Skills for SMEs

Supporting specialised skills development: Big Data, Internet of Things and Cybersecurity for SMEs

Final report

Written by Capgemini Invent, European DIGITAL SME Alliance, Technopolis Group
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ABSTRACT

This study report concludes an initiative by the European Commission and EASME to supporting specialised skills development related to Big Data, Internet of Things (IoT) and Cybersecurity for small and medium-sized enterprises (SMEs) in Europe. The report includes an analysis of the potential benefits and barriers for technology adoption by SMEs and presents a vision, roadmap and toolbox to increase the capacity of industry, social partners, education and training organisations and policy makers at all levels to promote and support the acquisition of these skills by SMEs in Europe. It is built on broad stakeholder and expert consultation via workshops, surveys, interviews and a high-level conference. It includes references to good practices and lessons learned derived from them to identify elements relevant to scaling up.

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EXECUTIVE SUMMARY

Rationale for an SME-centred skills development strategy

The digital revolution is not only about large tech companies but also essentially about start-ups and SMEs that provide or use digital solutions. **SMEs are vital to the European economy**, making up 99% of Europe's businesses[1] and accounting for two-thirds of total employment. The variety is huge, from innovative and fast-growing companies that provide or use digital solutions, to those that face significant challenges such as acquiring the necessary skills to benefit from digital technologies.

Whereas improving basic digital skills is already a challenge, the emergence of technologies such as big data, IoT and cybersecurity is creating significant new specialised skills gaps, shortages and mismatches, especially for SMEs, who cannot afford to compete with large enterprises to attract and retain the scarce digital talents. There are **serious skills shortages at every level in the hierarchy of SMEs**: from e-Leadership skills to ICT-professionals to users' digital skills. This is an issue, as European SMEs run the risk of missing out on the huge market potential. German association Bitkom estimates economic damage for German companies to be around 10-billion-euro of revenues as a result of shortage of IT specialists[2]. Strategies such as up- or re-skilling via offering training to employees in SMEs is far from common practice. Less than 10% of SMEs provide training to ICT specialists and less than one in five SMEs offers training to other employees. Currently, more than 90% of European SMEs consider themselves lagging behind in digital innovation.[3]

The Commission has identified IoT, big data and cybersecurity as areas where European SMEs would benefit from an increase in the skills level. Both IoT and big data hold enormous potential to maximise customer intelligence, optimise internal processes, renew business models and develop innovative services and solutions. In times where SMEs are increasingly targeted by cyber-attacks, cybersecurity is essential to ensure business continuity and protect the value chain that SMEs are part of.

A strategy that enables technology adoption and skills development

Ambitious skills policies and well-targeted supporting measures are thus needed to facilitate the access of SMEs to Europe's digital talent pool. After thorough stakeholder consultation, **this initiative brought forward a strategy** for supporting SMEs with skills development to adopt new technologies such as cybersecurity, big data and internet of things (IoT).

Designing solutions to solve this skills gap at all levels requires an understanding of both why and how an organisation adopts technology as business opportunity, and the required human capital to deliver on that investment. A study for the European Commission[4] showed that digital transformation is enabled by strong IT competences and professionalism at the individual and team level, and digital organisational capabilities at enterprise level. It is about investing in building a capability at the organisational level, and consequently finding

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1 European Commission (2018), Entrepreneurship and small and medium-sized enterprises (SMEs). Available at: https://ec.europa.eu/growth/smes_nl

2 https://nos.nl/nieuwsuur/artikel/2315072-duitsland-past-immigratiewet-aan-om-honderdduizenden-vacatures-te-kunnen-vullen.html

3 European Commission (2018), Capitalising on the benefits of the Fourth Industrial Revolution. Available at: https://publications.europa.eu/en/publication-detail/-/publication/cf1793da-184c-11e8-ac73-01aa75ed71a1/language-en/format-PDF/source-66408543

4 Digital organisational frameworks and IT Professionalism, by Capgemini Invent with empirica and IDC, for EC/EASME. Published here: https://op.europa.eu/en/publication-detail/-/publication/58563e8f-3e30-11e9-8d04-01aa75ed71a1/language-en.

the right people to build competences necessary for that capability. Employees fulfil roles associated with those competences, using methods and tools to add specific value. The developed **digital capability reference framework** could help SMEs to better understand—when deciding to invest in certain capabilities—what they need in terms of competences development and provides an overview of the relevant frameworks (and related certification) for selection.

SMEs using technologies tend to perceive cybersecurity as 'some operational IT function' rather than as a core part of their digital strategy. Other SMEs find it difficult to grasp the potential that big data and IoT offer to their business. For these SMEs, awareness of business opportunities and the translation of this awareness into a clear business case could be a start to their digital transformation journey. This journey could subsequently lead them to accurately plan and implement digitalisation measures as well as facilitating a proper understanding of what concrete skills are needed to deliver on that promise. Digital SMEs might be more advanced and already have a clear understanding of which skills they require and how these skills contribute to the functioning of their business model. They still compete with large enterprises on a tight job market, which hinders growth. SMEs need a strategy on developing those digital skills in their organisation.

Joint leadership to strengthen Europe's digital sovereignty

To keep Europe competitive on a global stage, and to create a strong and vital SME landscape, there is a clear need for leadership to guide European SMEs in their progressive acquisition of strategic digital skills. This endeavour will strengthen Europe's digital sovereignty and stimulate triple-helix collaboration to achieve better tailoring of education and training.

Such leadership should enable an increased adoption of cybersecurity, big data, and IoT by European SMEs via supporting measures that strengthen ecosystems and structurally enhance the supply of necessary skills and facilitate organisational development. We envision a "**European Skills for SMEs Partnership**" consisting of private and public stakeholders to provide the necessary strategic leadership. The aim of the **European Skills for SMEs Partnership** is to focus on measures, which can be put into **action at EU level**, while taking into account the wider digital strategy of the EU. This way, the partnership could go beyond the focus on IoT, Big Data and Cybersecurity skills that was present in this initiative.

An evidence-based roadmap to deliver the ambition

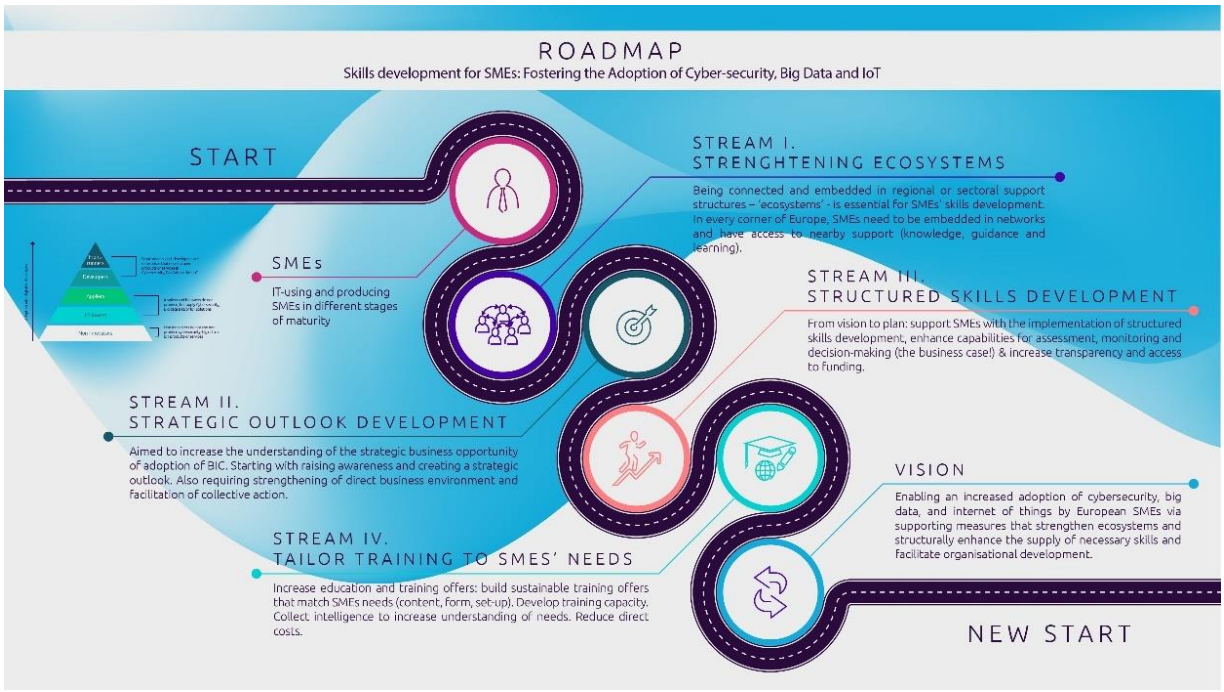
The vision is operationalised in a roadmap[5] with supporting measures targeting both the European as well as national, regional and local levels. This plan builds on good practices identified across Europe (see an overview of these in chapter 5) and rests on **three evidence-based principles**:

- **Industry-led**: effective workforce development requires a good understanding of the needs of those it addresses: the small- and medium-sized enterprises. Via collaboration and participation, intelligence can be gathered on the actual needs of the companies to feed into and accelerate policy and education initiatives. A closer connection to enterprises and their owners will contribute to increased awareness since information and skills on new technologies can also travel along the supply chains and via B2B relationships.

[5] The project developed four streams to support the vision of enhancing SME skills in IoT, Big Data and Cybersecurity: (I) Strengthening ecosystems, (II) Strategic outlook development, (III) Structured skills development, (IV) Tailoring training to SMEs' needs. The measures are derived at different levels of governance and actors: SMEs/business owners, ecosystems (including education providers, chambers etc.) vs. regional & local governments as well as national and EU level. Skills4SMEs Partnerships extracts those measures and actions developed as part of the project, which can be applied on the European level.

- **Tailored and innovative education and training**: offerings need to be tailored to make them useful for SMEs. This requires innovation of current approaches: modular, blended courses, targeted at SMEs in their specific sector and geography, delivered with flexible timing, with practical content to enable direct action of the SME. Since technology adoption is a strategic choice, training should be tuned towards the ICT professional in an SME as well as the leadership/management. Co-creation is another element of this principle.
- **Government (co-)funded and data-driven**: upskilling and reskilling of the workforce requires a strong commitment of the public sector to invest in new initiatives and to ensure the continuity of existing successful initiatives. Good practices have shown that SMEs need to contribute on the operational level (e.g. when taking courses, via cost-sharing models), but the overall strategy will require substantial public investment. A proper monitoring of how the money spent yields results, combined with research to monitor trends in industry needs, should allow to efficiently and effectively invest and feed into education and training offerings.

Figure 1 Visualisation of the roadmap's main streams of action



The need to look beyond IoT, Big Data and Cybersecurity

SMEs encounter skills gaps at every layer of their organisation and are increasingly under pressure as they compete with large companies on a tense job market short of digital talent.

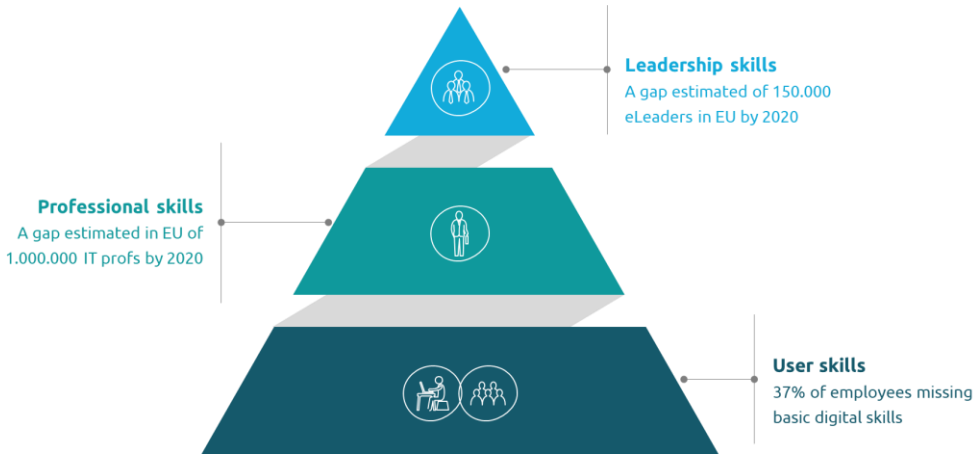
In line with the overall rationale to enhance 'digital sovereignty'[6], i.e. to reach a certain level of autonomy in ICT related technologies which would allow the EU to independently pursue its own interests, there is a need to enhance the uptake of skills that allow SMEs to autonomously handle technology. Consequently, this would require the development of specialist skills in the identified areas (cybersecurity, IoT and big data) and beyond (e.g. AI, quantum computing, blockchain, critical chip technologies). To develop this capacity in a sustainable manner, it is necessary to strengthen monitoring and foresight (see Pillar II

[6] Von der Leyen does not speak about 'digital sovereignty', but used the term "**mastery and ownership of key technologies in Europe"** in a speech at the European Parliament (27 November 2019),

Available at: https://ec.europa.eu/commission/presscorner/detail/en/SPEECH_19_6408

of the Partnership), and to build EU skills leadership in areas that are considered vital to the economy.

Figure 2 Skills gaps related to roles in a SME[7]



It seems reasonable to build on areas where Europe already has a competitive advantage and which would, at the same time, advance the goal of greater "digital autonomy/sovereignty", e.g. in Open Source software development or distributed ledger technologies/blockchain. Education and training schemes developed to that end need to be of high quality (meet conditions for a quality label, see Pillar I) and make sure that they do not only help SMEs gain skills in using certain ICT tools, but enhance their digital autonomy by increasing ICT specialist skills.[8] The aim is to not just train a wide range of SME employees, but to digitise the economy via a highly skilled workforce in SMEs.

A European Skills for SMEs strategy to focus on growth

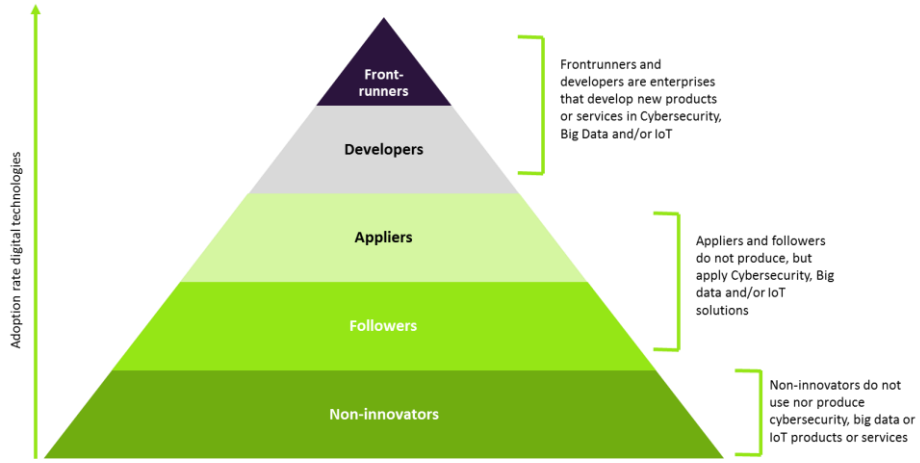
At the same time, policymakers need to be aware that measures need to be tailored to the different types of SMEs, which can be roughly categorised according to maturity and size. Maturity (as displayed in figure below): frontrunners and developers, appliers and followers, non-innovators (in terms of maturity). Regarding size it is important to distinct between micro SMEs (up to 10 employees), small enterprises (up to 50 employees), and medium-sized companies (50-250 employees)[9]. While it will be pivotal for nearly all businesses to digitise in the short to medium term (at least to a certain degree), an EU-driven strategy needs to focus on those aforementioned SMEs, where it will be most beneficial, effective, and have the greatest impact on driving competitiveness and growth. It should also contribute to the development of EU technological/digital sovereignty. Therefore, the European Skills for SMEs Partnership should focus on those SMEs in all sectors, not only the ICT sector, that have a propensity to grow, to digitise and internationalise their business to make use of the EU internal market. The main targets are thus "**followers & appliers**" and "**frontrunner & developer**" SMEs.

[7] The EU lacks around 1 million ICT specialists and this figure could grow to 2 million by 2030. Source: DG CONNECT, VICTORY (Vacancies for ICT- Online Repository: Data Collection)

[8] In general, digital skills encompass a range of basic to highly advanced skills that enable the use of digital technologies (digital knowledge) on the one hand, and basic cognitive, emotional or social skills necessary for the use of digital technologies on the other hand. In its background report on skills for a digital world, the Organisation for Economic Cooperation and Development (OECD) distinguishes four types of ICT-related skills necessary at the workplace. See: http://www.europarl.europa.eu/RegData/etudes/IDAN/2017/595889/EPRS_IDA(2017)595889_EN.pdf

[9] See: https://ec.europa.eu/growth/smes/business-friendly-environment/sme-definition_en

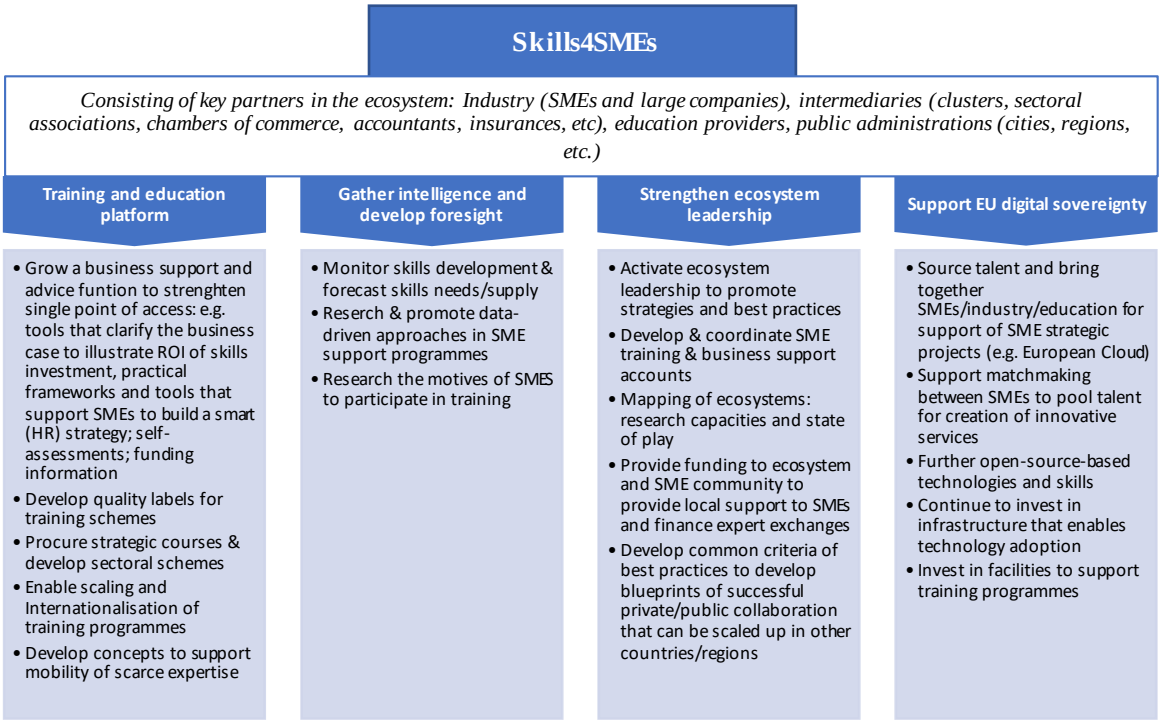
Figure 3 Segmentation of SMEs based on maturity in the uptake of big data, IoT and cybersecurity



The European Skills for SMEs (Skills4SMEs) Partnership

This proposal sets out the different recommended actions of the Skills4SMEs Partnership by grouping them into four pillars. The actions build on the principles set out above, i.e. the Partnership needs to be industry-led, data-driven and provide a knowledge-sharing platform on how to develop tailored, innovative education and training to SMEs.

Figure 4 Skills4SMEs Partnership



We propose to develop a **European Skills4SMEs Partnership** that is dedicated to building a stronger alliance between the public and the private sector to offer leadership and a vision for skills development for SMEs in Europe. The Partnership should be accompanied with dedicated investments that enable a **long-term, strategic approach** and reduce uncertainties by allowing for long-term commitments.

The platform should drive and coordinate the following pivotal measures aimed at achieving the projected vision in the period up to 2030:

1. **Training & education platform.** This platform will be the **single access point to information** about SME skills development at EU level. It targets the intermediaries

that are engaged to support SMEs directly. The platform will provide and promote quality labels on selected training schemes and give SMEs and individuals throughout Europe access to those courses. The platform also needs to develop a proactive business support function where **intermediaries** can find tools, practical frameworks, assessments, funding schemes etc. that they can bring to their local SME communities—and which will also be promoted across Europe by a dissemination campaign. It will support the scaling and internationalisation of selected courses by providing translations and promoting them on a European level.

- Enable scaling up of successful training programmes, from basic translation to providing methods or blueprints for developing successful training programmes
- Grow a business support and advice function on the platform: e.g. offer tools that clarify the business case to illustrate ROI of skills investment, publish (links to) practical frameworks and tools that support SMEs to build a smart (HR) strategy; offer self-assessments for SMEs in specific technology domains; provide information on funding for trainings. It should be accessible for and promoted/pushed towards intermediaries
- Develop quality labels of European training schemes based on quality criteria and standards (e.g. e-CF) and mapping according to strategic skills priorities from Pillar II "Intelligence" to increase transparency and trust as well as overall quality
- Develop concepts and practical examples to support the mobility of scarce expertise (within education & training systems and between industry and education & training systems)
- Procure strategic courses and/or develop sectoral schemes that can benefit SMEs across Europe; ideally courses or schemes tailored to the needs of a specific sector (building on the Blueprint projects) or technology

2. **Intelligence & monitoring**. This task of the partnership aims to gather insights that establish a coherent, clear picture of the needs of SMEs and the supply of training and skills on the market. It should apply the methodology to forecast future developments around supply and demand of skills for SMEs. It should also take stock and research data-driven approaches at the national level to increase insights into demand/supply at aggregated level.
    - Monitor SMEs' skills development and develop foresight on skills needs and supply
    - Promote data-driven approaches in SME support programmes
    - Research the motives of SMEs to participate in training
3. **Ecosystem[10] leadership**. Measures consisting of strengthening and facilitating the ecosystem and aimed at involving all relevant stakeholders in the partnership. This would include developing a joint approach with triple helix actors (policy, education, and industry associations) but also with accountants and insurance providers. It would require building strong partnerships at the European and national level. Develop SME training & business support accounts in collaboration with national administrations and the ecosystem, considering the national contexts.

[10] The ecosystem (consisting of clusters, associations or chambers and the supply chain and business environment of SMEs) needs to be aware of skills needs – they are the intermediaries that can raise awareness among SMEs or develop collective action to bridge a skills gap, e.g. by offering VET training in collaboration with SMEs or by establishing stronger partnerships with universities or research communities, or by designing training programmes according to SMEs' needs. At the same time, they need to work towards developing the capacity for strategic outlook in SMEs. SMEs need to be aware of their skills needs and develop strategies to fulfil them. These insights and actual training schemes need to be developed at the local level – the EU level will only be responsible for sharing best practices and developing "blueprints" based on successful cases.

- Activate ecosystem leadership to promote strategies and best practices to raise awareness of SMEs for technology adoption, e.g. via their B2B environment and supply chains
- Research the potential of SME training & business support schemes that would allow SMEs to invest in training
- Mapping of ecosystems: research capacities and state of play, and connect to parallel initiatives at EU level to create synergies
- Provide funding to ecosystem and SME community to provide local support to SMEs and finance expert exchanges
- Develop common criteria of best practices to develop blueprints of successful private/public collaboration that can be scaled up in other countries/regions

4. **Support EU Digital Sovereignty.** Build on ICT industry frontrunners to strengthen SME skills and develop leadership in strategic areas by bringing together larger companies, SMEs, and research and education. Based on the strategic priorities at Pillar II ("Intelligence"), stimulate the collaboration of innovative SMEs with industry and academia to engage in consortia for innovation projects. Build on the strong open source community to further skills in developing an ecosystem of non-proprietary software and related skills.
   - Source talent and bring together SMEs/industry/education to support strategic projects (e.g. European Cloud, blockchain, AI, open source software)
   - Support matchmaking between SMEs to pool talent for the creation of innovative services[11]
   - Promote open source-based technologies and skills
   - Continue to invest in infrastructure that enables technology adoption
   - Invest in facilities to support training programmes

Required investments at national and EU level

The actions at EU level refer to initiating and intensifying collaboration, knowledge sharing, and providing tools at EU level that support the creation of a common European language and will require funding to initiate this development. The countries, and various stakeholders in those countries, can benefit from the actions deployed here. However, they will have to deploy their own national and/or regional skills strategies, and especially start to plan for investing in skills development schemes that are pivotal to support SMEs in their digital transformation. This requires a long-term and dedicated investment.

An essential element in advancing skills development in SMEs is the **scaling of existing good practices in learning programmes**. A recent study[12] for the European Commission analysed the funding models of education and training programmes targeting the workforce at national and EU level to understand how successful initiatives can be scaled up to increase impact. Practices that have proven their value and address a strong stakeholder demand need – deserve! – scaling to increase impact. The study comes forward with recommendations in five areas: vision & long-term strategy, scalable multi-stage funding intervention, massive investments & new ways of funding, means to guide future policy development, and high-tech skills hubs to connect key actors.

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[11] See ICT Competence Center initiative in Berlin

[12] High-tech skills for Europe – Scaling-up best practices and re-focusing funding programmes and incentives, for the EC/EASME, available via http://skills4industry.eu .

Investments needed in skills strategies are indeed massive but essential to advance. To give an order of magnitude of what is needed: according to Eurostat, only 32% of European SMEs had a formally defined ICT security policy in place. This means approximately 17 million SMEs did not and will have to acquire these skills by investing in training courses to develop that knowledge in-house or hire it externally. In similar fashion, statistics reveal that only 12% of SMEs were using some type of big data source, compared to 33% of large enterprises. Closing that gap would require to reach at least five million SMEs. From good practices, it becomes apparent that co-funding or cost-sharing models are most effective. Good practices across Europe reveal current levels of investments – at different government levels:

- **Skillnet Ireland** runs a budget of €35.9 million for 2020, with the total investment in upskilling by Skillnet Ireland likely to exceed €60 million when employers' contributions are added.[13] Skillnet Ireland works in partnership with 50 industry bodies and enterprise clusters, providing training and innovation support to over 16.000 businesses, and they upskill 56.000 workers throughout the country every year.
- The **German Federal Ministry for Economic Affairs and Energy**[14] (BMWi) launched a funding programme called 'Go-Digital' of €7.2 million (in 2 phases) which enables nearly 700 projects. The subsidy voucher system that activates skills development in SMEs via external consultants has been successful and revealed an appetite for further expansion of this scheme.
- The **JADS SME Data-lab**[15] is an excellent local example from Den Bosch (NL), which helps SMEs to create value with data. Over 100 SMEs entered the lab to come out with a proof-of-concept or tailor-made solution that helped them reduce costs or increase revenues. There is a standard fee of €2500 and half of the money goes to the data science students that JADS staffs on these projects.

However, more dedicated funding schemes for skills development in SMEs are needed across Europe to increase technology adoption and close current skills shortages in SMEs. Part of this could come from EU funding, but most of this amount will be an investment by national, regional and local entities aiming to boost competitiveness of SMEs and drive their economies forward.

Further investments would be needed at EU level to secure the development of the proposed Skills4SMEs platform and partnership, including the proposed measures to develop quality labels, concepts for scaling good practice of learning programmes and funding models, to monitor SMEs' skills development and develop foresight on skills needs and supply, to activate ecosystem leadership, and to support matchmaking between SMEs to pool talent for creation of innovative services.

The 'blueprint for sectoral cooperation on skills'[16] is one of the key initiatives of the skills agenda for Europe, investing €28 million of funding in 2018[17] and launching new sectors yearly. Recently, a new chapter was launched that addresses the cybersecurity, software and blockchain sector, among others.

Another initiative to start in 2020 is the European Digital Academy. The overall objective of the European Digital Academy is to contribute to the development, reskilling and upskilling of European citizens and SMEs on some of the key emerging technologies (AI,

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13 https://www.skillnetireland.ie/welcomes-increase-in-funding-budget-2020/

14 https://www.bmwi.de/Redaktion/DE/Pressemitteilungen/2019/20190429-mit-einem-klick-zur-passenden-digitalisierungs-beratung-startschuss-go-digital.html

15 https://jadsmkbdatalab.nl/about-us/

16 https://ec.europa.eu/social/main.jsp?catId=1415&langId=en

17 https://eacea.ec.europa.eu/erasmus-plus/actions/key-action-2-cooperation-for-innovation-and-exchange-good-practices/sector-skills-alliances_en

Blockchain, robotics, cybersecurity, IoT). It will be done by developing a new platform closely connected to the European Portal for Digital Skills and Jobs. The platform will map the online learning opportunities from different providers in an easy-to-access manner. In addition, modern and highly engaging online training modules will be developed based on the needs identified by the project.

Further investments would be needed at the national level (including regions and cities) to invest in skills development for all relevant digital areas (not only cybersecurity), to push for change in education and training systems to become more adaptive to new demands, and to mobilise expertise with relevant intermediaries in regions and cities to increase engagement of SMEs in digital transformation and corresponding skilling activities.

PART I: THE STATE OF PLAY

1. INTRODUCTION

This final report has been prepared for the European Commission as part of the service contract EASME/COSME/2017/007 on Supporting Specialised Skills Development: Big Data, Internet of Things and Cybersecurity for small and medium-sized enterprises (SMEs).

1.1. Rationale

Businesses all over the world are going through a new wave of disruptive technological change. This digital revolution is powered by digital technologies characterised by very fast innovation, high-growth rates and substantial market potential. This digital revolution is not only about large tech companies but essentially about start-ups and SMEs that provide or use digital solutions. SMEs are vital to the European economy, making up 99% of Europe's businesses[18]. The variety is huge, from innovative and fast-growing companies that provide or use digital solutions, to those that face significant challenges such as acquiring the necessary skills to benefit from digital technologies.

To fully leverage the potential of the digital revolution to the advantage of European businesses and citizens and to address the challenges that come with it, the European Commission adopted the Digital Single Market Strategy[19] and a Communication on "Digitising European Industry: Reaping the full benefits of a Digital Single Market"[20]. The latter Communication introduces a set of coherent policy measures and aims to establish a framework for coordination between national and EU-level initiatives and relevant policy actions including investments in digital innovations and infrastructure, accelerating the development of ICT standards, exploring regulatory conditions and adaptation of the workforce, including up-skilling the (future) workforce.

This is important, as unlocking the potential that comes with the digital revolution is not always straightforward. The potential benefits of realising the DSM for the EU economy are estimated at almost 415 billion EUR per year, creating hundreds of thousands of new jobs[21]. At the same time, several factors hinder European enterprises to unlock this potential. An important factor here is skills, as the need for new multidisciplinary and digital skills is exploding[22]. 90% of all jobs[23] are expected to require some kind of digital competence in the near future, and at the same time 37%[24] of the EU labour force has an insufficient level of digital skills. This is an issue, as Europe underperforms on its

[18] European Commission (2018), Entrepreneurship and Small and medium-sized enterprises (SMEs). Available at: https://ec.europa.eu/growth/smes_nl

[19] European Commission (n.d.), Digital Single Market: Bringing down barriers to unlock online opportunities. Available at: https://ec.europa.eu/commission/priorities/digital-single-market_en

[20] European Commission (2016), Communication: Digitising European Industry - Reaping the full benefits of a Digital Single Market. Published April. Available at: https://ec.europa.eu/digital-single-market/en/news/communication-digitising-european-industry-reaping-full-benefits-digital-single-market

[21] European Commission (n.d.), Digital Single Market: Bringing down barriers to unlock online opportunities. Available at: https://ec.europa.eu/commission/priorities/digital-single-market_en

[22] European Commission (2016), Communication: Digitising European Industry - Reaping the full benefits of a Digital Single Market. Published April. Available at: https://ec.europa.eu/digital-single-market/en/news/communication-digitising-european-industry-reaping-full-benefits-digital-single-market

[23] European Commission (2017). New report shows digital skills are required in all types of jobs. Published May. Available at: https://ec.europa.eu/digital-single-market/en/news/new-report-shows-digital-skills-are-required-all-types-jobs

[24] European Commission (2017), Human capital: digital inclusion and skills. Available at: http://ec.europa.eu/newsroom/document.cfm?doc_id=44390

digital potential relative to the United States. The European digital frontier, represented by the ICT sector and its digitisation of assets, uses, and labour, is only 60% as digitised as the US frontier[25].

The European Commission, EU Member States and stakeholders have been active in addressing the digital skills gap for several years. For instance, already in 2007, a Communication was adopted on "e-Skills for the 21st Century: Fostering Competitiveness, Growth and Jobs[26]. The latest major EU action to address the skills gap is focussing the Skills Agenda for Europe, adopted by the European Commission in 2016. The agenda recognises the need for EU citizens to receive opportunities to develop transversal skills. Skills acquisition and development are recognised as essential to increase the performance of national and international labour markets. The agenda in particular demonstrates a need for a unified approach in combating the widening skills gap. While it is true that national labour markets as well as education and training systems are tackling country-specific issues, at the same time the EU Member States face similar problems. Precisely these similarities should act as a unifying factor when producing and promoting common means to answer the growing demand for a highly skilled workforce. Several measures support the implementation of the Agenda, including a Blueprint for Sectoral Cooperation on Skills[27] and the Digital Skills and Jobs Coalition[28].

Whereas improving basic digital skills is already a challenge, the emergence of technologies such as big data, IoT and cybersecurity is creating significant new specialised skills gaps, shortages and mismatches, especially for SMEs, who cannot afford to compete with large enterprises to attract and retain the scarce digital talents. This is an issue, as European SMEs run the risk to miss the huge market potential. Currently, already more than 90% of European SMEs consider themselves lagging behind in digital innovation[29].

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[25] Bughin, J., Hazan, E., Labaye, E., Manyika, J., Dahlström, P., Ramaswamy, S., & Cochin de Billy, C. (2016), Digital Europe: Realising the continent's potential. Published June. Available at: https://www.mckinsey.com/business-functions/digital-mckinsey/our-insights/digital-europe-realizing-the-continents-potential

[26] Joinup (2007), EU: e-skills for the 21st century: fostering competitiveness, growth and jobs. Published November. Available at: https://joinup.ec.europa.eu/document/eu-e-skills-21st-century-fostering-competitiveness-growth-and-jobs

[27] European Commission (2017), Blueprint for sectoral cooperation on skills: Responding to skills mismatches at sectoral level. Available at: http://ec.europa.eu/social/BlobServlet?docId=16962&langId=en

[28] European Commission (2014), The Digital Skills and Jobs Coalition. Published October. Available at: https://ec.europa.eu/digital-single-market/en/digital-skills-jobs-coalition

[29] European Commission (2018), Capitalising on the benefits of the 4th Industrial Revolution. Available at: https://publications.europa.eu/en/publication-detail/-/publication/cf1793da-184c-11e8-ac73-01aa75ed71a1/language-en/format-PDF/source-66408543

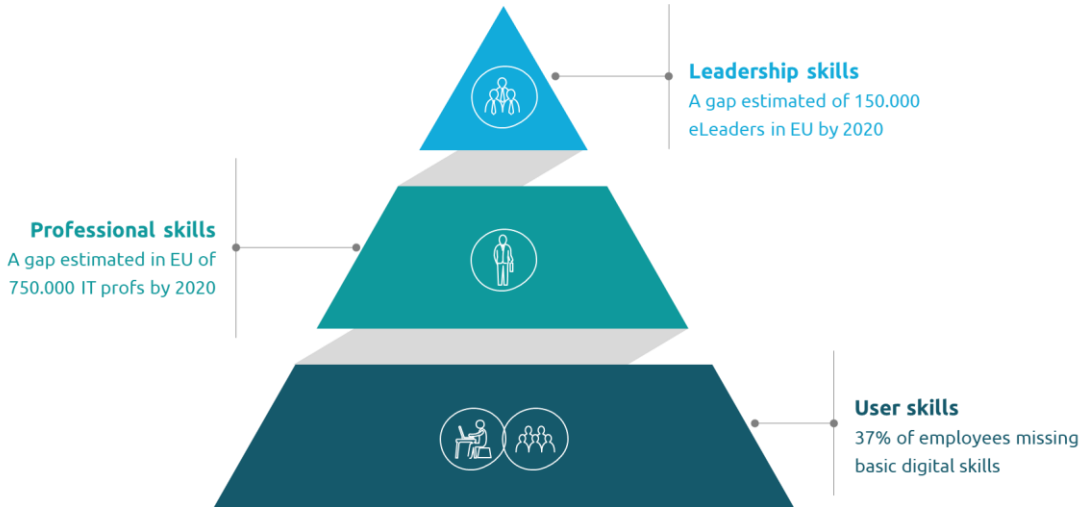

Figure 5 Skills gaps across roles in an enterprise

Ambitious skills policies and well-targeted supporting measures are thus needed to facilitate the access of SMEs to Europe's digital talent pool. The present initiative researches, identifies, designs, tests and validates such specific measures for supporting specialised skills development related to big data, Internet of Things (IoT) and cybersecurity – hereafter referred to as BIC technologies - for SMEs in Europe.

This report is part of a service contract EASME/COSME 2017/007, which is based on the Regulation (EU) No 1287/2013 of the European Parliament and of the Council of 11 December 2013 establishing a Programme for the Competitiveness of the Enterprises and small and medium-sized enterprises (hereafter "COSME") (2014-2020) and repealing Decision No. 1639/2006/EC. More particularly, it is based on the Commission Implementing Decision concerning the adoption of the Work Programme for 2016 and the financing for the implementation of Programme for the Competitiveness of Enterprises and Small and Medium-sized Enterprises (C (2016) 63 final of 18/1/2016) and its Annex. It is foreseen under item "GRO/SME/16/C/12 - New skills for the digital transformation of enterprises, manufacturing and key enabling technologies" of the COSME 2016 Work Programme.

1.2. Objectives

The main objective of this new initiative was to research, design, test and validate specific measures supporting specialised skills development related to big data, Internet of Things (IoT) and cybersecurity for SMEs in Europe. The results of the initiative contribute to strengthening SMEs' workforce adaptability and capacity for the short to medium term.

The ultimate goal is to increase the capacity of industry, social partners, education and training organisations and policy makers at all levels to promote and support the acquisition of these skills by SMEs in Europe.

The work is based on a demand-led, pragmatic and results-oriented approach with a view to proposing concrete measures. Concrete results of this initiative include, inter alia:

- A shared vision for skills development for SMEs on BIC technologies for the coming years until 2023;
- A roadmap consisting of supporting measures to achieve that vision, and a toolbox facilitating the implementation;
- A monitoring mechanism to monitor skills gaps and to track progress of the implementation in the coming years until 2023.

The figure below summarises these three elements and shows how the vision, the implementation of the vision and a monitoring mechanism for tracking the realisation of the vision fit together.

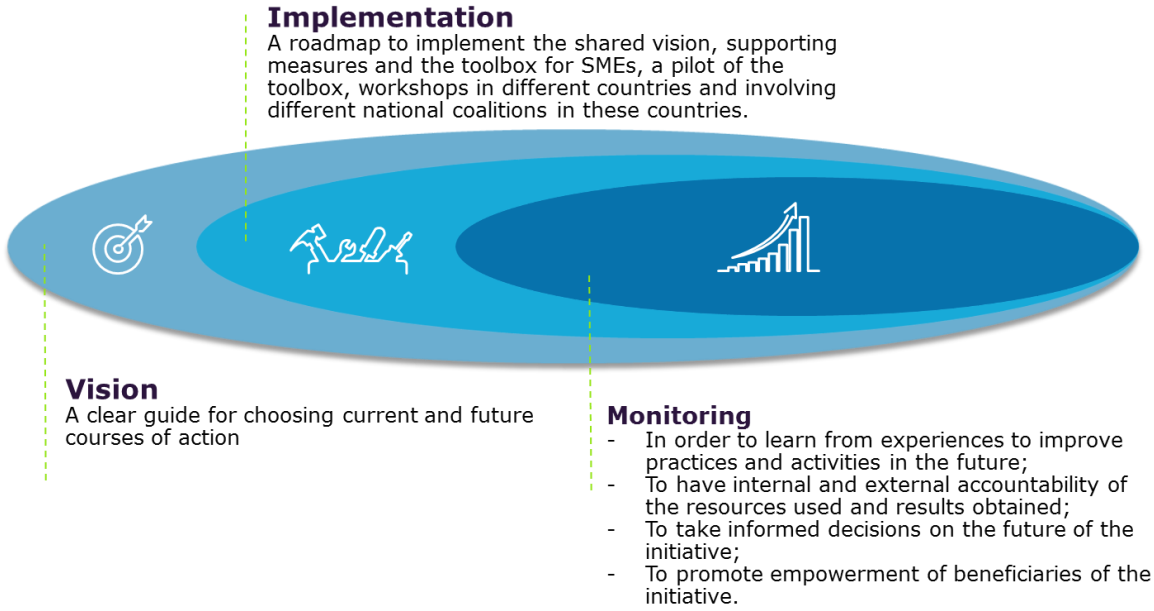

Figure 6 Holistic perspective on the activities under this initiative

The activities are performed with a view to supporting the goals set out in the New Skills Agenda for Europe, and the activities build on previous and on-going activities supported by the European Commission, such as the New Skills Agenda for Europe30, the Blueprint initiatives on Sectoral Cooperation for Skills and other related initiatives. It is input for the new SME strategy the European Commission is working on

1.3. Scope

This initiative focused on supporting specialised skills development related to BIC technologies for small and medium-sized enterprises (SMEs) in Europe. Hence, this initiative focuses on a group of enterprises that the European Commission defines as following: an enterprise is classified as being an SME if it does not have more than 249 employees and if its annual turnover does not exceed 50 million EUR or its balance sheet total is less than 43 million EUR31.

From a geographical perspective, this initiative focused mainly on the EU Member States. However, good practices from other regions are also taken into account and used for creating the roadmap and toolbox.

For this service contract, three major technological areas have been selected: big data, Internet of Things (IoT), and cybersecurity (BIC technologies). They have been identified

[30] European Commission (n.d.), New Skills Agenda for Europe. Available at: http://ec.europa.eu/social/main.jsp?catId=1223

[31] European Commission (2003), Commission recommendation concerning the definition of micro, small and medium-sized enterprises. Published May. Available at: http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32003H0361&locale=en

as priority areas in the context of the Digital Single Market strategy32 and are very closely interrelated. Multiple definitions are being used in the available literature for the three technologies. Sticking as close as possible to definitions used in related European initiatives, this initiative defines the technologies as following:

- **Big data**: "Big data refers to large amounts of data produced very quickly by a high number of diverse sources. Data can either be created by people or generated by machines, such as sensors gathering climate information, satellite imagery, digital pictures and videos, purchase transaction records, GPS signals, etc."[33]
- **The Internet of Things**: "The Internet of Things enables objects sharing information with other objects/members in the network, recognising events and changes so to react autonomously in an appropriate manner. The IoT therefore builds on communication between things (machines, buildings, cars, animals, etc.) that leads to action and value creation"[34]
- **Cybersecurity**: "Cybersecurity shall refer to security of cyberspace, where cyberspace itself refers to the set of links and relationships between objects that are accessible through a generalised telecommunications network, and to the set of objects themselves where they present interfaces allowing their remote control, remote access to data, or their participation in control actions within that cyberspace"[35]

1.4. Approach

A thorough approach was adopted to implement this service contract. This initiative was structured in three phases:

Figure 1-3

[32] European Commission (2015), Shaping the Digital Single Market. Published March. Available at: https://ec.europa.eu/digital-single-market/en/policies/shaping-digital-single-market

[33] European Commission (2018), Big Data. Available at: https://ec.europa.eu/digital-single-market/en/big-data

[34] European Commission (2014), Definition of a Research and Innovation Policy Leveraging Cloud Computing and IoT Combination. Available at: http://ec.europa.eu/newsroom/dae/document.cfm?doc_id=9472

[35] ENISA (2016), Definition of Cybersecurity - Gaps and overlaps in standardisation. Available at: https://www.enisa.europa.eu/publications/definition-of-cybersecurity

It built upon seven methods to collect data and insights to analyse the current state of play and to shape the way forward with regards to supporting specialised skills development for SMEs:

(1) **Desk research** – extensive literature and web source review aimed at detecting the most important policy papers, studies, strategies, reports, databases and training initiatives to analyse the current state of play with regards to skills development for SMEs.

(2) **Steering Committee and informal group** – a Steering Committee was installed at the start of the initiative. The steering committee consists of five independent experts renowned in the field, representing different stakeholder groups. They were asked to review the draft interim and final reports and provide written comments. The informal group represents the most relevant Key Stakeholders and consisted of 100 experts at the start and grew towards 250 over the course of the project.

(3) **Interviews** – over 80 interviews were conducted with stakeholders stemming from different backgrounds to better understand the state of play and to collect input for the way forward: academia, national and regional policy makers, SME manager/owners, educational institutions, network/cluster representatives, chambers of commerce, associations and independent experts. The interviews were conducted in 2018 and 2019[36].

(4) **Surveys** – a comprehensive online questionnaire was developed to obtain quantitative insights in SMEs skills needs, barriers and strategies, as well as gaining input on supporting measures for fostering skills development. The survey targeted both SMEs and SME experts, and was run twice. In 2019, a consultation survey was conducted with the aim to review the vision and roadmap with supporting measures.

(5) **Workshops –** six expert workshops[37] were conducted in 2018 and 2019. During these workshops, initial findings were validated, input was collected for a shared vision on supporting specialised skills development for SMEs and proposals of deliverables were discussed and improved. Members of the informal group and the Steering Committee participated in the workshops, representing different roles, expertise and countries within the European SME ecosystem.

(6) **High-level conference[38]** - the conference marked the final stage of this initiative to analyse and support SMEs' skills development, especially in the fields of Big Data, Internet of Things and Cybersecurity. It brought together around 150 participants who engaged in discussions with the experts that composed various panels covering the most essential themes of this initiative.

(7) **Alignment** with other relevant initiatives – To avoid reinventing the wheel and to learn from other but related initiatives, synergies were sought in order to leverage value. Most notably alignment with (but not limited to) initiatives such as the Blueprint initiatives for Sectoral Cooperation on Skills[39], the Digital Skills and Jobs

[36] Please see annex A for an overview of interviewees

[37] All workshop reports, agenda and participants' overview, and presentations are published here: https://www.digitalsme.eu/skills_publications/

[38] See for a coverage: https://www.digitalsme.eu/we-need-europe-for-a-comprehensive-upskilling-strategy-the-skills-for-smes-conference/

[39] European Commission (2017), Blueprint for sectoral cooperation on skills: Responding to skills mismatches at sectoral level. Available at: http://ec.europa.eu/social/BlobServlet?docId=16962&langId=en

Coalitions and the European Commission Pilot Project on digital skills: New Professions, New Educational Methods, New Jobs[40].

1.5. Structure of this document

This report groups the results into three main clusters. Part I describes the current state of play, and in addition to the present introduction it includes the following chapters:

- Chapter 2 describes the relevance of BIC technologies for SMEs, including among others adoption of these technologies by SMEs and barriers and drivers for taking up these technologies;
- Chapter 3 presents skills requirements for adopting BIC technologies;
- Chapter 4 zooms in on the skills strategies SMEs possess to acquire or develop the skills necessary to work with the three technologies;
- Chapter 5 highlights key public and private initiatives in the area of SME skills development in the area of BIC technologies.

After having described the current state of play in Part I, Part II can be characterised as forward-looking:

- Chapter 6 presents the five-year strategy on skills development for SMEs, describing the vision, and roadmap with supporting measures;
- Chapter 7 describes the toolbox.

Finally, Part III focuses on monitoring the state of play with regards to skills development:

- Chapter 8 presents a monitoring framework for monitoring supply and demand of skills necessary for SMEs to work with BIC technologies.

[40] European Commission (2018), Upskilling Europe's small businesses for the digital age. Available at: https://ec.europa.eu/digital-single-market/en/news/upskilling-europes-small-businesses-digital-age

2. THE RELEVANCE OF BIG DATA, INTERNET OF THINGS AND CYBERSECURITY FOR SMES

By completing the Digital Single Market, the EU could boost its economy by almost 415 billion EUR per year and create hundreds of thousands of new jobs[41]. New digital technologies play an important role in realising this potential. Within the context of this service contract, three technological areas have been selected: big data, IoT and cybersecurity. These areas are interrelated, as IoT devices for instance need to be secure as they are often connected over the Internet, and at the same time generate a wealth of data. The emergence of these technologies brings significant opportunities, but at the same time creates significant specialised skills gaps, especially for SMEs.

This chapter firstly provides some background about the emergence of the three technologies and related market developments (2.1), and then zooms in on the relevance of these technologies for SMEs (2.2). Section 2.3 presents how current technological trends impact the take-up of BIC technologies by SMEs, and section 2.4 describes the current state of play: to what extent are SMEs nowadays using these technologies? Section 2.5 concludes with an overview of barriers and drivers for the adoption of the emerging technologies by SMEs.

2.1. The emergence of big data, Internet of Things and cybersecurity

2.1.1. Big data

More and more volumes of data are produced, stored and published every day, every hour, every minute, and every second. In every domain, across every geography. With the emergence of IoT, the amount of data across the world is expected to increase further exponentially, with new market players, large operators and smaller niche actors. We have all seen the colourful infographics picturing the number of petabytes of data created over the Internet each second (figure 2-1).

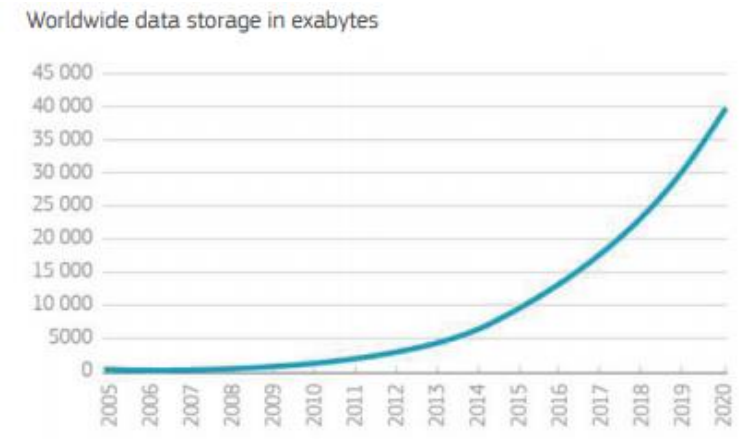

Figure 7 A global explosion of data[42]

[41] European Commission (n.d.), Digital single market: Bringing down barriers to unlock online opportunities. Available at: https://ec.europa.eu/commission/priorities/digital-single-market_en

[42] European Commission (2017), Enter the data economy: EU policies for a thriving data ecosystem. Published January. Available at: https://ec.europa.eu/epsc/sites/epsc/files/strategic_note_issue_21.pdf, based on the International Data Corporation Digital University Study

Data holds an enormous potential in various fields, such as health, food security, climate and resource efficiency to energy, intelligent transport systems and smart cities – and is considered "an essential resource for economic growth, job creation and societal progress"[43] by the European Commission.

Numerous studies have assessed the size of the potential prize. The data economy was valued at 272 billion EUR in 2015, with an expected growth of 5.6% per year to reach 739 billion EUR by 2020[44]. At the same time, the European Data Portal published a study assessing the overall direct value of open data (i.e., data that can be freely used, modified, and shared by anyone, for any purpose) for the EU 28+ to be of 75.7 billion EUR by 2020[45]. Some numbers may overlap slightly, but whatever it is that is measured, the numbers are substantial and will continue to grow.

The 2017 European Data Market study[46] showed that the data economy is already a reality today. Approximately 6.1 million EU citizens could be considered 'data workers' in 2016, and this number grows with around 2 to 3% per year, faster than average, potentially rising up to 10.4 million by 2020. Furthermore, these are not merely ICT jobs as might be expected: the ICT industry accounts for only around 11% of data workers, as opposed to professional services (20%), wholesale and retail (18%), and manufacturing (12%). The distribution of these jobs shows that the economy is increasingly becoming data-driven, including in sectors that are more traditional.

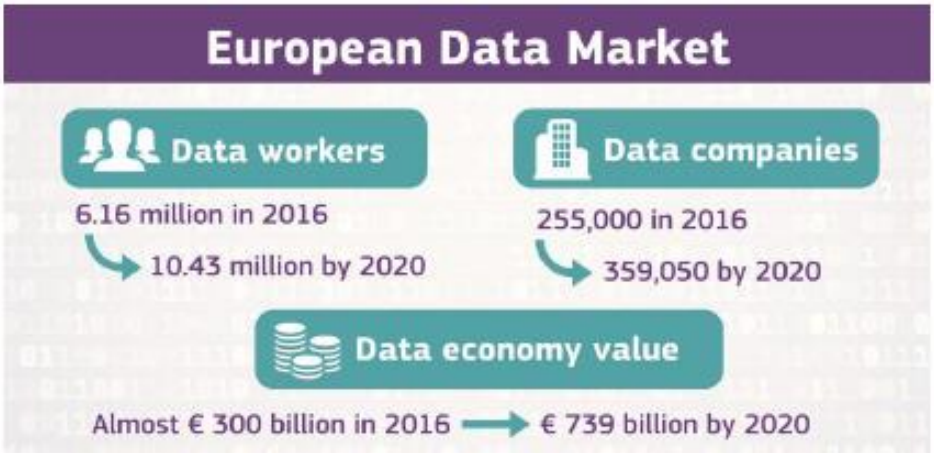

Figure 8 Key figures illustrating the European Data Market[47]

In 2016, the European data industry comprised almost 255,000 companies with a share of 14.1% of the 1.8 million enterprises populating the ICT and professional services

[43] European Commission (2017), Building a European data economy. Published January. Available at: https://ec.europa.eu/digital-single-market/en/policies/building-european-data-economy

[44] IDC (2017), European Data Market Study Final Report SMART 2013/0063. Report prepared for the European Commission. Available at: https://www.key4biz.it/wp-content/uploads/2018/04/SMART20130063_Final-Report_030417_2.pdf

[45] Capgemini Consulting (2015), Creating value through open data. Report prepared for the European Commission. Available at: https://www.europeandataportal.eu/sites/default/files/edp_creating_value_through_open_data_0.pdf

[46] IDC (2017), European Data Market Study Final Report SMART 2013/0063. Report prepared for the European Commission. Available at: https://www.key4biz.it/wp-content/uploads/2018/04/SMART20130063_Final-Report_030417_2.pdf

[47] IDC (2017), European Data Market Study Final Report SMART 2013/0063. Report prepared for the European Commission. Available at: https://www.key4biz.it/wp-content/uploads/2018/04/SMART20130063_Final-Report_030417_2.pdf

sectors. Growth in these numbers is constant in the period 2013-2016, and occurs across the EU, albeit more strongly in countries with a more highly concentrated ICT industry. Nonetheless, there is a margin for improvement: only 661,000 enterprises in 2016, corresponding to 6.4% of the 10.3 million potential user companies (excluding the government sector) can be characterised as data-driven users. This is relatively modest and shows that significant gains are still possible. Under high growth scenarios, an increase to around 359,000 companies by 2020 should be viable.

Many companies have understood the potential benefits of implementing data-driven decision making and are investing rapidly in big data technologies and services. The global market for big data-related hardware, software and professional services is growing rapidly and is expected to reach 43.7 billion euros by 2019[48]. However, not all companies have equal opportunities to reap the benefits of the emerging data market. Access to data and the ability to exploit the value are key. With limited access to data and data analytics, European companies will not be able to compete in global markets and SMEs and emerging companies are the ones set to lose the most[49]. What is worrying in this regard is that especially in Europe, too few companies are embracing digitisation: in 2015, only one in five European companies displayed a high or very high digital intensity[50], while only 6% of ICT and professional services companies were making strategic and intense use of data[51].

Equipping European SMEs with the means and tools to mine, process, store and analyse big data and generate value from it "is a means of securing future wealth and prosperity"[52]. In this regard, it is encouraging that the importance of the data economy is recognised on a European level, with the EU developing its vision for the data economy already more than a decade ago. In 2003, the EU for instance adopted legislation to foster the re-use of Public Data in Member States via the Public Sector Information (PSI) Directive 2003/98/EC[53]. Today, building a European data economy is a crucial part of the Digital Single Market strategy. The data economy initiative aims at fostering the best possible use of the potential of digital data to benefit the economy and society. It addresses the barriers that impede the free flow of data to achieve a European Digital Single Market[54].

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[48] European Commission (2017), Enter the data economy: EU policies for a thriving data ecosystem. Published January. Available at: https://ec.europa.eu/epsc/sites/epsc/files/strategic_note_issue_21.pdf

[49] Ibid.

[50] European Commission (2016). Commission staff working document: Europe's digital progress report 2016. Published May. Available at: https://ec.europa.eu/transparency/regdoc/rep/10102/2016/EN/10102-2016-187-EN-F1-1.PDF

[51] IDC (2017), European Data Market Study Final Report SMART 2013/0063. Report prepared for the European Commission. Available at: https://www.key4biz.it/wp-content/uploads/2018/04/SMART20130063_Final-Report_030417_2.pdf

[52] European Commission (2017), Enter the data economy: EU policies for a thriving data ecosystem. Published January. Available at: https://ec.europa.eu/epsc/sites/epsc/files/strategic_note_issue_21.pdf

[53] European Council/ European Parliament (2003), Directive 2003/98/EC of the European Parliament and of the Council of 17 November 2003 on the re-use of public sector information. Available at: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2003:345:0090:0096:en:PDF

[54] European Commission (2017), Building a European data economy. Published January. Available at: https://ec.europa.eu/digital-single-market/en/policies/building-european-data-economy

2.1.2. Internet of Things

The promise and potential of IoT is substantial. The worldwide IoT market is expected to grow to more than 7 trillion dollars by 2020[55]. At the same time, the development of the IoT market has only recently started, as in 2015, of all physical objects that can be connected to the Internet, less than 1% actually were connected. This means that just under 15 billion of the approximately 1.5 trillion items on earth were connected to the Internet at that time. This number is expected to increase up to level of more than 50 billion devices connected to the Internet by 2020[56]. Specifically, for the EU28, IDC expects the number of IoT connections to grow to a level of almost 6 billion in 2020, and revenues growing up to a level of 1,181 billion EUR in 2020[57]. Within the EU, the number of IoT connections is expected to increase from 1.8 million in 2013 to almost 6 billion in 2020, which means the IoT market will be worth more than one trillion dollars by then[58].

The growth in connectivity is expected to bring economic benefits, with IoT reshaping and transforming existing industrial structures. Borders between products and services, as well as borders between industries will become less obvious than today. This may materialise in innovative IoT services or applications, improved products, more efficient processes and a reduced consumption of resources and a better understanding of customers' needs. Examples include energy-saving smart streetlights, intelligent transport systems reducing congestion and IoT-based solutions supporting health monitoring and independent living at home – with demonstrated efficiency gains of care efforts of more than 20%[59].

2.1.3. Cybersecurity

The emergence of new technologies brings new opportunities for enhanced business performance and operations, but also introduces several information security and privacy risks. We all remember the massive WannaCry ransomware attack from 2017, targeting more than 200,000 systems from companies, government agencies and individuals in more than 150 countries. Major organisations such as the National Health Services (NHS) in the United Kingdom and Renault-Nissan had to halt production in some areas as a result[60]. Experts warn that WannaCry was just the beginning[61], and the numbers confirm this view. Since the beginning of 2016, more than 4,000 ransomware attacks occurred worldwide daily. This is an increase of 300% since 2015. Speaking about cyber incidents

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[55] Spencer, L. (2014), Internet of Things market to hit $7.1 trillion by 2020 : IDC. Published June. Available at: http://www.zdnet.com/article/internet-of-things-market-to-hit-7-1-trillion-by-2020-idc/

[56] Macaulay, J., Buckalew, L., & Chung, G. (2015), Internet of Things in logistics. Available at: http://www.dhl.com/content/dam/Local_Images/g0/New_aboutus/innovation/DHLTrendReport_Internet_of_things.pdf

[57] IDC & TXT (2015), Definition of a research and innovation policy leveraging cloud computing and IoT combination. Report prepared for the European Commission. Available at: https://ec.europa.eu/digital-single-market/en/news/definition-research-and-innovation-policy-leveraging-cloud-computing-and-iot-combination

[58] European Commission (2016), Advancing the Internet of Things in Europe. Published April. Available at: http://eur-lex.europa.eu/legal-content/de/TXT/?uri=CELEX%3A52016SC0110

[59] European Commission (2016), Commission staff working document: Advancing the Internet of Things. Published April. Available at: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52016SC0110&from=de

[60] Langde, R. (2017), WannaCry ransomware: A detailed analysis of the attack. Published September. Available at: https://techspective.net/2017/09/26/wannacry-ransomware-detailed-analysis-attack/

[61] Constantin, L. (2017), WannaCry attacks are only the beginning, experts warn. Published May. Available at: https://www.pcworld.com/article/3196927/security/wannacry-attacks-are-only-the-beginning.html

in general, around 80% of companies in Europe have experienced at least one cybersecurity incident in 2016[62].

More and more often, news items about various forms of cybercrime are dominating the news, illustrating that cybersecurity is now more important than ever. Various forms of cyber threats can be distinguished. The most important ones are the following[63]:

- Internal attacks, such as malicious employees that leak sensitive data;
- Phishing and spear phishing;
- DDoS attacks;
- Malware, such as ransomware, spyware, adware, bots and Trojans;
- SQL injection (vulnerabilities that allows hackers to steal or tamper with the database behind a web application);
- Bring Your Own Device (BYOD) technology that sets corporate networks at risk from unsecured devices that contain malicious applications.

The costs of cybercrime for those impacted are high and growing. Estimates show that the annual global costs of cybercrime will grow to around 4.8 trillion EUR by 2021[64]. However, the reputational damage for affected companies is often even bigger than the direct monetary damage[65].

Not only big companies, but also SMEs fall victim to cyber threats more and more often[66]. Although many owners of SMEs underestimate their risk of becoming the target of a cyber-attack, they are likely targets for cyber criminals[67] or state-sponsored attacks[68]. Today, SMEs are increasingly dependent on their information systems and networks to provide services and products and meet their business objectives. The vast majority of SMEs (excluding micro-enterprises) rely on some form of information system and many of them already have an online presence. Electronic communication networks, interconnected information systems and digital services are an essential part of an increasing number of SMEs[69].

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[62] European Commission (2017), State of the Union 2017 - Cybersecurity: Commission scales up EU's response to cyber-attacks. Published September. Available at: http://europa.eu/rapid/press-release_IP-17-3193_en.htm

[63] Information Age (2017), Seven nightmare cyber security threats to SMEs and how to secure against them. Published May. Available at: http://www.information-age.com/7-nightmare-cyber-security-threats-smes-secure-123466495/

[64] Cyber Ventures (2017), 2017 Cybercrime report. Available at: https://cybersecurityventures.com/2015-wp/wp-content/uploads/2017/10/2017-Cybercrime-Report.pdf

[65] Hamilton Places Strategies (2016), Cybercrime costs more than you think. Published February. Available at: https://www.hamiltonplacestrategies.com/insights/cybercrime-costs-more-you-think/

[66] The Guardian (2016), Huge rise in hack attacks as criminals target small businesses. Available at: https://www.theguardian.com/small-business-network/2016/feb/08/huge-rise-hack-attacks-cyber-criminals-target-small-businesses

[67] IQ in IT (2017), Why cybersecurity for SMEs is even more important in 2017. Available at: https://www.iqin.it/blog/why-cyber-security-smes-even-more-important-2017

[68] The Guardian (2018), UK businesses face growing threat from cyber-attacks – report. Published April. Available at: https://www.theguardian.com/technology/2018/apr/10/uk-businesses-face-growing-threat-from-cyber-attacks-report

[69] Mazzarol, T. (2015), SMEs engagement with e-commerce, e-business and e-marketing, Small Enterprise Research, 22:1, 79-90. https://doi.org/10.1080/13215906.2015.1018400 & Enisa (2016), Information

What also makes SMEs vulnerable is that they generally have relatively many different digital assets per individual user, their security is limited compared to bigger companies and they generally are less careful to prevent cyber-attacks[70]. Now that most large businesses have dedicated cybersecurity teams, cyber criminals increasingly target smaller enterprises. Perhaps SMEs are even a more likely target than large corporates, as due to a perceived lack of security, cyber criminals are increasingly looking towards SMEs as a gateway into the supply chain[71]. SMEs are not always aware of the fact that they contain valuable information for cyber criminals. On top of that, because of their limited resources, the damage for SMEs can be harder to overcome than for large businesses. Cybersecurity is therefore of crucial importance for the business continuity of an SME. Lack of cybersecurity sets SMEs at risk of reputational damage, financial damage and lower customer satisfaction. In the Netherlands, 40% of SMEs suffered from any form of digital fraud in 2017[72]. From the companies suffering from any form of digital fraud, 57% indicated that it caused financial damage[73]. Especially for SMEs, this financial damage can have a profound impact: 60% of SMEs that were victims of cyberattacks did not recover and had to shut down within six months[74].

