspondence between expenditure items and AI intensity coefficients and their definitions. All coefficients are by construction shares, taking values between 0 and 1. Each aggregate expenditure item has been treated with exactly one coefficient as indicated in the last column of Table 3. Basic descriptive statistics of the coefficients are given in Table 5 and their values for individual Member States are provided in Annex 1 (see Table 41). Below, the construction and use of AI coefficients to compute the AI share of each expenditure item is explained in detail.

AI academic teachers' compensation

To estimate the expenditures on AI education, data on compensation of academic teachers in AI university programmes is used. This value is obtained by multiplying the "**% of AI university programmes in country's total programmes**" coefficient by a country's total "Academic teachers' compensation".

The "% of AI university programmes in country's total programmes" coefficient is constructed by scanning the descriptions of university programmes using a set of AI-related keywords. Methodological details of this text matching exercise are described in the study by Lopez-Cobo et al. (2019). This report serves also as a source of data on the share of AI university programmes in country's total programmes.

Table 3: Investment items and corresponding AI intensity coefficients

Investment targets	Investment item	AI intensity coefficient applied
Talent, skills and life-long learning	ICT specialists' compensation	% 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
From the lab to the market	Organisational capital	
	Brand	
	Design	
	Research & development	% of AI patents in country's total number of patents
Data, technology and infrastructure	Computer hardware	% of AI patents in total number of ICT patents worldwide
	Computer software and databases	
	Telecommunications equipment	

Source: JRC.

AI ICT specialists' compensation

The expenditures on AI ICT specialists are estimated by multiplying "**% AI ICT specialists in country's total number of ICT specialists**" coefficient by country's total ICT specialists' compensation. This AI-intensity coefficient is computed in the following way: First, based on the Eurostat data on graduates by education level and programme orientation (educ_uoe_grad02), the number ICT graduates for the years 2015-2017 was obtained. Next, to get the number of graduates from AI ICT programmes, the result was multiplied by the share of AI university programmes in a country's ICT programmes. Then, the number of graduates from AI ICT programmes from the years 2015-2017 was divided by the total number of ICT specialists. The result serves as a proxy of the share of AI ICT specialists in the total number of ICT specialists. By multiplying it by the total ICT specialists' compensation obtained in step one (see 3.1), AI ICT specialists' compensation was obtained.

As in the case of AI academic teachers' compensation, the intermediary data on AI university programmes used to compute the share of AI ICT specialists in the total number of ICT specialists stem from the study by Lopez-Cobo et al. (2019).

AI-related corporate training, organisational capital, brand and design

To estimate the share of AI in expenditures on such intangible assets as corporate training, organisational capital, brand and design, patent data are used. It is assumed that the structure of the global stock of patents reflect the technology-based activities in the economy. Following this reasoning, one can expect that a share of patents in a certain technological field does not only mirror the importance of that technology in comparison with other technologies, but also approximates the intensity with which economic actors create and market products and services derived out of that particular technology. The capabilities of translating technological properties into economic goods and services by businesses are likely to be reflected in intangible capital related to a certain technology. Thus, taking the example of AI, economic actors do not only need technical understanding of AI, but also how it can be used to (re-)design business processes in order to create new or improve existing products or services. Leadership, managerial and organizational capabilities are necessary to identify opportunities and create business models to expand, optimize, and transform the business deploying AI technologies (Jaruzelski, Staack, & Shinozaki, 2016). Consequently, the expenses on complementary assets such as organisational capital, training brand equity and product design are scaled with the "**% of AI patents in total number of patents worldwide**" coefficient.

The source of patent data is the EPO PATSTAT database. AI patents were identified by scanning the titles and descriptions of patents using a set of AI-related keywords. This is a common practice of mapping new technologies in the technology space (IPO, 2019; WIPO, 2019). Methodological details of this text matching exercise are described in the study by De Prato et al. (2019). This report serves also as a source of data on the share of AI patents in the total number of patents.

Research & development

Country's "**% of AI patents in country's total number of patents**" coefficient multiplied by a country's total R&D expenditures is proposed as a measure the level of AI R&D expenditures in a given country. The rationale behind using this coefficient is that a country's overall patent stock reflects the structure of its R&D expenditures and activities.

The source of patent data is the EPO PATSTAT database and the source of AI patents is the study by De Prato et al. (2019).

Computer hardware, software and databases and telecommunications equipment

The expenses on databases, software, computer hardware and telecommunications equipment have been multiplied by the "**% of AI patents in the total number of ICT patents worldwide**" coefficient. The assumption behind constructing and applying such a coefficient is the following: the total number of ICT patents represents the overall stock of ICT products available on the market. The share of AI ICT products is thus approximated by the share of AI patents in the overall ICT patent pool.

The source of patent data is the EPO PATSTAT database and the source of AI patents is the study by De Prato et al. (2019).

ICT patents were identified using the IPC classification codes corresponding to the definition of ICT technology provided by the PREDICT project.

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 ICT patent applications over total ICT patent applications submitted worldwide.	Min. scenario: 2000-2016; Max. scenario: 2010-2016; 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 (ICT & non-ICT) patent over total number of patent applications submitted worldwide.		
% of AI patents in country's total number of patents	Number of all (ICT & non-ICT) patent applications over total number of patent applications submitted in a given country.		
% AI ICT specialists in country's total number of ICT specialists	Number of AI ICT specialists, approximeated by the number of AI ICT graduates in the years 2015-17, over total number of ICT specialists in a given country.	2018; StudyPortals and (Lopez-Cobo et al., 2019) 2015-2017; Eurostat educational statistics	Text matching on dictionary with AI terms with university programme descriptions (De Prato et al. 2019)
% of AI university programmes in country's total programmes	Number of specialized AI programs over all university programs available in a given country.	2018; StudyPortals and (Lopez-Cobo et al., 2019)	

Source: JRC.

It must be noted that the procedure to estimate the share of AI expenditures for the above listed expenditure items is based on macro-level aggregated data, which does not contain any links to a particular profile of enterprise or technology. Hence, the AI-related part of expenditures can be estimated only indirectly under two regularity assumptions. The first assumption states that the structure of demand equals the structure of supply of technologies. In case of ICT assets for example, this implies that the share of expenses on AI-related ICT assets is equal to the share of available ICT investment goods that contain AI solutions in total available stock of ICT investment goods. The second assumption states that the structure of supply will be similar to the structure of patented technological intellectual property. The second condition implies that the share of investment goods with AI related solutions corresponds to the share of AI patents in total patents. Similar regularity conditions are postulated for other expenditure categories. Both assumptions are certainly quite strong and introduce a bias to the extent in which they divert from the reality. For example the technological preferences of enterprises might be hyped. In such case the demand for AI solutions will be higher than indicated by the supply structure. Recognition of such effects would require microdata on the enterprise level. Under current approach they remain unknown. Hence, point estimates of AI-related expenditures have no account of the precision, such as confidence intervals.

To partially account for changes in the structure of supply and demand for AI technologies and skills in the economy, a min and max AI investments scenario was computed. In the min scenario, to take a long-term perspective of the AI impact on the economy, patent-based coefficients based on the period between 2000 and 2016 were used (see Table 4). The max scenario relies on patent coefficients computed for the period between 2010 and 2016 and is assumed to reflect the most recent developments in the field of AI and its diffusion in the economy. As patent coefficients under max scenario are larger, the implied AI estimates are larger as well.

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

statistics	% 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
std dev.	0.000	0.000	0.010	0.002	0.021
min	0.001	0.006	0.000	0.000	0.000
max	0.001	0.006	0.040	0.010	0.088
average	0.001	0.006	0.009	0.002	0.021
median	0.001	0.006	0.007	0.001	0.016
Q.1	0.001	0.006	0.002	0.000	0.006
Q.3	0.001	0.006	0.012	0.003	0.024

Source: JRC.

4 EU AI investments highlights

Table 6 presents the main AI investment highlights for the EU28 in 2018. The overall level of AI investments is estimated to be in the range of 7.0-8.4 billion euro depending on the scenario. This corresponds to 35-42% of the annual investment target set in the Coordinated Action Plan (EC, 2018b). Current spending in the EU28 is equivalent to 16.3 euro per capita or 0.04 percent of the EU's gross domestic product. For comparison, in 2018, total R&D spending in the EU accounts for 2.11 percent of the EU GDP.

Table 6: AI investment highlights in 2018 for the EU28.

EU28	total [BEUR]	% of GDP	per capita [EUR]	% of target
min scenario	7.0	0.044%	13.8	35.2%
max scenario	8.4	0.053%	16.3	41.8%

Note: For methodological details concerning the min and max scenario see Section 3.2.

Source: JRC based on EUROSTAT, Spintan and Intan-Invest data.

The composition of expenditures by AI investment targets is presented in Table 7. The majority of investments is targeted at labour and human capital covered by "Talent skills and life-long learning" target (58%). The smallest stream of funding has been directed at intangible assets, including R&D grouped within "From the lab to the market" target. This target accounts for nearly 13% of the total EU AI investments in 2018. Expenditures on AI-related "Data, technology and infrastructure" account for nearly 30% of the total AI investments in the EU.

Table 7: AI investment by targets at the EU28 level

Phase	% of Total	Mln. Euro
Talent, skills and life-long learning	58.04%	4,847.92
From the lab to the market	12.77%	1,066.27
Data, technology and infrastructure	29.19%	2,437.89
Total EU28	**100%**	**8,352.08**

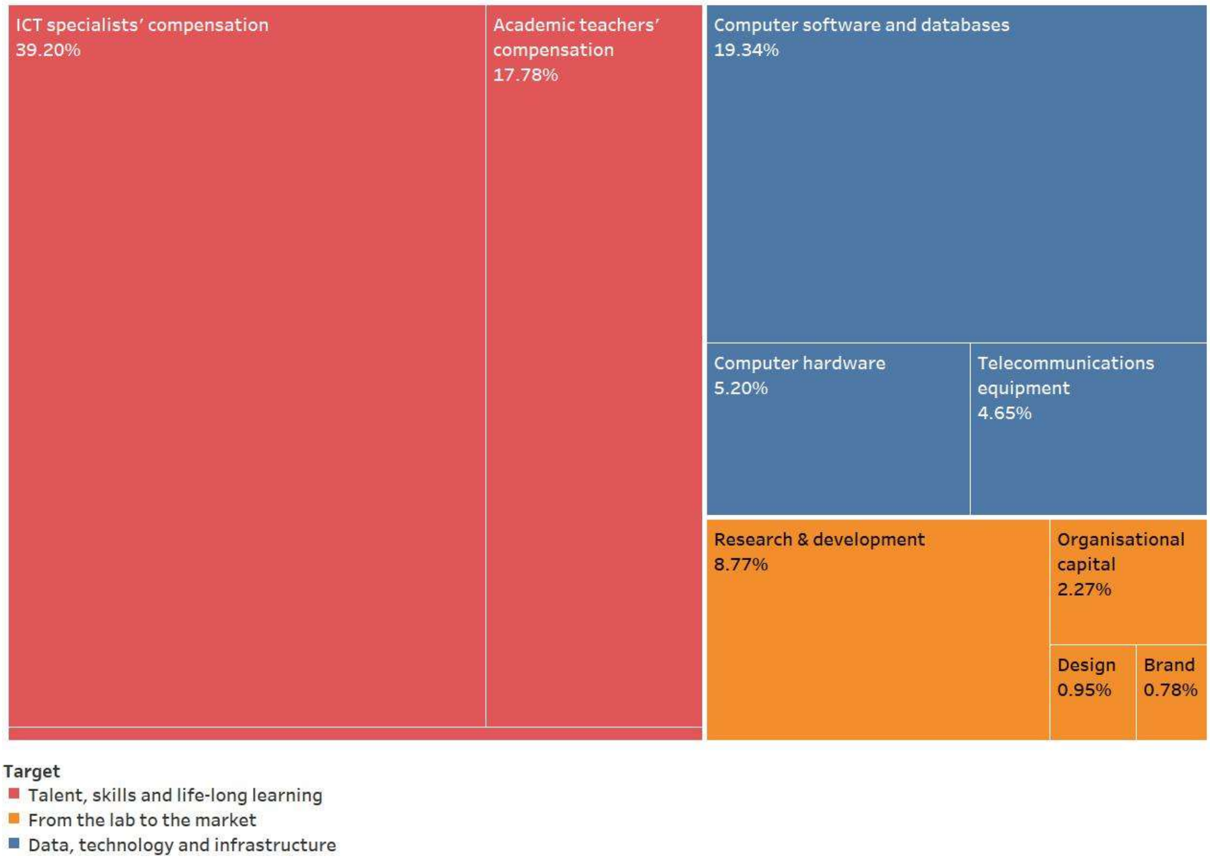
Note: Table presents estimates for the maximum scenario (see Section 3.2).

Source: JRC based on EUROSTAT, Spintan and Intan-Invest data.

The detailed composition of expenditures by expenditure items is presented in Figure 2 and Figure 3. The largest stream of funding was targeted at AI "ICT specialists' compensation", followed by "Computer software and databases" and "Education". Investments in intangible assets account for 30% of the total expenses - three times more than the expenses on hard infrastructure. This proportion is a lower bound of what is considered in the literature (2.7:1-4.5:1) (Brynjolfsson et al., 2018). Hence although all expenditure items need to increase in order to meet the overall target, there is more space for growth in intangibles, including R&D, software and databases.

Interestingly, contribution of the public sector is quite substantial and accounts overall to 42%. This share is slightly overestimated because, due limitations in statistical sources, all expenses on education have been classified under the public sector. In some countries, and in particular in the United Kingdom, the contribution of the private sector institutions to the tertiary education is high. After excluding this category, the public sector share in AI-related capital formation and labour compensation amounts to around 30% which is a significant proportion.

Figure 2: EU AI investments by target



Note: Figure presents estimates for the maximum scenario (see Section 3.2).
Source: JRC based on EUROSTAT, Spintan and Intan-Invest data.

Figure 3: EU AI investments by target and source

Source	Talent, skills and life-long learning			From the lab to the market				Data, technology and infrastructure			Grand Total
	ICT specialists' compensation	Academic teachers' compensation	Corporate training	Research & development	Organisational capital	Brand	Design	Computer hardware	Computer software and databases	Telecommunications equipment	
Private	20.36%		0.78%	7.17%	2.03%	0.75%	0.88%	4.31%	17.35%	4.07%	57.71%
Public	18.84%	17.78%	0.29%	1.59%	0.24%	0.03%	0.07%	0.89%	1.98%	0.58%	42.29%
Grand Total	39.20%	17.78%	1.06%	8.77%	2.27%	0.78%	0.95%	5.20%	19.34%	4.65%	100.00%

Note: Figure presents estimates for the maximum scenario (see Section 3.2).
Source: JRC based on EUROSTAT, Spintan and Intan-Invest data.

Finally, Table 8 below evidences highly positive correlation between various expenditure items. This points to a large complementarity between different types of investment. It can be seen that, in most of the cases, correlations between expenditure items within individual targets are strongly positive. The only exceptions are corporate training within the "Talent, skills and life-long learning" target and R&D within the "From the lab to the market" target. This indicates that the implementation of AI technology in production processes and creation of the technology are two distinct phenomena which are governed by separate sets of rules and possibly need to be targeted with different policy measures.

A closer look at the correlation coefficients between investment targets reveals that the complementarity is particularly strong among the "From the lab to the market" and "Data, technology and infrastructure" targets. This indicates the importance of investing into tangible and intangible assets for successful adoption of AI technologies.

Table 8: Correlation matrix for AI expenditure categories

	Talent, skills and life-long learning			From the lab to the market				Data, technology and infrastructure		
	ICT spec. comp.	Acad. teach. comp.	Corp. training	Org. capital	Brand	Design	R&D	Comp. hard.	Comp. soft. & datab.	Telco. equip.
ICT specialists' compensation	1									
Academic teachers' compensation	0.67	1								
Corporate training	0.41	0.35	1							
Organisational capital	0.25	0.31	0.82	1						
Brand	0.28	0.19	0.84	0.78	1					
Design	0.28	0.46	0.71	0.78	0.72	1				
Research & development	0.33	0.06	0.48	0.35	0.48	0.14	1			
Computer hardware	0.12	0.26	0.75	0.71	0.85	0.67	0.34	1		
Computer software and databases	0.17	0.46	0.52	0.78	0.51	0.72	0.08	0.44	1	
Telecommunications equipment	-0.01	0.07	0.5	0.47	0.61	0.56	0.15	0.45	0.4	1

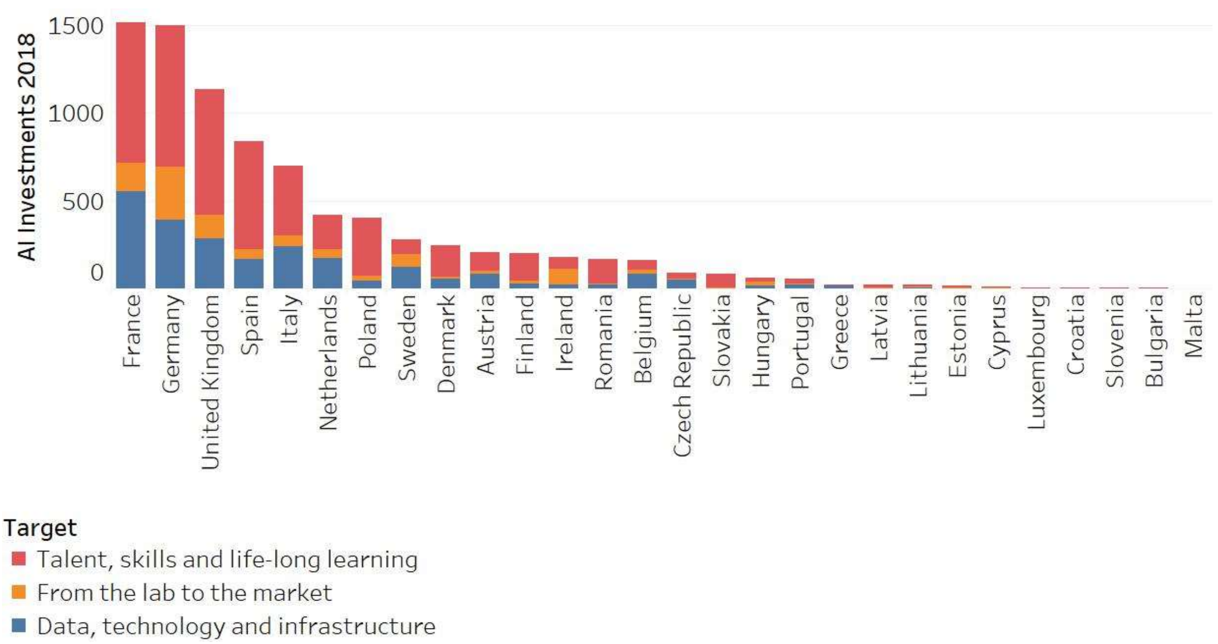
Note: Table presents correlations between estimates for the maximum scenario (see Section 3.2).

Source: JRC based on EUROSTAT, Spintan and Intan-Invest data.

5 AI investments in the EU Member States

AI investments at the Member States level in 2018 are presented in Figure 4. The highest absolute amount are expensed in the largest countries. France, Germany and the United Kingdom score top three with nearly 50% of the total AI expenditures in the EU.

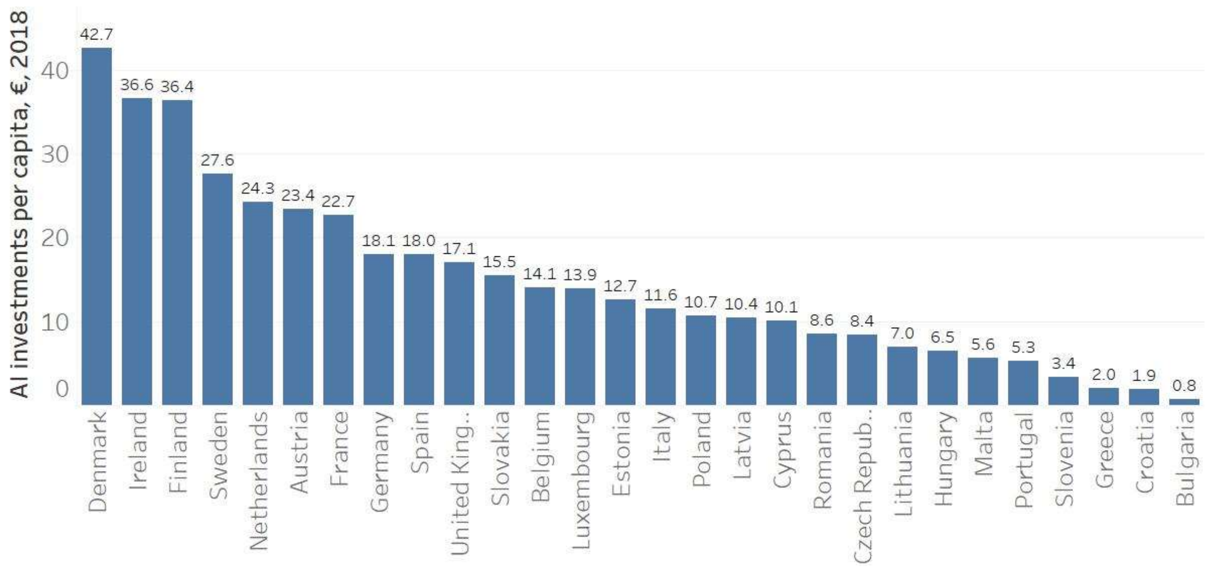
Figure 4: AI investments in the EU Member States



Note: Figure presents estimates for the maximum scenario (see Section 3.2).
Source: JRC based on EUROSTAT, Spintan and Intan-Invest data.

The above picture changes substantially when the per capita investments are examined (see Figure 5). Nordic countries and Ireland are the top scorers, disbursing more than 35 Euro per capita on AI investments. In general there is a huge variation among the Member States in per capita expenditures, with developing economies spending considerably less than developed ones.

Figure 5: AI investments per capita in the EU Member States



Note: Figure presents estimates for the maximum scenario (see Section 3.2).
Source: JRC based on EUROSTAT, Spintan and Intan-Invest data.

6 Country profiles

The following sections present detailed information about AI investments in EU countries, i.e.:

1. **AI investments** presenting:
   - The level of AI investments in MEuro in 2018 under the min and max scenario (for methodological details, see Section 3.2)
   - AI investments per capita in 2018
   - Share of a country's AI investment in the annual investment target set in the Coordinated Action Plan (EC, 2018b), i.e. 20 Bln Euro.
2. **AI investments by three targets**:
   - Talent, skills and life-long learning
   - From the lab to the market
   - Data, technology and infrastructure.
3. **AI investments by targets and sources**
4. **A country's AI investments profile** in spider diagram that shows the performance of each country for each investment item per capita. The country performance is compared against the EU average AI investment per capita.

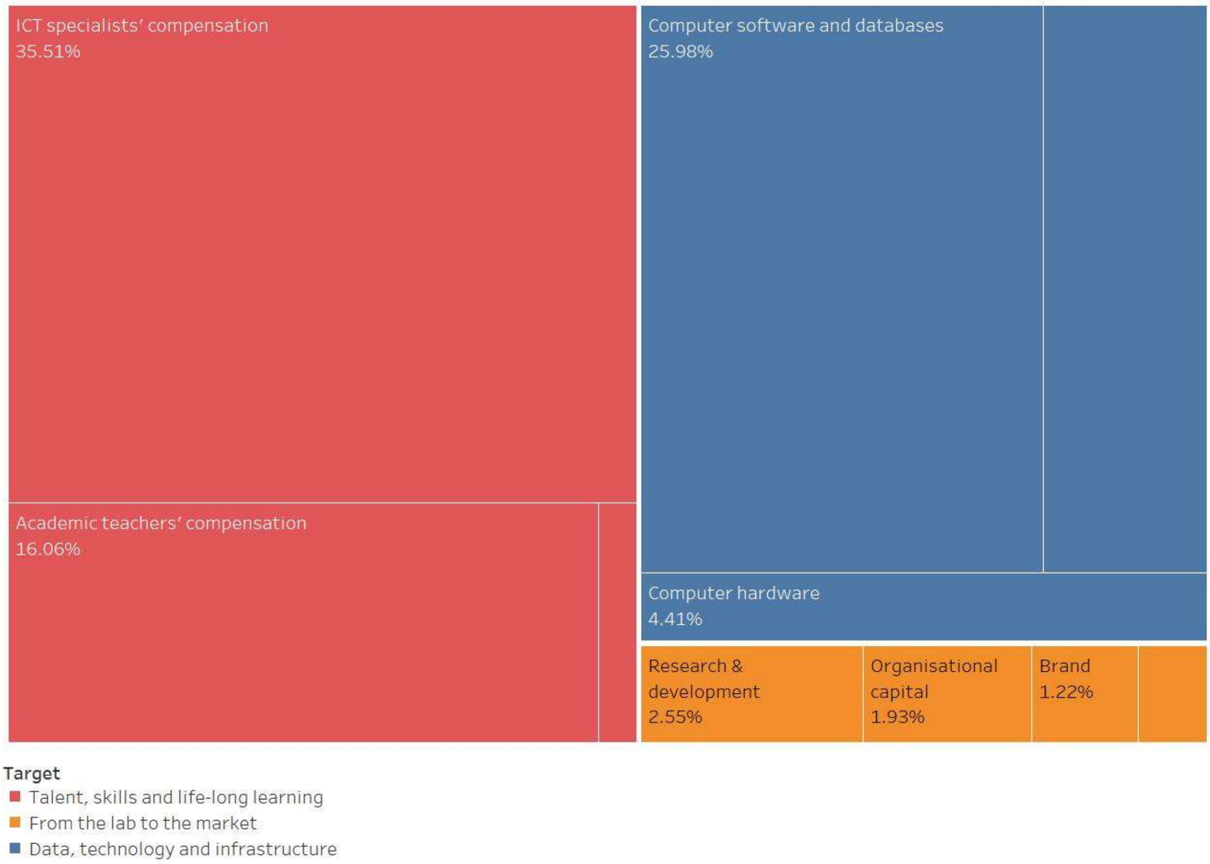
6.1 Austria

Table 9: AI investments highlights in 2018 for Austria.

Austria	Total [MEUR]	Per capita [EUR]	% of target
min scenario	170.4	19.3	0.85%
max scenario	206.6	23.4	1.03%

Source: JRC based on EUROSTAT, Spintan and Intan-Invest data.

