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Digitalisation of SMEs

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ACRONYMS

5G	Fifth Generation of Broadband
AI	Artificial Intelligence
AML	Anti Money Laundering
AR	Augmented Reality
BEEHC	Business Economy (except activities of holding companies)
CE	Circular Economy
CRM	Client Relationship Management
CSR	Corporate Social Responsibility
D4SMEs	Digital for SMEs Global Initiative
DESI	Digital Economy and Society Index
DLTs	Distributed Ledger Technologies
DX	Digital Transformation
EC	European Commission
EPC	European Policy Centre
ERM	Enterprise Risk Management
ERP	Enterprise Resource Planning
ESG	Environmental, Social, and Governance
GDP	Gross Domestic Product
GeSI	Global Enabling Sustainability Initiative
GNI	Gross National Income
GRI	Global Reporting Initiative
HPC	High Performance Computing
IaaS	Infrastructure as a Service
ICT	Information and Communications Technology
IIoT	Industrial Internet of Things
IoT	Internet of Things
IR/4IR	Industrial Revolution / Fourth Industrial Revolution
ISO	International Standardisation Organisation
KETs	Key Enabling Technologies
LEs	Large Enterprises
ML	Machine Learning
NACE	Statistical classification of economic activities in the European Community
NFBS	Non-financial business sector
NFR	Non-financial Reporting
OECD	Organisation for Economic Cooperation and Development
PaaS	Platform as a Service
PPS	Purchasing Power Standards
RFID	Radio-frequency identification
SaaS	Software as a Service
SAFE	EC/ECB Survey on Access to Finance
SBA	Small Business Act for Europe
SDGs	Sustainable Development Goals
UN	United Nations
VR	Virtual Reality
VSEs	Very Small Enterprises
WEF	World Economic Forum

Introduction

This background document provides detailed information for some of the topics addressed in the Annual Report on European SMEs 2020/21.

- Chapter 1 provides an extensive review of the recent literature on the digitalisation of SMEs;
- Chapter 2 presents 8 detailed case studies of SMEs having digitalised their activities;
- Chapter 4 showcases 4 public programs aimed at supporting the digitalisation of SMEs;
- Chapter 5 presents the results of a statistical analysis of the determinants of the performance of EU SMEs from 2008 to 2016; and,
- Chapter 6 provides a statistical analysis of the drivers of SME digitalisation using firm-level data from the 2020 Flash Eurobarometer 486 Survey on 'SMEs, Start-Ups, Scale-ups and Entrepreneurship'.

1 Key findings of the recent literature on Digital Transformation of SMEs

1.1 *The process of digital transformation*

Digital Transformation (to be denoted as DX across this literature review), is the profound and accelerating transformation of business activities, processes, competencies and models to fully leverage the changes and opportunities of digital technologies and their impact across society in a strategic and prioritised way, with present and future shifts (i.e. socio-economic, environmental, technological etc.) in mind. DX, in the integrated and connected sense of the term, requires, among other factors, the transformation of business models; activities/functions; processes; ecosystems; asset management; organisational culture; ecosystem and partnership models; and customer, worker and partner approaches (i-SCOOP, 2021).

Even though DX brings proven benefits to firms, the public sector and individuals, it comes with certain challenges, barriers and potential negative impacts that require proper understanding in order to establish the most appropriate ecosystem within a supportive policy and regulatory framework. This literature review aims to present key insights gathered from recent academic and semi-academic papers on DX, starting with its definition and continuing with explanations of the key digital technologies involved; their main purposes; the main actors; key company determinants, both internal and external; the impact of COVID-19 on DX; DX performance at national, sectoral and firm levels; the benefits and impacts created by DX; the impact of SME DX on sustainability; and proposed solutions for boosting DX.

At the beginning of a new, yet challenging decade that started with a severe economic crisis caused by the COVID-19 pandemic, in addition to pressing climate, environmental and societal challenges, it has become even more important to accelerate the **twin green and digital transformations**. As prioritised under the new growth strategy of the **EU Green Deal,**[1] followed by the '**EU Recovery Plan – NextGenerationEU'**[2] and the **EC 2021 Work Programme**[3] this twin transformation will ensure compliance with **Paris Agreement**[4] objectives on climate, as well as with the **UN Sustainable Development Goals (SDGs),**[5] to realise the '**2030 Global Agenda for Sustainable Development'**, as defined by the UN.[6]

1.1.1 *From Digitisation to Digitalisation and Digital Transformation*

Digitisation, digitalisation and DX are three commonly and interchangeably used terms, even though they have different meanings (i-SCOOP, 2021), thus it is key to understand the differences.

Digitisation refers to the transformation of physical information into electronic sequences, from an analogue to a digital format, characterised by lower storage, processing and transmission costs (Loebbecke & Picot, 2015; Yoo et al., 2010; Li et al., 2016; Sebastian et al., 2017; Vendrell-Herrero et al., 2017; Dougherty & Dunne, 2012). However, the concept of **digitalisation** is defined by Clerck[7] as the use of digital technologies and data (digitised and natively digital) in order to create revenue and improve business. In other words, to transform business processes (not just to digitise them) and to create an environment for digital business, whereby digital information is at its core, using digitalised data (resulting from the concept of digitisation) and cutting-edge technologies to improve existing business processes. In addition to redefining existing business processes by using digital technologies, digitalisation involves supplying new (digital) goods and services (Verhoef et al., 2021). Brennen and Kreiss (2014) define digitisation as the material process of converting individual analogue streams of information into digital bits, while digitalisation can be regarded as the restructuring of many domains of social life around digital communication and media infrastructures.

DX is seen as the next step after digitalisation. A precise definition was introduced by Hess et al. (2016), highlighting that DX is concerned with "changes that digital technologies can bring about in a company's business model, products, processes and organisational structure". DX is about using digital capabilities (such as big data,

[1] See: https://ec.europa.eu/info/strategy/priorities-2019-2024/european-green-deal_en
[2] See: https://ec.europa.eu/info/strategy/recovery-plan-europe_en
[3] See : https://ec.europa.eu/commission/presscorner/detail/en/ip_20_1940
[4] See : https://ec.europa.eu/clima/policies/international/negotiations/paris_en
[5] See : https://sdgs.un.org/goals
[6] See : https://sdgs.un.org/2030agenda
[7] www.i-scoop.eu/digitization-digitalization-digital-transformation-disruption

IoT and cloud computing) to revolutionise the customer experience, to outdo the competition and to create an innovative business model adapted to this digital era (Westerman, 2011). DX involves a holistic change, emphasising cultural, organisational and relational changes to better cater to both business and customer needs (Morandini, Thum-Thysen, & Vandeplas, European Commission, 2020; Observatory of Public Sector Innovation, 2020; Bartholomae, 2018).

Various **DX frameworks** have been defined, in which the common denominator is that DX is not just about technology but about **transformative changes** that affect the way value is created and captured inside a given company. For instance, according to the DX framework proposed by the MIT Center for Digital Business, companies must first transform the **customer experience** by building data analytics capabilities to more deeply understand their customers' needs and preferences. Secondly, they must **transform internal processes** as well as their **business model** in order to move forward in their transformation journey (Westerman, 2011). According to the framework published by the Global Centre for Digital Business Transformation (Wade et al., 2017), during a DX, companies must actively consider their strategy on go-to-market, engagement, operations, and organisational structure and ethos. Rogers (2016) identified five domains of strategy that DX is changing: **customer, competition, data, innovation** and **value proposition.** These axes are also discussed by Uhl & Gollenia (2014), who found **that customer-centricity, innovation capability, operational excellence using data capabilities** and **a competitive mindset are all key to success in transforming a firm digitally** to remain competitive in the future.