Cyber threats are not only a threat for business continuity but can also be a driver for growth for companies active in the cybersecurity market. It can even bring competitive advantage according to Capgemini research[75]. The increase in cybersecurity incidents stimulates the demand for high-quality, affordable and interoperable cybersecurity products and solutions. Cybersecurity is one of the fastest growing sectors of the ICT market. Worldwide spending on cybersecurity products and services reached more than 120 billion USD in 2017. In the last decade, the market was growing 8-10% annually, while predictions for 2017–2020 envisage further steady growth[76]. This number is estimated to exceed 0.8 trillion EUR cumulatively over the next years until 2022[77]. In Europe specifically, the cybersecurity market is estimated to grow from 21.8 billion EUR in 2015 to 30.6 billion EUR in 2020[78].

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security and privacy standards for SMEs. Published June. Available at: https://www.enisa.europa.eu/publications/standardisation-for-smes

[70] Ibid.

[71] Fresh Business Thinking (2016), Cybersecurity is a growing priority – don't be the weak link. Published May. Available at: http://www.freshbusinessthinking.com/cybersecurity-is-a-growing-priority-dont-be-the-weak-link/

[72] Kamer van Koophandel (2018), Boost je business met big data. Available at: https://kvk.instantmagazine.com/e-zines-kvk/big-data#!/big-data-en-veiligheid

[73] Ibid.

[74] SMESEC (n.d.), A lightweight cybersecurity framework for thorough protection. Available at: https://smesec.eu/index.html

[75] https://www.capgemini.com/2018/05/cybersecurity-the-new-competitive-advantage-for-retailers/

[76] Cybersec (2017), European cybersecurity market. Published June. Available at: https://cybersecforum.eu/en/the-2nd-issue-of-the-european-cybersecurity-market-already-available-download/

[77] Cyber Ventures (2017), 2017 Cybercrime report. Available at: https://cybersecurityventures.com/2015-wp/wp-content/uploads/2017/10/2017-Cybercrime-Report.pdf

[78] MicroMarketMonitor (n.d.), Europe cybersecurity market. Available at: http://www.micromarketmonitor.com/market/europe-cyber-security-4129808188.html

The supply of ICT security products and services on the European market is being characterised as fragmented[79]. As a result, ICT companies might need to undergo different certification processes to sell its products and services in several Member States. The urgency of acting upon cybersecurity threats is being recognised at the EU level. To spur further a European single cybersecurity market, the European Commission has already initiated a framework for cybersecurity certification to overcome the issue of fragmentation[80]. Many European SMEs are active in the cybersecurity market, especially in niche markets (e.g. cryptography) and in well-established markets with new business models (e.g. antivirus software), but they are often unable to scale up their operations[81].

Cybersecurity was also a central element in the 2018 State of the Union speech by President Juncker[82]. One of the proposals include the creation of a Network of Cybersecurity Competence Centres, coordinated by a new European Cybersecurity Industrial, Technology and Research Competence Centre. Leveraging the already existing 660 cybersecurity centres across the EU, this new initiative seeks to[83]:

- Pool, share and ensure access to existing expertise;
- Help deploy EU cybersecurity products and solutions;
- Ensure long-term strategic cooperation between industries, research communities and governments;
- Co-invest and share costly infrastructure.

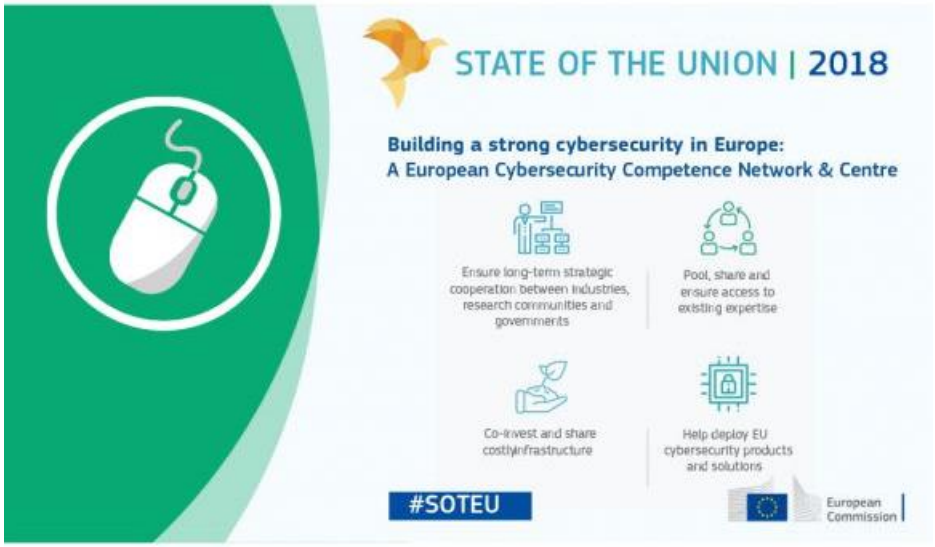


Figure 9 Creating a European Cybersecurity Competence Network & Centre[84]

[79] European Commission (2015), Cybersecurity industry. Published December. Available at: https://ec.europa.eu/digital-single-market/en/cybersecurity-industry

[80] European Commisison, (2017), The EU cybersecurity certification framework. Published September. Available at: https://ec.europa.eu/digital-single-market/en/eu-cybersecurity-certification-framework

[81] European Commission (2016), Commission signs agreement with industry on cybersecurity and steps up efforts to tackle cyber-threats. Published July. Available at: http://europa.eu/rapid/press-release_IP-16-2321_en.htm

[82] https://ec.europa.eu/digital-single-market/en/news/state-union-2018-cybersecurity-commission-proposes-invest-stronger-and-pioneering-cybersecurity

[83] Ibid.

[84] Ibid.

2.2. Opportunities for SMEs to benefit from these technologies

2.2.1. Big data

The amount of data produced is growing exponentially, as shown in section 2.1. These big numbers underline the macro-economic benefits of the data economy, but do not tell us how value is created at a mere micro-economic level – and thus how individual companies can benefit from the data economy. When we zoom in on the exploitation and commercialisation of big data at a micro-level, it appears that data has potential for organisations of all shapes and sizes, and these organisations turn data into value in various ways[85]. Several different actors are involved in the process of data creation to data services and products, as shown in Figure 10.

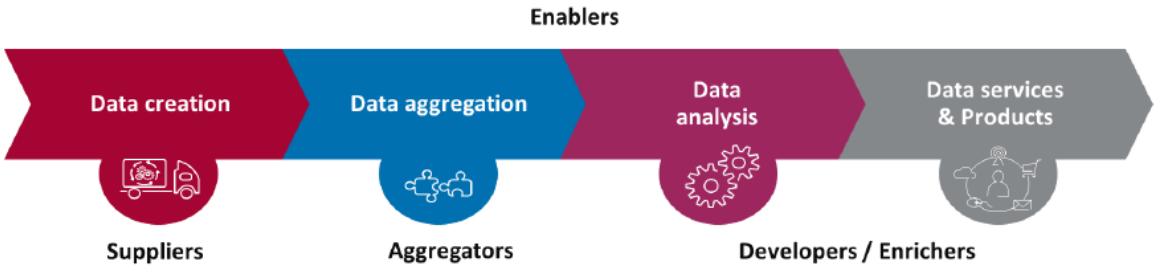


Figure 10 The data value chain – including archetypes

The emerging data economy offers opportunities for new types of companies. Data creation is done by the Suppliers. The data is subsequently collected and aggregated by the so-called Aggregators. Developers use the data for the development of new applications, while Enrichers use data to gain new and better insights from the analysis of the data. Enablers facilitate the supply or use of open data for the other archetypes, for instance by providing platforms from which the data can be extracted.

The emerging data economy offers new opportunities for specialists and niche players – naturally a domain of SMEs. Specialisation and differentiation of products and services are among the most significant success factors for SMEs. The development of more niche market demand could enable SMEs to strengthen their competitive advantages and to reduce their structural disadvantage stemming from resource constraints and limited ability to develop economies of scale.

Companies not only re-use data generated by themselves. Datasets can be purchased on the market, but perhaps more importantly, increasingly companies can also make use of open data. The European Data Portal shows that governments are maturing on their open data journey, meaning that more and more EU governments publish high-quality open data[86]. The European Data Market Monitoring Tool illustrates that big data offers market value in different industries – with substantial differences between industries. (Figure 2-5).

[85] Capgemini Invent (2017), Re-using open data: A study on companies transforming open data into economic & societal value. Available at: https://www.europeandataportal.eu/sites/default/files/re-using_open_data.pdf

[86] Capgemini Invent (2017), Open data maturity in Europe in 2017. Published November. Available at: https://www.europeandataportal.eu/sites/default/files/edp_landscaping_insight_report_n3_2017.pdf

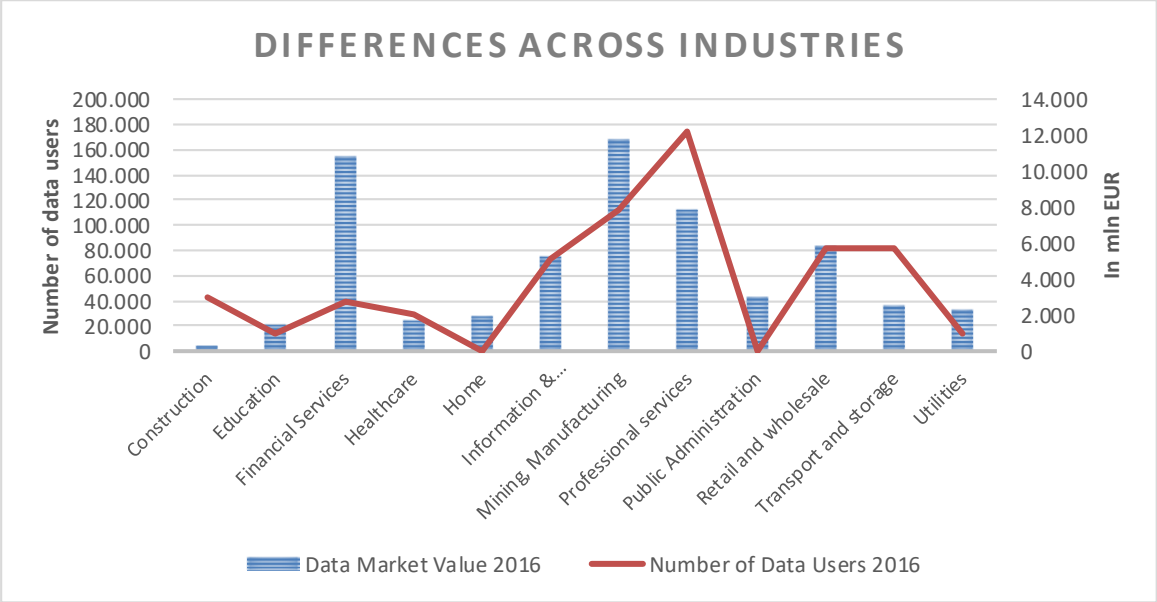


Figure 11 Market value and data workers across industries[87]

While the above paragraphs show that the expected benefits depend on the type of company and the sector in which the company is active, it does not tell us what the benefits of working with big data are for the 'average' company. A recent study showed that the use of big data can result in several competitive advantages[88]:

- Improving business intelligence;
- Improving research and accelerating innovation;
- Reducing costs and improving customer satisfaction by more personalised services[89];
- Improving and renewing products and/or services and creating new ones according to customers' needs;
- Better adjusting their marketing to their target group, thus making marketing more effective;
- Better understanding and optimised business processes, such as optimised product stocks based on models that predict buying behaviour.

In addition, the EU publication on the data economy states that "companies can use big data analytics to help them develop new products and services, to re-engineer their business processes and better manage their supply chains, to strengthen fraud detection, to improve security and risk management and to gain clearer insights into customer needs"[90]. An advantage that SMEs have in this regard, because of their size, is that they tend to be more flexible in using the insights generated from big data in order to increase

[87] IDC (2017), European Data Market Study Final Report SMART 2013/0063. Report prepared for the European Commission. Available at: http://datalandscape.eu/

[88] New Gen Apps (2017), 5 Benefits: Competitive advantages of Big Data in business. Published July. Available at: https://www.newgenapps.com/blog/importance-benefits-competitive-advantage-big-data

[89] European Commission (2014), Big Data. Published July, updated March 2018. Available at: https://ec.europa.eu/digital-single-market/en/policies/big-data

[90] European Commission (2017), Enter the data economy: EU policies for a thriving data ecosystem. Published January. Available at: https://ec.europa.eu/epsc/publications/strategic-notes/enter-data-economy_en

sales, reduce costs, improve customer satisfaction, increase productivity and accelerate innovation.

Insight box – Producers of big data solutions

An example is the Slovenian SME eVineyard[91]. This company provides solutions and an application based on big data to help growers with the management of their vineyard. By combining multiple sources of data, this application helps the grower making irrigation, harvesting or treatment decisions in the vineyard. Another company making successfully use of big data technologies is DataCentric. This Spanish SME builds data-driven technology solutions. DataCentric expertise stems from its experience of creating and delivering databases for marketing and sales and managing its customers' data[92].

SME owners indicate to expect benefits in several areas when working with big data, most notably an improved customer experience based on better insights and improved insights in client needs[93]. Other benefits include, inter alia, the ability to develop new products or services and better insights into internal processes, allowing SMEs to improve and further rationalise these processes (Figure 12).

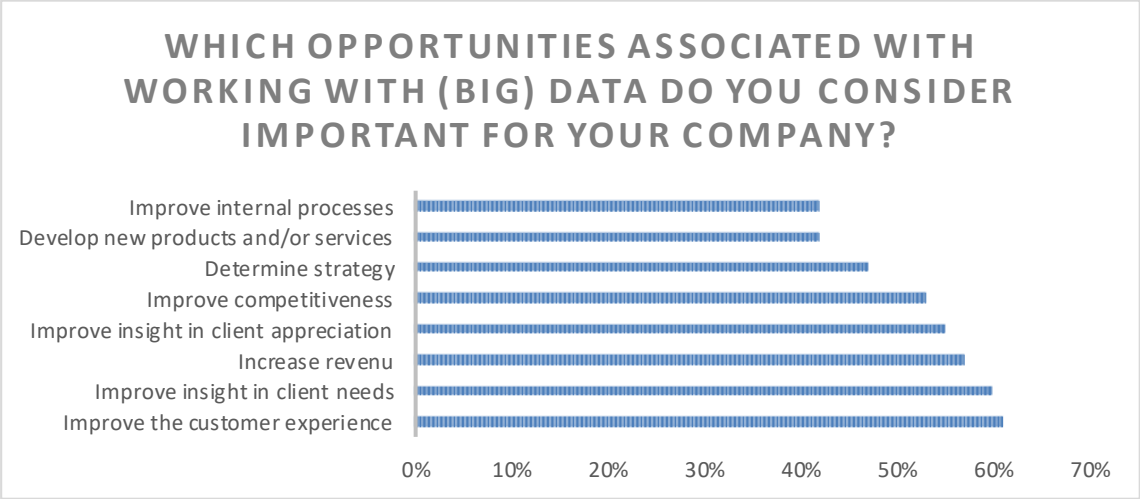


Figure 12 Opportunities associated with (big) data

The quantified micro-level benefits of using big data and digital technologies in general are underscored in numerous studies. Firms that adopt data-driven decision-making have been found to have a 5-6% higher output and productivity[94]. SMEs already working with big data are growing faster than SMEs not using big data technologies, reporting an average growth of 5%[95]. Research among financial managers of larger organisations

[91] http://www.evineyardapp.com/

[92] Big Data Value Association (2017), SMEs in the European data-economy. Published November. Available at: http://www.big-data-value.eu/wp-content/uploads/2018/01/SMEs-Brochure-2017.pdf

[93] Van der Veen, M., Smetsers, D., Van den Born, A. & Bosma, B. (2017), Ondernemen met (big) data door het mkb. Kamer van Koophandel and Jheronimus Academy of Data Science. Published January. Available at: https://www.kvk.nl/download/20170110%20Rapport%20Ondernemen%20met%20big%20data%20door%20het%20mkb_tcm109-431240.pdf

[94] European Commission (2017), Enter the data economy: EU policies for a thriving data ecosystem. Published January. Available at: https://ec.europa.eu/epsc/sites/epsc/files/strategic_note_issue_21.pdf

[95] Bluemine (n.d.), Big data in het mkb: wat levert het u op? Available at: http://www.bluemine.nl/wp-content/uploads/2017/06/Bluemine_infographic_Big_Data-V1.pdf

shows that in 60% of the cases, the deployment of big data results in increased revenues. Existing products and services become more profitable in 83% of the cases[96]. Overall, the productivity of SMEs could increase by 30 to 75% by using modern automation in production, digital tools in product design, and an effective production and resource planning.

This all points to the conclusion that big data is primarily seen as an engine for growth, a view that is confirmed by our survey respondents. The fact that it provides opportunities for growth is seen as one of the biggest benefits by 30% of the respondents, followed by the perception that it can be used to distinguish companies from their competitors (indicated by 16%) and the belief that it is a driver of additional revenue streams (14%).

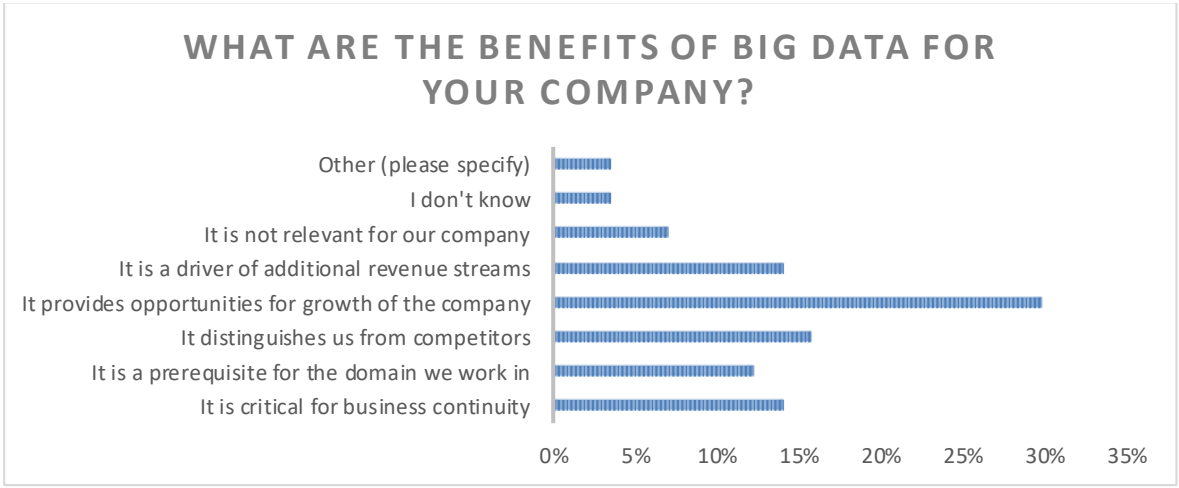
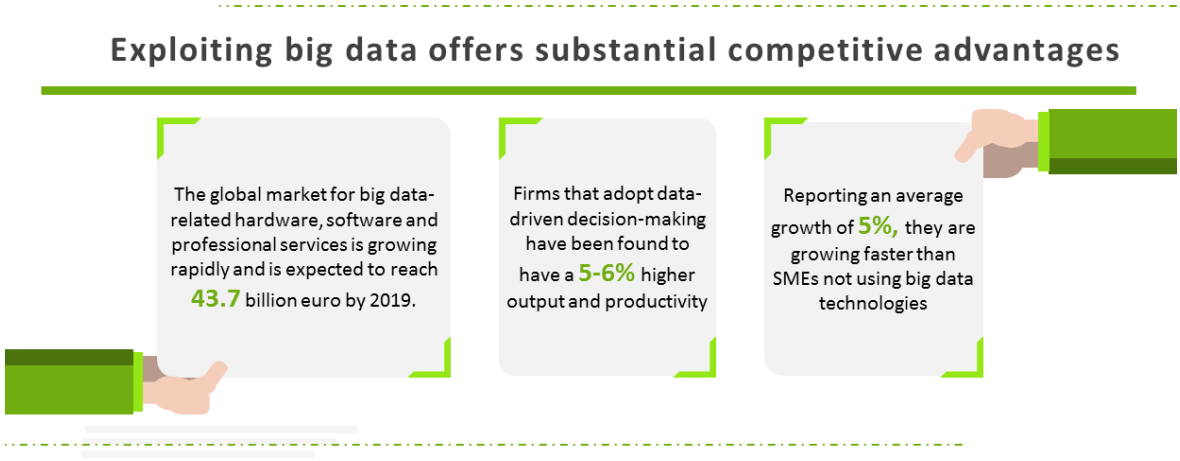


Figure 13 Benefits of big data. Source: survey



2.2.2. Internet of Things (IoT)

The benefits described in the section above particularly apply for companies working with big data, but as there are many overlaps with IoT, benefits may also hold ground for companies working with IoT. IDC described the more specific benefits of IoT applications

[96] Ibid.

for large companies, SMEs and other businesses in their report 'Leveraging Cloud Computing and IoT Combination'[97]:

- Increased return on R&D investments;
- Additional innovative services;
- Shorter time to market;
- Supply-Chain management & logistics improvements;
- Increased business processes efficiency;
- Productivity improvements;
- Enhanced asset utilization.

Other sources[98] state that IoT can improve and optimise processes, goods and services, that IoT enables the design of new products and services, reduces the need for human interventions (and thus human errors) and enable new business models. According to research by THINKstrategies, the benefits of IoT for businesses fall into four categories[99]:

(1) *Diagnostics and reporting*: IoT devices allow the company to better respond to product or service issues when they arise. More and more devices include an alert feature that notifies the supplier when a problem occurs. The supplier can remotely diagnose the issue and initiate a solution. This functionality can reduce the time needed to solve the issue and keep customer dissatisfaction to a minimum;

(2) *Predictive and preventive analysis*: because of the possibility to embed greater intelligence into the product or service, the supplier can be notified of an issue before it becomes a real problem. This allows preventive action from the side of the supplier, so bigger problems will not occur;

(3) *Information collection*: IoT products and services allow for the collection of big data about the way the product or service is used. This makes it easier to serve the customer's needs and also provides valuable insights into additional products and services that customers are interested in;

(4) *Business transformation*: the information and insights gathered by IoT can uncover new business opportunities. For example, data gathered in connected cars can be used by insurance companies to better determine appropriate insurance rate plans that are based on more accurate risk assessments.

Our survey respondents largely confirm this picture, and similar to big data, this leads to the conclusion that IoT is primarily seen as a driver of growth. 23% of the respondents indicate that it provides opportunities for growth of the companies, and 16% indicate that it is a driver of additional revenue streams.

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[97] IDC & TXT (2015), Definition of a Research and Innovation Policy Leveraging Cloud Computing and IoT Combination. Report prepared for the European Commission. Available at: https://ec.europa.eu/digital-single-market/en/news/definition-research-and-innovation-policy-leveraging-cloud-computing-and-iot-combination

[98] E.g. Business News Daily (2013), Internet of Things has big startup potential. Published November. Available at: https://www.businessnewsdaily.com/5450-internet-of-things-business-opportunities.html

[99] Kaplan, J. M. (2015), Attaining four levels of Internet of Things benefits. Published February. Available at: http://sandhill.com/article/attaining-four-levels-of-internet-of-things-benefits/

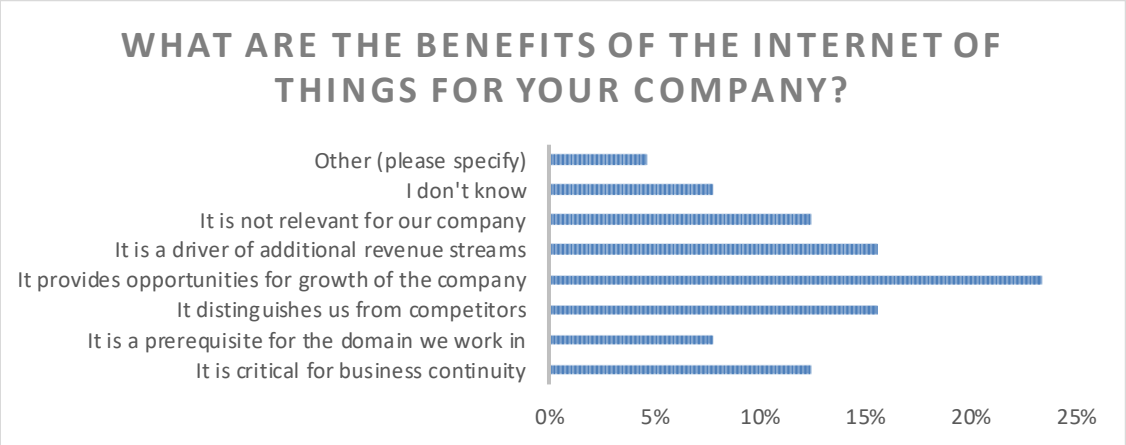

Figure 14 Benefits of IoT. Source: survey

It is important to note that one can distinguish benefits for users and benefits for suppliers. Much of the IoT market is based on business-to-business interactions, meaning that ICT vendors provide IoT technologies and solutions to business users, who leverage them to deliver services and applications to their customers. A group of so-called enabling companies play an important role in the IoT ecosystem, referring to big data companies, security providers, application developers, and other professional services companies[100]. The IoT ecosystem is populated by a number of different stakeholders, which can be categorised in three main categories[101]:

- Vendors providing components to the solution suppliers. This group covers a wide variety of companies in terms of size, vertical specialisation, and geographic reach. Examples are commercial service providers, systems integrators, hardware, software, and cloud service Providers.
- Suppliers who create IoT solutions and services for other enterprise customers. Many of the vendors noted above also build solutions for customers using their own and other suppliers' components. These suppliers design, build, and operate IoT solutions on behalf of their enterprise customers based on the components supplied by vendors.
- Customers/end-users who use the IoT solutions provided by ESPs. There are examples of users in most sectors who use IoT solutions.

SME technology companies are a major source of innovation in IoT. Their smaller size, shorter decision cycles and flexibility allow them to act adapt quickly to this emerging market, which can keep them ahead of slower moving larger companies[102]. Examples of SMEs successfully adopted IoT are presented below

Insight box – IoT producers

An example of a successful small company that applied IoT in product design is the Spanish company Drone Hopper[103]. Drone Hopper is a drone that can provide aerial

[100] IDC & TXT (2015), Definition of a Research and Innovation Policy Leveraging Cloud Computing and IoT Combination. Report prepared for the European Commission. Available at: https://ec.europa.eu/digital-single-market/en/news/definition-research-and-innovation-policy-leveraging-cloud-computing-and-iot-combination

[101] Ibid.

[102] Staff, I. (2017), The business drivers and challenges of IoT for SMEs. Published January. Available at: https://iotuk.org.uk/the-business-drivers-and-challenges-of-iot-for-smes/

[103] https://www.drone-hopper.com/home

support for fighting wildfires. The drone has a maximum capacity of 300 litres of water and includes control systems, thermographic cameras and a navigation system.

SMEs can also facilitate the creation of IoT applications, such as the Swedish company H&D Wireless AB[104]. This company enables wireless sensor and multimedia data access to the Internet for a low price. H&D Wireless solutions can be used in devices such as smart energy meters and smart medical devices.

2.2.3. Cybersecurity

Digitalisation creates opportunities for businesses of all sizes, but these opportunities come with several information security and privacy risks. Addressing these risks plays a significant role in business success nowadays, as growing security threats may potentially disrupt business continuity and cause monetary and reputational damage to SMEs[105]. Effectively addressing cybersecurity risks results in concrete benefits. Research by ENISA[106] shows that there are multiple specific drivers for European SMEs for the uptake of cybersecurity:

- Mitigating information security and privacy risks: adoption of information security and privacy standards is an effective way to mitigate these risks;
- Increasing consumer trust: users trust organisations more if they know their personal data will be safe with them;
- Demonstrating commitment to regulatory compliance: these regulations can be on a national level or on a European level, such as the General Data Protection Regulation, for which noncompliance can result in fines of up to 4% of the annual turnover of businesses if they do not have their data security and privacy measures in order[107];
- Creating competitive advantage: when businesses have their cybersecurity in order, it could be easier for them to attract and retain customers.

The increase in cyber incidents brings substantial business opportunities for those active in the cybersecurity market. Several domains within the cybersecurity ecosystem can be distinguished in which SMEs can be active: from cybersecurity governance, traceability and audit, identity access management, data security and cryptography, messaging security, application security, security of infrastructure and equipment, consulting and training to operational and outsourcing services[108].

[104] http://www.hd-wireless.se/

[105] ENISA (2016), Information security and privacy standards for SMEs. Published June. Available at: https://www.enisa.europa.eu/publications/standardisation-for-smes

[106] Ibid.

[107] GDPR Portal (n.d.), GDPR key changes. Available at: https://www.eugdpr.org/key-changes.html

[108] Digital SME Alliance (2017), Europe needs a cybersecurity strategy to foster its SME ecosystem. Published July. Available at: https://www.digitalsme.eu/europe-needs-cybersecurity-strategy-foster-sme-ecosystem/

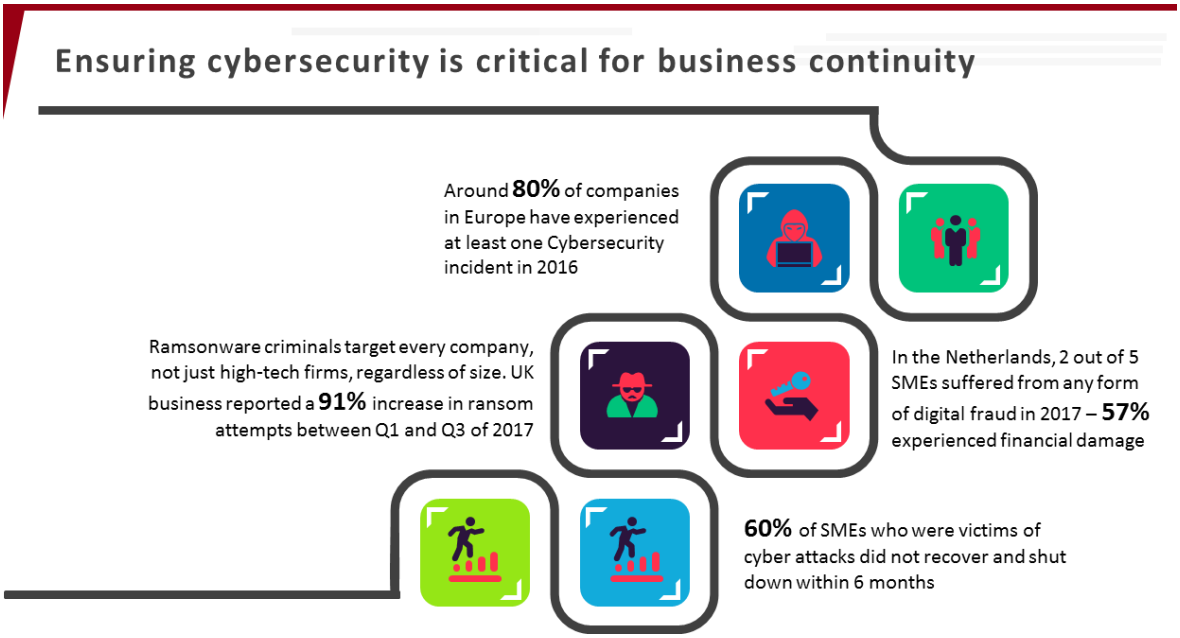

Figure 2.9

As cybersecurity is relevant for everyone using the Internet (organisations of all sizes, for companies, governments, consumers, etc.), the cybersecurity market is enormous. Examples of companies that benefit from this growing market by providing cybersecurity solutions are provided in below insight box.

Insight box – Cybersecurity producers

ZenMate[109] is a German company that provides businesses with several services and products: international quality assurance, data and employee security solutions, a solution to encrypt private calls and for anonymous business research, IP address protection, and a solution for gaining unrestricted content for remote workers.

Another example is FLO Live[110], an UK-based company that provides IoT security solutions to create a secure, cloud-based ecosystem for IoT.

The fact that business continuity is essential for every business is also underlined in our survey. When asked about the importance of the three technologies, cybersecurity is considered to be very important – scoring 5,72 out of 7. In fact, cybersecurity is considered to be substantially more important than big data and IoT.

[109] https://zenmate.com/home-page/

[110] http://flolive.net/

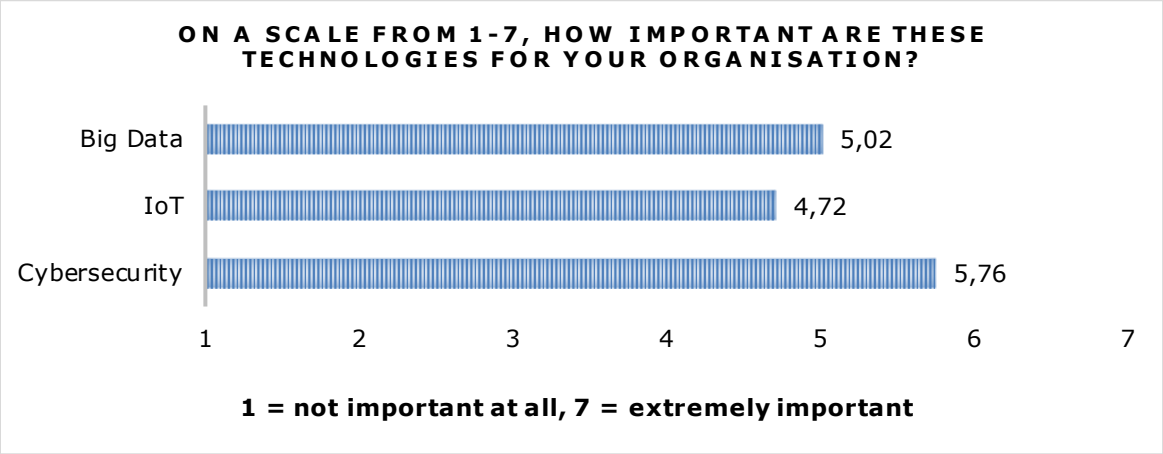

Figure 2-10 Importance of Big Data, IoT, Cybersecurity. Source: survey

2.3. The impact of technological trends on the take-up by SMEs

2.3.1. Impact of technological trends on technology adoption

The technological landscape is evolving fast. As the digital frontier expands, there is constant pressure on SMEs to adapt and evolve. New technologies may change the status quo of the market and may bring opportunities for SMEs or act as a threat for positions gained in the market. Some trends may be more disruptive than others. New technologies may also impact the extent to which SMEs are able to adopt BIC technologies – and affect the demand for specialised skills. This section presents the most relevant technological trends for the three technologies and the way they will affect the take-up by SMEs. To identify and select the most important trends and their impacts, an extensive analysis of leading publications from major technology advisory firms was carried out. The selection of trends was based on the following criteria:

- Publications are max. two years old;
- Trends identified are documented by at least three separate sources;
- Trends are related to or impact big data, IoT and/or cybersecurity;
- They are disruptive technologies, meaning that they are rapidly advancing, they have a broad potential scope of impact, may affect significant economic value, and they can dramatically change the status quo of the market[111].

Following these search criteria 25 trends have been discovered for 2018 and beyond, within the areas of cybersecurity, big data and IoT. These trends are expected to significantly impact SMEs. These 25 trends have been clustered into six main domains, that all impact SMEs in a different way. Figure 15 presents an overview of the six domains and how they affect the take up of emerging technologies by SMEs. Annex B provides a more detailed overview.

[111] McKinsey (2013), Disruptive technologies: Advances that will transform life, business, and the global economy. Published May. Available at: https://www.mckinsey.com/business-functions/digital-mckinsey/our-insights/disruptive-technologies

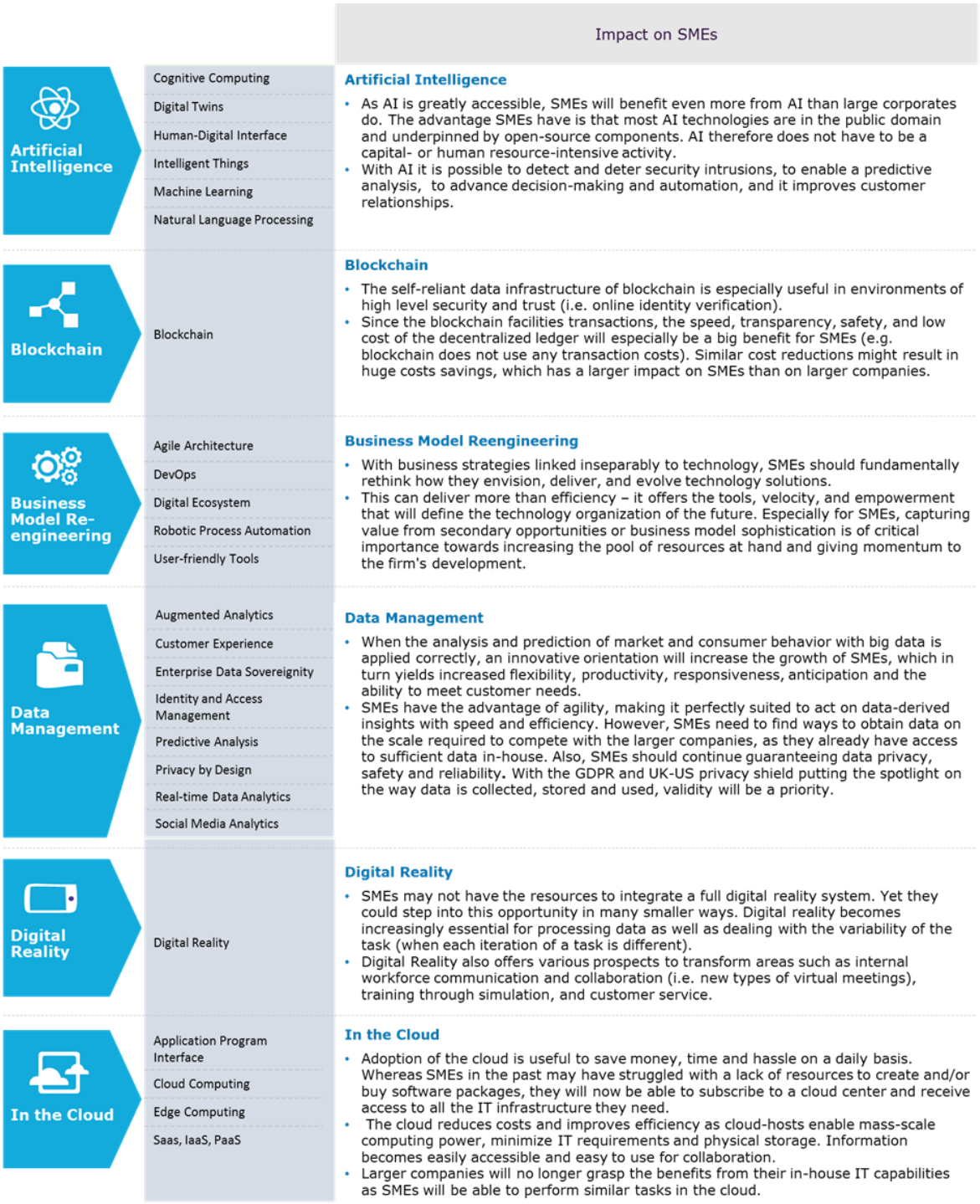

Figure 15 The main technological trends affecting the take up of big data, IoT and cybersecurity by SMEs [112]

At first, artificial intelligence will impact SMEs significantly, because today most AI technologies have appeared in the public domain and are underpinned by open-source components[113]. Therefore, it does not have to be a capital or HR-intensive activity. The increasing importance of AI facilitates the take-up of both big data, IoT, and cybersecurity. Whereas cybersecurity could be described as a precondition to deploy AI,

112 For a detailed description of the methodology and sources that underpin the identification of trends and he analysis of the impact on SME take up, please refer to Annex B

113 Financial Times (2017), SMEs can challenge big beasts by snapping up AI benefits first. Published October. Available at: https://www.ft.com/content/8b053fe4-a1ca-11e7-9e4f-7f5e6a7c98a2

AI might perhaps even more impact the big data and IoT domain, as AI relies on big data technologies – and possibly data generated by IoT technologies. For instance, digital twins[114] are digital representations of (the behavior of) a physical object or process that help optimise business performance, using real-time data. They provide visibility and insight in the operations of their machines in the context of the (IoT) environment they are part of.

Secondly, blockchain technology has the potential to impact SMEs significantly as well, because the cost savings as a result of using the decentralised ledger (i.e., an asset database that can be shared across a network of multiple sites, geographies or institutions[115)] of the blockchain technology will have a large impact as SMEs are less resource-intensive. It is especially useful in environments with a high level of security and trust (e.g., online identity verification). Blockchain will primarily spur the take-up of cybersecurity, and to a lesser extent big data and IoT.

Thirdly, business model reengineering refers to the newest business strategies linked inseparably to technology, which causes SMEs to rethink fundamentally how they envision, deliver and evolve technology solutions. The trends listed in this category impact all three technological areas – although some to a greater extent than others.

Fourthly, SMEs should consider responsible data management to fully exploit their agility, because the use of data is perfectly suited to predict and analyse market and consumer behaviour. SMEs can thereby act on data-derived insights with speed and efficiency. Obviously, this domain mainly impacts the take-up of big data by SMEs, and to a lesser extent IoT. The trends 'Identity and Access Management' and 'Privacy by Design' also foster SME take-up of cybersecurity.

Fifthly, digital reality is an umbrella term for Augmented Reality (AR), Virtual Reality (VR), Mixed Reality (MR), 360° video, and immersive technology. It offers various ways for SMEs to transform positively business areas such as internal workforce communication, collaboration, training and development. Digital reality primarily affects the take-up of big data and IoT, as digital reality becomes increasingly essential for processing and presenting data. Digital reality technologies offer various prospects for enterprises to transform areas such as internal workforce communication and collaboration (e.g., new types of virtual meetings), training through simulation, and customer service.

At last, the advent of the cloud will continue to proliferate in SMEs. Businesses are no longer using the cloud solely as a tool - the focus has shifted towards finding the right way to use it. The advent of the Cloud has created significant changes to organisations: it has evolved from personal cloud storage to entire organisations moving all their data to the cloud. Increasing usage of cloud solutions impacts all three technologies. Whereas SMEs in the past may have struggled with a lack of resources to create and/or buy software packages or other IT resources, they will now be able to subscribe to a cloud center and receive access to the IT infrastructure they need. It reduces costs and improves efficiency as cloud-hosted servers enable mass-scale computing power and minimise IT requirements, physical storage and software updates. Information becomes easily accessible and easy to use for collaboration. Lastly, the cloud adds security for its users by backing up data and decrease the opportunities for hackers.

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[114] Koppel, A. (n.d.), Meet the digital twin –the key technology in your smart factory. Available at: https://medium.com/@i4ms_eu/meet-the-digital-twin-the-key-technology-in-your-smart-factory-16d5cf0dd284

[115] Shankar, S. (2017), Centralized ledgers vs. distributed ledgers (layman understanding). Published July. Available at: https://medium.com/@shyamshankar/centralized-ledgers-vs-distributed-ledgers-layman-understanding-52449264ae23

In general, the sectors that are most affected by the trends listed above are banking and financial services, manufacturing, health care, retail, media, and telecommunications[116]. From a geographical perspective, one can state that Member States that are performing well with regards to the integration of digital technologies by business are more likely to quickly adopt emerging digital trends. Member States performing well in this regard are Denmark, Finland, Ireland and Sweden[117]. Romania, Poland, Bulgaria and Hungary are the least developed as for the integration of digital technologies by businesses. The emergence of these new technologies will undoubtedly affect the demand for skills, dependent on where an SME is positioned: is it an ICT user or an ICT supplier? From a supplier perspective, most of the technologies described point towards the development of integrated and automated infrastructures. This requires not only the skills to build and innovate hard- and software (e.g. data centres), but also requires standardisation and interoperability skills[118]. From a user perspective, the ability to understand, select and manage vendors, standards and interoperability become drivers of competitive advantage. Skills profiles required by ICT users will become more business-oriented and project-oriented, including the ability to outsource (e.g. ability to select vendors, be an informed buyer) and/or rely on standardised platforms and services[119]. Lastly, interviewees state that with the emergence of new technologies, human judgement will become more important than ever. For this, one needs to understand the intrinsic logic of technologies to come to a weighted decision.

2.4. Adoption of big data, Internet of Things and cybersecurity by SMEs

The previous sections illustrated the increasing importance of BIC technologies, their relevance for SMEs and how current and future trends may impact the take-up of these technologies. This chapter zooms in on the current state of play: to what extent are SMEs already able to work with these emerging technologies? Big data, IoT or cybersecurity might be more relevant for some SMEs than others, depending on their characteristics. This section therefore firstly describes a segmentation model, providing a means to focus on those SMEs for who adoption of one of these technologies is most relevant.

2.4.1. Segmentation of SMEs

The SME landscape is diverse, with varieties in terms of size, sector, geography, technological intensity, and markets served. SMEs can be (potential) users and suppliers of emerging technologies. This makes it necessary to reduce (part of) the complexity by clearly defining the target group of this initiative. In this respect, interviewees on the one hand stress the urgency of ensuring cybersecurity for "every company connected to the Internet", and that "big data offers opportunities even for the bakery around the corner". On the other hand, it is argued that an approach can only be effective if it is targeted, specific and industry-relevant. Building on a segmentation model from the Dutch Chamber of Commerce, five segments can be distinguished that indicate to what extent companies are engaged in (technological) innovation.

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[116] For a detailed description of the methodology and sources that underpin the identification of trends and the analysis of the impact on SME take up, please refer to Annex B

[117] European Commission (2015), Integration of digital technology by enterprises. Published June. Available at: https://ec.europa.eu/digital-single-market/en/integration-digital-technology

[118] Hüsing, T., Dashja, E., Gareis, K., Korte, W. B., Stabenow, T., & Markus, P. (2015), e-Leadership skills for small and medium sized enterprises. Published October. Available at: http://eskills-lead.eu/fileadmin/lead/reports/lead_final_report.pdf

[119] Ibid.

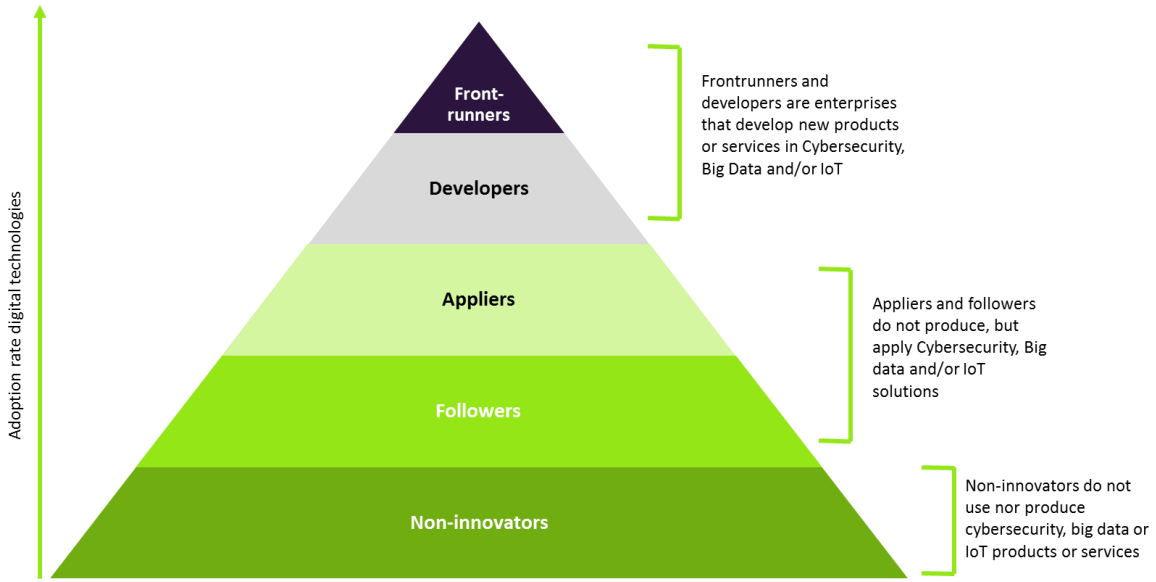

Figure 16 Segmentation of SMEs based on maturity in the uptake of big data, IoT and cybersecurity[120]

The above four groups (frontrunners, developers, appliers and followers) are focusing on renewal and innovation of processes, products and services, whereas the non-innovators are not. Given the fact that this initiative focuses on innovative technologies, this initiative will primarily focus on the above four groups. By building on and collaborating with companies that understand and are already working – or are potentially working - with these technologies, this initiative will be best able to define what is needed. The group of non-innovators will automatically benefit from the results, as they for instance might become better aware of the added value of one of the technologies as a result of one of the actions proposed but will require a different approach to get involved.

Assuming that skills needs differ per type of SME, building on this model allows this initiative to identify skill needs for the different groups, and to target the vision and proposals for supporting measures accordingly.

2.4.2. Big data

Focussing on the big data playing field, it can be noticed that in 2018, 12% of the European SMEs were actually using some type of big data source, compared to 33% of large enterprises[121]. There are still a lot of technological opportunities to be exploited by SMEs, with the adoption rates of big data lagging behind of other key digital technologies, most notably social media, eInvoicing and Electronic Information Sharing (Figure 17).

[120] https://www.kvk.nl/download/Hoe_innoveert_NL_rapportage_tcm109-451143.pdf

[121] Eurostat Community survey on the usage of information and communication technologies in enterprises, 13 December 2018

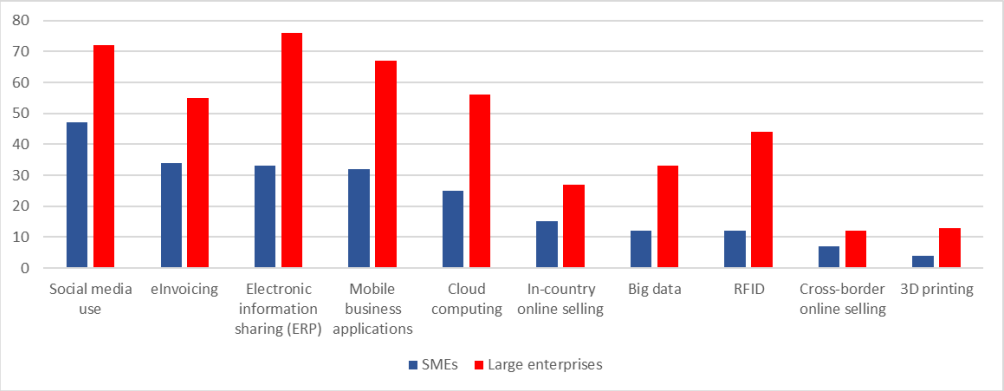

Figure 17 Adoption of some key digital technologies by company size (Eurostat 2017/2018)

Whereas data stemming from own internal processes (e.g., smart meter data, sensors) are the most used data source for large enterprises, SMEs are more likely to use geo-data or data generated by social media. Substantial differences exist between countries regarding the use of big data by SMEs. SMEs from countries such as Malta, the Netherlands, and Ireland seem to be ahead of other countries, specifically Hungary, Austria and Cyprus (Figure 18) [122].

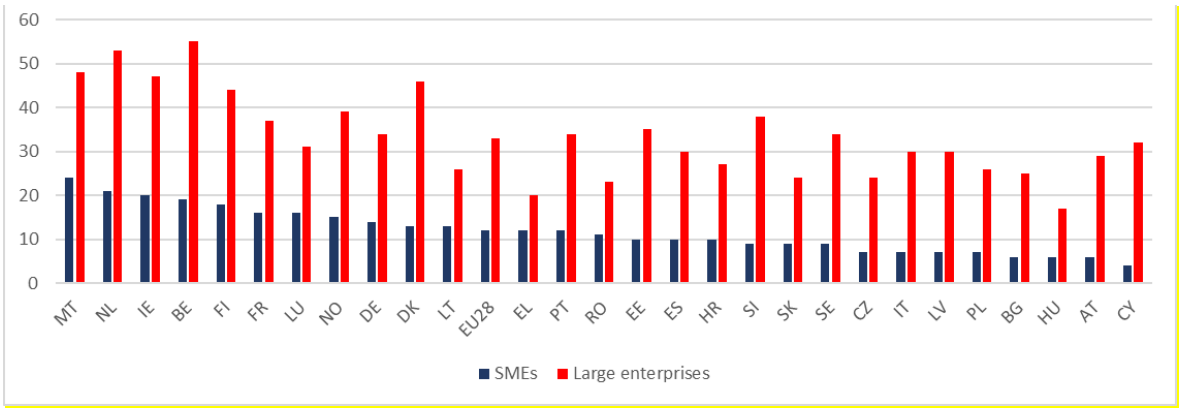

Figure 18 Percentage of enterprises analysing big data sources (Eurostat 2018)

The above numbers refer to the situation in 2018. Other studies show similar findings. Based on a representative sample of more than 4,000 companies, evidence from the Netherlands shows that still only 13% of the Dutch SMEs is currently working with big data, and 15% is planning to do so[123]. Only a fraction – less than 1% - of Dutch SMEs is ready for the application of big data in their business processes. Size matters in this regard: Larger SMEs are more likely to be ready for big data[124].

The picture sketched above relates to SMEs using big data technologies. Data users are organisations that generate, exploit, collect and analyse digital data intensely and use what they learn to improve their business[125]. They represent the demand-side of the market and may use solutions provided by data suppliers: companies who have the

[122] Ibid.

[123] Van der Veen, M., Smetsers, D., Van den Born, A. & Bosma, B. (2017), Ondernemen met (big) data door het mkb. Kamer van Koophandel and Jheronimus Academy of Data Science. Published January. Available at: https://www.kvk.nl/download/20170110%20Rapport%20Ondernemen%20met%20big%20data%20door%20het%20mkb_tcm109-431240.pdf

[124] CBS (n.d.), Are SMEs ready for big data? Available at: https://www.cbs.nl/en-gb/our-services/innovation/project/are-smes-ready-for-big-data-

[125] http://datalandscape.eu/european-data-market-monitoring-tool-2018

production and delivery of data-related products, services and technologies as their main activity. The European Data Market Monitoring Tool estimates the total number of data users in the 28 EU Member States (EU28) at a level of 661,050 in 2016, of which most companies are SMEs: 98.9%[126]. Together, they represent 6.4% of the total number of companies in the EU28. The number of data users is growing over time, as show in Figure 19.

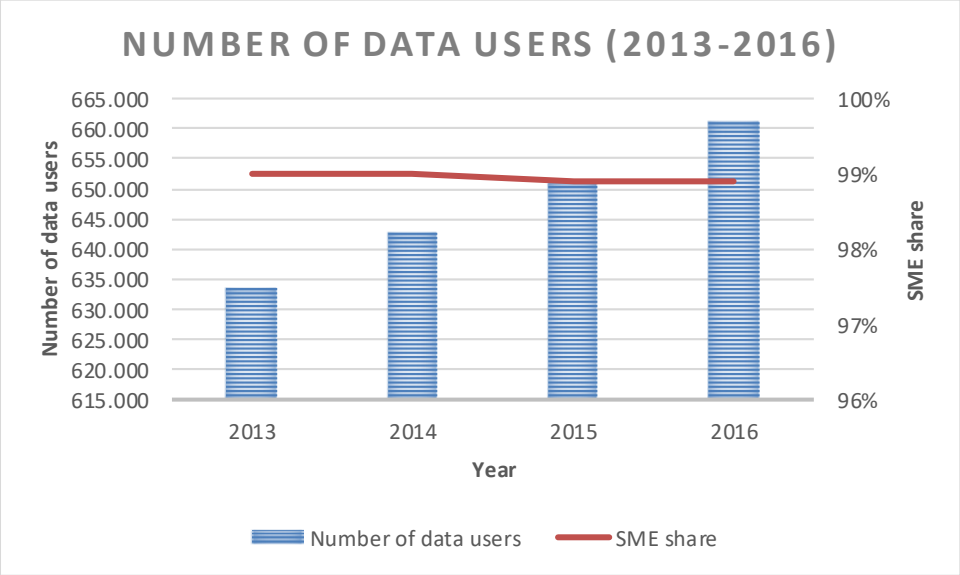

Figure 19 Number of data users

Looking at the distribution per country, two-third of the total population of data users can be found in the UK, Germany, Italy and Spain, with the UK being in the lead accounting for more than 150,000 data users[127]. Not surprisingly, these are also the larger EU economies, and the group of user companies reflects the overall structure of the economy. When looking at the share of data users on the total number of companies, the Netherlands, the UK, Ireland and Luxembourg are leading the way, with user companies accounting for 9% to 12% of their total amount of companies. Data users can be found in every sector. Most data-user companies can be found in the professional services industry, manufacturing, wholesale and retail and transport – together representing almost two-third of Europe's data users. At the same time, the ICT sector, healthcare and finance demonstrated strong growth rates in 2016, illustrating their dynamism in terms of adoption of big data technologies[128].

The European Data Market Monitoring Tool has also provided estimates about the supply side of the market. It has to be noted that the boundaries between demand and supply are not so clear-cut, since for instance companies, which develop a good capability to exploit their own data, may become in turn resellers of their own data to third parties. The supply side is labelled as 'data companies'. The SME share in data companies is more or less equal to the share of SMEs in the population of data users: 98.9% in 2016. The total number of data companies is however significantly lower than the number of data

[126] IDC (2017), European Data Market Study Final Report SMART 2013/0063. Report prepared for the European Commission. Available at: http://datalandscape.eu/

[127] Ibid.

[128] Ibid.

users: 254,850 in 2016. Similar to the development noticed concerning data users, the number of data companies is growing (Figure 20).

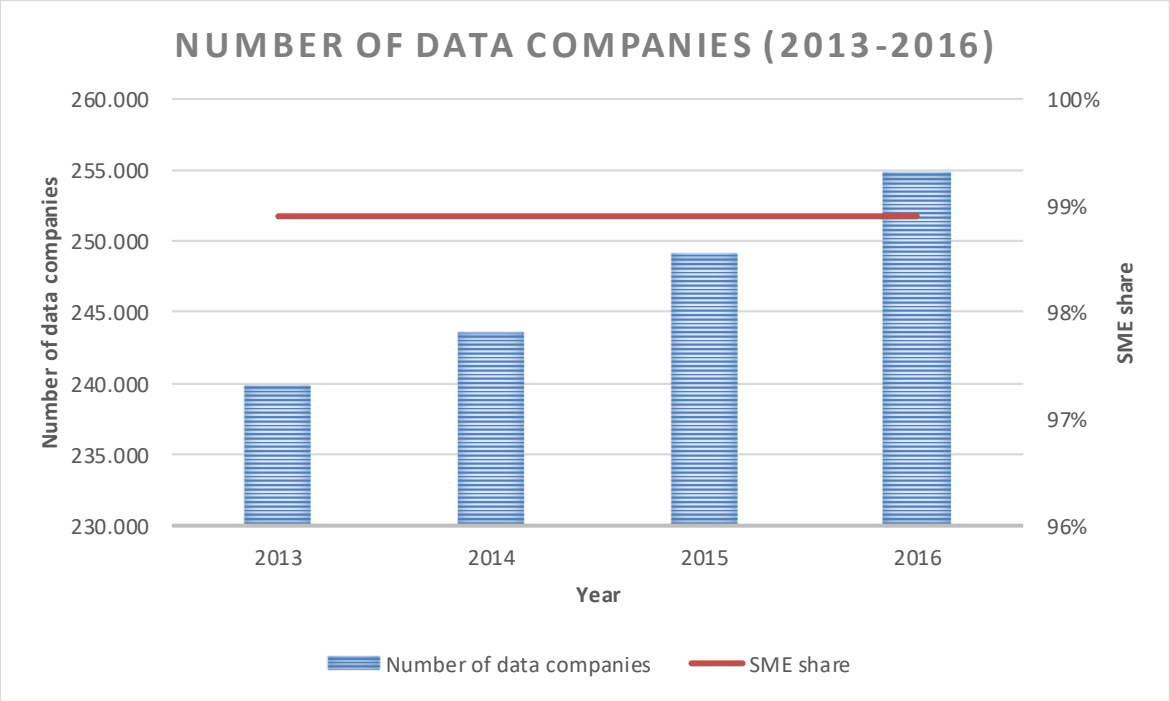

Figure 20 Number of data companies

Data companies in Europe tend to be heavily concentrated in the UK and Germany. This distribution does not simply reflect the size of national economies, but is closer correlated with the presence of a strong ICT industry. When looking at the intensity of data companies' presence – the share of data companies on the total number of companies in the reference sectors – we notice that Ireland (22.6%) and the UK (20.8%) are topping the league[129]. Both are benefiting from their effort to pursue the data economy. The group of followers, consisting of the Netherlands, Italy, Austria, Germany, Sweden, Denmark and Greece, used to have a lively ICT industry. From a sectoral perspective, data companies tend to be heavily concentrated in two sectors: the ICT sector and the professional services industry[130].

2.4.3. Internet of Things

As discussed in section 2.1.2, the market potential for IoT solutions is substantial. Specific numbers that detail the IoT uptake of SMES are hard to come by, and even more when also differentiating between IoT users and suppliers. At the same time, a comparison of several figures does shed light on the extent to which SMEs are able to work with IoT.

IoT technology is becoming cheaper as the technology becomes more mainstream. The IoT market still continues to grow due to the considerable increase in the number of IoT devices. Europe has nearly a 40% share of the world's IoT market. This share is expected to be stable in the coming years[131]. Substantial differences exist between countries and

[129] IDC (2017), European Data Market Study Final Report SMART 2013/0063. Report prepared for the European Commission. Available at: http://datalandscape.eu/

[130] Ibid.

[131] European Commission (2014), Definition of a Research and Innovation Policy Leveraging Cloud Computing and IoT Combination. Available at: http://ec.europa.eu/newsroom/dae/document.cfm?doc_id=9472

across sectors when it comes to the take-up of IoT. Although all EU Members States will participate to the IoT revolution, those countries that have traditionally invested more in ICT are expected to gain from the IoT revolution earlier than those that do not invest in ICT. Consequently, these countries (UK, Germany, and France) are forecasted to take over half the IoT revenues in the EU, with the top 6 (the above plus Spain, Italy, and Netherlands) over 75%[132].