Figure 6: AI investments by target in Austria, 2018



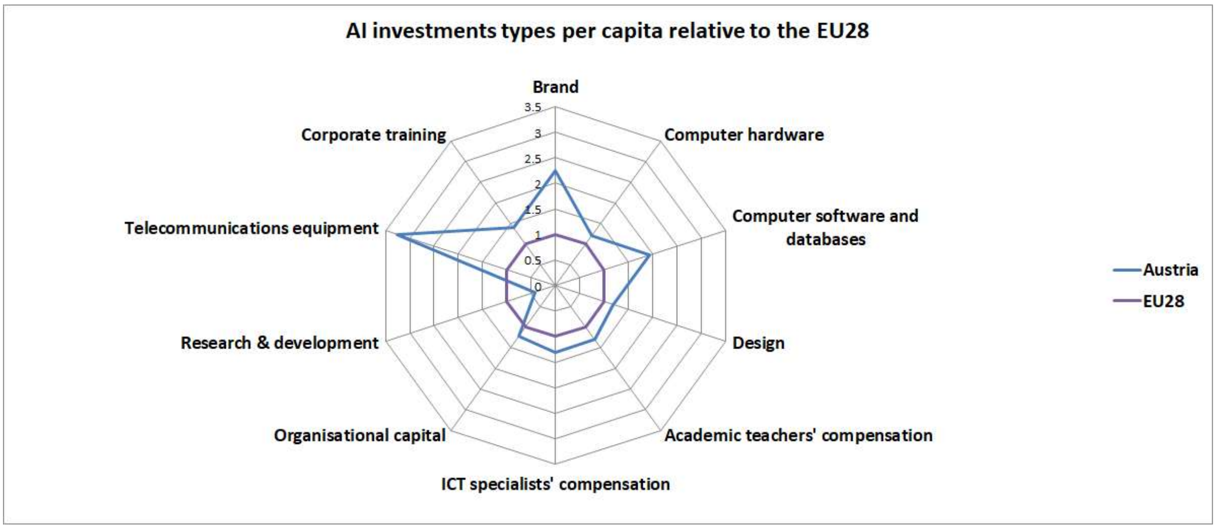
Source: JRC based on EUROSTAT, Spintan and Intan-Invest data.

Figure 7: EU AI investments by target and source in Austria, 2018

Source	Talent, skills and life-long learning			From the lab to the market				Data, technology and infrastructure			Grand Total
	ICT specialists' compensation	Academic teachers' compensation	Corporate training	Research & development	Organisational capital	Brand	Design	Computer hardware	Computer software and databases	Telecommunications equipment	
Private	16.33%		0.99%	2.02%	1.72%	1.18%	0.73%	3.71%	23.98%	7.99%	58.66%
Public	19.18%	16.06%	0.05%	0.53%	0.21%	0.04%	0.05%	0.70%	1.99%	2.54%	41.34%
Grand Total	35.51%	16.06%	1.03%	2.55%	1.93%	1.22%	0.79%	4.41%	25.98%	10.53%	100.00%

Source: JRC based on EUROSTAT, Spintan and Intan-Invest data.

Figure 8: AI investments by type per capita in Austria vs. EU28 average, 2018



Source: JRC based on EUROSTAT, Spintan and Intan-Invest data.

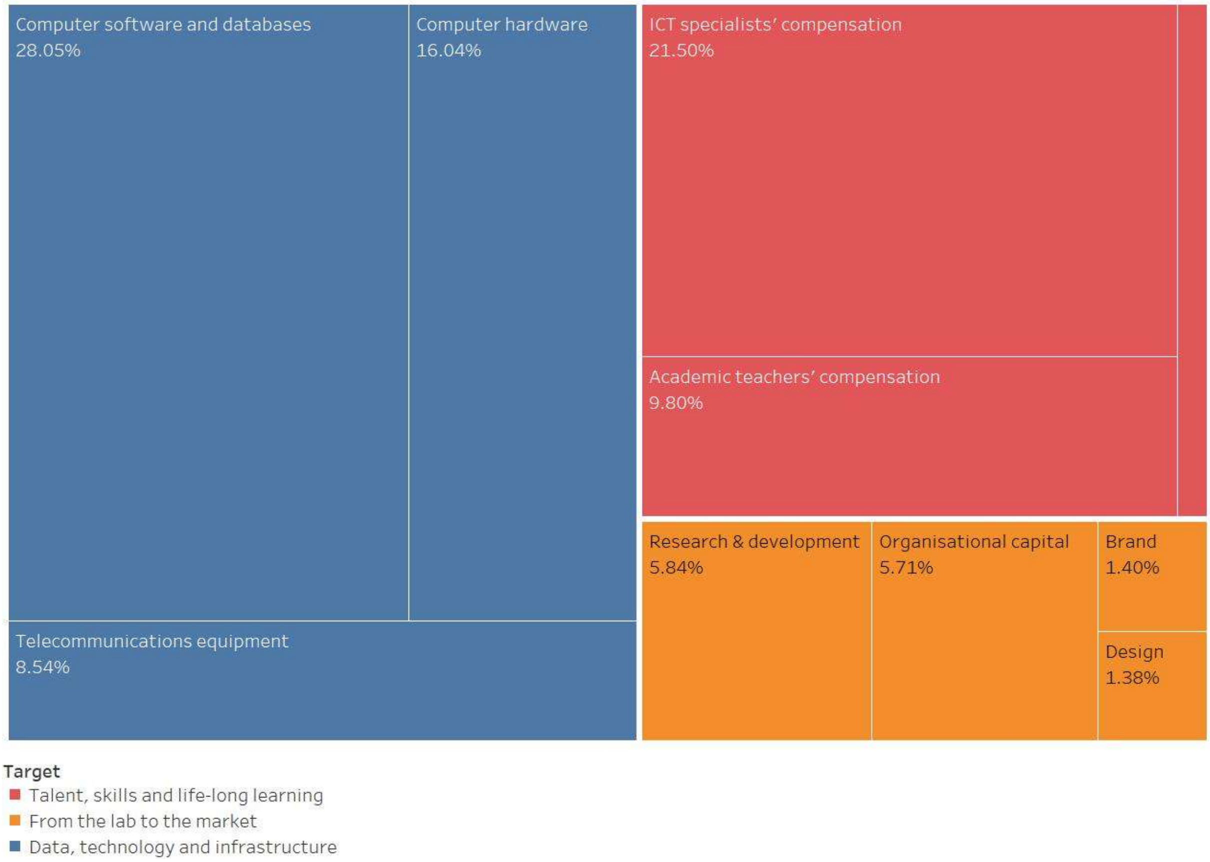
6.2 Belgium

Table 10: AI investments highlights in 2018 for Belgium.

Belgium	Total [MEUR]	Per capita [EUR]	% of target
min scenario	123.7	10.9	0.62%
max scenario	160.2	14.1	0.80%

Source: JRC based on EUROSTAT, Spintan and Intan-Invest data.

Figure 9: AI investments by target in Belgium, 2018



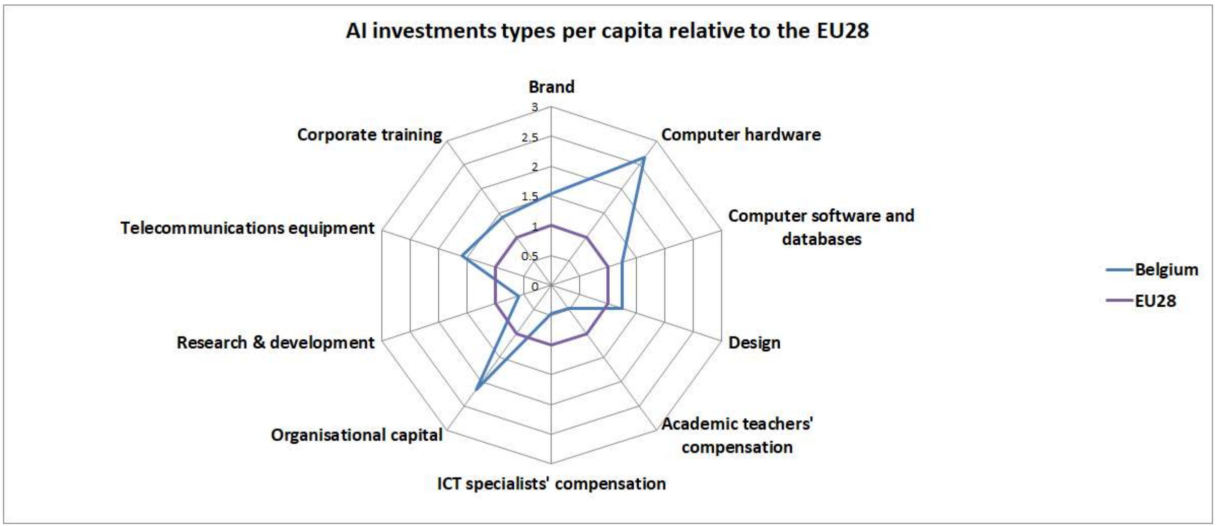
Source: JRC based on EUROSTAT, Spintan and Intan-Invest data.

Figure 10: EU AI investments by target and source in Belgium, 2018

Source	Talent, skills and life-long learning			From the lab to the market				Data, technology and infrastructure			Grand Total
	ICT specialists' compensation	Academic teachers' compensation	Corporate training	Research & development	Organisation al capital	Brand	Design	Computer hardware	Computer software and databases	Telecommuni cations equip ment	
Private	10.62%		1.31%	4.58%	5.02%	1.37%	1.35%	14.78%	24.79%	8.36%	72.18%
Public	10.88%	9.80%	0.43%	1.26%	0.68%	0.03%	0.03%	1.26%	3.27%	0.18%	27.82%
Grand Total	21.50%	9.80%	1.74%	5.84%	5.71%	1.40%	1.38%	16.04%	28.05%	8.54%	100.00%

Source: JRC based on EUROSTAT, Spintan and Intan-Invest data.

Figure 11: AI investments by type per capita in Belgium vs. EU28 average, 2018



Source: JRC based on EUROSTAT, Spintan and Intan-Invest data.

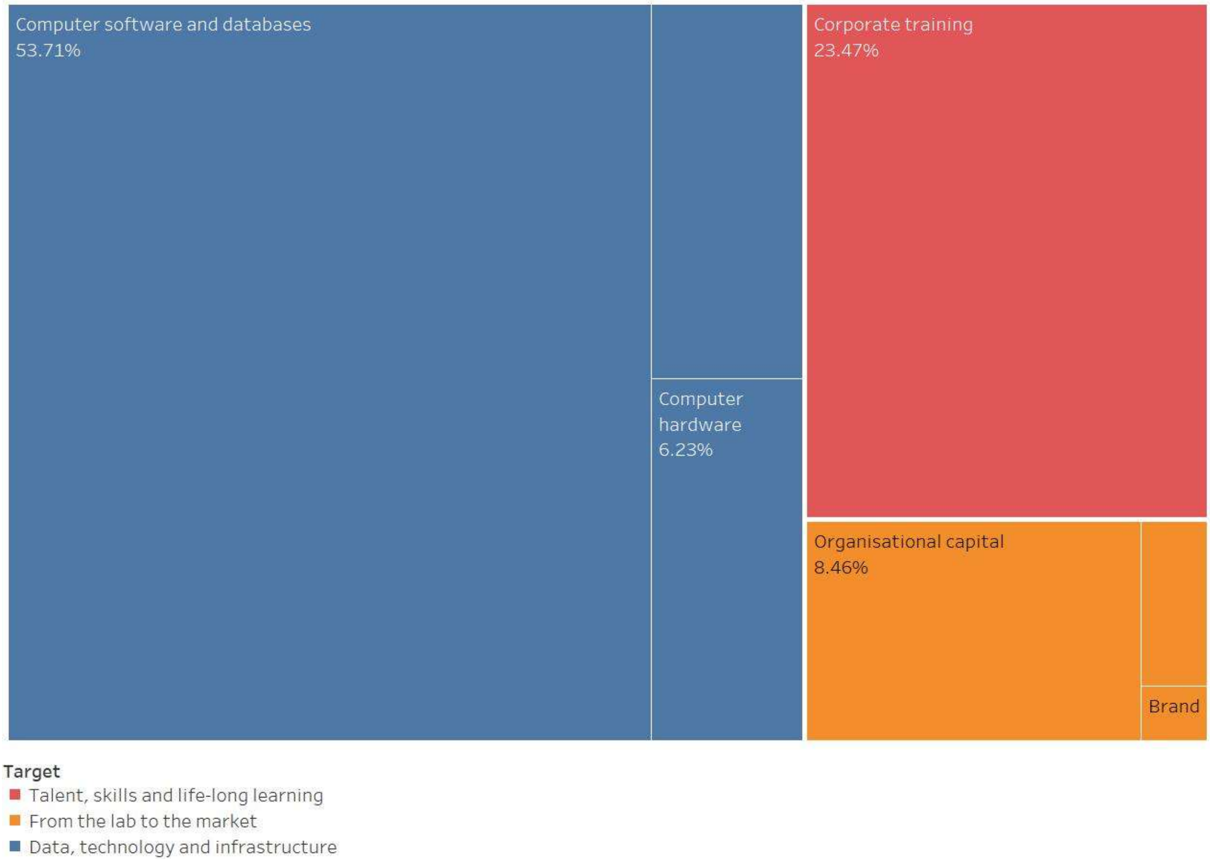
6.3 Bulgaria

Table 11: AI investments highlights in 2018 for Bulgaria

Bulgaria	Total [MEUR]	Per capita [EUR]	% of target
min scenario	3.8	0.5	0.02%
max scenario	5.3	0.8	0.03%

Source: JRC based on EUROSTAT, Spintan and Intan-Invest data.

Figure 12: AI investments by target in Bulgaria, 2018



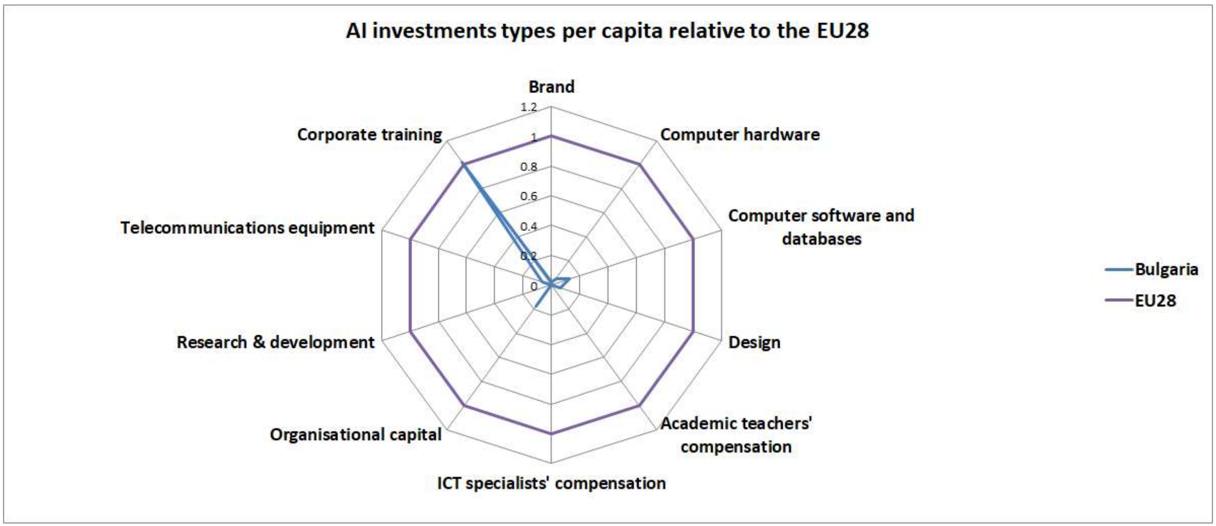
Source: JRC based on EUROSTAT, Spintan and Intan-Invest data.

Figure 13: EU AI investments by target and source in Bulgaria, 2018

Source	Talent, skills and life-long learning			From the lab to the market				Data, technology and infrastructure			Grand Total
	ICT specialists' compensation	Academic teachers' compensation	Corporate training	Research & development	Organisation al capital	Brand	Design	Computer hardware	Computer software and databases	Telecommuni cations equip ment	
Private	0.0%		18.6%	0.0%	6.7%	0.3%	1.0%	5.9%	50.1%	6.1%	88.7%
Public	0.0%	0.0%	4.8%	0.0%	1.7%	0.1%	0.3%	0.4%	3.6%	0.4%	11.3%
Grand Total	0.0%	0.0%	23.5%	0.0%	8.5%	0.4%	1.3%	6.2%	53.7%	6.4%	100.0%

Source: JRC based on EUROSTAT, Spintan and Intan-Invest data.

Figure 14: AI investments by type per capita in Bulgaria vs. EU28 average, 2018



Source: JRC based on EUROSTAT, Spintan and Intan-Invest data.

6.4 Croatia

Table 12: AI investments highlights in 2018 for Croatia

Croatia	Total [MEUR]	Per capita [EUR]	% of target
min scenario	5.1	1.2	0.03%
max scenario	7.8	1.9	0.04%

Source: JRC based on EUROSTAT, Spintan and Intan-Invest data.

Figure 15: AI investments by target in Croatia, 2018

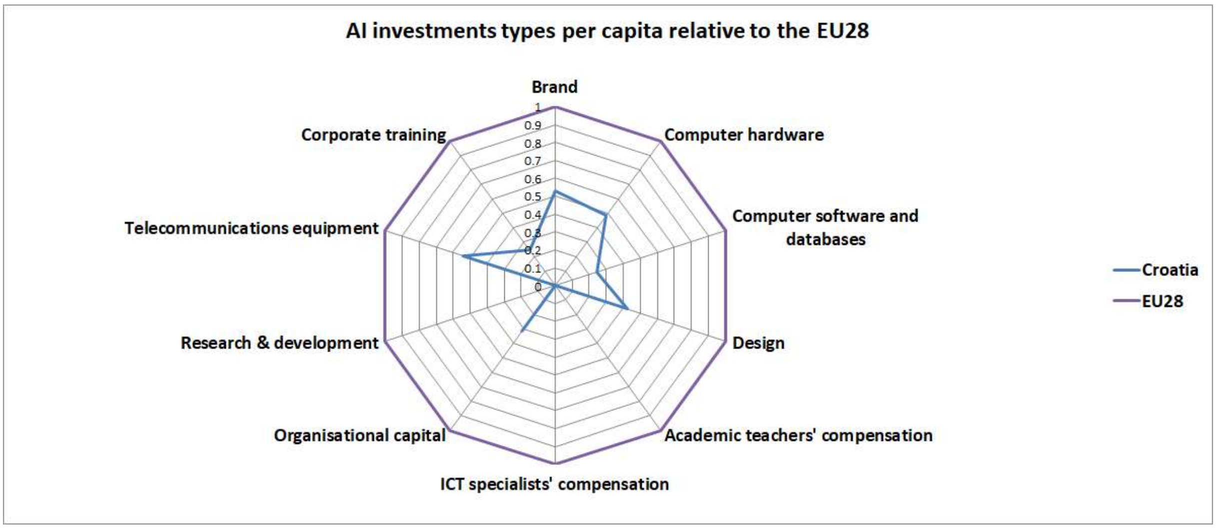
Source: JRC based on EUROSTAT, Spintan and Intan-Invest data.

Figure 16: EU AI investments by target and source in Croatia, 2018

Source	Talent, skills and life-long learning			From the lab to the market				Data, technology and infrastructure			Grand Total
	ICT specialists' compensation	Academic teachers' compensation	Corporate training	Research & development	Organisation al capital	Brand	Design	Computer hardware	Computer software and databases	Telecommuni cations equip ment	
Private	0.0%		1.9%	0.0%	5.7%	3.5%	3.2%	16.9%	34.9%	19.9%	86.0%
Public	0.0%	0.0%	0.4%	0.0%	0.5%	0.1%	0.3%	4.8%	6.3%	1.8%	14.0%
Grand Total	0.0%	0.0%	2.2%	0.0%	6.2%	3.6%	3.4%	21.7%	41.2%	21.7%	100.0%

Source: JRC based on EUROSTAT, Spintan and Intan-Invest data.

Figure 17: AI investments by type per capita in Croatia vs. EU28 average, 2018



Source: JRC based on EUROSTAT, Spintan and Intan-Invest data.

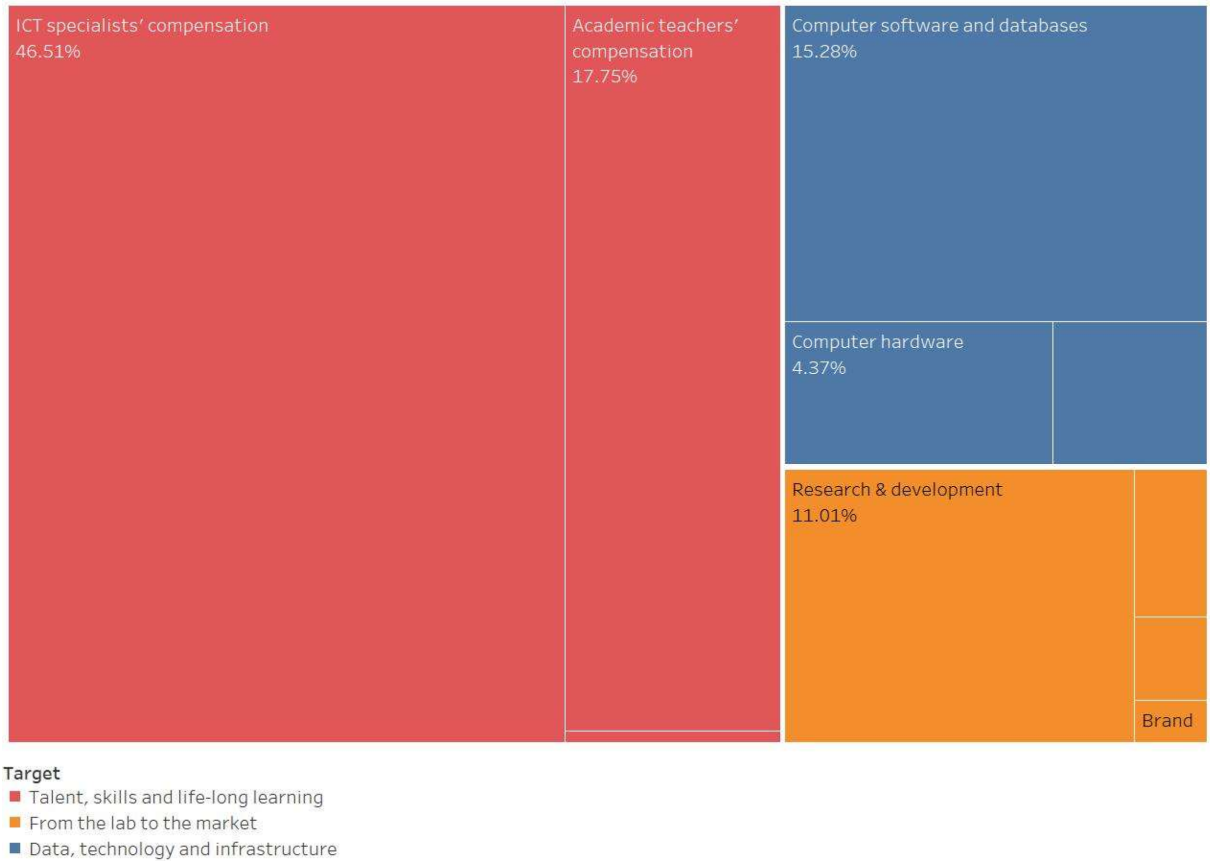
6.5 Cyprus

Table 13: AI investments highlights in 2018 for Cyprus

Cyprus	Total [MEUR]	Per capita [EUR]	% of target
min scenario	5.1	1.2	0.03%
max scenario	7.8	1.9	0.04%

Source: JRC based on EUROSTAT, Spintan and Intan-Invest data.

Figure 18: AI investments by target in Cyprus, 2018



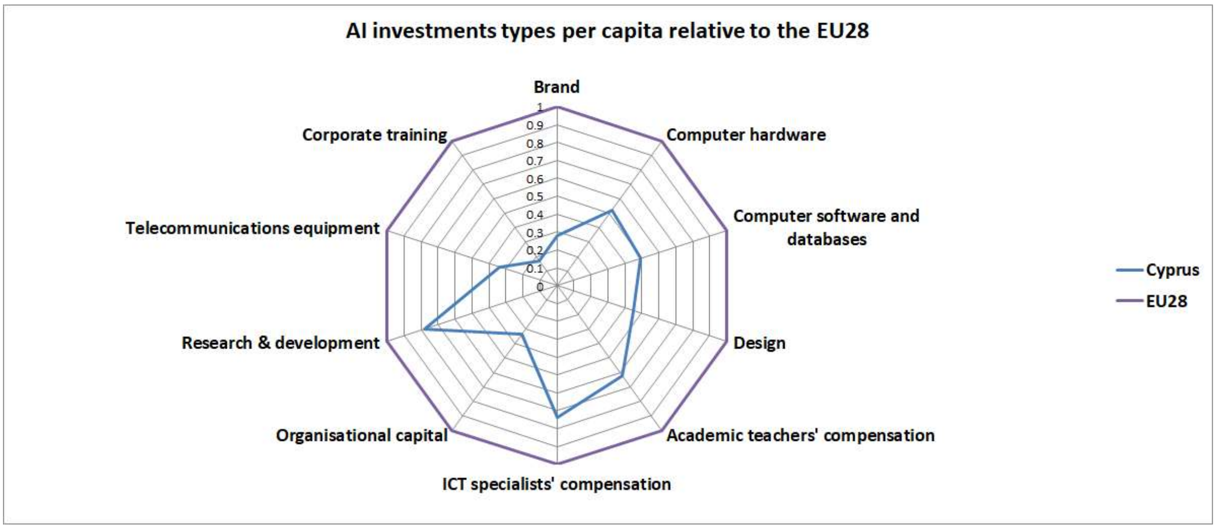
Source: JRC based on EUROSTAT, Spintan and Intan-Invest data.

Figure 19: EU AI investments by target and source in Cyprus, 2018

Source	Talent, skills and life-long learning			From the lab to the market				Data, technology and infrastructure			Grand Total
	ICT specialists' compensation	Academic teachers' compensation	Corporate training	Research & development	Organisation al capital	Brand	Design	Computer hardware	Computer software and databases	Telecommuni cations equip ment	
Private	23.38%		0.23%	7.07%	1.09%	0.33%	0.64%	2.75%	13.52%	2.49%	51.50%
Public	23.13%	17.75%	0.06%	3.94%	0.13%	0.03%	0.05%	1.62%	1.76%	0.03%	48.50%
Grand Total	46.51%	17.75%	0.29%	11.01%	1.23%	0.35%	0.69%	4.37%	15.28%	2.52%	100.00%

Source: JRC based on EUROSTAT, Spintan and Intan-Invest data.

Figure 20: AI investments by type per capita in Cyprus vs. EU28 average, 2018



Source: JRC based on EUROSTAT, Spintan and Intan-Invest data.