The **European Commission (EC)** defines DX as "a fusion of advanced technologies that integrates physical and digital systems and when combined with innovative business models and processes, leads to the creation of smart products, services and significant improvement of productivity" (DigitaliseSME, 2020). The **Organisation for Economic Cooperation and Development** (**OECD)** defines DX as "the process of adoption of digital technologies and methods by an organisation, typically those that have either not been including the digital factor as part of their core activities or have not kept up with the pace of change in digital technologies" (Observatory of Public Sector Innovation, 2020).

1.1.2 *Main technologies adopted for Digital Transformation*

The EC's working paper entitled 'Shaping the digital transformation in Europe' identifies basic **information and communication technologies (ICTs)** as the cornerstone to advanced digitalisation (DG CNECT, 2020). Based on the vision of the EC, there are two clusters of technologies that will build on a robust ICT environment to usher effective DX across societies: enabling technologies and infrastructure, and high impact applied technologies. **Enabling technologies and infrastructure** include machine learning (ML) and artificial intelligence (AI), big data analytics, quantum and high performance computing (HPC), Internet of Things (IoT, including edge computing), next generation internet and 5G/6G infrastructure, cloud computing, digital platforms and distributed ledger technology (DLT). **High impact applied technologies** include the use of advanced industrial robotics, industrial IoT (IIOT), virtual and augmented reality (VR/AR), digitally enabled biotechnologies, 3D printing and additive manufacturing. Also considered as high-impact applied technologies are multimodal deployments of different sets of advanced technologies for the development of smart cities, connected and autonomous vehicles (CAVs), digital energy innovation and sustainability, and advanced materials. The combination of these technologies with appropriate business processes and a digitally conducive institutional environment has the potential to support firms' competitiveness and improve the quality of societal and environmental goods (Ferreira, Moreira, Pereira, & Durão, 2020).

The most recently launched EU Initiative in support of EU industrial policy, '**Advanced Technologies for Industry',**[8] merges the previous **Key Enabling Technologies (KETs) Observatory**[9] and **Digital Transformation Monitor**[10] initiatives, and focuses on the advanced technologies that will **help industries to successfully manage a shift towards a low-carbon and knowledge-based economy**. The following **16 advanced technologies** have been identified under this initiative: advanced manufacturing technology; advanced materials; artificial intelligence; augmented and virtual reality; big data; blockchain; cloud computing; connectivity; industrial

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[8] https://ati.ec.europa.eu/
[9] https://ec.europa.eu/growth/tools-databases/kets-tools/kets-observatory
[10] https://ec.europa.eu/growth/tools-databases/dem/monitor/

biotechnology; internet of things; micro- and nanoelectronics; mobility; nanotechnology; photonics; robotics; and security.

Likewise, the **'OECD Digital for SMEs Global Initiative (D4SME)'**[11] aims to support SME digitalisation by focusing on accelerating digitally-driven transformations in supply chains and business models, mainly around the following technology domains: big data and AI; blockchain & DLTs; cloud computing; digital platforms; fintech; and IoT / Industrial IoT.

In addition to the previously mentioned technologies, the following are regarded as **EU Internal Market policy agenda priorities**: **3D-printing** especially in advanced manufacturing, **5G & 6G**, **next generation cloud, edge computing, cybersecurity, and quantum technologies.** Connectivity is a crucial building block of DX, enabling data to flow, people to collaborate, and more objects to connect to the internet, thereby transforming manufacturing, mobility and logistic chains. As a result, gigabit connectivity, powered with secure fibre and 5G infrastructures, has been indicated as an investment priority in 'Shaping Europe's Digital Future' and also included as a pillar of EU strategic priorities for 2019-24 in 'A Europe Fit for the Digital Age.[12] Another EU priority is to increase public trust in digital technologies by ensuring maxiumum protection against cyber attacks through a combination of **cybersecurity** and **ethical use of AI.** As part of this goal, a **European Common Data Space** is therefore being planned, which will provide an ultra secure environment for big data collection and sharing. The EC is aiming to lead a global standardisation process for new generation technologies such as **algorithms, blockchain**, **quantum technologies** and **supercomputing**, as has been successfully achieved for 5G and IoT, in order to allow the deployment of **interoperable technologies** and **secure data sharing.**[13]

1.1.3 *Main purposes of digital transformation*

The 'SME Digitalisation' study commissioned by Vodafone (Deloitte, 2020) identifies **four main categories of digital technologies** used by SMEs in their DX process: **connectivity; process digitalisation and automation; cloud; online presence, collaboration and communication**. Some of these categories provide quick wins for SMEs, requiring only minimal investment in hardware, integration and implementation. The categories of **connectivity** and **online presence,** requiring fixed and/or mobile broadband as the key enabler, allow deployment of various online tools to facilitate business processes such as: online communication and collaboration; the online selling of goods and services; internet-based solutions to reduce customer interactions and thereby free up human resources; contactless payments; and QR codes for direct ordering. **Process digitalisation and automation**, on the other hand, uses connected devices, and can range from the relatively simple, such as the digitalisation of manual business processes (e.g. e-signing documents) to the more sophisticated, incorporating connected sensors and hardware ecosystems (IoT) to reduce contact processes (e.g. contactless check-in/check-out) and optimise industrial processes (e.g. Industry 4.0 manufacturing). The latter can be enhanced even further through automation, using connected devices with machine-to-machine (M2M) communication capabilities that enable an increase in labour productivity. Meanwhile, **cloud based services** reduce the need for ICT infrastructure and allow remote access to data and services from any place, at any time, through any internet-enabled device. This benefits SMEs in a variety of ways, such as: **increasing efficiency and flexibility** by converting expensive infrastructure investments into variable service costs; **enabling data-driven innovation** that brings productivity gains through the use of powerful cloud based computing power to leverage big data; making use of services provided by third party cloud providers to **ensure smooth and reliable operations,** as well as **better compliance with data protection regulations** (i.e. GDPR), by implementing protection of the company's own data as well as that of their customers.

The 'Digital With Purpose: Delivering a SMARTer2030' report (GeSI & Deloitte, 2019), commissioned by the Global Enabling Sustainability Initiative (GeSI),[14] provides another view of the main purposes of digital technology deployment under DX. The study first defines **seven key technologies** (i.e. digital access, fast internet, cloud, IoT, Cognitive, Digital Reality, Blockchain) as broadly representative of the way digital capability will evolve in the medium term and their critical influence on the world. In order to assess the impact of these technologies on the

[11] https://www.oecd.org/going-digital/sme/
[12] https://ec.europa.eu/info/strategy/priorities-2019-2024_en
[13] https://ec.europa.eu/info/sites/info/files/communication-shaping-europes-digital-future-feb2020_en_3.pdf
[14] https://gesi.org

Sustainable Development Goals (SDGs) (see Chapter 3.5 of this report), the study defines **'impact functions'** grouped under **4 main categories** as:

- **Connect & Communicate:** Connecting people to each other and to critical information;
- **Monitor & Track:** The real-time, extensive observation of the world and its natural and man-made systems;
- **Analyse, Optimise & Predict:** The development of insights from data, and the use of those insights to drive process efficiency and infer the future;
- **Augment & Autonomate:** Provision of an 'active bridge' between digital and physical, from simulation through augmentation to the creation of autonomous systems.