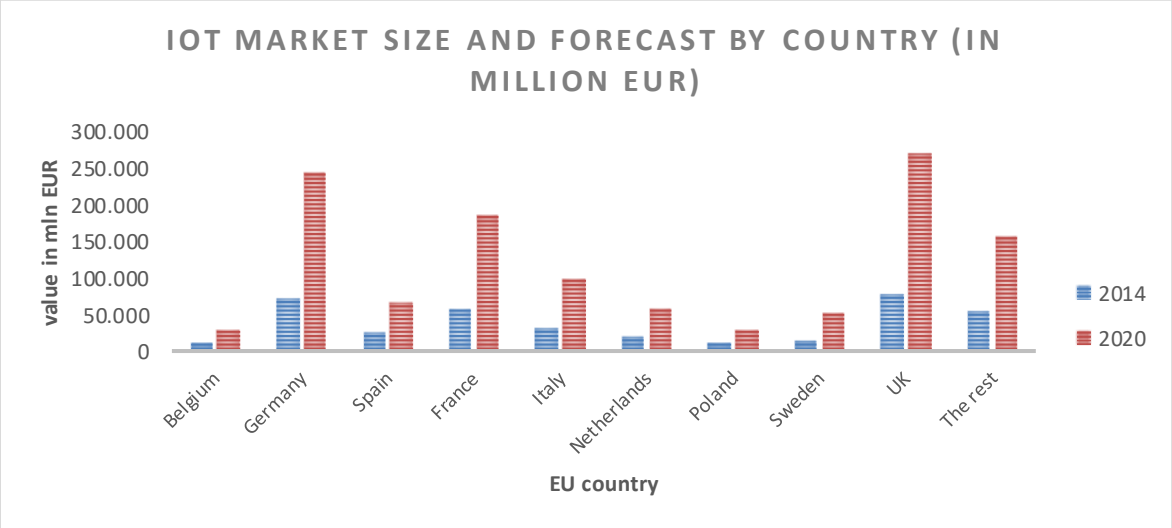

Figure 21 IoT market size in 2014 and forecast of IoT market size in 2020 per EU country

When looking at sectoral differences, those sectors that have traditionally invested more in ICT are expected to enjoy most of the benefits. IoT will impact all sectors, but the take-up in manufacturing, finance and utilities will grow faster than the EU average. Manufacturing, finance and the public sector are expected to be the biggest IoT markets in 2020 (Figure 22)[133].

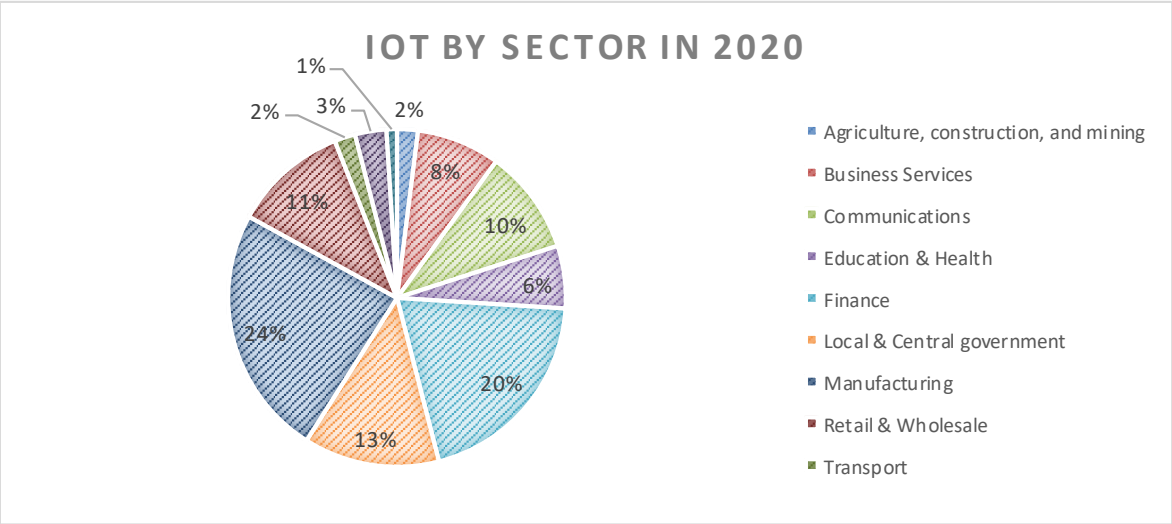

Figure 22 IoT by sector in 2020

[132] Ibid.

[133] Ibid.

The potential of IoT is huge, but several studies point to the fact that many businesses are still in the early stages of IoT adoption, where its use is limited to a single business function, rather than being committed to a formal business–wide program[134]. As regard the role of SMEs in IoT adoption, the report 'Definition of a Research and Innovation Policy Leveraging Cloud Computing and IoT Combination'[135] states that SMEs play a relevant role in the development of the emerging IoT combined ecosystems and their diffusion. They mainly refer to the role SMEs can have in the supply ecosystem, and state that SMEs currently have insufficient capability to enter this market. One of the recommendations is to increase their capability, and to facilitate their access to the necessary technology platforms to develop applications and services. SMEs are primarily active in the group of ICT vendors – providing components to solution providers. Examples include systems integrators, hard- and software providers and cloud service providers. The role of SMEs within this IoT ecosystem can be more substantial, adopting IoT on a larger scale. Several factors are preventing SMEs from doing so: insufficient investments and organisational barriers to change, concerns about privacy and data protection, mismanagement of security risks, and a lack of standards and interoperability across fragmented European markets preventing economies of scale and scope[136].

Focussing on the user-side, the Vodafone IoT Barometer[137] shows that the proportion of companies using IoT (adopters) has more than doubled since 2013: Adoption has risen from 12% in 2013 to 29% in 2017. This conclusion is based on research among 1,278 respondents (30% SMEs) globally. Furthermore, 84% of adopters agree that their adoption/use of IoT solutions has grown in the last 12 months. IoT is impacting almost every sector, and an increased use of IoT can be noticed across industries. Larger organisations show higher adoption rates but compared to 2013, smaller companies are much closer in 2017.

2.4.4. Cybersecurity

In the cybersecurity industry, one can distinguish between companies active in developing and providing cybersecurity solutions (supply side) and companies that use cybersecurity solutions to ensure continuity of their business operations. Starting with the latter, the potential number of SMEs that might use cybersecurity solutions is enormous, given that ensuring cybersecurity is key for every SME connected to the Internet.

In their 2016 study on Information security and privacy standards for SMEs[138], ENISA concludes that despite rising concerns on information security risks, the level of SMEs' information security and privacy standard adoption in Europe is relatively low. Equally, their uptake is not largely perceived as a priority. This is in line with the 2018 Hiscox small business cyber-risk report[139], stating that seven in 10 businesses globally are

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[134] Among others: Information Age (2017), US and Europe businesses lag behind in IoT adoption. Published February. Available at: http://www.information-age.com/us-europe-businesses-lag-behind-iot-adoption-123464372/ & Capgemini (2018), Unlocking the business value of IoT in operations. Available at: https://www.capgemini.com/wp-content/uploads/2018/03/dti-research_iot_web.pdf

[135] European Commission (2014), Definition of a Research and Innovation Policy Leveraging Cloud Computing and IoT Combination. Available at: http://ec.europa.eu/newsroom/dae/document.cfm?doc_id=9472

[136] Ibid.

[137] Vodafone (n.d.), IoT Barometer 2017/18. Available at: http://www.vodafone.com/business/news-and-insights/white-paper/iotbarometer

[138] Enisa (2016). Information security and privacy standards for SMEs. Published June. Available at: https://www.enisa.europa.eu/publications/standardisation-for-smes

[139] Hiscox (2018), Small business cyber risk report. Available at: https://www.hiscox.com/documents/2018-Hiscox-Small-Business-Cyber-Risk-Report.pdf

unprepared for a cyber-attack. Small businesses are disproportionately vulnerable because they are less likely to have strategies in place to avoid attacks, detect them early, and reduce the damage. In the US, 65% of small businesses fail to act after a cyber-incident.

Effectively ensuring cybersecurity is not limited to having technological solutions in place. SMEs need to implement formal information security processes, technical mechanisms and organisational measures, embedded in a solid cybersecurity policy. The existence of an ICT security policy would imply an enterprise's strategy to safeguard data and ICT systems as well as mandatory obligations for all employees. With such a policy, companies can address several risks, with the risk of destruction or corruption of data due to an attack or some other unexpected incident being the risk mostly addressed by enterprises' ICT security policies. The Eurostat Community survey on ICT usage and e-commerce in enterprises looked at adoption rates of ICT security policies and found that the share of large enterprises that had a formally defined ICT security policy was almost three times the share of small ones[140] (figure 2-19).

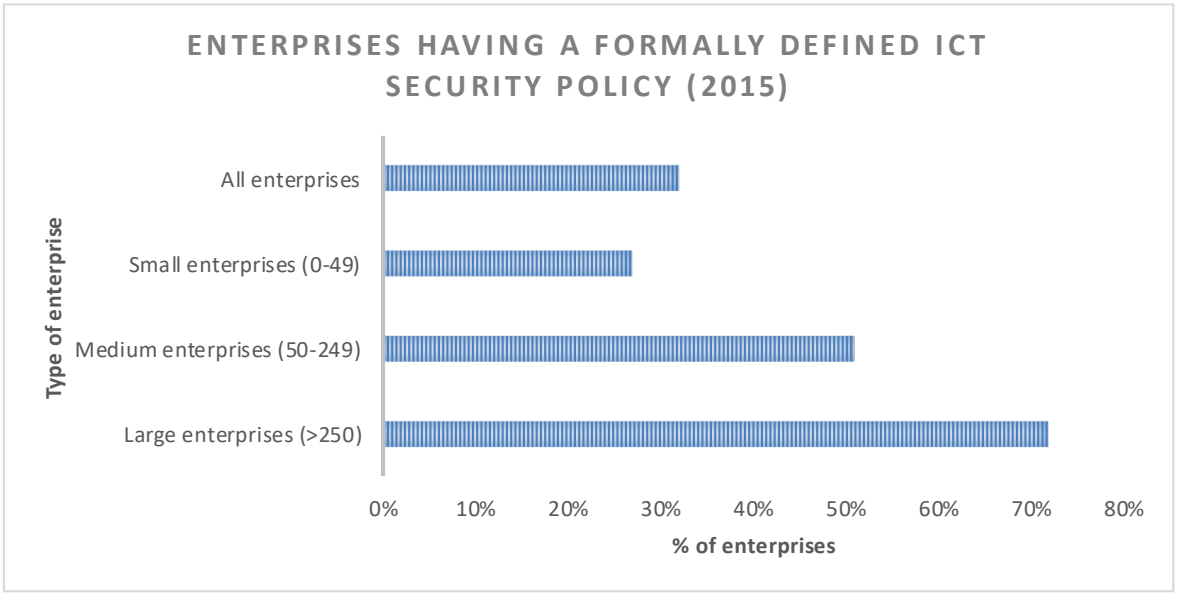

Figure 2-19

Company size clearly plays a role, with SMEs lagging substantially behind larger enterprises. Some countries are more advanced than others. On average, 32% of the enterprises in the EU28 had a formally defined ICT security policy in 2015, but shares of 51% and 49% were registered in respectively Sweden and Portugal[141]. Frome a sectoral perspective, enterprises in the ICT sector are most likely to have such a policy in place (60% of enterprises), followed by enterprises active in professional, scientific and technical activities (49%). Lowest shares were found in the construction sector (20%) and real estate (25%).

Zooming in on the degree to which SMEs actually adopt specific measures aimed at reducing their risk of becoming a victim of cyber criminals, evidence shows that there is a lot of room for improvement. For instance, according to the UK Government 2015

[140] Eurostat (2015), ICT security in enterprises. Available at: http://ec.europa.eu/eurostat/statistics-explained/index.php/ICT_security_in_enterprises

[141] Ibid.

Information Security Breaches Survey[142], only 49% of SMEs participating in the survey had conducted a security risk assessment in the previous year. Furthermore, research from the Dutch Chamber of Commerce shows that 88% of SMEs have installed virus scanners on company PCs[143]. Other measures taken by the majority of SMEs includes running frequent back-ups, checking the details of invoices and installing firewalls on company PCs (figure 2-20). At the same time, a substantial part of SMEs remains unprotected against digital fraud, as a result of lacking basic measures (e.g. virus scanner, firewall).

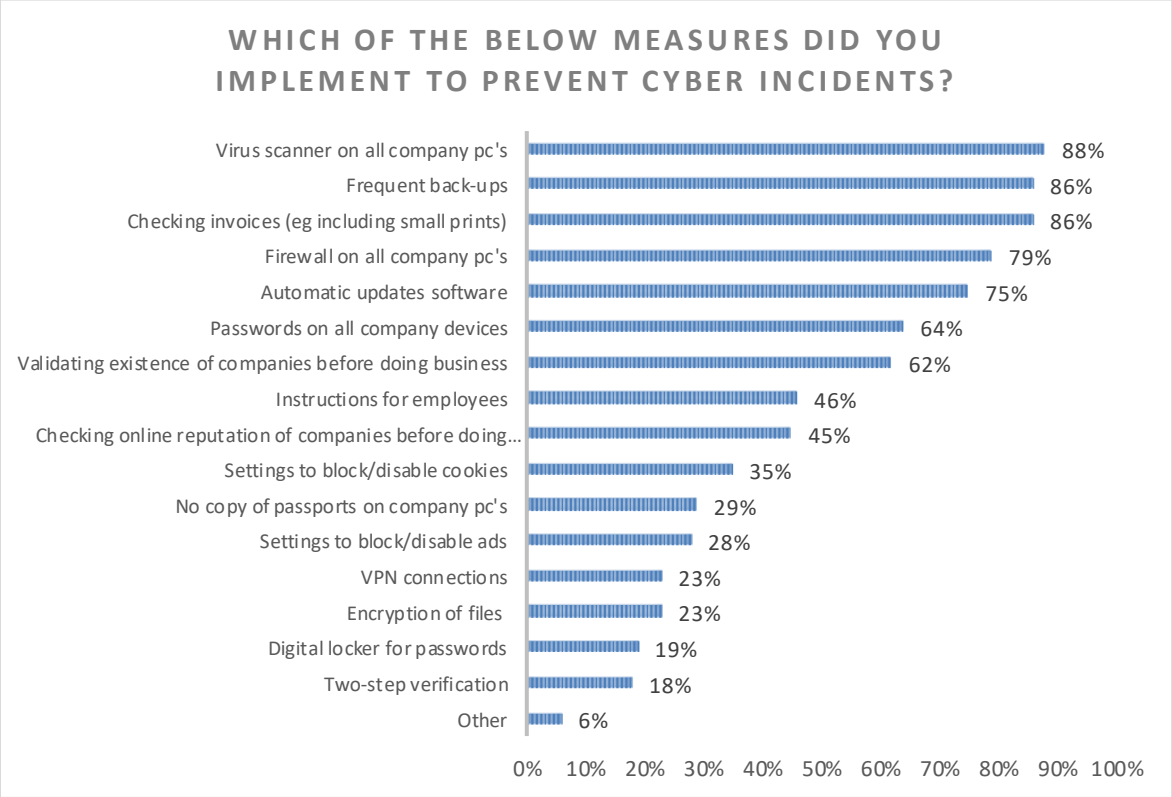

Figure 23 Measures implemented by SMEs to prevent cyber incidents

The industry in which an SME is active and the size of an SME influence their likelihood of protecting themselves against cybercriminals. Firstly, the industries, best protecting themselves against digital fraud in terms of measures taken, are: ICT and media, the industry, finance, and the professional services sector[144]. The agricultural sector and the construction industry are the least protected sectors. Secondly, micro-enterprises (up to 10 employees) are less likely than larger SMEs (10-250 employees) to implement security measures, underlining again the factor company size.

Taking the perspective of cybersecurity suppliers, the European market for suppliers of cybersecurity solutions can be characterised as fragmented, which is one of the main

[142] Proposal for a Regulation on the protection of individuals with regard to the processing of personal data and on the free movement of such data. Available at: http://eur-lex.europa.eu/legalcontent/en/TXT/?uri=CELEX:52012PC0011

[143] Smetsers, D. & Van der Beek, J. (2017), Preventie door het mkb tegen ditigale fraude. Kamer van Koophandel. Published September. Available at: https://www.kvk.nl/download/Onderzoeksrapportage_Fraude_sept170920-2_tcm109-449039.pdf

[144] Ibid.

barriers to the development of a strong European cybersecurity industry[145]. Unfortunately, reliable recent sources about the European cybersecurity industry in terms of number of enterprises, turnover or employees are scarce[146]. Following a study published in 2009[147], the EU market has been dominated by a small group of global vendors, competing with a high number of smaller European suppliers. Back then, the top five vendors controlled 20.4% of total market (and they all came from outside the EU)[148]. A more recent ECSO position paper estimates the number of companies active in the EU cybersecurity market at a level of 60,000 companies, of which 98% are SMEs and start-ups[149].

Following another report prepared by ECSO[150], the European industry can be divided into three parts: high grade, low grade and mid-grade cybersecurity. High grade refers to a niche market for companies originating from the defence sector. Given restrictions on public procurement, a protected and high-level European offer has been developed. The low-grade cybersecurity market is largely dependent on non-European companies. As the offer for the general public, Business-to-Consumer (B2C), is mainly based outside Europe, new European companies entering the market are often acquired by non-European actors. Players such as Microsoft, IBM, CISCO, Symantec are dominating this market, often offering end-to-end solutions combining the implementation of network protection strategies with governance solutions and identity access management services. The mid-grade European cybersecurity market refers to the protection of critical infrastructures and public authorities is quite dispersed, and SMEs play an important role here. The large majority of the thousands of European companies active in this area are SMEs having a turnover under 5 million EUR and less than 50 persons. They are highly specialised in one area and do not offer the whole range of cybersecurity solutions. These SMEs operate in specific niches in domestic markets, with low levels of internationalisation.

An analysis of the French cybersecurity market and actors within it sheds some more light on the take-up of SMEs and the role SMEs play in the cybersecurity ecosystem[151]. The French market for cybersecurity solutions is highly polarised, relying on a very few big players on the one hand and a galaxy of small, to very small, companies on the other hand, with only a few medium-sized companies. SMEs are mainly operating in three sub-sectors: 1) training, consulting and services; 2) encryption, signature and authentication

[145] European Parliamentary Research Service (2017), Achieving a sovereign and trustworthy ICT industry in the EU. Published December. Available at: http://www.europarl.europa.eu/RegData/etudes/STUD/2017/614531/EPRS_STU(2017)614531_EN.pdf

[146] Ibid.

[147] IDC & Government Insights (2009), The European network and information security market: Scenario, trends and challenges. Report prepared for the European Commission. Available at: http://ec.europa.eu/information_society/newsroom/cf/dae/document.cfm?doc_id=2153

[148] Ibid.

[149] ECSO (2017), Position paper: Initial position on the EU cybersecurity package. Report prepared for the European Commission. Published October. Available at: http://www.ecs-org.eu/documents/uploads/ecso-position-paper-on-cybersecurity-package.pdf

[150] ECSO (2016), European cybersecurity industry proposal for a contractual public-private partnership. Published June. Available at: http://ecs-org.eu/documents/ecs-cppp-industry-proposal.pdf

[151] Direction Générale des Enterprises (2015), Analyse du marché et des acteurs de la filière industrielle française de sécurité. Published November. Available at: https://www.entreprises.gouv.fr/etudes-et-statistiques/analyse-du-marche-et-des-acteurs-la-filiere-industrielle-francaise-securite

tools; and 3) analysis, detection and mapping tools[152]. Whereas many SMEs are exclusively focusing on cybersecurity solutions, for the key players dominating the market – e.g. Atos, Orange, Airbus, Thales in France - cybersecurity is often only one of the several offerings they have in their portfolio.

A report analysing the United Kingdom cybersecurity market comes to the same conclusions, by characterising the market as being complex and fragmented. More forward-looking, they state that the cybersecurity market will only become more diverse over the next ten years as a much greater array of devices become interconnected and the targets for cyber-attacks evolve[153].

2.5. Barriers and drivers for the take-up of the technologies

BIC technologies hold significant potential value for European SMEs but unlocking the value of these technologies can be cumbersome. While 70% of SMEs realise they need to do something now, only 17% knows what to do[154]. Several different barriers hinder SMEs to reap the full benefits of these technologies. Barriers hindering SMEs to benefit from new technologies are important to address, as they result in delayed innovation and incapacity to adopt new technologies. For instance, with limited abilities to work with data analytics, European companies will not be able to compete in global markets and SMEs and emerging companies are the ones set to lose the most[155]. This section firstly describes the barriers for SMEs to adopt BIC technologies, and then zooms in on specific barriers for skills development.

2.5.1. Barriers for adopting emerging technologies

The most-cited[156] barrier for SMEs to adopt (one of) the three technologies is a lack of resources. The lack of resources includes shortages of human capital and insufficient financial capacity for the technologies and to compensate for the lack of human capital. These and other barriers are presented below.

(1) **Human capital**. In general, interviewees indicate Europe has a specialised skills shortage relevant to these technologies. People with the most essential skills for these technologies are in high demand and cost a premium to hire. Attracting staff with specialised skills is done in competition with large companies that offer high(er) salaries. If an SME manages to hire a person with relevant specialised skills, retention remains a challenge. Access to skilled labour is the number one

[152] CyberWorld (2017), The French cybersecurity industry: Its role in creating a European cybersecurity market. Published November. Available at: https://cyberworld.news/opinion-analysis/french-cyber-security-industry-role-creating-european-cyber-security-market/

[153] Pierre Audoin Consultants (2013), Competitive analysis of the UK cybersecurity sector. Published July. Available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/259500/bis-13-1231-competitive-analysis-of-the-uk-cyber-security-sector.pdf

[154] The Association of Swedish Engineering Industries and Research Institutes of Sweden (2016), Svenska företags syn på sin digitalisering. Available at: https://www.swedishict.se/sites/default/files/pub/swedishict.se/about/rapport-sverige-digitaliserar-2016.pdf

[155] European Commission (2017), Enter the data economy: EU policies for a thriving data ecosystem. Published January. Available at: https://ec.europa.eu/epsc/sites/epsc/files/strategic_note_issue_21.pdf

[156] During the interviews. See Annex X for more details about the interviews.

obstacle to growth for Swedish SMEs[157]. Skilled labour is becoming more and more a pain: whereas in 2011 just above 20% of Swedish SMEs indicated it as an obstacle to growth, this increased to a level of 28% in 2017. To illustrate, only 7% of Dutch SMEs indicate that they do have the in-house expertise to work with big data[158]. The skills required to work with data not only refer to the technical skills needed, but also interpersonal skills and the more generic expertise to recognise the relevance of big data.

(2) **Financial resources**. SMEs have fewer resources to buy new technologies and less access to stable revenue. Their return on investment also tends to have a larger lag as their customer base tends to be smaller than that of larger companies. As a result, they tend to struggle to commit to long-term financial investments, which are essential to internalise these technologies. Financial constraints also reduce risk-taking by SMEs, as newly acquired technologies are costly investments. These investments should be solutions to their current problems and leave little room for experimentation.

(3) **Lack of understanding**. To benefit fully from BIC technologies, knowing where and how to invest is essential. This requires people in strategic positions to understand the potential within their business model. This awareness is too often lacking. Whilst this holds true for the uptake of any new technology, it appears that the complexity of these new data-heavy technologies is a particular challenge. SMEs tend to be less aware of the potential and the activities required for making for instance optimal use of data. Risk averse behaviour is common, 'business as usual' is favoured and results in a reluctance to experiment and invest. If there is an interest in investing in the right people and technologies by those in strategic positions in SMEs, they often lack knowledge of what they need and how to obtain this.

(4) **Company size.** The adoption of digital technologies varies strongly with company size. In Europe, larger companies are much more likely to adopt digital technologies such as big data than SMEs[159]. As for the big data area, companies with an annual turnover less than 250,000 EUR generally do not see the added value of using big data. Companies with an annual turnover of over 1 million EUR do not doubt about the relevance of big data for their business. Growing companies also judge the relevance of (big) data more positively[160].

(5) **Characteristics of the SME owner/manager.** Interviewees indicate that tech-savvy, younger, owner/managers are more inclined to adopt new technologies. Examples were provided of situations in which the ownership of a family-owned

[157] Swedish Agency for Economic and Regional Growth (2018), Situation and Conditions of Enterprises 2017. Available at: https://tillvaxtverket.se/vara-tjanster/publikationer/publikationer-2018/2018-02-21-ratt-kompetens-till-foretagen.html

[158] Van der Veen, M., Smetsers, D., Van den Born, A. & Bosma, B. (2017), Ondernemen met (big) data door het mkb. Kamer van Koophandel and Jheronimus Academy of Data Science. Published January. Available at: https://www.kvk.nl/download/20170110%20Rapport%20Ondernemen%20met%20big%20data%20door%20het%20mkb_tcm109-431240.pdf

[159] European Commission (2017), Integration of digital technology. Available at: http://ec.europa.eu/newsroom/document.cfm?doc_id=44392

[160] Van der Veen, M., Smetsers, D., Van den Born, A. & Bosma, B. (2017), Ondernemen met (big) data door het mkb. Kamer van Koophandel and Jheronimus Academy of Data Science. Published January. Available at: https://www.kvk.nl/download/20170110%20Rapport%20Ondernemen%20met%20big%20data%20door%20het%20mkb_tcm109-431240.pdf

company is transferred from father to son. Personal experience with technology drives digital engagement of SMEs[161].

(6) **Lacking SME ecosystem.** The ecosystem of an SME contributes to its knowledge of and access to the technologies. Access, interconnection and exchange are important. SMEs in general tend to be adopters rather than inventors, unless research and innovation is their core business. While large companies may have innovation departments or in-house/co-funded incubators, SMEs tend not to be involved in the research and development of new technologies if it is not their core business. The following aspects of their ecosystem may influence an SME and its uptake of the technologies:

(a) SMEs that are primarily focused on research and innovation, and that work closely with academia and research organisations, have an advantage that makes them more likely to have the required skills to uptake the technologies;
(b) SMEs that are close to industrial clusters, or work for or with larger companies or other (public-private) partnerships are more likely to have access to up-to-date information and training. This makes them more likely to understand the benefits of the technologies (spill over effect);
(c) SMEs tend to be linked strongly in value chains, whereas larger companies are more likely to internalise functions. Such value chains create dependencies for SMEs, including risks of losing (part of) their position if they adapt to technologies that others do not wish to use.

(7) **Privacy and security concerns.** Privacy and security concerns may restrain companies from adopting emerging technologies. 34% of the small business in the US stated that privacy and security concerns are among their top three barriers to digital engagement[162].

The above barriers apply to all three technologies considered in this initiative. Barriers specific for each of the respective technologies are discussed in the following sections.

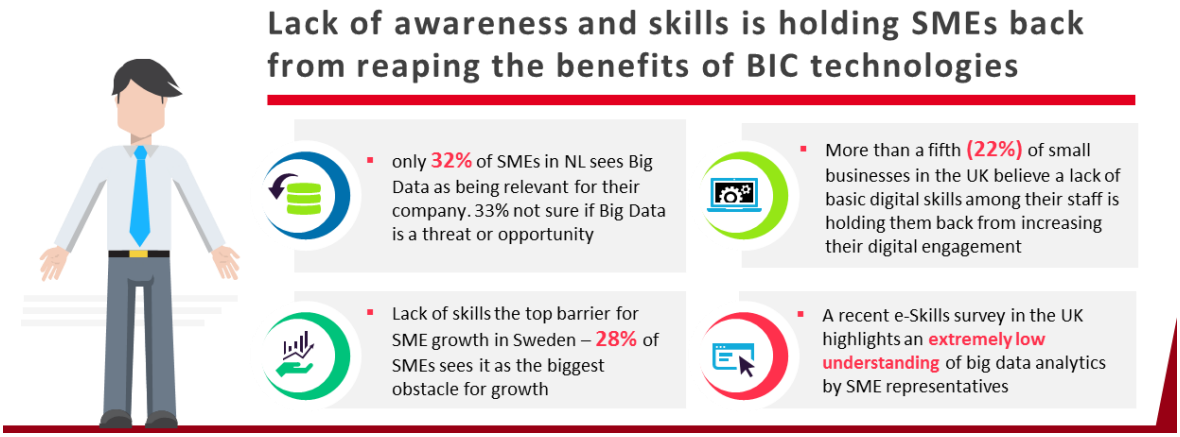

Figure 2-2124

[161] Deloitte (2017), Connecting small businesses in the US. Commissioned by Google. Available at: https://www2.deloitte.com/content/dam/Deloitte/us/Documents/technology-media-telecommunications/us-tmt-connected-small-businesses-Dec2017.pdf

[162] Deloitte (2017), Connecting Small Businesses in the US. Report prepared for Google. Available at: https://www2.deloitte.com/us/en/pages/technology-media-and-telecommunications/articles/connected-small-businesses.html

2.5.1.1. Specific barriers for adopting big data

Zooming in specifically on big data, a Dutch study focusing on the take-up of big data shows that in addition to the more generic barriers of respectively financial restraints, time restraints and a lack of expertise, data quality is also among the obstacles hindering SMEs to work with big data (figure 2-21). Releasing data and having a sufficient technical infrastructure in place are expected to be difficult.

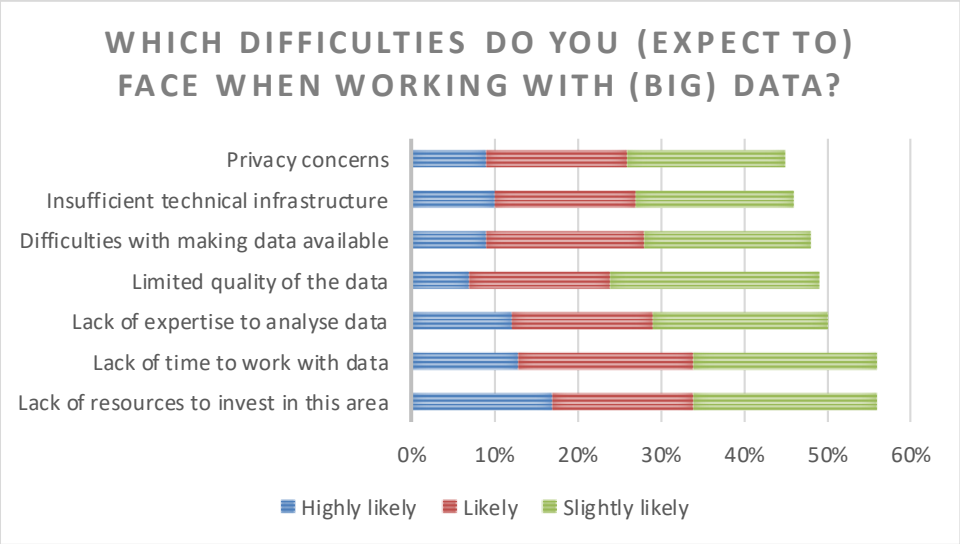

Figure 25 Difficulties faced by SMEs when working with big data[163]

Furthermore, the 2016 paper 'How Can SMEs Benefit from Big Data? Challenges and a Path Forward'[164] lists 14 factors that condition the poor adoption of business and big data analytics by SMEs, and they indicate the extent to which these barriers are related to what they classify as 'specific people and skills'. Among the barriers moderately related to people and skills are cultural barriers, shortage of affordable consulting and business analytics services, a non-transparent software market, a lack of intuitive software, and financial barriers. The four barriers classified as 'highly related to specific people and skills' are the following[165]:

(1) **Dominance of domain specialists**. As operating in a niche or specialised field is a strength of SMEs, the major part of the employees are domain specialists, with more generic functions poorly covered. This is not beneficial for spotting new business opportunities and trends outside of the respective domain, such as big data analytics.

(2) **Shortage of in-house data analytic expertise.** SMEs lack own employees with data analytics capabilities. In an Austrian survey[166], a lack of in-house data

[163] Van der Veen, M., Smetsers, D., Van den Born, A. & Bosma, B. (2017), Ondernemen met (big) data door het mkb. Kamer van Koophandel and Jheronimus Academy of Data Science. Published January. Available at: https://www.kvk.nl/download/20170110%20Rapport%20Ondernemen%20met%20big%20data%20door%20het%20mkb_tcm109-431240.pdf

[164] Coleman, S., Göb, R., Manco, G., Pievatolo, A., Tort-Martorelle, X. & M. Seabra Reis (2016), How Can SMEs Benefit from Big Data? Challenges and a Path Forward. Quality and Reliability Engineering International, Special Issue Article. https://doi.org/10.1002/qre.2008

[165] Ibid.

[166] Russegger, S., Freudenthaler, B., Güntner, G., Kieseberg, P., Stern, H. & F. Strohmeier (2015), Big Data und Data-driven Business für KMU. Digital Networked Data. Published May. Available at: https://www.salzburgresearch.at/wp-content/uploads/2015/06/Bericht-Roadblocks_final.pdf

analytics expertise was identified as a major barrier in the take-up of big data projects. Several factors play a role here[167]:

(a) High set-up costs, combined with uncertainty about future return on investments;
(b) Lack of management expertise to set up and embed a data analytics unit;
(c) Shortage of qualified workers and excessive staffing costs.

(3) **Bottlenecks in the labour market.** There is a growing shortage of qualified data analysts on the labour market. IDC studied the European data landscape, and forecasts that the structural imbalance between demand and supply will result in a data skills gap in 2020[168].

(4) **Lack of understanding.** A recent e-Skills survey in the UK[169] highlights an extremely low understanding of big data analytics by SME representatives, whereas among larger organisations, around 30% to 40% claim to have good or very good understanding of big data analytics. A recent Germany survey[170] portrayed a similar picture, with around 30% of respondents considering their big data knowledge to be good or very good.

2.5.1.2. Specific barriers for adopting IoT

The potential of IoT often is not realised. There are a number of reasons for this, of which security concerns and constrained analytical capabilities are amongst the most pressing barriers[171.] For IoT, SMEs need strong technological competences[172.] First, sensors increasingly generate huge volumes of data at a real-time basis. Companies would need a robust analytics platform to benefit from the growing volumes of structured and unstructured data – including the ability to 'clean' the unstructured data. Second, they need advanced analytics, and increasingly AI capabilities, ranging from descriptive to prescriptive analytics. Descriptive analytics are used to gain a granular view of the specific process that is being measured and monitored, and prescriptive analytics and AI to learn from past patterns and to anticipate on future developments. Third, the adoption of a 'security-by-design' approach is crucial to address cybersecurity threats.

IDC & TXT[173] state that ensuring SMEs' capability to enter the IoT market is a key challenge. Various obstacles need to be overcome: insufficient investments, organisational barriers to change, concerns about privacy and data protection,

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[167] Coleman, S., Göb, R., Manco, G., Pievatolo, A., Tort-Martorelle, X. & M. Seabra Reis (2016), How Can SMEs Benefit from Big Data? Challenges and a Path Forward. Quality and Reliability Engineering International, Special Issue Article. https://doi.org/10.1002/qre.2008

[168] IDC (2017), European Data Market Study Final Report SMART 2013/0063. Report prepared for the European Commission. Available at: http://datalandscape.eu/

[169] E-Skills UK (2013), Big Data Analytics Adoption and Employment Trends, 2012-2017. Available at: https://www.thetechpartnership.com/globalassets/pdfs/research-2013/bigdataanalytics_report_nov2013.pdf

[170] Vossen G, Lechtenbörger J, Fekete D. (2015), Big data in kleinen und mittleren Unternehmen - eine empirische Bestandsaufnahme. Westfälische Wilhelms-Universität Münster, Germany. Available at: http://www.wi1.uni-muenster.de/pi/iai/publikationen/BigData.pdf

[171] Capgemini (2018), Unlocking the business value of IoT in operations. Available at: https://www.capgemini.com/wp-content/uploads/2018/03/dti-research_iot_web.pdf

[172] Ibid.

[173] European Commission (2015), Definition of a research and innovation policy leveraging cloud computing and IoT combination. Published May. Available at: https://ec.europa.eu/digital-single-market/en/news/definition-research-and-innovation-policy-leveraging-cloud-computing-and-iot-combination

mismanagement of new security risk, and a lack of standards and interoperability across fragmented European markets – preventing economies of scale. Other barriers identified by Ericsson[174] include the lack of a convincing business case, security concerns and risks associated with change. A lack of qualified personnel is also among the barriers, and refers not only to the technical perspective, but also to difficulties with evaluating the value capture of IoT. The Internet of Things Business Index[175] highlighted a lack of IoT skills and knowledge as one of the top-three barriers holding businesses back from adopting IoT.

Adding to the above, in 2018 Capgemini[176] stated that the potential value associated with IoT is often going unrealised. IoT initiatives do not achieve their goals or reach a meaningful scale, with initiatives remaining stuck in a proof-of-concept stage. This is mainly the result of the inability to establish a clear business case, security concerns, constrained analytical capabilities and uncertainty about IoT standards and protocols.

2.5.1.3. Specific barriers for adopting cybersecurity

There are various specific barriers for the adoption of cybersecurity by SMEs. This is problematic not only because SMEs are already vulnerable to cyber threats, but also because security concerns are barriers for the adoption of both big data and IoT. The use of these new technologies brings new opportunities, but also introduces information security and privacy risks. There are many dimensions to effective cybersecurity and data protection—from strategy and operations, to governance and culture—but one of the biggest problems is simply the lack of talent[177]. Those companies that attract and retain cybersecurity talent will be much more successful in managing digital risk and profiting from big data and IoT. In 2015, ENISA stated that despite rising concerns on information security risks, the level of SMEs' information security and privacy standard adoption is relatively low[178]. The report clusters the barriers that contribute to the limited uptake of cybersecurity practices by SMEs in four categories[179]:

- Knowledge and engagement: awareness of standards, limited awareness of how standards add business value, prevailing perception that cyberattacks are mainly threatening large enterprises, design of standards mainly driven by larger enterprises;
- Capabilities and resources: the implementation of information security and privacy standards can be demanding in terms of financial resources. For SMEs that have internalised the ICT function, often one employee is responsible for security along with his/her other ICT responsibilities, resulting in limited time and dedication for

[174] Ericsson, Deloitte & DI Digital (2015), Every. Thing. Connected. A study of the adoption of 'Internet of Things' among Danish companies. Published July. Available at: https://digital.di.dk/SiteCollectionDocuments/Analyser/IoT_Report_onlineversion.pdf

[175] The Economist (2017), The Internet of Things business index 2017. Available at: https://www.eiuperspectives.economist.com/sites/default/files/EIU-ARM-IBM%20IoT%20Business%20Index%202017%20copy.pdf

[176] Capgemini (2018), Unlocking the business value of IoT in operations. Available at: https://www.capgemini.com/wp-content/uploads/2018/03/dti-research_iot_web.pdf

[177] Cagemini (2017), Cybersecurity talent: The big gap in cyber protection. Available at: https://www.capgemini.com/wp-content/uploads/2018/02/the-cybersecurity-talent-gap-v8_web.pdf

[178] ENISA (2015), Information security and privacy standards for SMEs. Recommendations to improve the adoption of information security and privacy standards in small and medium enterprises. Available at: https://www.enisa.europa.eu/publications/standardisation-for-smes/at_download/fullReport

[179] Ibid.

security practices. SMEs that have outsourced the ICT function may suffer from limited internal knowledge about cyber threats;

- Shortage of standards in specific areas: there are limited European or international standards designed to assist small organisations towards ensuring appropriate protection of personal data;
- Implementation aspects: Standards are often hard to understand for SMEs not having the inhouse expertise for translating standards into specific tasks and activities. Especially when there is a lack of clear implementation guidelines.

Digital transformation cannot take place without a solid cybersecurity approach. The more a company becomes dependent on ICT and the more a company embraces emerging technologies such as big data and IoT, the more crucial cybersecurity becomes. Moreover, measures aimed at addressing the barriers for cybersecurity will also positively affect the take-up of big data and IoT.

2.5.2. Barriers for skills development within SMEs

The previous section made clear that the availability of the necessary skills is one of the top barriers for SMEs to adopt emerging technologies. To boost further specialised skills development, it is not only necessary to ensure that future professionals become educated in these areas, but also current employees will need to develop their skills portfolio. To keep their skills relevant, employees will need to keep learning during their career. There are concerns about lifelong learning and education and training of grown-ups. For instance, in 2016, only 10.8% of adults aged between 25 and 64 years old participated in education and training[180]. Just under half (45%) of all persons employed by medium-sized enterprises and 46% of those employed by small enterprises participated in vocational training programmes in 2010[181]. Larger enterprises are far more likely than SMEs to provide training to their persons employed (figure 2-22).

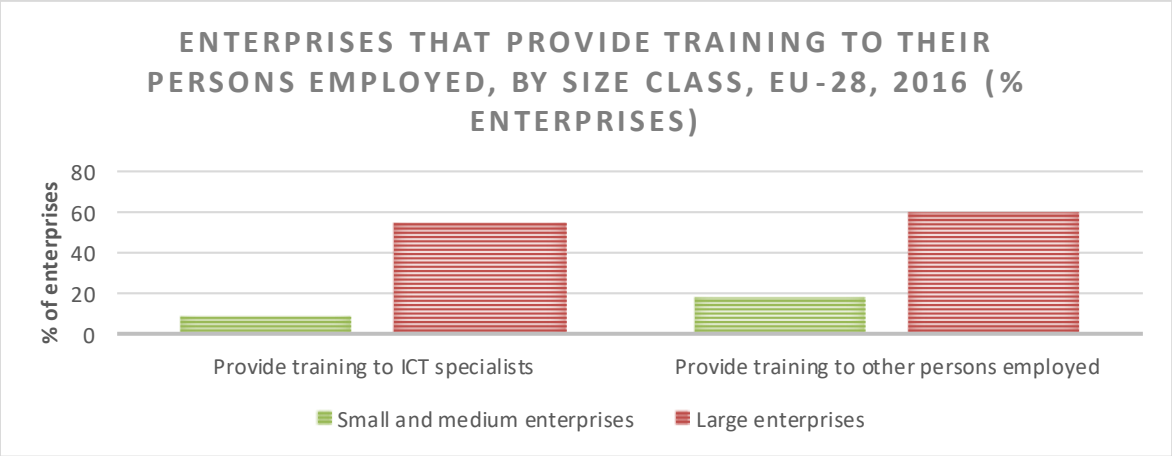

Figure 26 Enterprises that provide training[182]

[180] Eurostat (2017), Lifelong learning, 2011 and 2016. Available at: http://ec.europa.eu/eurostat/statistics-explained/index.php?title=File:Lifelong_learning,_2011_and_2016_(%C2%B9)_(%25_of_the_population_aged_25_to_64_participating_in_education_and_training)_YB17.png

[181] Eurostat (2017), Vocational education and training statistics. Available at: http://ec.europa.eu/eurostat/statistics-explained/index.php/Vocational_education_and_training_statistics

[182] Eurostat (2018), ICT specialists - statistics on hard-to-fill vacancies in enterprises. Published May. Available at: http://ec.europa.eu/eurostat/statistics-explained/index.php/ICT_specialists_-_statistics_on_hard-to-fill_vacancies_in_enterprises

When trying to meet their need for skills development, European SMEs face several barriers. These barriers can be clustered into three categories: SME internal barriers and obstacles for training, finding suitable methods and techniques for training and coping with current and structural challenges of competence development[183]. Concerning SME internal barriers, the barriers hindering SMEs most are the following:

(1) **Organisational barriers**. Company owners struggle with organising training for their employees especially within smaller firms, where each employee is needed every day, and where the absence of an employee directly impacts the daily operations;

(2) **Financial barriers**. Sending employees to (external) trainings has a financial impact on a company. They might not only need to pay for the training itself, but the absence of employees can also have an impact on revenues. It is difficult for micro businesses and small firms to find the financial resources needed to offer training to their employees[184].

(3) **HR and skills development policy**. Compared to larger enterprises, HR processes and skills development are not organised in a systematic way or with a long-term approach within SMEs. This might hamper a continuous focus on skills development.

(4) **Perception of training needs.** SME owners do not always perceive training as important. This might have to do with cultural particularities of a certain sector, a lack of opportunities or a lacking long-term approach, with SME owners not seeing the direct benefit of training. Training is often done informally on the job. For SMEs, it is difficult to determine the quality and alignment of training offerings to their needs.

(5) **Resource pooling and SME cooperation.** The involvement in networks, cooperation or cluster activities enable SMEs to engage more effectively in ongoing training and skills development. However, solid SME networks or clusters are not yet reality everywhere across Europe, and it requires managerial capabilities to become anchored in such networks.

With regards to suitable methods and techniques for training, the barriers hindering SMEs most are the following:

(1) **Training methods often do not fit the specific needs of SMEs**. Training programmes and methods available on the market are too often unsuited to the size and needs of SMEs[185], both in content and in form.

(2) **Lack of training and competence development for managerial staff**. The smaller a company, the more the performance of such a company is dependent on the owner or manager. The continuous development of skills and knowledge of managers is therefore of crucial importance. As compared to managers in larger companies, those in SMEs less often have an initial training period in management

[183] European Commission (2009), Guide for training in SMEs. Available at: http://ec.europa.eu/social/BlobServlet?docId=4202

[184] European Commission (2009), Guide for training in SMEs. Available at: http://ec.europa.eu/social/BlobServlet?docId=4202

[185] Ibid.

schools[186]. In the current rapidly evolving business environment, continuous upskilling might be needed to meet changing demands.

(3) **Recognition of skills and competences is challenging**. Informal learning processes are an important means to boost further firm performance in SMEs. At the same time, documenting informal learning might be challenging. Documentation of learning leads to increased confidence. For individual employees, the recognition and validation of learning experiences is also important since it enhances their opportunities on the labour market[187].

With regards to addressing current and structural challenges of competence development, the most important barriers are the following:

(4) **Demographic change**. The European workforce is greying. Consistently low birth rates and higher life expectancy are transforming the shape of the EU's age pyramid[188]. Age management has become a challenge for companies in general, and in particular for SMEs.

(5) Against the background of demographic change, many SMEs struggle with retaining a qualified workforce and attracting new qualified talents[189]. The 'digital native' millennial generation will make up 75% of the workforce by 2020, but is difficult to retain as employees. A benefit SMEs have is that whereas only 18% of millennials believe large businesses are the ideal employer, 47% of millennials are more willing to work at an SME than at a larger company[190].

(6) **Internationalisation.** The emergence of global value chains forces SMEs to adapt themselves to global competition and allows them to benefit from new opportunities. Acting on a global playing field requires particular skills, for instance with regards to language, communication and cultural sensitivity.

2.5.3. Synthesis

The above three clusters of barriers for skills development emphasize that skills development is not straightforward for SMEs. Participating in training courses not only depends on internal factors such as capacity and financial resources, but also on the 'fit' between SME training demands and courses available on the market, and external factors such as internationalisation and demographic change. Hence, measures addressing skills development within SMEs should be developed from a holistic viewing point, taking into account various categories of barriers. Based on the above, seven categories of barriers can be identified, all containing multiple specific barriers. These barriers are explained in more detail in Table 5.

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[186] Ibid.

[187] Ibid.

[188] Eurostat (2018), Population structure and ageing. Published May. Available at: http://ec.europa.eu/eurostat/statistics-explained/index.php/Population_structure_and_ageing

[189] European Commission (2009), Guide for training in SMEs. Available at: http://ec.europa.eu/social/BlobServlet?docId=4202

[190] McMath (2017), Millennials will make up 75% of the workforce by 2020. Published November. Available at: https://blog.sodexoengage.com/big-businesses-vs-sme

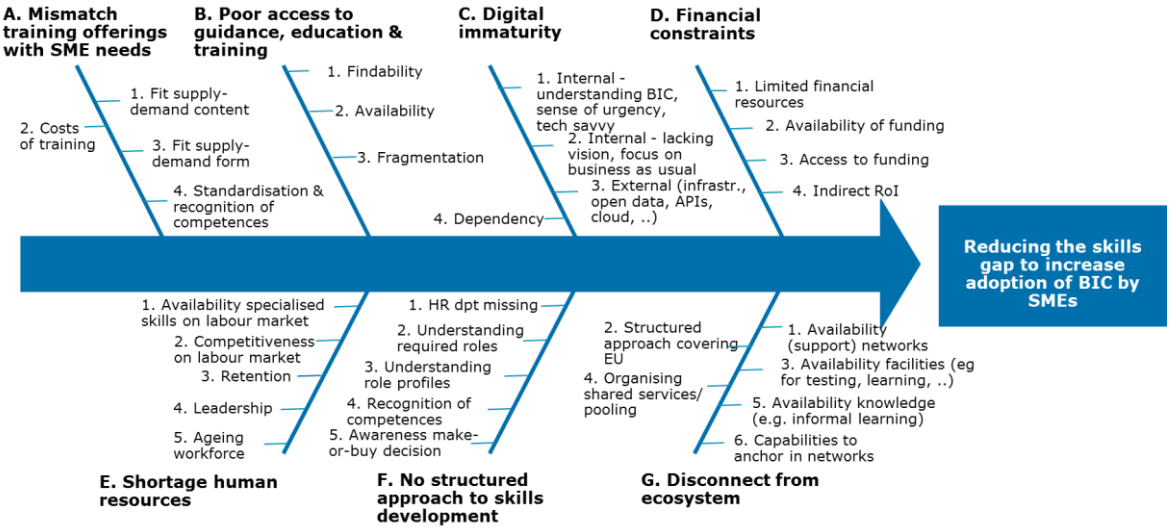

Figure 27 Synthesis of barriers for skills development in SMEs

Cluster	Explanation barriers
A. Training offerings	**1. Content**: Available trainings not tailored to specific needs of SMEs, e.g. too theoretical, not focusing on BIC specifically, in other languages;
	2. Form: Trainings are delivered in formats not always suitable for SMEs, e.g. too long, during work-hours, balance online/offline, etc.;
	3. Costs: Available trainings are often too costly for SMEs, who have to prioritise their investments because of limited financial resources;
	4. Standardisation & **recognition competences**: Available trainings are not part of widely accepted framework. Informal learnings processes are important for SMEs, but these learning experiences are not documented / validated.
B. Access to guidance, education & training	**1. Findability**: If trainings, tools and information are available, they are not always findable by SMEs and not made available at 'natural' places SMEs go;
	2. Availability: Specific trainings, tools and information in the area of BIC technologies are not always available for SMEs;
	3. Fragmentation: Guidance & training is sometimes available, but highly fragmented across Europe: in some regions, extensive support structures exist whereas in other regions hardly any information, tooling, training or other support is available.
C. Tech maturity	**1. Internal – tech savvy**: A lack of tech savviness of SME manager/owners leads to manager/owners not understanding the value of BIC technologies, or not recognising the sense of urgency to adopt BIC. Lack of tech savviness also contributes to managers/owners not knowing what types of products and services are appropriate to buy for their business. The lack of standards makes this even more complicated. It also makes SMEs dependent;
	2. Internal – operational focus: Too often, SMEs focus on the short term, on business as usual, and lack a long-term vision (e.g. on technology);
	3. External infrastructure: An external infrastructure focusing on the take up of emerging technologies (e.g. open data, APIs, open source solutions) might incentivize SMEs to develop the skills needed to adopt BIC.
	4.Dependency on external contractor: Less capacity to test and try out (linked to general financial risk above) and less know-how on negotiation of contract terms for service level agreements, thus a higher risk of agreeing to unfavourable or unnecessary ones.
D. Financial resources	**1. Limited financial resources**: It is difficult for SMEs to find the financial resources needed to offer training to their employees;
	2. Availability of funding: Support in the form of funding has proven to be effective (e.g. Skillnet IE), but is not equally available throughout the EU;
	3. Access to funding: If funding is available, SMEs might not be aware or do not know how to get access to funding. Being connected or embedded in networks facilitates access to funding;
	4. Indirect Return on Investment (ROI): SMEs have limited financial resources. The return on training investments tends to have a relatively large lag. As a result, they tend

Cluster	Explanation barriers
	to struggle to commit to long-term financial investments, which are essential to internalise BIC technologies.
E. Human resources	**1. Labour market**: the availability of specialised BIC skills are scarce on the market;
	2. Competitiveness on labour market: To attract talents, SMEs need to compete with big corporates who can afford higher salaries. At the same time, SMEs might benefit from 'millennials' who might appreciate the flexibility, agility and start-up culture of SMEs;
	3. Retention: Even if one is able to attract BIC talents, retention remains a challenge in today's competitive labour market;
	4. Leadership: The smaller a company, the more the performance of such a company is dependent on the owner or manager. The continuous development of their skills and knowledge is of crucial importance;
	5. Greying workforce: Age management has become a challenge for companies in general, and in particular for SMEs
F. Awareness skills needs	**1. HR department**: HR processes and skills development are often not organised in a systematic way or with a long-term approach within SMEs;
	2. Awareness roles required: Perception and awareness of roles required to build the capabilities to adopt BIC;
	3. Awareness skills needed: Perception and awareness of competences required (training needs) per role. Standardisation of roles;
	4. Standardisation & recognition competences: Available trainings are not part of widely accepted framework. Informal learnings processes are important for SMEs, but these learning experiences are not documented / validated;
	5. Awareness make-or-buy decision: Difficulties with decision to internalise skills or to hire skills on the market – lack of standardisation. This creates difficulties in professional commissioning.
G. Ecosystem / network	**1. Availability networks**: The involvement in networks, cooperation or cluster activities enable SMEs to engage more effectively in ongoing training and skills development;
	2. Structured approach: Availability of support structures throughout the EU. Currently fragmented and not coordinated at EU level;
	3. Availability facilities: Facilities for testing and learning (e.g. incubators) are not always available;
	4. Organising shared services: Shared services (pooling of companies) within a network can be beneficial, but can be perceived as difficult to organise;
	5. Available knowledge: both tacit and explicit knowledge cannot always tapped in to (peers, knowledge institutes, big corporates);
	6. Managerial capabilities: SME manager/owners need to have the capabilities to become anchored in networks/clusters/ecosystems.

3. SKILLS REQUIREMENTS RELATED TO BIG DATA, INTERNET OF THINGS AND CYBERSECURITY

The previous section underlined that lack of access to skills is one of the top barriers hindering SMEs to adopt BIC technologies. However, what are actually the competences needed to work with these technologies, and where is the mismatch between the skills needed by SMEs and the skills available most prominent? This chapter firstly describes generic and overarching skills needed to work with BIC technologies. It then zooms in on the specialised skills needed to work with each of the three technologies, by presenting specific skills profiles (section 3.2 – 3.4). This chapter concludes with describing skills gaps in section 3.5: areas where demand and supply for specialised skills do not match and where action is needed.

3.1. Generic skills

In general, skills requirements are evolving fast. The technological landscape changes rapidly, with skills requirements changing accordingly. Businesses are already having difficulties finding the right people. In 2015, 40% of businesses in the EU reported having difficulties in finding employees with the right skills[191]. This might even become worse in the near future, as 9 out of 10 jobs will require digital skills[192], and currently only 57% of Europeans has a basic level of digital skills[193].

As for the actual uptake of big data, IoT and cybersecurity, interviewees stress the importance of technological expertise ('hard' skills), soft skills (or personal, transversal skills) and business expertise and the combination thereof. These skills areas are summarised in figure 3-1.

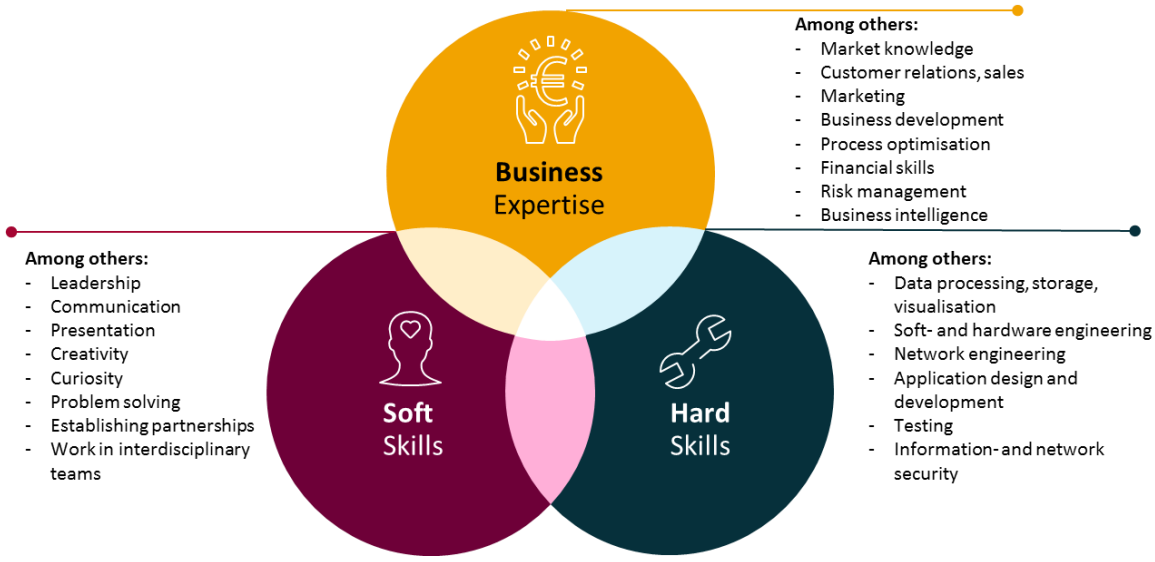

Figure 28 Skills areas needed and examples of specific skills[194]

[191] Cedefop (2015), Skill shortages and gaps in European Enterprises. Available at: http://www.cedefop.europa.eu/files/3071_en.pdf

[192] European Commission (2017), The digital skills gap in Europe. Published October. Available at: https://ec.europa.eu/digital-single-market/en/news/digital-skills-gap-europe

[193] Ibid.

[194] Based on desk research and interviews

Hard skills refer to the mere technical skills needed to work with big data, IoT and/or cybersecurity. These skills are often highly specific in nature and particular to an occupation[195]. An example is the ability to acquire, structure and clean data for analysis. The analysis and subsequent ability to extract insights and value from data is also a hard skill, including working with tools such as SQL, Hadoop and Python. Typical jobs requiring a deep technical expertise include software engineers, programmers, data scientists, algorithm developers and security specialists.

Soft skills are transferable skills that everyone has and that everyone uses, like the ability to work in a team, leadership, creativity, collaboration, the ability to establish partnerships, communication skills and problem-solving[196]. They are also called transversal skills, or (inter)personal skills.

Business expertise refers to a set of skills essential to run a business, such as a basic knowledge of financial accounts, business development skills and risk management, the ability to form business and skills development strategies in a company, the ability to select appropriate and relevant technologies, and domain knowledge (e.g., understanding a specific market).

The importance of both hard skills, soft skills and business expertise is in line with conclusions drawn from the literature. A French study[197] for instance distinguishes three core skills areas for working with cybersecurity: technical skills (e.g., protection of applications, access and identity management, security audit), functional skills (information protection, business continuity management, cybersecurity supervision) and transferable skills (adaptability and flexibility, confidentiality, intellectual curiosity). Furthermore, in the UK, small businesses consider technical skills, communication skills and self-management skills the most important skills for the future growth of their business. In ICT-related fields, research in the UK identified five different skill sets required in future employees: Security skills; business skills (balancing technical skills with wider business objectives); technology-specific skills; interpersonal skills; and analytical/research skills (e.g., to interpret operational data) [198]. Small businesses consider technical skills as most important for the future growth of their company.

[195] Eqavet (n.d.), Soft skills. Available at: https://www.eqavet.eu/eu-quality-assurance/glossary/soft-skills

[196] UNESCO (2016), Glossary article: soft skills. Published December. Available at: https://unevoc.unesco.org/print.php?q=Glossary+article:+soft+skills

[197] OPIIEC (2017), Les formations et les compétences en France sur la cybersécurité. Available at: https://www.fafiec.fr/images/contenu/menuhaut/observatoire/etudes/2017/cybers%C3%A9curit%C3%A9/21-05-2017_Etude_cybersecurite_infographie.pdf

[198] E-Skills UK (2012), Technology insights 2012. Available at: https://www.thetechpartnership.com/globalassets/pdfs/research-2012/technologyinsights_2012_ni_15jan13.pdf

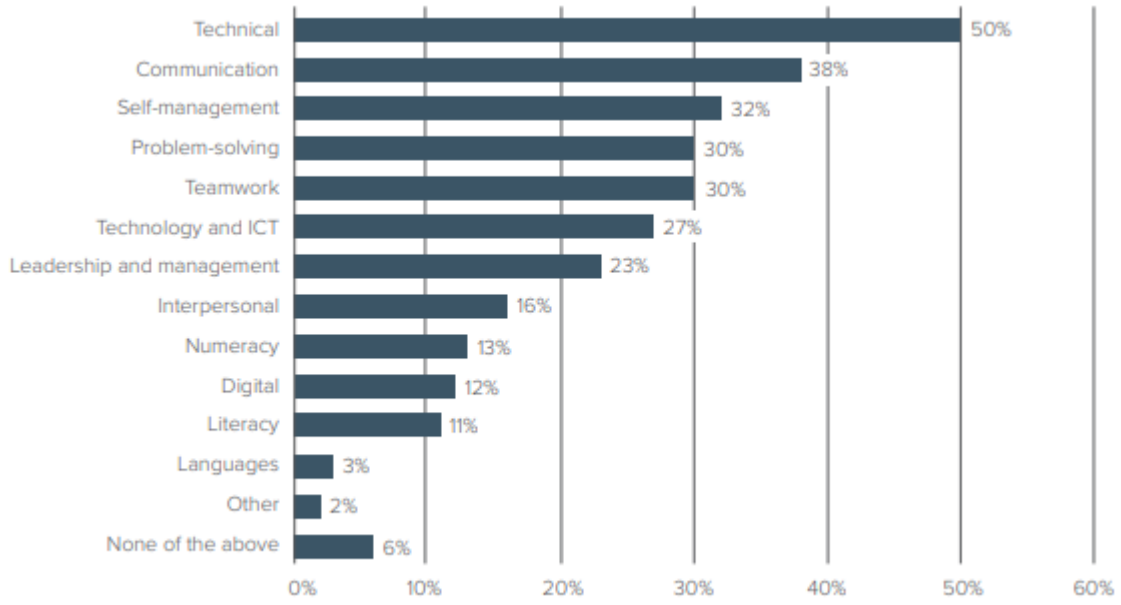

Figure 29 Skills SMEs consider most important to their future growth (2017)[199]

This is not entirely consistent with the view of interviewees. In general, they confirm the need for technically skilled workers, but they tend to put even more emphasis on the importance of soft skills and business expertise. Business expertise in this context refers among others to the ability to understand the basics of emerging technologies and its implications for an SME's business model. Furthermore, experts argue that for SMEs, soft skills might be even more important than for larger enterprises. As SMEs might have difficulties with attracting digital talents due to limited financial resources, they might overcome this competitive disadvantage by connecting and collaborating with others (more on skills strategies in section 4). This requires the skills to connect, communicate, establish partnerships and to work together.

[199] Peate, A. (2017), Learning the ropes: Skills and training in small businesses. Published December. Available at: https://www.fsb.org.uk/docs/default-source/fsb-org-uk/skills-and-training-report.pdf?sfvrsn=0

BIC technologies

SMEs suffer from a lack of both ICT specialists and e-leaders

In the future, **9 out of 10** jobs will require digital skills.

However, evidence shows that today, only **57%** of Europeans has sufficient basic digital skills.

There were **8.2 million** ICT specialists in the EU in 2016, up from **7.3 million** 3 years earlier. However, the supply of ICT specialists cannot keep pace with demand: it is estimated that there will be over 500,000 unfilled vacancies for ICT professionals by 2020

For e-leaders, it is estimated that there will be a gap of up to **250,000** e-leaders by 2020 in Europe. Around **70%** of e-leaders are found in SMEs.

Specifically, for BIC technologies, the situation is even worse

Data specialists accounted for (far) less than **1%** of total employment in most Member States, but demand for data specialists is increasing fast.

Data

In the UK, the demand for 'big data' specialists is forecasted to increase by **160%** between 2013 and 2020, and estimated to represent an additional **346,000** big data jobs

Another lesson drawn from the interviews is that SME managers/owners tend to overestimate the complexity of big data technologies. They may associate big data with enormous datasets and complex algorithms in a programming language most people do not understand. This can be the case, but data analytics is not necessarily about complex algorithms. For an SME, even a basic Excel sheet combining customer characteristics and sales data can be used to derive valuable insights from. Various sources suggest curiosity is the main skill that people working with data should possess[200] [201]. This again underlines the importance of soft skills. Domain knowledge is then necessary to derive insight from the data and understand the implications[202].

Taken together, persons working with these technologies needs to possess a diverse range of interdisciplinary skills, which are difficult to find united in a single person. The importance of interdisciplinary skills is also reflected by the increasing demand for so-called "T-shaped professionals"[203]. These professionals possess a deep knowledge about a specific area of expertise and have the ability to apply knowledge across multiple situations.