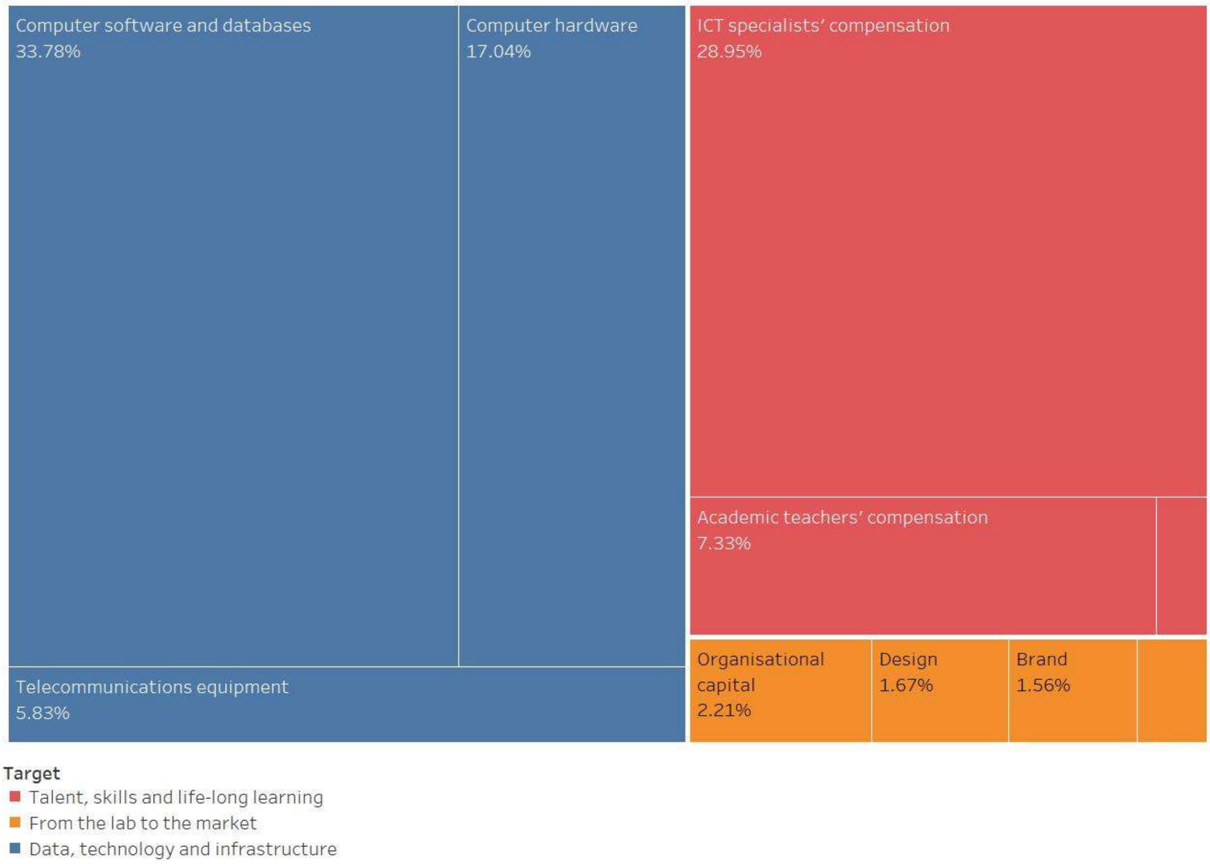
6.6 Czechia

Table 14: AI investments highlights in 2018 for Czechia

Czechia	Total [MEUR]	Per capita [EUR]	% of target
min scenario	68.9	6.5	0.34%
max scenario	89.4	8.4	0.45%

Source: JRC based on EUROSTAT, Spintan and Intan-Invest data.

Figure 21: AI investments by target in Czechia, 2018



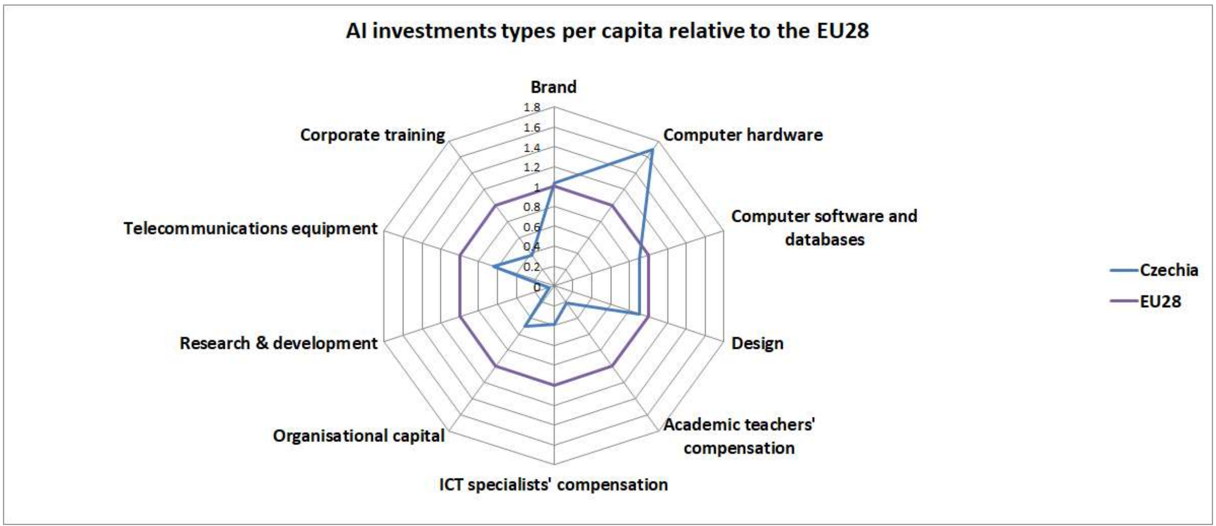
Source: JRC based on EUROSTAT, Spintan and Intan-Invest data.

Figure 22: EU AI investments by target and source in Czechia, 2018

Source	Talent, skills and life-long learning			From the lab to the market				Data, technology and infrastructure			Grand Total
	ICT specialists' compensation	Academic teachers' compensation	Corporate training	Research & development	Organisation al capital	Brand	Design	Computer hardware	Computer software and databases	Telecommuni cations equip ment	
Private	15.64%		0.53%	0.65%	2.04%	1.53%	1.66%	15.06%	31.65%	5.15%	73.92%
Public	13.32%	7.33%	0.26%	0.19%	0.17%	0.03%	0.01%	1.98%	2.12%	0.68%	26.08%
Grand Total	28.95%	7.33%	0.79%	0.84%	2.21%	1.56%	1.67%	17.04%	33.78%	5.83%	100.00%

Source: JRC based on EUROSTAT, Spintan and Intan-Invest data.

Figure 23: AI investments by type per capita in Czecha vs. EU28 average, 2018



Source: JRC based on EUROSTAT, Spintan and Intan-Invest data.

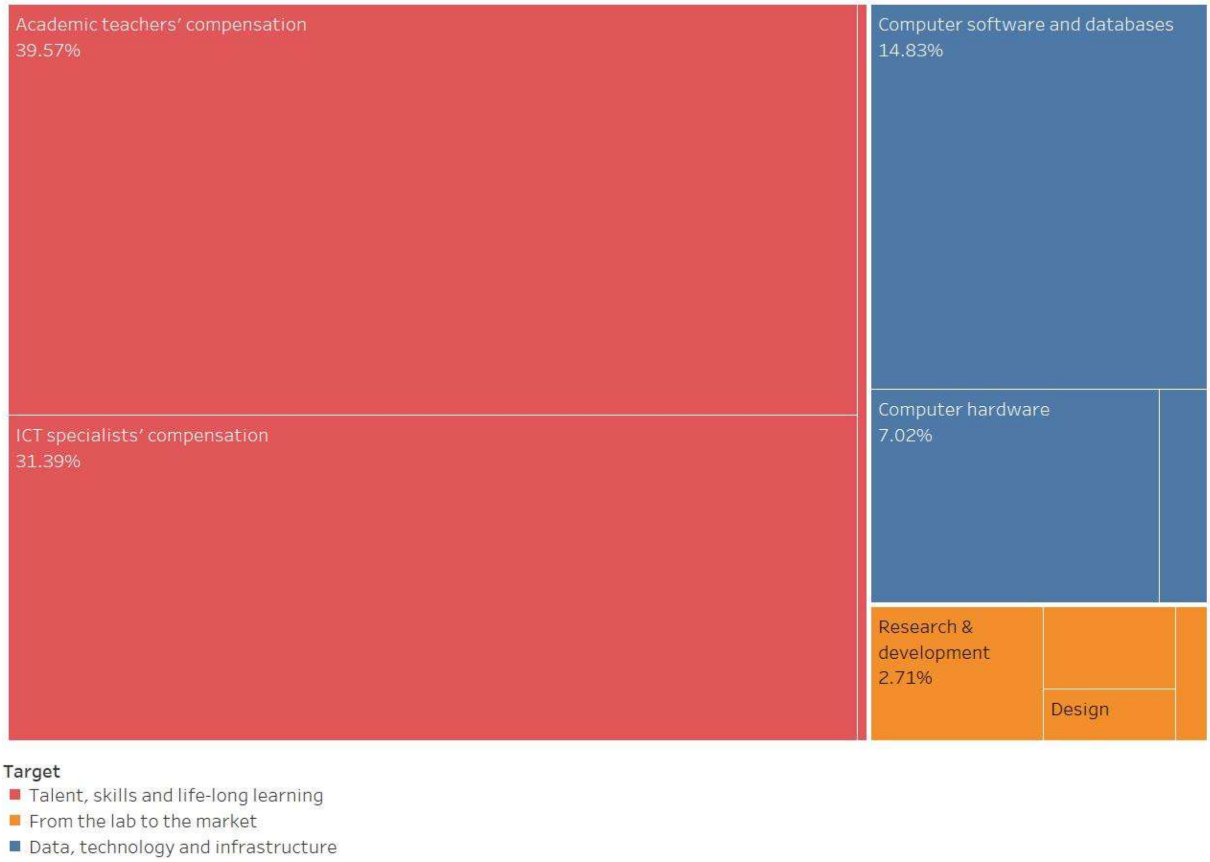
6.7 Denmark

Table 15: AI investments highlights in 2018 for Denmark

Denmark	Total [MEUR]	Per capita [EUR]	% of target
min scenario	221.5	38.3	1.11%
max scenario	246.6	42.7	1.23%

Source: JRC based on EUROSTAT, Spintan and Intan-Invest data.

Figure 24: AI investments by target in Denmark, 2018



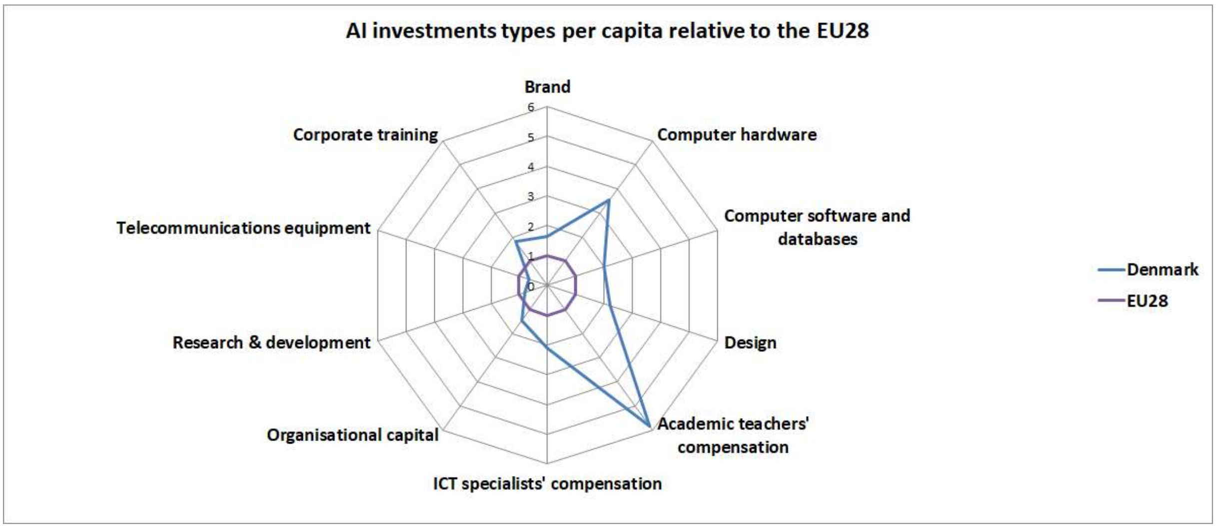
Source: JRC based on EUROSTAT, Spintan and Intan-Invest data.

Figure 25: EU AI investments by target and source in Denmark, 2018

Source	Talent, skills and life-long learning			From the lab to the market				Data, technology and infrastructure			Grand Total
	ICT specialists' compensation	Academic teachers' compensation	Corporate training	Research & development	Organisational capital	Brand	Design	Computer hardware	Computer software and databases	Telecommunications equipment	
Private	12.86%		0.70%	1.90%	1.05%	0.47%	0.76%	5.64%	13.78%	1.11%	38.26%
Public	18.53%	39.57%	0.04%	0.81%	0.22%	0.02%	0.04%	1.38%	1.05%	0.06%	61.74%
Grand Total	31.39%	39.57%	0.73%	2.71%	1.28%	0.49%	0.80%	7.02%	14.83%	1.17%	100.00%

Source: JRC based on EUROSTAT, Spintan and Intan-Invest data.

Figure 26: AI investments by type per capita in Denmark vs. EU28 average, 2018



Source: JRC based on EUROSTAT, Spintan and Intan-Invest data.

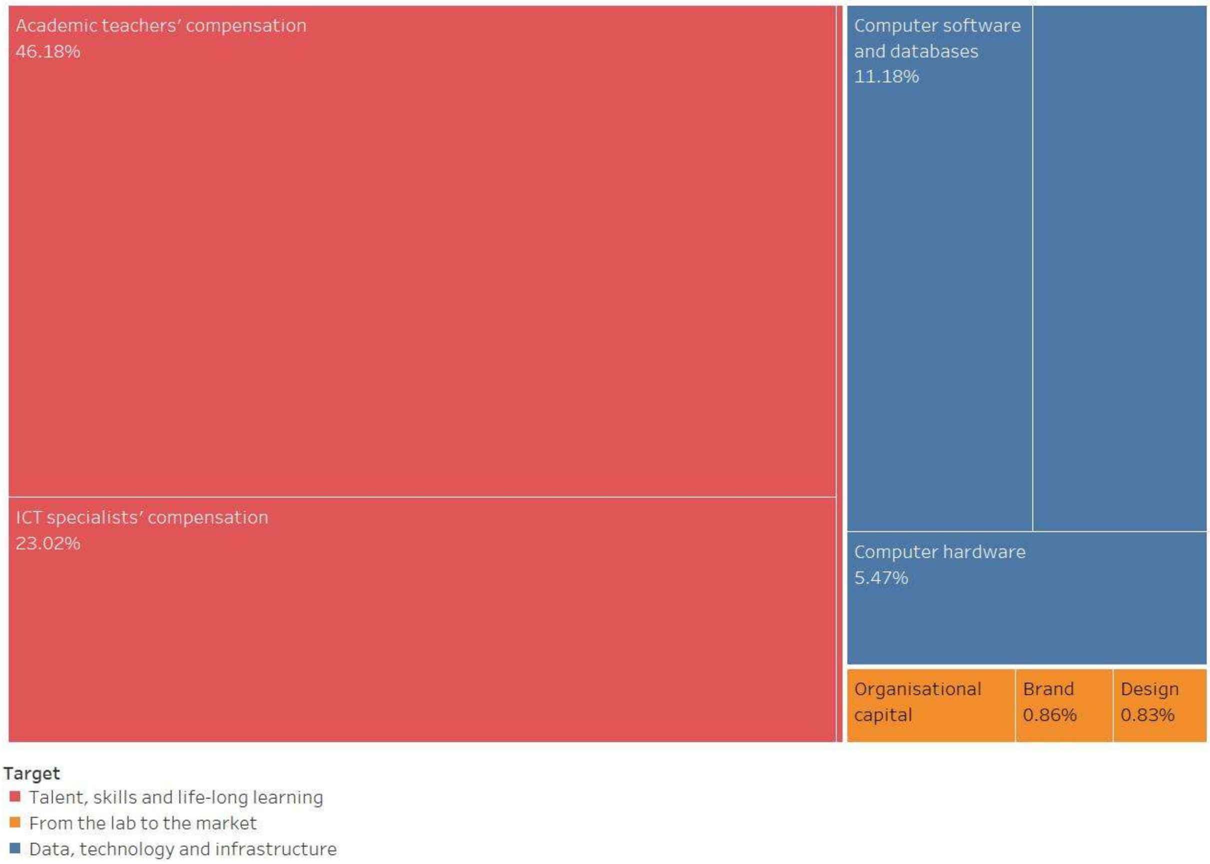
6.8 Estonia

Table 16: AI investments highlights in 2018 for Estonia

Estonia	Total [MEUR]	Per capita [EUR]	% of target
min scenario	14.9	11.3	0.07%
max scenario	16.7	12.7	0.08%

Source: JRC based on EUROSTAT, Spintan and Intan-Invest data.

Figure 27: AI investments by target in Estonia, 2018



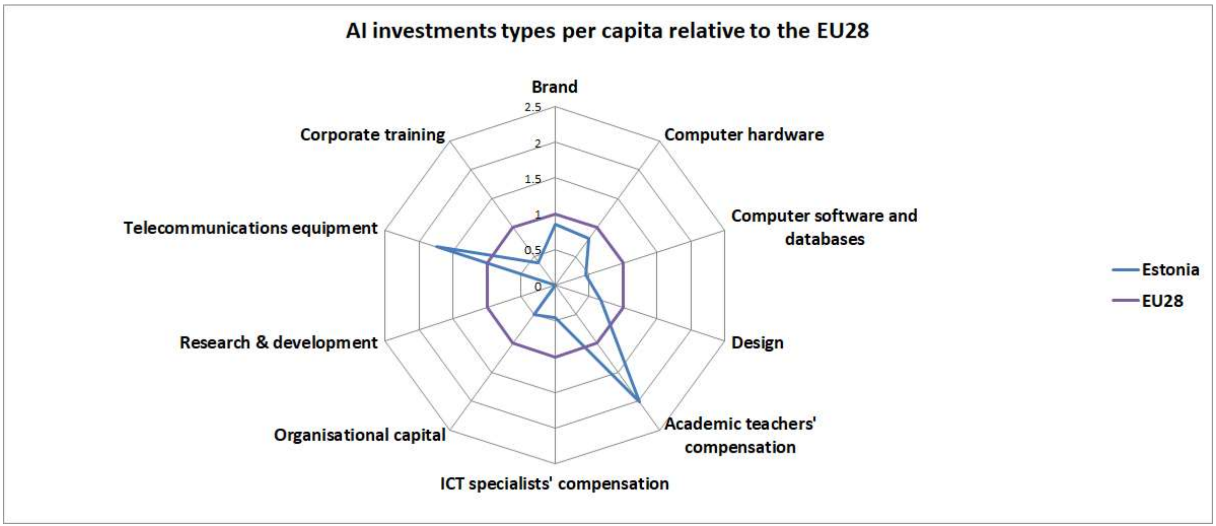
Source: JRC based on EUROSTAT, Spintan and Intan-Invest data.

Figure 28: EU AI investments by target and source in Estonia, 2018

Source	Talent, skills and life-long learning			From the lab to the market				Data, technology and infrastructure			Grand Total
	ICT specialists' compensation	Academic teachers' compensation	Corporate training	Research & development	Organisation al capital	Brand	Design	Computer hardware	Computer software and databases	Telecommuni cations equip ment	
Private	11.9%		0.4%	0.0%	1.4%	0.8%	0.8%	4.5%	8.1%	8.6%	36.5%
Public	11.1%	46.2%	0.1%	0.0%	0.1%	0.0%	0.1%	1.0%	3.1%	1.9%	63.5%
Grand Total	23.0%	46.2%	0.5%	0.0%	1.5%	0.9%	0.8%	5.5%	11.2%	10.5%	100.0%

Source: JRC based on EUROSTAT, Spintan and Intan-Invest data.

Figure 29: AI investments by type per capita in Estonia vs. EU28 average, 2018



Source: JRC based on EUROSTAT, Spintan and Intan-Invest data.

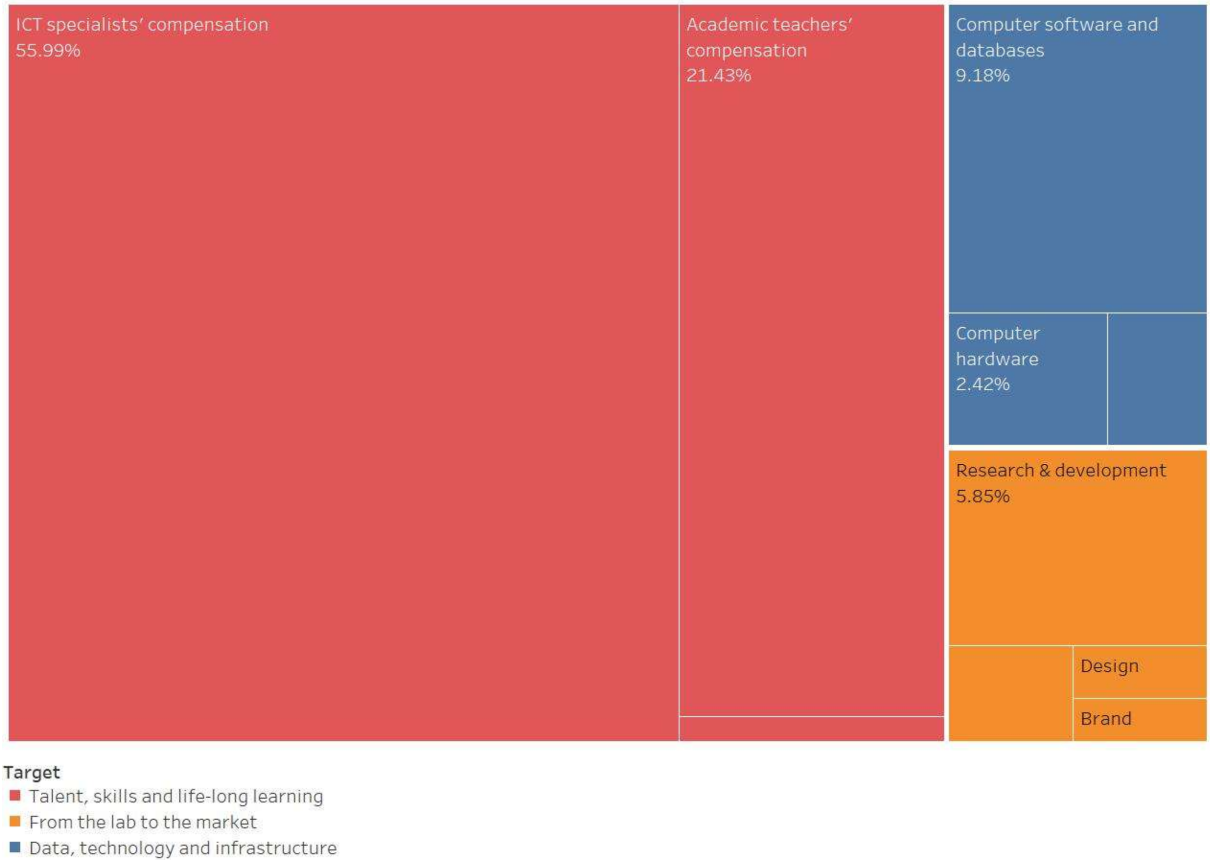
6.9 Finland

Table 17: AI investments highlights in 2018 for Finland

Finland	Total [MEUR]	Per capita [EUR]	% of target
min scenario	185.7	33.7	0.93%
max scenario	200.6	36.4	1.00%

Source: JRC based on EUROSTAT, Spintan and Intan-Invest data.

Figure 30: AI investments by target in Finland, 2018



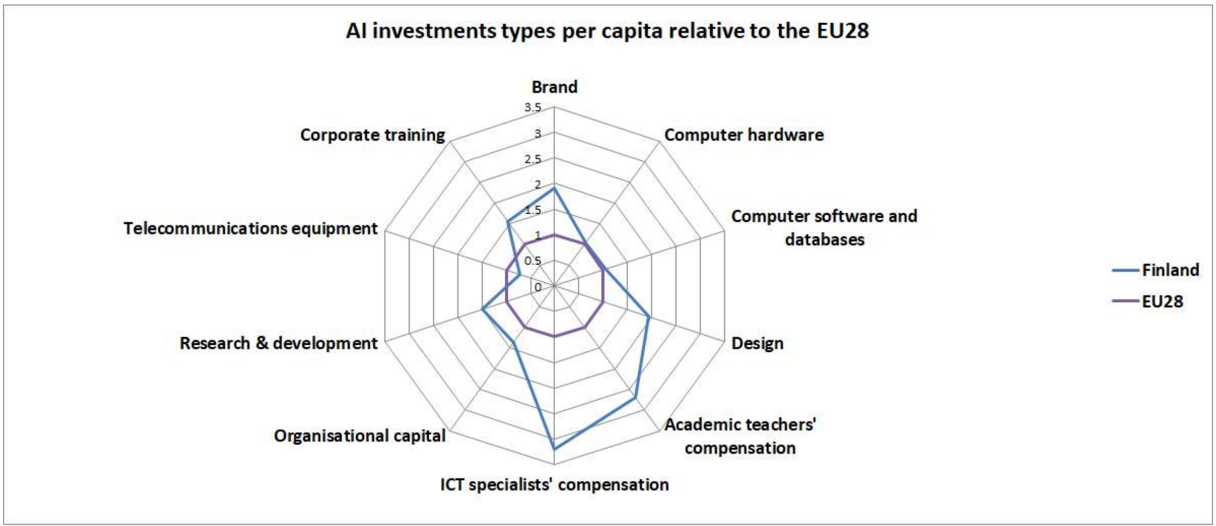
Source: JRC based on EUROSTAT, Spintan and Intan-Invest data.

Figure 31: EU AI investments by target and source in Finland, 2018

Source	Talent, skills and life-long learning			From the lab to the market				Data, technology and infrastructure			Grand Total
	ICT specialists' compensation	Academic teachers' compensation	Corporate training	Research & development	Organisational capital	Brand	Design	Computer hardware	Computer software and databases	Telecommunications equipment	
Private	34.21%		0.58%	4.31%	1.19%	0.66%	0.72%	2.15%	7.93%	1.44%	53.19%
Public	21.78%	21.43%	0.17%	1.54%	0.19%	0.01%	0.10%	0.27%	1.25%	0.08%	46.81%
Grand Total	55.99%	21.43%	0.74%	5.85%	1.38%	0.67%	0.82%	2.42%	9.18%	1.52%	100.00%

Source: JRC based on EUROSTAT, Spintan and Intan-Invest data.