The **type of digital technology being adopted varies across sectors**, in line with business needs. Based on the results of the 2019 EIB Investment Survey, the **Internet of Things (IoT)** is the main group of technologies currently being implemented by manufacturing, construction, services and infrastructure firms (EIB, 2020). **DX in manufacturing is associated with Industry 4.0**, the use of real time data and information in networking all the individual elements of the manufacturing process, with the aim of decreasing the complexity and cost of operation, whilst increasing the efficiency and effectiveness of production. **Industry 4.0** leverages Information Communication Technology (ICT) applications and is intended to integrate 3D printing, big data technologies, cyber-physical systems (CPS), distributed and decentralised control, embedded systems, IoT and robotics into the production process (Almada-Lobo, 2014; EFRA, 2013; Kotynkova, 2016; Schmidt, et al., 2015). Key technologies for the **construction sector** include 3D printing, drone technology, IoT, and virtual reality. **Service companies** mostly use big data, IoT, platform technology, and virtual reality. **Infrastructure firms** use 3D printing, big data, IoT, and platform technology.

The process of DX requires a lot of research and experimentation with new technologies and business models (OECD, 2019). Not all firms are willing to take the risk of investing in DX. Among the ones that do, less than 30% succeed, and their success rates vary, depending on the industry. For **digital savvy industries, such as high-tech, media and telecoms**, the success rate is around 26%; while for **traditional industries such as oil and gas, automotive, infrastructure and pharmaceuticals** it varies between 4% and 11% (McKinsey & Company, 2018).

1.2 *Key determinants of digital transformation*

The 'OECD Digital for SMEs Global Initiative (D4SME)'[15] defines market conditions, regulatory environment and infrastructure as **enabling framework conditions**; skills, finance and innovation as **firm level drivers**; and **digital technologies** as all the digitally driven transformations in supply chains and business models. D4SME aims to promote knowledge sharing and dialogue between governments, regulators, business sectors and other institutions concerning these different dimensions in order to accelerate SME DX.

The use of **data** is central to this transformation process. The unison of **data and digital technologies** results in an increasing degree of overlap between the physical, digital and biological realms of business activities (DG CNECT, 2020). For instance, 3D printing decreases the monetary and time costs of the production process, data analysis improves product efficiency, digital databases enable real-time monitoring, thereby facilitating management of the services being provided, and digital technology improves the production process, by allowing instant and seamless exchange of information between the production and procurement departments of manufacturing companies (DigitaliseSME, 2020).

The decision to invest in DX, and the resulting outcomes, depend on **company capabilities and incentives**. Complementarities exist between the two (Sorbe, Gal, Nicoletti & Timiliotis, 2019; OECD, 2018). The remainder of this section presents the factors affecting DX in three parts. The first part discusses factors internal to the company; the second part presents the external factors; and the third part touches upon the impact of the COVID pandemic on SME DX.

[15] https://www.oecd.org/going-digital/sme/resources/D4SME-Brochure.pdf

1.2.1 *Internal factors*

Managerial ability is an important factor in determining the likelihood of a companies' decision to invest in DX and the returns that the investments will generate. Strong managerial skills correlate with higher digital adoption; poor managerial skills stifle productivity gains. High performance work practices also facilitate DX, by increasing the company's adaptability to technological change (Sorbe, Gal, Nicoletti, & Timiliotis, 2019; Gal, Nicoletti, Renault, Sorbe, & Timiliotis, 2019; OECD, 2018).

Access to talent is central to DX. The EC recently reported that more than 70% of firms indicated 'access to talent' as a key obstacle to new investments (European Commission, 2020). The capacity to advance the competencies of existing employees and swiftly recruit new talent, according to the business needs of the company, are essential to an effective digital transition. SMEs often have higher skill deficiencies compared to large companies. SMEs also tend to invest less in training for upskilling. According to the 2019 European Commission SME report, the **key digital skills deficits** are as follows: 41% of SMEs lack software development skills; 35% lack complex data analysis and mathematics skills; 33% cannot access digital strategy skills; 31% find it difficult to acquire digital project management skills; close to 30% lack either website development or data/database management skills; 26% lack basic data input and processing skills. This shortage of digital skills is also highlighted in various academic papers (Abel-Koch, et al., 2019; Vogelsang et al., 2019).

Capability and resource fit, coupled with the **ability to connect a digital strategy with a concrete business model** are all key to DX, together with a firm's capacity to efficiently allocate its resources (APEC, 2020). The ability to easily adjust production volume, contingent on the degree of a venture's success, reduces transition costs (OECD, 2013; OECD, 2019). However, SMEs often fail to fully realise the consequences of digitalisation for their organisational structures, operations and strategies, resulting in difficulties in identifying the most suitable tools for their business needs (Thrassou , Uzunboylu, Vrontis, & Christof, 2020).

Pre-existing business dependencies can influence DX. Dependency on a technology or security protocol for data storage and exchange, or on the compatibility of an existing infrastructure, can impose constraints on the use of digital technologies. Technology dependencies may also stem from outside the company through interaction with counterparts (i.e. partner businesses, governments, customers). Counterpart needs and challenges can influence transition; there is an interdependence between the DX of companies and the level of digital literacy of their counterparts (Iliescu, 2020; Peillon & Dubruc, 2019).

Variation in behavioural characteristics at individual or group level can impact the likelihood of DX (Vogelsang, Liere-Netheler, Packmohr, & Hoppe, 2019)**.** At individual level, fear of losing control, fear of data loss, fear of transparency/acceptance, and fear of job loss impairs the adoption of digital technologies. At group level, adherence to traditional roles/principles, risk aversion and fear of failure are likely to discourage the transition. All these contribute to a company's innovation culture (APEC, 2020).

1.2.2 *External factors*

Good access to communication networks and services is a prerequisite for DX (OECD, 2019)**.** Availability and affordability of (high-speed) network connection, devices, software and applications increases the likelihood and benefits of DX for companies, governments and individuals. However, companies and individuals located in rural areas of OECD countries often have poor access to broadband, leading to low rates of DX (European Commission, 2018; Probst et al., 2018; Shenglin et al., 2020). Additionally, there is a growing digital divide between SMEs and large firms in terms of the connectivity required to be able to access digital infrastructures and platforms. Smaller firms remain less connected (OECD D4SME).[16]

Access to finance is vital to DX (OECD, 2019)**.** It is often the case that firms, especially SMEs, do not have the financial reserves needed for DX. Access to appropriate external forms of finance correlates with higher digital adoption rates (OECD, 2019). Although the existence of venture capital, coupled with tax regimes that do not excessively favour debt over equity financing, can improve access to finance for SMEs, the principal cause of variation in access to finance, based on company size, is information asymmetries. Credit institutions often lack access to information that will allow them to determine the expected profitability of projects or the quality of

[16] https://www.oecd.org/cfe/smes/latestdocuments/D4SME%20First%20Roundtable%20Proceedings.pdf

firm management. This increases the perceived risk of default, which leads to underprovision of finance (Altman, 1968; Bester, 1987; Ennew & Binks, 1996; Stiglitz & Weiss, 1981). The emergence of information asymmetries is particularly common between credit institutions and SMEs pursuing DX. This is because SMEs pursuing DX tend to request sizeable investments in intangible assets or to seek financing to diversify into new business/markets.