The "T-shaped Professionals" are in high demand for their ability to innovate, advance research, build relationships and strengthen their organisation. They are sought after because of problem complexity and the pace of change. Complexity means the number of areas of knowledge that must be combined to solve problems is growing. Almost every unsolved problem today requires different disciplines - engineers, managers, behavioural and social scientists, communications, and policy makers – to work together[204]. The T-shaped professional can be recognised for two main characteristics:

- Depth of knowledge - The vertical stroke of "T" represents the knowledge of the person in the respective field (discipline, system). The current education system is mainly producing I-shaped professionals with disciplinary knowledge about a particular industry. To understand the system, one must know how it functions from top to bottom. They must have intelligence regarding analytical thinking & problem solving.
- Breadth of expertise - The horizontal stroke of "T" represents the ability to apply knowledge across multiple situations. It is made up of empathy and enthusiasm about other people's disciplines. To create an innovative and creative process one has to be actively part of a wide range of activities with the industry that acknowledges particular expertise. It requires skills such as teamwork, communication, networking, critical thinking, and project management.

[200] Calugar, O. (2015). The curiosity advantage: the most important skills for data science. Published July. Available at: https://conferences.oreilly.com/strata/big-data-conference-uk-2015/public/schedule/detail/39814

[201] Davenport, T. H. & Patil, D. J. (2012). Data scientist: The sexiest job of the 21st century. Published October. Available at: https://hbr.org/2012/10/data-scientist-the-sexiest-job-of-the-21st-century

[202] Carrara, W., Fischer, S., & Van Steenbergen, E. (2015), Analytical report 2: E-skills and open data. Published December 2015. Available at: https://www.europeandataportal.eu/sites/default/files/edp_analytical_report_n2_-_e-skills.pdf

[203] Crider, K. (2015), Bridging the gap to the future by investing in T-shaped professional development. Published November. Available at: https://trainingindustry.com/articles/it-and-technical-training/bridging-the-gap-to-the-future-by-investing-in-t-shaped-professional-development/

[204] J.C. Sphorer, eSkills Manifesto 2016

Figure 30 The T-shaped professional[205]

There are several reasons why T-shaped professionals are valuable to businesses[206]:

- T-shaped professionals are willing to keep on learning to keep their skills up to date;
- They are empathetic, which allows them to tackle problems from different perspectives – which is useful for smooth collaboration in a team;
- They have the analytical skills necessary to find solutions with a broad vision;
- They are good at solving problems because of their combination of wide knowledge and specialised expertise;
- T-shaped professionals are able to innovate, advance research, build relationships and strengthen their organisation.

These T-shaped professionals might be even more relevant for SMEs than for larger enterprises, as a single person might have to fulfil different roles within an SME because of SMEs' limited human resources.

This initiative focuses specifically on the skills requirements for three different roles within an SME, being managers, IT professionals and advanced users:

- Managers: Small business owner/managers who are responsible for managing (parts of) their company. Management is commonly defined as the alignment and coordination of multiple activities in an organisation[207];
- IT professionals: those who have the ability to develop, operate and maintain ICT systems and for whom ICTs constitute the main part of their job[208];

[205] Careers Unbound (2016), Hiring T-shaped professionals to build collaborative teams. Published March. Available at: http://www.careersunbound.com/hiring-t-shaped-professionals-build-collaborative-teams/

[206] Careers Unbound (2016), Hiring T-shaped professionals to build collaborative teams. Published March. Available at: http://www.careersunbound.com/hiring-t-shaped-professionals-build-collaborative-teams/

[207] Vitez, O. (n.d.), The definition of small business management. Available at: http://smallbusiness.chron.com/definition-small-business-management-3994.html

[208] OECD (2005), New perspectives on ICT skills and employment. Published April. Available at: http://www.oecd.org/internet/ieconomy/34769393.pdf

- Advanced users: competent users of advanced, and often sector-specific, software tools. ICTs are used as a tool for these users but are not their main job[209].

With regards to BIC technologies, interviewees state that managers should at least possess a basic knowledge of the implications of emerging technologies and the solutions available. At the same time, as a manager does not have to be a qualified accountant to understand financial accounts, they do not need highly specialised skills to understand the implications of new technologies.

As for both IT professionals and advanced users, interviewees argue that their skills requirements are evolving. Whereas in the past, they were highly specialised in a specific software tool and used to work for years with the same software, they should now increasingly be able to possess a helicopter view, as technology evolves fast and new ready-to-use solutions become easily available. For many IT professionals, this implies a shift from operational services to strategic services. This means that they can monitor market developments, assess the usefulness of new solutions and provide advice relevant to the business model of their organisation.

In general, working with BIC technologies requires closer collaboration between the manager, the IT professional and the advanced user. Interviewees state that too often, managers and IT professionals do not speak the same language. On the one hand, managers would need a digital strategy mindset, whereas IT professionals would need the technical skills but also a basic level of business understanding. Managers should be able to identify and organise the right processes and products, whereas IT professionals and advanced users should be able to provide on the one hand advice about solutions to be used within these projects and processes, and on the other hand to implement these solutions.

3.2. Specific skills

This section focuses on the specific skills needed to work with BIC technologies. To provide the foundation for the actual assessment of skills gaps, skills profiles can be developed for each of the three focus domains. The key competence areas that employees in SMEs should obtain to successfully work with one of the three technologies can be defined, further specified by using the European e-Competence Framework (e-CF). This is a common framework for ICT Professionals in all industry sectors. It provides a reference of 40 competences as applied at the Information and Communication Technology (ICT) workplace, using a common language for competences, skills, knowledge and proficiency levels[210]. Each key competence area is further detailed with the relevant e-CF competences, specifying for each target user the required level of proficiency[211].It is important to keep in mind that the skills profiles are simplified profiles, aiming to portray a generic picture of the skills needed. They not claim to be exhaustive and may vary between sectors and different maturity levels.

During the interviews, it was often mentioned that SME managers/owners not only lack awareness about the importance of BIC technologies. If they are aware of the benefits of a certain technology, they often do not know what is needed to work with it. The skills profiles developed for each of the technological areas provide SMEs with an overview of the competences they have to develop to work with big data, IoT and/or cybersecurity.

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[209] OECD (2005), New perspectives on ICT skills and employment. Published April. Available at: http://www.oecd.org/internet/ieconomy/34769393.pdf

[210] http://www.ecompetences.eu/

[211] For the methodology used for defining the skills profiles, please see Annex A.

This enables SMEs to assess the skills they currently have against the skills required, including proficiency levels.

Three different roles are included in the skills profiles: the manager, the IT professional and the advanced user. The skills they need to possess depend on many factors, from which the type of company is an important one. In this study, we distinguish between producers of BIC technologies and supplier of BIC technologies. As for the manager, the type of company does not substantially impact the required competences and proficiency levels. Whether being a producer or user of for instance big data, the competence 'Business Plan Development' is said to be equally important. The situation is different for the IT professional. Here, a clear distinction between users and producers is included in the skills profiles. On the producer side, IT professionals work on the development of solutions (e.g. software solutions) in the area of BIC technologies, for instance big data applications. This big data application can subsequently be purchased by 'users', who use this application to generate new insights. Although the IT professional might be involved on the user side as well, their role is different from the IT professional on the side of the producer. Whereas on the producer side IT professionals need to develop such an application, on the user side it is for instance important that the IT professional can assess the different applications available on the market, which requires an understanding of the functioning of this application, knowing what its advantages and limitations are. Roughly speaking, one can state that the required competences for the IT professional are equal for both the user and the producer, but that proficiency levels differ. Therefore, in each skills profile, the IT professional is further broken down into the user side and the supplier side. Then, for the advanced user, this role refers primarily to the user side. Here, it is important to note that 'the' user does not exist. For instance, in the big data area this may refer to either the data analyst, data steward or the data engineer. Therefore, although on a generic level we have included the required competences and proficiency levels in the skills profiles, for each skills profile this role is further specified and elaborated on below each table.

Lastly, it is important to note that the skills profiles presented for each technology do not include soft (or 'personal') skills and business expertise, while our analysis showed that these skills categories are important with respect to BIC technologies. Reason for not including it into the skills profiles is that the e-CF not yet covers soft skills and business expertise – although it is planned to include these categories in the update of the e-CF to version 4.0.

3.2.1. Big data

The e-competence skills required for deploying big data in an SME can be divided in eight fundamental core competence areas, as shown in Table 1. Firstly, qualified big data managers will need to develop a big data strategy, underlining the added value of big data for their company and how that added value can be generated. Secondly, the SME also demands business development skills, as to integrate the big data strategy (envisioned by managers), the technological possibilities (envisioned by IT professionals) and the core business of the SME (envisioned by advanced users). Then the several steps in the data value chain come into play. In the process of using big data, IT professionals and advanced users need to know how to collect relevant and reliable data. Then, IT professionals need to know how and where to safely and efficiently store data. Subsequently, the skills to analyse and visualise data are key for IT professionals and advanced users. After the collection, storage, analysis and visualisation of data, based on the data, managers should own the competence to make data-driven decisions. Since big data extends the volume and complexity of data, cybersecurity skills become fundamental as well to ensure data protection.

Skill/related e-CF competence	Managers	IT professionals		Advanced users
		Producers	Users	

Strategy making:				
A.1. IS & Business Strategy Alignment	5	-	-	-
Business development:				
A.3. Business Plan Development	5	4	4	3
Data collecting:				
A.6. Application Design	-	5	3	1
D.12. Digital Marketing	-	2	2	2
Data storing/warehousing:				
A.6. Application Design	-	5	3	-
Data analysis:				
D.10 Information & Knowledge Management	-	4	5	3
E.1. Forecast Development	-	3	5	3
Data visualisation:				
D.12. Digital Marketing	-	2	2	2
Decision making:				
A.7. Technology Trend Monitoring	4	-	-	-
D.12. Digital Marketing	2	-	-	-
E.4. Relationship Management	4	-	-	-
Cybersecurity skills				
	see profile Cybersecurity			
	e-Competence proficiency level (1-5)			

Table 1 Big data e-CF skills profile

All of the above competence areas are to a certain extent important to work with big data, but some more important than others. According to our survey respondents, data analysis (indicated by 77%) and data-driven decision making (73%) are the most important competences, followed by cybersecurity, business development and strategy making. This again underlines the conclusion that a mix of skills is required to work with these technologies, with different types of skills listed in this top-five of skills most important for big data.

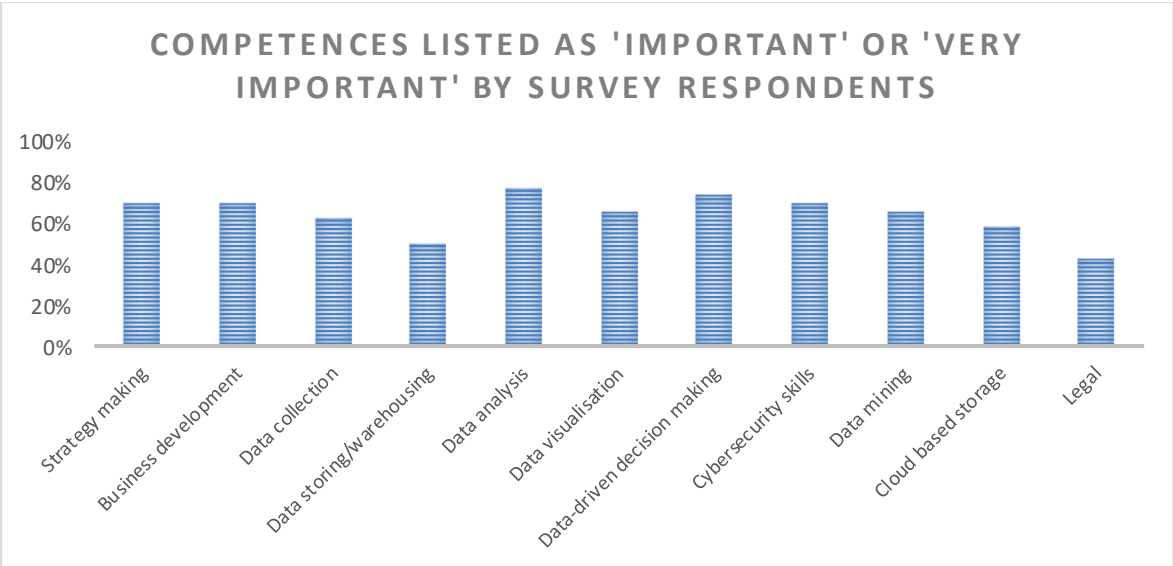


Figure 31 Most important competence areas according to survey respondents. Source: survey

Whereas the above table primarily described the type of competences needed, we can also analyse big data from the angle of roles required. Following this perspective, the Capgemini Academy has developed a framework describing the various roles involved when working with big data. They distinguish between the Data Analyst, the Big Data Business Analyst, the Data Engineer, the Data Software Architect, the Data Steward and the Data Scientist

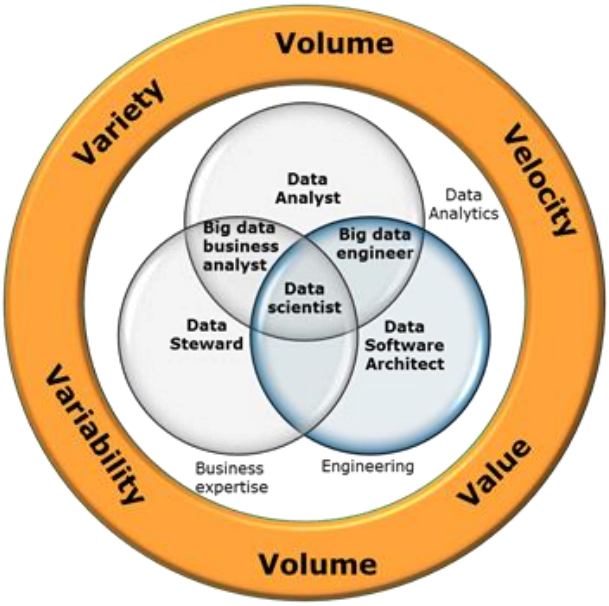


Figure 32 Big data roles

3.2.2. Internet of Things

For IoT, seven fundamental competence areas can be distinguished that employees in SMEs should obtain to successfully use and implement IoT solutions in their organisation. Managers must know how to make a strategy that accommodates and extends the business of the SME. Managers, IT professionals and advanced users should be capable of defining how this strategy can promote business development. Thereafter, IT professionals on the supplier side need software and application engineering skills to build IoT solutions, and IT professionals on the user side need a basic proficiency level of these skills in order to work with the IoT solutions. In some cases, they might also need to have the hardware engineering competencies to actually build the robotics, electronics, sensors, actuators, etc. In order to connect successfully all parts of the IoT network, the IT professionals require knowledge of interoperable network engineering. As IoT solutions generate more data, more data security issues and more complex data structures, SMEs with IoT usage need to rely on cybersecurity skills, as well as big data skills. Precise cybersecurity and big data skills depend on the nature and impact of the IoT solution adopted by the SME.

Skill/related e-CF competence	Managers	IT professionals		Advanced users
		Producers	Users	
Strategy making:				
A.1. IS & Business Strategy Alignment	5	-	-	-
Business development:				
A.3. Business Plan Development	5	4	4	3
Software and application engineering:				
A.6. Application Design	-	3	2	-

B.1. Application Development	-	3	2	-
B.6. Systems Engineering	-	4	2	-
Hardware engineering:				
B.1. Application Development	-	3	2	-
B.6. Systems Engineering	-	4	2	-
Interoperable network engineering:				
B.4. Solution Deployment	-	3	4	-
Cybersecurity skills				
	see profile Cybersecurity			
Big data skills				
	see profile Big data			
	e-Competence proficiency level (1-5)			

From the competence areas listed above, survey respondents indicate – perhaps a bit surprisingly – that business development and strategy making are the competences mostly needed to work with IoT. An explanation could be that, as an interviewee stated, 'IoT applications are everywhere nowadays. The trick is to pick the right ones – the safe ones – and to use them to the advantage of your business model – or to innovate your business model'. The third most important competence area is software and application engineering, which can be categorised as a typical 'hard' skill

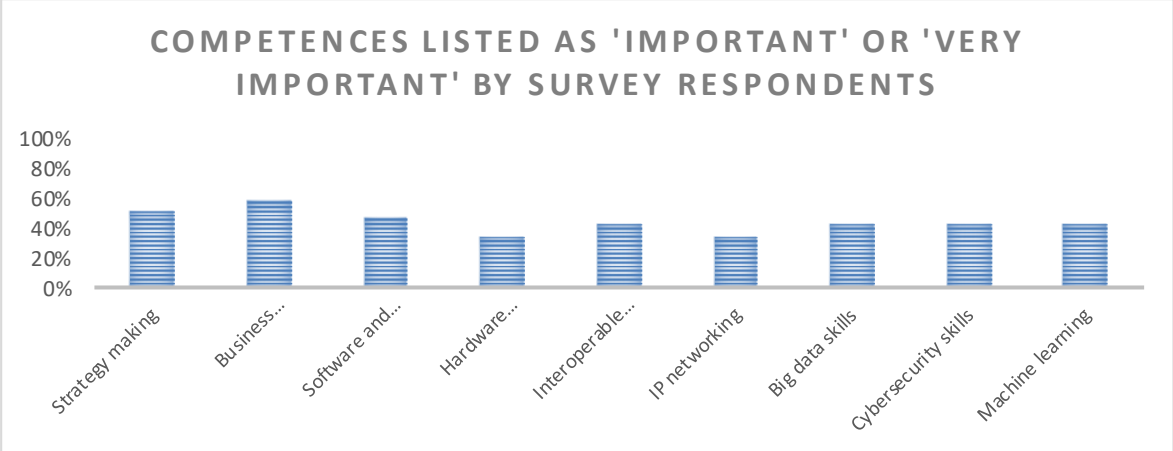


Figure 33 Most important competence areas according to survey respondents. Source: survey

3.2.3. Cybersecurity

As for the cybersecurity skills profile, seven fundamental competence areas can be identified as being relevant for adopting cybersecurity (Table 4). Firstly, cybersecurity requires strategy-making competences to define a suitable overall cybersecurity framework for the company. Managers and IT professionals should be capable of assessing risks and obtaining the legal compliance knowledge to prevent privacy issues and legal claims. Knowledge on how to develop risk and compliance policies that connect the strategy and risk assessment to procedures that fit the way employees work is necessary for managers and advanced users. IT professionals and advanced users should have knowledge of data protection and network protection. Lastly, IT professionals and advanced users also need to be skilled in monitoring and mitigating threats to prevent and solve cybersecurity issues.

Also for cybersecurity, for IT professionals there is a difference in the skills required by providers of cybersecurity software as compared to users of cybersecurity solutions.

Skill/corresponding e-CF competence	Managers	IT professionals		Advanced users
		Producers	Users	
Strategy making:				
A.1. IS & Business Strategy Alignment	5	-	-	-
D.1. Information Security Strategy Development	5	-	-	-
Legal compliance:				
B.3. Testing	2	3	3	1
E.8. Information Security Management	4	3	3	2
Risk assessing:				
E.3. Risk Management	4	3	3	-
E.8. Information Security Management	4	3	3	-
Developing risk and compliance policy:				
E.3. Risk Management	4	-	-	2
E.8. Information Security Management	4	-	-	2
Data protection:				
B.6. Systems Engineering	-	4	3	3
D.12. Digital Marketing	-	2	3	2
Network protection:				
D.1. Information Security Strategy Development	-	5	5	4
Threat monitoring and mitigation:				
A.6. Application Design	-	3	2	1
D.1. Information Security Strategy Development	-	5	5	4
E.3. Risk Management	-	3	3	2
	e-Competence proficiency level (1-5)			

More than for big data and for IoT, survey respondents indicate that all of the above competence areas are quite important for working with cybersecurity. For every competence area, at least 60% of the respondents find that this competence is 'important' or 'very important' to adopt cybersecurity. Most important areas are data protection and the awareness or education of employees, for instance with regards to recognising suspicious emails.

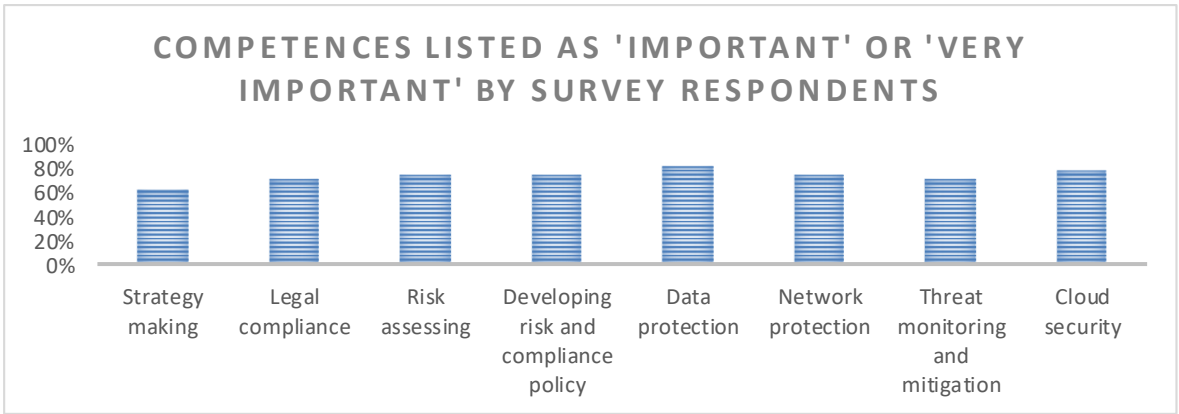


Figure 34 Most important competence areas according to survey respondents. Source: survey

Whereas the above table primarily described the type of competences needed, we can also analyse cybersecurity skills from the angle of roles required. Following this perspective, the Capgemini Academy has developed a framework describing the various roles involved when working with cybersecurity. They distinguish between the following generic roles: Chief Information Security Officer, Information Security Officer, Business Information Security Architect, Information Security Manager, Information Security Architect, Technical Information Security Specialist

Figure 35 Generic roles cybersecurity

3.3. Skills gaps, shortages and mismatches

The previous sections highlighted the generic and specific skills SMEs would need to adopt BIC technologies. This section zooms in on the areas where mismatches between the supply of skilled labour and SME demand for skills are the biggest. These areas are being referred to as skills gaps. This section first describes generic digital skills gaps and then zooms in on specialised skills gaps.

3.3.1. General

The digital talent gap is widening. In the light of today's trend towards digital transformation, information and communication technology has become an integral part of business functioning. This has resulted in an increasing demand for both employees with basic digital skills and ICT specialists[212]. In the future, 9 out of 10 jobs will require digital skills[213]. Evidence shows that today, only 57% of Europeans has sufficient basic digital skills. Looking only at those people currently in employment, there are 145 million workers (67%) who have at least basic level skills[214]. There were 8.2 million ICT specialists in the EU in 2016, up from 7.3 million 3 years earlier[215]. The share of highly-skilled ICT professionals varies considerably between countries: from 6.6% of total employment in Finland to 1.4% in Greece[216].

The number of persons employed as ICT specialists in the EU28 grew by 39.5% during the period from 2006 to 2016, which was more than 10 times as high as the

[212] ICT specialists are defined as persons who have the ability to develop, operate and maintain ICT systems and for whom ICTs constitute the main part of their job. Source: OECD, 2004

[213] European Commission (2017), The digital skills gap in Europe. Published October. Available at: https://ec.europa.eu/digital-single-market/en/news/digital-skills-gap-europe

[214] Capgemini Consulting, Empirica, & IDC (2018), Digital organisational frameworks and IT professionalism. Published January. Available at: https://www.capgemini.com/nl-nl/wp-content/uploads/sites/7/2015/12/digital-organisational-frameworks-and-it-professionalism.pdf

[215] European Commission (2015), The Digital Economy and Society Index (DESI). Published February. Available at: https://ec.europa.eu/digital-single-market/en/desi

[216] Eurostat (2017), ICT specialists in employment. Published December. Available at: http://ec.europa.eu/eurostat/statistics-explained/index.php/ICT_specialists_in_employment

corresponding increase (3.6%) of total employment[217]. However, the supply of ICT specialists cannot keep pace with demand: it is estimated that there will be over 500,000 unfilled vacancies for ICT professionals by 2020[218].

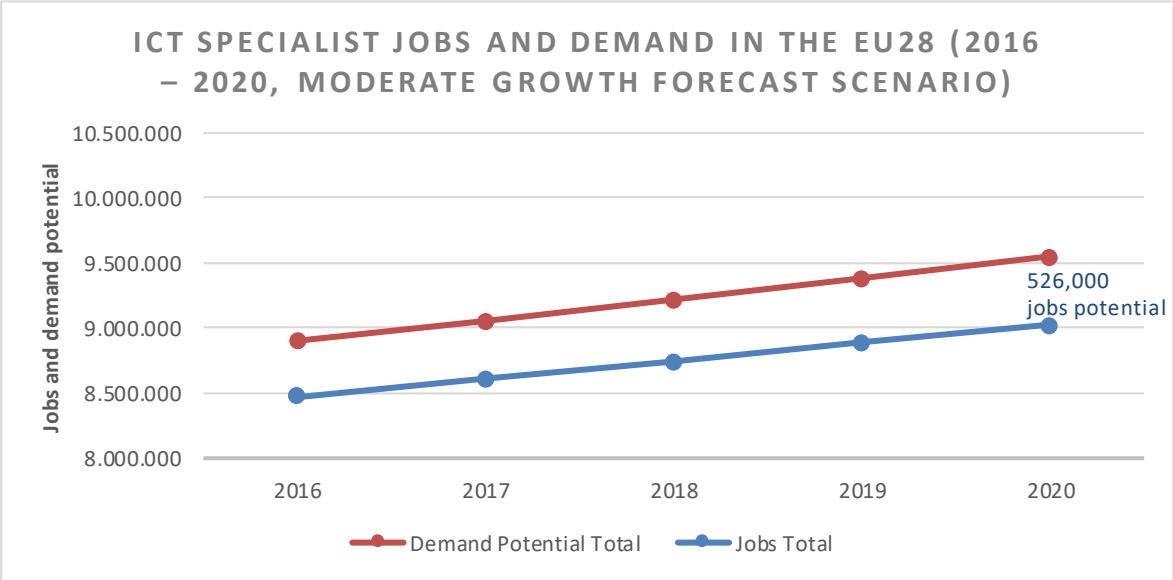


Figure 36 ICT specialist jobs and demand in the EU28 (2016-2020)[219]

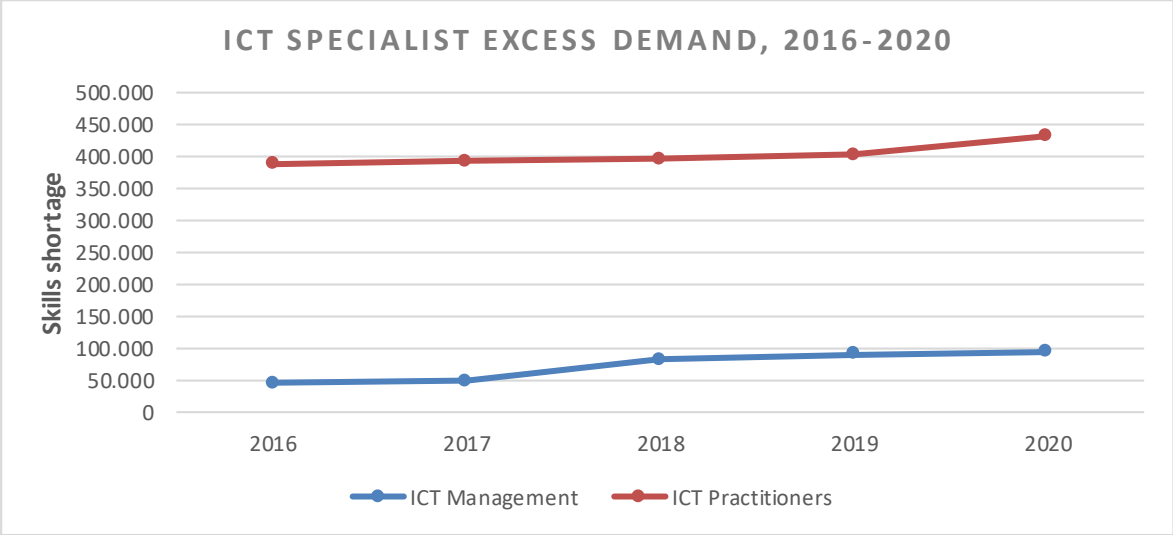
The same study differentiated by role, distinguishing ICT practitioners and ICT management. In the 'moderate growth forecast scenario', the ICT specialist workforce in Europe will grow from 8.5 million in 2016 to 9.0 million in 2020, of which 7.6 million will be ICT practitioners and 1.5 million ICT management and analysis level employees. Figure 3-10 shows that the skills gap widens, both for ICT management and ICT practitioners[220].

[217] Ibid.

[218] European Commission (2017), The digital skills gap in Europe. Published October. Available at: https://ec.europa.eu/digital-single-market/en/news/digital-skills-gap-europe

[219] This report was drafted in October and November 2018 – ahead of new publications regarding these statistics (expected in December 2018 or January 2019).

[220] Capgemini Consulting, Empirica, & IDC (2018), Digital organisational frameworks and IT professionalism. Published January. Available at: https://www.capgemini.com/nl-nl/wp-content/uploads/sites/7/2015/12/digital-organisational-frameworks-and-it-professionalism.pdf



Taking into account the moderate growth scenario, we can conclude that although the supply of ICT specialists is growing, the supply is still being outperformed by an increasing demand – both for managers and ICT practitioners.

Other sources also underline skills gaps with regards to both technically skilled personnel as well as managers that need the competences which enable an individual to initiate and guide ICT-related innovation at all levels of an enterprise – described as e-Leadership skills[221]. For instance, for three groups of industry employees (engineers, researchers, production workers) the European Commission states that skill shortages are most significant in technical training, ICT literacy, science, technology, engineering and mathematics (STEM), problem solving skills, self-directed learning, communication, teamwork and time management[222]. A lack of technical specialist skills was also found to be the main explanation for digital skills shortages in the 'tech' sector, with surveyed employers reporting 85% of hard-to-fill positions within their workforce in this area[223]. The Dutch Employee Insurance Agency UVW frequently maps hard-to-fill vacancies[224] in the ICT area, reporting a shortage of technically skilled specialists in several roles – primarily persons with a higher professional education.

Hard-to-fill vacancies 2018	
Higher professional education	***Academic education***
ICT programmers	ICT Architects
Embedded software engineers	Data-warehouse developers
PLC-programmers	
System designers	

[221] Hüsing, T., Dashja, E., Gareis, K., Korte, W. B., Stabenow, T., & Markus, P. (2015), e-Leadership skills for small and medium sized enterprises. Published October. Available at: http://eskills-lead.eu/fileadmin/lead/reports/lead_final_report.pdf

[222] European Commission (2018), Capitalising on the benefits of the 4th Industrial Revolution. Published February. Available at: https://ec.europa.eu/info/sites/info/files/4threvolution_p4p-report_2017.pdf

[223] TP 2015b. Employer Insights: skills survey 2015. The Tech Partnership. Published May 1. Available at: https://www.thetechpartnership.com/link/7498c7abf3664f28a644246d1da9348b.aspx?id=1335&epslanguage=en. [Accessed June 17 2015].

[224] UWV (2018), ICT-beroepen: factsheet arbeidsmarkt. Published April. Available at: https://www.uwv.nl/overuwv/Images/ICT_beroepen_factsheet_arbeidsmarkt.pdf

Database- and application administrators	
BI specialists	
Information/business analysts	
Specialists technical infrastructure	
CRM/ERP advisors	
Security specialists	
Advisors information security	

Table 2 Hard-to-fill ICT vacancies in the Netherlands, 2018

Also, for e-leadership skills, necessary for driving successful innovation and capitalising on advances in information and communication technologies, demand will not match supply in the future[225]. It is estimated that there will be a gap of up to 250,000 e-leaders by 2020 in Europe[226]. Around 70% of e-leaders are found in SMEs[227].

3.3.2. Specialised skills gaps

Skills shortages are hindering SMEs across the three technologies, and these shortages are expected to increase even further in the near future according to interviewees. Interviewees and workshop participants stressed the importance of hard skills and business expertise but tend to put even more emphasis on the importance of soft skills. With reference to hard skills, interviewees mention data scientists, software engineers, algorithm developers, programmers, data engineers, data structurers, data architects, data administrators, (AI) developers, product owners and security specialists as roles where the mismatch between supply and demand is most prominent. These highly specialised skills are scarce in supply on the labour market, and SMEs need to compete with bigger corporates to acquire people with these skills. The extent to which these skills are needed obviously depends on the maturity level of an SME working with one of the three technologies. Interviewees state that these highly specialised hard skills are especially relevant for frontrunners and developers.

Looking at what our survey respondents indicate, the results are somewhat surprising. When asked about their access to skills as to one of the technologies, they indicate for all technologies a quite positive score. Each technology reports a score higher than five, meaning that they have sufficient access to skills.[208]

[225] Empirica (2015), e-Leadership skills for small and medium sized enterprises. Available at: http://eskills-lead.eu/fileadmin/lead/reports/lead_final_report.pdf

[226] http://eskills-lead.eu

[227] Hüsing, T., Korte, W. B., & Dashja, E. (2015), e-Skills in Europe: Trends and forecasts for the European ICT professional and digital leadership labour markets. Published November. Available at: http://eskills-lead.eu/fileadmin/lead/working_paper_-_supply_demand_forecast_2015_a.pdf

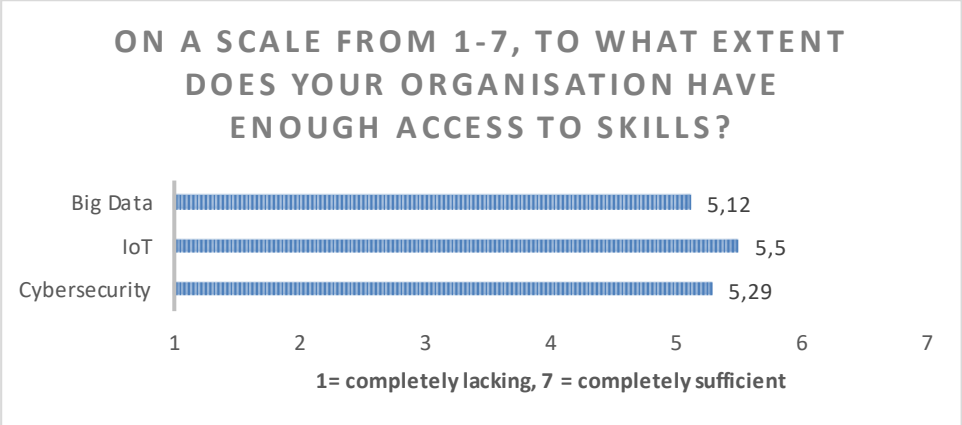


Figure 37 Access to skills. Source: survey

Whereas both the literature, interviewees and experts during the workshop all underline a skills gap, our survey seems to point to a different conclusion. An explanation could be the nature of the respondents. Above, we already stated that the 'hard' skills gap particularly hold ground for frontrunners and appliers. These groups are not that much represented in our survey. The group labelled as 'already professionally working with one of the technologies' represents less than 45% of the total, with other groups being in lower maturity stages (e.g. 'beginning to apply BIC', or 'aware of the value, but not yet applying it'). As the skills gap primarily holds ground for those companies in higher maturity stages, this could explain while our survey did not reveal the skills gap as such.

The skills gap seems to hold ground for the management level as well as for the professionals working with the technologies, interviewees state. Firstly, managers often lack understanding of the basics of new technologies and its business implications. As described earlier, technological solutions might (partially) replace skill needs for particular SME segments. However, this still requires a basic proficiency level of understanding the technologies, and one has to be able to assess several technology vendors against predefined criteria. Managers too often lack these competences, interviewees indicate. Secondly, SME managers may lack soft skills, such as the skills to connect, to communicate and to work in interdisciplinary teams. This is especially true for founding managers with a technology background (tech-entrepreneurs). As for both the IT professional and the advanced user, interviewees argue that increasingly they generally lack the ability to possess a helicopter view. This means that, given the fact that technology evolves fast, they are not locked in to software or solutions, but that their skills and knowledge exceeds a single solution. As of today, more is demanded from IT professionals and advanced users than just executing their task. This implies a shift from operational services to mere strategic services. They for instance need to have the proficiency of multiple programming languages, and the ability to switch between those. They generally lack the consultancy and advice skills that are increasingly needed to provide the management with input about solutions available on the market. Interviewees often speak of a distance between the manager and the professionals working with the technologies. Taken together, persons working with these technologies needs to possess a diverse range of interdisciplinary skills, which are difficult to find united in a single person.

Skills shortages are thus found both for managers as well as for professionals working with BIC technologies, and shortages are faced across the three technologies. The numbers below illustrate the magnitude of the problem for each of the technologies.

Looking at the big data area, it is stated that the lack of supply of a data-savvy workforce in Europe is a problem[228]. Data specialists accounted for (far) less than 1% of total employment in most Member States[229]. To illustrate, in the UK, the demand for 'big data' specialists is forecasted to increase by 160% between 2013 and 2020, and estimated to represent an additional 346,000 big data jobs[230]. Furthermore, Sweden will be short of 70,000 ICT-specialists by 2022[231]. This shortage is found in several competence areas, most notably in programming and system architecture. Groups that are smaller today but where the need is growing rapidly are qualified data analysts and information security specialists. Looking specifically at SMEs, survey respondents indicate that data analysis, business development and data storing and warehousing are the competence areas where shortages are most prominent in the big data area.

With regard to cybersecurity, the forecast is that Europe will face a projected skills gap of 350,000 cybersecurity professionals by 2022, according to a recent Frost & Sullivan report[232]. The demand for professionals is growing, but supply is not keeping pace. In Europe, 66% of the professionals believe there are too few cybersecurity professionals within their department. North America shows a similar shortage (68%), and a majority believes that it is a result of a lack of qualified personnel. Capgemini[233] assessed a set of core digital skills necessary for organisations with aspirations of digital leadership and concludes that corporate demand for cybersecurity skills is rising faster than supply, and the demand for cybersecurity is not likely to diminish in the next few years. 68% of organisations surveyed reported a high demand for cybersecurity skills compared to 61% demanding big data skills and 64% analytics skills. Demand for these skills was then set against the availability of proficient skills already present in the organisation. This identified a 25-percentage point gap for cybersecurity skills, compared to a 20 percentage point gap for big data and a 13 percentage point gap for analytics (figure 3-12).

[228] European Commission (2017), Enter the data economy. Published January. Available at: https://ec.europa.eu/epsc/sites/epsc/files/strategic_note_issue_21.pdf

[229] OECD (2015), Science, Technology and Innovation Policy Note on 'Datadriven Innovation for Growth and Well-being', OECD Publishing, Paris, October 2015.

[230] SAS & The Tech Partnership (2014), Big Data Analytics. Assessment of Skills for Labour and Skills 2013-2020. Available at: https://www.thetechpartnership.com/globalassets/pdfs/research-2014/bigdata_report_nov14.pdf

[231] IT & Telekomföretagen (2017), IT-kompetensbristen - en rapport om den svenska digitala sektorns behov av spetskompetens. Published November. Available at: https://www.itot.se/2017/11/it-kompetensbristen-en-rapport-om-den-svenska-digitala-sektorns-behov-av-spetskompetens/

[232] Ashford, W. (2017), Europe faces shortage of 350,000 cyber security professionals by 2022. Published June. Available at: http://www.computerweekly.com/news/450420193/Europe-faces-shortage-of-350000-cyber-security-professionals-by-2022

[233] Lievre, F. (2018), Business leaders report urgent need for cybersecurity skills as digital talent gap widens. Published February. Available at: https://www.capgemini.com/news/business-leaders-report-urgent-need-for-cybersecurity-skills-as-digital-talent-gap-widens/

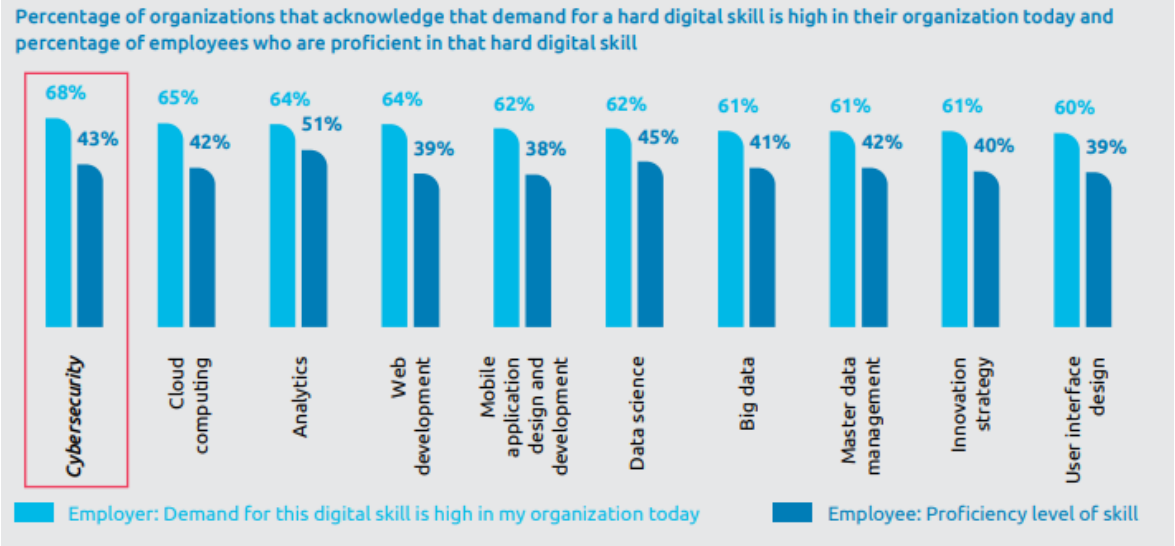
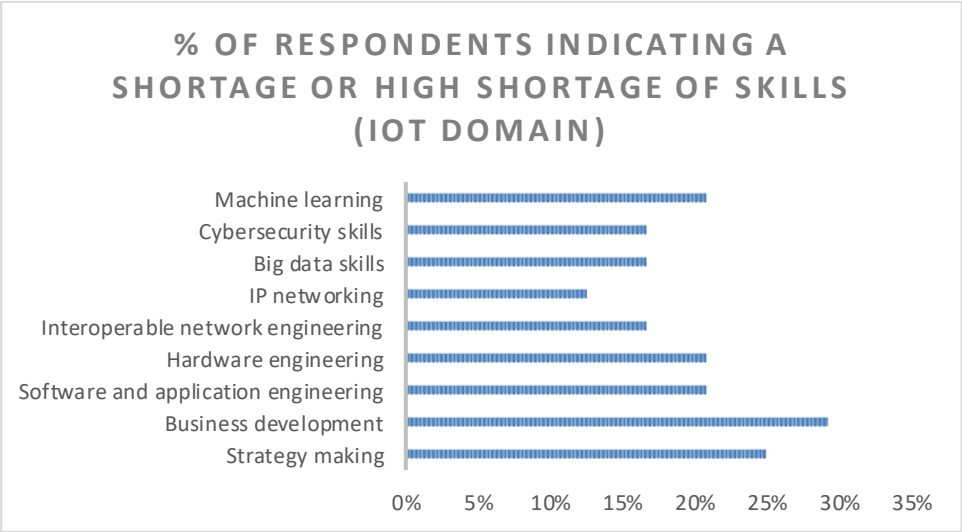


Figure 38 The digital talent gap is widest in the cybersecurity domain[234]

Looking specifically at SMEs, survey respondents indicate that cloud security is the competence area where the skills gap is most prominent in the cybersecurity domain, followed by data protection and threat monitoring and mitigation. Fourth comes network protection.

For IoT, no specific figures for Europe were found. However, based on the evidence with regards to shortages of ICT professionals, STEM-educated professionals, cybersecurity professionals and big data professionals, it would be safe to assume that the skills gap identified for big data and cybersecurity also (at least partially) holds ground for IoT. According to our survey respondents, this is partially true, as business development and strategy making are the competence areas where the skills gap is most prominent for IoT – which is more or less in line with the big data domain. After these, a series of more hard skills stands out as areas where skills shortages are experienced, such as machine learning and various types of engineering.



[234] Buvat, J., Turner, M., Slatter, M., & Puttur, R. K. (2018), Cybersecurity talent: the big gap in cyber protection. Available at: https://www.capgemini.com/wp-content/uploads/2018/02/the-cybersecurity-talent-gap-v8_web.pdf

Figure 39 Skills gaps IoT. Source: survey

Several sources underline that a talent shortage is hampering IoT development [235]. The industry is currently experiencing a major shortage of qualified IoT professionals, and it could persist for the next five to seven years. The talent challenge in the IoT is not down to a lack of a specific skill, but a lack of professionals with the required combination of IoT skills. Among others, IoT professionals need big data skills, software engineering skills and IT security skills[236].

3.3.3. Conclusions

As stated earlier, 'the SME' does not exist. SMEs take various forms and have different natures. The different groups of SMEs as identified in the segmentation model have different skill needs, and as such, skills gaps differ per group. In general, the demand for highly specialised skills tends to concentrate at the supply side of the market, among the ICT suppliers. Hard skills – related to e.g. software engineers, data scientists, programmers, security specialists – are said to be especially relevant for frontrunners and developers, according to interviewees. These specialised skills are scarce in supply on the labour market, and SMEs need to compete with bigger corporates to acquire people with these skills. This is a problem of quantity mostly, as the SMEs in these categories understand what they need.

This is different for SMEs in the lower maturity levels of the pyramid. Profiles required by ICT users become more business-oriented and project-oriented, with a strong focus on the design of new services and apps, and the ability to outsource/rely on standardised platforms and solutions[237].

Soft skills are relevant for all segments, but are perhaps even more important for appliers and followers. For these types of SMEs, it might be essential to be 'connected' to overcome their competitive disadvantage of having restricted resources. Instead of developing the necessary skills in-house, they might make use of the skills of ecosystem or value chain partners, technological solutions available on the market or hire expertise. This still requires a basic knowledge of the implications of emerging technologies and the solutions available. An SME needs to be aware against which criteria technological solutions, vendors and externals can be assessed. With regard to the latter, SMEs need to know the competences that they need in order to work with BIC technologies. During the workshops and interviews, experts confirmed the view that – especially for the group of followers in the segmentation model – awareness of 1) the benefits of emerging technologies and 2) skills needs are still important issues that should be addressed. In many initiatives focusing on the uptake of emerging technologies, such as the German Mittelstand 4.0 initiative, awareness raising is still one of the core activities in their service portfolio.

Competence (self-) assessment tools could be useful in this context as well, especially if they are related to recognised standards such as the e-Competence Framework, ISO standards or even (in the case of cybersecurity) to the American NIST framework.

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[235] Newcombe, M. (2018), IPv6-only world on the horizon. Published June. Available at: https://www.eetimes.com/author.asp?section_id=36&doc_id=1332655; Wright, B. (2018), How a talent shortage is hampering IoT development. Published March. Available at: https://www.idgconnect.com/abstract/29718/how-talent-shortage-hampering-iot-development

[236] Ibid.

[237] Hüsing, T., Dashja, E., Gareis, K., Korte, W. B., Stabenow, T., & Markus, P. (2015), e-Leadership skills for small and medium sized enterprises. Published October. Available at: http://eskills-lead.eu/fileadmin/lead/reports/lead_final_report.pdf

Finally, it seems SMEs are mostly in need of increasing their cyber hygiene and would need to embed this in their digital strategy. This addresses anyone working in the organisation. The SME would be helped with basic cybersecurity by design standards of products and services, for instance via quality labels, but at least to make transparent for the SME what could be done to increase cyber hygiene in a trustworthy manner.

4. SKILLS STRATEGIES

As it was discussed in the previous chapters, the SME landscape is diverse, therefore the approach of firms to the use of technologies and the types of skills needed to use them vary significantly across firms. The literature review and analysed interviews highlight that existing skills needs in SMEs could be grouped in three categories, namely, hard skills, soft skills and business expertise. The type of skills gaps, or their combination, depend on the level to which a company is engaged in (technological) innovation. For example, hard skills are especially relevant for frontrunners and developers, while soft skills are relevant for all segments, but are even more important for appliers and followers. There are multiple strategies that SMEs follow to acquire the needed skills. This chapter presents a variety of available strategies or 'pathways' and factors that determine the selection of a particular strategy.

4.1. Strategy needs

4.1.1. A skills strategy implies a conscious decision

The company decision to explore opportunities related to the use of BIC technologies is (eventually) a choice that is made by SME management team or owners, based on business rationale. According to our interview results, as well as, the research of Barnard, Bakkers and Wunsche (2017)[238] most SMEs understand that investing in novel technologies provides a competitive advantage. Paradoxically, interview results highlight that decision-makers in SMEs tend to lack the necessary knowledge about available, useful technologies and their potential. Due to dynamic changes in the market of technologies even the IT professionals or technology experts in SMEs struggle to keep track of changes in the market and to understand the use and application of particular technologies. Technology providers are moving towards business models whereby they serve as consultants that inform companies about the functionalities of particular technologies, however, according to some interview respondents, many providers fail to explain the use of technologies in simple terms, applied to the context of the company and their effect on business processes or on products/services in a specific company.

Around a quarter of interview respondents emphasized that apart from the lack of familiarity with the market of technologies, company managers/owners do not sufficiently master strategic thinking and communication skills to design and successfully implement technology integration and skills development strategies. The absence of experience in creating appropriate strategies demotivates SMEs to embark on digital transformation and disables them in addressing skills gaps. In light of transformative effect of technologies in SMEs, the skills strategies should be well-designed and adjusted according to changes in a company. The process of adjustment is company-specific, it involves costs and, consequently, business risks. Many interviewees highlighted that if a company is successful in its business without undergoing digital transformation it is unlikely to take unnecessary risks. In addition, in countries or regions where there are fewer digitally oriented, innovative companies, SMEs are less optimistic about the potential of BIC technologies and are less willing to explore the market of these

[238] Barnard, C., Bakkers, J. H., & Wunsche, S. (2017), The road to the digital future of SMEs. Published September. Available at: https://www.virginmediabusiness.co.uk/pdf/Insights%20Guides/The%20SMEs%20changing%20the%20world.pdf

technologies. Such observations reveal two findings: first, it confirms Everett Rogers' diffusion of innovation theory (1995)[239] that companies are more likely to follow a business trend rather than being a pioneer in the market; second, many SMEs are adjusting their business models based on collaboration with partners or requests of clients, underlining the importance of its ecosystem. If a partner or client does not request or is not able/willing to adjust to digital transformation, then there are fewer incentives or even disincentives to launch digital transformation in SMEs. Both findings underscore the importance of large-scale encouragement of the digital transformation to make it a market trend and to stimulate the use of technologies by partners and/or clients.

There are three major drivers of skill development in firms. First, the 'deciders' or **management** should show the commitment and strategy to ensure the operationalisation of digital transformation; second, the **organisation** must ensure that digital transformation is driven by cross-functional work and there is a sufficient knowledge transfer; and third, the **culture** in the firm should stimulate discussions on digital transformation goals and skills development needs[240]. Without such a supportive environment, the integration of BIC technologies, as well as, development of needed skills for the uptake of these technologies is highly problematic in SMEs.

According to the research conducted by the European Research Center for Information System[241], a successful digital transformation requires systematic skill development. It is argued that the readiness of companies to embrace digital transformation determines the approach towards skills development. The digital maturity model, presented in the following figure, depicts the stages of digital transformation and the corresponding strategies towards digital skills development.

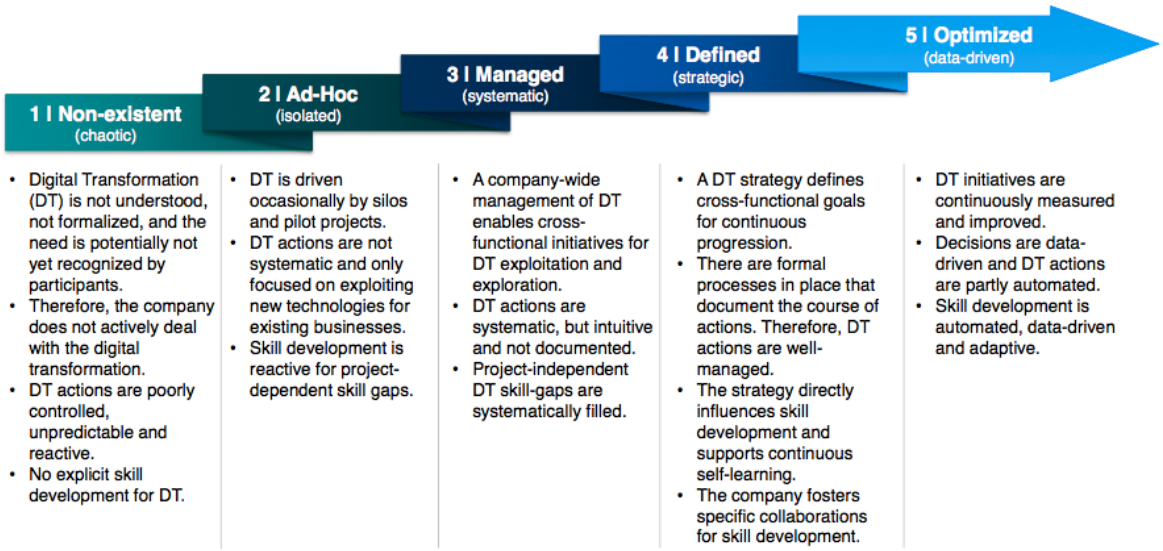


Figure 40 Digital maturity model: Skill Development for Digital Transformation[242]

[239] Rogers, E. (1995). Diffusion of Innovations. Retrieved from: https://web.stanford.edu/class/symbsys205/Diffusion%20of%20Innovations.htm

[240] Berghaus, S. & Beck, A. (2016), Stages in digital business transformation: results of an empirical maturity study. Available at: https://pdfs.semanticscholar.org/d416/aa50e0eb6abb3f5e6e5fa071931f9a494d28.pdf

[241] SAP (2017), Maturity model and best practice: skill development for digital transformation. Available at: https://www.sap.com/documents/2017/08/7630cfa8-cd7c-0010-82c7-eda71af511fa.html

[242] Ibid.

The first stage of the maturity model reflects the situation when SMEs do not recognise the potential of BIC technologies and thus do not invest in the development of appropriate skills. As a result, internal human resources are usually poorly managed; the decisions to develop skills are reactive, sporadic and lack consistency. From the 'chaotic' stage of digital transformation the companies enter the ad-hoc stage, where the development of skills is evolving depending on occasional digital projects or tasks. The systematic and strategic stages of digital transformation have a defined skills development approach, which leads to more effective and efficient use of technologies. A better use of technologies results in more investment for skills development and culminates in data-driven, adaptive formulation of skills development strategy. These findings are important for the initiative because the type of interventions; tools and methods supported by the initiative need to be selected and developed taken into account these different approaches to skills strategies, if one even exists.

Many interview respondents mentioned that digital maturity of an SME is correlated with technological intensity in a specific industrial or service sector. For example, digital maturity in the IT sector is expected to be higher, on average, than in the textile sector. This is in line with conclusions from major research institutes, underlining that substantial differences exist between industries if it comes to digital maturity. Figure 4-2 provides an example from Capgemini's Digital Transformation Institute.

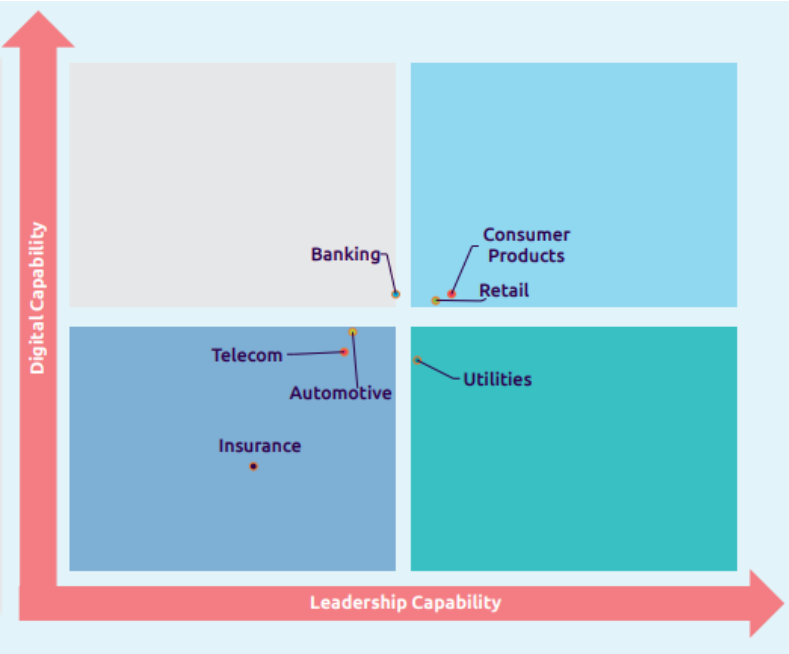


Figure 41 Digital mastery of industries[243]

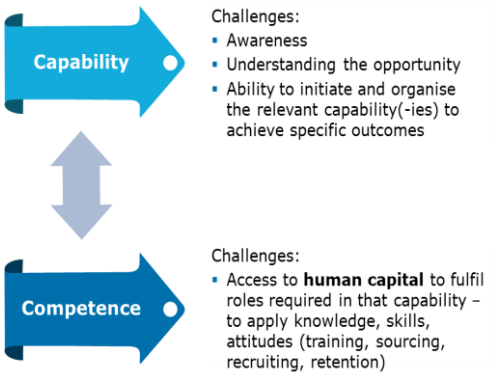
This observation highlights that the decisions of company managers or owners to adopt BIC technologies and to develop appropriate skills fundamentally depends on assessment of profitability of digital transformation in an SME. Thus, without a clear business case the SMEs in different industrial and service sectors do not strive to reach the highest stages of digital transformation.

The analysis of existing literature on the topic and interviews conducted reveal that the decisions of the management team or owners in SMEs play a central role for

[243] Capgemini Digital Transformation Institute (2018), Digital Mastery Survey. Available at: https://www.capgemini.com/wp-content/uploads/2018/07/Digital-Mastery-DTI-report_20180704_web.pdf

development of digital skills and for adoption of BIC technologies. It also acknowledges that SMEs tackle their skills needs on a sliding scale from ad hoc individual driven decisions (chaotic) to fully integrated into the technology strategy (data driven). The challenge for this initiative is to identify and tailor a vision that respects these different approaches by SMEs in the market at the moment.

The underlying concept requires understanding of the balance between an organisation's strategy on why and how to adopt technology as business opportunity, and the required human capital to deliver on that investment. It is about investing in building a capability at the organisational level, and consequently finding the right people to build competences necessary for that capability. Employees fulfil roles associated with those competences, using methods and tools to add specific value.



4.1.2. Different strategy needs for different users of the technologies in the SMEs

The analysis of our interviews shows that the use of BIC technologies demands an upgrade of skills for all employees within the company, including the regular users of technologies, the IT professionals and company managers. The regular users of technologies are expected to improve their digital literacy, while IT professionals should continuously invest in their knowledge of technologies and better their communication skills to inform users about functionalities of technologies and to incorporate the feedback of users for improvement of products and services. Managers in SMEs are expected to possess transversal digital skills to manage all business processes, think strategically and creatively about the use of technologies, as well as, to guide the IT professionals towards innovation. Both the literature review and the opinions of experts emphasise that the digitalisation of economy, and consequently of business, is transforming the labour market and the attitude towards education by stimulating life-long learning.

Depending on the role that the technology is or will be playing in an SME the business and skills strategy will be adjusted. Using the technologies for improving or transforming internal business processes often requires more people within the organisation to be involved and consequently have the appropriate skills. For example, in addition to physical reorganisation of production process, a change in ommunication and cooperation within the company may be needed. Using the technologies for product or service delivery however, has a stronger influence on external relations and may require a skills strategy to involve its partners in the value chain.

The following section will elaborate on the choice of an appropriate strategy for skills development.

4.2. Choosing the right strategy

4.2.1. Size of investment

There is a variety of strategies on digital skills development; the choice of a strategy is largely determined by the digital maturity stage of SMEs, which implies the willingness of the management team to embrace changes in a firm and the assessment of the impact of technologies on business processes. The cost-benefit analysis is normally guiding the choice of a strategy and the size of investment for skills development in an SME. If a technology is at the core of all business processes, and consequently has a large value for an SME, then a company is likely to invest more resources into skills development to

ensure effective operation of the technology[244]. In such a case, the number of people who receive training to upgrade their skills is likely to be larger than if a technology has a small function in a company. Hence, the size of investment into digital skills development in SMEs that are frontrunners and developers, have a defined (strategic) or optimized (data-driven) level of digital maturity, is expected to be larger.

Among other factors that influence the amount of investment for skills development is the proficiency level of needed skills that is determined by the type of technologies. In case of data analytics, coding and software development skills might be needed, in contrast to skills related to simple interaction with technologies. In light of a worldwide shortage of skills related to digitalisation in companies the size of investment in acquiring or gaining advanced skills is larger. Interviews with experts in the area of BIC technologies indicated that SMEs experience a greater shortage of skills, particularly advanced skills that are scarce, as a result of competition for talent with larger companies and less competitive salary offers.

4.2.2. Approaches to fill skills gap

A survey conducted by Capgemini Consulting in 2013[245] revealed that over 63% of companies are using traditional strategies to address skills gap, namely, the in-house solutions – training by colleagues or invited experts and recruitment, or the external solution – outsourcing of skills through partnerships with companies that possess needed skills. The latter involves the transfer of specific tasks or even business processes to a partner company, therefore some companies are unwilling to experience high reliance, to share sensitive information or the client base with a partner. The choice between internal versus external skills strategy is determined by multiple factors:

- Availability of a suitable trainer and a course either within an SME or outside of it;
- Ability to train employees, complexity of training;
- Frequency of use of needed skills;
- Potential to use needed skills in other tasks;
- Risks if skills are not developed in-house;
- Ease of doing business without needed skills in-house (with partners, clients);
- Direct costs of required training versus the costs of outsourcing;
- Investment costs of current staff upskilling and a fear of them leaving the company versus the cost of finding the right provider of skills;
- Opportunity cost for not continuing business as usual.

Only 13% of surveyed companies are using innovative methods, such as targeted company acquisition (the purchasing/merging with companies that have talent in specific technologies) or engagement with start-ups in business incubators and accelerators (the

[244] Kane, G. C., Palmer, D., Phillips, A. N., Kiron, D., & Buckley, A. N. (2016), Aligning the organisation for its digital future. Published July. Available at: https://sloanreview.mit.edu/projects/aligning-for-digital-future/

[245] Capgemini (2013), The digital talent gap: developing skills for today's digital society. Available at: https://www.capgemini.com/wp-content/uploads/2017/07/the_digital_talent_gap27-09_0.pdf

identification of talent or cooperation with start-ups)[246]. Some other successful approaches to closing the skills gap in companies are[247]:

- The organisation of training initiatives with firms that have similar skills gaps;
- Apprenticeships;
- Multi-sector partnerships with IT industries;
- Schools and public-sector agencies to adjust and enhance existing digital skills programmes;
- The encouragement of employees to join coding bootcamps;
- Cooperation with regional business development agencies or with Chambers of Commerce;
- Participation in publicly funded skills-focused programmes or initiatives.

The approach towards skills development in a SME is strongly influenced by several factors, such as available human resources, type of technologies, convenience, costs (time, financial resources) and a maturity stage at which skills development is needed. For example, the 'digitally born' SMEs, like university spin-offs focusing on data science, have a higher level of hard digital skills. These firms experiment more and develop skills on the job. These firms collaborate with other data science firms to cooperate and learn from interaction. Learning-by-doing is the most prominent in-house method for skill development, as they lack the resources to set up formal academies or traineeships.

4.2.3. Providers to fill skills gap

Aside from self-learning, there is a variety of providers to fill the skills gap, such as education institutions that offer more formal training to SMEs, public or publicly-funded organisations and private firms that are operating in the same industry or possess appropriate skills. According to interviews with experts, SMEs typically provide in-house/on-the-job training by their own employees or approach education institutions/training centres for a short-term course to improve skills of employees. Many SMEs do not invest substantial amounts of time and financial resources to find the most appropriate external training provider. Some companies that approached education institutions to improve the skills of employees argue that it is not sufficient, as more mentoring, face-to-face learning is needed to acquire skills[248]. Among other common critical remarks is the lack of connection of traditional training with a particular industrial or business sector, as the current skill needs require a flexible approach to ensure relevance and effectiveness of an education course[249].