Figure 32: AI investments by type per capita in Finland vs. EU28 average, 2018



Source: JRC based on EUROSTAT, Spintan and Intan-Invest data.

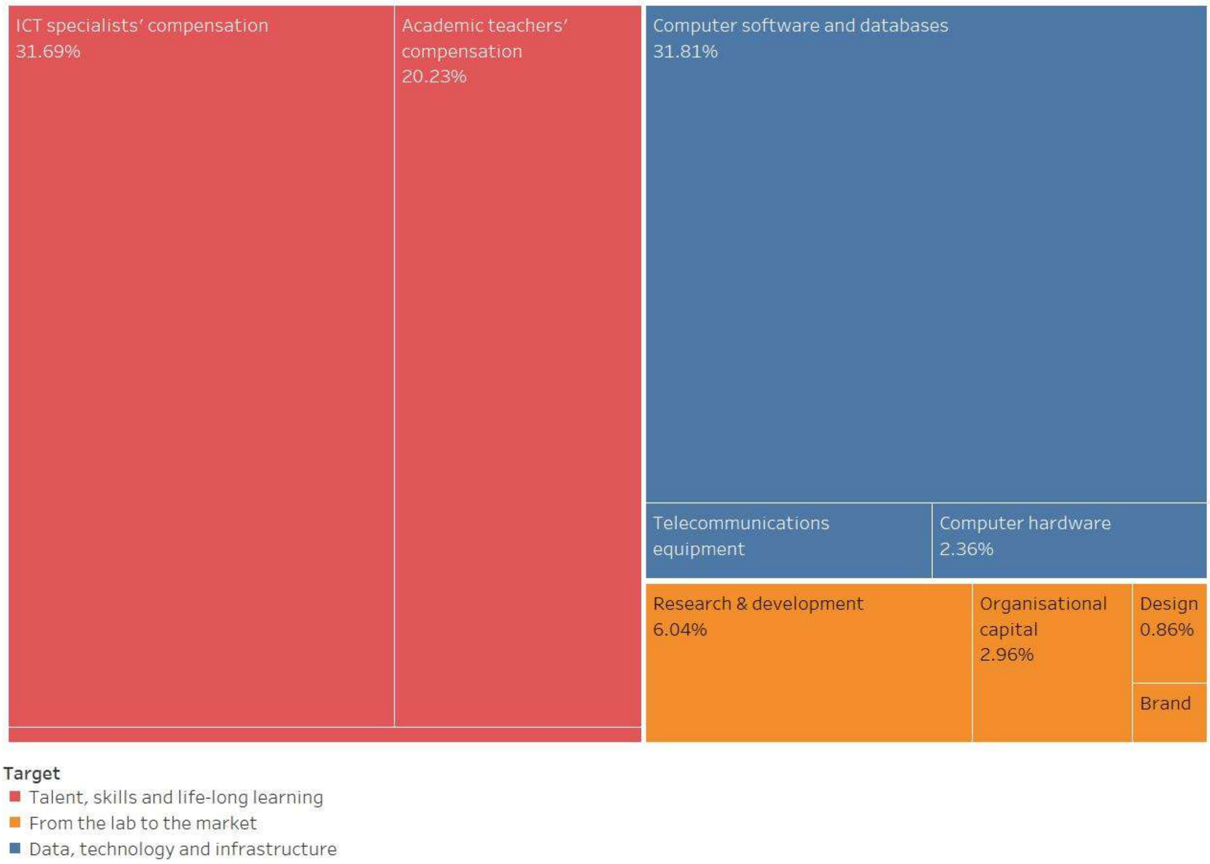
6.10 France

Table 18: AI investments highlights in 2018 for France

France	Total [MEUR]	Per capita [EUR]	% of target
min scenario	1242.3	18.6	6.21%
max scenario	1517.6	22.7	7.59%

Source: JRC based on EUROSTAT, Spintan and Intan-Invest data.

Figure 33: AI investments by target in France, 2018



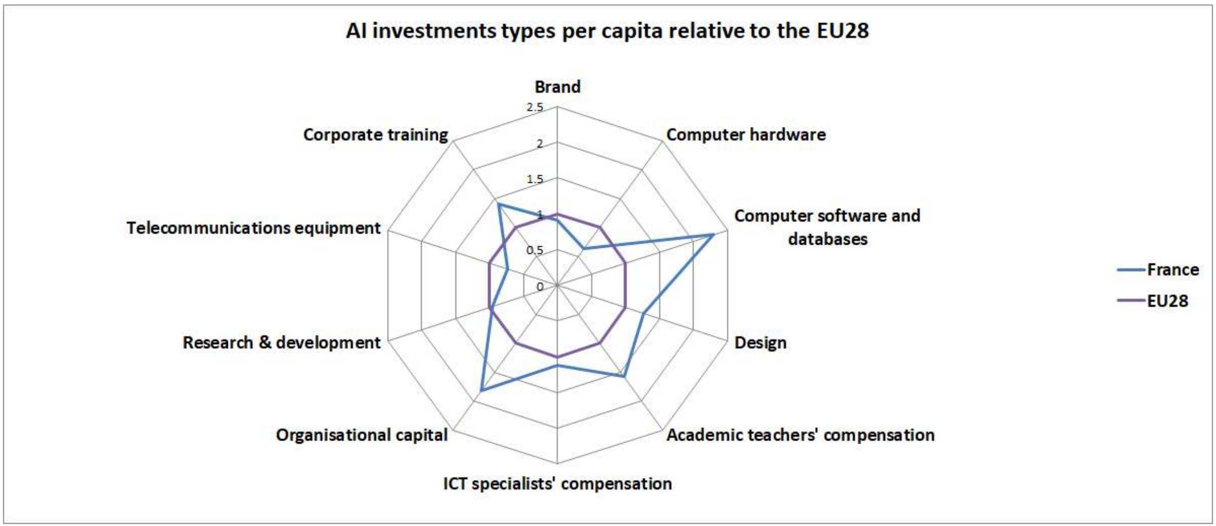
Source: JRC based on EUROSTAT, Spintan and Intan-Invest data.

Figure 34: EU AI investments by target and source in France, 2018

Source	Talent, skills and life-long learning			From the lab to the market				Data, technology and infrastructure			Grand Total
	ICT specialists' compensation	Academic teachers' compensation	Corporate training	Research & development	Organisational capital	Brand	Design	Computer hardware	Computer software and databases	Telecommunications equipment	
Private	17.63%		0.95%	5.53%	2.66%	0.48%	0.80%	1.79%	29.52%	2.40%	61.76%
Public	14.06%	20.23%	0.12%	0.52%	0.30%	0.03%	0.06%	0.57%	2.29%	0.06%	38.24%
Grand Total	31.69%	20.23%	1.07%	6.04%	2.96%	0.52%	0.86%	2.36%	31.81%	2.46%	100.00%

Source: JRC based on EUROSTAT, Spintan and Intan-Invest data.

Figure 35: AI investments by type per capita in France vs. EU28 average, 2018



Source: JRC based on EUROSTAT, Spintan and Intan-Invest data.

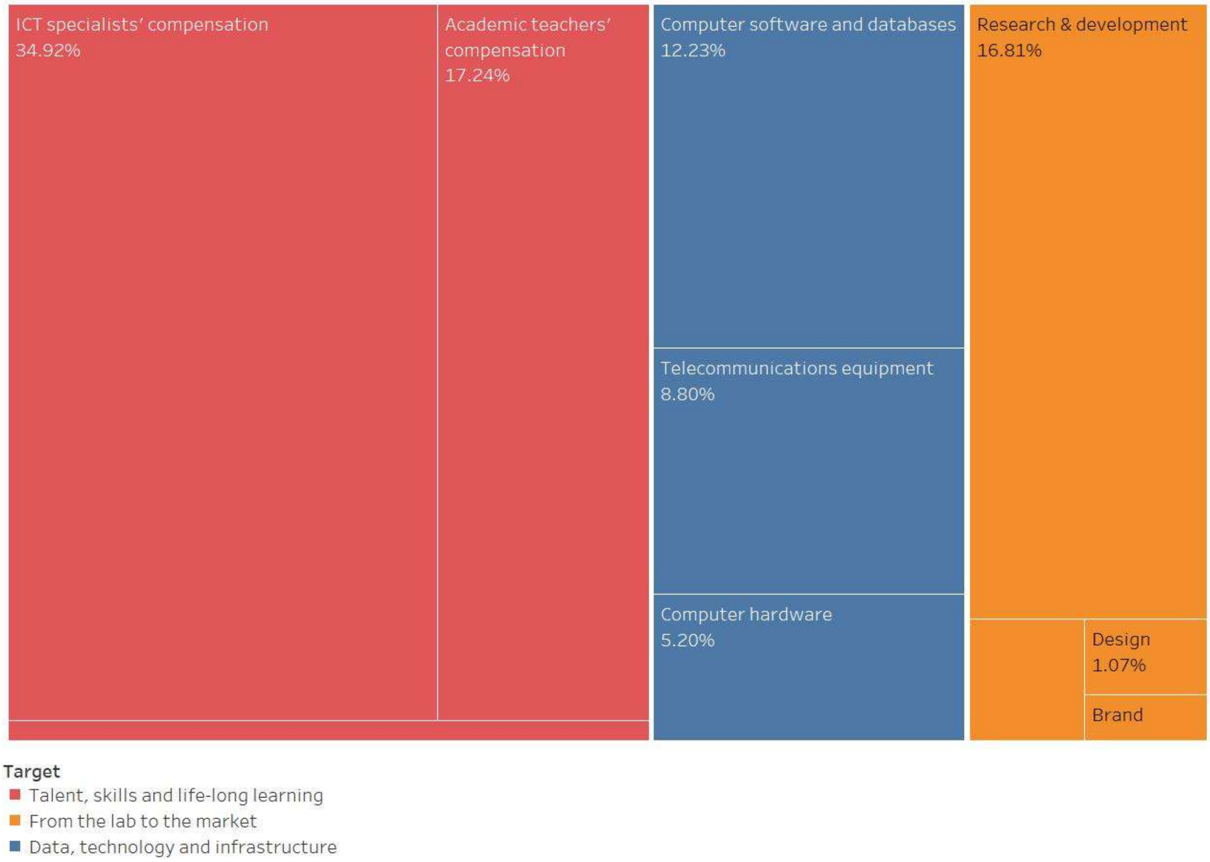
6.11 Germany

Table 19: AI investments highlights in 2018 for Germany

Germany	Total [MEUR]	Per capita [EUR]	% of target
min scenario	1182.1	14.3	5.91%
max scenario	1495.8	18.1	7.48%

Source: JRC based on EUROSTAT, Spintan and Intan-Invest data.

Figure 36: AI investments by target in Germany, 2018



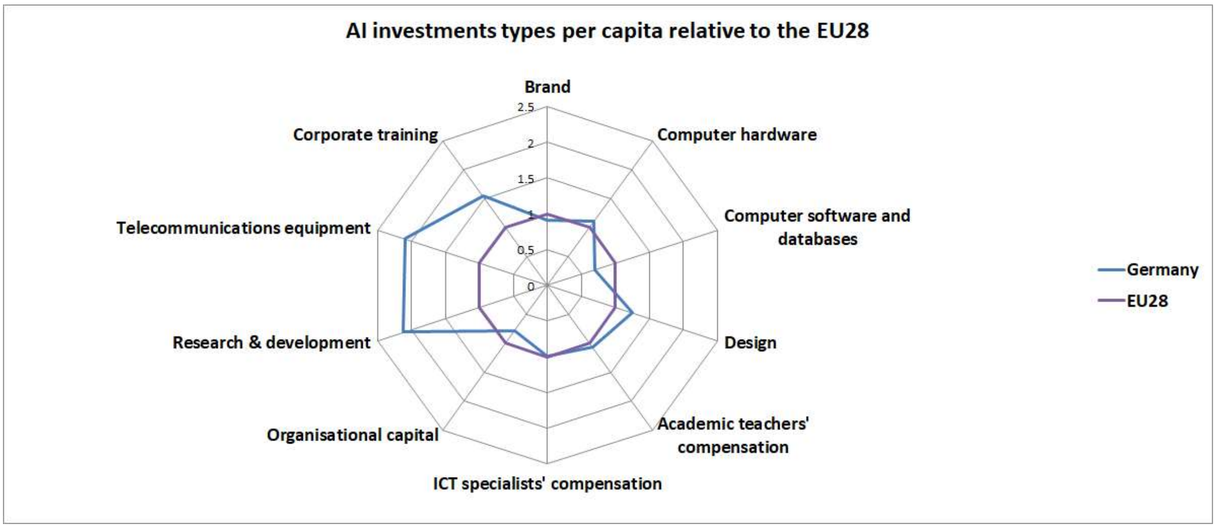
Source: JRC based on EUROSTAT, Spintan and Intan-Invest data.

Figure 37: EU AI investments by target and source in Germany, 2018

Source	Talent, skills and life-long learning: ICT specialists' compensation	Talent, skills and life-long learning: Academic teachers' compensation	Talent, skills and life-long learning: Corporate training	From the lab to the market: Research & development	From the lab to the market: Organisational capital	From the lab to the market: Brand	From the lab to the market: Design	Data, technology and infrastructure: Computer hardware	Data, technology and infrastructure: Computer software and databases	Data, technology and infrastructure: Telecommunications equipment	Grand Total
Private	19.28%		1.01%	13.87%	1.45%	0.63%	1.00%	4.73%	10.80%	7.23%	60.00%
Public	15.64%	17.24%	0.47%	2.94%	0.16%	0.01%	0.06%	0.47%	1.42%	1.58%	40.00%
Grand Total	34.92%	17.24%	1.48%	16.81%	1.62%	0.64%	1.07%	5.20%	12.23%	8.80%	100.00%

Source: JRC based on EUROSTAT, Spintan and Intan-Invest data.

Figure 38: AI investments by type per capita in Germany vs. EU28 average, 2018



Source: JRC based on EUROSTAT, Spintan and Intan-Invest data.

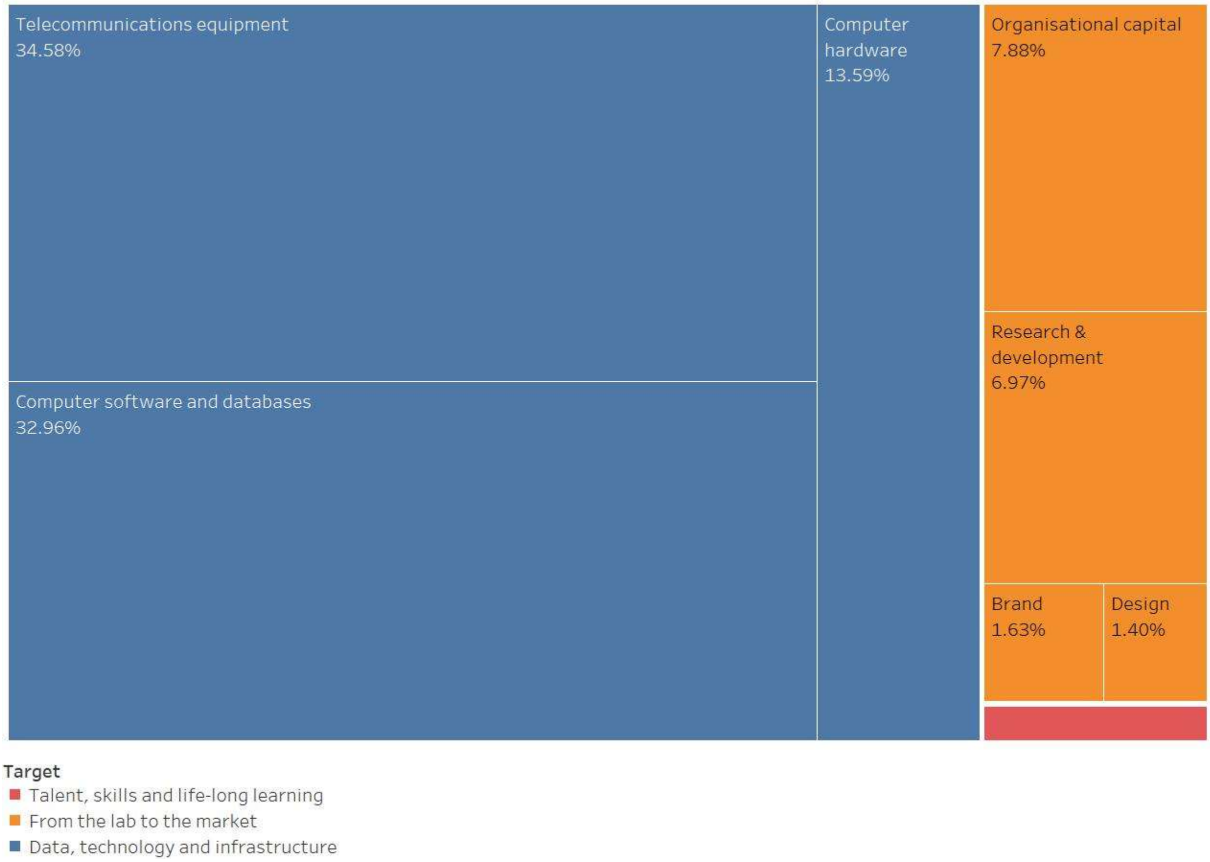
6.12 Greece

Table 20: AI investments highlights in 2018 for Greece

Greece	Total [MEUR]	Per capita [EUR]	% of target
min scenario	13.4	1.2	0.07%
max scenario	21.4	2.0	0.11%

Source: JRC based on EUROSTAT, Spintan and Intan-Invest data.

Figure 39: AI investments by target in Greece, 2018



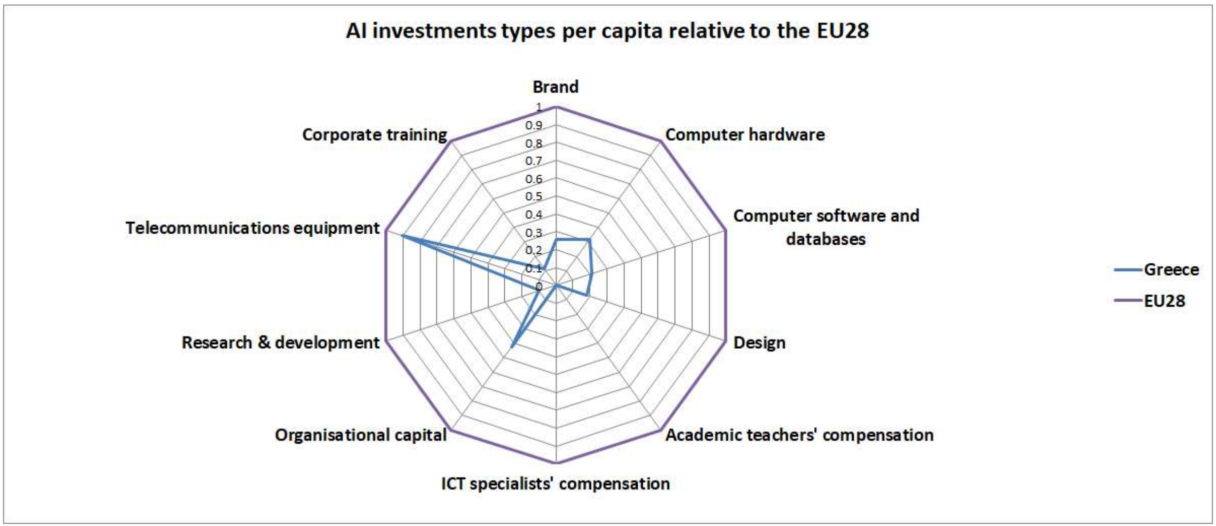
Source: JRC based on EUROSTAT, Spintan and Intan-Invest data.

Figure 40: EU AI investments by target and source in Greece, 2018

Source	Talent, skills and life-long learning			From the lab to the market				Data, technology and infrastructure			Grand Total
	ICT specialists' compensation	Academic teachers' compensation	Corporate training	Research & development	Organisational capital	Brand	Design	Computer hardware	Computer software and databases	Telecommunications equipment	
Private	0.0%		0.8%	2.9%	7.1%	1.6%	1.4%	11.3%	31.2%	28.7%	84.9%
Public	0.0%	0.0%	0.2%	4.1%	0.8%	0.1%	0.0%	2.3%	1.7%	5.9%	15.1%
Grand Total	0.0%	0.0%	1.0%	7.0%	7.9%	1.6%	1.4%	13.6%	33.0%	34.6%	100.0%

Source: JRC based on EUROSTAT, Spintan and Intan-Invest data.

Figure 41: AI investments by type per capita in Greece vs. EU28 average, 2018



Source: JRC based on EUROSTAT, Spintan and Intan-Invest data.

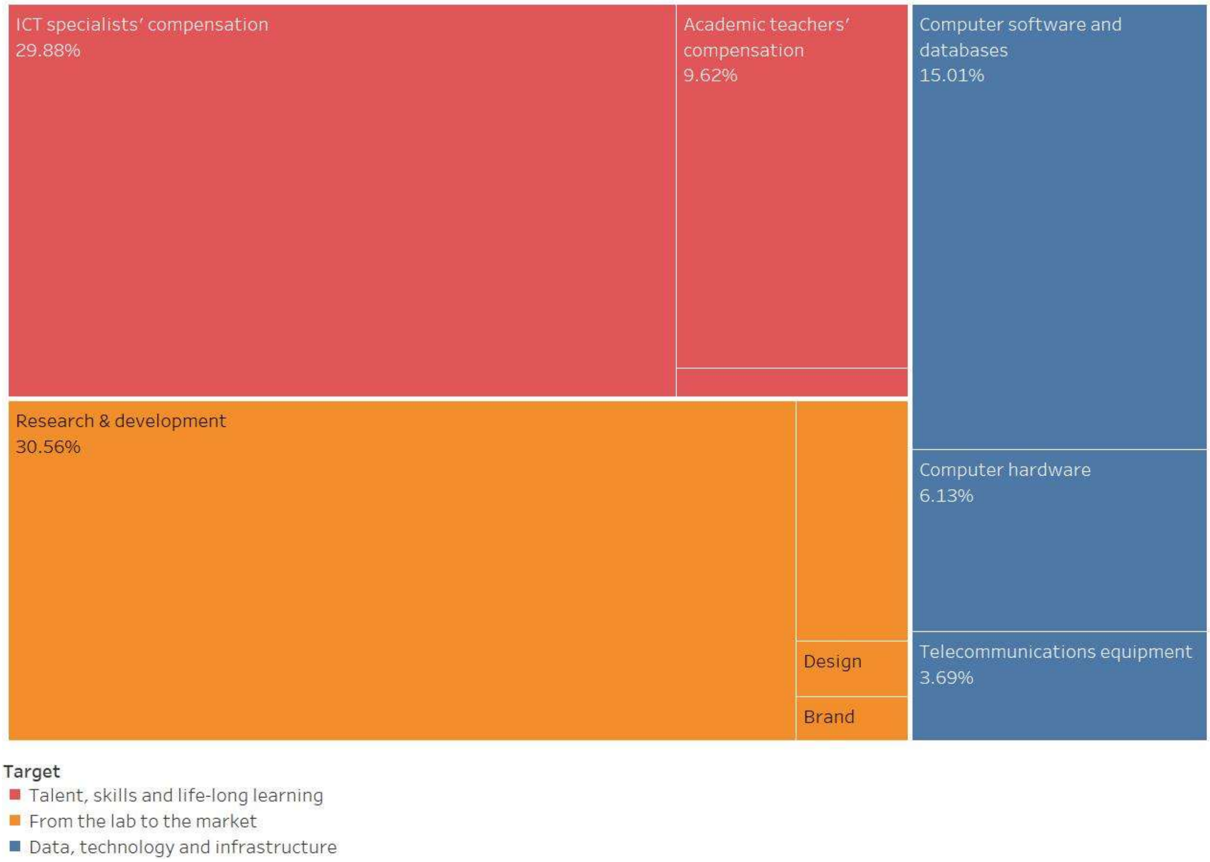
6.13 Hungary

Table 21: AI investments highlights in 2018 for Hungary

Hungary	Total [MEUR]	Per capita [EUR]	% of target
min scenario	46.0	4.7	0.23%
max scenario	63.2	6.5	0.32%

Source: JRC based on EUROSTAT, Spintan and Intan-Invest data.

Figure 42: AI investments by target in Hungary, 2018



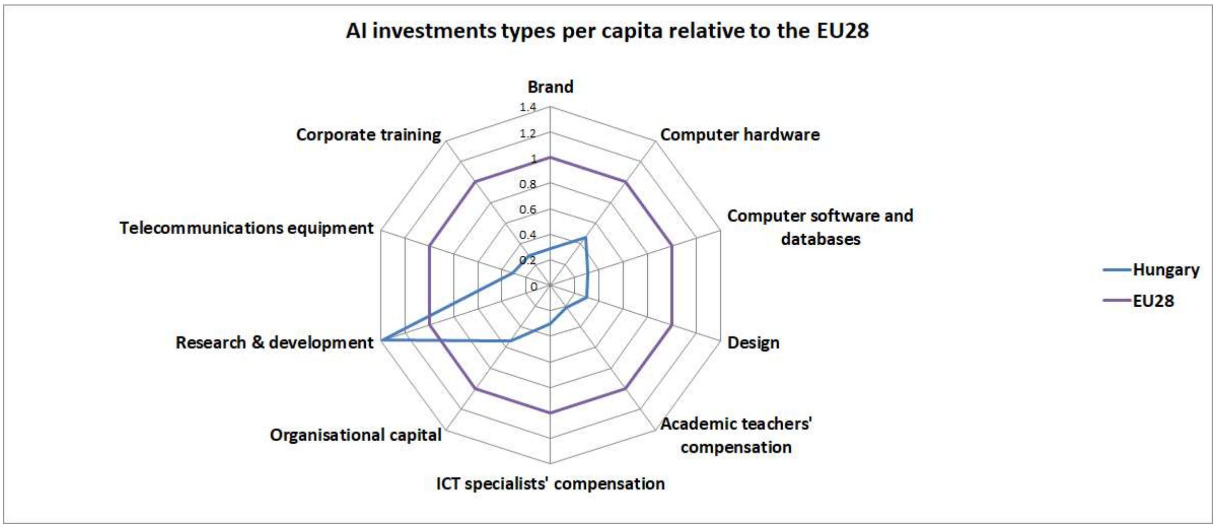
Source: JRC based on EUROSTAT, Spintan and Intan-Invest data.