High take up of digital technologies is associated with the existence of a dynamic market setting (Calvino et al, 2018). Dynamic markets are a hotspot for digitally innovating firms. The markets are characterised by high allocative efficiency due to entry and exit dynamics. Highly innovative firms enter and capture market share by being more successful in commercialising new technologies; inefficient firms are pushed out of the market. This incentivises incumbent firms to remain as close as possible to the technological frontier (Hendersen, 1993).

Access to data is another key determinant in the ability of companies to leverage AI/ML. SMEs have disadvantaged positioning due to their limited access to the large volumes of data needed to train machine-learning algorithms. They are also more vulnerable in terms of protecting their data and have difficulty in effectively managing data risks in compliance with regulations (OECD D4SME).[17]

Indeed, the combination of previously mentioned internal and external factors result in specific **challenges to SMEs on their DX journey** related to: the **availability of digital tools and technologies** required for digitalisation, including **good connectivity and awareness** of the availability of these digital tools; the **capacity of SMEs to engage with DX in terms of financial and time resources**; and the **capability of SMEs** to gauge, plan, implement and optimise their DX (Deloitte, 2020).

1.2.3 *Impact of COVID-19 pandemic on SME Digitalisation and Sustainable Development*

The COVID-19 pandemic has caused the greatest global economic slowdown since World War II. EU GDP is expected to contract by 7.35% in 2020, followed by a return to growth of 4.1 % in 2021, and a slower rise of 3.01 % in 2022 (ECFIN, 2020; DG CONNECT, 2020). In many countries, the pandemic has brought business activity to a standstill, resulting in job and revenue losses. This has had a profound effect on global value chains, caused by transportation system disruption, supply chain disruption due to labour input constraints, and a sharp fall in demand (Fu, 2020). At an aggregate level, COVID-19 caused a rise in unemployment, including permanent lay-offs and temporary furloughs, and a drop in business investment. The pandemic has also had an adverse effect on job matching, firm-specific capital and human capital (Portes, 2020). The '**SME Understanding Survey'** conducted by Context Consulting (Deloitte, 2020) reports that the cautious optimism expressed by many SMEs prior to the COVID-19 crisis, regarding a positive economic outlook for growth and investment, shifted dramatically during the pandemic as SMEs struggled for survival. **The economic impacts on SMEs, caused by the COVID-19 pandemic**, fall into three interrelated categories: a drop in customer demand and revenue, impacting cash flow and sustainability; supply chain disruptions; and challenges balancing employee capacity and welfare. The research highlights the shift in SME priorities from growing and resourcing their business, to finding new customers, managing business costs, streamlining business and staff, and finding new revenue streams if the core business is no longer able to operate.

The COVID-19 pandemic has affected both upstream and downstream activities of SMEs (Juergensen et al., 2020)**.** The SME presence is high (75% of total employment) in those sectors most affected by the pandemic: transport, manufacturing, construction, wholesale and retail, trade, air transport, accommodation and food services, real estate, professional services, and other personal services. The short term impacts of the crisis were more or less similar for the three following groups of manufacturing SMEs, but their medium to long term recovery is likely to be different. **Standalone SMEs**, which trade under their own brand, producing final goods for the consumer or industrial markets, are facing significant logistical challenges and demand side repercussions due to the reduction in consumers' purchasing power. **Specialist supplier SMEs**, which provide intermediate goods to larger firms, have also been hit severely both on the demand and supply sides. However, demand is likely to recover for this type of SME once restrictions are lifted and production restarts, as a result of their exclusive agreements with key customers. **Knowledge-based SMEs** which supply specialised knowledge-based assets to other firms or consumer markets, face less critical supply side challenges, since their performance is largely contingent on their capacity to perform day to day tasks remotely. **As a response to the COVID-19 repercussions, SMEs have increased debt leverage and, when possible, SMEs have attempted to digitalise their**

[17] https://www.oecd.org/cfe/smes/latestdocuments/D4SME%20First%20Roundtable%20Proceedings.pdf

activities. Information on debt finance since the onset of the COVID-19 crisis remains incomplete. Early estimates show: in Spain, the share of SMEs using bank finance jumped from 6% to 37% between October 2019 and March 2020; in France, firms accounting for an already high debt to GDP ratio (70%), took on EUR 100 billion in debt, with ¾ of that total taken on by SMEs; in Italy, the debt-to-equity ratio is expected to rise by between 90% and 110% (OECD, 2020). Social distancing rules motivated an accelerated adoption of digital services. A large portion of the workforce began to work remotely on a daily basis, consumers turned to e-commerce and online delivery services, students experimented with online learning and governments invested in digital services (DG CNECT, 2020).

DX can support business resilience. However, the investment required for transition is often prohibitive during periods of high uncertainty, such as a pandemic-induced economic crisis (Fitriasari, 2020). Digital technologies can introduce savings, allow the production process to become less contact intensive and support teleworking. Numerous private and public associations throughout the EU launched digital skills initiatives during the pandemic that targeted SMEs in their localities. For instance, the 'Digital Team Austria' initiative offers three months of pro-bono digital services aimed at SMEs transitioning to mobile working. The Italian 'Digital Solidarity' initiative offers video conferencing, access to mobile data and cloud computing, free of charge, among other services. Latvia is developing FinTech initiatives to support DX through better access to finance for SMEs. Finland offers EUR 500K for counselling and support services for entrepreneurs. Greece gives training vouchers to professionals from scientific sectors. Ireland offers mentoring and training courses to help SMEs with selling online.

As assessed and reported in the **Sustainable Development Report 2020** (Sachs et al., 2020), the requisite measures taken in response to the immediate threat of COVID-19, including the shutdown of many economic activities for weeks, have led to a global economic crisis with massive job losses and major impacts especially with respect to vulnerable groups. COVID-19 is expected to have severe negative impacts on most SDGs. The only bright spot in this picture is the reduction in environmental impacts which has resulted from the decline in economic activity. The pandemic is anticipated to have profound short term implications for progress towards the SDGs, based on the emerging data and findings from around the world, up to June 2020, as follows:

- Highly negative impact for SDGs 1, 2, 3, 8, 10 that are linked to poverty, hunger, wellbeing, economic growth and inequalities;
- Mixed or moderately negative impact for SDGs 4, 5, 6, 7, 9, 11, 16, 17 that are linked to education, gender equality, clean water, affordable clean energy, industry, innovation and infrastructure, sustainable cities and communities, justice, and partnerships;
- Still unclear impact for SDGs 12, 13, 14, 15 related to responsible consumption and production, climate action, life below water, and life on land.

1.3 *Trends in integration of digital technologies by European businesses*

Monitoring variation in the implementation of DX is key to addressing the adverse impacts of DX on economic convergence as well as on income and wealth inequality (Qureshi, 2020**)**. The European Parliament recently recognised the **digital divide** as an issue of concern (Negreiro & Madiega, 2019). The report argues that even though the digital divide has decreased in recent years, there are still economic dynamics that present cause for concern. The authors highlight the existence of a **sizeable gap in digital skills and investment (internet connectivity and AI)**, and also the limited number of digital champions and the deficit in advanced computing systems.