One of most common private initiatives for addressing the skills gap is outsourcing. SMEs contract specialised companies to provide tailored services without an SME having to set up the required infrastructure. In some cases, companies cooperate to work and develop skills together. According to the survey of business leaders in North America, Europe and APAC region, 46% of respondents are interested in outsourcing new digital skills and

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[246] Ibid.

[247] ITU (2018), Digital skills toolkit. Available at: https://www.itu.int/en/ITU-D/Digital-Inclusion/Documents/ITU%20Digital%20Skills%20Toolkit.pdf

[248] Oesch (2018), Digital skills gap: Where are we now? Published May. Available at: https://trainingindustry.com/articles/it-and-technical-training/digital-skills-gap-2018-where-are-we-now/

[249] Scorey, J. & Jones-Evans, D. (2017), SME skills survey 2017 final report. Published June. Available at: http://www.lskip.wales/downloads/SME%20Skills%20Survey%202017%20-%20Final%20English.pdf

24% of interviewees consider outsourcing digital skills training for in-house resources[250]. The outsourcing is expected not only to fill the skills gap, but also to improve operational efficiency, reduce costs and contribute to business growth.

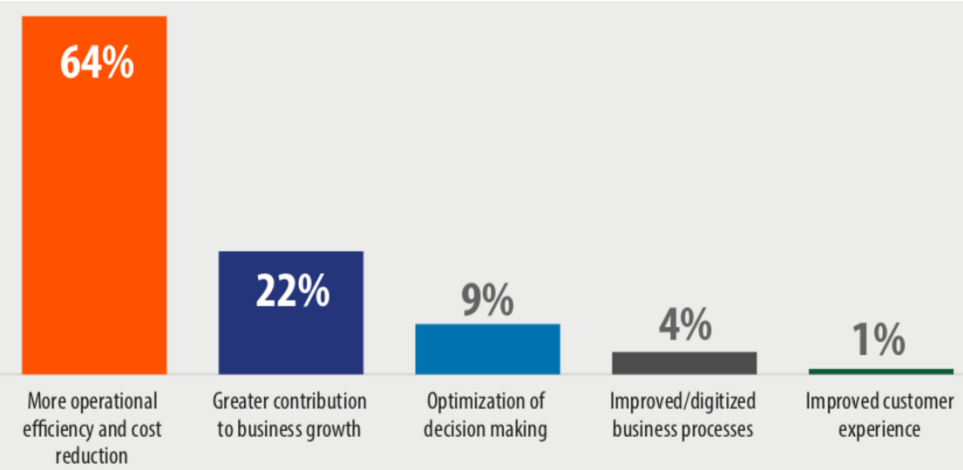

Figure 42 Answers of Infosys survey respondents on question "What is the biggest value that you seek from digital labour from partners?" [251]

Public-private-partnerships (PPP), where education providers, governments and business come together are less common, according to opinions of interviewees. However, several experts noted that some SMEs acquire skills through joining centres of excellence that provide networking and learning opportunities. In countries where digital skills gap is ineffectively or not actively addressed by private companies the public-sector actors are more likely to launch training initiatives, foster business linkage programmes and stimulate PPP in skills development[252].

Among less likely actions taken by SMEs to fill the skills gap are listed: the sending of employees to a full-time accredited MSc degree programme, the setting up of a training centre, a large investment in hiring a service provider or the alteration of a business model. All of these options are considered too expensive for SMEs.

The choice of a skills development strategy in SMEs normally relies on rational decision-making. There are many factors that are taken into consideration when an appropriate strategy is designed, however, the primary criteria for the selection of a strategy is cost-effectiveness, efficiency and opportunity costs. Considering that only the assessment of costs and benefits may reveal to a specific SME the best strategy for digital skills development, the firms should be well aware of advantages and disadvantages of various strategies. The following sections zoom into those aspects.

4.3. External skills strategies

External skills strategies are focused on outsourcing or hiring temporary 'extended workforce', such as experts or consultants, and forming alliance partnerships. Using external, short-term workers has several advantages, such as access to specialised skills

[250] Infosys (2018), Outsourcing in the age of intelligent automation. Available at: https://www.infosys.com/insights/digital-future/Documents/outsourcing-age-intelligent-automation.pdf

[251] Ibid.

[252] OECD (2013), Enhancing skills through public-private partnerships in Kazakhstan's information technology sector. Available at: https://www.oecd.org/countries/kazakhstan/Enhancing%20Skills%20though%20Public-Private%20Partnerships%20in%20Kazakhstan%27s%20Information%20Technology%20Sector.pdf

and flexibility of working arrangements and a lack of regular obligations on the part of an employer. The cost-effectiveness of hiring 'extended workforce' is debated, however, around 39% of executives in large US companies stated that the following approach results in saving of financial resources[253]. For SMEs, the current solution could address the urgent need to fill the skills gap.

The forming of alliance partnerships is considered an external skills strategy when a company is dividing tasks across partners. Such a strategy is similar to a regular outsourcing. The disadvantages of following external skills strategies include the loss of control, inability to monitor costs, performance of tasks and their quality, security risks associated with the use of available or accessible data, increasing reliance on partners and instability risks, transaction costs associated with communication and management of business processes[254].

4.4. Internal skills strategies

Internal skills strategies boil down to two options, namely upskilling employees or hiring professionals with demanded skills. Fundamentally, the internal skills strategies are concentrated on building skills capabilities within an SME. Such strategies, particularly internal company training and mentoring of employees, have undeniable advantages, such as increased skills transfer, greater satisfaction of employees, better tailoring of training towards skills needs and matching of a course with roles and responsibilities[255].

Despite the seeming benefits of such strategies, only the analysis of costs, benefits, effectiveness and efficiency of investments into skills of employees can reveal whether the chosen strategy is profitable for a particular SME. For example, the amount of time and financial resources spent on finding or training an employee, the identification or design of an appropriate education course, the intensity and use of acquired skills will determine to what extent the investment was expedient. The investment in employees may quickly turn into pure costs if an employee decides to leave an SME. Hence, internal skills strategies do not add more stability nor reduce risks for a company.

Among the tools for upskilling existing employees are listed Massive Open Online Courses (MOOCs), short courses via higher education institutes or private companies, in-house learning from colleagues, training within the company network and test & trial innovation investments.

(1) One of most popular formats for addressing the digital skills gap is MOOCs. The pacing of MOOCs can often be tailored to the individual, and the mode of training is virtual/online. Hence, employees can access any course at a convenient time and location[256]. Many employees prefer MOOCs to other types of training, however, as a result of non-interactive format their effectiveness is lower compared to other forms of training[257]. A significant number of MOOCs are free of

[253] Accenture (2014), How to manage an extended workforce for business agility. Published March. Available at: https://www.accenture.com/in-en/insight-outlook-managing-the-extended-workforce-talent

[254] Riggins, N. (2017), 20 advantages and disadvantages of outsourcing from your small business. Published February. Available at: https://smallbiztrends.com/2017/02/advantages-and-disadvantages-of-outsourcing.html

[255] Heathfield, S. M. (2018), Tap the power of internal training. Published May. Available at: https://www.thebalancecareers.com/tap-the-power-of-internal-training-1919298

[256] OECD (2016), Innovating education and education for innovation: the power of digital technologies and skills. Available at: http://www.oecd.org/education/ceri/GEIS2016-Background-document.pdf

[257] Radford, A. W., Robles, J., Cataylo, S., Horn, L., Thornton, J., & Whitfild, K. (2014), The employer potential of MOOCs: A mixed-methods study of human resource professionals' thinking on MOOCs. Available at: https://files.eric.ed.gov/fulltext/EJ1045984.pdf

charge; the exception are specialised, tailored courses, which charge a fee to receive a certificate of completion. Taking tailored courses require that an SME is aware of the types of skills needed. Since this is not always the case the benefit of MOOCs is questioned at times.

(2) A growing number of academic institutions, education centres and private companies offer short courses, open summer schools to assist firms in addressing the digital skills gaps. The attendance of a course by an employee requires an investment of time and finance. In contrast to MOOCs, short courses have a more intensive approach to study and many of them are provided only in classes. The advantage of such types of training is the ability to interact with other students and trainers/coaches, however, many existing courses are not specifically adjusted to skills needs of particular employees. Hence, their use depends on flexibility and relevance of curriculum, successful diagnostic of needed skills and effective communication with the trainer[258].

(3) The in-house learning from other colleagues could be a very effective method of training if needed skills are already available in an SME, the transfer of skills does not require significant investment of time and other resources, and if colleagues possess good teaching/mentoring skills. In addition, training by colleagues can be effective in building relationships with a new employee[259]. Training within the company network implies involvement of partners, which enables access to a greater number of specialists/trainers and other resources for learning. The usefulness of such type of training depends on the same factors as in in-house learning from colleagues.

(4) The test & trial innovation include a variety of training investments that are beyond the list of conventional methods. These more innovative methods include games, self-directed online learning and interaction with technologies[260].

When the decision is made to hire new staff rather than train current staff, SMEs tend to combine the skills requirements of new technologies with other tasks required in the organisation rather than hire a specific professional. As a result, there is an abundance of staff profiles for the three technologies in SMEs that include both the technology need and another company-specific need. This approach makes a one-size-fits-all approach for skills strategies of SMEs rather inappropriate, and also makes it a challenge for job-seekers with the right technology skills to identify these positions as appropriate to them.

To be able to fulfil the specific company need, it is not rare for SMEs to attract talent through their network of partners in their economic value chain and partners in regional initiatives such as traineeships. Although with the current high demand for digital talents, it is becoming more common to recruit from outside of the country and even outside of Europe.

To find the right staff to fit these rather company-specific criteria, SMEs currently often compete with higher salaries and/or more attractive working conditions offered by large

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[258] ECORYS UK (2016), Digital skills for the UK economy. Report prepared for the Department of Culture, Media & Sport. Published January. Available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/492889/DCMSDigitalSkillsReportJan2016.pdf

[259] Heathfield, S. M. (2018), Tap the power of internal training. Published May. Available at: https://www.thebalancecareers.com/tap-the-power-of-internal-training-1919298

[260] OECD (2016), Innovating education and education for innovation: the power of digital technologies and skills. Available at: http://www.oecd.org/education/ceri/GEIS2016-Background-document.pdf

companies. This will remain a challenge for SMEs as long as there remains a skills shortage.

4.5. Conclusion

Strategies of SMEs to approach skills needed for the three technologies at hand are motivated by a wide range of company specific factors. SME managers/owners embracing digital transformation are rare but are a step ahead in their approach towards digital skills development. Hence, the stage of digital maturity is associated with the skills development strategy chosen by an SME. The lack of knowledge and skills of managers/owners in SMEs prevents them from understanding the potential of these technologies and discourages investment in digital skills development.

Traditional digital skills development strategies, such as training, recruitment and outsourcing are most popular in companies – both large and small. The choice of the right strategy for an SME depends on an assessment of needed skills, available resources, amount of various types of investments and costs and use of acquired digital skills through cost-benefit, cost-effectiveness, efficiency and opportunity cost analyses. Both internal and external skills strategies have advantages and disadvantages, therefore neither of them secures an SME from business risks nor ensures that skills gaps in a company will be addressed.

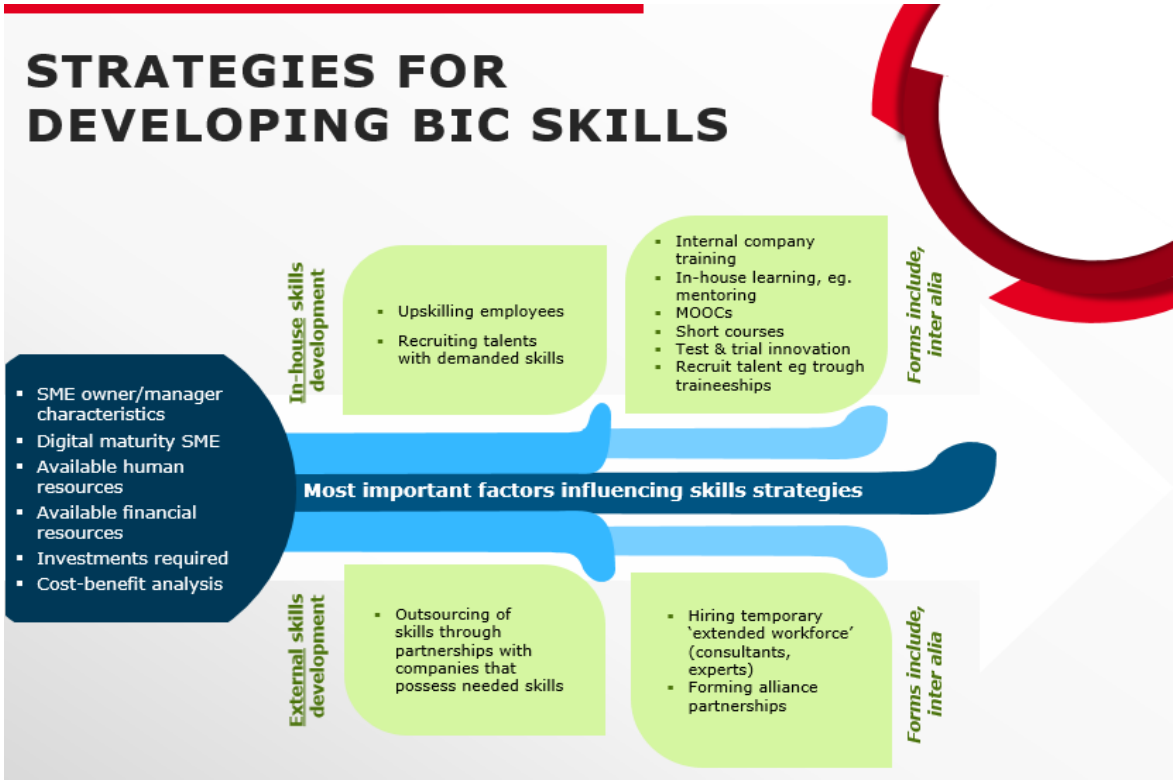

Figure 43 Strategies for developing big data, IoT and cybersecurity skills

5. KEY STRATEGIES AND POLICIES

The shortage of digital skills relevant for IoT, big data and cybersecurity in the European workforce has not gone unnoticed. Initiatives to combat this issue are abundant, and can be found at an EU, national, regional and sectoral level. However, the goals, methods and scope of these initiatives vary substantially. Broadly speaking, the initiatives can be divided into three overarching categories based on the aim of the initiatives. The first category is upskilling the current workforce and aimed at improving the expertise in a

particular domain to avoid obsolescence of skills[261]. The second category is reskilling the current workforce and has the goal of changing people from one domain of expertise to another. Both these approaches are for the short to medium-long term and are generally more relevant to SMEs. The third category is a more structural approach and aimed at educating the future workforce. This ensures that future generations possess digital skills once they enter the labour market.

The goal of this initiative is to stimulate the development of specialised skills for SMEs in Europe. It is therefore important to acknowledge that this initiative does not exist in a vacuum. This section discusses the initiatives that emerged during the desk research and interviews. First, the state-of-play will be discussed. This is followed by a more detailed discussion of the initiatives segmented by the type of initiator or funder. We distinguish between initiatives funded by or operating at the EU level, the level of member states, regional initiatives, private sector organisations, public-private-partnerships (PPPs) and the US. For each section, several initiatives relevant to SMEs will be highlighted to provide opportunities for learning from best practices. The final section will briefly discuss the three overarching categories of upskilling, reskilling and educating the future workforce.

5.1. Overview of relevant initiatives

The study collected over 50 skills-initiatives[262] relevant for boosting digital skills, which include basic interpersonal, communicative skills, as well as, advanced technical skills. The identification of initiatives was based on the Internet search of major European, national, regional and private digital skills programmes addressing (elements of) BIC skills development, announced on websites of public organisations or in public reports and research studies. Complementary to the desk research, interviewees were asked whether they were aware of relevant initiatives, and a call was placed upon the website of the European Digital SME Alliance inviting stakeholders to submit initiatives not already mapped by the research team. The results of the search are not exhaustive, but rather indicative of the diversity of available programmes. Around one-third of identified initiatives specifically focus on addressing skills needs in SMEs. This already highlights that most public, private digital skills development programmes do not specifically target small companies.

For a selection of good practices, covering public policies, academia and industry-led initiatives, the study provides a more detailed project descriptions in Annex E. These good practices provided for excellent insights that hugely supported the design of the vision and roadmap.

Fifteen European examples:

- Skillnet Ireland by the government of Ireland (Ireland)
- Cybersecurity Skills Initiative (CSI) by an Irish nationwide public-private coalition (Ireland)
- SME Datalab by Jheronimus Academy of Data Science (JADS) (the Netherlands)
- PROMPT by RISE Research Institutes of Sweden (Sweden)
- Cyber Resilience Centre by Brainport Eindhoven region (the Netherlands)
- ASTER by Emilia-Romagna region (Italy)

[261] Cedefop (2018), Insights into skill shortages and skill mismatch: learning from Cedefop's European skills and jobs survey. Luxembourg: Publications Office. Available at: http://data.europa.eu/doi/10.2801/645011%0AA

[262] Annex C lists these initiatives as part of the toolbox (further described in chapter 7)

- Recognising skills in data science by the Big Data Value Association (BDVA) (European)
- Community knowledge platform by VOICE (association of IT-using SMEs) (Germany)
- SMESEC by the SMESEC consortium for the European Commission (European)
- Make_SME_Digital (Blueprint skills training SMEs) by consortium for the European Commission (European)
- Mittelstand 4.0 Centres of Excellence by the Federal Ministry for Economic Affairs and Energy (Germany)
- Les Digiteurs by CCI Paris Ile-de France (France)
- SEnDIng by the University of Patras for the European Commission (European)
- Modern Enterprises Programme by the Hungarian Chamber of Commerce (Hungary)
- Innovation vouchers by Business Finland (Finland)

Three examples from outside of Europe:

- Cybersecurity support rangers by The Ministry of Economy, Trade and Industry (Japan)
- Cyber NYC by the New York City (USA)
- Skillsfuture initiative by Singapore government (Singapore)

5.2. Initiatives led and/or funded by the EU

There are several initiatives funded by the EU that focus on digital skills, of which seven large initiatives are analysed here. Five of those focus specifically on upskilling the current workforce. These five (IT Professionalism, Digital Skills and Jobs Coalition, ENISA Network, Digital Innovation Hubs and makes_me </digital>) are also particularly relevant to SMEs.

IT Professionalism has the goal to better understand how strategies for IT competences for SMEs could be developed263. This initiative is tailored towards SMEs, but is more focused on developing knowledge about these processes than actually providing tools SMEs could use.

The Digital Skills and Jobs Coalition brings together firms, education providers and non-profit organisations in EU member states[264]. Within each member state, several projects are executed with a diverse set of goals. Some of these projects focus on developing digital skills for SMEs. The objective of the coalition is to support the upskilling and retraining of the workforce and in particular support measures that help SMEs in attracting and retaining digital talents.

ENISA is the European Union Agency for Network and Information Security[265]. It acts as the center of expertise for cybersecurity. In this role, it provides information about technologies like IoT, big data and IT infrastructure. Since 2008, ENISA has provided cybersecurity training material for specialists that cover technical, operational and legal domains. Each domain has several topics and courses. For each topic, the target

[263] http://ictprofessionalism.eu

[264] European Commission (2014), The digital skills and jobs coalition. Published October. Available at: https://ec.europa.eu/digital-single-market/en/digital-skills-jobs-coalition

[265] https://www.enisa.europa.eu/about-enisa

audience is defined and handbooks, toolsets are provided free of charge. ENISA has developed several tools and training material specifically for SMEs, such as the Cloud Security Guide for SMEs[266].

Digital Innovation Hubs is the EU initiative within the Digital Single Market package that aims to complement national initiatives for digitizing industry and to support digital industrial revolution in the EU. Digital Innovation Hubs are one-stop-shops that assist companies, both small and large, to develop more competitive products and services using digital technologies. These Hubs provide knowledge, expertise, financing support and technology to companies that are willing to assist their customers, clients in experimenting with digital innovations.[267]

Makes_me </digital> is commissioned by the European Commission and managed by a consortium of BluSpecs, Civitta and UPTC[268]. It has a budget of 400.000 EUR and should be used in improving the digital skills of SME employees in Europe. This is done by choosing two regions in Europe with high unemployment rate and designing training programs to upskill the workforce. The next steps in this project are aimed at upscaling the initiative to other EU Member States.

The fifth initiative is Rethinking Education, a program set up in 2012 to meet the demand for higher skills and reduce unemployment[269]. For each of the EU Member States a country analysis was performed to function as a benchmark for evidence-based policymaking. This results in specific and tailor-made policies that will rethink the educational system per country to better align with the anticipated labor market needs of the next decade. The goals include reduction of early school leavers, promoting lifelong learning and more cooperation between educational institutions and training providers.

The European Union funded all initiatives. Some are financed through calls for tenders and managed by a consortium of partners, while others like ENISA and the Digital Skills and Jobs Coalition are agencies associated with the European Commission. The budget or amount of resources available to the initiatives varies, as a direct result of this structure. The initiatives that are outsourced have a fixed budget available. IT Professionalism and makes_me </digital> aim to study and design programs for digital skills but are not focused on European-wide upskilling. The run-time of these initiatives is therefore shorter.

The Digital Jobs and Skills Coalition, on the other hand, stimulates several programs related to the transforming of the economy and subsequent impact on skills needs. These programs include public, private and public-private partnerships to upskill, reskill and educate the workforce. Each program has different initiators and partners, and therefore different governance structure and budget.

In sum, the initiatives on the European level are currently deepening the understanding of the skills needs and piloting solutions to solve these issues. Practical and easy to find tools SMEs can use in their current needs are still in development.

Existing EU initiatives vary in terms of focus areas, target groups and approach/method for addressing skills gap, even if they are seeking to reach the same aim. To illustrate

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[266] https://www.enisa.europa.eu/publications/archive/training-material-SMEs

[267] European Commission (2018), Digital Innovation Hubs. Available at: http://s3platform.jrc.ec.europa.eu/digital-innovation-hubs

[268] European Commission (2017), Commission launches pilot project to design dedicated digital skills training programmes for small businesses. Published June. Available at: https://ec.europa.eu/digital-single-market/en/news/commission-launches-pilot-project-design-dedicated-digital-skills-training-programmes-small

[269] https://ec.europa.eu/education/policy/multilingualism/rethinking-education_en

this, the tables below present four EU initiatives that specifically focus on upskilling the current workforce.

5.2.1. Blueprint for sectoral cooperation on skills

As it discussed earlier, technological intensity and associated skills needs have sectoral patterns. This allows policy-makers to form sector-based initiatives in addressing skills gaps. Among the major advantages of the sectoral approach are the stimulation of skills development in the entire industry/sector, and the building of cooperation between several stakeholders. Since some companies require a tailored approach to address their skills needs, the sector-based initiatives might not always be flexible enough to accommodate to their needs.

One of the major current initiatives that have a sectoral approach in responding to skills gaps in industries is the Blueprint for Sectoral Cooperation on Skills. This initiative is part of the new Skills Agenda, therefore it is funded the European Commission. The Blueprint for Sectoral Cooperation on Skills provides a framework for strategic cooperation between key stakeholders, such as businesses, trade unions, and education and training institutions, aiming is to support a sectoral strategy for development of concrete actions in addressing skills needs in the short and medium terms[270]. Within the Blueprint for Sectoral Cooperation on Skills, there are five sector-oriented initiatives currently carried out[271], as described in Table 6, with more initiatives in other sectors to be launched towards the end of 2018 and in 2019

Sector	Initiative name	Initiative website
Automotive	Development and research on innovative vocational education skills (DRIVES)	https://www.project-drives.eu/en/home
Maritime technology	Maritime alliance for fostering the European blue economy through a marine technology skilling strategy (MATES)	https://projectmates.eu/
Space geo information	Towards an innovative strategy for skills development and capacity building in the space geo information sector supporting Copernicus User Uptake (EO4GEO)	http://www.eo4geo.eu/
Textile/clothing/ leather/footwear	Skills 4 smart TCLF industries 2030 (S4TCLF)	http://www.s4tclfblueprint.eu/
Tourism	The next tourism generation alliance (NGT)	https://nexttourismgeneration.eu/

Table 3 Blueprint initiatives per sector

5.3. Initiatives funded by Member States governments

The governments of the EU Member States recognise the importance of digital skills for the national and the EU economy, therefore individual countries introduce various training programmes for different population groups to reach specific national goals in digital transformation. The local SMEs take advantage of those initiatives, due to proximity, accessibility of trainings, better awareness about those programmes, and availability of training in local languages. Furthermore, companies will benefit from well-tailored training programmes and this is more likely to be the case when the initiative is

[270] European Commission (n.d.), Blueprint for sectoral cooperation on skills. Available at: http://ec.europa.eu/social/main.jsp?catId=1415&langId=en

[271] European Commission (2017), Erasmus+: Cooperation for innovation and the exchange of good practices (KA2). Available at: https://eacea.ec.europa.eu/sites/eacea-site/files/compendium_ssa_blueprint_2017final.pdf

offered by a local government that is aware of the specific needs of 'their' local SMEs, and related digital maturity levels and resources. Some nationally funded initiatives are indirectly contributing to digital skills development in the country through awareness-raising campaigns, knowledge-sharing programmes, setting-up of organisations that connect training providers and companies.

Thus far, this study has found a total of 26 initiatives funded by national governments in the EU28 Member States. Germany and Denmark account for seven and five initiatives respectively, with France coming third with three initiatives. However, while these three countries together account for over half of the national initiatives found thus far, we also acknowledge that this mapping exercise is not exhaustive, and many more initiatives exist. Our findings could be interpreted as a signal of the differences in awareness and action among the Member States. Five initiatives are presented in more detail further below, illustrating the diversity in terms of services offered and approach taken.

The national initiatives vary in relevance to SMEs. The relevance is determined by the actions or goals of the initiatives aimed at the upskilling or reskilling current workforce and which groups are targeted within this workforce. In total, 16 initiatives want to upskill the working population in terms of digital skills. However, digital literacy and inclusion are considered as key in the digital transformation as well. This is represented by the six initiatives that target the general population. Examples of these initiatives are Developing Digital Literacy in Estonia[272], the Good Things Foundation in the UK[273] and Cybervolunteers in Spain[274]. These projects aim to educate people in order for them to use computers and the Internet. In turn, this will enable them to participate in a digital society.

The remaining 10 initiatives that upskill the workforce are targeting professionals in general and sometimes SMEs in particular. Examples include helping SMEs to establish an online presence[275], to provide cybersecurity training[276] and to incorporate digital technologies into their businesses[277]. However, rarely any of the initiatives provide advanced digital skills. This indicates that the basic skills are perceived to be lacking by the initiatives. Public initiatives are likely to be general and basic due to their nature. Targeting more advanced digital skills is only probable if this serves the public good. Right now, this is not the case.

At the national level, there are no initiatives only focusing on reskilling the workforce. Reskilling is part of the Grande école du numérique in France[278] and INCoDe.2030 in Portugal[279]. However, upskilling and educating the future workforce are also goals of these initiatives. The idea to move people from one industry to another is therefore not popular. This can be explained by the nature of public initiatives too. Predicting the

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[272] German Federal Ministry for Economic Affairs and Energy (2016), Avoiding skills shortages and mismatches – New strategies for meeting companies' skilled labour needs. Published April. Available at: https://www.bmwi.de/Redaktion/EN/Publikationen/avoiding-skills-shortages-and-mismatches.pdf?__blob=publicationFile&v=2

[273] https://www.goodthingsfoundation.org

[274] https://www.cibervoluntarios.org/es

[275] http://transition-numerique.fr/centre-de-ressources/les-digiteurs-paris-ile-de-france/

[276] https://www.incibe.es/formacion/ciberseguridad-para-micropymes-y-autonomos

[277] https://hellofuture.org/case/digilyft/

[278] http://www.grandeecolenumerique.fr/

[279] http://www.incode2030.gov.pt

likelihood, timing and jobs that will disappear as a result of the digital transformation is very difficult. This could be a reason reskilling is not a major part of the public initiatives yet.

The identified German initiatives have a strong focus on Industry 4.0 and related (advanced) skills. Among seven mapped initiatives in Germany, five of them focus on SMEs in particular. Some of these initiatives represent the competence centers that function as network organisations. The so-called competence centers are not providing skills trainings themselves but bring SMEs in contact with funding and experts in relevant fields that can provide training. Similar competence centers are also found in Ireland (Skillnet)[280] and in France (Transition Numérique Ile-de-France)[281]. The latter initiative provides a network of consultants to SMEs that assists in using digital technologies.

Some miscellaneous approaches include the Human Capital Agenda ICT in the Netherlands, the initiatives that are focused on increasing the availability of open data by the Government of Denmark[282] and on utilizing libraries for knowledge sharing and skill development in Romania[283]. While these initiatives are relevant to combat the skills shortage through awareness raising on importance of digital skills and encouraging the use of digital technologies, they do not directly address the digital skill gaps of SMEs.

5.3.1. Regional initiatives

In addition to national governments, there are several regional and city level initiatives to support digital skills relevant to the three technologies in Europe. The regional initiatives have the advantage of involving local actors, building learning communities in cities, stimulating local knowledge sharing, analyzing local labour markets and supporting regional SMEs through tailored strategies. Below we have provided a selection of several initiatives.

In the Ile-de-France region, les Digiteurs focus solely on SMEs, providing them with an online resource centre and dedicated training to help enterprises develop their digital capacity and offer. The programme does not target specific sectors or types of skills. Training is provided through educational programmes and in-situ counselling. A coworking space and a showroom have also been installed for SMEs willing to try new equipment and technologies. This initiative was put in place by the Chamber of Commerce and Industry (CCI) of Paris-Ile-de-France in 2017, and is part of the national digital transition strategy. In February 2018, the CCI started a new partnership with les Echo-NetExplo, Google and SoLocal Group, called Le Coach Digital, which aims to provide fee-based training and business development to SMEs.

In Emilia-Romagna, the Clust-ER associations adopted a mid-way solution, by bringing together SMEs, students and developers of educational programs (research laboratories and centers for innovation belonging to the High Technology Network). Although the initiative is not directly aimed at upskilling, it helps building soft skills. As the whole supply chain meets at both managerial and IT level, SMEs can identify their needs in terms of skills but also in terms of new services that need to be provided in the region. IT staff can also share their experiences and advices. By working with education providers, they also get a chance to frame future programs in which their staff could enroll. The

[280] https://www.skillnetireland.ie

[281] http://transition-numerique.fr/centre-de-ressources/les-digiteurs-paris-ile-de-france/

[282] German Federal Ministry for Economic Affairs and Energy (2016), Avoiding skills shortages and mismatches – New strategies for meeting companies' skilled labour needs. Published April. Available at: https://www.bmwi.de/Redaktion/EN/Publikationen/avoiding-skills-shortages-and-mismatches.pdf?__blob=publicationFile&v=2

[283] https://www.medqidiacity.ro/

programme is run by ASTER, the Consortium for innovation and technology transfer of Emilia-Romagna.

In the Walloon region of Belgium, digital education is provided through a wider support to apprenticeship and in-situ training. The Wallonia Marshall plan 4.0 includes support to educational programmes, training for tutors in companies, an online match making platform for prospective trainees and interested companies, financial assistance for trainees and companies welcoming them. The Wallonia Marshall plan 2.0 was launched in 2015 with a budget of 304.5 million EUR, and it will last for four years[284].

Some regional initiatives are not specifically focusing on SMEs or on employees, but rather on larger population groups. In Ghent, the e-inclusion programme aims to give all citizens the opportunity to develop digital skills. The project being about digital inclusion, it mainly covers initial skills. The programme, which was launched in 2006, is managed in cooperation between the City of Ghent, the Public Centre for Social Welfare Ghent and Digipolis Ghent. Already in 2012, the programme was identified as a best practice for multi-stakeholder involvement for digital inclusion. Key to its success was its capacity to regularly launch innovative pilot-projects to keep up with new developments, the integration of digital initiatives across all local policies, and the active involvement of citizens.[285]

At the regional level, some initiatives have been ongoing for long enough to get interesting conclusions. See the example of Ghent (although the evaluation is already old: 2012). For most initiatives, it is too early to say if one has been more efficient than another. Most programmes try to combine several activities to fit the demand: from online resources for all to tailored consulting services for companies. As a result, the initiatives do not try to target a specific set of skills, but leave the possibility to companies taking part in the programme to ask for customised support.

5.4. Initiatives funded by the private sector in Member States

5.4.1. Insurance companies and accountancies can play a key role in making SMEs more cyberproof

The role of insurance companies and accountancies, especially in the field of cybersecurity, should not be underestimated.

Accountancies are in regular contact with SMEs and advise them on business continuity matters. Most accountants are SMEs themselves and hence can understand SMEs. They are well positioned to make SMEs aware of the threats (and opportunities) of cybersecurity, and trigger them to action. Accountancies across Europe are already developing initial points of view and checklists to support SMEs in this challenge (some can be found here).

Insurance companies on the other hand carry part of the societal risk of SMEs being impacted by cyber incidents. Increasingly insurance companies are moving to pro-active prevention policies to make SMEs aware about the risks and about easy steps to become

[284] Plan Marshall 4.0. Accueillez un stagiaire en alternance. Available at: http://planmarshall.wallonie.be/mesures/accueillez-un-stagiaire-en-alternance

[285] Mariën, I. & Van Audenhove, L. (2012). Towards a Multi-Stakeholder Approach for Digital Inclusion: A case study of Ghent's Digitaal Talent policy program. Published July. Available at: https://cris.vub.be/en/publications/towards-a-multistakeholder-approach-for-digital-inclusion-a-case-study-of-ghents-digitaal-talent-policy-program(0d1bda13-06b5-4f1d-bf73-523a039e0663).html

more secure and resilient. Via their insurance policies they have a financial lever to trigger SMEs to action.

5.4.2. Various private sector led training activities

Several other private sector-led skills development initiatives were found. These initiatives are provided and funded by a variety of private organisations, which include education organisations (schools, colleges, universities), professional training centers, private associations/clubs and companies that have digital skills experts that provide training. The private sector has the capacity to accommodate to different skills needs, therefore the variety of training specialisations (type of skills, skills level, sector orientation) and available modes of study (period of study, group/individual training, type of a trainer) is usually broader than of initiatives that are provided or funded by public organisations. The private sector initiatives can also be effective in fostering business collaboration with trainers/education providers and other companies that face similar skills gaps. Considering the diversity of available public and private sector digital skills initiatives it is difficult to make broad generalisations and find large distinctions between public and private sector programmes.

In our study, various private sector-led initiatives were found. These initiatives all aim to upskill the digital competencies of firms and SMEs in particular. Like all the other initiatives, they have a horizontal approach, meaning that they do not target specific sectors. The initiatives do place skill development in the larger context of growing businesses. For example, Facebook's initiative was launched in 2018 and aims to train 1 million people by 2020. It does this by collaborating with local organisations in, for the time being, Spain, Italy, Poland and France to educate people in digital literacy and media skills. In turn, this should enable people to effectively grow their businesses by enabling access to the online community.

The three other relevant initiatives are firms providing courses in digital skills (Coursedot, OAK3 Academy and General Assembly). Prices vary and depend on the courses. Coursedot allows the user to search for relevant courses based on a search term. The search term "data analysis" returns 223 hits, all courses on different software packages and levels286. The software producers often provide these courses. Microsoft has courses on data analysis in Excel in Germany that run for three days and cost 1,400 EUR[287]. On the higher end are courses by EMC on Big Data Science that take six days in the UK and cost 4,670 EUR[288]. An online data analysis short course provided by General Assembly costs 1,250 USD per learner and its duration is 10 weeks[289]. For SMEs it is difficult to discern the differences and quality between these courses.

However, all three firms do provide training in specialist roles and could provide training both online and on-campus. The fact that more specialised training is available is unique, in comparison to the other initiatives we found. However, sending people to train for multiple days on-location could pose problems for SMEs that cannot afford to send an employee to training for so long.

There are also course providers that are somewhat less relevant to SMEs. These courses are more generic (e.g. marketing courses by Google Digital Garage) or focused on reskilling the workforce (e.g. Udacity & Google Developer Scholarships Challenge in the

[286] https://coursedot.com/catalogsearch/result/index/?p=2&q=analyzing+data

[287] https://coursedot.com/20779a-analyzing-data-with-excel.html

[288] https://coursedot.com/emc-data-science-and-big-data-analytics.html

[289] https://generalassemb.ly/education/learn-data-analysis-online

EU). The least relevant initiatives focus on digital inclusion, reskilling or diversity. These issues are very important, but in the context of providing practical skills to SMEs on the short term not very relevant.

Technology companies are providing a large share of all the initiatives. Eight initiatives involve technology firms like Google, Facebook, and Samsung. Google is the most prolific, as it is involved in the Udacity & Google Scholarship, Codepact in the Netherlands, Google Analytics Academy, Google Growth Engine for Europe and Google Digital Garage. It often partners with local organisations to provide training, scholarships and courses to individuals. Many of the courses Google provides relate to marketing, data analysis and many other digital skills that people need to succeed. Many courses are free and used as an introduction to certain topics and can be taught online and offline depending on the initiative and the course.

5.5. Initiatives funded by public-private collaborations in Member States

We have also come across 27 collaborations between public and private organisations. Many of these take the form of network organisations, competence centres and knowledge-sharing networks. These could involve educational institutions like universities, (large) firms and branches of local ministries to provide training, education and knowledge about digital skills and technologies. Some initiatives also foster innovation by enabling partners to work together on projects and research. In turn this should lead to practical knowledge and the upskilling of the workforce. The initiatives that are based on public-private collaborations are usually promoted by one party, either public or private organisations, that is seeking support or engagement with other actors. Such initiatives could be an effective solution for building synergies, improving cooperation between public and private organisations and for reaching common objectives in terms of digital skills development. Many public private partnerships achieve faster results, reduce risks and costs of individual actors and, as a result, achieve higher efficiency. The disadvantages of such approaches are associated with complexity of collaboration between public and private organisations, such as mutual dependence, which can slow down the decision-making process, unbalanced risks of one party, market distortion through exclusion of companies/organisations that did not join the public-private initiative.[290]

Geographically speaking, the PPPs are very diverse. In our sample, many countries have two PPPs, but there is not one country with more than two. Examples include Austria, Denmark, Belgium, Sweden, Germany and Poland. The goals of these PPPs are also more diverse. Instead of focusing solely on upskilling, there is also more attention to reskilling and educating the future workforce compared to the public or private initiatives. As a result, initiatives are either relevant to SMEs now or they are not.

Examples of relevant initiatives include the Digital Hub in Denmark, The Big Data Value Association in Europe and PROMPT in Sweden. The Digital Hub brings together SMEs and digital talent through an online platform focused on emerging digital technologies. By bringing knowledge in the form of human capital and SMEs together, the digital skills of SMEs could be improved. The goal of PROMPT is similar, as firms develop courses in cooperation with universities to provide software competencies to the workforce that are relevant to businesses. These courses can also be followed online. The Big Data Value Association focuses on big data technologies and brings together data users, providers and researchers to enhance the ecosystem and foster innovation.

Crescere in Digitale from Google gives SMEs access to digital marketing skills, by matching SMEs with trainees. Google provides the training and the Italian government

[290] Rodriguez, J. (2018), Public Private Partnership Pros and Cons. Available at: https://www.thebalancesmb.com/public-private-partnership-pros-and-cons-844713

pays for the traineeships. They provide a monthly fee of 500 EUR for the duration of six months to the trainees; saving the SMEs money and letting them use the knowledge of the trainees. Furthermore, the SMEs build up a network and have contact with young professionals that might be interested in working for the SME after graduation. The entire program runs until the end of June in 2020 and aims to have paid for 5000 internships by that time.

The mapped public-private initiatives give an impression that collaborations between public and private organisations are aimed at fostering innovation by sharing knowledge and valorisation. This valorisation can be in the form of help for employee upskilling. However, they do risk providing very specialised courses that not all SMEs can benefit from. Furthermore, the involvement of SMEs that lack digital skills is not always clear. This too could result in the issue of other organisations pushing their own agenda and perceived needs, without corresponding to the needs of some SMEs that require either general or specific training.

Initiatives that are less relevant include checklists for cybersecurity and GDPR compliance, certification of digital excellence for schools and providing coding classes to students from primary to high school. The first set provides practical tools SMEs could use, but does nothing for skills development. The latter category is mainly involved in promoting the appeal of coding and digital skills to students and laying the foundation of digital skills of the future working generation.

5.6. Examples of initiatives in US

5.6.1. Overview of US support

The US traditionally invests little in active labour policies, explaining the limited number of public initiatives to support the uptake of digital skills among its businesses. Indeed, investment in this domain has halved in total funds allocated in the past 30 years[291]. Under the Obama administration, a number of public initiatives were launched at the national level. They usually involve grants from the Department of Commerce, but also from the Department of Defence (for cybersecurity programmes), which are then completed by State or other local public funds and public-private partnerships. The programmes usually focus on support to educational programmes and matching tools for job seekers and employers. As such, upskilling of employees is not a priority, since one of the key objectives is to reduce unemployment. However, some elements can be found in cybersecurity.

One example is the CASCADE (California Advanced Supply Chain Analysis and Diversification Effort) initiative funded by the Department of Defence and the State of California, launched in 2017 to develop cybersecurity-related education curricula, training, and apprenticeship programs[292]. The programme focuses on hard cybersecurity skills, but also entrepreneurial and other business skills (commercialization, supply chain outreach, etc.), and provided support and innovation vouchers for the acquisition of cybersecurity capacity by companies[293].

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[291] Council of Economic Advisers (2016) Active labor market policies: theory and evidence for what works. CEA issue Brief. Published December. Available at: https://obamawhitehouse.archives.gov/sites/default/files/page/files/20161220_active_labor_market_policies_issue_brief_cea.pdf

[292] CASCADE (n.d.), California advanced supply chain analysis and diversification effort. Available at: http://business.ca.gov/Programs/Innovation-and-Entrepreneurship/Cybersecurity/CASCADE

[293] State of California Office of the Governor (2018), Program summary. Published January. Available at : http://business.ca.gov/Portals/0/Files/CASCADE/CASCADE--ProgramSummary.pdf

The largest public programme launched in the US in the past years is TechHire, which supported the development of local initiatives that mostly focused on education and reskilling, often targeting specific communities, such as workers with non-traditional backgrounds, veterans, and deprived areas. The aim of the programme was to provide workers with the needed skills for well-paying, middle- and high-skilled, and high-growth jobs, through fast-track training organised via public-private partnerships.

The programme was not restricted to any sector or type of skills, but several initiatives launched under its umbrella focused on digital and IT skills. Initiatives were implemented in universities and community colleges, but also in other environments such as coding boot camps and online courses. Towards the end of the programme, more than 70 communities and 1500 employers were involved in diverse sectors (figures for digital skills were not available).

Cybersecurity has been a key focus of digital skills programme in the US. At the national level, the Department of Commerce launched NICE, the National Initiative for Cybersecurity Education. It aims to create an ecosystem of cybersecurity education, training, and workforce development. The initiative is still ongoing[294]. A successful example can be found in the State of Virginia, which combined both NICE and TechHire programmes to develop cybersecurity education for students and veterans[295]. The Cyber Vets Initiative includes two training programmes for the reskilling of veterans. The first one is a pilot public-private partnership consisting of a free online cybersecurity course to 200 veterans. The second one is a scholarship-based programme offering advanced technical training and contact with cybersecurity firms to veterans and spouses of active military workers[296].

As presented above, the TechHire and NICE programmes have supported the development of educational programmes in digital skills. As part of the NICE programme, 1 million USD was released in grants for the development of local and regional training cybersecurity programmes. In Virginia, the cybersecurity education initiative led to concrete results, with a multiplication by six of the number of students enrolled in the cybersecurity programme in 2016, compared to 2014[297]. Under the CyberVirginia label, all cybersecurity curricula can be found online by prospective students, who can also apply for a number of scholarships[298].

In the US, public funds are used to set up public-private partnerships to provide local, community-based initiatives. Most of them focus on education and reskilling, with the central objective of reducing unemployment. Direct support to companies – and SMEs specifically - per se is rare. Instead, many American companies rely on existing training courses, often provided by larger technology companies.

The US benefits from its leading IT companies. However, although several of them have set up grants and support for non-profit organisations (see for example Google's initiatives[299]), direct support to businesses is only offered as a paid-for service. Indirect

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[294] https://www.nist.gov/itl/applied-cybersecurity/nice/about

[295] Andrews, B. & Colangelo, M. (2016) Investing in Cybersecurity Workforce of Tomorrow. Available at: https://www.commerce.gov/news/blog/2016/12/investing-cybersecurity-workforce-tomorrow

[296] https://www.cybervets.virginia.gov/

[297] Andrews, B. & Colangelo, M. (2016) Investing in Cybersecurity Workforce of Tomorrow. Available at: https://www.commerce.gov/news/blog/2016/12/investing-cybersecurity-workforce-tomorrow

[298] https://www.cyberva.virginia.gov/education/

[299] https://www.google.org/our-work/economic-opportunity/

support can be received via non-profits. For example, some of Google funded initiatives support free-lance workers and business managers.

5.6.2. Comparing the US and the EU

To compare with the situation in the European Union, the United States follows a rather similar approach: the federal level has made public funds available (at least under Obama administrations), to support the development of digital skills. Most of it was used at a more local level, with States and local communities organising the set-up of specific initiatives.

Regarding the level of support, it must be noted that the federal level has decreased its financial support and that recent programmes do not seem to have been continued under the Trump administration, which contrasts with the EU ongoing effort to support digital skills. At the State level, as between European Member states, the involvement of the public administration in supporting digital skills programmes varies from one state to another, depending on their wealth, political orientation, but also on the strength of the existing IT sector. Unsurprisingly, California offers a very complete support, including to businesses.

As in the EU, most initiatives are not designed specifically for SMEs. The difference is mostly in discourse: while the EU and some Member States strongly insist on SMEs in their industrial policy, the US in general does not differentiate between companies of different sizes. Although we can expect smaller American businesses to benefit more from support initiatives, they are not targeted per se, while initiatives targeting the population are often tailored for specific groups and communities.

In term of sectors, cybersecurity is getting more attention in the US than in the EU, due to ongoing involvement of the US Department of Defense. In terms of the variety of offered skills trainings, both in the US and the EU the range of initiatives is very broad, and it includes everything from hard to soft skills, from coding to managing an IT business.

5.7. Learnings from the good practices

5.7.1. Upskilling the current workforce

The need for digital expertise is growing as IT departments move from facilitating roles inside organisations towards more strategically oriented roles. As one interviewee stated: "IT is becoming more important for the business and thus requires expertise in translating the needs of the market". This does not only require 'hard' IT skills, but also 'soft' business skills[300].

Initiatives tackling this issue typically teach basic IT skills to the general (working) population. This is not directly relevant to SMEs, however. In terms of upskilling the current workforce of SMEs, private training institutions and education providers, such as universities, offer courses to enrich the expertise of employees. Several interviewees pointed out that the relevance of these courses is difficult for an SME to assess. On top of that, courses should be given in self-paced format during non-working hours to allow SMEs and their employees to attend them. One interviewee stated: "The learning outcomes of courses should be aligned with the needs of SMEs. This requires communication between firms and education providers". Thus, to make courses relevant to SMEs, education providers and firms have to collaborate in curriculum development.

[300] Berger, T., & Frey, C. B. (2016), Digitalization, Jobs, and Convergence in Europe: Strategies for Closing the Skills Gap. Procedia - Social and Behavioral Sciences, *64*(4), 441–454. https://doi.org/10.1177/0002764217701217

Some universities already design courses with the community in mind and, as a result, IT course curricula should become more business-oriented[301].

Some interviewees called into question the necessity of developing digital skills for all SMEs. They acknowledge the likelihood and importance of data-driven firms and economies, but foresee a model in which the market will provide data services for firms. As one interviewee explained: "SMEs are not capable of doing anything with data themselves. Most of the time, both large and small firms will be buying data solutions from the market". One of these initiatives is Coursedot[302], an online marketplace that connects trainers and firms. Trainers can provide upskilling to firms both off- and online, tailored to the needs of the SME.

5.7.2. Reskilling the current workforce

The approach of reskilling the current workforce, is to quickly react to the shortage of IT professionals. People are encouraged to leave their current industry and to become IT professionals. Four initiatives in particular focus on retraining unemployed individuals. These initiatives are Social Builder (France), The Digital Academy (Czech Republic), ICT Professionals (Spain) and Code for All (Portugal). All of these initiatives are run by private organisations, but are not necessarily tailored to skills needed by SMEs.

In short, reskilling appears to be a small part of the initiatives we found. If it is included in an initiative, it is often privately run and focuses on unemployed people. Most initiatives that focus on reskilling are short and provide basic rather than advanced skills, as professional or long-term education is needed to reach a high level of digital proficiency. Many of these basic reskilling courses are sponsored by a third party (government or a private organisation), thereby reducing the fee for the participants. In this sense, reskilling enables people to acquire starting qualifications and enhance their position in the labour market. At the same time, it offers an opportunity to reduce the number of people in 'redundant' jobs once the digital transformation kicks in[303]. Hence, reskilling could be a solution only in case basic digital skills are in demand in the EU Member States.

5.7.3. Educating the future workforce

Formal education is the cornerstone of acquiring skills[304]. A long-term solution to closing the digital skills gap requires therefore adaptation of the current educational system. As mentioned under upskilling the current workforce, course curricula have to be made more relevant to SMEs. However, the curricula have to be adapted in primary and secondary schools as well.

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[301] Wamba, S. F. (2017), Big data analytics and business process innovation. Business Process Management Journal, *23*(3), 470–476. https://doi.org/10.1108/09574090910954864

[302] https://coursedot.com/

[303] Dolphin, T. (2015), Technology, globalisation and the future of work in Europe: Essays on employment in a digitised economy. Available at: http://www.ippr.org/files/publications/pdf/technology-globalisation-future-of-work_Mar2015.pdf?noredirect=1

[304] Berger, T., & Frey, C. B. (2016), Digitalization, Jobs, and Convergence in Europe: Strategies for Closing the Skills Gap. Published January. Available at: https://www.oxfordmartin.ox.ac.uk/downloads/reports/SCALE_Digitalisation_Final.pdf

Logical thinking, critical analysis, coding, algorithms and data-literacy should be taught in schools from an early age[305]. Coding became part of the curriculum in some British schools from the age of five[306]. Initiatives like ProgeTiger (Estonia), Coding Class (Denmark), Samsung Innovation Camp (Italy) and Codepact (The Netherlands) are aiming to familiarize children and students with coding and programming. These initiatives are often in partnerships with technology companies like Samsung, Google and Accenture, to provide training to children at no cost to the schools.

Crescere in Digitale (Italy) is an initiative in partnership with Google, providing paid internships to students. Students learn IT-related skills while doing an internship at SMEs. Students get a monthly allowance from the initiative and the SMEs get in contact with students that can help their businesses.

While the need to update or reform the educational system in Europe is mentioned often, one participant during the first expert workshop in Brussels said: "firms complain about educational institutions that their graduates do not possess the relevant hard skills". The explanation he gave was that the duration of educational programs is too long, meaning that skills acquired during that time are outdated when a student graduates. This is an argument for the idea of lifelong learning. As Cedefop points out, this should be the responsibility of both the individual and the firm, as both benefit from keeping skills and knowledge up-to-date[307].

Short-term initiatives cannot address the current and future digital skills gap, therefore there is a need for the greater focus on digital skills in formal education institutions at all level, from schools to universities. Existing initiatives recognise their limited potential in addressing skills gaps, therefore they serve only as temporary, immediate solutions. The future workforce needs to possess both knowledge, skills and life-learning mindset to quickly adapt to market needs and technological advances.

5.7.4. Conclusions

The definition of digital skills varies to a large extent. When digital skills are clearly defined, normally it is a narrow set of skills related to coding, programming or online marketing. These skills are important, but hardly cover the whole spectrum of digital skills. Hence, there is a need for a greater focus on combination of technical skills with the 21st century skills, such as critical thinking, communication, creativity.

The scale and variety of the digital skills gaps across the EU has given rise to an equally complex landscape of initiatives, projects and players that try to deal with the challenge. This challenge is tackled by increasing the availability of digital skills trainings for the workforce that focus on either upskilling, reskilling or by including digital skills in the curricula of formal education institutions. Digital skills initiatives that focus on upskilling are more common than those on reskilling, as upskilling is needed for a continuous improvement of skills and catching-up with technological progress, while reskilling is typically offered as a basic introduction into the ICT profession for unemployed. The education of future workforce is of utmost importance for addressing the digital skills

[305] Becker, T., Curry, E., Jentzsch, A., & Palmetshofer, W. (2016), New horizons for a data-driven economy: A roadmap for usage and exploitation of big data in Europe. Springer Open. Available at: https://doi.org/10.1007/978-3-319-21569-3_16

[306] Dolphin, T. (2015), Technology, globalisation and the future of work in Europe: Essays on employment in a digitised economy. Available at: http://www.ippr.org/files/publications/pdf/technology-globalisation-future-of-work_Mar2015.pdf?noredirect=1

[307] Cedefop (2018), Insights into skill shortages and skill mismatch: learning from Cedefop's European skills and jobs survey. Luxembourg: Publications Office. Available at: http://www.cedefop.europa.eu/en/publications-and-resources/publications/3075

gaps in the EU. The current short-term initiatives cannot replace in full capacity the lack of digital education at schools and higher academic institutions.

Considering the diversity of existing initiatives (e.g., type of training, skills levels), few of them are directly targeting skills gaps of SMEs. The majority of existing initiatives do not have a specific target group or a sector in which digital skills are being promoted. The generic approach in addressing skills gaps does not exclude SMEs, as they still benefit from trainings that are provided for the general population or for all companies and employees, but it might not address their particular needs and prevent access to training due to high competition for participation in an initiative. Nevertheless, currently, across the EU there are several digital skills initiatives on national, regional, EU levels that are specifically designed for SMEs, hence, various actors recognise particular needs and challenges in small organisations/companies.

The digital skills initiatives are provided at the regional, national and EU levels, and they are implemented by special agencies, consortia, PPPs or private sector organisations. Both public and private organisations offer digital skills trainings, however, the diversity of trainings provided by private companies is larger, due to market adjustment to specific company needs. The European level initiatives are more focused on understanding skills needs and offering easy-to-use online tools and basic trainings. The sectoral, regional and national initiatives allow to build cooperation between participants and other stakeholders, however, due to a narrower target group the sectoral approach might lead to a better alignment of digital skills training to needs of a particular sector. Among the major advantages of national and regional initiatives are availability of training in a local language, easy accessibility, involvement of local actors and conformity of training with national/regional digitalization strategies.

The private-public partnerships could be an effective solution for building synergies, improving cooperation between public and private organisations, pooling resources and for reaching common objectives in digital skills development. However, the disadvantage of such arrangement lies in complexity of collaboration between public and private organisations, such as long decision-making process. Our analysis shows that many of existing public-private initiatives are aimed at fostering innovation by sharing knowledge and valorization.

Since our study has not mapped all existing digital skills initiatives across the EU it is difficult to assess in what areas, sectors and geographical regions there is a lack of particular skills initiatives for SMEs. In contrast to the US, the EU seems to be lacking initiatives on cybersecurity, however, similarly to the EU, the US also uses the generic approach in addressing digital skills gaps. The majority of mapped digital skills initiatives are provided either across the EU or by Western European countries, particularly Germany, Denmark and France. This signals that at least the visibility of digital skills initiatives launched in Western Europe is higher than in Eastern Europe.

To combat the digital skills gap, a coordinated approach is needed. First, the digital skills need to be clearly defined. With a clear definition it is possible to identify specific needs of SMEs and how to address them. A structural change in the training and education of people in Europe is necessary to close the gap, but also to keep the skills up-to-date. Children need to be educated in the basic digital skills, so by the time they choose studies or careers they have basic digital skills and knowledge. From there, lifelong learning is needed to maintain these skills and keep them relevant in a changing environment.

To provide SMEs with digital skills in the short term, people can be upskilled or reskilled. However, prior to training, the education has to be aligned with the skills needs and expectations of SMEs. This includes clear and easy to understand learning outcomes. If employees are trained, the format has to be adjusted to the context of SMEs as well. This could include self-paced online courses and training on location or during the evenings.

PART II: THE WAY FORWARD

6. A FIVE-YEAR STRATEGY ON SKILLS DEVELOPMENT FOR SMEs

As illustrated in Part I of this report, the adoption of BIC technologies is of crucial importance for SMEs, primarily because of two main reasons: 1) ensuring business continuity, and 2) ensuring growth opportunities. At the same time, a lack of skills is one of the top barriers that holds SMEs back from adopting BIC technologies. There is a clear mismatch between supply and demand when it comes to BIC skills, both from a qualitative and a quantitative perspective. From a qualitative perspective, there is a need to ensure that the skills portfolio of current and future employees better match SME needs. As illustrated in section 4, skills required for adopting BIC depend on the maturity and type of an SME, but often involves a combination of hard skills, soft skills and business expertise. Too often, the type of skills that current and future employees possess are not in line with SMEs' needs. From a quantitative perspective, one needs to resolve the current scarcity on the market, especially with regards to hard skills. Europe needs to ensure that a sufficient number of people is qualified for working with BIC technologies – not only for the big corporates, but equally for SMEs.

Apart from labour market issues, SMEs encounter other barriers in their efforts to upskill their existing workforce and to attract talents, inter alia, limited financial and human resources, a mismatch between their skills needs and training offerings, and a lack of awareness. SMEs hardly provide training to their employees. Addressing these barriers is key for fostering SME skills development, and hence facilitating them in their journey to embrace BIC technologies.

This chapter presents a holistic strategy for addressing these barriers and is developed in close collaboration with relevant stakeholder groups.

6.1. Design principles

The development of a common vision for supporting specialised skills development for SMEs was guided by a number of design principles.

- The vision is **evidence-based** - the vision has to be based on an empirical analysis of the current state of play with regards to BIC skills developments for SMEs, in terms of a thorough assessment of SMEs' needs versus what is available, and barriers faced by SMEs. The approach taken in this initiative consists in extensive desk research, complemented by expert interviews and an online survey. Findings were then validated during expert workshops. This approach justifies the call for action as outlined further on in this section.
- The vision is **forward-looking** – as the BIC skills gap will not disappear from one day to the other, adopting a long-term and forward-looking approach is essential. Up- and reskilling the current and future workforce requires a consistent approach over years, in which 2023 should be considered as an intermediate milestone rather than a final destination.
- The vision is **demand-driven** – SMEs have some unique characteristics as compared to larger enterprises. These particularities should be taken into account in order for the vision and related actions to be effective. In addition, skills needs from SMEs change rapidly, as a result of the rapidly evolving BIC landscape. Both factors require involvement of SMEs, not only during the design phase but also during the implementation.
- The vision offers a **direction for development** – as the pace of change in the technological domains under consideration is tremendous, the vision sets out the general direction, from which actions can be distilled. However, as the technological landscape is evolving fast, it might be needed to tweak the timing, content and scope of actions over time, while the more general direction for development remains consistent.

- The vision is **action-oriented** – as described under the previous bullet, the vision sets out the general strategic direction. But as highlighted during the interviews, SMEs are best helped by concrete actions and solutions. Therefore, the vision should offer opportunities to derive concrete actions from it, for various relevant stakeholder groups.
- The vision is supported by main **stakeholder groups** – the problem analysis revealed that many different stakeholders have a role to play, so addressing the problem requires a shared vision that reflects the interest of key stakeholders at EU, national and regional levels, representing different backgrounds (public, private, PPP's).
- The vision is **international** – as the BIC skills gap is multi-country problem, with dependencies between countries (eg international talent sourcing), effectively addressing the BIC skills gap requires a multi-country approach and cross-border collaboration. Building on both European and US experiences, the vision primarily addresses the EU Member States.
- The vision addresses a **multilevel stakeholder field** – several stakeholders on several levels have a role to play in addressing BIC skills development for SMEs. Therefore, the vision should facilitate the identification of roles and concrete actions at different levels – European, national, regional - for different stakeholder groups. The latter can include public authorities, private actors, educational institutions and public-private partnerships.
- The vision acknowledges the **diverse SME landscape** – the vision acknowledges at the one hand the broad and diverse SME landscape, but on the other leaves enough room for action to derive from the vision that are targeted to specific SME categories and (industry-) specific.

6.2. Vision statement

The activities conducted led to the formulation of the following vision statement, which is supported and validated by a broad variety of relevant stakeholder groups that were consulted in the process:

Enabling an increased adoption of cybersecurity, big data, and internet of things by European SMEs via supporting measures that strengthen ecosystems and structurally enhance the supply of necessary skills and facilitate organisational development.

In this vision statement, the following elements are important:

- **SMEs are part of a value chain of companies**, which allows them to share, collaborate, learn and grow. Measures should strengthen these ecosystems, as they are the most effective driving force of increasing the adoption of big data, internet of things and cybersecurity.
- **Advancing the digital maturity of SMEs starts with a strategy to adopt technology to create business value**: understanding the skills a company requires, starts with an understanding of how the technology contributes to the company's strategy. Measures should be aimed at increasing awareness of how to embrace and embed these technologies in the digital strategy of the enterprise, and from that direction derive the competences and roles and skills involved to deliver on that strategic objective. Measures should also include concrete tools and instruments that facilitate capability development in the organisation (especially from an HR function point of view – which is often lacking or minimally organised in SMEs).
- **Technology adoption requires the right skillset**. Measures should be aimed towards increasing the supply of the necessary skills on the labour market, via upskilling programmes of employees in the company and by increasing the number of graduates in the relevant educational fields (universities, business schools, VET).

6.3. Supporting measures to be considered to boost skills development

In order for this vision to become effective, it needs to be operationalised and translated into concrete supporting measures to tackle the variety of barriers as presented in the root-cause analysis in section 2.5.3.

The underlying concept to design a roadmap with supporting measures stems from the understanding of the balance between an organisation's strategy on why and how to adopt technology as business opportunity, and the required human capital to deliver on that investment. It is about the decision to invest in building a capability at the organisational level ('decide'), to systematically plan for delivering on that decision ('plan'), and consequently finding the right people to build competences necessary for that capability ('execute'). Employees fulfil roles associated with those competences, using methods and tools to add specific value. We used this step-wise approach to structure the roadmap with supporting measures, building from the barrier's analysis. Besides these three generic steps of technology adoption, the fourth factor is the direct environment or ecosystem.

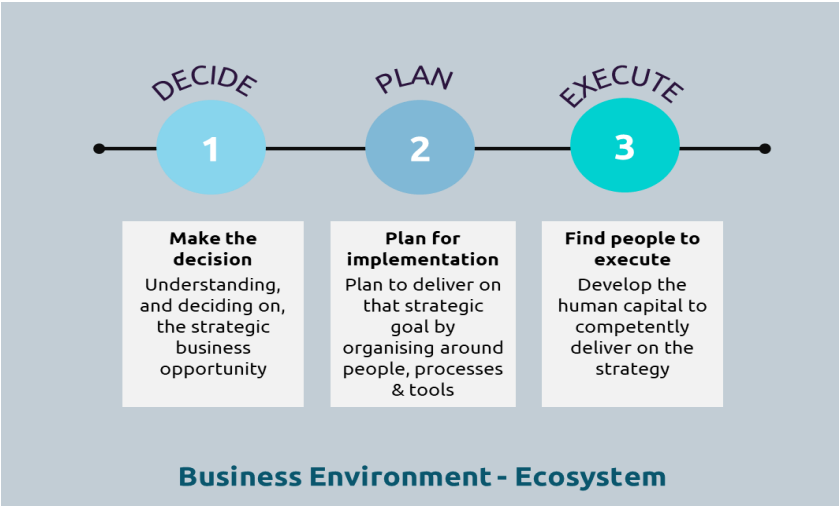

Figure 44 Step-wise approach for organisations to adopt new technologies for creating value

The supporting measures are consequently clustered into four thematic streams:

(1) **Strengthening ecosystems**: Being connected and embedded in regional or sectoral support structures – 'ecosystems' - is essential for SMEs' skills development. In every corner of Europe, SMEs need to be embedded in networks and have access to nearby support (knowledge, guidance and learning).