Figure 43: EU AI investments by target and source in Hungary, 2018

Source	Talent, skills and life-long learning			From the lab to the market				Data, technology and infrastructure			Grand Total
	ICT specialists' compensation	Academic teachers' compensation	Corporate training	Research & development	Organisational capital	Brand	Design	Computer hardware	Computer software and databases	Telecommunications equipment	
Private	14.05%		0.61%	30.28%	2.63%	0.52%	0.70%	5.15%	13.59%	3.10%	70.63%
Public	15.83%	9.62%	0.16%	0.28%	0.43%	0.04%	0.02%	0.98%	1.43%	0.59%	29.37%
Grand Total	29.88%	9.62%	0.76%	30.56%	3.06%	0.56%	0.72%	6.13%	15.01%	3.69%	100.00%

Source: JRC based on EUROSTAT, Spintan and Intan-Invest data.

Figure 44: AI investments by type per capita in Hungary vs. EU28 average, 2018



Source: JRC based on EUROSTAT, Spintan and Intan-Invest data.

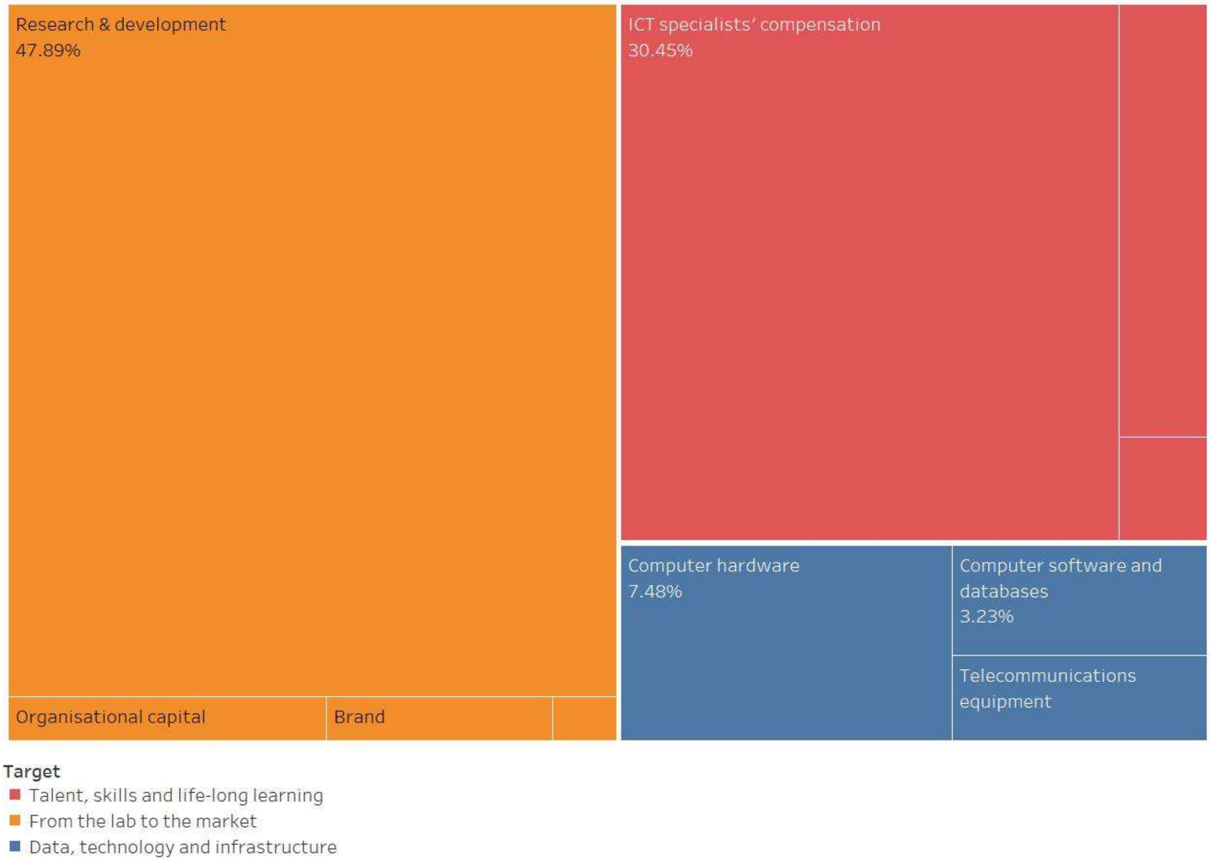
6.14 Ireland

Table 22: AI investments highlights in 2018 for Ireland

Ireland	Total [MEUR]	Per capita [EUR]	% of target
min scenario	148.5	30.7	0.74%
max scenario	176.9	36.6	0.88%

Source: JRC based on EUROSTAT, Spintan and Intan-Invest data.

Figure 45: AI investments by target in Ireland, 2018



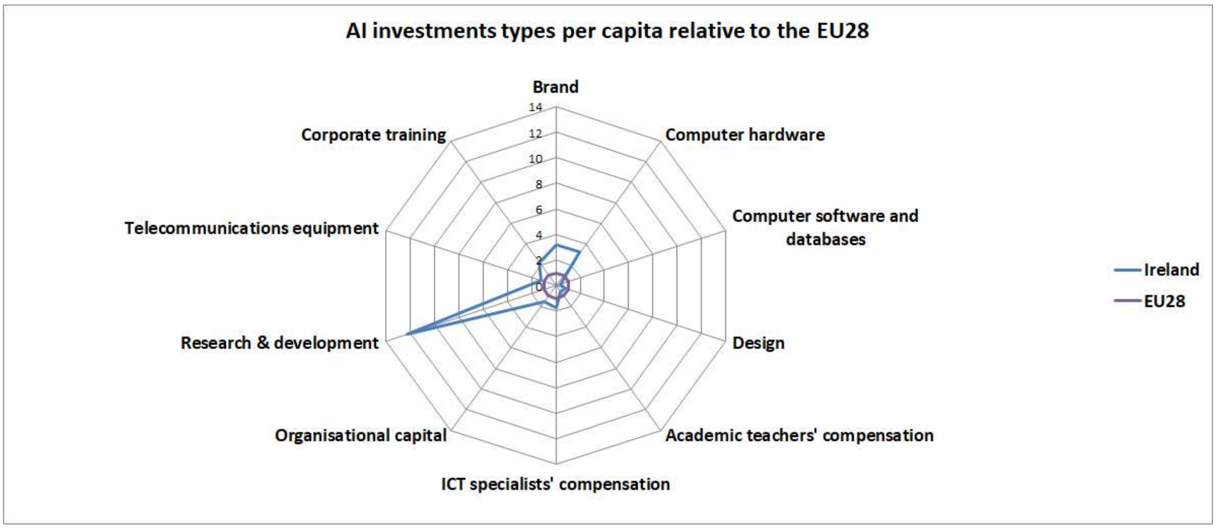
Source: JRC based on EUROSTAT, Spintan and Intan-Invest data.

Figure 46: EU AI investments by target and source in Ireland, 2018

Source	Talent, skills and life-long learning			From the lab to the market				Data, technology and infrastructure			Grand Total
	ICT specialists' compensation	Academic teachers' compensation	Corporate training	Research & development	Organisation al capital	Brand	Design	Computer hardware	Computer software and databases	Telecommuni cations equip ment	
Private	16.43%		0.58%	44.16%	1.36%	1.10%	0.29%	5.99%	2.54%	2.35%	74.81%
Public	14.02%	4.36%	0.46%	3.74%	0.22%	0.02%	0.03%	1.49%	0.69%	0.17%	25.19%
Grand Total	30.45%	4.36%	1.05%	47.89%	1.58%	1.12%	0.32%	7.48%	3.23%	2.51%	100.00%

Source: JRC based on EUROSTAT, Spintan and Intan-Invest data.

Figure 47: AI investments by type per capita in Ireland vs. EU28 average, 2018



Source: JRC based on EUROSTAT, Spintan and Intan-Invest data.

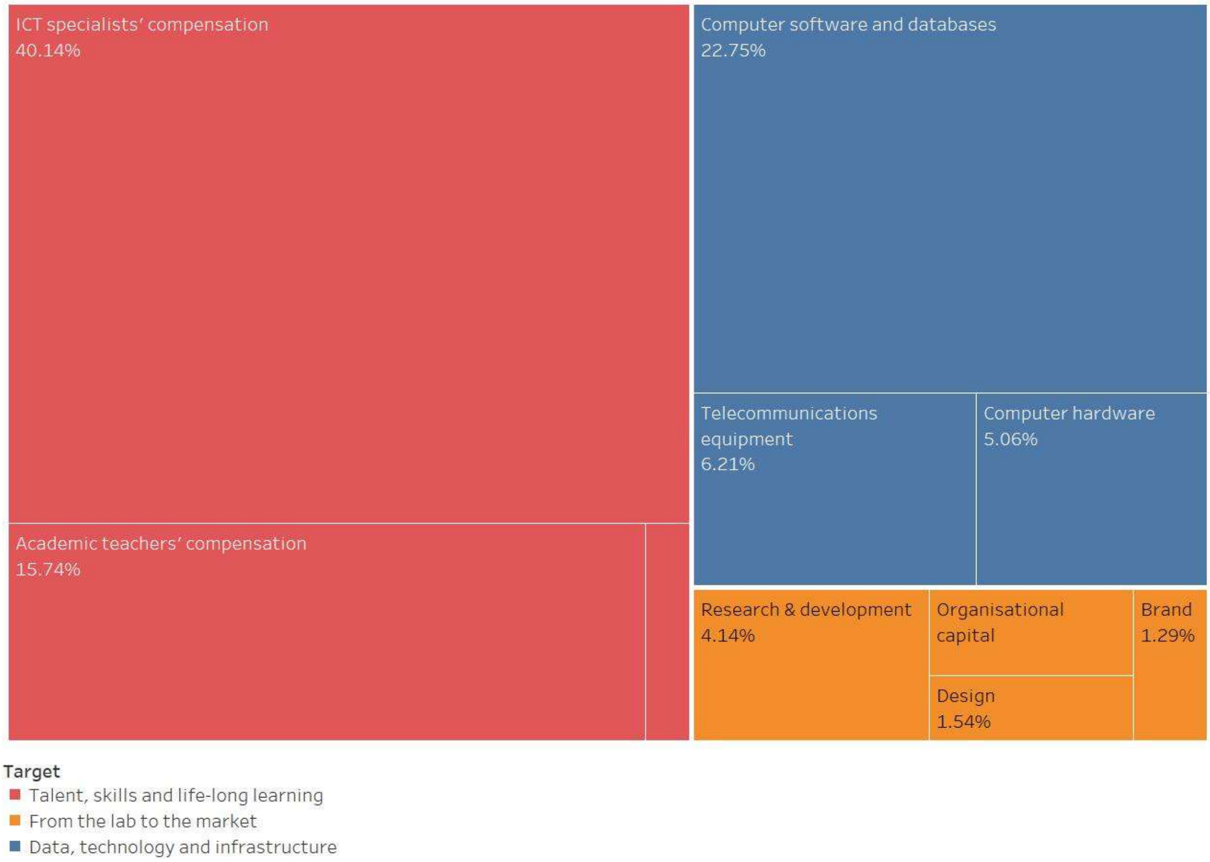
6.15 Italy

Table 23: AI investments highlights in 2018 for Italy

Italy	Total [MEUR]	Per capita [EUR]	% of target
min scenario	592.8	9.8	2.96%
max scenario	699.6	11.6	3.50%

Source: JRC based on EUROSTAT, Spintan and Intan-Invest data.

Figure 48: AI investments by target in Italy, 2018



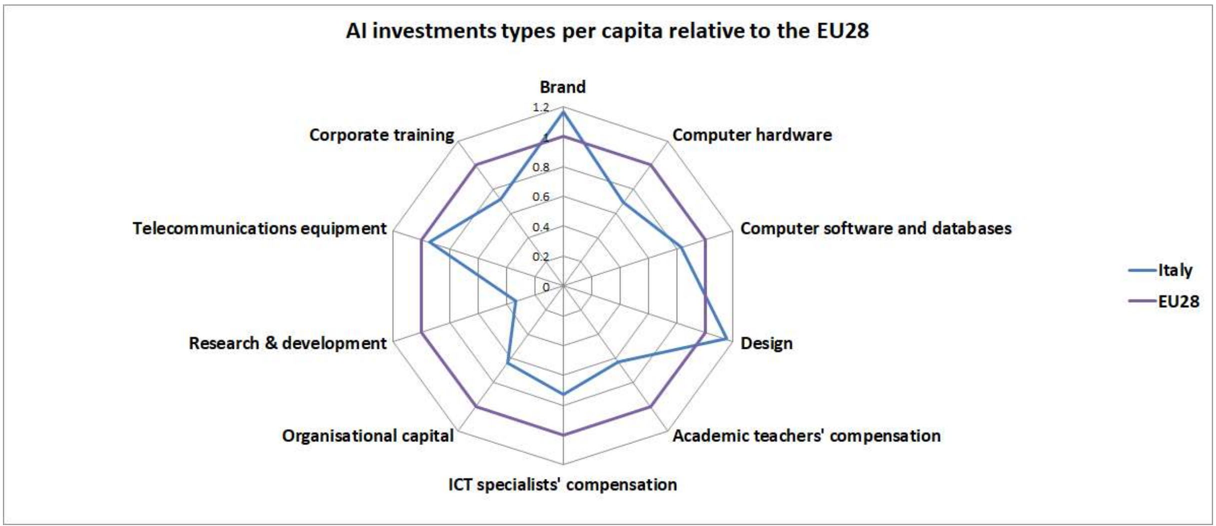
Source: JRC based on EUROSTAT, Spintan and Intan-Invest data.

Figure 49: EU AI investments by target and source in Italy, 2018

Source	Talent, skills and life-long learning			From the lab to the market				Data, technology and infrastructure			Grand Total
	ICT specialists' compensation	Academic teachers' compensation	Corporate training	Research & development	Organisation al capital	Brand	Design	Computer hardware	Computer software and databases	Telecommuni cations equip ment	
Private	21.00%		0.97%	2.81%	1.70%	1.27%	1.45%	4.47%	21.06%	5.64%	60.37%
Public	19.14%	15.74%	0.11%	1.33%	0.35%	0.01%	0.09%	0.59%	1.69%	0.57%	39.63%
Grand Total	40.14%	15.74%	1.08%	4.14%	2.05%	1.29%	1.54%	5.06%	22.75%	6.21%	100.00%

Source: JRC based on EUROSTAT, Spintan and Intan-Invest data.

Figure 50: AI investments by type per capita in Italy vs. EU28 average, 2018



Source: JRC based on EUROSTAT, Spintan and Intan-Invest data.

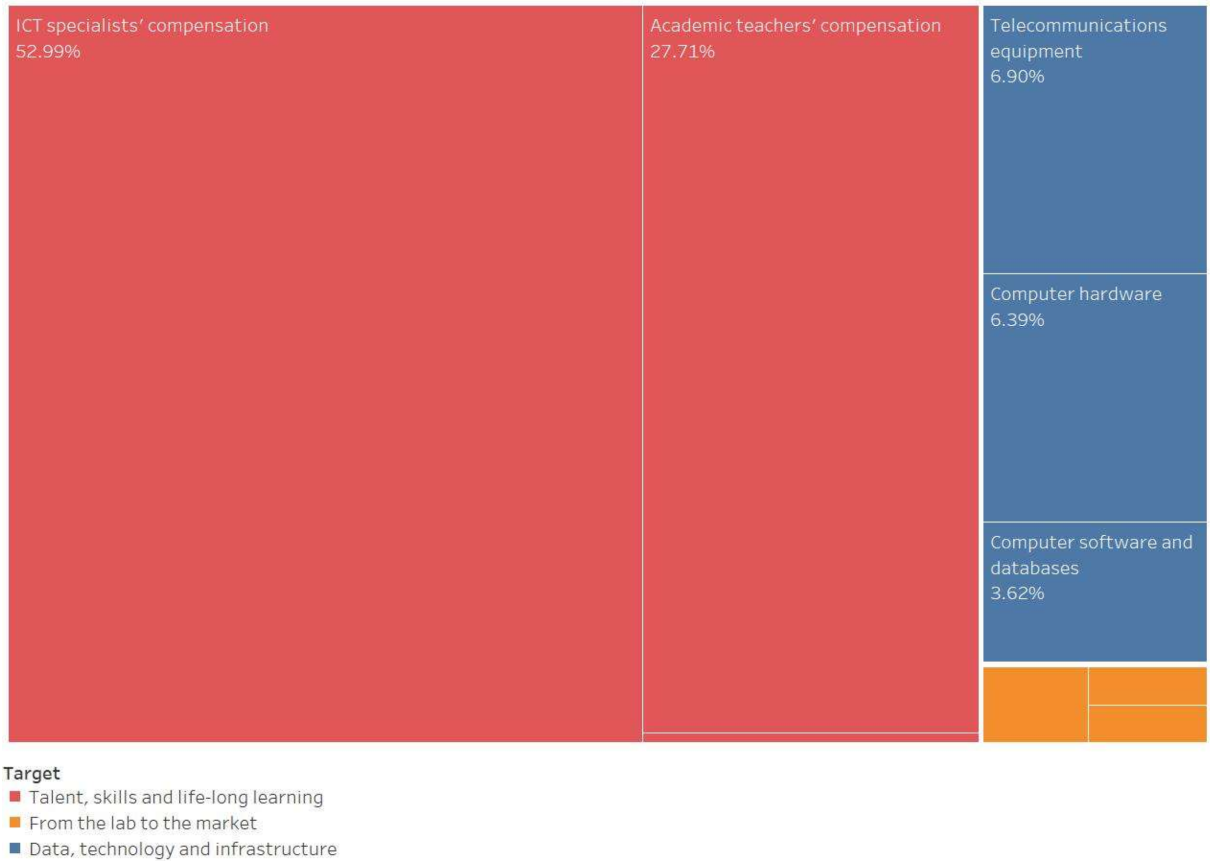
6.16 Latvia

Table 24: AI investments highlights in 2018 for Latvia

Latvia	Total [MEUR]	Per capita [EUR]	% of target
min scenario	18.7	9.7	0.09%
max scenario	20.1	10.4	0.10%

Source: JRC based on EUROSTAT, Spintan and Intan-Invest data.

Figure 51: AI investments by target in Latvia, 2018



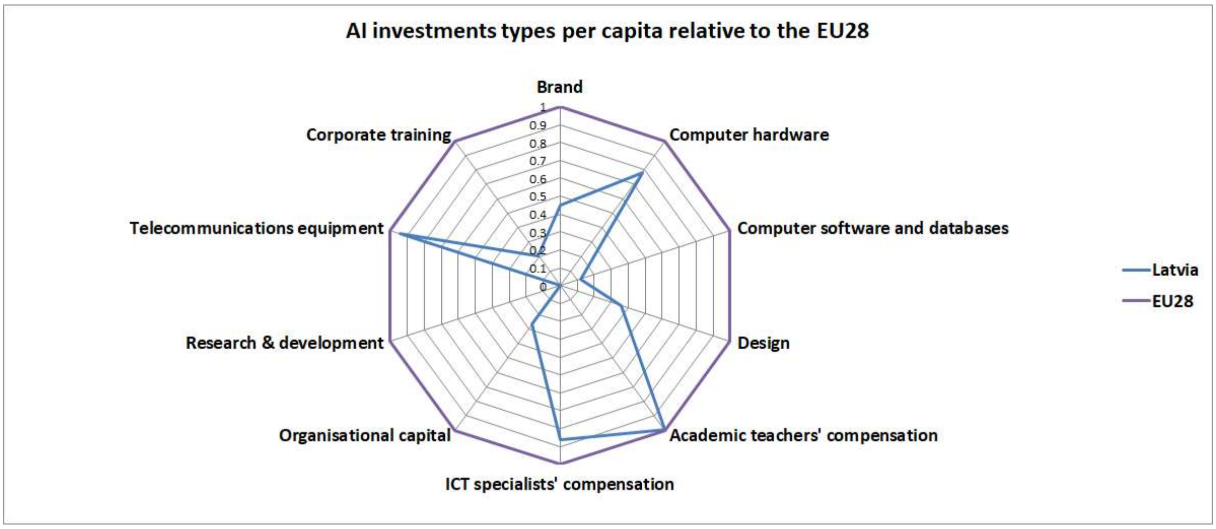
Source: JRC based on EUROSTAT, Spintan and Intan-Invest data.

Figure 52: EU AI investments by target and source in Latvia, 2018

Source	Talent, skills and life-long learning: ICT specialists' compensation	Academic teachers' compensation	Corporate training	From the lab to the market: Research & development	Organisational capital	Brand	Design	Data, technology and infrastructure: Computer hardware	Computer software and databases	Telecommunications equipment	Grand Total
Private	21.4%		0.3%	0.0%	0.9%	0.5%	0.5%	5.1%	3.3%	5.5%	37.5%
Public	31.6%	27.7%	0.1%	0.0%	0.1%	0.0%	0.0%	1.3%	0.3%	1.4%	62.5%
Grand Total	53.0%	27.7%	0.3%	0.0%	1.0%	0.6%	0.5%	6.4%	3.6%	6.9%	100.0%

Source: JRC based on EUROSTAT, Spintan and Intan-Invest data.

Figure 53: AI investments by type per capita in Latvia vs. EU28 average, 2018



Source: JRC based on EUROSTAT, Spintan and Intan-Invest data.

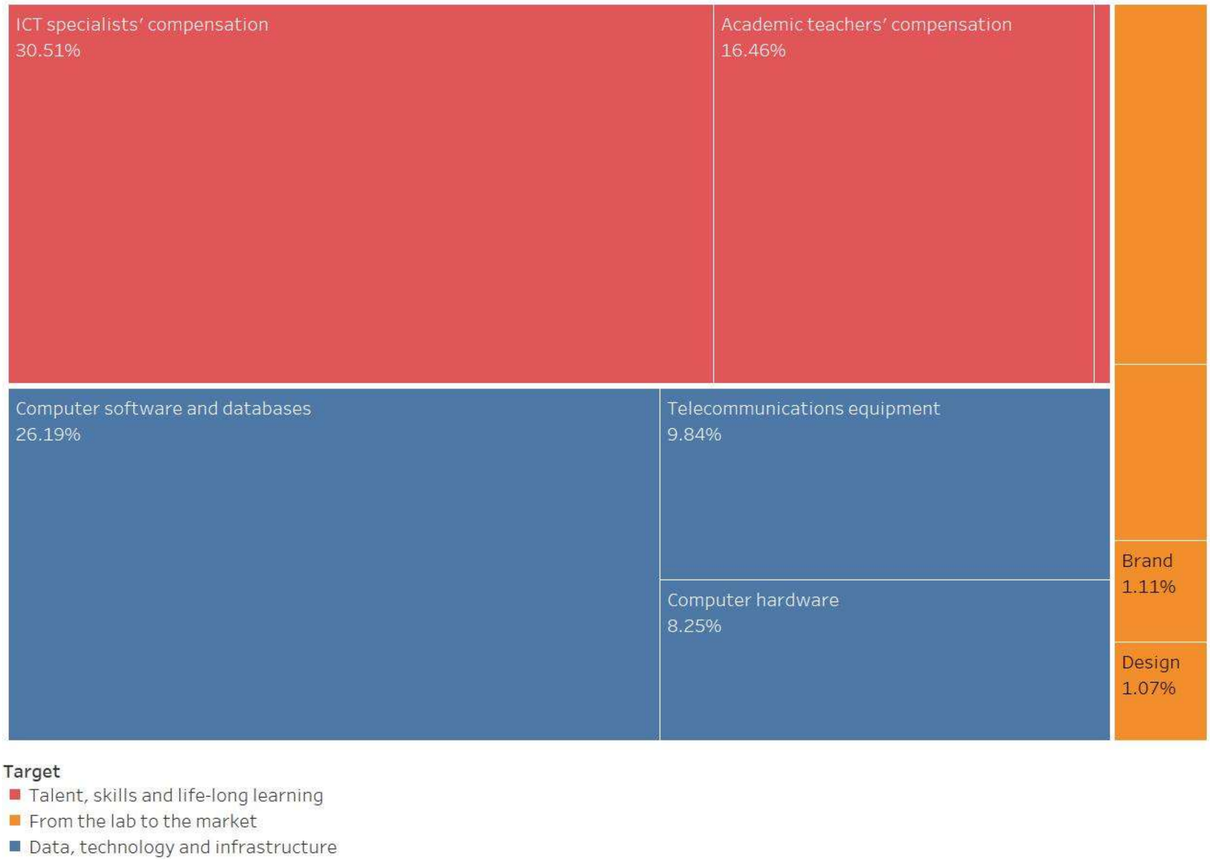
6.17 Lithuania

Table 25: AI investments highlights in 2018 for Lithuania

Lithuania	Total [MEUR]	Per capita [EUR]	% of target
min scenario	15.7	5.6	0.08%
max scenario	19.6	7.0	0.10%

Source: JRC based on EUROSTAT, Spintan and Intan-Invest data.

Figure 54: AI investments by target in Lithuania, 2018



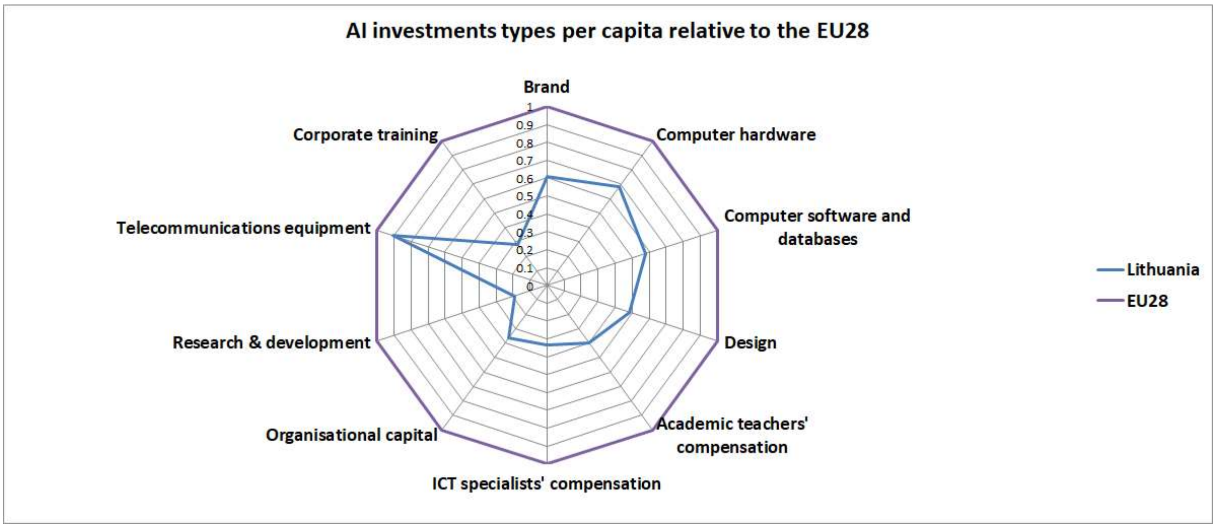
Source: JRC based on EUROSTAT, Spintan and Intan-Invest data.