To illustrate the progress and trends related to the integration of various digital technologies by European businesses, the following section will provide insights taken largely from the **2020 Digital Economy and Society Index (DESI)**,[18] which monitors Europe's overall digital performance and tracks the progress of EU countries with respect to their digital competitiveness. DESI is a composite index that observes variation in the digital performance of countries across five key dimensions: connectivity, human capital, use of internet services, integration of digital technology, and digital public services. Among these key pillars, particular attention will be paid to the **Integration of Digital Technology** (DESI, 2020) since it is highly linked to the DX of SMEs. Within this category, DESI makes assessments within the following areas: **integration of digital technologies**, by measuring

[18] For more information on DESI, see: https://ec.europa.eu/digital-single-market/en/digital-economy-and-society-index-desi

business digitalisation (i.e. electronic information sharing, social media, big data, cloud) and **e-commerce** (i.e. SMEs' online sales within and outside of their country, and their turnover from e-commerce); **usage of different digital technologies at enterprise level**, measured by using the **Digital Intensity Index (DII); analysis of ICT skills**; **adoption of digital technologies** (e.g. cloud based services such as Enterprise Resource Planning (ERP) software, Customer Relationship Management (CRM) systems, social media, etc.); analysis of key technologies such as **cloud computing, big data**, national and cross-border **e-commerce**; **web sales** (i.e. B2B, B2C, B2G) in addition to **emerging technologies** (e.g. blockchain, high performance computing (HPC), quantum technology, data and edge computing) as well as **cybersecurity**.

The data which was collected under the 'Integration of Digital Technology' pillar just before the pandemic showed large variations, depending on company size, sector and location. DESI 2020 shows that progress was being made by all EU Member States and in all key areas measured. Finland, Sweden, Denmark and the Netherlands were the top 4 overall digital performers, closely followed by Malta, Ireland and Estonia. The sub-sections which follow present a perspective on these major differences.

1.3.1 *Differences between integration of digital technologies*

The 'Integration of Digital Technology' pillar within DESI 2020 provides various DX performance insights, including a comparison between SMEs and Large Enterprises (LEs), as well as progress over time.

Based on the results of the 2019 'Eurostat Community Survey on ICT usage and e-commerce in enterprises' the DESI 2020 Report lists the following digital technologies as being used by both SMEs and LEs, in order of most to least frequently: **enterprise resource planning** (**ERP**); **customer relationship management** (**CRM**); **social media; e-commerce; cloud computing; big data; cross-border e-commerce.** SMEs lag behind LEs in adoption of nearly all digital technologies despite being connected to the internet at the same rate. The largest adoption gaps are in digitalisation of the internal organisational process (e.g. via ERP), where the greatest efficiency gains are to be made (Deloitte, 2020).

In terms of **cloud computing**, since 2018, across the EU market, there has been an increase in total revenues generated by public cloud services such as Infrastructure as a Service (IaaS), Platform as a Service (PaaS) and Software as a Service (SaaS). Among these, **SaaS** represents almost two thirds of total public cloud revenues generated across the EU market, with the trend rising from 2018 to 2021. The top four SaaS applications by total revenue were **customer relationship management** (**CRM)**, followed by **enterprise risk management** (**ERM**), **workflow and management applications** and **collaborative applications**, all of which increased their deployment rate between 2018-2021. However, in terms of revenue growth over the same period, the fastest growing SaaS application was **software security** (DESI, 2020).

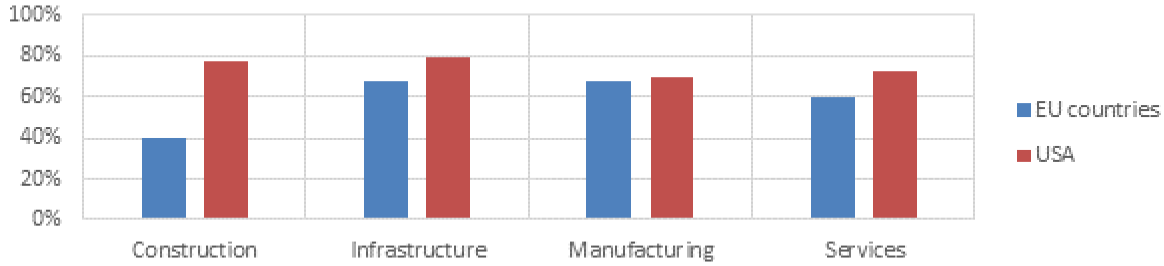
In 2018, on average, 12% of SMEs used **big data analytics** for analysing large volumes of data. SME take up was highest in Malta (25%), followed by the Netherlands, Belgium and Ireland with a usage rate of at least 20%. However, SMEs in Cyprus, Hungary, Austria and Bulgaria barely utilised big data at all. In terms of how data analysis was carried out, nearly 6% of enterprises analysed big data using geolocation technology on portable devices, while 4% analysed data from their smart devices or sensors (DESI, 2020).

One in five EU enterprises had already adopted **e-commerce** and online selling before the COVID-19 outbreak. As a result, the percentage of companies selling online between 2013 and 2019 increased by 3.5%. Prior to the pandemic, almost 15% of EU enterprises were active in online marketplaces in Europe using their own website or apps for selling online, while approximately 7% of all EU enterprises sold through e-commerce marketplaces. In terms of **cross-border e-commerce,** of the 17% of SMEs who sold online, only 7% sold online to customers in other EU countries, while 16% (representing almost all the enterprises who sold online) sold only to customers in their own country. Most of the enterprises selling online to other EU countries (62%) had not experienced any difficulties in doing so, while the rest reported obstacles related to economic factors (e.g. the high costs of delivering or returning products, a problem reported by 27% of enterprises) and/or linguistic and legal problems, experienced by 11% of enterprises (DESI, 2020).

1.3.2 *Differences between industries*

The speed and the extent of DX varies greatly across sectors. EU companies active in the infrastructure, services, and manufacturing sectors are more likely to undergo DX than those in the construction sector, as illustrated in the figure below. According to the United Nations Conference on Trade and Development (UNCTAD), the **top 10 industries affected most by digitalisation** are: media and entertainment; retail; high tech; healthcare systems and services; travel, transport and logistics; telecommunications; professional services; financial services; automotive and assembly; and consumer packaged goods (UNCTAD, 2017).

Figure 1 Implementation of DX in parts of business or organised around the entire business (in % of all firms)



Source: EIBIS 2019

Industries undergo DX at different speeds, which highlights the importance of understanding why and how firms in different sectors adopt new technologies. For instance, despite the use of digital technologies by firms active in agriculture, mining, and real estate, these industries are still likely to underperform compared to other sectors, such as manufacturing, when it comes to indicators that focus on investment in ICT or software (OECD, 2019). Table 1 presents a **taxonomy of sectors by usage intensity of digital technologies.** Transport equipment producers, ICT, finance, administrative and advertising services are among the industries that most use digital technologies and processes.

Table 1 Taxonomy of sectors by digital intensity, overall ranking for 2013-2015

ISIC Rev. 4 industry denomination	Quartile intensity	ISIC Rev. 4 industry denomination	Quartile intensity
Agriculture, forestry, fishing	Low	Wholesale and retail trade, repair	Medium-high
Mining and quarrying	Low	Transportation and storage	Low
Food products, beverages and tobacco	Low	Accommodation and food services activities	Low
Textiles, wearing apparel, leather	Medium-low	Publishing, audio-visual and broadcasting	Medium-high
Wood and paper products, and printing	Medium-high	Telecommunications	High
Coke and refined petroleum products	Medium-low	IT and other information services	High
Chemicals and chemical products	Medium-low	Finance and insurance	High
Pharmaceutical products	Medium-low	Real estate	Low
Rubber and plastic products	Medium-low	Legal and accounting activities, etc.	High
Basic metals and fabricated metal products	Medium-low	Scientific research and development	High
Computer, electronic, optical products	Medium-high	Advertising and other business services	High
Electrical equipment	Medium-high	Administrative and support services	High
Machinery and equipment n.e.c.	Medium-high	Public administration and defence	Medium-high
Transport equipment	High	Education	Medium-low
Furniture: other manufacturing: repairs	Medium-high	Human health activities	Medium-low
Electricity, gas, steam and air cond.	Low	Residential care and social work activities	Medium-low
Water supply; sewage, waste	Low	Arts, entertainment and recreation	Medium-high
Construction	Low	Other service activities	High

Source: Calvino et al. (2018) based on annual national accounts, STAN, ICIO, PIAAC, International Federation of Robotics, World Bank, Eurostat Digital Economy and Society Statistics, national labour force surveys, US CPS, INTAN-Invest and other national sources.