(2) **Strategic outlook development ('decide')**: Aimed to Increase the understanding of the strategic business opportunity of adoption of BIC. Starting with raising awareness and creating a strategic outlook. Also requiring strengthening of direct business environment and facilitation of collective action.

(3) **Structured skills development ('plan')**: From vision to plan: support SMEs with the implementation of structured skills development, enhance capabilities for assessment, monitoring and decision-making (the business case!) & increase transparency and access to funding.

(4) **Tailoring training to SMEs' needs ('execute'):** Increase education and training offers: build sustainable training offers that match SMEs needs (content, form, set-up). Develop training capacity. Collect intelligence to increase understanding of needs. Reduce direct costs.

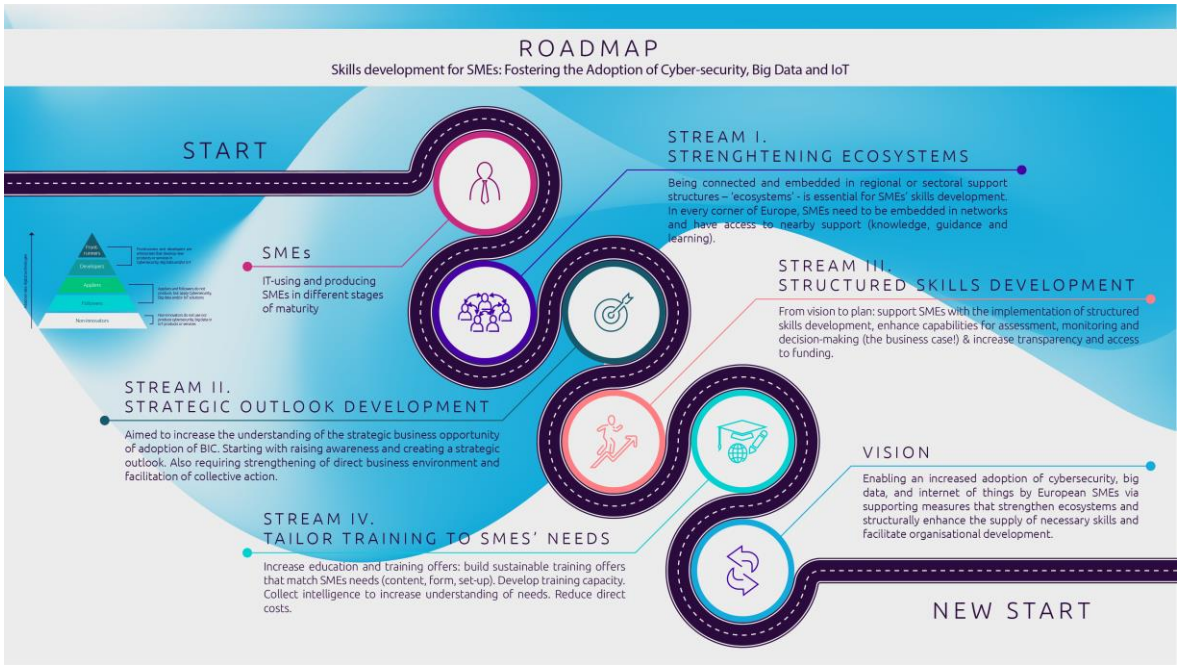

Figure 45 Visualisation of the roadmap's main streams of action

6.3.1. Stream A - Strengthening the ecosystem

Strengthening of the ecosystem revolves around the improvement of access for SMEs to knowledge, guidance and learning within their current and other ecosystems. As mentioned earlier, being connected and being embedded in regional or sectoral support structures – 'ecosystems' - is essential for SMEs' skills development. However, SMEs often lack access to such networks, to tacit and explicit knowledge and/or to facilities that help accelerate skills development. It can be difficult for them to organise shared services – which is easier in an ecosystem -, and the managerial capabilities to become anchored in ecosystems are sometimes lacking. Lastly, the availability of BIC skills support structures throughout the EU is currently fragmented, with some regions having sufficient and adequate services in place, whereas in others no services were found at all when it comes to BIC skills.

Being connected and having access to knowledge, guides in the area of BIC, education and facilities is key for SMEs. As an interviewee put it: "for SMEs, it is either link or die. In every corner of Europe, SMEs need to be embedded in networks and have access to nearby support". In this respect, it is encouraging that the European Commission foresees a crucial role for the Digital Innovation Hubs (DIH) in providing SME support, with the goal of having one hub in every region by 2020[308]. DIHs are one-stop-shops where companies can access and test digital innovations, gain the required digital skills, get advice on financing support and ultimately accomplish their digital transformation. As stated by the EC Commissioner on Digital Economy and Society: "All companies should benefit of a DIH in their region to support the digital transformation. By ensuring a strong pan-EU network of DIHs with an investment of €100 min per year btw 2016-2020 we make sure everyone is included, in all regions"[309].

The measures for strengthening of the ecosystem (and initiatives) are clustered along three sub-goals:

[308] https://ec.europa.eu/digital-single-market/en/blog/digital-innovation-hubs-joining-forces-accelerate-digital-transformation-european-industry

[309] https://twitter.com/GabrielMariya/status/1027330339734253569

A1. Mapping of ecosystems;
A2. Strengthening and expanding existing ecosystems;
A3. Boosting the effectiveness of the ecosystems.

A1. Mapping of ecosystems

The mapping of ecosystems is aimed at determining the current state of play by mapping of existing ecosystems, identifying their strengths & weakness and increase transparency thereof. The overall aim of this sub-goal is to contribute to the availability of and access to regional support structures and facilitate the access of SMEs to concrete guidance, education and training in the area of BIC skills development offered by these regional support structures.

In order to gather the necessary intelligence on the ecosystems to meet these sub-goals, two measures are proposed. The first measure is the investment in research to understand the state of play & existing capacities. This includes, for example, the mapping of access points/hubs to improve transparency, undertake gap analysis, and the take-up of shared services centres.

The measures described include an assessment of stakeholder involvement for each of the measures; and relevant sources, like handbooks, guidance notes or examples of successful initiatives.

Stakeholder involvement is classified in the following categories:

- Lead: central coordinator, monitors actions undertaken
- Act: main responsible for implementation of key actions
- Support: responsible for non-key actions feeding into key actions or participating in a non-leading role in key actions
- Encourage: incentivize participation of other stakeholder groups

Subject	Description
Stream/ Sub-goal	A. Strengthening the ecosystem > 1. Mapping of ecosystems
Measure	**Invest in research to understand the state of play and existing capacities**
Short description	Desired output of the research includes, inter alia, a mapping of access points/hubs to improve transparency, and the take-up of shared services centers. Based upon the research, a gap analysis, exploring the difference between current and desired future state
Stakeholder involvement	• European Commission: Lead & Act – conduct or commission research • National governments: Support European Commission – provide input • Education: Support European Commission – provide input • Industry: Support European Commission – provide input • Associations: Support European Commission – provide input • Other: -

The second measure is the creation of shared databases and tools to make information accessible to stakeholders. This allows more efficient distribution of information and insights, most notably best practices, among stakeholders

Subject	Description
Stream / Sub-goal	A. Strengthening the ecosystem > 1. Mapping of ecosystems
Measure	**Created shared databases and tools to make information accessible to stakeholders**
Short description	Online available information, accessible to the public, on
Stakeholder involvement	• European Commission: Lead & Act - exchange best practices • National governments: Act - database and tool development • Education: Support national government – provide input, dissemination • Industry: - • Associations: - • Other: Intermediaries – support national government – provide input, dissemination

A2. Strengthening and expanding existing ecosystems

The strengthening and expansion of the existing ecosystems aims to support existing networks, hubs and initiatives to reach a more comprehensive coverage which will allow them access to every SME.

Three measures are proposed to achieve these aims. Firstly, policies and funding programmes that help to support SME communities, networks and ecosystems should be develop and supported. This measure is geared towards providing every SME in EU with a nearby hub where they can benefit from information, training, guidance on skills development. In particular, support to the Digital Innovation Hubs should be prioritised as good example of a hub that has enabled SMEs communities.

The digital innovation hub initiative seeks to build synergies with already ongoing relevant initiatives. A wealth of expertise already exists in Europe, with competence centres in several areas already being operational. In addition to 660 cybersecurity competence throughout the EU, over 200 so called Digital Innovation Hubs 310 throughout the EU are providing support to companies in their respective regions. Digital Innovation Hubs are one-stop-shops that support companies to become more competitive by using digital technologies. They are based upon technology infrastructure (competence centre) and provide access to the latest knowledge, expertise and technology to support their customers with piloting, testing and experimenting with digital innovations. As proximity is considered crucial, they act as a first regional point of contact, a doorway. A DIH is a regional multi-partner cooperation and can also have strong linkages with service providers outside of their region supporting companies with access to their services. Figure 6-2 illustrates the functioning of Digital Innovation Hubs.

[310] http://s3platform.jrc.ec.europa.eu/digital-innovation-hubs

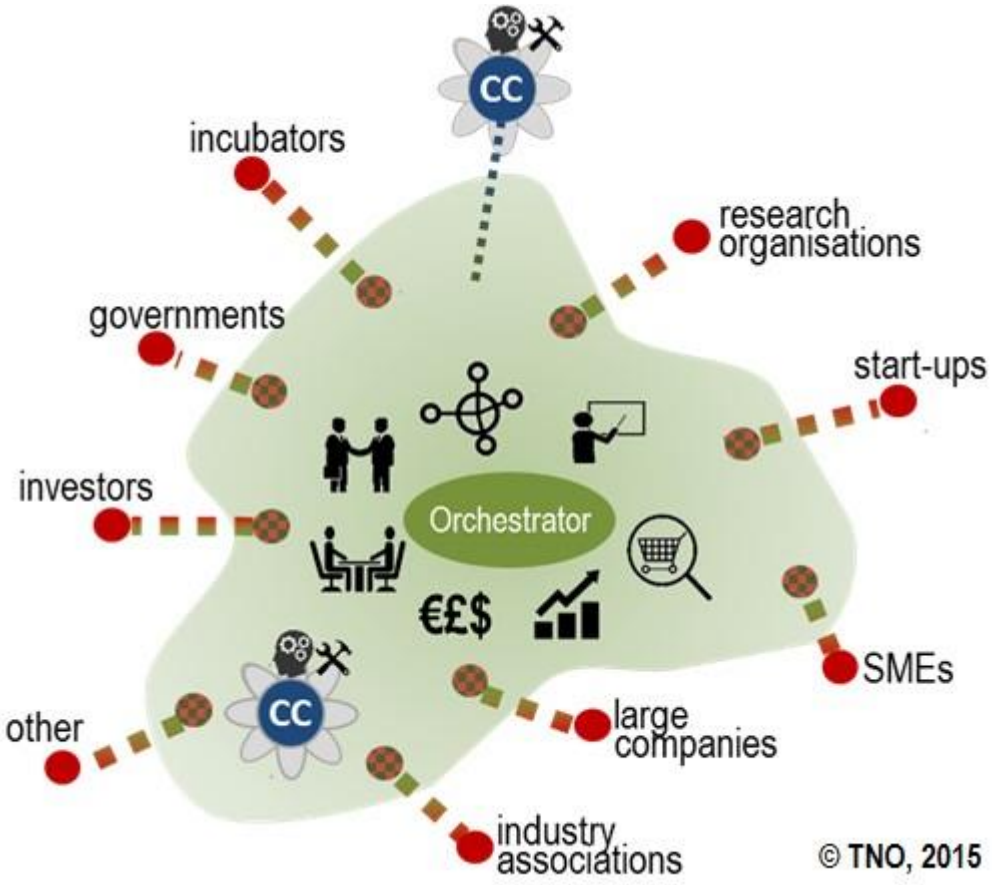

Figure 46 The functioning of Digital Innovation Hubs[311]

The present initiative seeks to leverage the wealth of competence centers already operational, as DIH's address several of the barriers identified in this initiative: findability and availability of guidance, education and training, and limited financial resources. Moreover, the target group and technologies covered by DIH's are in line with the present initiative, as DIH's have a particular focus on SMEs – although their support is not limited to SMEs – and the use of digital technologies such as big data, IoT and cybersecurity.

Subject	Description
Stream / Sub-goal	A. Strengthening the ecosystem > 2. Strengthening and expanding existing ecosystems
Measure	**Develop and support policies & funding programmes that help to support SME communities, networks and ecosystems**
Short description	Leverage existing Digital Innovation Hubs or stimulate the creation of new ones by stimulating downstream actors (CoCs, business dev agencies, regional business clusters etc.) to organise/create such hubs, offering every SME in Europe to benefit from a nearby support

[311] Ibid.

	center. Key here is to stimulate existing or new DIHs to explicitly address the topic of skills development.
Purpose	Addressing B1, B2, B3, F2, F3, F5, G1, G2, G5.
Stakeholder involvement	• European Commission: Lead & Act – develop policies and funding programmes • National governments: Support European Commission – roll-out of policies and programmes • Education: - • Industry: - • Associations: - • Other: -

Secondly, research on the existing policies and initiatives landscape is required to identify and promote good practices. This allows to leverage lessons learned from successful initiatives instead of reinventing the wheel

Subject	Description
Stream/ Sub-goal	A. Strengthening the ecosystem > 2. Strengthening and expanding existing ecosystems
Measure	**Research the existing policy & initiatives landscape to identify and promote good practices**
Short description	Successful initiatives in the area of BIC skills development for SMEs exist, but are fragmented and not equally available in the EU. Their availability tends to be skewed towards Western and Northern Europe. Europe should investigate the development of a mechanism to: • Sustain successful practices in this area; • Transfer lessons learned to other regions; Scale successful practices where possible
Stakeholder involvement	• European Commission: Lead & Act – promotion of practices • National governments: Act – collect information; Support – promotion of practices • Education: - • Industry: - • Associations: Support national governments – collection, promotion • Other: -

As part of this measure, clarifying the business case for SMEs may be an important step to make SMEs understand the importance of investment in BIC skills.

Subject	Description

Stream / Sub-goal	A. Strengthening the ecosystem > 2. Strengthening and expanding existing ecosystems
Measure	**Clarify the business case to illustrate ROI and support informed decision making**
Short description	Provide examples of positive business cases for SMEs. Preferably supported by a simple tools to support SMEs in calculating the BIC skills investment
Stakeholder involvement	• European Commission: Lead / Act – clarify business case, promote • National governments: Support - promote • Education: Support - promote • Industry: - • Associations: Support - promote • Other: Intermediaries - Support - promote

Thirdly, policies which help to mobilise accelerators/downstream actors need to be extended and, where no specific policies are in place yet, developed. In this measure, special attention needs to me given to ensure involvement of SMEs themselves to make sure policies are aligned with SME needs

Subject	Description
Stream / Sub-goal	A. Strengthening the ecosystem > 2. Strengthening and expanding existing ecosystems
Measure	**Extend and develop policies which help mobilising accelerators/downstream actors**
Short description	Getting accelerators/downstream actors mobilized by means of interpersonal communication and peer-to-peer exchange with a focus on joint goals.
Stakeholder involvement	• European Commission: - • National governments: Lead/Act - develop policies • Education: - • Industry: Support national governments – provide input • Associations: • Other: Downstream - Support national governments – provide input

A3. Boosting the effectiveness of the ecosystems

The boosting of the effectiveness of the ecosystems is aimed at ensuring that the support offered by the ecosystem to SMEs is optimally focused on achieving the overarching goal of e-skills development within SMEs. To this aim, two measures are proposed.

Firstly, EU and national programs that facilitate knowledge sharing should be initiated. Knowledge sharing allows stakeholder within the ecosystem to learn from others about

the optimal method to support SMEs in their understanding of the need of investment in BIC skills and the ways in which to obtain these skills.

Subject	Description
Stream / Sub-goal	A. Strengthening the ecosystem > 3. Boosting the effectiveness of the ecosystems
Measure	**Initiate EU and national programs that facilitate knowledge sharing**
Short description	The development of programs that aim to connect and mobilize people and resources within the ecosystem with a focus on knowledge sharing and mutual learning. Important to ensure any exchange of knowledge is based upon information that is relevant and up-to-date.
Stakeholder involvement	• European Commission: Lead/Act – EU level • National governments: Act – national level • Education: Support – contribute input for knowledge sharing • Industry: Support – contribute input for knowledge sharing • Associations: - • Other: -

Secondly, a collaboration between hubs and education is expected to improve the match between demand for information and skills from the side of SMEs and its supply as offered by education. A better match ensures a more effective adaption of BIC by SMEs. One such example is the JADS MKB Data-lab in the Netherlands, which offers tools and solutions to SMEs that allow them to integrate data science into their business by means of PoCs.

Subject	Description
Stream / Sub-goal	A. Strengthening the ecosystem > 3. Boosting the effectiveness of the ecosystems
Measure	**Stimulate collaboration between hubs and education system to better tailor to needs**
Short description	Information available at hubs on skills needs of SMEs can strengthen the adaption of BIC within SMEs
Stakeholder involvement	• European Commission: - • National governments: Lead • Education: Act – improve curriculum • Industry: Act – transfer information on needs • Associations: Support industry – stocktaking of needs • Other: Intermediaries – Support industry – stocktaking of needs

6.3.2. Stream B - Strategic outlook development

Being connected and having access to knowledge, guides in the area of BIC, education and facilities is key for SMEs. As an interviewee put it: "for SMEs, it is either link or die. In every corner of Europe, SMEs need to be embedded in networks and have access to nearby support". In this respect, it is encouraging that the European Commission foresee a crucial role for the Digital Innovation Hubs (DIH) in providing SME support, with the goal of having one hub in every region by 2020[312]. DIHs are one-stop-shops where companies can access and test digital innovations, gain the required digital skills, get advice on financing support and ultimately accomplish their digital transformation. As stated by the EC Commissioner on Digital Economy and Society: "All companies should benefit of a DIH in their region to support the digital transformation. By ensuring a strong pan-EU network of DIHs with an investment of €100 min per year btw 2016-2020 we make sure everyone is included, in all regions"[313].

B1. Raise awareness within SMEs
B2. Strengthen the direct business environment of SMEs
B3. Facilitate collective action

B1. Raise awareness within SMEs

Instead of jumping into developing BIC skills, SMEs first need to be able to articulate their skills need: what are exactly the roles needed, and which skills do these roles need to have to work with BIC technologies? Information of SME managers and/or owners on the potential of the BIC technologies is an important first measure.

Subject	Description
Stream / Sub-goal	B. Strategic outlook development > 1. Raise awareness within SMEs
Measure	**Inform SME managers/owners about the potential of BIC technologies and encourage innovation**
Short description	Improve awareness and facilitate the implementation of cybersecurity requirements and standards – that includes adaptation of the standards for SMEs. The latter is already initiated in various initiatives, among which the "Info sec for SMEs Guide" by Digital SME Alliance. This assists SMEs in setting up ISO / IEC 27001 on information security management. An investigation of what is already being developed, such as the aforementioned guide, should lead to the identification of blind spots. Within these blind spots, action should be taken. This should be combined with a promotion and awareness campaign, making SMEs aware of cybersecurity requirements and standards and the existence of such guides.
Stakeholder involvement	• European Commission: Lead • National governments: Act - develop/encourage policies

[312] https://ec.europa.eu/digital-single-market/en/blog/digital-innovation-hubs-joining-forces-accelerate-digital-transformation-european-industry

[313] https://twitter.com/GabrielMariya/status/1027330339734253569

	• Education: - • Industry: - • Associations: Support national governments – promotion of insights • Other: -
Relevant resources	Info sec for SMEs

Specialised HR departments are often lacking in SMEs and a slow adoption of existing competence frameworks in existing trainings further contribute to a lack of awareness and difficulties in pinpointing the skills to be developed to benefit from BIC technologies. To address this challenge, the ecosystem of the SMEs can play a supportive role in raising awareness among SMEs by offering information.

Subject	Description
Stream Sub-goal	B. Strategic outlook development > 1. Raise awareness within SMEs
Measure	**Support organisations, initiatives and platforms that foster collaboration and knowledge sharing**
Short description	Nearby support for SMEs is essential, as they tend to have a regional focus. Regional training programmes have the potential of linking SMEs to other SMEs that follow the same training, thus facilitating sustainable networks, knowledge sharing and peer-2-peer learning. Effective existing training mechanisms offer a portfolio of services, addressing the several stages of maturity, from awareness to action: starting with best practices and company visits, to business model redesign, actual experimenting, testing, etc.
Stakeholder involvement	• European Commission: - • National governments: Lead/Act – develop support policies • Education: - • Industry: - • Associations: Support initiatives • Other: Intermediaries - Act - develop initiatives
Relevant resources	Mittelstand 4.0

Intermediaries can also play an important role in the adaption of BIC technologies within SMEs. Furthermore, if SME owner/managers do not know what they need, they are not able to assess whether it is more beneficial to internalise certain skills or to hire them on the market.

Intermediaries like accountants have a trusted relationship with SMEs, meaning they can also act as trusted advisor in relation to BIC adoption. Similarly, other stakeholders in the ecosystem may play a similar role in advising SMEs on BIC. Insurance companies are in frequent contact with SMEs and have a similar interest as the SMEs to prevent SMEs being exposed to societal risks (e.g. cyberattacks targeting the SME).

Subject	Description
Stream / Sub-goal	B. Strategic outlook development > 1. Raise awareness within SMEs
Measure	**Involve intermediaries that can act as advisors in adoption of BIC technologies – in particular engage accountancies and insurance companies to increase (cybersecurity) awareness and prevention**
Short description	Stimulate intermediaries to (further) extend their role as advisor to also include advisory services on BIC technologies. **Accountancies** are in regular contact with SMEs and advise them on business continuity matters. Most accountants are SMEs themselves and hence can understand SMEs. They are well positioned to make SMEs aware of the threats (and opportunities) of cybersecurity, and trigger them to action. Accountancies across Europe are already developing initial points of view and checklists to support SMEs in this challenge (some can be found here). **Insurance** companies on the other hand carry part of the societal risk of SMEs being impacted by cyber incidents. Increasingly insurance companies are moving to pro-active prevention policies to make SMEs aware about the risks and about easy steps to become more secure and resilient. Via their insurance policies they have a financial lever to trigger SMEs to action.
Stakeholder involvement	• European Commission: Stimulate – Uptake by associations at European level • National governments: Stimulate – Uptake by associations at the national level • Education: - • Industry: - • Associations: Intermediaries associations – support intermediaries • Other: Intermediaries - Act - offer advisory services on BIC adoption

An alternative and more pressing route to raise awareness consists of legal obligation. Most notably, cybersecurity is an area with potential negative externalities in the form of network infection throughout a broader ecosystem. Consequently, there may be ground to consider legislation related to cybersecurity.

Subject	Description
Stream / Sub-goal	B. Strategic outlook development > 1. Raise awareness within SMEs
Measure	**Investigate the feasibility of legal enforcement of cybersecurity**
Short description	Our analysis shows that awareness of cybersecurity is still an issue for many SMEs, while cyberattacks may impact the whole value

	chain. Therefore, the feasibility of a legal enforcement of cybersecurity should be investigated, including accompanying cybersecurity assessments to support organisations in their uptake of cybersecurity. Penalties and tax credits can be considered.
Stakeholder involvement	• European Commission: - • National governments: Lead • Education: - • Industry: Support national government – feasibility assessment • Associations: Support national government – feasibility assessment • Other: -

B2. Strengthen the direct business environment of SMEs

The technological savviness of SME owner/managers depends on a multitude of factors, of which one is age. Overall, SME owner/managers have difficulties understanding the impact of BIC technologies, or realising the urgency to act on it. A long-term vision on adopting BIC is lacking, and the focus is rather on operational matters. In addition to this internal perspective, also the technological maturity of the environment plays a role, as an environment stimulating for instance open data fosters the uptake of big data. To address the above portrayed relatively low 'tech maturity', both internal and external, several measures are proposed.

First, collaboration with researchers can be stimulated to improve SMEs possibilities in the field of BIC. One such example is the cooperative research centres program in Australia.[314]

Subject	Description
Stream / Sub-goal	B. Strategic outlook development > 2. Strengthen the direct business environment of SMEs
Measure	**Stimulate collaborative projects between SMEs and researchers**
Short description	The technological maturity of SME manager/owners can be improved, and SMEs can be supported in the adoption of BIC by working together with technology experts, such as researchers. To this end, research schemes can be developed specifically aimed at starting joint projects between SMEs and researchers on the topic of skills development for SMEs. Moreover, data labs may enable SMEs to explore the potential of BIC.
Stakeholder involvement	• European Commission: - • National governments: Lead/Act - Encourage uptake • Education: Act – engage with SMEs • Industry: Act – engage with Education

[314] https://www.business.gov.au/assistance/cooperative-research-centres-programme/cooperative-research-centres-projects-crc-ps

	• Associations: Support industry – engagement with Education • Other: -

Second, continues investment in infrastructure will remain important as necessary condition to allow SMEs to build up a business case on investment in BIC.

Subject	Description
Stream / Sub-goal	B. Strategic outlook development > 2. Strengthen the direct business environment of SMEs
Measure	**Continue to invest in infrastructure that enables technology adoption**
Short description	Efforts to improve framework conditions such as open data, open APIs, the data sharing economy, should be continued and sustained to facilitate the adoption of big data and IoT. But also investment into the main physical infrastructure (broadband, 5G) will warrant continued attention.
Stakeholder involvement	• European Commission: - • National governments: Lead/Act – develop infrastructure policy, stimulation of investment • Education: - • Industry: - • Associations: - • Other: Infra providers - Act –Invest in infrastructure

Third, a matchmaking platform can catalyse SMEs in their steps into BIC.

Subject	Description
Stream / Sub-goal	B. Strategic outlook development > 2. Strengthen the direct business environment of SMEs
Measure	**Design a matchmaking platform that links technology solutions in the area of BIC with SME needs**
Short description	Development of platforms at local/regional level with a specific focus on (IT-using) SMEs. To ensure optimal platform impact, transparency on quality of services and prices of services offered should be ensured. Possibly, the platform may also facilitate in joint procurement and shared services (described under B3).
Stakeholder involvement	• European Commission: Act – Exchange of best practices • National governments: Support local regional governments – platform development stimulation • Education: Support Intermediaries – provide technology solutions • Industry: - • Associations: -

	• Other: Intermediaries – Lead/Act – develop platforms; Local/regional government – Support - platform development

As fourth and final measure, national cybersecurity frameworks can strengthen SMEs' business environment.

Subject	Description
Stream / Sub-goal	B. Strategic outlook development > 2. Strengthen the direct business environment of SMEs
Measure	**Stimulate the development of national Cybersecurity frameworks for SMEs**
Short description	The development of a national framework helps to create a common language to compare the business practices to prevent and tackle cyber risks. The framework may help an enterprise to plan a cyber risk management strategy, developed over the time according to its business, size and other distinguishing and specific elements of the enterprise. Adoption of the framework can be mandatory or voluntary, and can be accompanied by for instance checklists, and self-assessments. Interviewees also suggested to investigate the feasibility of cybersecurity audits under the framework. In the initial audit phase (first years), financial support from the government could be required, while after some time communities should be self-supporting with regards to the auditor.
Stakeholder involvement	• European Commission: - • National governments: Lead/Act – stimulation of developments, promotion of the frameworks • Education: - • Industry: - • Associations: Support national government - promotion of the frameworks • Other: Intermediaries – Support national government - promotion of the frameworks, ENISA – support national governments – inform on developments

B3. Facilitate collective action

One common challenge for SMEs is overcoming the small scale of the company, resulting in diseconomies of scale. Investment that are partly fixed, that is similar for each company, weight relatively heavier on small firms in comparison to large firms. To overcome this challenge, collective actions with other SMEs or with partners within the value chain may be used.

Most notably, SMEs may want to explore joint procurement and shared services. By sharing the burden among more parties, the (financial) barriers for SMEs reduce. One such example is the Cyber Resilience Center Brainport initiative in the Netherlands. [315]

[315] https://www.brainport.nl/nieuws-ontwikkelingen/primeur-brainport-eindhoven-voor-ketenweerbaarheid-cybersecurity

Subject	Description
Stream/ Sub-goal	B. Strategic outlook development > 3. Facilitate collective action
Measure	**Promote and facilitate joint procurement and shared services**
Short description	SMEs alone might not have the financial resources to effectively ensure cybersecurity or to work with big data/IoT but organising shared services with other SMEs (or joint procurement) might enable them to work with BIC. Such cooperation can also be achieved with large companies in the value chain. Further investigation into the conditions and success factors and the proven instruments to drive shared services is recommended.
Stakeholder involvement	• European Commission: - • National governments: Lead/Act - review blocking regulation • Education: - • Industry: - • Associations: Support national government - promotion of the frameworks • Other: Intermediaries – Support national government - promotion of the frameworks

6.3.3. Stream C - Structured skills development

The technological savviness of SME owner/managers depends on a multitude of factors, of which one is age. Overall, SME owner/managers have difficulties understanding the impact of BIC technologies, or realising the urgency to act on it. A long-term vision on adopting BIC is lacking, and the focus is rather on operational matters. In addition to this internal perspective, also the technological maturity of the environment plays a role, as an environment stimulating for instance open data fosters the uptake of big data.

To address the above portrayed relatively low 'tech maturity', both internal and external, the following sub-goals are identified.

C1. Support implementation of structured skills development
C2. Enhance capabilities for monitoring & decision-making in SMEs
C3. Increase transparency and access to funding

C1. Support implementation of structured skills development
Professionals possessing the specialised skills needed to work with BIC technologies are scarce. SMEs face several challenges in this regard, within the context of an ageing European workforce. SMEs compete with big corporates to attract and retain talents that possess the required combination of skills. And it is not just about attracting and retaining talents; also, continuous development of skills and knowledge is essential for the growth of their company. To overcome these challenges, this initiative foresees the following measures.

Existing initiatives form an important starting point. Plenty of blueprints, framework and tools are available that can support in their structured skills development. Examples in Europe include the e-Competence framework (e-CF) and the EDISON program for data science. In the United States, the NIST cybersecurity framework, can serve as an example.

Subject	Description
Stream/ Sub-goal	C. Structured skills development > 1. Support implementation of structured skills development
Measure	**Promote blueprints, practical frameworks and tools that support SMEs to build a smart (HR) strategy**
Short description	The blueprints, frameworks and tools identify which competences are necessary to be able to develop specific capabilities; and which roles are involved into achieving these capabilities. Preferably, the blueprints, frameworks and tools also offer a self-assessment that allows SMEs to obtain a clear insight into any gaps between available and required competences.
Stakeholder involvement	• European Commission: - • National governments: Lead • Education: Act - identify tools • Industry: Act - express needs • Associations: Act - tailoring tools to SME needs • Other: Downstream - support Industry – identification of needs

Key insights from the various blueprints, frameworks and tool may be bundled into a single, easily accessible starters guide for SMEs.

Subject	Description
Stream / Sub-goal	C. Structured skills development > 1. Support implementation of structured skills development
Measure	**Develop 'how to start'-guidance for SMEs**
Short description	Consolidation of information from blueprints, frameworks and tools into a single source. Tailoring the information for different company size classes. Explore improvement on accessibility of the document, including editorial and the location (e.g. a single web-portal).
Stakeholder involvement	• European Commission: Lead/Act – develop materials, promotion • National governments: Support European Commission – promotion • Education: - • Industry: - • Associations: Support European Commission – promotion • Other: -

Also within value chains, various examples of actions supportive to SMEs skills development, most notably in cyber resilience, are available. One such example is the

cyber resilience centre Brainport in the Netherlands.[316] In this initiative, the larger firms support SMEs with respect to their cybersecurity to improve the overall resilience of the entire value chain.

Subject	Description
Stream / Sub-goal	C. Structured skills development > 1. Support implementation of structured skills development
Measure	**Promote examples of value chains supporting SMEs to become cyber resilient**
Short description	Similar to joint procurement and shared services, as discussed under stream B3, cooperation within the value chain can offer benefits to SMEs to improve cyver resilience
Stakeholder involvement	• European Commission: Lead • National governments: Support Associations - Encourage associations • Education: - • Industry: Initiate practices to strengthen the value chain • Associations: Act - collect examples • Other: Downstream - support associations – collect examples

Structured skills development is bound to be more successful if a proper stocktaking of the skilsl potential within the company is properly assessed, for example by means of an aptitude test. One such a successful example is Skillnet Ireland, where a significant untapped potential for cyber skills turned out to be present.

Subject	Description
Stream / Sub-goal	C. Structured skills development > 1. Support implementation of structured skills development
Measure	**Tap into talent and involve staff in the development of a company HR strategy**
Short description	Test for latent skills already present within the company by means of an aptitude test.
Stakeholder involvement	• European Commission: - • National governments: Lead • Education: Support industry – offer insights • Industry: Act - amend HR strategy • Associations: Support industry – encourage action • Other: Downstream- Support Industry – offer insights, encourage action

[316] https://cwbrainport.nl

To make attraction of qualified external staff easier, a recognition mechanism for BIC skills. An important initiative to recognise informal learning is presented by the BDVA Skills Task Force[317].

Subject	Description
Stream / Sub-goal	C. Structured skills development > 1. Support implementation of structured skills development
Measure	**Design an EU-wide mechanisms to recognise skills acquired through informal and non-formal training**
Short description	Various mechanisms are available, like accreditation, academic degrees, certificates, labels, and badges. Especially badges, supported by online verification of their authenticity and ownership, are a low-threshold method to support skill recognition.
Stakeholder involvement	• European Commission: Lead/Act - create mechanism • National governments: - • Education: - • Industry: - • Associations: - • Other: -

C2. Enhance capabilities for monitoring & decision-making in SMEs

Monitoring will support SMEs in understanding and strengthening their process of skills development. It will also allow to better assess where further strengthening is most needed and decide to invest.

One important measure for monitoring is the facilitation to self-assessment.

Subject	Description
Stream / Sub-goal	C. Structured skills development > 2. Enhance capabilities for monitoring & decision-making in SMEs
Measure	**Facilitate self-assessments to enable SMEs to detect skills gap in their organisation**
Short description	Building on the work conducted in this initiative (first concept of a self-assessment), a new European initiative should be launched specifically focusing on the development of a self-assessment, taking into account regional and sectoral particularities and the various types of SMEs that exist.
Stakeholder involvement	• European Commission: Lead • National governments: - • Education: Act - develop assessment • Industry: - • Associations: - • Other: Downstream actors – Support European Commission - promote

[317] https://www.digitalsme.eu/digital/uploads/20190412_4th-Workshop_2nd-ppt_Presentation-BDVe.pdf

To ensure any investment into skills training is effective, quality of trainings should be clear. For this purpose, quality labels for BIC trainings should be considered. Examples can be found is, inter alia, Germany[318] and the Netherlands[319]

Subject	Description
Stream / Sub-goal	C. Structured skills development > 2. Enhance capabilities for monitoring & decision-making in SMEs
Measure	Research the possibility of quality labels for BIC-trainings
Short description	The use standardised competence frameworks and certificates allows SME manager/owners to assess the value of trainings and provides them with insights in the competences professionals have. This makes it easier for them to 1) assess the value of trainings when considering sending their employees to training, and 2) in case of recruiting professionals, to assess the value of the trainings they have conducted. To this end, it should be investigated to what extent it is possible to develop standardised certificates throughout the EU. This allows SME manager/owners in country A to better understand the quality of training in country B. The specific target group of SMEs should be considered when investigating such certificates. They need to be adapted for the scale and affordability to SMEs – as there will be specific competences and skills needed to implement BIC technologies (both by SMEs, but also by the "consultants" to the SMEs.
Stakeholder involvement	• European Commission: Lead/Act - arrange mutual recognition • National governments: Act - explore/develop regulatory labels • Education: Act - explore/develop voluntary labels • Industry: - • Associations: - • Other: -

Further enhancement of monitoring can be achieved in the form of stocktaking of market trends. As example, the market insights reporting initiative of VOICE, an association for IT-using SMEs, can be mentioned.[320]

Subject	Description
Stream / Sub-goal	C. Structured skills development > 2. Enhance capabilities for monitoring & decision-making in SMEs

[318] Trusted Cloud Initiative (https://www.trusted-cloud.de/).

[319] https://mkb.nl/nieuws/bedrijfsleven-ontwikkelt-risicomodel-en-keurmerk-cyberbeveiliging

[320] https://voice-ev.org/wissensplattform/

Subject	Description
Measure	**Monitor market trends to inform SMEs**
Short description	Collect information on, inter alia, market developments like new services, new suppliers, and conditions of service (to prevent lock-in). The monitor can also help to decrease dependency on external providers by stimulating the anchoring of every SME in networks/ecosystems/value chains. Such networks improve SMEs access to knowledge and facilitate peer-to-peer learning. Networks can either be regional or sectoral (or both).
Stakeholder involvement	• European Commission: Lead/Act – monitoring EU/global trends • National governments: Act - monitoring national trends • Education: - • Industry: Support – formation of value chains, knowledge transfer • Associations: Act – Stimulate value chain knowledge transfer • Other: Intermediairies – support national governments – monitor trends

C3. Increase transparency and access to funding

As for all investments, financing plays an important role.

Subject	Description
Stream / Sub-goal	C. Structured skills development > 3. Increase transparency and access to funding
Measure	**Increase funding for skills development in SMEs**
Short description	A successful example comes from Ireland, where Skillnet Ireland acts as a broker between education and companies. Companies that want to participate in Skillnet need to form a network (based on region and/or industry) with which they need to cooperate and propose to Skillnet explaining their need for skills development. If Skillnet accepts their proposal, Skillnet provides a grant of 50%. The other 50% comes from the network of companies itself. In addition to financial support, Skillnet matches the skill need with their network of educators, they provide mentoring and coaching, ongoing enablement and strategic support, and they conduct an independent evaluation of every program. This approach is quite successful, and it is worthwhile exploring further its success factors and conditions for upscaling/replicating this initiative in other EU countries.
Stakeholder involvement	• European Commission: Support national governments - funding • National governments: Lead/Act - funding • Education: - • Industry: -

	• Associations: - • Other: -

Subject	Description
Stream / Sub-goal	C. Structured skills development > 3. Increase transparency and access to funding
Measure	**Promote and scale successful funding mechanisms that foster skills development**
Short description	Identify which mechanisms have proven to be successful, identify the success factors driving this success and apply these, taking into account local circumstances.
Stakeholder involvement	• European Commission: Lead/Act – promote funding mechanisms • National governments: Support European Commission - promotion • Education: Support European Commission - promotion • Industry: - • Associations: Support European Commission - promotion • Other: Intermediaries - Support European Commission - promotion

6.3.4. Stream D - Tailoring training to SMEs' needs

Currently, too often available trainings in the area of BIC skills are not in line with SMEs' needs. Specific trainings in the area of BIC are scarce (focus is often on digital skills in the broadest sense), the form in which trainings are provided are not ideal for SMEs and too often, trainings are too expensive. Another problem is that the trainings that exist are not part of widely accepted framework. This results in difficulties with assessing the value of trainings. To address the current mismatch between available training offerings and SME's needs, the following measures contribute to ensuring a better match between available training offerings and training needs of SMEs.

Embarking on BIC technologies requires investments in several elements, of which one is training of personnel. Having restrained financial resources, SMEs need to prioritise their investments. An indirect return on investment may lead to the fact that training of personnel in the area of BIC is not among the top priorities. External funding is required but is not always available or is not easily accessible by SMEs.

The technological savviness of SME owner/managers depends on a multitude of factors, of which one is age. Overall, SME owner/managers have difficulties understanding the impact of BIC technologies, or realising the urgency to act on it. A long-term vision on adopting BIC is lacking, and the focus is rather on operational matters. In addition to this internal perspective, also the technological maturity of the environment plays a role, as an environment stimulating for instance open data fosters the uptake of big data.

Professionals possessing the specialised skills needed to work with BIC technologies are scarce. SMEs face several challenges in this regard, within the context of an ageing European workforce. SMEs compete with big corporates to attract and retain talents that possess the required combination of skills. And it is not just about attracting and retaining

talents: also for SME owner/managers, continuous development of skills and knowledge is essential for the growth of their company.

The following sub-goals enable the tailoring of training needs.

D1. Increase education and training offers
D2. Develop training capacity
D3. Collect intelligence
D4. Reduce direct costs for SMEs

D1. Increase education and training offers

Trainings are essential for skills development. For trainings to be optimally effective, they need to be closely aligned with the training needs. Further improvement of the understanding of training needs by education providers can support this alignment.

Subject	Description
Stream / Sub-goal	D. Tailoring training to SMEs' needs > 1. Increase education and training offers
Measure	**Increase understanding of education providers on how to identify training needs, target groups & tailor offers**
Short description	Making sure that teachers and professors continuously advances skills and knowledge based on the latest insights from industry. Think of teacher exchange schemes, training programmes or the development of new (standardised) modules that teachers and professors can use in the area of BIC.
Stakeholder involvement	• European Commission: Lead/Act – develop guidance, promotion • National governments: Support European Commission - promotion • Education: - • Industry: - • Associations: Support European Commission - promotion • Other: -

Although seemingly contradictory to the previous measure, trainings should make use of certain key principles to ensure optimal knowledge transfer.

Subject	Description
Stream / Sub-goal	D. Tailoring training to SMEs' needs > 1. Increase education and training offers
Measure	**Promote use of standard approaches and frameworks to increase effectiveness in training courses**
Short description	Training offerings should be newly set up or restructured both in form and content so that they are tailored to the needs of SMEs and go beyond 'generic' digital skills, and rather focus specifically on BIC: • Modular, blended, not necessarily during business hours. Innovative methods (eg gaming) should be explored. • Focus specifically on BIC

	• Trainings are practical, include whole chain, and include concrete examples • Trainings are provided in a plain language and in the mother language of the SME Easy participation by SME should be the leading guiding principle when developing the trainings. Both owners as well as skills specialists should be targeted with the trainings.
Stakeholder involvement	• European Commission: Lead/Act - develop standards • National governments: Act – promotion of standards • Education: - • Industry: - • Associations: - • Other: -

The development of BIC skills throughout the company may go beyond just targeting the specialists (see the description of the previous measure). Especially inclusion of BIC modules in non-technical curricula will help to ensure broad support and understanding for the usefulness of BIC skills throughout the entire organisation.

Subject	Description
Stream / Sub-goal	D. Tailoring training to SMEs' needs > 1. Increase education and training offers
Measure	**Integrate BIC modules in non-tech curricula**
Short description	Embedding technical modules in general non-technical (e.g. business administration) courses. Integrate technical skills in existing or new courses addressing the current workforce; and embed these technical modules in curricula aimed at addressing the future workforce (students). An example could be a module on cybersecurity.
Stakeholder involvement	• European Commission: - • National governments: Lead • Education: Act - amend curricula • Industry: - • Associations: - • Other: -

Existing frameworks and blueprints can offer a solid and efficient basis for the further development of education and training offers. One example of such a source is DG Connect's Makes-me-digital initiative.[321]

Subject	Description
Stream / Sub-goal	D. Tailoring training to SMEs' needs > 1. Increase education and training offers

[321] https://makesmedigital.eu

Subject	Description
Measure	**Build on existing co-ooperation frameworks between education and industry, and existing blueprints for training for SMEs**
Short description	Frameworks and blueprints to both develop, but also upscale education and training offers.
Stakeholder involvement	• European Commission: - • National governments: Lead/Act – identify blueprints, promotion • Education: Support national government – identify blueprints; Act - tailor training programmes • Industry: - • Associations: - • Other: -

To stimulate the attractiveness of BIC skills within education, enough internships should be ensured.

Subject	Description
Stream / Sub-goal	D. Tailoring training to SMEs' needs > 1. Increase education and training offers
Measure	**Stimulate internships**
Short description	Create internships for students with BIC relevant skills
Stakeholder involvement	• European Commission: - • National governments: - • Education: Support - offer interns • Industry: Act - create BIC internships • Associations: Lead • Other: -

D2. Develop training capacity

Currently, too often available trainings in the area of BIC skills are not in line with SMEs' needs. Specific trainings in the area of BIC are scarce (focus is often on digital skills in the broadest sense), the form in which trainings are provided are not ideal for SMEs and too often, trainings are too expensive. Another problem is that the trainings that exist are not part of widely accepted framework. This results in difficulties with assessing the value of trainings. To address the current mismatch between available training offerings and SME's needs, the following measures contribute to ensuring a better match between available training offerings and training needs of SMEs.

Increase in mobility of scarce experts was achieved in Sweden.[322]

Subject	Description
Stream / Sub-goal	D. Tailoring training to SMEs' needs > 2. Develop training capacity
Measure	**Increase mobility of scarce experts**
Short description	Most notably, increasing the possibility to combine two (or more) part-time positions, for example one in academia and one in business, will improve the availability of high-level expert to business.
Stakeholder involvement	• European Commission: - • National governments: Support education • Education: Lead/Act – explore possibility for part-time contracts for key experts • Industry: Act – explore possibility for part-time contracts for key experts • Associations: - • Other: -

For an effective out-roll of training, sufficient training facilities suitable should be available.[323]

Subject	Description
Stream / Sub-goal	D. Tailoring training to SMEs' needs > 2. Develop training capacity
Measure	**Invest in facilities to support training programmes**
Short description	Investment in facilities concerns physical location. Typically, these may be avialable at hubs of within the local ecosystem (e.g. Digityser in Brussels). Test labs may be needed for cybersecure IoT devices.
Stakeholder involvement	• European Commission: - • National governments: Act – stimulate investment • Education: Lead/Act - develop facilities • Industry: - • Associations: - • Other: -

D3. Collect intelligence

[322] Malin Rosqvist, Driving innovation and improving competences in Swedish SMEs; https://www.digitalsme.eu/digital/uploads/3rd-Workshop_1st-ppt_2019-02-08_MalinRosqvist.pdf

[323] See, for example, Recommendation from thesis *IoT matchmaking platform for SMEs* (TU Delft); https://repository.tudelft.nl/islandora/object/uuid:e31a8e50-8f7c-4601-ad97-27a292092554/datastream/OBJ

Training development may be supported by data on SME trainings needs and participation motives.

Subject	Description
Stream / Sub-goal	D. Tailoring training to SMEs' needs > 3. Collect intelligence
Measure	**Promote data-driven approaches in SME support programmes**
Short description	Achieve better insight into SME training needs to align policy and training offers by collecting SME consumption levels of trainings. Aggregation of data, either at regional level and/or national level, may provide insightful patterns to identify SME needs.
Stakeholder involvement	• European Commission: Lead/Act - Specify information needs programmes • National governments: Stimulate Education • Education: Act - Information collection • Industry: - • Associations: • Other:

Subject	Description
Stream / Sub-goal	D. Tailoring training to SMEs' needs > 3. Collect intelligence
Measure	**Research motives of SMES to participate in training**
Short description	While this study offers much insights into reasons for non-participation of SMEs, more research into the positive drivers is useful.
Stakeholder involvement	• European Commission: Lead/Act – research motives • National governments: Stimulate Industry • Education: - • Industry: Act - Provide insights • Associations: Stimulate Industry • Other: -

D4. Reduce direct costs for SMEs

Embarking on BIC technologies requires investments in several elements, of which one is training of personnel. Having restrained financial resources, SMEs need to prioritise their investments. An indirect return on investment may lead to the fact that training of personnel in the area of BIC is not among the top priorities. Funding has been discussed in stream C3. Here, the focus lies on reduction of the direct costs. The following measures can be considered.

Innovation voucher scheme have proven their worth in, inter alia, Finland, the Netherlands and Lithuania.[324]

Subject	Description
Stream / Sub-goal	D. Tailoring training to SMEs' needs > 4. Reduce direct costs for SMEs
Measure	**Stimulate innovative voucher schemes for fostering BIC skills development**
Short description	In order to foster SME skills development and to stimulate experimenting with BIC, voucher schemes can be put in place. Voucher schemes have proven to be effective in different contexts, and already exist with regard to innovation etc. (see examples further below). The challenge is to integrate a skills dimension with regards to emerging technologies within those schemes. European policymakers should investigate an approach to: • Sustain successful voucher schemes and to integrate the skills dimension in schemes; • Transfer lessons learned to other regions; • Scale successful practices where possible and stimulate the development of voucher schemes in case they do not yet exist. As a primary funding vehicle, the ESF can be used. In this case, it is important to include a focus on educational purposes, and to specify for a range of technologies. Besides dedicating the voucher schemes to skills development/training (educational purposes), one should also investigate the option of dedicating vouchers to the implementation of cybersecurity standards. The best way to develop personal skills is by aligning them to the organizational improvements. For instance, it is not by coincidence that Agile (SCRUM) is implemented by "coaching", which is "learning by doing it" – The same principle holds ground for SMEs with regard to the implementation of cybersecurity standards.
Stakeholder involvement	• European Commission: - • National governments: Lead/Act – develop, stimulate schemes • Education: - • Industry: - • Associations: - • Other: -

6.3.5. Governance: Creating overarching governance for skills

There is a need to create a stronger partnership between the public and the private sector in order to offer leadership and vision for digital skills and jobs in Europe. This

[324] https://www.businessfinland.fi/en/for-finnish-customers/services/funding/sme/innovation-voucher/; https://www.verslilietuva.lt/paslaugos/kompetenciju-vauceris/

entails a specific commitment from all the stakeholders in order to pursue common objectives and make investments to achieve them.

Build and further develop public-private partnerships on ICT skills and jobs, including industry and trade associations, national, regional and local governments, companies, education institutions, research and ICT professionals. Our recommendation is for the **establishment a European Public Private Partnership (PPP)** for Skills and Jobs, as such entity is perfectly suited to enable a **long-term, strategic approach** and reduce uncertainties by allowing for long-term commitments.

In addition, this PPP needs to be accompanied by close collaboration with research and universities as well as industry to develop an evidence-based approach to skills development, that can help identify future skills needs for the digital transformation.

This strategic and evidence-based approach to skills development needs to consider market needs, thus laying the basis for innovation in Europe. It is important differentiate between the different types of new technologies or skills. For instance, cybersecurity is a horizontal topic, but big data or IoT depend very much on the specific business model of a company. Thus, there is a need to distinguish measures according to market demands and needs, and therefore, to base action on evidence and research on market demands.

7. TOOLBOX

7.1. Purpose of the toolbox

The purpose of the toolbox is to facilitate knowledge sharing and to encourage stakeholders to engage in (new) initiatives that will support SMEs in adopting new technologies and developing the required skills. It aims to point stakeholders towards tools that have demonstrated a certain added value and that can help others in setting-up or scaling up initiatives.

The toolbox is created primarily for stakeholders involved in the organisation of skills initiatives for SMEs. Some of the tools can also be of use for SMEs themselves, but it is much more likely SMEs will look for support in their direct environment and ecosystem. These tools are most likely to reach SMEs via dissemination by for instance policymakers and associations.

7.2. Design of the toolbox

There are various ways to design and structure a toolbox. In this approach, the tools are mapped to the streams in the roadmap. This should allow for an intuitive understanding of 'what' to find 'where'. As an example, assumeing a stakeholder is planning to develop an initiative aimed at supporting SMEs with structured skills development (stream 3), he/she will find relevant materials mapped to that stream.

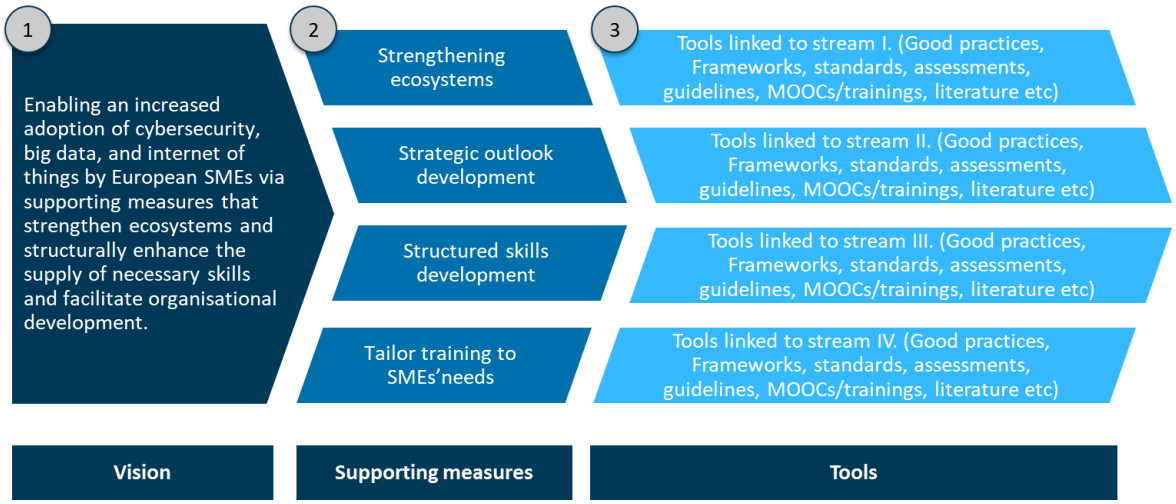

Figure 47 Meta-model of the toolbox

The toolbox consists of the following types of tools:

- **Good practices**: skills-initiatives that have contributed to one or more of the action streams in the roadmap. These were further categorised as support programme/strategy, training programme, or network/collaboration initiative.
- **Frameworks**: recognised overviews, outlines or skeletons that can guide SMEs in deciding on an approach to plan for developing the human capital that is needed to implement the digital strategy (i.e. following adoption of big data, IoT or cybersecurity in the enterprise's strategy). In particular, frameworks that support competence development (such as the e-CF, NIST, EDISON).
- **Self-assessments**: assessments that either support (employees of) SMEs in determining their level of competence for a role in cybersecurity, big data or IoT, or support the organisation in assessing their level of maturity regarding these technologies.

- **MOOC's**: Massive Open Online Courses (MOOCs) aim at unlimited participation and open access via the web. In addition to traditional course materials, such as filmed lectures, readings, and problem sets, many MOOCs provide interactive courses with user forums to support community interactions among students, professors, and teaching assistants, as well as immediate feedback to quick quizzes and assignments.
- **Guides & others**: this category consists of guides, white papers, reports and various other materials that inform users about the topics relevant for this study.

Throughout the study, relevant 'tools' were collected to grow the knowledge base. The toolbox is not exhaustive, though via the EU-wide research, interviews, surveys and workshops at least covers most of the relevant items.

The toolbox itself is a list created in excel (presented in **Appendix C**), whereby each tool is mapped to the most relevant action stream and most relevant sub-goal per stream. Complementary to the toolbox, a selection of good practices is further detailed in Appendix E.

The toolbox will become available in an online mode via our partners of the European DIGITAL SME Alliance.

PART III: MONITORING SKILLS DEVELOPMENT

8. PROVIDE A COMPARISON WITH THE US AND PROPOSE INDICATORS AND MONITORING MECHANISMS FOR INTERNATIONAL COMPARISONS

8.1. Overview this task

The monitoring mechanism for digital skills is presented in four sections as described in Figure 8-1.

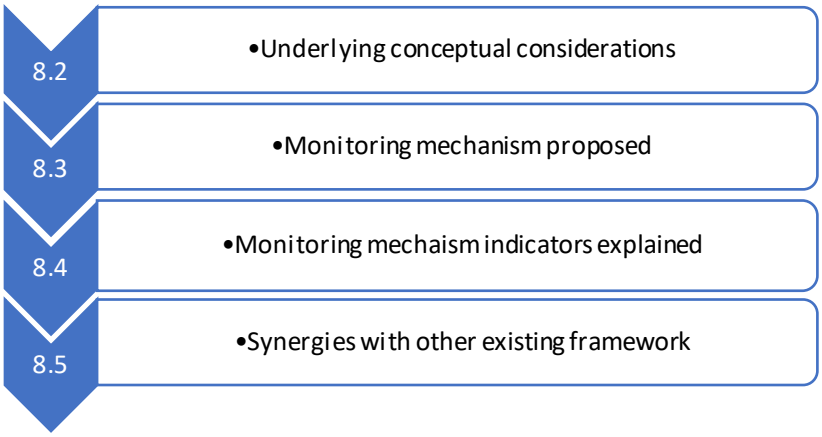

Figure 8-1. Content creation path towards the Final Report

8.2. Conceptual considerations accounted for in the proposed monitoring mechanism

The suggested monitoring mechanism is developed based on the following considerations:

- It is based on an **ICT specific Supply and Demand indicator framework**. The framework relies on **traditional data sources** from providers of consolidated data across multiple countries (and meeting the SMART criteria), in view of allowing international comparison with the US and other countries at the level of ICT for which data availability is greater compared to the thematic areas in focus.
- It is intended for **international comparison** accounting for extra and intra EU coverage; the first layer looks at a wider geographical scale and focuses on baseline indicators that rely on internationally harmonised data sources, or possible to be harmonised with a good degree of accuracy, especially looking at the US. The second layer focuses on the EU by including specific sub-dimensions that are mostly relevant and available at EU level.
- Its indicator framework design **accommodates for Big data, Internet of Things and Cybersecurity specific indicators**. These mostly rely on alternative data sources and available reports; thus, the country availability is at times scattered, and replicability could be limited. An assessment of the indicators showing potential to be further monitored and to be compared at international level is provided.
- In recognition of the needs of policy making in terms of anticipating future demand and supply for skills and act to reduce the gap between supply and demand it has been considered important to also **highlight critical indicators which can provide signals of future skills supply and demand** in the thematic areas but also in comparison to the US.
- **It builds on existing frameworks,** in view to limit/avoid the parallel existence of multiple monitoring mechanisms of skills at EU level and capitalise on the synergies.

8.3. The Monitoring mechanism

The digital skills monitoring mechanism proposed is grounded on a skills Supply-Demand framework making use of ICT specific indicators for which data availability is richer.

The supply and demand framework is further split into training and labour indicators. The ICT indicators extend to the three thematic areas (Big Data, IoT and Cybersecurity) for which indicators deemed critical for the needs of policy making are proposed.

The rationale behind this choice is that ICT is the closest conceptual framework to Big Data, IoT, and Cybersecurity. In terms of existing statistical data and indicators it allows for a comprehensive monitoring framework to be built for the EU.

To inform a monitoring mechanism for each of the thematic areas substantial original work would be needed using new data sources or extensive surveys with industry/labour force (see Table 8-3 and Table 8-6 for suggestions on extending the conceptual framework from ICT to the thematic areas). In recognition of the urgency for policy makers to monitor the gap between the current supply and demand and anticipate the future demand for skills, indicators that provide signals and can be monitored regularly are proposed.

For an international comparison with the US even at the ICT level very limited indicators are available. For this reason and in consideration of the need for the EU to monitor digital skills not just within its core but also with international competitors a selection of indicators serving this purpose are proposed.

The monitoring mechanism in its practical application is expected to be utilised as the indicator framework upon which basis analytics can be performed, namely forecasting and foresight exercises.

Figure 8-2 shows our proposed Demand-Supply monitoring framework.

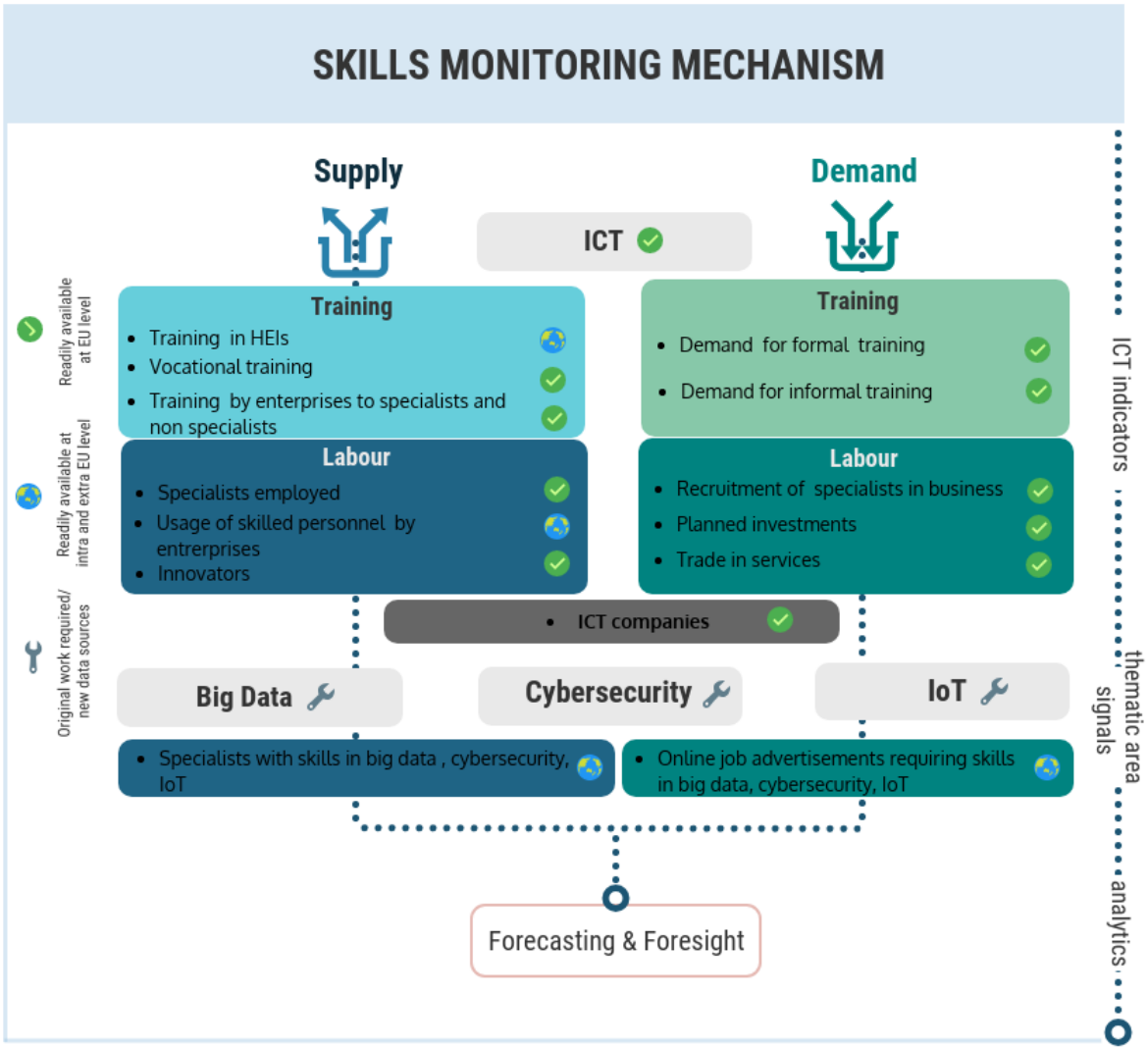

Figure 8-2 Supply-demand framework for the monitoring mechanism

8.3.1. Sources

Indicators are sourced from Eurostat (as a primary source) and other sources such as the WEF, the European Cluster Collaboration Platform and others. The availability of data by company size (SMEs *versus* large companies) is also part of the monitoring mechanism. As explained in more detail in the box below, the OECD is the main source for data at non-EU level, and notably for the comparison with the US.

The comparison with the US

Official US data seem not to have the same coverage and richness than EU data, and do not have indicators that one can directly map against data for Europe. **The OECD** is the source that mostly has comparable data with the EU, but for some OECD indicators, US data are not available. The data availability for the US is detailed in the demand and supply indicators overview tables (tables 8 and 10 further below).

We detail below other sources explored for the US, together with the limitations to use them in a comparison with the EU:

- **World Bank**: It has data on Higher Education Information System (HEI), but the classification of programs is quite broad and does not specify ICTs. The closest program type to look at would be "sciences programs".