Figure 55: EU AI investments by target and source in Lithuania, 2018

Source	Talent, skills and life-long learning			From the lab to the market				Data, technology and infrastructure			Grand Total
	ICT specialists' compensation	Academic teachers' compensation	Corporate training	Research & development	Organisational capital	Brand	Design	Computer hardware	Computer software and databases	Telecommunications equipment	
Private	15.59%		0.58%	1.61%	1.78%	1.09%	0.99%	7.24%	23.76%	8.65%	61.29%
Public	14.91%	16.46%	0.12%	2.33%	0.14%	0.02%	0.09%	1.02%	2.43%	1.19%	38.71%
Grand Total	30.51%	16.46%	0.70%	3.94%	1.92%	1.11%	1.07%	8.25%	26.19%	9.84%	100.00%

Source: JRC based on EUROSTAT, Spintan and Intan-Invest data.

Figure 56: AI investments by type per capita in Lithuania vs. EU28 average, 2018



Source: JRC based on EUROSTAT, Spintan and Intan-Invest data.

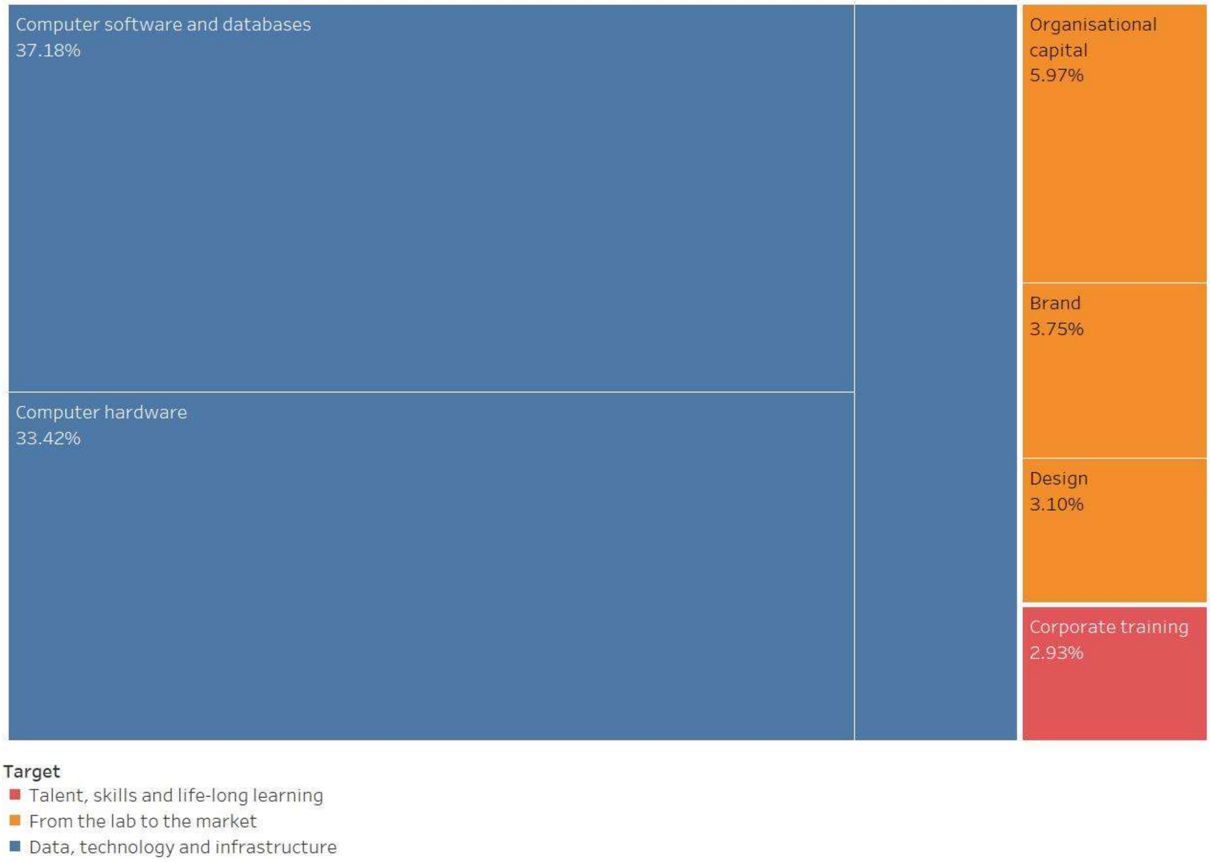
6.18 Luxembourg

Table 26: AI investments highlights in 2018 for Luxembourg

Luxembourg	Total [MEUR]	Per capita [EUR]	% of target
min scenario	5.5	9.1	0.03%
max scenario	8.4	13.9	0.04%

Source: JRC based on EUROSTAT, Spintan and Intan-Invest data.

Figure 57: AI investments by target in Luxembourg, 2018



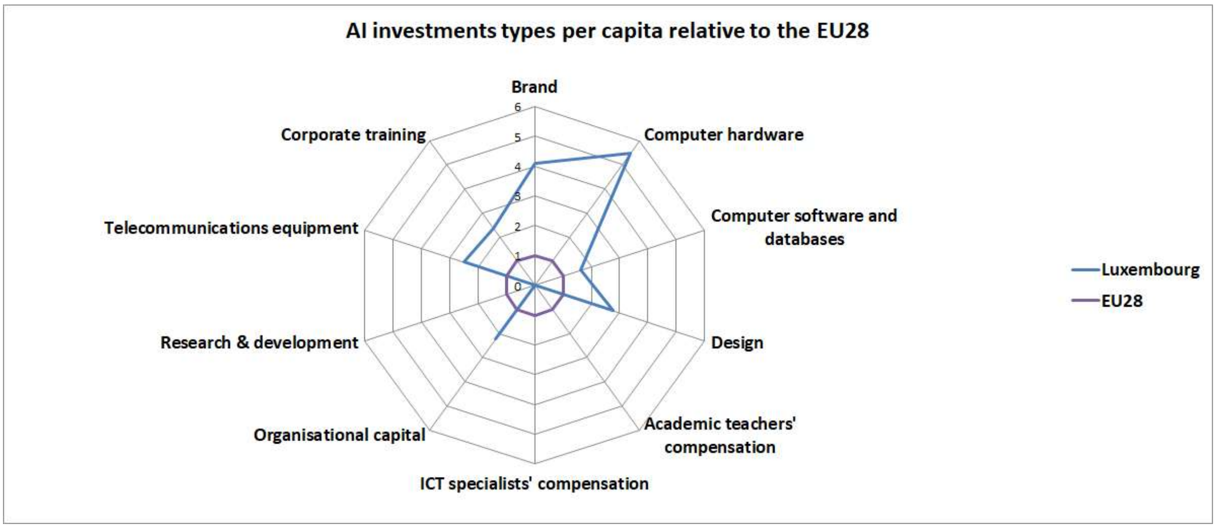
Source: JRC based on EUROSTAT, Spintan and Intan-Invest data.

Figure 58: EU AI investments by target and source in Luxembourg, 2018

Source	Talent, skills and life-long learning: ICT specialists' compensation	Talent, skills and life-long learning: Academic teachers' compensation	Talent, skills and life-long learning: Corporate training	From the lab to the market: Research & development	From the lab to the market: Organisation al capital	From the lab to the market: Brand	From the lab to the market: Design	Data, technology and infrastructure: Computer hardware	Data, technology and infrastructure: Computer software and databases	Data, technology and infrastructure: Telecommuni cations equip ment	Grand Total
Private	0.0%		2.9%	0.0%	5.7%	3.6%	3.0%	32.0%	35.3%	13.2%	95.6%
Public	0.0%	0.0%	0.1%	0.0%	0.2%	0.2%	0.1%	1.4%	1.9%	0.5%	4.4%
Grand Total	0.0%	0.0%	2.9%	0.0%	6.0%	3.8%	3.1%	33.4%	37.2%	13.7%	100.0%

Source: JRC based on EUROSTAT, Spintan and Intan-Invest data.

Figure 59: AI investments by type per capita in Luxembourg vs. EU28 average, 2018



Source: JRC based on EUROSTAT, Spintan and Intan-Invest data.

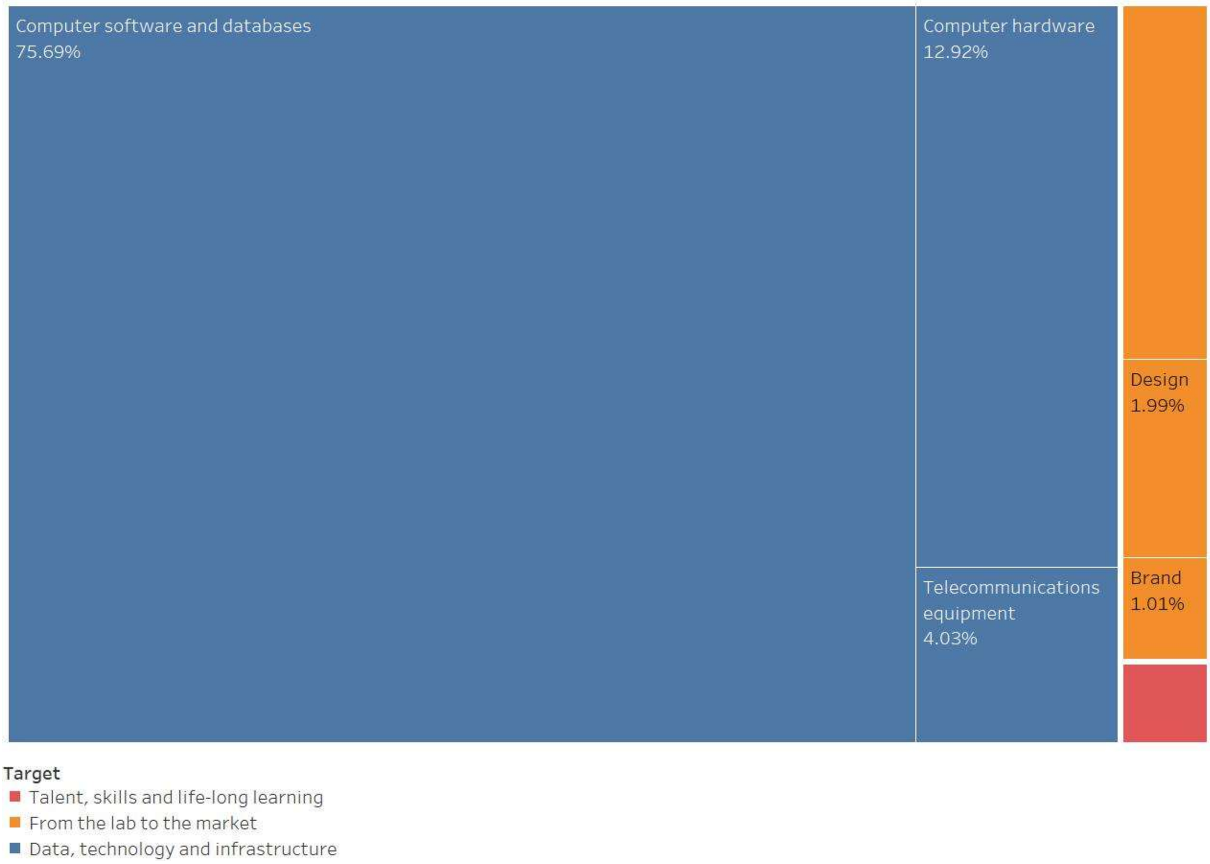
6.19 Malta

Table 27: AI investments highlights in 2018 for Malta

Malta	Total [MEUR]	Per capita [EUR]	% of target
min scenario	1.7	3.5	0.01%
max scenario	2.7	5.6	0.01%

Source: JRC based on EUROSTAT, Spintan and Intan-Invest data.

Figure 60: AI investments by target in Malta, 2018



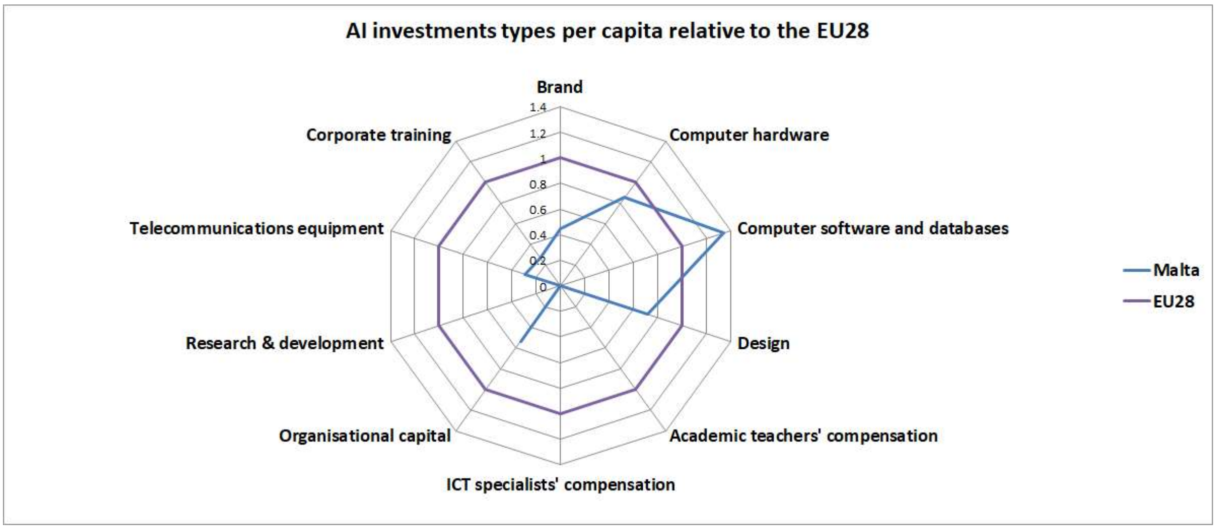
Source: JRC based on EUROSTAT, Spintan and Intan-Invest data.

Figure 61: EU AI investments by target and source in Malta, 2018

Source	Talent, skills and life-long learning			From the lab to the market				Data, technology and infrastructure			Grand Total
	ICT specialists' compensation	Academic teachers' compensation	Corporate training	Research & development	Organisation al capital	Brand	Design	Computer hardware	Computer software and databases	Telecommuni cations equip ment	
Private	0.0%		0.7%	0.0%	3.1%	0.9%	1.8%	10.1%	63.0%	4.0%	83.7%
Public	0.0%	0.0%	0.2%	0.0%	0.4%	0.1%	0.2%	2.8%	12.7%	0.0%	16.3%
Grand Total	0.0%	0.0%	0.8%	0.0%	3.5%	1.0%	2.0%	12.9%	75.7%	4.0%	100.0%

Source: JRC based on EUROSTAT, Spintan and Intan-Invest data.

Figure 62: AI investments by type per capita in Malta vs. EU28 average, 2018



Source: JRC based on EUROSTAT, Spintan and Intan-Invest data.

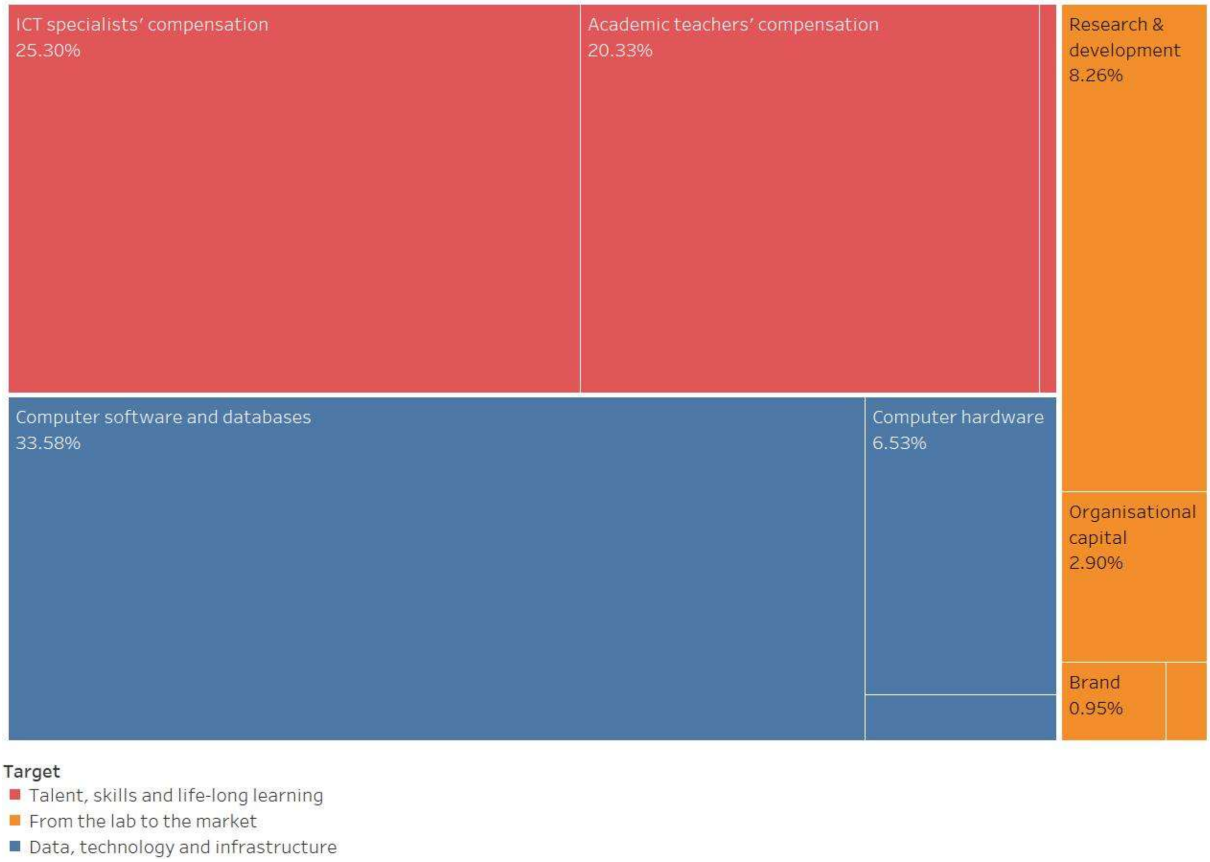
6.20 The Netherlands

Table 28: AI investments highlights in 2018 for the Netherlands, 2018

Netherlands	Total [MEUR]	Per capita [EUR]	% of target
min scenario	333.0	19.4	1.67%
max scenario	416.7	24.3	2.08%

Source: JRC based on EUROSTAT, Spintan and Intan-Invest data.

Figure 63: AI investments by target in the Netherlands, 2018



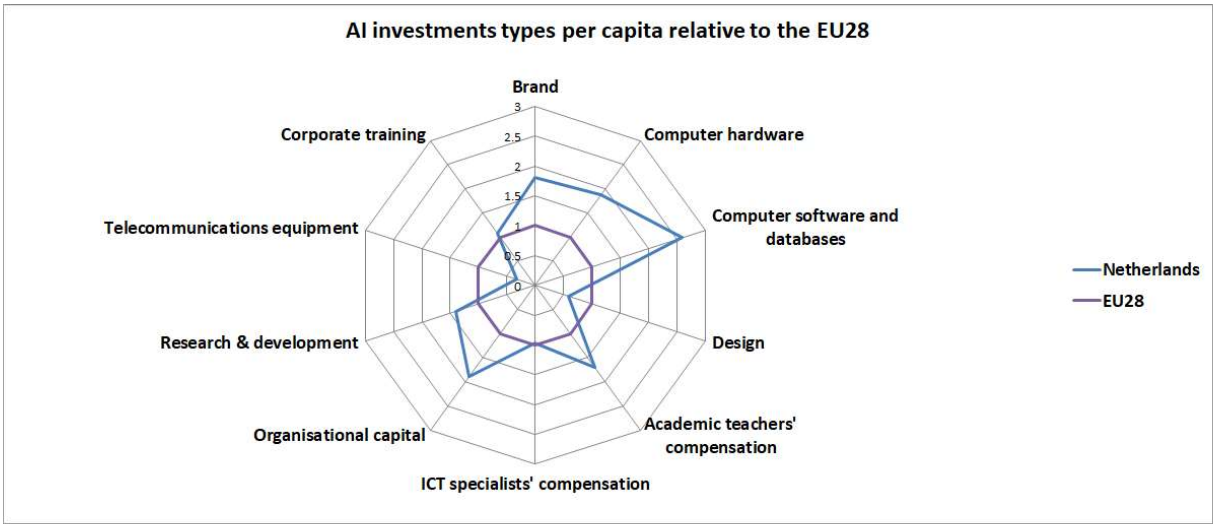
Source: JRC based on EUROSTAT, Spintan and Intan-Invest data.

Figure 64: EU AI investments by target and source in the Netherlands, 2018

Source	Talent, skills and life-long learning			From the lab to the market				Data, technology and infrastructure			Grand Total
	ICT specialists' compensation	Academic teachers' compensation	Corporate training	Research & development	Organisational capital	Brand	Design	Computer hardware	Computer software and databases	Telecommunications equipment	
Private	14.28%		0.68%	5.38%	2.62%	0.91%	0.36%	5.29%	25.60%	0.57%	55.68%
Public	11.02%	20.33%	0.10%	2.88%	0.27%	0.04%	0.01%	1.24%	7.99%	0.44%	44.32%
Grand Total	25.30%	20.33%	0.78%	8.26%	2.90%	0.95%	0.37%	6.53%	33.58%	1.00%	100.00%

Source: JRC based on EUROSTAT, Spintan and Intan-Invest data.

Figure 65: AI investments by type per capita in the Netherlands vs. EU28 average, 2018



Source: JRC based on EUROSTAT, Spintan and Intan-Invest data.

6.21 Poland

Table 29: AI investments highlights in 2018 for Poland

Poland	Total [MEUR]	Per capita [EUR]	% of target
min scenario	381.8	10.1	1.91%
max scenario	404.8	10.7	2.02%

Source: JRC based on EUROSTAT, Spintan and Intan-Invest data.

Figure 66: AI investments by target in Poland, 2018

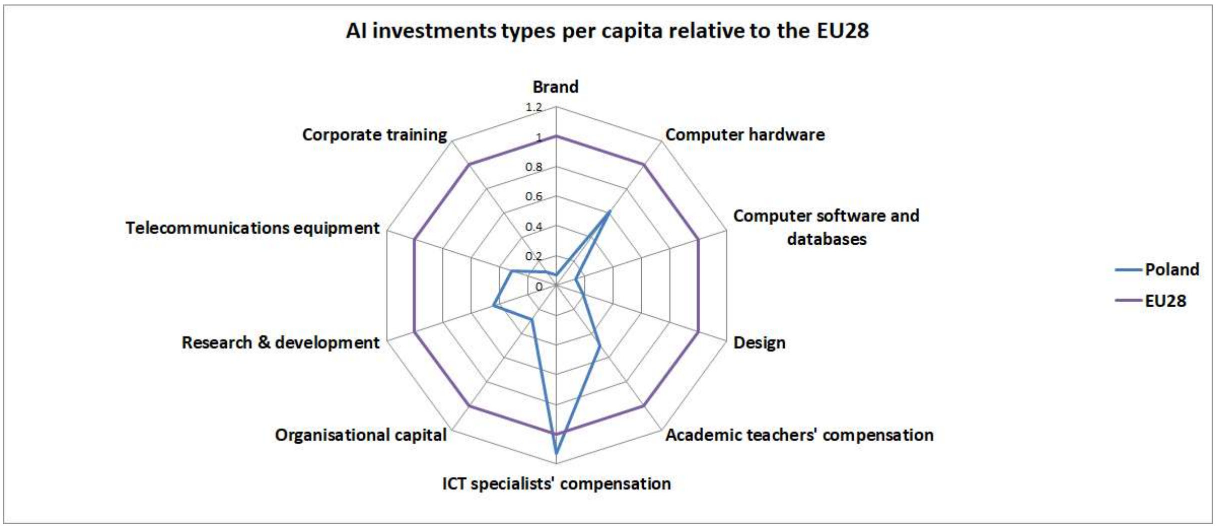
Source: JRC based on EUROSTAT, Spintan and Intan-Invest data.

Figure 67: EU AI investments by target and source in Poland, 2018

Source	Talent, skills and life-long learning			From the lab to the market				Data, technology and infrastructure			Grand Total
	ICT specialists' compensation	Academic teachers' compensation	Corporate training	Research & development	Organisational capital	Brand	Design	Computer hardware	Computer software and databases	Telecommunications equipment	
Private	33.71%		0.14%	4.31%	0.78%	0.07%	0.21%	3.97%	3.23%	1.83%	48.25%
Public	34.12%	13.60%	0.04%	1.66%	0.21%	0.02%	0.06%	0.89%	0.74%	0.41%	51.75%
Grand Total	67.83%	13.60%	0.18%	5.97%	0.99%	0.08%	0.27%	4.87%	3.98%	2.24%	100.00%

Source: JRC based on EUROSTAT, Spintan and Intan-Invest data.

Figure 68: AI investments by type per capita in Poland vs. EU28 average, 2018



Source: JRC based on EUROSTAT, Spintan and Intan-Invest data.