1.3.3 *Differences based on company size and age*

Only 17% of SMEs in Europe have already integrated digital technologies into their business, compared to 54% of large companies, according to the 2018 **Digital Innovation Hubs Working Group** report (DG CONNECT, 2018; European Commission, 2020; OECD, 2020). SMEs are often unaware of or ignore the potential benefits of DX, or find it challenging to identify their needs and to develop a strategy to address them, and/or cannot access the skilled labour force and financial resources necessary for effective use of digital technologies to boost productivity growth and innovation in the products/services they provide (Kopke et al., 2016). Since 2019, a large share of SMEs has already begun or intends to begin adopting digital practices. The 2019 '**Going Digital European SME Survey**' (Abel-Koch et al (2019), conducted with SMEs from 5 large European economies (France, Germany, Poland, Spain and the United Kingdom) found that the most common digital activities adopted by SMEs were **electronic invoicing** and **software to facilitate collaborative work** (60% of respondents). Less frequently used by SMEs were enabling technologies and infrastructure, such as AI (20%) and big data analytics (32%), along with high impact applied technologies, such as 3D printing and additive manufacturing, advanced industrial robotics, Industrial IoT, and virtual and augmented reality (VR & AR). (Abel-Koch et al., 2019; Sorbe et al., 2019).

The 2020 OECD statistics for 'ICT Access and Usage by Businesses', show that **small EU SMEs (10-49 employees) are lagging behind larger businesses (250+ employees) in terms of adoption of virtually all digital technologies**. This ranges from basic connectivity to more complex and higher return technologies such as cloud computing, big data analysis, CRM, ERP, e-Commerce, fast broadband, social media, and websites. Indeed, SMEs lag behind their larger counterparts even in basic connectivity, with the gap much larger in certain countries, such as Greece and Hungary. This gap is even greater for high speed connectivity across the EU-27, with only 46% of small businesses using 30+ Mbps broadband compared to 80% of larger businesses, and a similar-sized gap for 100+ Mbps usage: 19% versus 53%. For the **more advanced technologies** enabled by high-speed connectivity, the digital divide between small and large businesses is even bigger (Deloitte, 2020).

There is also a digital **divide within sectors, between smaller and larger firms, as well as in terms of firm age**, as indicated by the EIB study (Rückert, Veugelers, & Weiss, 2020) comparing manufacturing and services sectors in the EU and USA. For example, 30-35% of small manufacturing firms in the EU and the US were categorised as 'persistently non-digital', compared to only 10-15% for large manufacturing firms. In **services**, this gap was lower, with younger small firms relatively closer to large firms in terms of digital adoption. However, older, small firms significantly lagged behind, with a digital adoption rate approximately 15 percentage points lower than that of their younger counterparts and large businesses.

DESI 2020 compares the **different digital technology adoption rates of SMEs** (10-249 employees) **and LEs**. The largest gap can be seen in digitalisation of internal organisational processes (i.e. ERP) followed by cloud, big data, CRM, e-Commerce and social media. Similar results can also be seen in the **DESI Digital Intensity Index (DII)**, which is based on the 2019 Eurostat Community Survey of ICT usage in enterprises. The same survey indicates a major difference in **the employment of internal ICT specialists, related to company size**. ICT specialists are employed in 75% of LEs, 42.5% of medium-size companies (50-249 employees), but only 15% of small companies (10-49 employees).[19]

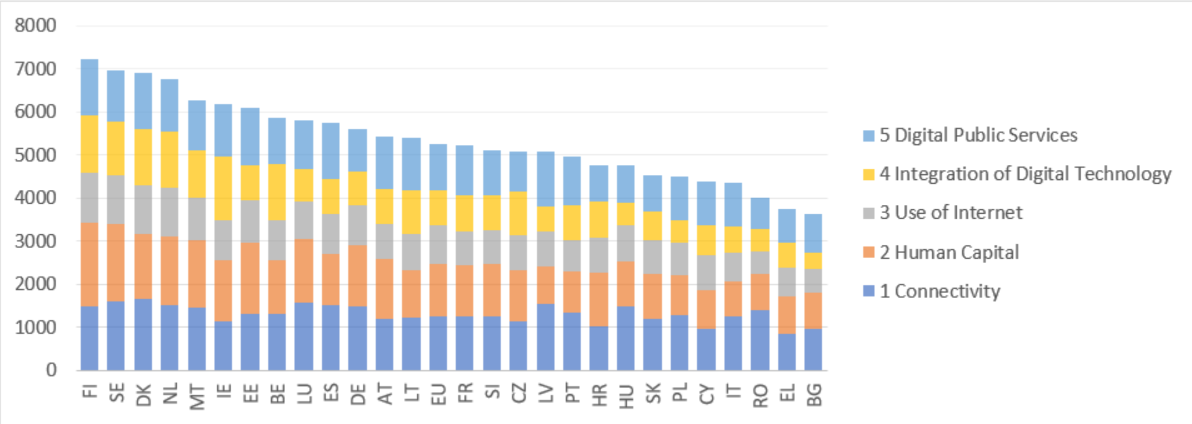
1.3.4 *Differences between EU Member States*

National economies undergo DX at different speeds, and also exhibit major regional differences. This section will present key findings from DESI related to the **overall performance of EU Member States in implementing all five key dimensions (connectivity, human capital, use of internet, integration of digital technology, and digital public services).** Each country is given a general ranking based on their scores for 37 indicators across five dimensions. However, each dimension is weighted differently to arrive at the overall score: 25% for connectivity, 25% for human capital, 20% for integration of digital technology, and 15% for use of both internet and digital public services.

[19] https://eufordigital.eu/wp-content/uploads/2020/06/DESI2020Thematicchapters-FullEuropeanAnalysis.pdf

Finland, Sweden, Denmark and the Netherlands were the top 4 digital performers, closely followed by Malta, Ireland and Estonia, while Italy, Romania, Greece and Bulgaria were the 4 lowest scoring digital performers (Figure 2).

Figure 2 EU-27 Digital Economy and Society Index 2020 Scores



Source: DESI 2020

Based on the progress made in 2015-20 across each dimension, on average, EU-27 Member States have mainly improved their performance in **connectivity** (demand and supply side of fixed and mobile broadband), **use of internet** (the number of people using the internet and the type of activities performed online) and **digital public services** (demand and supply of digital public services, and the availability/quality of open data)**. Integration of digital technology** and **human capital** have progressed at a relatively slower pace. Overall, however, the majority of EU Member States have not progressed significantly with DX since 2015.