- **UNESCO Institute for Statistics (UIS)**: UNESCO's data covers basic ICT skills of the general population (e.g., % youth and adults who have used basic arithmetic formulae in a spreadsheet), but no advanced skills and no focus on employees or enterprises are included.
- **World Inequality Database on Education (WIDE):** As in the UIS data, it only covers basic ICT skills of the general population.
- **The National Center for Education Statistics (NCES)** does not provide data on tertiary, vocational education, nor training in enterprises. They seem to focus on younger students. The highest level is "high-school graduates".
- **US Census**: It provides data on number of tertiary education students in general, but not per field. It seems not to contain data of employees being trained in ICT or enterprises investing in ICT training.
- **Eurostat:** A few Eurostat indicators contain data on the U.S. This is, nevertheless, in very limited cases, and not for the indicators covered in this project.
- **Pew Research**: Although no relevant quantitative data could be found, Pew Research studies provide somewhat related qualitative anecdotal evidence: (i) The Future of Jobs and Jobs Training (2017); (2) The State of American Jobs (2016); (3) What the Public Knows about Cybersecurity (2017).
- **Mimeo report**[325], The State of Learning and Development in 2016: It provides a general overview of learning and training programs and systems in the US, but without focus on ICT. It is based on the answers of 425 learning and development professionals.
- **2016 Training Industry Report**:[326] It provides figures on the skills training industry in the US. It is based on 644 survey responses. No focus on advanced ICT skills.
- **ASTD's State of the Industry Report** (2013, 2016): General information on the investment of US companies on staff learning and development without specific focus on ICT skills. It is based on a survey of 475 organisations.

[325] https://www.insynctraining.com/pages/The_State_of_Learning_and_Development_in_2016.pdf

[326] https://trainingmag.com/sites/default/files/images/Training_Industry_Report_2016.pdf

8.4. Monitoring mechanism indicators explained

This section presents the indicators collected on supply and demand of skills. The main observation drawn is that while there is good data coverage for ICT-related indicators on skills, with different available sources that apt to be used for comparisons at international level (and with the US), the data potentially available to construct the indicators selected for the three areas (Big Data, IoT, Cybersecurity) are not readily available and require substantial original work. At the same time, we found existing initiatives that are moving forward to extend the scope of existing statistics to cover new types of works and related skills.

In what follows, we provide a summary table introducing the indicators at ICT level currently available. For each indicator we specify the years available, the source, the prospected continuity in the future, and the availability for the US and for SMEs. We then also provide a set of indicators following the proposed framework that could be collected in the future on the three thematic areas and an indication of one indicator for supply and one for demand that could be used to provide signals at EU level and the US and can be collected now and regularly in the future.

8.4.1. Supply

ICT - PROPOSED MONITORING FRAMEWORK AND CORRESPONDING INDICATORS

The logic behind the selection of the indicators for skills supply under training and the labour market is described below.

Sub-dimension	Pillars suggested	Explanatory notes
Training	ICT training at HEIs	Training categories cover the three main sources of supply, thus, Higher Education Institutes (HEIs), vocational training providers and businesses. Account is made for training provided to specialists and non-specialists.
	ICT vocational training	
	ICT training by enterprises - to specialists	
	ICT training by enterprises - to non-specialists	
Labour market	ICT specialists employed	In recognition of the digital transformation present across multiple professions labour supply looks at not only the ICT specialists employed but also more broadly the use of ICT skills by enterprises. A note with respect to the labour classification definition should be made: The ICT specialist workforce is a broader category than ICT professionals, which are a set of occupations corresponding to a sub-group of the ICT specialist workforce. Data collected so far refer to ICT specialists. **ILO ISCO codes** are the standard classification for occupations, together with **ESCO at European level**. The two can be harmonised (converted). ILO ISCO data available online only use the first level of the taxonomy (1-digit), however raw data until 4-level can be retrieved under request. More information on the ISCO codes can be found in **Error! Reference source not found.**, in the context of its use in the study Digital Organisational Frameworks and IT Professionalism EASME/COSME/2016/016.
	Usage of ICT skills by enterprises	
	ICT innovation	
(Demand and Supply indicator)	Presence of ICT companies	The presence of companies or clusters can be considered a proxy of supply of specific skills (i.e. ICT skills).

Table 8-1 framework of supply and assessment for ICT

Figure 8-3 and Table 8-2 visualise and summarise the indicators collected for Supply of ICT-related skills.

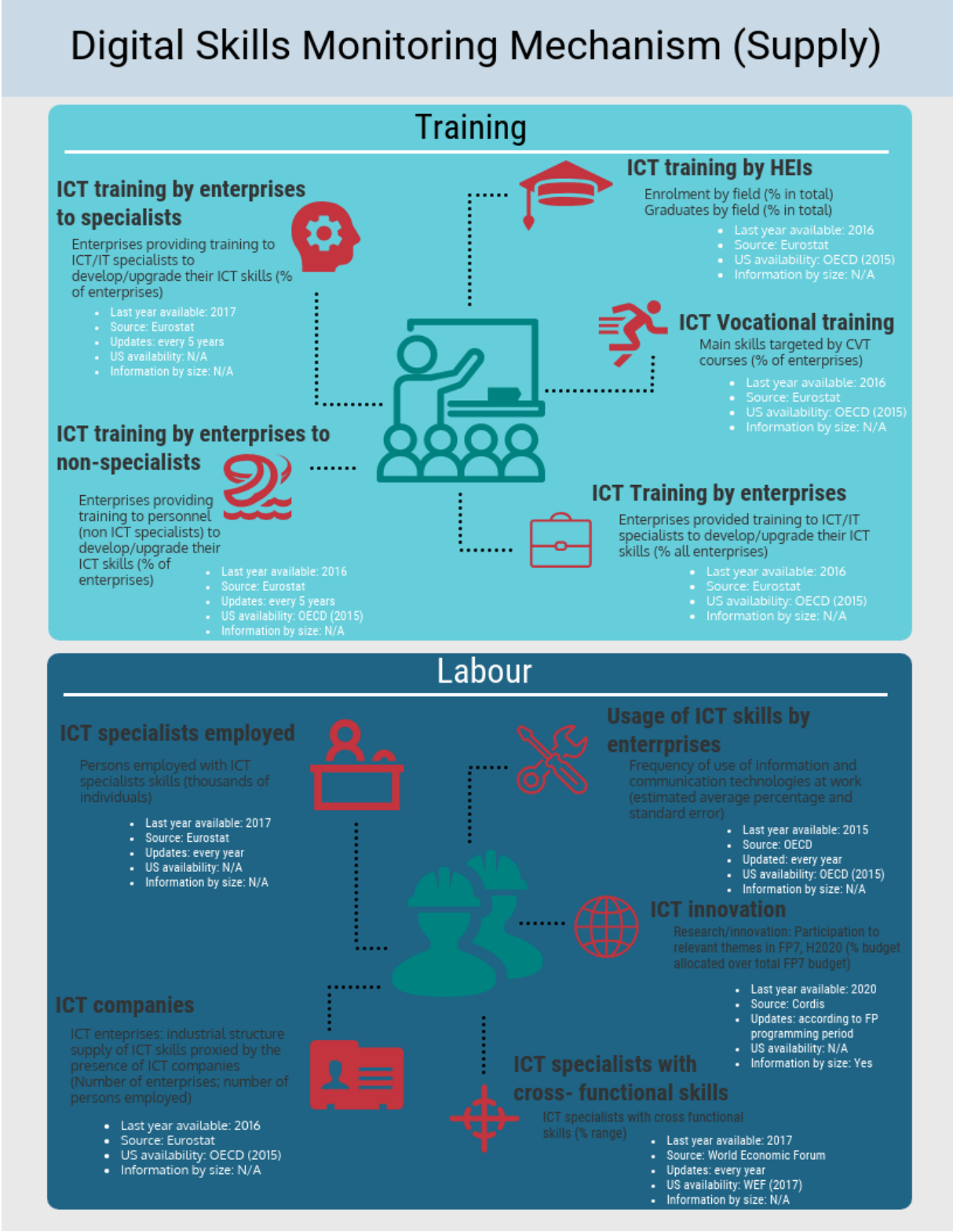

Figure 8-3 Summary of indicators on ICT Supply

Dimension	Sub-dimension	Indicator	Years available	Source	Notes on continuity in the future	US availability (source)	Availability by size (SMEs)
Training	ICT training by HEIs	Enrolment by field (% in total)	2012 - 2016	Eurostat	Unclear	2015 only (OECD)	No
Training		Graduates by field (% in total)	2005, 2010,	Eurostat	Unclear	2015 only (OECD)	No

Dimension	Sub-dimension	Indicator	Years available	Source	Notes on continuity in the future	US availability (source)	Availability by size (SMEs)
			2012, 2013 2014, 2015 2016				
Training	ICT vocational training	Main skills targeted by CVT courses (% enterprises)	2005, 2010, 2015	Eurostat	Every 5 years	No	Yes
Training	ICT training by enterprises - to specialists	Enterprise provided training to ICT/IT specialists to develop/upgrade their ICT skills (% all enterprises)	2012-2017	Eurostat	Yearly	No	Yes
Training	ICT training by enterprises	Enterprise provided training to other persons employed to develop/upgrade their ICT skills (% of all enterprises)	2012-2018	Eurostat	Yearly	No	Yes
Training	ICT training by enterprises - to non-specialists	Enterprise provided training to their personnel (not ICT specialists) to develop/upgrade their ICT skills (% of all enterprises)	2012-2019	Eurostat	Yearly	No	Yes
Labour	ICT specialists employed	Persons Employed with ICT Specialist Skills (Thousands of individuals)	2004-2017	Eurostat	Yearly	No	Yes
Labour	Usage of ICT skills by enterprises	Frequency of use of information and communication technologies at work (Estimated average percentage and standard error)	2012-2015	OECD	Yearly	Same as for EU (OECD)	No
Labour	ICT innovation	Research/innovation: Participation to relevant themes in FP7, H2020 (% budget allocated over total FP7 budget)	2007-2020	Cordis	According to FP programming period	No	Until 2013 through Corda database
Labour	ICT specialists with cross-functional skills	ICT specialists with cross-functional skills (% range)	2017	World Economic Forum (WEF)	Yearly (new release Sept 2018)	Yes (not all EU countries)	No
Labour (supply & demand)	ICT companies	ICT enterprises: Industrial structure - supply of ICT skills proxied by the presence of ICT companies (Number of enterprises; Number of persons employed)	2010-2016	Eurostat	Yearly	No (for US the the Economic Census Industry Classification Report includes sector, but IT is aggregated with Legal,	Yes

Dimension	Sub-dimension	Indicator	Years available	Source	Notes on continuity in the future	US availability (source)	Availability by size (SMEs)
						Advertising and Accounting)	
Labour (supply & demand)	ICT companies	Presence of relevant clusters (Number of clusters)	current	Cluster collaboration platform	Updated online on a regular basis	No	No

Table 8-2 framework of supply for ICT level - available indicators[327]

BIG DATA, IOT AND CYBERSECURITY PROPOSED MONITORING FRAMEWORK AND CORRESPONDING INDICATORS

Initiatives to set the ground for the design of indicators at the thematic level come from traditional and new data sources. One of them is led by ILO, who carries out a thorough monitoring and assessment of the ISCO codes in view of keeping them up to speed with the changing dynamics of the job market and relevant occupations. Piloting projects using new data are also taking place such as the work in the exploratory big data report of the European Innovation Scoreboard on skills supply from university websites.[328]

Key findings on Big Data, IoT and Cybersecurity skills supply are summarised below. From the indicators listed we propose in the short term to regularly monitor the availability of specialists with skills in big data, cybersecurity, IoT using LinkedIn. The representativeness of Linkedin, corrections for biases in the data, the limitations in terms of what it captures (e.g. skills quoted in education, experience or skills of users' profiles) and how the indicators constructed with this database should be interpreted are important aspects to understand before utilising the indicator for analytics and policy recommendations.

SUPPLY Sub-dimension	Pillars suggested	Assessment (from the review of data) Big data	IoT	Cyber security	Notes
Training	Training at HEIs	⊕	⊕	⊕	Only possible by crawling undergraduate, graduate, post-graduate study portals.
	Vocational training	⊕	⊕	⊕	Only possible by crawling online courses
	Training by enterprises - to specialists	⊕	Yes	⊕	Best captured by surveys Included for IoT in the Eurostat ICT usage in enterprises (isoc_e) through "access to and use of the Internet and other network technologies for connecting objects and devices (Internet of Things)", but raw data are needed from Eurostat. Data available until 2017, yearly update, breakdown by size class and sector (NACE).
	Training by enterprises - to non-specialists	na	na	na	Not applicable for non-specialists.

[327] When different sources are used between the EU and the US it is because not all EU countries are OECD members, thus the priority for EU coverage is given to Eurostat when available. In addition, 2015 is the starting-year for the OECD, while Eurostat has longer time-series.

[328] Available at: https://ec.europa.eu/docsroom/documents/30362/attachments/1/translations/en/renditions/native

SUPPLY Sub-dimension	Pillars suggested	Assessment (from the review of data) Big data	IoT	Cyber security	Notes
Labour market	Specialists (employed)	⊕	⊕	⊕	Numbers of individuals with corresponding skills on their LinkedIn profile (Currently developed by DG GROW in the Advanced Technologies for Industry project and included by the World Economic Forum in their report "The Global Human Capital Report 2017", available yearly since 2013[329], data not available for the US.
	Usage of ICT skills by enterprises	Yes	Yes	⊕	-Community Survey on ICT usage and e-commerce in enterprises - Module G: Big data analysis (data availability overview and details in the overview report). -Community Survey on ICT usage and e-commerce in enterprises - Module D: Use of cloud computing services (data availability overview and details in the overview report). - Collecting quantitative Data on the State of play of Artificial Intelligence and other New Technologies - SMART 2019/0019 - Included in the survey of this study under the question "*What is the relationship of your company to cybersecurity/IoT/Big Data*? Our company… 1) Is (potential) user of this technology, 2) Is producer of this technology, 3) Is both user and producer of this technology, 4) Does not use nor produce this technology
	Innovation	Yes	Yes	Yes	Data is available for Europe (2007-2017) through Fp7, H2020 Cordis and E-corda databases. Thematic areas need to be chosen.

Table 8-3 framework of supply and assessment for thematic areas

Notes
⊕: requires substantial original work as indicators are not readily available but is feasible.

8.4.2. Demand

ICT - PROPOSED MONITORING FRAMEWORK AND CORRESPONDING INDICATORS

The logic behind the selection of the indicators for skills demand under training and the labour market is described below.

Sub-dimension	Pillars suggested	Explanatory notes
Training	Demand for formal methods of ICT training	Demand of training is covered by specific statistics collected by Eurostat and the WEF looking at the demand for acquisition of specific skills, at formal and informal level. Skills demand is proxied by the completion of computer courses or other training courses (through formalized education or self-study).
	Demand for informal methods of ICT training	
Labour market	Recruitment of ICT specialists in business	Demand of (ICT) labour is proxied by the presence of hard-to-fill vacancies, recruitment statistics for specific tasks/skills, as well as by investment plans in the (ICT) field. Trade in services proxied by the demand of ICT services by partner country is also considered as a proxy for labour demand.
	Planned investments in ICT	
	Trade in ICT services (by partner country)	
(Demand and Supply indicator)	Presence of ICT companies	The presence of companies or clusters and the change in the cluster composition can be considered a proxy of demand of specific skills (i.e. ICT skills).

[329] Data are only available on PDF version, thus extraction should run by scraping if no raw data provided by the WEF.

Table 8-4: framework of demand and assessment for ICT

Figure 8-4 and Table 8-4 visualise and summarise the indicators collected for Demand on ICT-related skills.

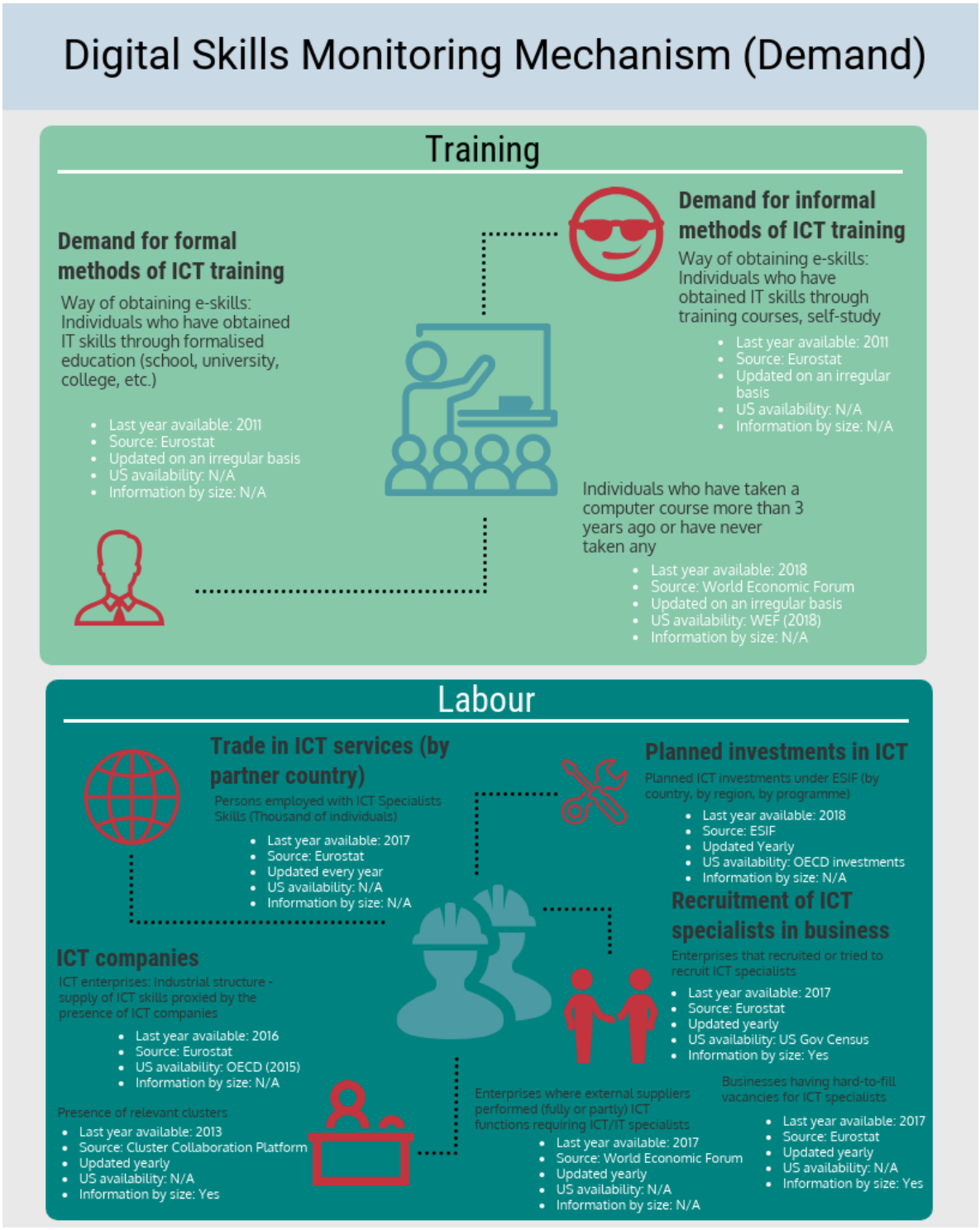

Figure 8-4 Summary of indicators on ICT Demand

Dimension	Sub-dimension	Indicator	Years available	Source	Notes on continuity in the future	US availability (source)	Availability by size (SMEs)
Training	Demand for formal methods of	Way of obtaining e-skills:	2005 2006	Eurostat	Irregular	No	No

Dimension	Sub-dimension	Indicator	Years available	Source	Notes on continuity in the future	US availability (source)	Availability by size (SMEs)
	ICT training	Individuals who have obtained IT skills through formalized education (school, university, college, etc.)	2007 2011				
Training	Demand for informal methods of ICT training	Way of obtaining e-skills: Individuals who have obtained IT skills through training courses, self-study (books, CD-ROMs, etc. & learning by doing)	2005 2006 2007 2011	Eurostat	Irregular	No	No
Training	Demand for informal methods of ICT training	Individuals who have taken a computer course more than 3 years ago or have never taken any	2018	WEF	Unsure	Yes (WEF)	No
Labour	Trade in ICT services (by partner country)	Trade in ICT services by partner country	1960-2014	Eurostat	Yearly	Yes (World Bank/OECD)	No
Labour	Planned investments in ICT	Planned ICT investments under ESIF (by country, by region, by op prog)	1960-2018	ESIF	Yearly	Yes (OECD investments)	No
Labour	Recruitment of ICT specialists in business	Enterprises that recruited or tried to recruit ICT specialists	2012-2017	Eurostat	Yearly	Yes (US Census)	Yes
Labour	Recruitment of ICT specialists in business	Businesses having hard-to-fill vacancies for ICT specialists	2012-2017	Eurostat	Yearly	No	Yes
Labour	Recruitment of ICT specialists in business	Enterprises where external suppliers performed (fully or partly) ICT functions	2007-2017	WEF	Yearly	No	No

Dimension	Sub-dimension	Indicator	Years available	Source	Notes on continuity in the future	US availability (source)	Availability by size (SMEs)
		requiring ICT/IT specialists					
Labour (supply & demand)	ICT companies	ICT enterprises: Industrial structure - supply of ICT skills proxied by the presence of ICT companies	2012-2017	Eurostat	Yearly	No	Yes
Labour (supply & demand)	ICT companies	Presence of relevant clusters	2013	Cluster collaboration platform	Updated online on a regular basis	No	Yes

Table 8-5: framework of demand for ICT level - available indicators[330]

BIG DATA, IOT AND CYBERSECURITY PROPOSED MONITORING FRAMEWORK AND CORRESPONDING INDICATORS

Initiatives to set the ground for the design of indicators at the thematic level come from traditional and new data sources. One of them comes from Cedefop constructing demand indicators using online job vacancies currently using ISCO codes which could however be tailored given the use of big data.

Key findings on Big Data, IoT and Cybersecurity skills supply are summarised below. From the indicators listed we propose in the short term to regularly monitor online job advertisements requiring skills in big data, cybersecurity, IoT. This can be done via coordination with the work cedefop is currently conducting or using LinkedIn data. The jobs data of LinkedIn includes both jobs posted directly on LinkedIn via LinkedIn Jobs as well as jobs ingested from over 40,000 sources including company websites, applicant tracking systems, job boards, aggregators and job feeds. LinkedIn has developed algorithms to identify and remove duplicate job posts from ingested sources.

DEMAND					Notes on sourcing data
Sub-dimension	Pillars suggested	Assessment (from the review of data)			
		Big data	IoT	Cyber security	
Training	Demand for formal methods of ICT training	⊕	⊕	⊕	Webcrawling of University websites for enrolments in ICT courses by thematic area[331]
	Demand for informal methods of ICT training	⊕	⊕	⊕	Webcrawling of ICT vocational websites for enrolments Skills type of LinkedIn members, by age and degree of specialization, WEF Global Human Capital Report 2017, updated

[330] When different sources are used between the EU and the US it is because not all EU countries are OECD members, thus the priority for EU coverage is given to Eurostat when available. In addition, 2015 is the starting-year for the OECD, while Eurostat has longer time-series.

[331] Pilot run by NESTA for the European Innovation Scoreboard 2018, file:///Users/eleonora/Downloads/EIS%20Exploratory%20Report%20B-Big%20data%20(1).pdf page 5

DEMAND					Notes on sourcing data
					yearly, since 2013. Not available for the US[332].
Labour market	Recruitment of thematic area specialists in business	⊕	⊕	⊕	Online Job vacancies: Cedefop, due in March 2019: currently assessing which data will be covered. Only EU) Technopolis group in the context of Digital Cities Challenge (number of jobs in ICTs, only for limited number of European cities, only for 2018) Index calculated as ratio of the number of InMails i.e. recruiter outreach via LinkedIn's network sent on average over the last 12 months to unique members with the specific skill as a proxy of demand of skills. CapGemini report "Digital Talent Gap – Are companies doing enough? 2017[333]". European and US data. DG GROW is currently designing LinkedIn based Indicators for demand using the available jobs data within the Advanced Technologies for Industry project.
	Use of Big Data analysis by business	Yes	⊕	⊕	Percentage of total enterprises; with own employees, with external service providers, with both own employees and external service providers. OECD, 2016. Not available for US.
	Planned investments in the thematic areas	Yes	Yes	Yes	Crunchbase - Availability of venture capital in total ICT; Number of investors, regularly updated online.

Table 8-6: framework of demand and assessment for thematic areas indicators

⊕: requires substantial original work as indicators are not readily available but is feasible

8.5. Building on existing frameworks – towards a single monitoring framework

Other existing frameworks and initiatives at EU-level have been scrutinised to assess synergies with our monitoring mechanism and the indicators collected. More specifically, we checked:

- additional relevant indicators,
- alternative data collection methodologies and,
- the extendibility of the alternative approach and data to the three areas (Big Data, IoT and Cybersecurity).

The assessment of the existing frameworks was done having in mind the following questions:

- What are the commonalities between the indicators collected and the ones collected in the scope of the other monitoring framework, for ICT and prospected the three thematic areas?
- To what extent the other approaches can be used and adapted for the collection of indicators on the three thematic areas?
- Ultimately, what should we retain and what should we discard? How the other frameworks could use our proposed framework as reference?

[332] Note: Raw Data by country are only available through the report. They need to be extracted by scarping.

[333] Report link: https://www.capgemini.com/news/capgemini-and-linkedin-release-new-report-on-the-digital-talent-gap-employees-are-investing-their-own-resources-to-remain-competitive/

Figure 8-5 summarises the assessment of the other existing initiatives and frameworks under observation, further developed below. Potential additions and changes to the currently proposed set of indicators will be discussed with the European Commission.

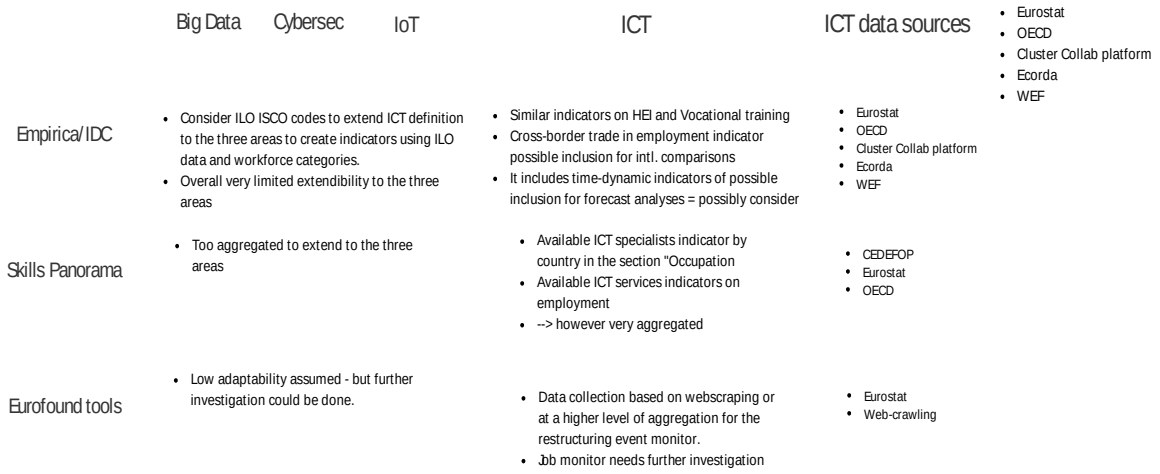

Figure 8-5 Monitoring framework proposed and synergies with other frameworks and initiatives

Source: Author's elaboration

e-Skills and e-Leadership skills in Europe, Digital Organisational Frameworks and IT Professionalism EASME/COSME/2016/016 (Empirica)

- In the context of the project e-Skills and e-Leadership Skills in Europe, Demand and Supply Forecasts (2016-2020) (Digital Organisational Frameworks and IT Professionalism EASME/COSME/2016/016), for e-Skills, Empirica builds a Supply-Demand framework to run a forecast with two scenarios. Differently from our approach based on Training and Labour indicators for both Supply and Demand, the Empirica's Supply framework can be split into two groups of indicators: 1) Labour and 2) Training, while the demand side is based on 1) Labour (vacancies and, jobs).
- A relevant indicator for international comparisons is the one on immigration-emigration, that is similar to our "trade in services by partner country indicator". Alternative formulations and sources could eventually be considered as for example the cross-border trade in employment (for which OECD indicators could be used). This extension would only be relevant for ICTs and not for the other three areas because of data aggregation limitations.
- Other useful indicators proposed under the Supply side would be Lateral entry and Category change, however, novel work of data collection (as well as more information on Empirica's sources and method) should be accounted for.
- Concerning the demand side, vacancies are a relevant indicator.
- The e-Skills Empirica framework uses a definition of ICT Specialists and ICT Profession based on ISCO codes. In view of extending these codes to create relevant indicators on employment (occupations) for Big Data, IoT and Cybersecurity, **we appreciate that ILO ISCO codes are the best reference and the most widely used one, in terms of detailed workforce topologies.** To use ISCO codes would create a solid base for further monitoring and for replicability. However, from a conceptual point of view, additional workforce type codes should be considered on top of the ones used for ICTs, as the applications of these three areas are broader than ICT only. Ultimately, raw data from ILO should be assessed to further explore this hypothesis. More information can be found in **Error! Reference source not found.**

While Empirica's approach provides a good granularity for the ICT area it has not an immediate application to the other three areas. Further analysis can be done, nonetheless, on the usability of ILO ISCO codes (as done by Empirica) to create workforce categorisations for the other areas.

The Skills Panorama

The Skills Panorama is the online platform for skills monitoring and anticipation by the European Commission and powered by CEDEFOP. Indicators are presented by:

- Source
- Dataset
- Alphabetical order
- Policy theme (European skills index, People and skills, matching skills and jobs, future jobs, labour market context)
- Country (EU28)
- Occupation. The skills panorama occupation type (i.e. workforce) is in line with ILO ISCO codes, thus largely also in line with our proposed typologies structure. Associate professionals include ICT technicians. Statistics available cover i) future employment growth, ii) occupations employed in the sector iii) employment shares, iv) employment by level of education v) by age and future employment openings (from the CEDEFOP database).
- Sector. The sectors include ICT services with statistics on i) future employment growth, ii) occupations employed in the sector iii) employment shares, iv) employment by level of education v) by age (all data from Labour Force Survey)

Key EU trends to 2030 also includes a section on Demand for and Supply of Skills, with two reported indicators 1) Share of job openings by level of education 2016-2030 and 2) Labour force share by level of qualification 2011-2030. Overall the following considerations can be made:

- The data aggregation reported by the Skills Panorama website is quite high, thus not allowing making further considerations on the use of the data for additional areas (i.e. big data, etc.).
- The codes used by CEDEFOP are always ISCO or ESO, and in all cases, translated in one of the two so to be able to make international comparisons.
- Similarly to Empirica, there is a forecast aspect (skills anticipation, at ISCO codes 3-digit)
- The study team has contacted CEDEFOP to assess details about the granularity of the data collected by them, and to confirm with them if there is any planned activity on specifically the areas covered by this study (ICT, Big data, IoT, Cybersecurity). CEDEFOP has confirmed that for the quasi totality of the data collected, data granularity would not allow us to extract information and indicators at the level of the thee areas under observation. An exception to keep monitored for the future is about "online vacancies" for which data collection will potentially reach ISCO 4-digit level. ICT occupations will be covered for sure. The project will deliver the first results for seven EU countries in March 2019, to reach EU28 coverage by mid-2020.
- For some occupations (high-tech occupations, vacancies) CEDEFOP reported difficulties to use ISCO codes, at 3-4 digit, and mentioned that further adaptations at higher-level (ILO level) are needed to accommodate for the changing nature of occupations in the high-tech area.

Eurofound tools

The Eurofound European Monitoring Centre on Change – EMCC includes two relevant monitors accounting for skills and/or jobs by sector/area: 1) the European Restructuring Monitor and the 2) European Jobs Monitor. After a review of the resources available online, the following can be concluded:

- **Restructuring Monitor**: the information reported in the restructuring events database is gathered by a network of correspondents carrying out a wide-ranging screening of daily and business press and online sources. The events covered concern only large-scale companies in the EU28 countries as well as Norway. An event is included if it entails the announced destruction or creation of at least 100 jobs, or at least 10% of the workforce at sites employing more than 250 people. In view of our study's objectives and scope, a weak linking potential is envisaged given that data refer only to large-scale companies, and that the highest sectoral disaggregation goes to the level of "information/communication" business area (industry classification not specified).
- **European Job Monitor**: it focuses on structural change statistics, using proxies of job quality like wages and skills levels. Further investigation would be needed to assess more in-depth the type of data used, sectors, and occupations covered as the full dataset seems not accessible online.

APPENDIX A: LIST OF INTERVIEWEES

Expert interviewees round 1 (February – June 2018)

	First Name	Name	Title/Role	Organisation
1	Cristina	Barros	Coordinator SMEs dimension	Portuguese National Initiative for Digital Competences (INCoDe)
2	Maria	Beck	Geschäftsstellenleiterin Digital in NRW	Mittelstand 4.0
3	Bas	Bosma	Assistant Professor of Data Science and Entrepreneurship	Jheronimous Academy of Data Science (JADS)
4	Agata	Boutanos	Director of the Representation to the European Union	Union of Entrepreneurs and Employers
5	Jiri	Branka	Expert Department for Skills and Labour Market	CEDEFOP
6	Lena	Carlsson	Deputy director general	Tillväxtverket
7	Joris	Castermans	Business developer IoT	Slimdesign; Twente University
8	Mary	Cleary	Deputy Chief Executive Officer; Coordinator of Irish Digital Skills and Jobs Coaltion	Irish Computer Society & CEN Workshop on ICT Skills
9	Thomas	Cooney	Professor in Entrepreneurship	Dublin Institute of Technology
10	Raphaël	Crouan	Founder & CEO; board member & chair for SMEs	Startupbootcamp IoT Program; AIOTI
11	Ans	De Vos	Professor	Antwerp Management School
12	Danilo	D'Elia	Senior Policy Manager	ECSO
13	Yuri	Demchenko	Coordinating partner at EDISON ConsortiumUniversity of Amsterdam	EDISON Consortium
14	Pavlin	Dobrev	Research and development manager	Bosch Software Innovation
15	Branimir	Dzenopoljac	Advisor	ICT Cluster of Central Serbia
16	Patrick	Farlang Slavenburg	Co-founder	Smartified
17	Anders	Flodstrom	Educational Director	EIT Digital (EIT ICTLabs)
18	Richard	Foggie	Advisor	Innovate UK (knowledge transfer network)
19	Marko	Grobelnik	Coordinator of Digitalna Slovenija	the Slovenian Chamber of Commerce and the Ministry of Public Administration
20	Paul	Healy	Chief Executive	Skillnet
21	Valentin	Hueber	Engineering and Technology Consulting (ICT) Delegate	Syntec Numérique
22	Mara	Jakobsone	Coordinator of E-prasmju partrnerība (E-skills partnership), vice-presiden	LIKTA
23	Gábor	Kismihók	Research Group Leader	Technische Informationsbibliothek (TIB)
24	Elzbieta	Ksiazek	Deputy Director	Poznan Science and Technology Park
25	Ruud	Mannaart	Advisor, product manager, innovation, data and retail	Chamber of Commerce
26	Lucia	Mazzoni	ICT Regional Technology Platform Coordinator	Aster
27	Ernestina	Menasalvas	Chair of the TF on Skills and Education	Big Data Value Association
28	Leo	Mrsic	Professor	Algebra University
29	Merete	Nørby	International Senior Consultant, Ph.D	MADE

	First Name	Name	Title/Role	Organisation
30	Agis	Papantoniou	CEO	Cognizone
31	Andrea	Parola	General Manager	European e-Skills Association
32	Kenny	Pool	Chairman Big Data Innovation Hub	Dell Technologies
33	Nicolò	Pranzini	ASTER - High Competences and Startup Unit	ASTER - High Competences and Startup Unit
34	Luigi	Rebuffi	CEO and founder	European Cyber Security Organisation (ECSO)
35	Paul	Roevens	Director	Lead-IT
36	Niels Peter	Rønmos	Chief Special advisor Digital Unit/ Data scientist in center for digital innovation	Danish Business Authority
37	Stefan	Schumacher	Director	Voice e.V. (Association of the IT Using SMEs)
38	Bo	Sejer Frandsen	CEO	IT Forum (Digital SME national member)
39	George	Sharkov	Head	Cybersecurity Bulgarian Government
40	Egbert-Jan	Sol	CTO and professor	TNO, Radboud University
41	Richard	Stevens	Consulting Director, IDC European Government Consulting	IDC Italy
42	Stefano	Tirati	Vice President	EFVET
43	Staffan	Truvé	CTO and professor	Recorded Future
44	Constantinos	Tsiourtos	Executive Director	Cyprus Cybersecurity Organization
45	Hans	Van Bragt	Projectleider	Big Data Value Center
46	Arthur	Van der Wees	Founder	Arthur's Legal
47	Philippe	van Impe	Directeur	Digityser
48	Rob	Van Kranenburg	Founder IOT council	IOT council
49	Andrea	Zapparoli Manzoni	Member of Board of Directors	CLUSIT
50	Thilo	Zimmermann	Project Manager Future Work Lab	Fraunhofer

Expert interviewees round 2 (June - November 2019)

	First Name	Name	Title/Role	Organisation
1	Geert	Asselbergs	Senior project lead	Stichting Platform Bètatechniek
2	Maria	Beck	Geschäftsstellenleiterin Digital in NRW	Mittelstand 4.0
3	Marco	Bianchini	Policy Analyst	Centre for Entrepreneurship, SMEs, Regions and Cities, OECD
4	Christiaan	Boiten	Advisor	Eurocommerce
5	Laurentiu	Bunescu	CEO	All Digital
6	Danilo	d'Elia	Senior policy analyst	European Cyber Security Organisation (ECSO)
7	Gerard	Doyle	Network manager, Cybersecurity Skills Initiative	Technology Ireland ICT Skillnet
8	Dave	Feenan	Network manager	Technology Ireland ICT Skillnet
9	Samuel	Fricker	Ph.D., Professor at FHNW University of Applied Sciences and assistant professor at Blekinge Institute of Technology	SMESEC (ATOS contributing)
10	Jörg	Friedrich	Head of Department Educational Policy	VDMA
11	Elena	Garrido	Cluster manager	AERTIC

12	Paul	Gisby	Senior manager	Accountancy Europe
13	Poul-Erik	Hansen	Director	CENSEC
14	Margot	Hol	Analyst	Achmea
15	Danny	Jaspers	Business lead Cyber	Achmea
16	Youssef	Kalad	CTO-office, Cyber initiatives	New York City
17	Gordon	Kirstein	CEO	MoveTech
18	Daan	Kolkman	Initiator	JADS SME Datalab
19	Timo	Kos	Executive Director Extension School	Technical University Delft
20	Katarzyna	Koziol	Enterprise and Single Market Adviser	SME United
21	Anne	Lidgard	Director, Senior Advisor	Swedish Innovation Agency VINNOVA
22	Robert Jan	Marringa	Project Lead Brainport Development	Two For Innovation
23	Fabio	Massimo	Chair, board member	TC428, Digital SME Alliance
24	Steffen	Maurer	Chief Information Security Officer	MoveTech
25	Ernestina	Menasalvas	Lead of BDVA Task Force 9: Skills and Education	Big Data Value Association, and University Madrid
26	Guido	Ongena	Senior researcher HU Data Lab	Univesity of Applied Sciences Utrecht
27	Nicolò	Pranzini	Advisor	ASTER - High Competences and Startup Unit
28	Petra	Püchner	Commissioner for Europe	Minister of Economic Affairs, Labour and Housing of Baden-Wuerttemberg, Germany
29	Pascal	Ravesteijn	Professor in Process Innovation & Information Systems	HU Business School Utrecht, University of Applied Sciences
30	Stefan	Schumacher	Director	Voice e.V. (Association of the IT Users SME)
31	Franziska	Seimys	Policy support	VDMA
32	Bo	Sejer Frandsen	CEO, board member, vice-president	IT-forum, AIOTI, European DIGITAL SME Alliance
33	Josine	van de Ven	Dr. Ing.	TNO
34	Arjan	Van den Born	Research Institute Director	Tilburg Institute of Governance
35	Csaba	Virag	Head	Cybersecurity Competence Center Hungary
36	Rainer	Wendt	Member of WG SKILLS: digital skills, social dialogue, movement of workers, competence centers at DIGITAL SME	BITMi, IIBA, PMI

Alignment meetings with related initiatives (February 2018 – August 2018)

	Name	Project/Initiative
1	Svatopluk Štolfa	Development and Research on Innovative Vocational Education Skills (DRIVES)
2	Lucía Fraga Lago	Maritime Alliance for fostering the European Blue economy through a Marine Technology Skilling Strategy (MATES)
3	Milva Carbonaro	Towards an innovative strategy for skills development and capacity building in the space geo information sector supporting Copernicus User Uptake (EO4GEO)
4	Silvia Barbone	The Next Tourism Generation Alliance (NGT)
5	Christine Simon, Katarzyna Szumielewicz	Makes_me_digital
6	Mayte Carrecedo	I4MS

APPENDIX B: METHOD AND SOURCES OF THE ANALYSIS OF TECHNOLOGICAL TRENDS

For the analysis of the technology trends and market developments described in section 2.3, 25 research articles from leading research firms were compared and analysed. The following criteria were used to identify technological trends:

- Publications are max. 2 years old;
- Trends identified are documented by at least three separate sources;
- Trends are related to or impact big data, IoT and/or cybersecurity;
- They are disruptive technologies, according to the definition provided by McKinsey[334], meaning that they are rapidly advancing, they have a broad potential scope of impact, may affect significant economic value, and they can dramatically change the status quo of the market;
- For the search process, the following keywords were used: IoT, big data, cybersecurity, movements, trends, market developments, technology, outlook, 2018

(1) Accenture (2018), Accenture Technology Vision. Available at: https://www.accenture.com/t20180227T215953Z__w__/us-en/_acnmedia/Accenture/next-gen-7/tech-vision-2018/pdf/Accenture-TechVision-2018-Tech-Trends-Report.pdf#zoom=50

(2) Atomico (2017), State of European Tech Report 2017. Available at: https://2017.stateofeuropeantech.com/

[334] Manyika, J., Chui, M., Bughin, J., Dobbs, R., Bisson, P., & Marrs, A. (2013), Disruptive technologies: Advances that will transform life, business, and the global economy. Published May. Available at: https://www.mckinsey.com/business-functions/digital-mckinsey/our-insights/disruptive-technologies

(3) Bain & Company (2017), Finding Europe's Edge in the Internet of Things. Available at: http://www.bain.com/publications/articles/finding-europes-edge-in-the-internet-of-things.aspx

(4) Capgemini (2017) Technovision Parallel Digital Realities 2017. Available at: https://www.capgemini.com/wp-content/uploads/2017/07/technovision_2017_-_parallel_digital_realities.pdf

(5) Capgemini (2017) Trends in Cybersecurity 2017. Available at: https://www.capgemini.com/nl-nl/wp-content/uploads/sites/7/2017/11/1b-085-17-trends-in-cybersecurity_web.pdf

(6) Capgemini (2018) 2018 Predictions: Disruptive Technologies. Available at: https://www.capgemini.com/gb-en/2018/01/2018-predictions-disruptive-technologies/#

(7) Capgemini (2018) 2018 predictions: cybersecurity. Available at: https://www.capgemini.com/gb-en/2018/01/2018-predictions-cybersecurity/

(8) Cisco Systems (2018), Annual Cybersecurity Report. Available at: https://www.cisco.com/c/m/en_au/products/security/offers/cybersecurity-reports.html

(9) Deloitte (2018), Technology Industry Outlook. Navigating toward the future: Leveraging technology advances in the digital transformation era. Available at: https://www2.deloitte.com/content/dam/Deloitte/us/Documents/technology-media-telecommunications/us-tmt-2018-technology-industry-outlook.pdf

(10) Deloitte (2018), Tech Trends 2018. The symphonic enterprise. Available at: https://www2.deloitte.com/content/dam/insights/us/articles/Tech-Trends-2018/4109_TechTrends-2018_FINAL.pdf

(11) Deloitte (2015), Five questions about social media analytics in the energy and resources industries. Available at: https://www2.deloitte.com/us/en/pages/finance/articles/five-questions-about-social-media-analytics-in-energy-and-resources-industries.html

(12) Enisa (2017) ENISA Threat Landscape Report 2017. Available at: https://www.enisa.europa.eu/publications/enisa-threat-landscape-report-2017

(13) European Commission (2017), The Digital Economy and Society Index. Available at: https://ec.europa.eu/digital-single-market/en/desi

(14) EY (2018), Is the next evolution of big data, big judgment? Available at: http://www.ey.com/Publication/vwLUAssets/EY-data-analytics-in-hospitality/$FILE/EY-data-analytics-in-hospitality.pdf

(15) Gartner (2017), Top 10 Strategic Technology Trends for 2018. Available at: https://www.gartner.com/doc/3811368?refval=&pcp=mpe

(16) Gartner (2018), The Top Security Trends for Midsize Enterprises. Available at: https://www.gartner.com/webinar/3690017

(17) Gartner (2017), 100 Data and Analytics Predictions for 2021. Available at: https://www.gartner.com/imagesrv/media-products/pdf/tealium/Tealium-1-47GUGIN.pdf

(18) IBM (2017), Top 5 IoT trends transforming business in 2018. Available at: https://www.ibm.com/blogs/internet-of-things/top-5-iot-trends-in-2018/

(19) IDC (2017), Worldwide IT Industry 2018 Predictions. Available at: https://www.idc.com/getdoc.jsp?containerId=US43171317

(20) McKinsey & Company (2017), What's Now and Next in Analytics, AI, and Automation. Available at: https://www.mckinsey.com/global-themes/digital-disruption/whats-now-and-next-in-analytics-ai-and-automation#

(21) McKinsey & Company (2017), Fueling growth through data monetization. Available at: https://www.mckinsey.com/business-functions/mckinsey-analytics/our-insights/fueling-growth-through-data-monetization

(22) McKinsey & Company (2016), Digital Europe: Pushing the frontier, capturing the benefits. Available at: https://www.mckinsey.com/~/media/McKinsey/Business%20Functions/McKinsey%20Digital/Our%20Insights/Digital%20Europe%20Pushing%20the%20frontier%20capturing%20the%20benefits/Digital-Europe-Full-report-June-2016.ashx

(23) PricewaterhouseCoopers (2018), Tech breakthroughs megatrend: how to prepare for its impact. Available at: https://www.pwc.com/gx/en/issues/technology/tech-breakthroughs-megatrend.html

(24) PricewaterhouseCoopers (2017), Emerging trends 2017. What's ahead on the global cybersecurity and privacy landscape? Available at: https://www.pwc.com/us/en/cybersecurity/assets/cybersecurity-trends.pdf

(25) Saviant Consulting (2018), IoT and Data Analytics Predictions for 2018. Available at: http://www.saviantconsulting.com/blog/iot-data-analytics-predictions-2018.aspx

APPENDIX C: TOOLBOX OVERVIEW

Good practices - various skills initiatives			Typology	Most relevant stream of roadmap	Most relevant sub-goal of that stream
1	Digital Skills for SMEs	http://www.glbulgaria.bg/en/digisme	Training program	1. Strengthening ecosystems	1. Created shared databases and tools to make information accessible to stakeholders
2	SME:Digital	https://investindk.com/-/media/invest-in-denmark/files/danish-digital-growth-strategy2018.ashx?la=en&hash=8F378A9E64FAD29D44530C3238D9720DA44EC3CA https://eng.em.dk/media/10554/digital-strategy-fact-sheet.pdf	Support programme/ strategy	2. Support strategic outlook development	2. Stimulate existing and new policy initatives that inform SME managers/owners about the potential of BIC technologies and encourage innovation (e.g. programmes, campaigns, events)
3	NumericALL & Fit4coding – training jobseekers into web developers in Luxembourg	https://www.numericall.fr/	Training program	4. Tailor education and training offers	4. Innovate educational programmes (co-creation, badging) to stimulate collaboration between SMEs and education
4	Digitaal.Talent@ Gent – Unlocking the Digital Potential of all Citizens in Belgium	https://stad.gent/samenleven-welzijn-gezondheid/alle-gentenaars-digitaal	Training program	1. Strengthening ecosystems	1. Develop policies & funding programmes that help to support SME communities, networks and ecosystems (clusters), such as Digital Innovation Hubs
5	Wallonia Marshall Plan 4.0.	http://planmarshall.wallonie.be/le-plan-0	Network / collaboration	3. Strengthen structured skills development	3. Promote blueprints, practical frameworks and tools that support SMEs to build a smart (HR) strategy (incl. tools to support recruitment, hiring, dvlpment)
6	Grande école du numérique in France	http://www.grandecolenumerique.fr/	Training program	4. Tailor education and training offers	4. Innovate educational programmes (co-creation, badging) to stimulate collaboration between SMEs and education
7	Samsung Innovation Camp in Italy	https://www.innovationcamp.it	Training program	4. Tailor education and training offers	4. Increase understanding of education providers on h2 identify training needs, target groups & tailor offers
8	IT Talents Training Camp	http://ittalents.bg/home	Training program	4. Tailor education and training offers	4. Promote and scale successful funding mechanisms that foster skills development (e.g. cost-sharing models)
9	Coding Class in Denmark	https://itb.dk/artides/fremtidens-kompetencer/coding-class	Training program	4. Tailor education and training offers	4. Integrate BIC modules in non-tech curricula, even offer it for free, to increase potential talent pool
10	The Digital Academy	https://www.czechitas.cz/en/portfolio/digital-academy	Training program	4. Tailor education and training offers	4. Stimulate development of practical cybersecurity training programmes (eg in VET), SMEs' needs based, using labs
11	IT for SHE	http://www.itforshe.pl/	Training program	4. Tailor education and training offers	4. Increase mobility of scarce experts (in Edu & Edu-Industry)
12	ProgeTiger	http://www.hitsa.ee/it-education/educational-programmes/progetiger	Training program	4. Tailor education and training offers	4. Integrate BIC modules in non-tech curricula, even offer it for free, to increase potential talent pool

Good practices - various skills initiatives			Typology	Most relevant stream of roadmap	Most relevant sub-goal of that stream
13	SMESEC	https://smesec.eu/about.html	Guide/ toolbox	1. Strengthening ecosystems	1. Created shared databases and tools to make information accessible to stakeholders
14	Big Data Value Association	http://www.bdva.eu	Network / collaboration	1. Strengthening ecosystems	1. Develop policies & funding programmes that help to support SME communities, networks and ecosystems (clusters), such as Digital Innovation Hubs
15	Digital Transition programme	http://www.eurocommerce.eu/media/143276/European%20SME-Action%20Programme.pdf	Training program	1. Strengthening ecosystems	1. Develop policies & funding programmes that help to support SME communities, networks and ecosystems (clusters), such as Digital Innovation Hubs
16	Les Digiteurs. Transition Numérique Ile-de-France	http://transformation-digitale-tpe-pme.cci-paris-idf.fr/sommaire/ https://www.lesdigiteurs.cci-paris-idf.fr/notre-ambition-votre-entreprise	Network / collaboration	4. Tailor education and training offers	4. Promote existing blueprints for training for SMEs
17	Web@cademie Women ambition – A second-chance coding school! in France	http://webacademie.org/ambitionFeminine	Training program	4. Tailor education and training offers	4. Innovate educational programmes (co-creation, badging) to stimulate collaboration between SMEs and education
18	Kompetenzzentrum Fachkräftesicherung (KOFA) ("one-stop-shop"	https://www.bmwi.de/Redaktion/EN/Publikationen/avoiding-skills-shortages-and-mismatches.pdf?__blob=publicationFile&v=2	Guide/ toolbox	3. Strengthen structured skills development	3. Promote blueprints, practical frameworks and tools that support SMEs to build a smart (HR) strategy (incl. tools to support recruitment, hiring, dvlpment)
19	Codepact	https://www.bmwi.de/Redaktion/EN/Publikationen/avoiding-skills-shortages-and-mismatches.pdf?__blob=publicationFile&v=2	Network / collaboration	4. Tailor education and training offers	4. Innovate educational programmes (co-creation, badging) to stimulate collaboration between SMEs and education
20	Go-Digital	http://www.bmwi.de/Redaktion/DE/Artikel/Digitale-Welt/foerderprogramm-go-digital.html	Support programme/ strategy	1. Strengthening ecosystems	1. Develop policies & funding programmes that help to support SME communities, networks and ecosystems (clusters), such as Digital Innovation Hubs
21	Alliance for Initial and Further Training 2015–2018	https://www.bmwi.de/Redaktion/EN/Publikationen/avoiding-skills-shortages-and-mismatches.pdf?__blob=publicationFile&v=2	Training program	4. Tailor education and training offers	4. Stimulate internships to provide students with practical experience and SMEs with potential employees
22	Mittelstand Digital	http://www.bmwi.de/Redaktion/DE/Dossier/mittelstand-digital.html	Support programme/ strategy	1. Strengthening ecosystems	1. Stimulate collaboration between hubs and education system to better tailor to needs
23	Crescere in Digitale	http://www.crescereindigitale.it/ and http://foodinnovationprogram.org/googl	Training program	4. Tailor education and training offers	4. Innovate educational programmes (co-creation, badging) to stimulate

Good practices - various skills initiatives			Typology	Most relevant stream of roadmap	Most relevant sub-goal of that stream
		e-partners-with-italian-government-to-launch-made-in-italy-and-crescere-in-digitale/			collaboration between SMEs and education
24	German-Italian Cooperation on Industry 4.0	https://www.plattform-i40.de/I40/Redaktion/EN/Downloads/Publikation-gesamt/german_italian_cooperation.pdf?__blob=publicationFile&v=2	Network / collaboration	1. Strengthening ecosystems	1. Initiate EU and national programs that facilitate knowledge sharing and create platforms where 3rd parties and SMEs can access relevant materials (single multi-sector portal at EU level)
25	Mittelstand 4.0	http://www.mittelstand-digital.de/DE/Foerderinitiativen/mittelstand-4-0.html	Guide/ toolbox	2. Support strategic outlook development	2. Support organisations, initiatives and platforms tht foster collaboration and knowledge sharing amongcompany managers/owners for adoption of BIC technologies and new business models (e.g. business clubs/associations/clusters, buddy support schemes, training programs for a group of company managers)
26	The Mittelstand 4.0 Competence Center eStandards	https://www.kompetenzzentrum-estandards.digital/	Guide/ toolbox	1. Strengthening ecosystems	1. Stimulate collaboration between hubs and education system to better tailor to needs
27	Digitales Handwerk	http://www.handwerkdigital.de/	Network / collaboration	3. Strengthen structured skills development	3. Facilitate self-assessments to enable SMEs to detect skills gap in their organisation
28	Skillnet Ireland	https://www.skillnetireland.ie	Network / collaboration	1. Strengthening ecosystems	1. Develop policies & funding programmes that help to support SME communities, networks and ecosystems (clusters), such as Digital Innovation Hubs
29	SMEs trainings for digital technologies and innovation development in Latvia	http://www.mmu.lv/	Training program	4. Tailor education and training offers	4. Promote existing blueprints for training for SMEs
30	Samsung Digi Pass	http://www.samsungdigipass.ee/ee	Training program	4. Tailor education and training offers	4. Innovate educational programmes (co-creation, badging) to stimulate collaboration between SMEs and education
31	AMETIC ICT Professionals	http://ametic.es/es/FTI	Network / collaboration	4. Tailor education and training offers	4. Stimulate innovative voucher schemes for fostering BIC skills development that do not have a high burden (Go Digital Germany)
32	Skills Plus	https://www.kompetansenorge.no/English/Basic-skills/Competenceplus/	Support programme/ strategy	4. Tailor education and training offers	4. Promote existing blueprints for training for SMEs
33	INCoDe.2030	http://www.incode2030.gov.pt	Support programme/ strategy	1. Strengthening ecosystems	1. Develop policies & funding programmes that help to support SME communities, networks and ecosystems (clusters), such as Digital Innovation Hubs
34	Cybervolunteers : Cibervoluntarios	https://www.cibervoluntarios.org/es	Network / collaboration	4. Tailor education and training offers	4. Increase mobility of scarce experts (in Edu & Edu-Industry)

Good practices - various skills initiatives			Typology	Most relevant stream of roadmap	Most relevant sub-goal of that stream
	promoting technological volunteering in Spain				
35	Skillsfuture Singapore	http://www.skillsfuture.sg/AboutSkillsFuture	Support programme/ strategy	4. Tailor education and training offers	4. Increase funding for skills development in SMEs
36	Digital Skills and Jobs Coalition Pledge Viewer	http://pledgeviewer.eu		1. Strengthening ecosystems	1. Created shared databases and tools to make information accessible to stakeholders
37	SMART071	https://www.economie071.nl/projecten/smart071/	Support programme/ strategy	4. Tailor education and training offers	4. Innovate educational programmes (co-creation, badging) to stimulate collaboration between SMEs and education
38	ECSO's European Human Resources Network for Cyber (EHR4CYBER) Task Force	https://www.digitalsme.eu/digital/uploads/3rd-Workshop_2n-ppt_EH4CYBER_presentation0802019.pdf	Network / collaboration	4. Tailor education and training offers	4. Increase understanding of education providers on h2 identify training needs, target groups & tailor offers
39	BDVA Skills Task Force and the BDVeProject	http://www.bdva.eu/task-force-overview	Network / collaboration	1. Strengthening ecosystems	1. Develop policies & funding programmes that help to support SME communities, networks and ecosystems (clusters), such as Digital Innovation Hubs
40	"From volume to value The big data strategy" of Emilia Romagna	https://formazionelavoro.regione.emilia-romagna.it/alta-formazione-ricerca/allegati/emilia-romagna-big-data-community_web.pdf/@@download/file/EMILIA%20ROMAGNA%20BIG%20DATA%20COMMUNITY_WEB.pdf	Guide/toolbox	1. Strengthening ecosystems	1. Develop policies & funding programmes that help to support SME communities, networks and ecosystems (clusters), such as Digital Innovation Hubs
41	JADS MKB Datalab	www.jadsmkbdatalab.nl	Counselling	4. Tailor education and training offers	4. Stimulate internships to provide students with practical experience and SMEs with potential employees
42	Digital Champions BE	www.digitalchampions.be	Network / collaboration	1. Strengthening ecosystems	1. Develop policies & funding programmes that help to support SME communities, networks and ecosystems (clusters), such as Digital Innovation Hubs
43	PROMPT, Professional Master in Software Engineering	http://www.promptedu.se/	Training program	4. Tailor education and training offers	4. Promote existing blueprints for training for SMEs
44	Cyber Skills Initiative (CSI)	https://www.ictskillnet.ie/news/cybersecurity-skills-initiative-launch-at-cyberconf/	Network / collaboration	2. Support strategic outlook development	2. Stimulate the development of national Cybersecurity frameworks for SMEs
45	SEnDIng	http://sending-project.eu	Training program	4. Tailor education and training offers	4. Promote use of standards and frameworks to increase uniformity in training courses

Good practices - various skills initiatives			Typology	Most relevant stream of roadmap	Most relevant sub-goal of that stream
46	Modern Business Program (Hungary)	www.vallalkozzdigitalisan.hu	Support programme/ strategy	2. Support strategic outlook development	2. Support organisations, initiatives and platforms tht foster collaboration and knowledge sharing amongcompany managers/owners for adoption of BIC technologies and new business models (e.g. business clubs/associations/clusters, buddy support schemes, training programs for a group of company managers)
47	Cyber Resilience Centre Brainport	https://cwbrainport.nl/	Network / collaboration	2. Support strategic outlook development	2. Support organisations, initiatives and platforms tht foster collaboration and knowledge sharing amongcompany managers/owners for adoption of BIC technologies and new business models (e.g. business clubs/associations/clusters, buddy support schemes, training programs for a group of company managers)
48	Innvation vouchers Finland	https://www.businessfinland.fi/en/for-finnish-customers/services/funding/research-and-development/innovation-voucher/	Training program	4. Tailor education and training offers	4. Increase funding for skills development in SMEs
49	VOICE Cyber security platform	https://voice-ev.org/wissensplattform/	Support programme/ strategy	3. Strengthen structured skills development	3. Research the possibility of quality labels so SMEs recognise value of a training
50	Cyber security Rangers (jpn)	https://www.meti.go.jp/english/press/2019/0611_002.html	Counselling	2. Support strategic outlook development	2. Stimulate existing and new policy initatives that inform SME managers/owners about the potential of BIC technologies and encourage innovation (e.g. programmes, campaigns, events)
51	Cyber New York City (Cyber NYC)	https://www.cyber-nyc.com/	Support programme/ strategy	1. Strengthening ecosystems	1. Stimulate collaboration between hubs and education system to better tailor to needs
52	Innovation vouchers Flevoland	https://voucherregelingflevoland.nl/	Training program	4. Tailor education and training offers	4. Increase funding for skills development in SMEs
Frameworks			**Typology**	**Most relevant stream of roadmap**	**Most relevant sub-goal of that stream**
1	DigComp	https://ec.europa.eu/jrc/en/digcomp	Framework	4. Tailor education and training offers	4. Promote use of standards and frameworks to increase uniformity in training courses
2	IT Professionalism: Digiframe	http://ictprofessionalism.eu	Framework	4. Tailor education and training offers	4. Promote use of standards and frameworks to increase uniformity in training courses
3	makes_me </digital> (Digital Skills: New Professions, New Educational Methods, New Jobs - Smart2016/1006)	https://makesmedigital.eu	Framework	4. Tailor education and training offers	4. Increase funding for skills development in SMEs

Good practices - various skills initiatives			Typology	Most relevant stream of roadmap	Most relevant sub-goal of that stream
4	EDISON Data Science Framework	https://ec.europa.eu/digital-single-market/en/news/edison-training-scientists-today-and-tomorrow	Framework	4. Tailor education and training offers	4. Promote use of standards and frameworks to increase uniformity in training courses
5	A lightweight Cybersecurity framework for thorough protection	https://smesec.eu/index.html	Framework	4. Tailor education and training offers	4. Promote use of standards and frameworks to increase uniformity in training courses
6	National Initiative for Cybersecurity Education (NICE)	https://www.nist.gov/itl/applied-cybersecurity/nice	Framework	3. Strengthen structured skills development	3. Promote blueprints, practical frameworks and tools that support SMEs to build a smart (HR) strategy (incl. tools to support recruitment, hiring, dvlpment)
Self-assesments			**Typology**	**Most relevant stream of roadmap**	**Most relevant sub-goal of that stream**
1	Readiness for Innovation Self-assessment Tool	http://www.sircon.co.uk/afrcinnovationassessment/	Self-assesments	2. Support strategic outlook development	2. Stimulate existing and new policy initatives that inform SME managers/owners about the potential of BIC technologies and encourage innovation (e.g. programmes, campaigns, events)
2	Finding your Cybersecurity Career Path	https://www.edx.org/course/finding-cybersecurity-career-path-uwashingtonx-cyb004x	Self-assesments	2. Support strategic outlook development	2. Stimulate existing and new policy initatives that inform SME managers/owners about the potential of BIC technologies and encourage innovation (e.g. programmes, campaigns, events)
3	SME Cloud Security Tool	https://www.enisa.europa.eu/topics/doud-and-big-data/cloud-security/security-for-smes/sme-guide-tool	Self-assesments	2. Support strategic outlook development	2. Stimulate existing and new policy initatives that inform SME managers/owners about the potential of BIC technologies and encourage innovation (e.g. programmes, campaigns, events)
4	Entreprises, les clés d'une application réussie du GDPR	http://www.cigref.fr/wp/wp-content/uploads/2017/11/CIGREF-GT-AFAI-CIGREF-TIF-Donnees-Personnelles-et-Systemes-d-Informations-GDPR-2017.pdf	Self-assesments	2. Support strategic outlook development	2. Stimulate existing and new policy initatives that inform SME managers/owners about the potential of BIC technologies and encourage innovation (e.g. programmes, campaigns, events)
5	Cyber Risico Scan	https://veiligzakelijkinternetten.cyberstatus.nl/	Self-assesments	2. Support strategic outlook development	2. Stimulate existing and new policy initatives that inform SME managers/owners about the potential of BIC technologies and encourage innovation (e.g. programmes, campaigns, events)
6	Cybersecurity Competence Center	https://voice-ev.org/wissensplattform/	Self-assesments	2. Support strategic outlook development	2. Stimulate existing and new policy initatives that inform SME managers/owners about the potential of BIC technologies and encourage innovation (e.g. programmes, campaigns, events)