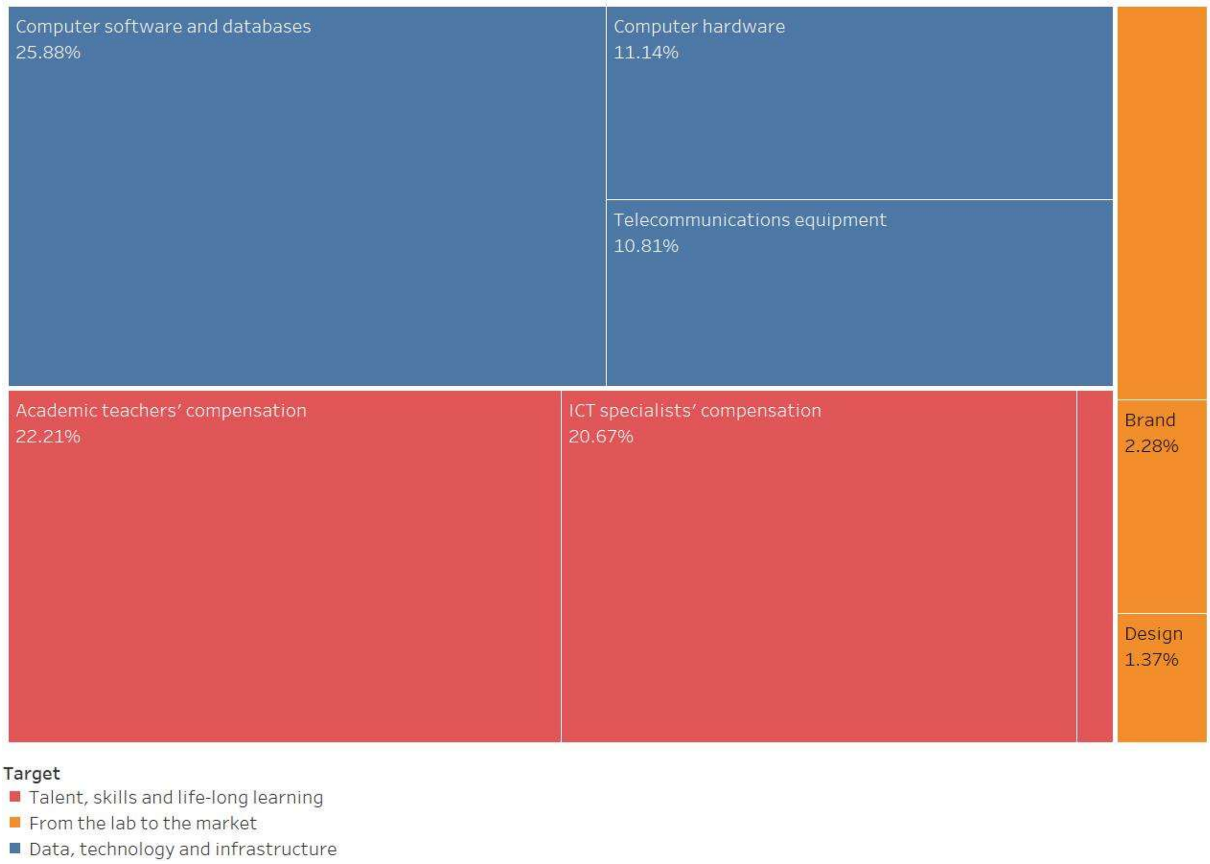
6.22 Portugal

Table 30: AI investments highlights in 2018 for Portugal

Portugal	Total [MEUR]	Per capita [EUR]	% of target
min scenario	56.1	5.5	0.28%
max scenario	54.5	5.3	0.27%

Source: JRC based on EUROSTAT, Spintan and Intan-Invest data.

Figure 69: AI investments by target in Portugal, 2018



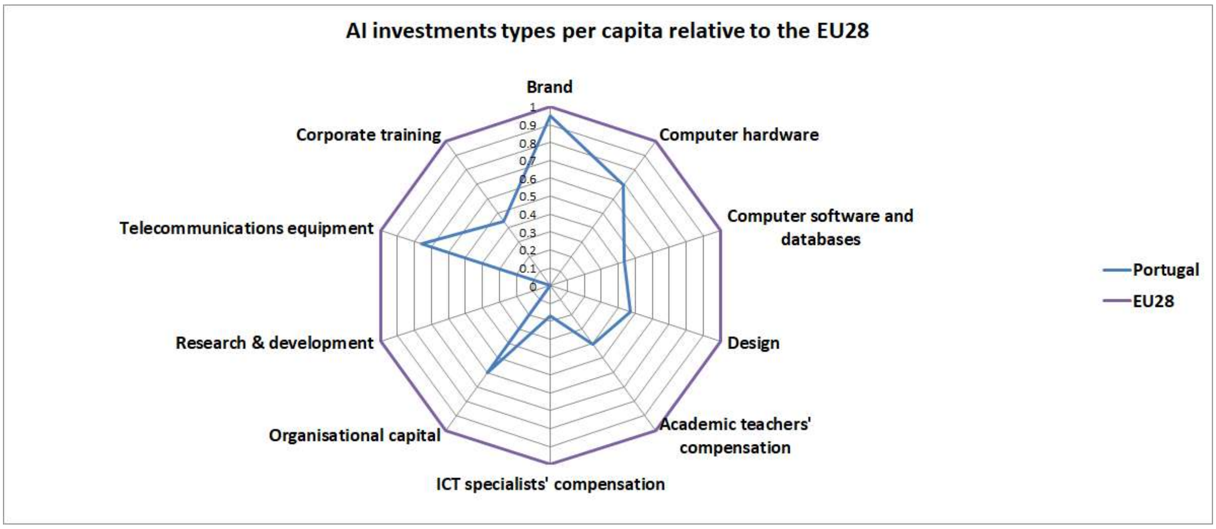
Source: JRC based on EUROSTAT, Spintan and Intan-Invest data.

Figure 70: EU AI investments by target and source in Portugal, 2018

Source	Talent, skills and life-long learning			From the lab to the market				Data, technology and infrastructure			Grand Total
	ICT specialists' compensation	Academic teachers' compensation	Corporate training	Research & development	Organisational capital	Brand	Design	Computer hardware	Computer software and databases	Telecommunications equipment	
Private	9.4%		1.3%	0.0%	3.8%	2.2%	1.3%	8.8%	20.7%	10.7%	58.1%
Public	11.3%	22.2%	0.2%	0.0%	0.4%	0.1%	0.1%	2.4%	5.2%	0.1%	41.9%
Grand Total	20.7%	22.2%	1.5%	0.0%	4.2%	2.3%	1.4%	11.1%	25.9%	10.8%	100.0%

Source: JRC based on EUROSTAT, Spintan and Intan-Invest data.

Figure 71: AI investments by type per capita in Portugal vs. EU28 average, 2018



Source: JRC based on EUROSTAT, Spintan and Intan-Invest data.

6.23 Romania

Table 31: AI investments highlights in 2018 for Romania

Romania	Total [MEUR]	Per capita [EUR]	% of target
min scenario	157.0	8.0	0.78%
max scenario	167.0	8.6	0.84%

Source: JRC based on EUROSTAT, Spintan and Intan-Invest data.

Figure 72: AI investments by target in Romania, 2018

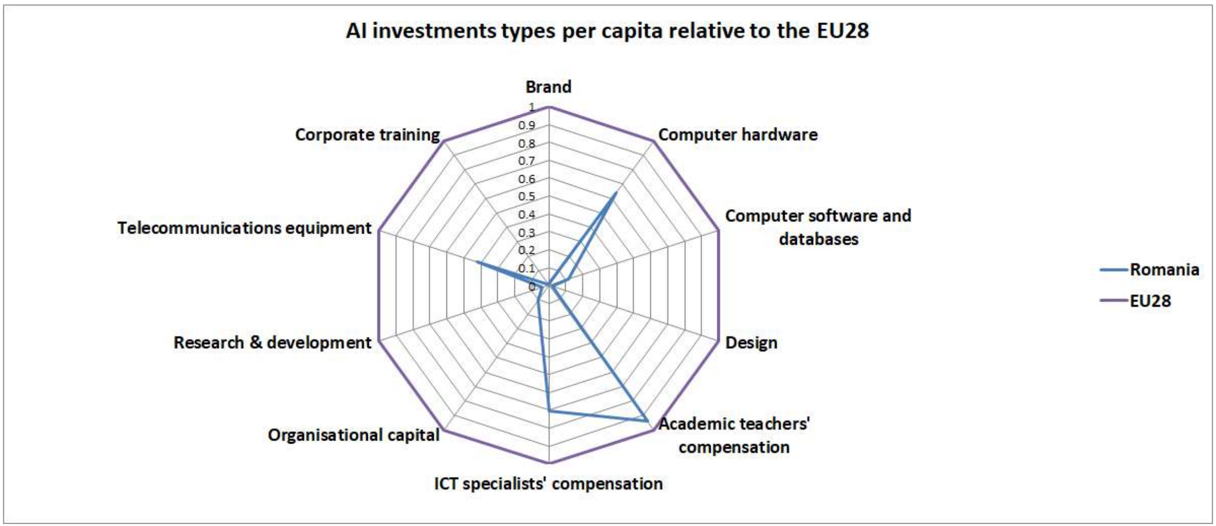
Source: JRC based on EUROSTAT, Spintan and Intan-Invest data.

Figure 73: EU AI investments by target and source in Romania, 2018

Source	Talent, skills and life-long learning			From the lab to the market				Data, technology and infrastructure			Grand Total
	ICT specialists' compensation	Academic teachers' compensation	Corporate training	Research & development	Organisational capital	Brand	Design	Computer hardware	Computer software and databases	Telecommunications equipment	
Private	29.02%		0.02%	0.24%	0.36%	0.01%	0.03%	5.07%	4.24%	1.77%	40.76%
Public	23.52%	31.90%	0.00%	0.40%	0.09%	0.00%	0.01%	1.29%	0.08%	1.94%	59.24%
Grand Total	52.54%	31.90%	0.02%	0.63%	0.45%	0.02%	0.04%	6.36%	4.33%	3.71%	100.00%

Source: JRC based on EUROSTAT, Spintan and Intan-Invest data.

Figure 74: AI investments by type per capita in Romania vs. EU28 average, 2018



Source: JRC based on EUROSTAT, Spintan and Intan-Invest data.

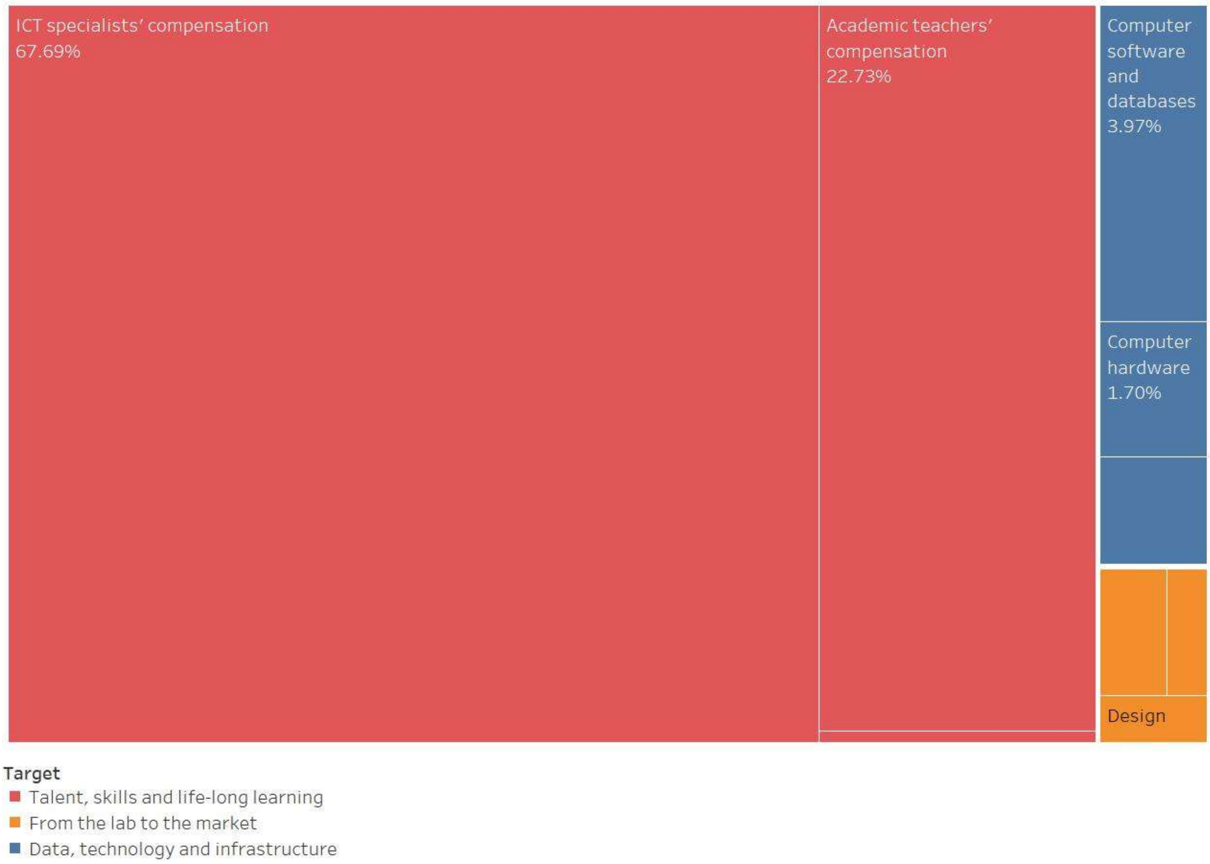
6.24 Slovakia

Table 32: AI investments highlights in 2018 for Slovakia

Slovakia	Total [MEUR]	Per capita [EUR]	% of target
min scenario	82.3	15.1	0.41%
max scenario	84.1	15.5	0.42%

Source: JRC based on EUROSTAT, Spintan and Intan-Invest data.

Figure 75: AI investments by target in Slovakia, 2018



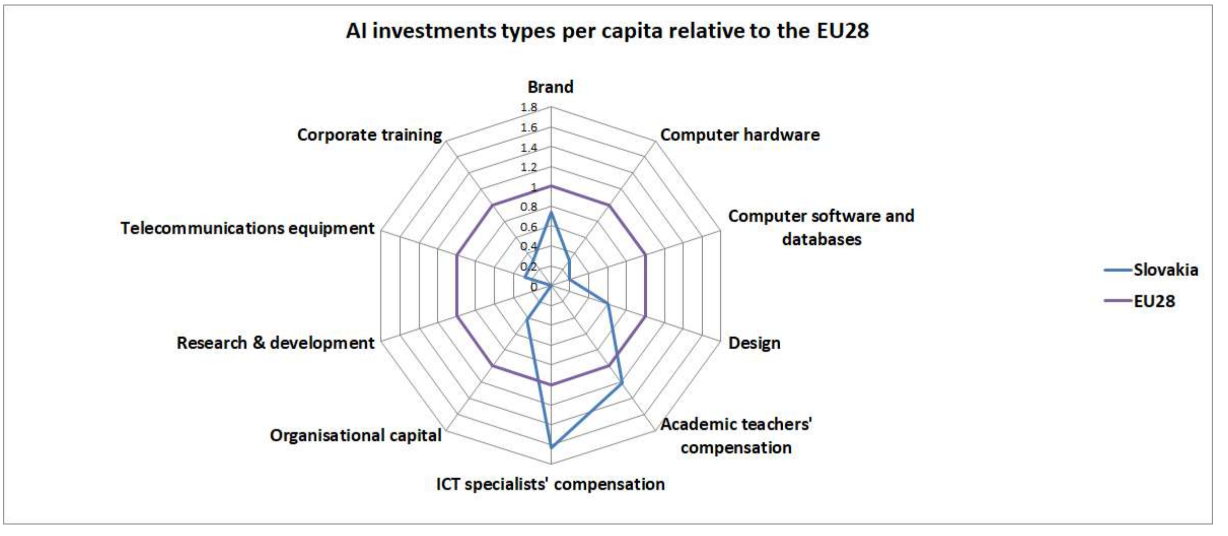
Source: JRC based on EUROSTAT, Spintan and Intan-Invest data.

Figure 76: EU AI investments by target and source in Slovakia, 2018

Source	Talent, skills and life-long learning			From the lab to the market				Data, technology and infrastructure			Grand Total
	ICT specialists' compensation	Academic teachers' compensation	Corporate training	Research & development	Organisational capital	Brand	Design	Computer hardware	Computer software and databases	Telecommunications equipment	
Private	31.5%		0.3%	0.0%	0.9%	0.6%	0.6%	1.5%	3.0%	1.2%	39.6%
Public	36.2%	22.7%	0.1%	0.0%	0.1%	0.0%	0.0%	0.2%	1.0%	0.1%	60.4%
Grand Total	67.7%	22.7%	0.3%	0.0%	1.0%	0.6%	0.6%	1.7%	4.0%	1.4%	100.0%

Source: JRC based on EUROSTAT, Spintan and Intan-Invest data.

Figure 77: AI investments by type per capita in Slovakia vs. EU28 average, 2018



Source: JRC based on EUROSTAT, Spintan and Intan-Invest data.

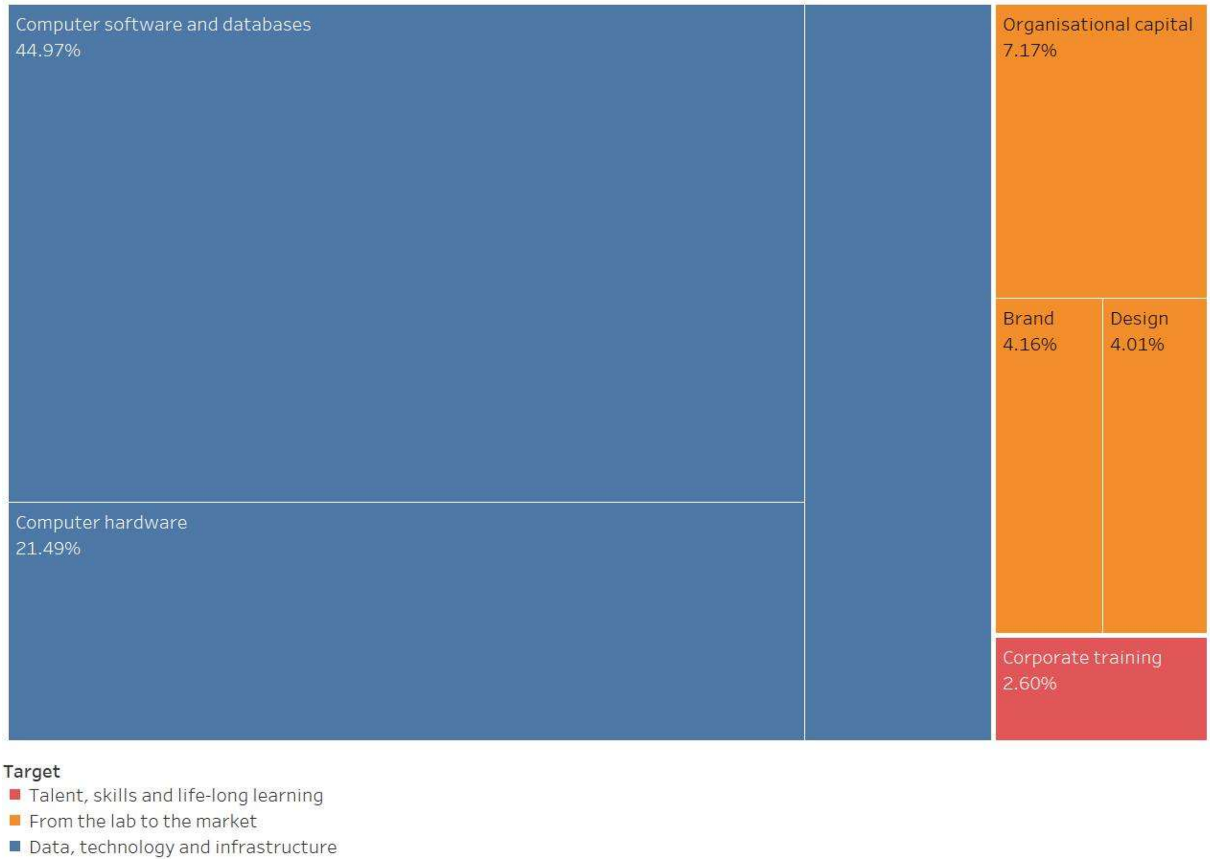
6.25 Slovenia

Table 33: AI investments highlights in 2018 for Slovenia

Slovenia	Total [MEUR]	Per capita [EUR]	% of target
min scenario	5.0	2.4	0.03%
max scenario	7.0	3.4	0.03%

Source: JRC based on EUROSTAT, Spintan and Intan-Invest data.

Figure 78: AI investments by target in Slovenia, 2018



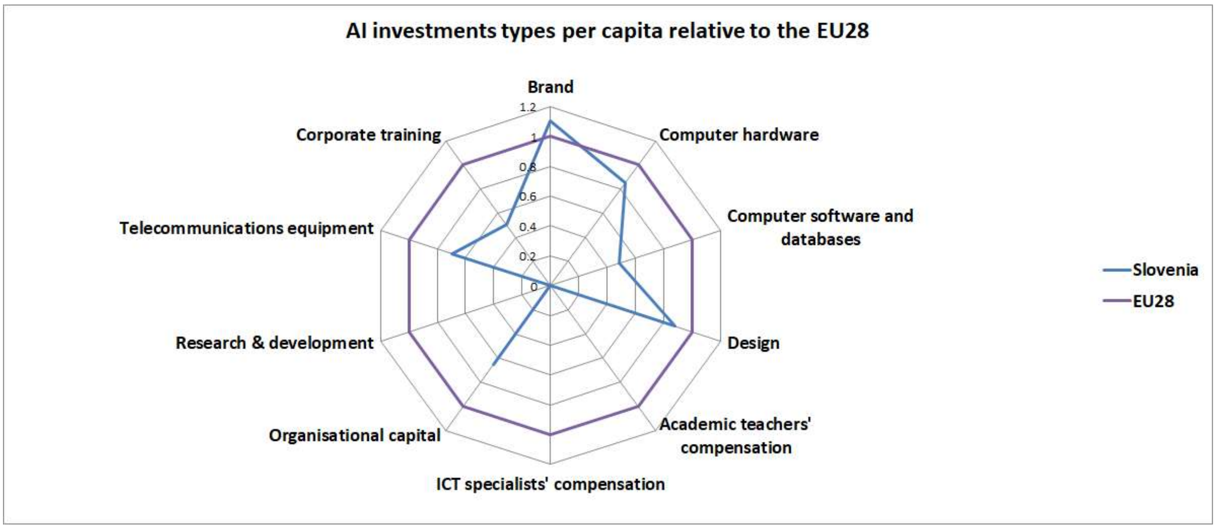
Source: JRC based on EUROSTAT, Spintan and Intan-Invest data.

Figure 79: EU AI investments by target and source in Slovenia, 2018

Source	Talent, skills and life-long learning			From the lab to the market				Data, technology and infrastructure			Grand Total
	ICT specialists' compensation	Academic teachers' compensation	Corporate training	Research & development	Organisation al capital	Brand	Design	Computer hardware	Computer software and databases	Telecommuni cations equip ment	
Private	0.0%		2.2%	0.0%	6.6%	4.1%	3.7%	17.1%	38.6%	14.4%	86.6%
Public	0.0%	0.0%	0.4%	0.0%	0.5%	0.1%	0.3%	4.4%	6.4%	1.2%	13.4%
Grand Total	0.0%	0.0%	2.6%	0.0%	7.2%	4.2%	4.0%	21.5%	45.0%	15.6%	100.0%

Source: JRC based on EUROSTAT, Spintan and Intan-Invest data.

Figure 80: AI investments by type per capita in Slovenia vs. EU28 average, 2018



Source: JRC based on EUROSTAT, Spintan and Intan-Invest data.

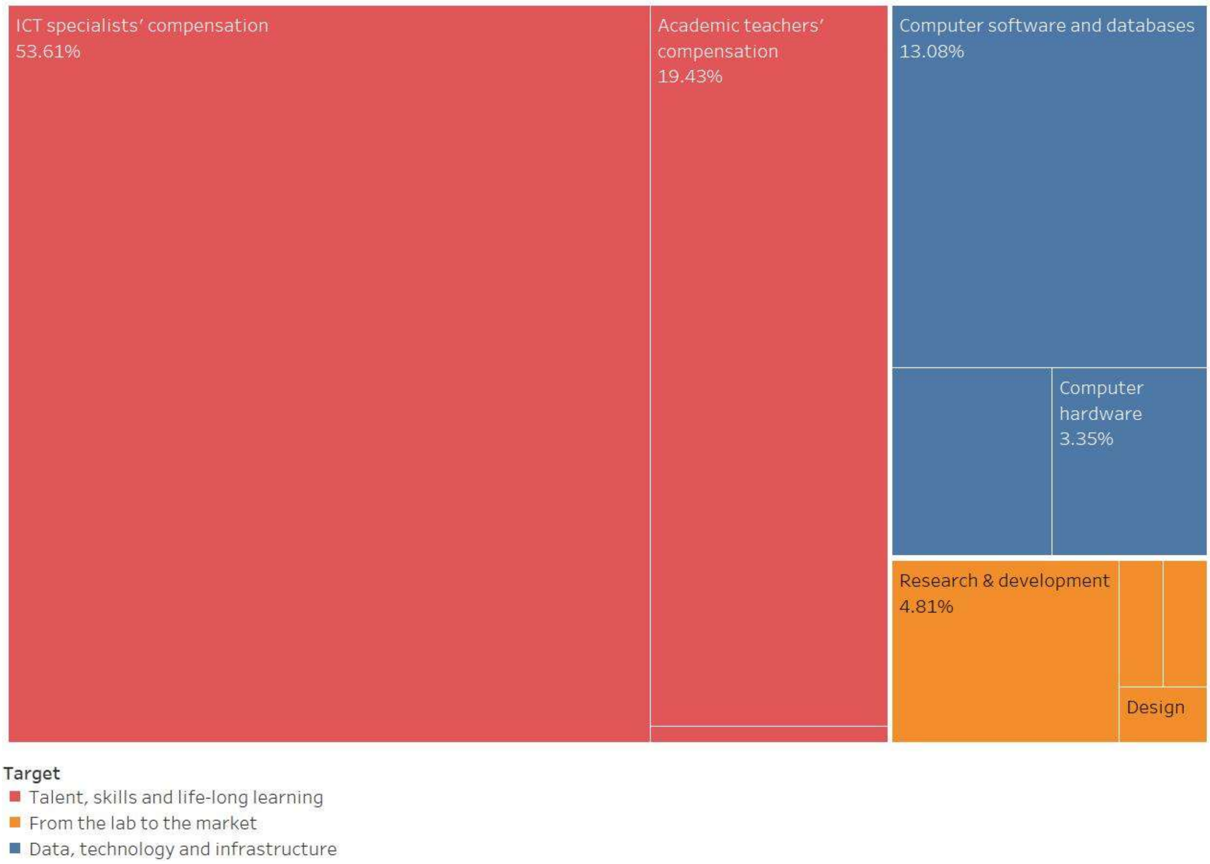
6.26 Spain

Table 34: AI investments highlights in 2018 for Spain

Spain	Total [MEUR]	Per capita [EUR]	% of target
min scenario	760.2	16.3	3.80%
max scenario	839.0	18.0	4.19%

Source: JRC based on EUROSTAT, Spintan and Intan-Invest data.