The key conclusions on the overall performance of Member States across these five dimensions, based on the DESI 2020 results, are as follows[20]:

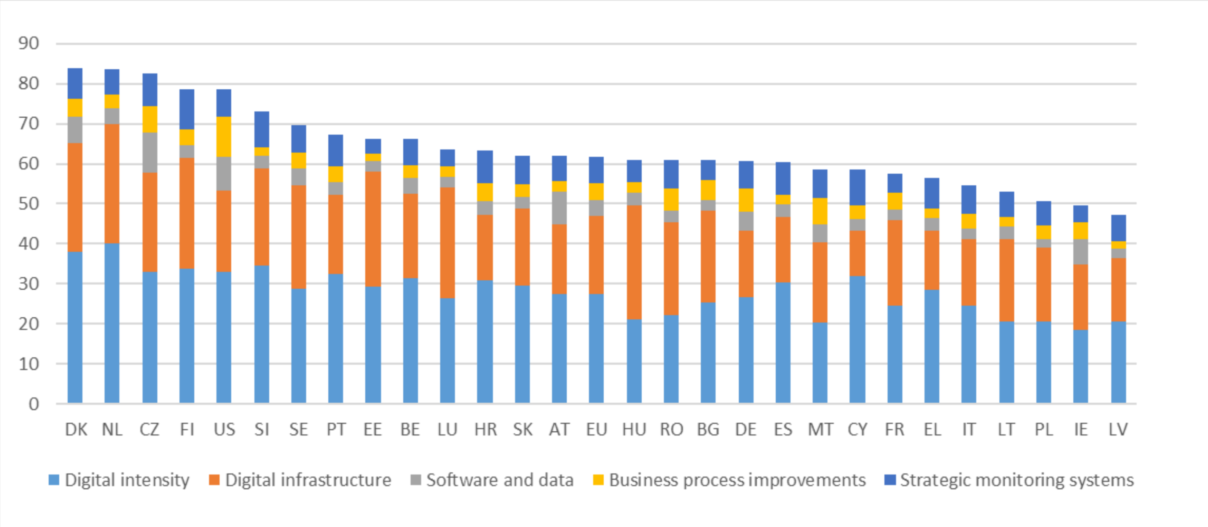
- Even though **connectivity** has improved over time, still more efforts are needed to foster investment in 'Very High Capacity Networks', both fixed and mobile, to address fast growing needs. So far, only 17 Member States have provided access to the 5G radio spectrum;
- More progress in **digital skills** is needed. 42% of the EU population still lacks at least basic digital skills, while enterprises report that filling vacancies for ICT specialists is a key challenge;
- **Use of internet services** (such as the consumption of online content like videos, music, and games, as well as video calls, online shopping and banking that are used by individuals for personal entertainment and as part of their professional or business life) have increased sharply due to the pandemic, despite already being at high levels before the crisis;
- Even though **enterprises are increasingly integrating digital technologies**, **SMEs still lag behind large businesses in the adoption of nearly all technologies,** despite being connected to the internet at the same rate. The biggest adoption gaps are in **digitalisation of internal organisational processes,** advanced cloud services, big data analytics and e-commerce;
- There is a rising trend in the usage of **digital public services** in the areas of **eGovernment** and **eHealth**, which allows for increased efficiency and cost savings for governments and businesses, improved transparency, and greater participation of citizens in political life.

The **European Investment Bank Digitalisation Index** is another tool for monitoring the comparative progress of EU Member States in terms of the **digital technology adoption of firms** and the **quality of currently available infrastructure and investment.** Member States are ranked on the basis **of five digitalisation pillars,** with firm level information collected through the 'European Bank Investment Survey' (EIB, 2020). Based on the 2019/2020 results, Denmark, Netherlands, Czechia and Finland were the European digital frontrunners (outperforming the US). Slovenia, Sweden, Portugal, Estonia, Belgium, Luxembourg, Croatia, Slovakia and Austria outperformed the EU average. Greece, Italy, Lithuania, Poland, Ireland and Latvia were the weakest performers. This survey

[20] See: https://ec.europa.eu/commission/presscorner/detail/en/IP_20_1025

approach allows recent developments to be identified, and does not aim to capture hard data, such as frequency of internet usage or online transactions.

Figure 3 EIBIS Digitalisation Index



Source: European Investment Bank Investment Survey (EIBIS) 2019 (EIB, 2020).

1.3.5 *Differences between EU-27 and non-EU Countries*

The **International Digital Economy and Society Index (I-DESI)**[21] aims to replicate EU DESI by using 24 datasets to benchmark the digital performance of 45 countries: the EU-27 and 18 non-EU countries around the world (Australia, Brazil, Canada, Chile, China, Iceland, Israel, Japan, Mexico, New Zealand, Norway, Russia, Serbia, South Korea, Switzerland, Turkey, United Kingdom, and United States).

According to the findings of I-DESI 2020 (Foley et al., 2021), EU-27 Member States performed better than the 18 non-EU countries in the dimension of 'connectivity' (the deployment and take-up of fixed and mobile broadband) and 'digital skills'. Non-EU countries, on the other hand, performed better in the dimensions of 'citizen use of internet services' and 'digital public services'. In general, EU-27 Member States compared well with the 18 non-EU countries, with the highest performing EU-27 countries having similar or higher levels of digital performance than the best performing non-EU countries. Finland was the leading Member State in the I-DESI index and part of the 'EU Top 4' together with Sweden, the Netherlands and Denmark. The EU top 4 ranked among the top ten global performers, in second place after the US, followed by Switzerland, Norway, Iceland, Australia, and Israel. The EU Top 4 also outscored Korea and Japan. However, average EU digital performance was lower than all the previously mentioned countries, although better than that of China, Russia, the EU Bottom 4, Serbia, Mexico, Brazil and Chile.

In terms of the **Integration of Digital Technology** dimension, which measures the digitalisation of businesses (i.e. technology availability and technology absorption) as well as e-commerce (i.e. selling online and using secure internet servers), average EU-27 performance increased in 2017 for the first time since 2013. However, it slipped behind again in 2018, when ten out of the 18 non-EU countries were ranked above the EU-27 average on this dimension, led by Switzerland and Israel, followed by the top four EU-27 Member States: Finland, Sweden, the Netherlands and Denmark. The normalised performance scores of EU-27 Member States in 2018 differed to varying degrees from those of the non-EU countries under consideration, across the following indicators:

- Availability of the latest technology: EU-27 (51.8) vs non-EU countries (58.8);
- Business technology absorption: EU-27 (41.8) vs non-EU countries (47.7);
- e-Commerce - SMEs selling online : EU-27 (29.1) vs non-EU countries (43.6) ;
- e-Commerce - secure internet services : EU-27 (36.0) vs non-EU countries (27.9).

21 For more information on I-DESI, see: https://ec.europa.eu/digital-single-market/en/news/i-desi-2020-how-digital-europe-compared-other-major-world-economies

1.4 *The benefits and impacts brought about by the digital transformation of SMEs*

The wider **benefits of digitalisation for SMEs include:** improved financial performance as a result of optimising revenue channels and reducing costs; productivity gains leading to greater efficiency; access to new customers through expanded geographical reach; and more access to information along with more productive processes to foster innovation (Deloitte, 2020).