Good practices - various skills initiatives			Typology	Most relevant stream of roadmap	Most relevant sub-goal of that stream
Guides & others			**Typology**	**Most relevant stream of roadmap**	**Most relevant sub-goal of that stream**
1	Avoiding skills shortages and mismatches – New strategies for meeting companies' skilled labour needs	https://www.bmwi.de/Redaktion/EN/Publikationen/avoiding-skills-shortages-and-mismatches.pdf?__blob=publicationFile&v=2	Support programme/ strategy	4. Tailor education and training offers	4. Stimulate internships to provide students with practical experience and SMEs with potential employees
2	EU GDPR Checklist for Corporate Implementation	http://www.bmwi.de/Redaktion/DE/Publikationen/Digitale-Welt/datenschutzgrundverordnung.html	Guide/ toolbox	3. Strengthen structured skills development	3. Facilitate self-assessments to enable SMEs to detect skills gap in their organisation
3	Community Boost EU Facebook	https://newsroom.fb.com/news/2018/01/community-boost-europe/	Training program	4. Tailor education and training offers	4. Promote existing blueprints for training for SMEs
4	Digital Schools of Distinction in Ireland	http://www.digitalschools.ie/	Network / collaboration	4. Tailor education and training offers	
5	Digital skills gap in Europe	http://ec.europa.eu/newsroom/dae/document.cfm?doc_id=47880	Guide/toolbox	2. Support strategic outlook development	2. Design a matchmking platform that links technology solutions in the area of BIC with SME needs
6	The Additional Qualifications for Digital Competences Programme	https://media.nesta.org.uk/documents/Readie_Digital_Skills_booklet_online.pdf	Support programme/ strategy	4. Tailor education and training offers	4. Promote existing blueprints for training for SMEs
7	Continuous Professional Development for ICT&L in Ireland	https://www.ics.ie/news/what-is-continuous-professional-development-	Training program	3. Strengthen structured skills development	3. Decrease dependency on external providers
8	Human Capital Agenda ICT	https://www.bmwi.de/Redaktion/EN/Publikationen/avoiding-skills-shortages-and-mismatches.pdf?__blob=publicationFile&v=2	Support programme/ strategy	3. Strengthen structured skills development	3. Monitor market trends to inform (esp. IT-using) SMEs
9	Data Pitch	https://datapitch.eu/	Support programme/ strategy	1. Strengthening ecosystems	1. Develop policies which help mobilising accelerators/downstream actors
10	Commit2Data	https://www.dutchdigitaldelta.nl/uploads/pdf/Commit2data-DDD-Flyer-november-17_171116_100106.pdf	Support programme/ strategy	2. Support strategic outlook development	2. Stimulate collaborative projects between SMEs and researchers
11	IT in Bank, in Poland	http://itnabank.pl/	Training program	3. Strengthen structured skills development	3. Research how career switches can be facilitated to increase the talent pool (esp. in cyber security) and scale good practices
12	Code for All	http://www.academiadecodigo.org	Training program	4. Tailor education and training offers	4. Integrate BIC modules in non-tech curricula, even offer it for free, to increase potential talent pool

Good practices - various skills initiatives			Typology	Most relevant stream of roadmap	Most relevant sub-goal of that stream
13	Opening Opportunities in Romania	http://openingopportunities.ro/	Training program	4. Tailor education and training offers	4. Innovate educational programmes (co-creation, badging) to stimulate collaboration between SMEs and education
14	Social Builder	https://socialbuilder.org	Training program	4. Tailor education and training offers	4. Innovate educational programmes (co-creation, badging) to stimulate collaboration between SMEs and education
15	Find "hidden" jobs among SMEs – match with job seekers	https://www.bmwi.de/Redaktion/EN/Publikationen/avoiding-skills-shortages-and-mismatches.pdf?__blob=publicationFile&v=2	Network / collaboration	2. Support strategic outlook development	2. Design a matchmking platform that links technology solutions in the area of BIC with SME needs
16	Rethinking Education	https://europa.eu/rapid/press-release_IP-12-1233_en.htm	Support programme/ strategy	4. Tailor education and training offers	4. Increase understanding of education providers on h2 identify training needs, target groups & tailor offers
17	Digilyft Kickstart	https://hellofuture.org/case/digilyft/	Counselling	4. Tailor education and training offers	4. Increase funding for skills development in SMEs
18	Good Things Foundation	https://www.goodthingsfoundation.org	Network / collaboration	2. Support strategic outlook development	2. Support organisations, initiatives and platforms tht foster collaboration and knowledge sharing amongcompany managers/owners for adoption of BIC technologies and new business models (e.g. business clubs/associations/clusters, buddy support schemes, training programs for a group of company managers)
19	OAK3 Academy	http://www.oak3.be	Training program	4. Tailor education and training offers	4. Stimulate innovative voucher schemes for fostering BIC skills development that do not have a high burden (Go Digital Germany)
20	BSI Group BIM	https://www.bsigroup.com/en-GB/our-services/training-courses/BIM-training-courses/	Training program	4. Tailor education and training offers	4. Promote existing blueprints for training for SMEs
21	Unionlearn	https://www.unionlearn.org.uk	Network / collaboration	2. Support strategic outlook development	2. Involve intermediaries in an SME that can act as advisors for SME managers/owners in adoption of BIC technologies (e.g. accountants, insurance companies, ICT interns)
22	Digital Innovation Hubs	http://s3platform.jrc.ec.europa.eu/digital-innovation-hubs	Network / collaboration	1. Strengthening ecosystems	1. Develop policies & funding programmes that help to support SME communities, networks and ecosystems (clusters), such as Digital Innovation Hubs
23	LEAD-IT	www.lead-it.be	Counselling	2. Support strategic outlook development	2. Design a matchmking platform that links technology solutions in the area of BIC with SME needs
24	IoT Device Security Lab	https://www.digitalsme.eu/digital/uploads/2nd-Workshop_Skills-for-SMEs_3rd-	Network / collaboration	4. Tailor education and training offers	4. Invest in facilities to support training programmes (eg labs)

Good practices - various skills initiatives			Typology	Most relevant stream of roadmap	Most relevant sub-goal of that stream
		ppt_Khani_IoT_Sec_lab_Short1_7-Dec-18.pdf			
25	Southampton Data Science Academy	https://southamptondata.science/	Training program	1. Strengthening ecosystems	4. Increase funding for skills development in SMEs
26	Knowledge Transfer Partnerships for data science in SMEs	https://www.ncl.ac.uk/maths-physics/business/ktp/	Support programme/ strategy	4. Tailor education and training offers	4. Promote existing blueprints for training for SMEs
27	Digital Cities	https://www.dellemc.com/en-us/industry/digital-cities/index.htm	Guide/toolbox	1. Strengthening ecosystems	1. Initiate EU and national programs that facilitate knowledge sharing and create platforms where 3rd parties and SMEs can access relevant materials (single multi-sector portal at EU level)
28	Cyber Welfare	https://www.cyberwelfare.it/	Guide/toolbox	1. Strengthening ecosystems	1. Created shared databases and tools to make information accessible to stakeholders
29	Digital Learning Centre	http://www.softwaremanager.eu/	Training program	3. Strengthen structured skills development	3. Promote blueprints, practical frameworks and tools that support SMEs to build a smart (HR) strategy (incl. tools to support recruitment, hiring, dvlpment)
30	Cyber Ready	https://certification.comptia.org/why-certify/cyber-ready	Training program	4. Tailor education and training offers	4. Stimulate development of practical cybersecurity training programmes (eg in VET), SMEs' needs based, using labs
31	IT-Ready	https://www.creatingitfutures.org/	Counselling	3. Strengthen structured skills development	3. Research how career switches can be facilitated to increase the talent pool (esp. in cyber security) and scale good practices
32	Datafabriek/ The Data Factory	https://onlinetouch.nl/villay/ingovernment-04-2018/16;Essay#/16 (dutch read)	Training program	4. Tailor education and training offers	4. Invest in facilities to support training programmes (eg labs)
33	Bronnen: wie helpt mij verder met data?	https://www.kvk.nl/download/20173047_invulbare-pdf_databronnen_171215-proef2_tcm109-452575.pdf	Network / collaboration	2. Support strategic outlook development	2. Support organisations, initiatives and platforms tht foster collaboration and knowledge sharing amongcompany managers/owners for adoption of BIC technologies and new business models (e.g. business clubs/associations/clusters, buddy support schemes, training programs for a group of company managers)
34	Big data: groeikansen voor ondernemers	https://www.kvk.nl/download/Whitepaper-Big-Data_tcm109-408602.pdf	Guide/ toolbox	2. Support strategic outlook development	2. Stimulate existing and new policy initatives that inform SME managers/owners about the potential of BIC technologies and encourage innovation (e.g. programmes, campaigns, events)
35	Best Practices for Statistical Data Analysis	http://data.library.virginia.edu/statlab/best-practices-for-statistical-data-analysis/	Guide/ toolbox	4. Tailor education and training offers	4. Integrate BIC modules in non-tech curricula, even offer it for free, to increase potential talent pool
36	Training material open data	https://www.europeandataportal.eu/en/	Guide/ toolbox	4. Tailor education and training offers	4. Integrate BIC modules in non-tech curricula, even offer it for

Good practices - various skills initiatives			Typology	Most relevant stream of roadmap	Most relevant sub-goal of that stream
		resources/more-training-materials			free, to increase potential talent pool
37	E-Book Big Data	http://kvk.instantmagazine.com/e-zines-kvk/big-data	Guide /toolbox	2. Support strategic outlook development	2. Stimulate existing and new policy initatives that inform SME managers/owners about the potential of BIC technologies and encourage innovation (e.g. programmes, campaigns, events)
38	Digital Journey Tracker	https://www.sirris.be/digitaljourneytracker	Guide/ toolbox	2. Support strategic outlook development	2. Stimulate existing and new policy initatives that inform SME managers/owners about the potential of BIC technologies and encourage innovation (e.g. programmes, campaigns, events)
39	Informationspool	https://www.allianz-fuer-cybersicherheit.de/ACS/DE/Informationspool/_function/Informationspool_Formular.html?nn=9960654	Guide /toolbox	2. Support strategic outlook development	2. Stimulate existing and new policy initatives that inform SME managers/owners about the potential of BIC technologies and encourage innovation (e.g. programmes, campaigns, events)
40	Konsolidierte Gefährdungsmatrix mit Risikobewertung 2016	https://www.allianz-fuer-cybersicherheit.de/ACS/DE/_/partner/Partnerbeitrag_ISPs_Gefaehrdungsmatrix_2016.pdf?__blob=publicationFile&v=4	Guide/ toolbox	2. Support strategic outlook development	2. Stimulate existing and new policy initatives that inform SME managers/owners about the potential of BIC technologies and encourage innovation (e.g. programmes, campaigns, events)
41	Cloud Security Guide for SMEs	https://www.enisa.europa.eu/publications/cloud-security-guide-for-smes	Guide/ toolbox	2. Support strategic outlook development	2. Stimulate existing and new policy initatives that inform SME managers/owners about the potential of BIC technologies and encourage innovation (e.g. programmes, campaigns, events)
42	SME Guide for the Implementation of ISO/IEC 27001 on Information Security Management	https://www.digitalsme.eu/digital/uploads/SME-Guide-for-the-implementation-of-ISOIEC-27001-on-information-security-management.pdf	Guide/ toolbox	2. Support strategic outlook development	2. Stimulate existing and new policy initatives that inform SME managers/owners about the potential of BIC technologies and encourage innovation (e.g. programmes, campaigns, events)
43	Bescherm je bedrijf tegen cybercrime!	https://veiliginternetten.nl/bescherm-je-bedrijf-tegen-cybercrime/	Guide/ toolbox	2. Support strategic outlook development	2. Stimulate existing and new policy initatives that inform SME managers/owners about the potential of BIC technologies and encourage innovation (e.g. programmes, campaigns, events)
44	Digitale fraude: preventie door mkb kan beter	https://www.kvk.nl/download/Infographic%20Preventie%20door%20het%20mkb%20tegen%20digitale%20fraude%20definitief_tcm109-449038.pdf	Guide/ toolbox	2. Support strategic outlook development	2. Stimulate existing and new policy initatives that inform SME managers/owners about the potential of BIC technologies and encourage innovation (e.g. programmes, campaigns, events)
45	De 5 basisprincipes van veilig digitaal ondernemen	https://www.digitaltrustcenter.nl/de-5-basisprincipes-van-veilig-digitaal-ondernemen	Guide/ toolbox	2. Support strategic outlook development	2. Stimulate existing and new policy initatives that inform SME managers/owners about the potential of BIC technologies and encourage innovation (e.g. programmes, campaigns, events)

Good practices - various skills initiatives			Typology	Most relevant stream of roadmap	Most relevant sub-goal of that stream
46	Cyber Resilience Lab	https://cyreslab.org/	Training program	4. Tailor education and training offers	4. Stimulate development of practical cybersecurity training programmes (eg in VET), SMEs' needs based, using labs
47	Privacy in Technology: Standards and Practices for Engineers and Security and IT	https://my.iapp.org/NC__Product?id=a191a000000QL2eAAG	Guide/ toolbox	2. Support strategic outlook development	2. Stimulate existing and new policy initatives that inform SME managers/owners about the potential of BIC technologies and encourage innovation (e.g. programmes, campaigns, events)
48	Privacy Program Management	https://iapp.org/resources/article/privacy-program-management/	Guide/ toolbox	2. Support strategic outlook development	2. Stimulate existing and new policy initatives that inform SME managers/owners about the potential of BIC technologies and encourage innovation (e.g. programmes, campaigns, events)
49	Practitioner's toolkit for PES Building Career Guidance and Lifelong Learning	http://ec.europa.eu/social/main.jsp?langId=en&catId=89&newsId=9060&furtherNews=yes	Guide /toolbox	3. Strengthen structured skills development	3. Promote blueprints, practical frameworks and tools that support SMEs to build a smart (HR) strategy (incl. tools to support recruitment, hiring, dvlpment)
50	Publicatie Internet of Things	https://www.kvk.nl/download/KvK%20IoT%20Publicatie_tcm109-399524.pdf	Guide /toolbox	2. Support strategic outlook development	2. Stimulate existing and new policy initatives that inform SME managers/owners about the potential of BIC technologies and encourage innovation (e.g. programmes, campaigns, events)
51	Internet of Things: kansrichtingen	https://www.kvk.nl/download/KvK%20Internet%20of%20Things%20-%20A3%20werkbladen_tcm109-399525.pdf	Guide /toolbox	2. Support strategic outlook development	2. Stimulate existing and new policy initatives that inform SME managers/owners about the potential of BIC technologies and encourage innovation (e.g. programmes, campaigns, events)
52	Businesskansen met IoT	https://kvk.instantmagazine.com/e-zines-kvk/internet-of-things#	Guide/ toolbox	2. Support strategic outlook development	2. Stimulate existing and new policy initatives that inform SME managers/owners about the potential of BIC technologies and encourage innovation (e.g. programmes, campaigns, events)
53	Business is Great Britain	http://www.greatbusiness.gov.uk/domoreonline/	Guide/to olbox	2. Support strategic outlook development	2. Stimulate existing and new policy initatives that inform SME managers/owners about the potential of BIC technologies and encourage innovation (e.g. programmes, campaigns, events)
54	Cloud Watch HUB	http://www.cloudwatchhub.eu/SMEs	Guide/to olbox	1. Strengthening ecosystems	1. Created shared databases and tools to make information accessible to stakeholders
		_			
Massive Open Online Courses (MOOCs)		_	**Typology**	**Most relevant stream of roadmap**	**Most relevant sub-goal of that stream**
1	Udacity & Google Developer Scholarships Challenge in the EU	https://blog.udacity.com/2017/09/announcing-60000-challenge-scholarships-udacity-google.html	MOOC	2. Support strategic outlook development	2. Support organisations, initiatives and platforms tht foster collaboration and knowledge sharing amongcompany managers/owners for adoption of BIC technologies and new business models (e.g. business clubs/associations/clusters, buddy support schemes, training programs for a group of company managers)

Good practices - various skills initiatives			Typology	Most relevant stream of roadmap	Most relevant sub-goal of that stream
2	Skillman	http://learn.skillman.eu	MOOC	1. Strengthening ecosystems	1. Created shared databases and tools to make information accessible to stakeholders
3	Analytics Academy (Google)	https://analytics.google.com/analytics/academy/	MOOC	4. Tailor education and training offers	4. Integrate BIC modules in non-tech curricula, even offer it for free, to increase potential talent pool
4	Google Growth Engine for Europe	https://grow.google/intl/europe	MOOC	2. Support strategic outlook development	2. Support organisations, initiatives and platforms tht foster collaboration and knowledge sharing amongcompany managers/owners for adoption of BIC technologies and new business models (e.g. business clubs/associations/clusters, buddy support schemes, training programs for a group of company managers)
5	Cybersecurity for Small Businesses	https://www.sba.gov/course/cybersecurity-small-businesses/	MOOC	4. Tailor education and training offers	4. Stimulate development of practical cybersecurity training programmes (eg in VET), SMEs' needs based, using labs
6	Incibe	https://translate.google.com/translate?hl=nl&sl=es&u=https://www.incibe.es/formacion/ciberseguridad-para-micropymes-y-autonomos&prev=search	MOOC	4. Tailor education and training offers	4. Stimulate development of practical cybersecurity training programmes (eg in VET), SMEs' needs based, using labs
7	Google Digital Garage	https://learndigital.withgoogle.com/digitalewerkplaats	MOOC	1. Strengthening ecosystems	1. Created shared databases and tools to make information accessible to stakeholders
8	Studyportals	https://www.shortcoursesportal.com/search/#q=di-282|lv-short|tc-EUR&start=0&order=relevance	MOOC	1. Strengthening ecosystems	1. Created shared databases and tools to make information accessible to stakeholders
9	LoRa Academy	https://lora-developers.semtech.com/resources/lora wan-academy/	MOOC	4. Tailor education and training offers	4. Promote existing blueprints for training for SMEs
10	Aan de slag met big data. Denk groot, start klein	http://bigdata.movietrader.tv/clipcard2/bigdatamooc?hd=true	MOOC	4. Tailor education and training offers	4. Integrate BIC modules in non-tech curricula, even offer it for free, to increase potential talent pool
11	Microsoft Introduction to Big Data	https://www.edx.org/course/microsoft-professional-program-big-data-microsoft-dat229x	MOOC	4. Tailor education and training offers	4. Integrate BIC modules in non-tech curricula, even offer it for free, to increase potential talent pool
12	Big Data Capstone Project	https://www.edx.org/course/big-data-capstone-project-adelaidex-datacapx	MOOC	4. Tailor education and training offers	4. Integrate BIC modules in non-tech curricula, even offer it for free, to increase potential talent pool
13	Big Data Fundamentals	https://www.edx.org/course/big-data-fundamentals-adelaidex-bigdatax	MOOC	4. Tailor education and training offers	4. Integrate BIC modules in non-tech curricula, even offer it for free, to increase potential talent pool
14	Microsoft Professional	https://www.edx.org/course/microsoft-professional-	MOOC	4. Tailor education and training offers	4. Integrate BIC modules in non-tech curricula, even offer it for

Good practices - various skills initiatives			Typology	Most relevant stream of roadmap	Most relevant sub-goal of that stream
	Capstone: Big Data	capstone-big-data-microsoft-dat230x-0			free, to increase potential talent pool
15	Knowledge Management and Big Data in Business	https://www.edx.org/course/knowledge-management-big-data-business-hkpolyux-ise101x-3	MOOC	4. Tailor education and training offers	4. Integrate BIC modules in non-tech curricula, even offer it for free, to increase potential talent pool
16	Big Data Analytics Using Spark	https://www.edx.org/course/big-data-analytics-using-spark-uc-san-diegox-dse230x	MOOC	4. Tailor education and training offers	4. Integrate BIC modules in non-tech curricula, even offer it for free, to increase potential talent pool
17	Big Data Analytics	https://www.edx.org/course/big-data-analytics-adelaidex-analyticsx	MOOC	4. Tailor education and training offers	4. Integrate BIC modules in non-tech curricula, even offer it for free, to increase potential talent pool
18	SLQ Tutorial	https://www.w3schools.com/sql/default.asp	MOOC	4. Tailor education and training offers	4. Integrate BIC modules in non-tech curricula, even offer it for free, to increase potential talent pool
19	Analytics Decision Making	https://www.edx.org/course/analytics-decision-making-babsonx-bpet-statx-0	MOOC	4. Tailor education and training offers	4. Integrate BIC modules in non-tech curricula, even offer it for free, to increase potential talent pool
20	Introduction to Data Analytics for Managers	https://www.edx.org/course/introduction-data-analytics-managers-michiganx-ds120x	MOOC	4. Tailor education and training offers	4. Integrate BIC modules in non-tech curricula, even offer it for free, to increase potential talent pool
21	Introduction to Data Analysis	https://eu.udacity.com/course/intro-to-data-analysis--ud170	MOOC	4. Tailor education and training offers	4. Integrate BIC modules in non-tech curricula, even offer it for free, to increase potential talent pool
22	Intro to Data Science	https://eu.udacity.com/course/intro-to-data-science--ud359	MOOC	4. Tailor education and training offers	4. Integrate BIC modules in non-tech curricula, even offer it for free, to increase potential talent pool
23	A/B Testing by Google	https://eu.udacity.com/course/ab-testing--ud257	MOOC	4. Tailor education and training offers	4. Integrate BIC modules in non-tech curricula, even offer it for free, to increase potential talent pool
24	Emerging Technologies: from Smartphones to IoT to Big Data Specialization	https://www.coursera.org/specializations/emerging-technologies	MOOC	4. Tailor education and training offers	4. Integrate BIC modules in non-tech curricula, even offer it for free, to increase potential talent pool
25	MicroMasters Big Data	https://www.edx.org/micromasters/big-data	MOOC	4. Tailor education and training offers	4. Integrate BIC modules in non-tech curricula, even offer it for free, to increase potential talent pool
26	Data Warehousing for Business Intelligence Specialization	https://www.coursera.org/specializations/data-warehousing	MOOC	4. Tailor education and training offers	4. Integrate BIC modules in non-tech curricula, even offer it for free, to increase potential talent pool
27	Learn Python	https://www.codecademy.com/learn/learn-python	MOOC	4. Tailor education and training offers	4. Integrate BIC modules in non-tech curricula, even offer it for free, to increase potential talent pool

Good practices - various skills initiatives			Typology	Most relevant stream of roadmap	Most relevant sub-goal of that stream
28	Exploratory Data Analysis	https://www.coursera.org/learn/exploratory-data-analysis	MOOC	4. Tailor education and training offers	4. Integrate BIC modules in non-tech curricula, even offer it for free, to increase potential talent pool
29	Visualize Business Data with Tableau	https://www.coursera.org/specializations/data-visualization	MOOC	4. Tailor education and training offers	4. Integrate BIC modules in non-tech curricula, even offer it for free, to increase potential talent pool
30	Data Visualization	https://www.coursera.org/learn/datavisualization	MOOC	4. Tailor education and training offers	4. Integrate BIC modules in non-tech curricula, even offer it for free, to increase potential talent pool
31	Data Science for Executives	https://www.edx.org/professional-certificate/data-science-executives	MOOC	4. Tailor education and training offers	4. Integrate BIC modules in non-tech curricula, even offer it for free, to increase potential talent pool
32	Data Science Specialization	https://www.coursera.org/specializations/jhu-data-science	MOOC	4. Tailor education and training offers	4. Integrate BIC modules in non-tech curricula, even offer it for free, to increase potential talent pool
33	Applied Data Science Specialization	https://www.coursera.org/specializations/applied-data-science	MOOC	4. Tailor education and training offers	4. Integrate BIC modules in non-tech curricula, even offer it for free, to increase potential talent pool
34	Become a Data Analyst	https://eu.udacity.com/course/data-analyst-nanodegree--nd002	MOOC	4. Tailor education and training offers	4. Integrate BIC modules in non-tech curricula, even offer it for free, to increase potential talent pool
35	Predictive Analytics for Business	https://eu.udacity.com/course/predictive-analytics-for-business-nanodegree--nd008	MOOC	4. Tailor education and training offers	4. Integrate BIC modules in non-tech curricula, even offer it for free, to increase potential talent pool
36	Cybersecurity Fundamentals	https://www.edx.org/course/cybersecurity-fundamentals-ritx-cyber501x-1	MOOC	4. Tailor education and training offers	4. Stimulate development of practical cybersecurity training programmes (eg in VET), SMEs' needs based, using labs
37	Information Security Management	http://www.ecfalliance-training.org/course/index.php?categoryid=5&lang=nl	MOOC	4. Tailor education and training offers	4. Stimulate development of practical cybersecurity training programmes (eg in VET), SMEs' needs based, using labs
38	Cybersecurity Risk Management	https://www.edx.org/course/cybersecurity-risk-management-ritx-cyber503x	MOOC	4. Tailor education and training offers	4. Stimulate development of practical cybersecurity training programmes (eg in VET), SMEs' needs based, using labs
39	Cybersecurity Capstone	https://www.edx.org/course/rit-cybersecurity-capstone	MOOC	4. Tailor education and training offers	4. Stimulate development of practical cybersecurity training programmes (eg in VET), SMEs' needs based, using labs
40	Introduction to Cybersecurity	https://www.edx.org/course/introduction-cybersecurity-uwashingtonx-cyb001x	MOOC	4. Tailor education and training offers	4. Stimulate development of practical cybersecurity training programmes (eg in VET), SMEs' needs based, using labs
41	Cybersecurity Basics – a Hands-on Approach	https://www.edx.org/course/cyber-security-basics-a-hands-on-approach	MOOC	4. Tailor education and training offers	4. Stimulate development of practical cybersecurity training programmes (eg in VET), SMEs' needs based, using labs
42	Building a Cybersecurity Toolkit	https://www.edx.org/course/building-cybersecurity-	MOOC	4. Tailor education and training offers	4. Stimulate development of practical cybersecurity training

Good practices - various skills initiatives			Typology	Most relevant stream of roadmap	Most relevant sub-goal of that stream
		toolkit-uwashingtonx-cyb003x			programmes (eg in VET), SMEs' needs based, using labs
43	Introduction to Cybersecurity	https://www.futurelearn.com/courses/introduction-to-cyber-security/9	MOOC	4. Tailor education and training offers	4. Stimulate development of practical cybersecurity training programmes (eg in VET), SMEs' needs based, using labs
44	Ciberseguridad para micropymes y autónomos	https://www.incibe.es/formacion/ciberseguridad-para-micropymes-y-autonomos	MOOC	4. Tailor education and training offers	4. Stimulate development of practical cybersecurity training programmes (eg in VET), SMEs' needs based, using labs
45	Cybersecurity	http://scholarship-positions.com/open-university-free-online-course-on-cyber-security/2015/08/05/	MOOC	4. Tailor education and training offers	4. Stimulate development of practical cybersecurity training programmes (eg in VET), SMEs' needs based, using labs
46	Cybersecurity and its Ten Domains	https://www.coursera.org/learn/cyber-security-domain	MOOC	4. Tailor education and training offers	4. Stimulate development of practical cybersecurity training programmes (eg in VET), SMEs' needs based, using labs
47	Cybersecurity Specialization	https://www.coursera.org/specializations/cyber-security	MOOC	4. Tailor education and training offers	4. Stimulate development of practical cybersecurity training programmes (eg in VET), SMEs' needs based, using labs
48	Essentials of Cybersecurity	https://www.edx.org/professional-certificate/uwashingtonx-essentials-cybersecurity	MOOC	4. Tailor education and training offers	4. Stimulate development of practical cybersecurity training programmes (eg in VET), SMEs' needs based, using labs
49	The Business of Cybersecurity Capstone	https://www.coursera.org/learn/business-of-cybersecurity-capstone	MOOC	4. Tailor education and training offers	4. Stimulate development of practical cybersecurity training programmes (eg in VET), SMEs' needs based, using labs
50	MicroMasters Cybersecurity	https://www.edx.org/micromasters/ritx-cybersecurity	MOOC	4. Tailor education and training offers	4. Stimulate development of practical cybersecurity training programmes (eg in VET), SMEs' needs based, using labs
51	Cybersecurity Developing Program for your Business Specialization	https://www.coursera.org/specializations/cybersecurity-developing-program-for-business	MOOC	4. Tailor education and training offers	4. Stimulate development of practical cybersecurity training programmes (eg in VET), SMEs' needs based, using labs
52	Cybersecurity Mobility	https://www.coursera.org/learn/cybersecurity-mobility#	MOOC	4. Tailor education and training offers	4. Stimulate development of practical cybersecurity training programmes (eg in VET), SMEs' needs based, using labs
53	Network Security	http://online.stanford.edu/course/network-security	MOOC	4. Tailor education and training offers	4. Stimulate development of practical cybersecurity training programmes (eg in VET), SMEs' needs based, using labs
54	Network Forensics Training	https://www.enisa.europa.eu/topics/trainings-for-cybersecurity-specialists/online-training-material/technical-operational#building	MOOC	4. Tailor education and training offers	4. Integrate BIC modules in non-tech curricula, even offer it for free, to increase potential talent pool

Good practices - various skills initiatives			Typology	Most relevant stream of roadmap	Most relevant sub-goal of that stream
55	Enabling Technologies for Data Science and Analytics: The Internet of Things	https://www.edx.org/course/enabling-technologies-data-science-columbiax-ds103x-1	MOOC	4. Tailor education and training offers	4. Integrate BIC modules in non-tech curricula, even offer it for free, to increase potential talent pool
56	Getting Started with the Internet of Things	https://www.edx.org/course/getting-started-with-the-internet-of-things-iot-4	MOOC	4. Tailor education and training offers	4. Integrate BIC modules in non-tech curricula, even offer it for free, to increase potential talent pool
57	The Internet of Things	https://www.class-central.com/course/futurelearn-the-internet-of-things-3820	MOOC	4. Tailor education and training offers	4. Integrate BIC modules in non-tech curricula, even offer it for free, to increase potential talent pool
58	Developing IoT Solutions with Azure IoT	https://www.edx.org/course/developing-iot-solutions-azure-iot-microsoft-dev225x-0	MOOC	4. Tailor education and training offers	4. Integrate BIC modules in non-tech curricula, even offer it for free, to increase potential talent pool
59	Fog Networks and the Internet of Things	https://www.class-central.com/mooc/2731/coursera-fog-networks-and-the-internet-of-things	MOOC	4. Tailor education and training offers	4. Integrate BIC modules in non-tech curricula, even offer it for free, to increase potential talent pool
60	Internet of Things: Roadmap to a Connected World	https://mitxpro.mit.edu/courses/course-v1:MITProfessionalX+IOTx+2016_T2/about	MOOC	4. Tailor education and training offers	4. Integrate BIC modules in non-tech curricula, even offer it for free, to increase potential talent pool
61	Internet of Things Specialization	https://www.coursera.org/specializations/internet-of-things	MOOC	4. Tailor education and training offers	4. Integrate BIC modules in non-tech curricula, even offer it for free, to increase potential talent pool
62	A Developer's Guide to the Internet of Things	https://www.mooc-list.com/course/developers-guide-internet-things-iot-coursera	MOOC	4. Tailor education and training offers	4. Integrate BIC modules in non-tech curricula, even offer it for free, to increase potential talent pool
63	An Introduction to Programming for the Internet of Things	https://www.coursera.org/specializations/iot	MOOC	4. Tailor education and training offers	4. Integrate BIC modules in non-tech curricula, even offer it for free, to increase potential talent pool
64	Software Architecture for the Internet of Things	https://www.coursera.org/learn/iot-software-architecture	MOOC	4. Tailor education and training offers	4. Integrate BIC modules in non-tech curricula, even offer it for free, to increase potential talent pool
65	Embedded Hardware and Operating Systems	https://www.coursera.org/learn/embedded-operating-system	MOOC	4. Tailor education and training offers	4. Integrate BIC modules in non-tech curricula, even offer it for free, to increase potential talent pool
66	Wireless Communities Emerging Technologies	https://www.coursera.org/learn/wireless-communication-technologies	MOOC	4. Tailor education and training offers	4. Integrate BIC modules in non-tech curricula, even offer it for free, to increase potential talent pool
67	Cybersecurity and the Internet of Things	https://www.coursera.org/learn/iot-cyber-security	MOOC	4. Tailor education and training offers	4. Integrate BIC modules in non-tech curricula, even offer it for free, to increase potential talent pool
68	Digital Business Academy	https://digitalbusinessacademy.technation.io/	MOOC	4. Tailor education and training offers	4. Integrate BIC modules in non-tech curricula, even offer it for free, to increase potential talent pool

APPENDIX D: DETAILED ASSESSMENT OF THE EMPIRICA APPROACH

The table below summarizes the Empirica framework for e-Skills focused on ICT, the type of indicators collected and the considerations in light of our proposed monitoring mechanism.

Assigned macr0-area	Indicator collected Empirica/IDC	Considerations in comparison with the proposed monitoring mechanisms for ICT	Extendibility to IoT, Big Data, and Cybersecurity	Actions/suggestions
SUPPLY				
Labour	ICT HE graduates	**Data source** not mentioned. **Corresponding indicators in the proposed monitoring framework**: Enrolment by field % and Graduates by field %	New data to be collected	Same angle approached by our framework
Training	ICT vocational training graduates	**Corresponding indicators in the proposed monitoring framework**: Main skills targeted by CVT courses (% enterprises)	New data to be collected	Same angle approached by our framework
Labour	STEM (science, technology, engineering, mathematics) entries	**Corresponding indicators in the proposed monitoring framework**: Not considered in our framework.	Too broad to be adapted to the three areas.	Could be included for ICT
Labour (internal mobility)	Lateral entries	**Data source**: not available; assumed estimated. **Missing information** on lateral entry definition specification: i.e. Does it cover passing from a non-ICT department to an ICT department? **Corresponding indicators in the proposed monitoring framework**: Not considered in our framework. Time-dynamic indicator	Depending on data source. Expected novel work to be done for data collection.	Interesting indicator about internal mobility, relevant for SMEs, however, novel work to be done for data collection.
Labour	Category change	**Data source**: not available. **Missing information** on definition specification with reference to "category". **Corresponding indicators in the proposed monitoring framework**: Not	More information is needed to assess. Expected novel work to be done for data collection.	Interesting indicator, however, novel work to be done for data collection.

Assigned macr0-area	Indicator collected Empirica/IDC	Considerations in comparison with the proposed monitoring mechanisms for ICT	Extendibility to IoT, Big Data, and Cybersecurity	Actions/suggestions
		considered in our framework. Time-dynamic indicator		
Labour	Business management entries	**Corresponding indicators in the proposed monitoring framework**: Not considered in our framework. Time-dynamic indicator	More information is needed to assess.	
Labour (Cross-border trade in employment)	Emi-immigration	More relevant in a time dynamic growth model. In a static model, relevant indicator can be the **OECD indicators on Trade in Employment (TiM)** – e.g. Domestic Employment embodied in foreign final demand (by partner) , distinguishing by Source Industry. The relevant sector is SIC code C72 Computer and Related activities.	Data aggregation does not allow extension to the three areas.	OECD indicators on Trade in Employment (TiM) could be explored (missing data, country coverage) for ICT. It provides a supply indicator of labour in an international dimension.
DEMAND				
Labour	Vacancies	**Data source**: not available. **Corresponding indicators in the proposed monitoring framework:** we do not consider vacancies. We consider "Recruitment of ICT specialists", "planned investments in ICT" and "trade in ICT services".	Adaptable, depending on the data collection method (for example through web-scraping)	Possible to look at vacancies, however not sure if the two indicators would differ significantly. Novel work needs to be done for data collection.
Labour	Jobs	**Data source**: not available.	Adaptable, depending on the data collection method (for example through web-scraping)	NA

Table 7 Detailed review of ISCO codes for ICT, Big Data, IoT and Cybersecurity workforce definition

E-Skills - ICT definition and applicability to Big Data, IoT and Cybersecurity

Another relevant element that we have reviewed in the scope of e-Skills Empirica framework is the definition of ICT Specialists and ICT Profession based on ISCO codes, in view of assessing the possibility to extend those categories to Big Data, IoT and Cybersecurity to create relevant indicators on employment.

Empirica refers to ICT specialist and ICT profession workforce of the **ILO International Standard Classification of Occupations 2008 (ISCO-08).** ICT is one of the 'thematic views' (or focuses) of ISCO-08, together with and among others Agriculture, Health and Tourism. ISCO-08 thus contains an expansion and update of the categories for these occupations.

We reviewed **both ILO ICT thematic view** and the slightly adapted Empirica ICT specialist workforce definition in view of assessing its degree of replicability within the monitoring mechanism proposed and more specifically, the relevance of the workforce types for both ICT and the three areas (IoT, Cybersecurity and Big Data).

Looking at the professional categories proposed by our study, thus i) Managers, ii) Professionals and iii) Advanced Users, the ILO ISCO categories cover 'Professionals' and 'Technicians and Associates', plus a number of additional relevant codes (i.e. codes in ISCO 7 and ISCO 1). Empirica takes a step further to include the Manager (ISCO 1) category and to suggest some adaptations among which the category Mechanics and Servicers.

As ILO ISCO codes are broadly used as reference (also by the EU Skills Panorama for example), we propose the following workforce types for ICT for this study, compatible with the ILO ISCO proposed classification and the Empirica one:

1. **ILO ISCO categories 'ICT thematic view'**	2. **Empirica ICT workforce definition categories**	3. **Proposed final categories**
4. **Professionals**	5. Manager	6. Manager
7. **Technicians and Associates**	8. Professionals	9. Professionals
10.	11. Technicians/Associates	12. Technicians/Associates
13.	14. Mechanics and Servicers	15. Advanced Users (includes Mechanics and Services)

Table 8 Review of ISCO ICT codes, Empirica approach and proposed professionals (workforce) definition

In terms of the adaptability of ILO ISCO codes to IoT, Cybersecurity and Big Data, the ICT codes are not directly usable, and further analysis, considerations and assumptions should be made in view of exploring their use.

ILO ISCO codes are the best reference available in terms of workforce topologies details. To use ISCO codes would create a solid base for further monitoring and for replicability.

From a conceptual and technological point of view, additional workforce type codes should be considered on top of the ones used for ICTs, as the applications of these three areas are broader than ICT only. Following ILO ISCO codes, these could be, for example, 2149 Engineer profession not elsewhere specified, 4-digit codes from 8 Plant and Machine Operators and Assemblers, 216 Architects, planners, surveyors and designers, etc.

Different degrees of relevance can be assumed for each code depending on the specific area, thus, a matrix of weights (or any other alternative that allows to assess the codes relevance) should be created to select the relevant codes, for each area.

Raw data from ILO would be needed to assess to what degree one could go further down in typologies granularity. ILO uses a coding system that assigns words to specific codes when collecting data through the survey to create 4-digit ISCO codes. In its report on the status of implementation of ISCO (2015), the ILO mentions that "There may, for example, be a need to determine whether an increasing number of jobs in ICT referred to as "architects" (enterprise architect, solutions architect, software architect, network architect, systems architect ...) are adequately covered by the existing unit groups or reflect new or emerging occupations. Similarly, there may be a need to determine whether new social media occupations are emerging at the boundary between ICT and

the world of marketing and advertising (search engine optimization (SEO) specialist, SEO strategist, online community manager) or whether these are specializations of existing occupations"[335]. The extension of the codes to new types of occupations, as well as a further code update for the ICT occupations, is thus hypothetically possible, however, it would require aligning with the ILO.

In absence of raw ILO sources, we summarize below a proposed workforce types list, following ILO ISCO codes and Empirica.

ICT, Big Data, IoT and Cybersecurity workforce		ISCO-08 code	
Managers (1)	ICT service managers	**1330**	
Professionals	Systems analysts	2511	
	Core ICT practitioners - professional level		
	Software developers	2512	
	Web and multimedia developers	2513	
	Applications programmers	2514	
	Software and applications developers and analysts n.e.c.	2519	
	Database designers and administrators	2521	
	Systems administrators	2522	
	Computer network professionals	2523	
	Database and network professionals n.e.c.	2529	
	Other ICT practitioners - professional level		
	Electronics engineers	2152	
	Telecommunications engineers	2153	
	Graphics and Multimedia Designers	2166	
	Information technology trainers	2356	
	ICT sales professionals	2434	
Technicians and Associates	**Core ICT practitioners - associate/technician level**		
	ICT operations technicians	3511	
	ICT user support technicians	3512	
	Computer network and systems technicians	3513	
	Web technicians	3514	
	Other ICT practitioners - associate/technician level		
	Electronics engineering technicians	3114	
	Broadcasting and audio-visual technicians	3521	
	Telecommunications engineering technicians	3522	
Advanced users			
Craft and related trade workers (1)	**Mechanics and servicers**		
	Electronics mechanics and servicers	7421	
	ICT installers and servicers	7422	
Other advanced users	*(Considered as users also when they are indicated under Professional activities by the specific code)*		

Table 9 Detailed review of ISCO codes for ICT, Big Data, IoT and Cybersecurity workforce definition

Source: authors' elaboration based on ILO ISCO codes and Empirica
Notes:
(1) Empirica definition

[335] Hunter, D. (ILO) (2015), The status of implementation and plans for future revision of the International Standard Classification of Occupations, 2008 (ISCO-08), ESA/STAT/AC.289/34
https://unstats.un.org/unsd/classifications/expertgroup/egm2015/ac289-34.PDF

APPENDIX E: DETAILED DESCRIPTION OF GOOD RACTICES

Good practices further detailed below:

- Skillnet Ireland by the government of Ireland
- Cybersecurity Skills Initiative (CSI) by an Irish nationwide public-private coalition
- SME Datalab by Jheronimus Academy of Data Science (JADS)
- PROMPT by RISE Research Institutes of Sweden
- Cyber Resilience Centre by Brainport Eindhoven region
- ASTER by Emilia-Romagna region
- Recognising skills in data science by the Big Data Value Association (BDVA)
- Community knowledge platform by VOICE (association of IT-using SMEs)
- SMESEC by the SMESEC consortium for the European Commission
- Make_SME_Digital (Blueprint skills training SMEs) by consortium for the European Commission
- Mittelstand 4.0 Centres of Excellence by the Federal Ministry for Economic Affairs and Energy Germany
- Les Digiteurs by CCI Paris Ile-de France
- SEnDIng by the University of Patras for the European Commission
- Modern Enterprises Programme by the Hungarian Chamber of Commerce
- Innovation vouchers by Business Finland
- Cybersecurity support rangers by The Ministry of Economy, Trade and Industry Japan
- Cyber NYC by the New York City
- Skillsfuture initiative by Singapore government

Name good practice	Skillnet Ireland
Responsible organisation(s)	Business support agency of the Government of Ireland
Duration (start/end)	Since 2013
Funding	Public (by the Minister for Education and Skills)
Budget	Total investment of €36.27m (€17.7 (Skillnet Ireland funding) + €18.57m (Enterprise contributions)
Targeted skills	A range of Skillnet Ireland funded programmes that deliver a wide range of skills
Objectives of the initiative	• Advance the competitiveness, productivity and innovation of Irish businesses through enterprise-led workforce development • Facilitate increased participation in enterprise training and workforce learning in Ireland.
Concise description	Skillnet Ireland is a business support agency of the Government of Ireland. It focuses on funding support, promoting of upskilling, business networking, career development, developing future skills and policy. A Skillnet Network is a collection of private-sector businesses that collaborate to address skills needs within their sector or region. There are:

Name good practice	Skillnet Ireland
	• Single Sector Networks: these Skillnet Networks work with businesses in specific sectors, developing bespoke solutions to meet existing and emerging skills needs within those sectors. • Multi Sector Networks: These Skillnet Networks work with businesses in specific regions, developing bespoke solutions to meet existing and emerging skills needs within specific regions. The 65+ Skillnet Learning Networks assist businesses, small and large, to identify the skills needed to develop their businesses and to support their teams. The Skillnet model has particular appeal for SMEs as the cost of training is subsided by Skillnet Ireland. In addition, the design, sourcing and delivery of training is all coordinated by the Skillnet Network itself, enabling easy access to training but also moving much of the administrative burden away from the firm.
Results	68 Networks. Support over 16.000 business nationwide and provide a wide range of valuable learning experiences to over 55.000 trainees. 441.846 total training days, 56.182 total people trained
Rationale for selection	The initiative shows a successful approach that contributes to: • Strengthening ecosystems: • Strategic outlook development: • Structured skills development: • Tailoring training to SME's needs
Lessons learned for roadmap and/or scaling up	
Website(s) initiative	https://www.skillnetireland.ie/about/funding-for-upskilling/

Name good practice	Cybersecurity Skills Initiative (CSI) Ireland
Responsible organisation(s)	A national public-private coalition lead by Technology Ireland ICT Skillnet and Skillnet Ireland
Duration (start/end)	2018
Funding	Public-private
Budget	Unknown
Targeted skills	Cyber security skills
Objectives of the initiative	The programme has a clear structure to achieve success (the 'road to excellence') which builds on five objectives: • Cybersecurity Skills Pathways, • Organic growth (broaden the skills base by fostering internal mobility), • Cybersecurity is a Business issue not just an IT issue • New Entrants (attract and retain young people), • Continuous professional development (CPD).
Concise description	The Cybersecurity Skills Initiative (CSI) is a direct response to the most consistent need of companies across all sectors and of all sizes – how to adequately protect their business in the face of the escalating cyber threat.

Name good practice	Cybersecurity Skills Initiative (CSI) Ireland
	Central to this need is the growing shortage of skilled cybersecurity personnel to protect against and respond to security breaches. And this is happening at a time when unemployment is rapidly decreasing and the competition for the available technically skilled personnel is intense. The CSI contains a comprehensive plan to train 5,000 people in cybersecurity skills and help 4,000 companies to tackle the cybersecurity skills issue over the next three years. One interesting course is the Cyber Aptitude Test which facilitates career change into cybersecurity and has proven to tap into new supply of resources to fill the skills gap/tackle existing mismatch.
Results	
Rationale for selection	The initiative shows a successful approach that contributes to: • *Strengthening ecosystems:* • *Strategic outlook development:* • *Structured skills development:* • *Tailoring training to SME's needs*
Lessons learned for roadmap and/or scaling up	
Website(s) initiative	https://www.ictskillnet.ie/cyber-security-skills/, https://www.ictskillnet.ie/wp-content/uploads/2019/04/CSI-Brochure-2019.pdf

Name good practice	SME Datalab
Responsible organisation(s)	JADS
Duration (start/end)	6 till 10 weeks per project
Funding	Public-Private partnership
Budget	Day charge an additional fee of €2.500 for each project that they do, half of this budget goes to the student that did the job
Targeted skills	Big data
Objectives of the initiative	• Helping organizations to create value with data.
Concise description	JADS MKB Datalad helps organisation to create value with data. They do this by doing short term project with data scientists (that are still in college). In case the students get stuck, the experienced professionals or scientists will be there to help or guide them. JADS MKB Datalab mainly focusses on projects that can create cost reduction or revenue increase. In some cases, the client wants more than just one project, in cases like that, there will be multiple project to get to the required result.
Results	More than 70 companies (in different sizes and industries) are helped in with totally different issues
Rationale for selection	The initiative shows a successful approach that contributes to: • Strengthening ecosystems:

Name good practice	SME Datalab
	• Strategic outlook development: • Structured skills development: • Tailoring training to SME's needs
Lessons learned for roadmap and/or scaling up	
Website(s) initiative	https://jadsmkbdatalab.nl/about-us/

Name good practice	PROMPT
Responsible organisation(s)	RISE
Duration (start/end)	Unknown
Funding	Owned by Swedish State and work in collaboration with and on behalf of the private and public sectors and academia.
Budget	Unknown
Targeted skills	*Cybersecurity, big data & IoT skills*
Objectives of the initiative	• Products, technologies, processes and materials that contribute to a sustainable future and a competitive Swedish business community.
Concise description	RISE is Sweden's research institute and innovation partner. Through our international collaboration programmes with industry, academia and the public sector, we ensure the competitiveness of the Swedish business community on an international level and contribute to a sustainable society. Our 2,800 employees engage in and support all types of innovation processes. RISE is an independent, State-owned research institute, which offers unique expertise and over 100 testbeds and demonstration environments for future-proof technologies, products and services.
Results	Our turnover was approximately SEK 3 billion. Owner of and partner in 60% of Sweden's total test and demonstration environments
Rationale for selection	The initiative shows a successful approach that contributes to: • Strengthening ecosystems: • Strategic outlook development: • Structured skills development: • Tailoring training to SME's needs
Lessons learned for roadmap and/or scaling up	
Website(s) initiative	https://www.ri.se/en/better-future-and-those-who-take-us-there

Name good practice	Cyber resilience centre
Responsible organisation(s)	Brainport, Eindhoven region

Duration (start/end)	
Funding	Public-Private partnership
Budget	
Targeted skills	Cybersecurity
Objectives of the initiative	• Increase the resilience of high industries firms in the Netherlands against cyber attacks
Concise description	Achieve a higher cyber resilience by offering a trusted environment on participants where they share knowledge, information, and best practices with each other
Results	Unknown
Rationale for selection	The initiative shows a successful approach that contributes to: • Strengthening ecosystems: • Strategic outlook development: • Structured skills development: • Tailoring training to SME's needs
Lessons learned for roadmap and/or scaling up	
Website(s) initiative	https://cwbrainport.nl/

Name good practice	ASTER
Responsible organisation(s)	Emilia-Romagna
Duration (start/end)	Since 1985 ASTER has shaped and defined pathways and tools for innovation, industrial research, technology transfer and for the improvement of high-quality skills and careers on innovation
Funding	Public and private organisations
Budget	Unknown
Targeted skills	Big data
Objectives of the initiative	• Foster the region's sustainable growth by developing innovation and knowledge, attractiveness and internationalisation of the region...
Concise description	ASTER is the Consortium for innovation and technology transfer of the Emilia-Romagna region of Italy ASTER promotes industrial research as the main driver of sustainable economic development and collaborates with company associations to develop joint research and corporate strategies and actions, facilities and services for industrial research, and the enhancement of human capital working in these areas. ASTER manages the Emilia-Romagna High Technology Network, consisting of industrial research laboratories and Innovation Centres, providing research, expertise, tools and resources to business and to help drive innovation in companies

Name good practice	ASTER
Results	The High Technology Network currently involves: 82 laboratories, 14 Innovation Centres, 10 Technopoles
Rationale for selection	The initiative shows a successful approach that contributes to: • Strengthening ecosystems: • Strategic outlook development: • Structured skills development: • Tailoring training to SME's needs
Lessons learned for roadmap and/or scaling up	
Website(s) initiative	https://www.ub-cooperation.eu/pdf/cases/S_Case_Study_Aster.pdf

Name good practice	Recognising Skills in Data Science
Responsible organisation(s)	BDVA
Duration (start/end)	The BDV PPP was launched in 2014, but its operationalization has been especially pushed forward with the launch of the LEIT work programme 2016/2017 The objectives of the Association) are to boost European Big Data Value research, development and innovation and to foster a positive perception of Big Data Value.
Funding	Public
Budget	Unknown
Targeted skills	Big data
Objectives of the initiative	• Positioning Europe as the world leader in the creation of Big Data Value.
Concise description	The Big Data Value Association (BDVA) is an industry-driven international not–for-profit organisation with 200 members all over Europe and a well-balanced composition of large, small, and medium-sized industries as well as research and user organizations. BDVA is the private counterpart to the EU Commission to implement the Big Data Value PPP program. The mission of the BDVA is to develop the Innovation Ecosystem that will enable the data and AI-driven digital transformation in Europe delivering maximum economic and societal benefit, and, achieving and sustaining Europe's leadership on Big Data Value creation and Artificial Intelligence
Results	Unknown
Rationale for selection	The initiative shows a successful approach that contributes to: • Strengthening ecosystems: • Strategic outlook development: • Structured skills development: • Tailoring training to SME's needs
Lessons learned for roadmap and/or scaling up	
Website(s) initiative	

Name good practice	Recognising Skills in Data Science
Name good practice	VOICE Community Knowledge Platform
Responsible organisation(s)	The Federal Association
Duration (start/end)	The Federal Association emerged at the end of 2011 from the merger of the organizations CIOcolloquium and CIO-Circle. VOICE is organized as a registered association with headquarters in Berlin and offices in Cologne, Munich and Hamburg.
Funding	Public
Budget	Unknown
Targeted skills	Cybersecurity
Objectives of the initiative	• Further enhance the competitiveness of member companies through the use of digital technologies - with a targeted exchange on the top issues of digitization and by safeguarding the interests of user companies in national and European policies and in IT. provider shaft.
Concise description	Voice offers its clients a competent, attractive and dynamic platform. VOICE is today the largest representation of digital decision-makers on the user side in German-speaking countries. They represent a cross section of DAX, MDAX and medium-sized companies.
Results	
Rationale for selection	The initiative shows a successful approach that contributes to: • Strengthening ecosystems: • Strategic outlook development: • Structured skills development: • Tailoring training to SME's needs
Lessons learned for roadmap and/or scaling up	
Website(s) initiative	https://voice-ev.org/wissensplattform/

Name good practice	SMESEC
Responsible organisation(s)	Various org
Duration (start/end)	The SMESEC suite will be developed in 36 months by a strong consortium of 12 partners from 7 countries
Funding	The consortium is led by ATOS, with many years of experience in project management and cyber-security, and involves large companies, SMEs, research centers, and universities. While supported by research centers and universities, SMESEC is an industry-oriented project, where the private companies will cover more than 73% of the total project costs. This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 740787 (SMESEC)
Budget	
Targeted skills	Cybersecurity

Name good practice	SMESEC
Objectives of the initiative	• High-quality cybersecurity solutions attractive to SMEs with a restricted budget • Provide cybersecurity training and awareness for SMEs and all type of employees • Test and validate our solution with four initial use cases and have an open call when the solution is more mature • Ready to market solution
Concise description	SMESEC is a project proposed by an international group of experts as a response to the cyber-security challenges of SMEs with a limited background on cyber-security and a restricted budget
Results	
Rationale for selection	The initiative shows a successful approach that contributes to: • Strengthening ecosystems: • Strategic outlook development: • Structured skills development: • Tailoring training to SME's needs
Lessons learned for roadmap and/or scaling up	
Website(s) initiative	https://www.smesec.eu/about.html

Name good practice	Blueprint skills training SMEs
Responsible organisation(s)	Makes me digital consortium for the European Commission
Duration (start/end)	Designing a shared vision for skills development for SMEs on Big Data, Internet of Things and Cybersecurity for the coming years until 2023
Funding	Public
Budget	€ 400.000
Targeted skills	Cybersecurity, IoT and big data
Objectives of the initiative	• The main objective of this initiative is to research, identify, design, test and validate specific measures supporting specialised skills development related to Big Data, Internet of Things (IoT) and Cybersecurity for small and medium-sized enterprises in Europe • The aim of the project is to provide the European Commission with a structured programme for the training of SME employees and unemployed persons with digital skills that are required in the modern work place.
Concise description	The European Commission and EASME took the initiative to analyse and support SMEs' skills development for Big Data, Internet of Things and Cybersecurity. This initiative is managed by a consortium of Capgemini Consulting, Technopolis Group and the European DIGITALSME Alliance.
Results	Courses developed on full stack, data analytics, cybersecurity and digital marketing
Rationale for selection	The initiative shows a successful approach that contributes to: • Strengthening ecosystems: • Strategic outlook development: • Structured skills development: • Tailoring training to SME's needs
Lessons learned for roadmap and/or scaling up	
Website(s) initiative	https://makesmedigital.eu

Name good practice	Mittelstand 4.0
Responsible organisation(s)	Federal Ministry for Economic Affairs and Energy Germany
Duration (start/end)	2015 - ungoing
Funding	*Public*
Budget	Unknown
Targeted skills	*Cybersecurity, big data, IoT skills or combination*
Objectives of the initiative	• To raise awareness among SMEs about the technological and economic potential of digitialisation, including industrie 4.0 and about challenges involved • To support the development of needs-oriented, secure, and market-ready solutions for SMEs by providing opportunities to view and test these out in practice • To provide key information and knowledge for established transfer agencies and multipliers
Concise description	Regional 'Mittelstand 4.0 centres of excellence' that receive funding from the Federal Ministry for Economic Affairs and Energy, and the Centre of Excellence for the 'Digitalisation of Skilled Crafts' help German SMEs become more aware of Industry 4.0, and provide them with information, training and opportunities to test their Industry 4.0 applications. Demonstration and learning factories help companies try out new things – under the close eye of industry experts – and put their own technologies, product or customer interfaces to the test before making an investment. These services are supplemented by the work done by the Mittelstand 4.0 agencies: These agencies use multipliers to answer companies' questions on a host of transversal issues linked to digitalisation – such as cloud computing, digital communication, processes, trade, etc..
Results	Planned annual investment of 40 billion EUR by German Industry in Industry 4.0 applications by 2020 153 billion EUR additional growth created through Industry 4.0 by 2020
Rationale for selection	The initiative shows a successful approach that contributes to: • Strengthening ecosystems: • Strategic outlook development: • Structured skills development: • Tailoring training to SME's needs
Lessons learned for roadmap and/or scaling up	
Website(s) initiative	

Name good practice	SEnDIng Project
Responsible organisation(s)	University of Patras
Duration (start/end)	1st December 2017 - 30th November 2020
Funding	*Co-funded by the Erasmus+ Programme of the European Union*
Budget	*€982.537*
Targeted skills	Big data and IoT skills

Name good practice	SEnDIng Project
Objectives of the initiative	• To address the skills gap of DS and IoT professionals by targeting the IT sector and other economy's sectors (e.g. banking, energy, and logistics) that have demands for high-qualified DS and IoT professionals. • To provide DS and IoT professionals with skills and competences, that meet the needs of employers, are transferable and recognized among European countries. • To design a common reference scheme of competences, skills, knowledge and proficiency levels for DS and IoT professionals in accordance with European frameworks (e.g. eCF and ESCO). • To design and provide two modular learning outcome oriented VET programs, one targeting DS and another IoT. • To design a mechanism for the certification of skills and competences provided to learners
Concise description	The SEnDIng project has developed a VET program which is based on modular and learning outcomes-oriented curricula that combine technical knowledge and skills at Data Science and Internet of Things domains with transversal skills and competences.
Results	Phase 1: 103 hours asynchronous online training (10 hours per week from November 2019 to January 2020). Phase 2: 20 hours face to face training during February 2020 that will be held in Athens, Nicosia and Sofia during 2 weekends. Phase 3: 4 months on-the-job training in the period from March 2020 to August 2020. On-the-job training will take place at your business premises and there is the possibility to support you in defining the case studies your employees will work on, so that they are relative to your business activities.
Rationale for selection	The initiative shows a successful approach that contributes to: • Strengthening ecosystems: • Strategic outlook development: • Structured skills development: • Tailoring training to SME's needs
Lessons learned for roadmap and/or scaling up	
Website(s) initiative	http://sending-project.eu/index.php/en/

Name good practice	Modern Enterprises' Program
Responsible organisation(s)	Hungarian Chamber of Commerce
Duration (start/end)	08/2015 untill 2021
Funding	Public (Hungarian Chamber of Commerce & European Fund for Regional Development – EU)
Budget	18.077.000 Euro
Targeted skills	*Cybersecurity, big data, IoT skills or combination*

Name good practice	Modern Enterprises' Program
Objectives of the initiative	• Offer personalized and knowledgeable assistance and not-restitutable advice for business IT-developments. • Help firms and guide them in their digital transformation
Concise description	The program conducts surveys, suggest IT-developments, solutions, offers discounts, brings together events
Results	16.733 member firms, 1.948 discounts, 264 events
Rationale for selection	The initiative shows a successful approach that contributes to: • Strengthening ecosystems: • Strategic outlook development: • Structured skills development: • Tailoring training to SME's needs
Lessons learned for roadmap and/or scaling up	
Website(s) initiative	https://vallalkozzdigitalisan.hu/index.html

Name good practice	Innovation vouchers Finland
Responsible organisation(s)	Business Finland
Duration (start/end)	Created on 1ste January 2018 by the merger of two organizations: Finpro and Tekes.
Funding	Public
Budget	
Targeted skills	*Cybersecurity, big data, IoT skills or combination*
Objectives of the initiative	• We enable companies to grow internationally and also create world-class business ecosystems and a competitive business environment for Finland…
Concise description	Business Finland offers Finnish companies a unified customer journey for innovation activities, internationalization, investments, and tourism promotion.
Results	958M Funding applied, 2906 new products, services or other innovations generated, 1303 patents and 816 theses.
Rationale for selection	The initiative shows a successful approach that contributes to: • Strengthening ecosystems: • Strategic outlook development: • Structured skills development: • Tailoring training to SME's needs
Lessons learned for roadmap and/or scaling up	
Website(s) initiative	https://www.businessfinland.fi/en/for-finnish-customers/about-us/results-and-impact/

Name good practice	Digityser

Responsible organisation(s)	DigitYser is the Digital Innovation Hub of Brussels where communities gather to boost digitalskills, empower entrepreneurship and facilitate digital transformation.
Duration (start/end)	Unknown
Funding	*Un*
Budget	
Targeted skills	*Cybersecurity, big data, IoT skills or combination*
Objectives of the initiative	• Contribute to a better society
Concise description	
Results	
Rationale for selection	The initiative shows a successful approach that contributes to: • Strengthening ecosystems: • Strategic outlook development: • Structured skills development: • Tailoring training to SME's needs
Lessons learned for roadmap and/or scaling up	
Website(s) initiative	https://digityser.org/

Name good practice	**Cybersecurity Support Ranger**
Responsible Organization(s	The Ministry of Economy, Trade and Industry Japan
Duration (start/end)	Unknown
Funding	Public
Budget	Unknown
Targeted skills	Cybersecurity
Objectives of the initiative	• Aiming to raise awareness on cybersecurity among SMEs and popularize cybersecurity measures tailored to the current situations of SMEs. • Supporting SMEs in taking cybersecurity efforts in collaboration with regional associations and companies
Concise description	The Ministry of Economy, Trade and Industry (METI) and the Information-technology Promotion Agency, Japan (IPA) have been advancing the Project for Demonstrating Measures for Supporting SMEs in Conducting Post-Accident Measures Involving Cybersecurity (Cybersecurity Support Ranger), aiming to raise awareness on cybersecurity among SMEs and popularize cybersecurity measures tailored to the current situations of SMEs
Results	Unknown
Rationale for selection	The initiative shows a successful approach that contributes to:

Name good practice	Cybersecurity Support Ranger
	• Strengthening ecosystems: • Strategic outlook development: • Structured skills development: • Tailoring training to SME's needs
Lessons learned for roadmap and/or scaling up	
Website(s) initiative	https://www.meti.go.jp/english/press/2019/0611_002.html

Name good practice	Cyber NYC
Responsible organization(s)	New York City Economic Development Corporation
Duration (start/end)	Established in 2018
Funding	*Public-Private partnership*
Budget	100 million
Targeted skills	*Cybersecurity, big data, IoT skills or combination*
Objectives of the initiative	• Make New York City a global leader in cyber innovation and to catalyse 10,000 jobs
Concise description	A suite of strategic investments to grow New York City's cybersecurity workforce, help companies drive innovation, and build networks and community spaces
Results	unknown
Rationale for selection	The initiative shows a successful approach that contributes to: • Strengthening ecosystems: • Strategic outlook development: • Structured skills development: • Tailoring training to SME's needs
Lessons learned for roadmap and/or scaling up	
Website(s) initiative	https://www.cyber-nyc.com/

Name good practice	SKILLSFUTURE
Responsible organisation(s)	Singapore Government
Duration (start/end)	Unknown
Funding	Public
Budget	Unknown
Targeted skills	*Cybersecurity, big data & IoT skills / all kind of skills*

Name good practice	SKILLSFUTURE
Objectives of the initiative	• A national movement to provide Singaporeans with the opportunities to develop their fullest potential throughout life, regardless of their starting points.
Concise description	No matter where you are in life – schooling years, early career, mid-career or silver years – you will find a variety of resources to help you attain mastery of skills. Skills mastery is more than having the right paper qualifications and being good at what you do currently; it is a mindset of continually striving towards greater excellence through knowledge, application and experience
Results	Unknown
Rationale for selection	The initiative shows a successful approach that contributes to: • Strengthening ecosystems: • Strategic outlook development: • Structured skills development: • Tailoring training to SME's needs
Lessons learned for roadmap and/or scaling up	
Website(s) initiative	https://www.skillsfuture.sg/

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