Figure 81: AI investments by target in Spain, 2018



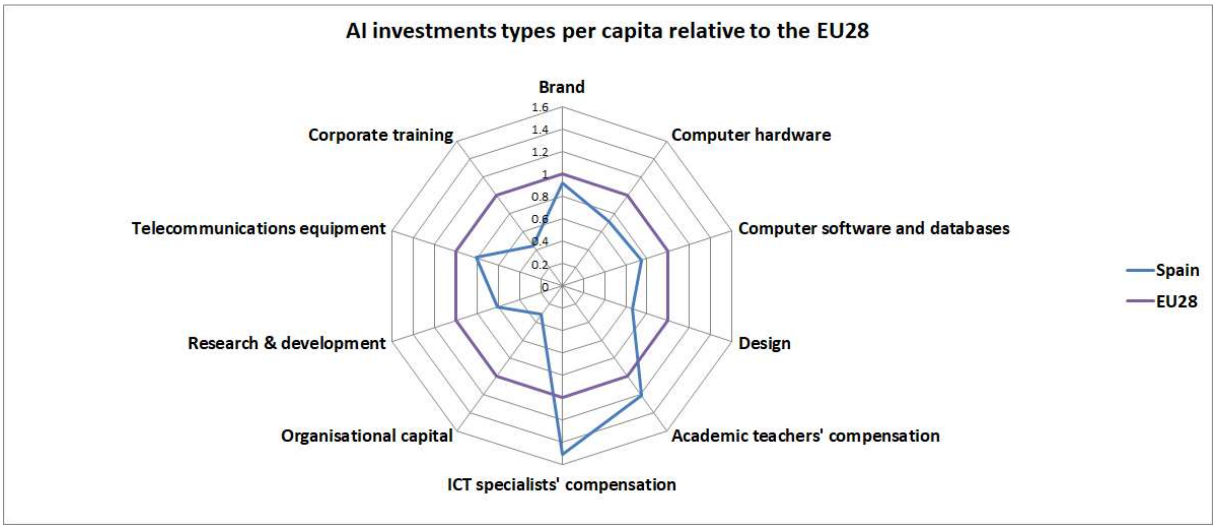
Source: JRC based on EUROSTAT, Spintan and Intan-Invest data.

Figure 82: EU AI investments by target and source in Spain, 2018

Source	Talent, skills and life-long learning			From the lab to the market				Data, technology and infrastructure			Grand Total
	ICT specialists' compensation	Academic teachers' compensation	Corporate training	Research & development	Organisation al capital	Brand	Design	Computer hardware	Computer software and databases	Telecommuni cations equip ment	
Private	23.10%		0.40%	3.58%	0.59%	0.63%	0.52%	2.16%	12.29%	3.34%	46.61%
Public	30.52%	19.43%	0.02%	1.23%	0.05%	0.02%	0.05%	1.18%	0.79%	0.09%	53.39%
Grand Total	53.61%	19.43%	0.42%	4.81%	0.65%	0.65%	0.57%	3.35%	13.08%	3.43%	100.00%

Source: JRC based on EUROSTAT, Spintan and Intan-Invest data.

Figure 83: AI investments by type per capita in Spain vs. EU28 average, 2018



Source: JRC based on EUROSTAT, Spintan and Intan-Invest data.

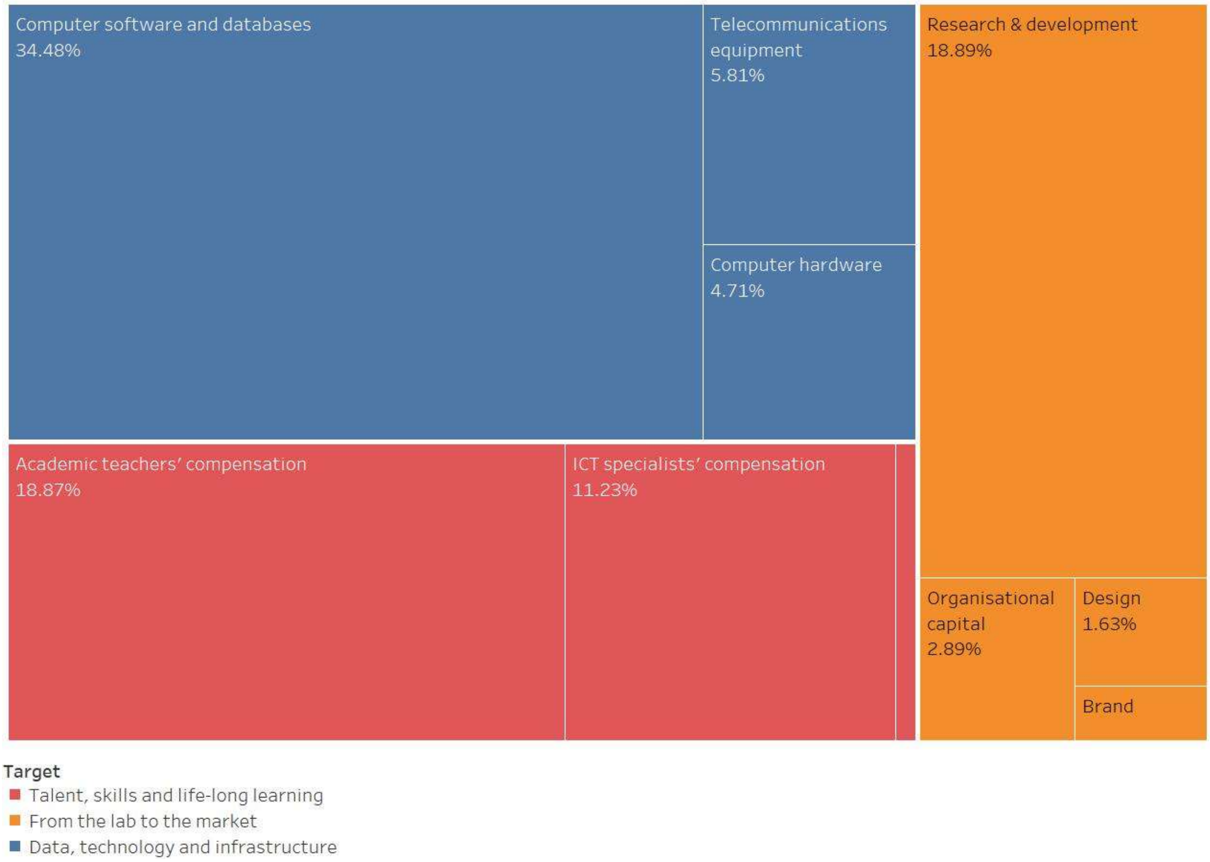
6.27 Sweden

Table 35: AI investments highlights in 2018 for Sweden

Sweden	Total [MEUR]	Per capita [EUR]	% of target
min scenario	207.9	20.5	1.04%
max scenario	279.6	27.6	1.40%

Source: JRC based on EUROSTAT, Spintan and Intan-Invest data.

Figure 84: AI investments by target in Sweden, 2018



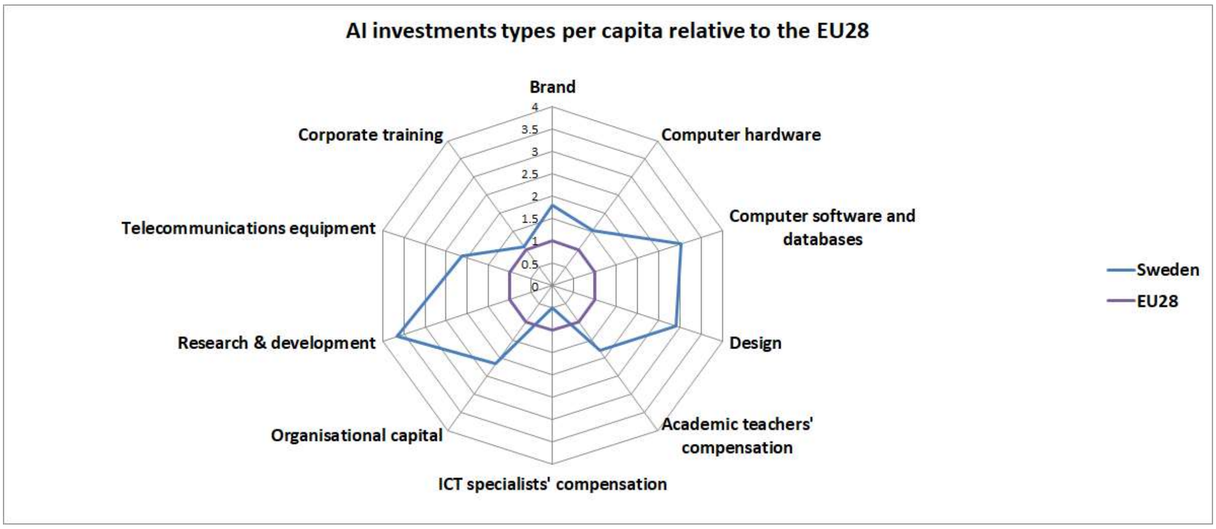
Source: JRC based on EUROSTAT, Spintan and Intan-Invest data.

Figure 85: EU AI investments by target and source in Sweden, 2018

Source	Talent, skills and life-long learning			From the lab to the market				Data, technology and infrastructure			Grand Total
	ICT specialists' compensation	Academic teachers' compensation	Corporate training	Research & development	Organisational capital	Brand	Design	Computer hardware	Computer software and databases	Telecommunications equipment	
Private	5.22%		0.54%	18.22%	2.57%	0.77%	1.50%	4.30%	30.54%	5.48%	69.15%
Public	6.01%	18.87%	0.14%	0.66%	0.32%	0.06%	0.12%	0.40%	3.93%	0.33%	30.85%
Grand Total	11.23%	18.87%	0.67%	18.89%	2.89%	0.83%	1.63%	4.71%	34.48%	5.81%	100.00%

Source: JRC based on EUROSTAT, Spintan and Intan-Invest data.

Figure 86: AI investments by type per capita in Sweden vs. EU28 average, 2018



Source: JRC based on EUROSTAT, Spintan and Intan-Invest data.

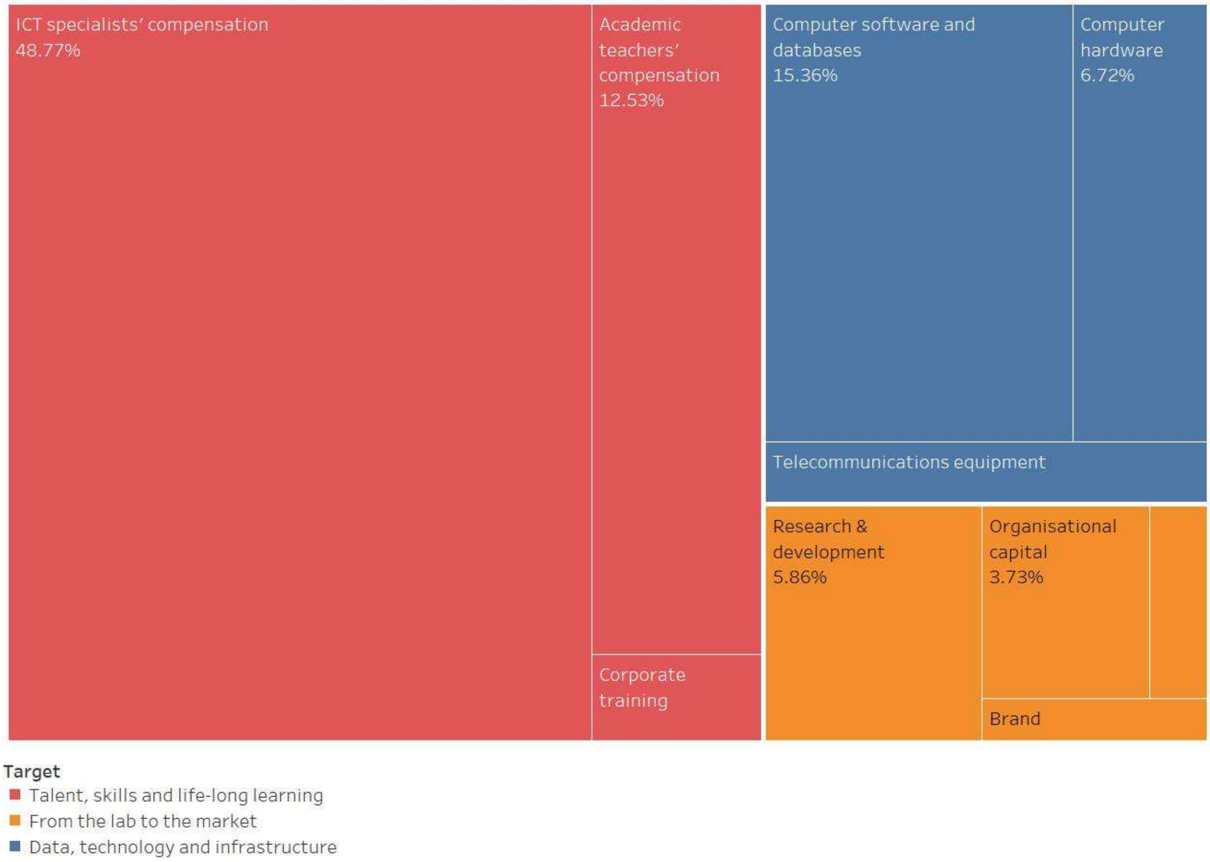
6.28 The United Kingdom

Table 36: AI investments highlights in 2018 for the United Kingdom

United Kingdom	Total [MEUR]	Per capita [EUR]	% of target
min scenario	995.4	15.0	4.98%
max scenario	1132.3	17.1	5.66%

Source: JRC based on EUROSTAT, Spintan and Intan-Invest data.

Figure 87: AI investments by target in the United Kingdom, 2018



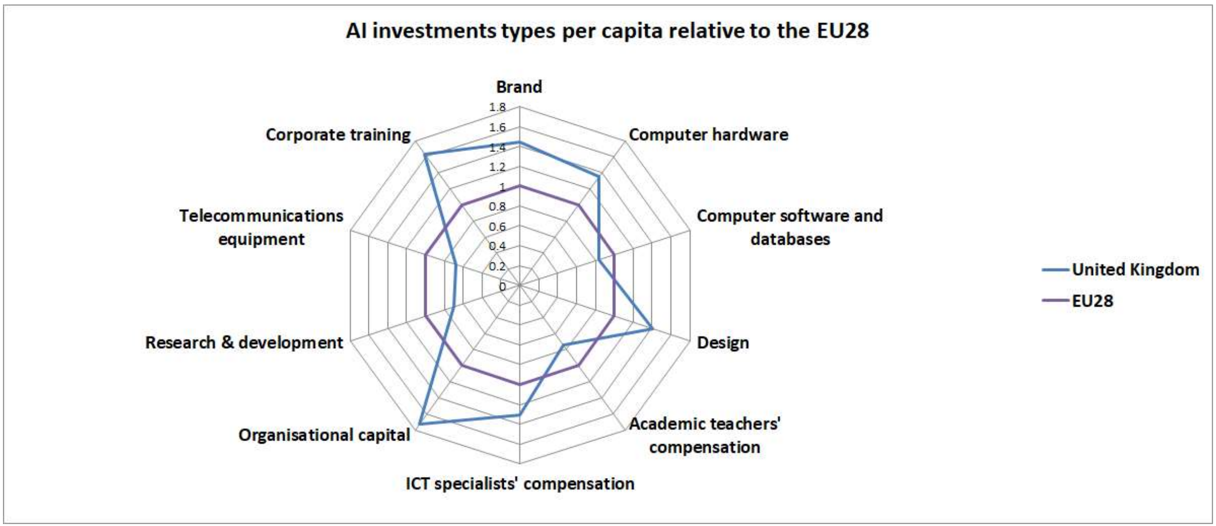
Source: JRC based on EUROSTAT, Spintan and Intan-Invest data.

Figure 88: EU AI investments by target and source in the United Kingdom, 2018

Source	Talent, skills and life-long learning			From the lab to the market				Data, technology and infrastructure			Grand Total
	ICT specialists' compensation	Academic teachers' compensation	Corporate training	Research & development	Organisational capital	Brand	Design	Computer hardware	Computer software and databases	Telecommunications equipment	
Private	26.41%		0.74%	3.78%	3.45%	1.01%	1.16%	5.30%	13.73%	2.85%	58.42%
Public	22.37%	12.53%	0.92%	2.08%	0.28%	0.07%	0.11%	1.43%	1.63%	0.16%	41.58%
Grand Total	48.77%	12.53%	1.66%	5.86%	3.73%	1.08%	1.27%	6.72%	15.36%	3.01%	100.00%

Source: JRC based on EUROSTAT, Spintan and Intan-Invest data.

Figure 89: AI investments by type per capita in the United Kingdom vs. EU28 average, 2018



Source: JRC based on EUROSTAT, Spintan and Intan-Invest data.

7 Concluding remarks

The current report addresses the issue of the unavailability of data on investments in AI. Taking the lack of consensus about what AI is and what is the level of investment in AI as a point of departure, it presents an original methodology to estimate AI investments. Then, it documents the process of compiling data on a set of expenditures and AI-intensity coefficients that are used to proxy the level of AI investments in three investment targets relevant for the creation and implementation of AI: *Talent, skills and life-long learning*, *From the lab to the market* and *Data, technology and infrastructure*.

Considering that neither official data on AI investments nor established methodology to estimate them exist, the current approach relies on a number of proxy measures and regularity assumptions about the correspondence between supply and demand of AI-related skills and technologies. For example, with respect to proxy measures, the estimation considerably relies on patent-based intensities of R&D activities or the structure of ICT goods purchase patterns. Similarly, shares of AI university programmes are used in estimating the number of AI ICT specialists. All these choices have significant results for the final estimation results.

In spite of the limitations of the study, it can be considered as a first attempt to estimate economy-wide investments in creating and implementing AI, one of the most transformative GPT of our times. By highlighting the role of different stages, actors and capabilities involved in the AI uptake, it attempts to enlarge the perspective on the efforts necessary to roll out AI in an economy.

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Annexe

Annex 1. Data on the Member States level.

Table 37: Expenditures in the Member States on target "Talent, skills and life-long learning", 2018 [MEUR]

Country	ICT specialists' compensation	Academic teachers' compensation	Corporate training
Austria	10,764.7	3,509.0	3,780.0
Belgium	16,387.9	2,799.2	4,935.1
Bulgaria	1,210.5	306.9	2,206.1
Croatia	1,096.2	195.4	307.6
Cyprus	515.0	111.8	44.4
Czechia	4,365.8	530.4	1,255.7
Denmark	5,422.1	2,817.5	3,201.3
Estonia	809.6	156.2	158.5
Finland	9,431.3	1,186.6	2,646.0
France	67,795.1	12,553.3	28,755.5
Germany	66,862.6	14,356.5	39,103.9
Greece	2,368.1	583.8	373.0
Hungary	3,224.8	396.3	854.3
Ireland	7,653.1	1,156.3	3,282.7
Italy	19,579.0	5,071.6	13,375.8
Latvia	268.7	114.1	123.0
Lithuania	818.5	132.6	242.2
Luxembourg	1,196.0	101.4	434.3
Malta	259.5	53.2	38.9
Netherlands	22,133.2	4,893.6	5,724.4
Poland	13,318.5	2,261.9	1,306.1
Portugal	3,965.7	923.1	1,405.4
Romania	3,383.9	791.6	65.2
Slovakia	1,579.6	216.8	513.8
Slovenia	1,167.3	178.0	321.2
Spain	30,877.4	6,642.2	6,287.8
Sweden	14,786.6	2,870.4	3,339.8
United Kingdom	83,640.5	14,535.8	33,333.5
Grand Total	**394,881.3**	**79,445.4**	**157,415.5**

Source: JRC based on EUROSTAT, Spintan and Intan-Invest data.

Table 38: Expenditures in the Member States on target "From the lab to the market", 2018 [MEUR]

Country	Organisational capital	Brand	Design	Research and development
Austria	7,062.1	4,463.2	2,872.2	10,753.4
Belgium	16,189.7	3,957.6	3,902.6	12,322.1
Bulgaria	795.0	39.2	118.4	406.6
Croatia	848.9	492.2	474.6	702.8
Cyprus	190.1	54.5	107.0	163.0
Czechia	3,502.7	2,464.0	2,636.2	3,225.3
Denmark	5,572.7	2,140.1	3,483.9	8,951.0
Estonia	437.4	253.6	244.5	341.0
Finland	4,913.1	2,377.4	2,909.6	6,050.0
France	79,470.2	13,846.3	23,139.8	54,299.0
Germany	42,825.0	16,978.5	28,285.7	91,466.9
Greece	2,979.6	617.3	530.3	1,508.2
Hungary	3,424.6	625.4	801.4	1,922.5
Ireland	4,958.8	3,515.7	997.4	26,942.3
Italy	25,409.1	15,919.1	19,059.9	24,723.9
Latvia	339.5	196.9	189.8	203.8
Lithuania	668.3	387.5	373.6	217.3
Luxembourg	884.3	555.8	458.8	414.0
Malta	166.5	47.8	93.7	36.5
Netherlands	21,365.1	7,039.8	2,743.9	11,687.6
Poland	7,079.3	609.1	1,909.8	3,940.9
Portugal	4,040.8	2,198.5	1,323.3	2,656.3
Romania	1,328.7	51.9	118.8	1,006.2
Slovakia	1,509.7	900.6	893.2	708.6
Slovenia	886.3	513.9	495.5	885.5
Spain	9,622.3	9,708.9	8,475.1	17,939.2
Sweden	14,303.4	4,102.6	8,050.3	15,280.8
United Kingdom	74,783.2	21,618.7	25,480.7	39,389.1
Grand Total	**335,556.7**	**115,676.0**	**140,170.2**	**338,143.9**

Source: JRC based on EUROSTAT, Spintan and Intan-Invest data.

Table 39: Expenditures in the Member States on target "Data, technology and infrastructure", 2018 [MEUR]

Country	Computer hardware	Computer software and databases	Telecommunications equipment
Austria	1,444.4	8,512.3	3,451.9
Belgium	4,075.0	7,126.3	2,170.3
Bulgaria	52.5	452.1	54.2
Croatia	267.6	508.1	267.0
Cyprus	60.7	212.0	34.9
Czechia	2,415.4	4,787.5	826.7
Denmark	2,746.6	5,800.1	458.2
Estonia	144.9	296.0	276.9
Finland	770.0	2,920.0	483.0
France	5,680.5	76,564.3	5,927.3
Germany	12,329.9	29,012.8	20,887.3
Greece	460.5	1,116.8	1,171.8
Hungary	614.8	1,505.1	370.1
Ireland	2,098.6	907.0	705.5
Italy	5,613.7	25,248.0	6,886.7
Latvia	203.6	115.3	219.9
Lithuania	257.2	815.9	306.7
Luxembourg	443.7	493.5	181.2
Malta	54.5	319.4	17.0
Netherlands	4,318.2	22,194.9	663.8
Poland	3,124.7	2,553.4	1,439.5
Portugal	964.1	2,239.2	935.7
Romania	1,684.5	1,146.5	982.9
Slovakia	226.4	529.7	180.7
Slovenia	237.9	497.8	172.6
Spain	4,452.7	17,400.8	4,562.0
Sweden	2,086.9	15,288.1	2,577.7
United Kingdom	12,072.8	27,587.1	5,408.6
Grand Total	**68,902.3**	**256,150.0**	**61,620.2**

Source: JRC based on EUROSTAT, Spintan and Intan-Invest data.

Table 40: Compensation of ICT specialists with tertiary education, 2018

Country	Number of ICT specialists with tertiary education [thousands]	Annual labour cost per worker – private sector [EUR]	Annual labour cost per worker – public sector [EUR]	Total compensation of ICT specialists - private sector [BEUR]	Total compensation of ICT specialists - public sector [BEUR]
EU28	5,597.6	75,094.5	67,095.1	207.8	187.0
Austria	119.9	95,990.2	85,092.9	5.0	5.8
Belgium	171.4	104,393.7	88,355.1	8.1	8.3
Bulgaria	65.9	18,164.1	18,561.4	0.6	0.6
Croatia	34.9	32,491.7	30,562.4	0.5	0.6
Cyprus	9.1	62,528.8	51,638.8	0.3	0.3
Czechia	117.2	37,931.5	36,481.8	2.4	2.0
Denmark	70.3	79,278.4	75,703.1	2.2	3.2
Estonia	23.3	35,388.0	34,082.7	0.4	0.4
Finland	116.0	83,892.2	77,547.4	5.8	3.7
France	853.1	85,970.4	72,588.1	37.7	30.1
Germany	814.2	83,368.5	80,632.8	36.9	29.9
Greece	47.7	55,145.2	45,407.4	1.1	1.2
Hungary	106.6	29,793.3	30,670.5	1.5	1.7
Ireland	81.0	101,493.6	87,405.5	4.1	3.5
Italy	213.3	104,461.4	81,008.9	10.2	9.3
Latvia	9.4	29,555.5	27,956.3	0.1	0.2
Lithuania	30.7	27,669.0	25,685.6	0.4	0.4
Luxembourg	11.3	109,104.7	98,705.6	0.8	0.4
Malta	6.6	44,512.0	35,287.8	0.1	0.1
Netherlands	302.6	78,800.6	66,918.1	12.5	9.6
Poland	353.7	38,898.6	36,501.8	6.6	6.7
Portugal	60.8	65,348.2	65,124.3	1.8	2.2
Romania	132.2	25,167.3	26,148.1	1.9	1.5
Slovakia	52.8	31,799.2	28,453.9	0.7	0.8
Slovenia	23.7	49,982.1	48,603.9	0.6	0.6
Spain	510.4	63,655.0	58,307.2	13.3	17.6
Sweden	204.3	77,264.6	68,608.3	6.9	7.9
United Kingdom	1,055.2	83,851.5	74,457.2	45.3	38.4

Source: JRC based on EUROSTAT data.

Table 41: AI intensity coefficients on the Member States level in the max scenario.

	% 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
Austria	0.001	0.006	0.007	0.000	0.009
Belgium	0.001	0.006	0.002	0.001	0.006
Bulgaria	0.001	0.006	0.000	0.000	0.000
Croatia	0.001	0.006	0.000	0.000	0.000
Cyprus	0.001	0.006	0.008	0.006	0.014
Czechia	0.001	0.006	0.006	0.000	0.012
Denmark	0.001	0.006	0.014	0.001	0.035
Estonia	0.001	0.006	0.005	0.000	0.049
Finland	0.001	0.006	0.012	0.002	0.036
France	0.001	0.006	0.007	0.002	0.024
Germany	0.001	0.006	0.008	0.003	0.018
Greece	0.001	0.006	0.000	0.001	0.000
Hungary	0.001	0.006	0.006	0.010	0.015
Ireland	0.001	0.006	0.007	0.003	0.007
Italy	0.001	0.006	0.014	0.001	0.022
Latvia	0.001	0.006	0.040	0.000	0.049
Lithuania	0.001	0.006	0.007	0.004	0.024
Luxembourg	0.001	0.006	0.000	0.000	0.000
Malta	0.001	0.006	0.000	0.000	0.000
Netherlands	0.001	0.006	0.005	0.003	0.017
Poland	0.001	0.006	0.021	0.006	0.024
Portugal	0.001	0.006	0.003	0.000	0.013
Romania	0.001	0.006	0.026	0.001	0.067
Slovakia	0.001	0.006	0.036	0.000	0.088
Slovenia	0.001	0.006	0.000	0.000	0.000
Spain	0.001	0.006	0.015	0.002	0.025
Sweden	0.001	0.006	0.002	0.003	0.018
United Kingdom	0.001	0.006	0.007	0.002	0.010

Source: JRC based on EUROSTAT, Spintan and Intan-Invest data.

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