DX is reported to bring benefits in three broad areas: industrial management, marketing, and access to knowledge resources. Many researchers suggest that ICT innovations can **boost the efficiency and effectiveness** that is fundamental for economic growth and is also a critical factor for sustainable competitiveness in the global marketplace. A wide range of research emphasises the **rapid growth** of SMEs when they integrate ICTs into their **business processes** and thereby benefit from increased opportunities in **international markets** such as global collaborations, improved awareness of business opportunities across global value chains, and the ability to form new relationships with business partners and customers. Likewise, the digitalisation of **business models** offers a number of advantages: **cost reductions, a wider selection of products, richer and more transparent/traceable information through blockchain solutions, and a rise in performance efficiency and sufficiency** by improving market orientation, task management and advanced market knowledge. In particular, the integration of **internet and web-based technologies** provides a digital means of delivery of services and/or products to the consumer. It also provides a mechanism for communication that enhances interactions with customers, as well as image and product development, leveraging sales and revenues and expansion into international markets much earlier and faster than without the use of digital tools. Digitalisation also facilitates **knowledge acquisition and enhances business networking**, which empowers SMEs to interact more widely and closely with others, such as customers, investors, local authorities, business partners, suppliers and multinational enterprises, all of which creates sustainable competitive advantages. In addition, it allows new working conditions and training options for employees (Thrassou, et al., 2020).

DX improves labour productivity and therefore firm productivity (Abel-Koch et al., 2019). The use of digital technologies for monitoring and optimising production processes can **improve the workflow and help optimise production inputs** in terms of volume, as well as in terms of characteristics that allow **customised production**. It can also improve the production of goods and services through standardisation and **increases in quality and speed of production** (DigitaliseSME, 2020). Overall productivity gains are a function of digital technologies, a firm's organisational capital and management skills, and the realisation of complementary investments and innovations associated with business process improvements and task automation. As a result, the full realisation of productivity gains can be expected to be a lengthy process (Sorbe et al., 2019).

DX permits the supply of digital goods and services, as well as the development of customised goods and services. In addition to the development of virtual platforms and other types of digital goods, companies making use of digital analytics can harness data relating to customer preferences to design goods that are perfectly tailored according to individual preferences (DigitaliseSME, 2020).

DX allows access to new markets. Digital marketing and online platforms can be used to identify and reach out to potential consumers. Digital technologies also give access to global value chains through collaboration technologies, e-commerce platforms, and production of digitally advanced goods and services. **DX brings revenue growth to SMEs through internationalisation, as well as increased competitiveness within their national market** (OECD, 2019)**.** Meanwhile, **the adoption of digital practices by one firm can impact the performance of its (global) value chain collaborators.** Collaboration platforms, social networks, augmented/virtual reality, cloud computing and crowdfunding generate value through linking physical capital and labour across a given value chain. This involves three modes of adoption of digital technologies: digitalisation and integration of vertical and horizontal value chains; digitalisation and customisation of products and services; deployment of digital business models and customer access (Savastano et al., 2018).

The adoption of digital practices by one firm impacts the performance of its competitors. Providing that a welcoming business environment and good access to skilled labour are both in place, DX increases market competition. Within any given industry, firms which are more productive often benefit most from the adoption of digital technologies, as a result of becoming early adopters and therefore becoming better placed to launch complementary reorganisation of production processes (Sorbe et al., 2019).

In terms of the **deployment of specific digital technologies** by SMEs, the following benefits were identified in the first roundtable of the OECD D4SME[22]:

- **Digital infrastructure and platforms:** Access to affordable and reliable **digital infrastructure** is critical for helping SMEs to compete in just-in-time and data-driven production systems and to scale up internal capacity (e.g. by accessing platform services such as **cloud computing**). Access to **digital platforms** can help SMEs lower transaction costs (e.g. related to finding information, negotiating prices, monitoring transactions or trading) and to reach **new markets;**
- **AI:** The deployment of AI, in combination with other technologies, can enable SMEs to make important productivity gains by providing unique insights into their business and market. Thanks to **IoT**, which is based on the hyper-connectivity of sensors, devices, and systems that support machine-to-machine communication, a high quality and volume of **data** can be gathered and exchanged through high speed **5G** , and then leveraged using **AI and data analytics** to empower new data-driven business models;
- **Blockchain and Distributed Ledger Technologies (DLTs):** These technologies can be beneficial to SMEs by allowing an immediate and secure transfer of value and ownership within a decentralised digital network, without an intermediary and in total transparency. This facilitates international trade, supply chain management, payments and transparency, impacting productivity and access to finance, reducing transaction costs, and enhancing ecosystem collaboration, while helping address the counterfeiting issue in global trade flows. Financial services and systems architecture are currently the primary focus of blockchain-based solutions, but these solutions also have the potential to transform a wide range of other industries such as healthcare, social services, advertising, education, food and logistics;
- **Fintech:** The financial sector is at the forefront of digital innovation and fintech has already largely transformed the industry. SMEs and entrepreneurs have benefited from these developments by gaining access to a broader range of financing sources that better meet their needs in terms of ease and access. Fintech holds promise for different types of SMEs, including innovative SMEs and startups, underserved segments and established SMEs that have previously used traditional lending channels, allowing them to benefit from lower transaction costs, better credit risk assessment and customised and rapid services.

Effective adoption of digital technologies and practices is expected to unlock net benefits of approximately USD 100 trillion globally between 2016 and 2025 (World Economic Forum, 2018). While DX leads to job losses, the net outcome is expected to be positive; new jobs are expected to be generated due to complementarities with skilled labour (Sorbe et al., 2019).

1.5 The digital transformation of SMEs and the impact on sustainability

1.5.1 Sustainable Development Goals (SDGs) for meeting the 2030 Global Agenda

The sustainable development goals (**SDGs**) of the '**2030 Agenda for Sustainable Development**', adopted by the UN in Sept 2015, provide a shared blueprint for peace and prosperity for people and the planet, establishing an urgent call to action involving all countries in a global partnership.[23] The **Paris Agreement**[24] signed in Dec 2015, aims to strengthen the global response to the threat of climate change, while achieving **UN SDGs**. One of the most important characteristics of the 2030 Agenda is its universality, relevant to all communities, from local to global. SDGs cover a broad range of topics related to sustainable development, defined under 17 goals with 169 targets. In general, SDGs, as an integrated framework, fall into 3 main categories[25] related to the economy, the biosphere/environment, and the social/societal (Belyaeva & Lopatkova, 2020):

- **Biosphere** covers topics related to **climate change** (i.e. SDG 13 - Climate Action), aimed at reducing emissions, ensuring resilience to natural disasters, and enhancing the ability to act; **natural resources** covers SDG 6 - Clean Water and Sanitation, SDG 14 - Life Below Water, and SDG 15 - Life On Land, with the goal of conserving these domains;
- **Society** covers the topics of basic human needs, amenities and utilities, and a fair and just society (i.e. SDG 1 - No Poverty, SDG 2 - Zero Hunger, SDG 3 - Good Health and Well-being, SDG 4 - Quality Education,

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[22] https://www.oecd.org/cfe/smes/latestdocuments/D4SME%20First%20Roundtable%20Proceedings.pdf
23 https://sdgs.un.org/goals
24 https://ec.europa.eu/clima/policies/international/negotiations/paris_en
25 https://gesi.org/research/download/36

SDG 5 - Gender Equality, SDG 7 - Affordable and Clean Energy, SDG 11 - Sustainable Cities and Communities and SDG 16 - Peace, Justice and Strong Institutions);

- **Economy** covers the following topics related to **inclusive growth and sustainable industry**: SDG 8 - Decent Work and Economic Growth, SDG 9 - Industry, Innovation and Infrastructure, SDG 10 - Reduced Inequalities, and SDG 12 - Responsible Consumption and Production.

Since 2015, the EU has been at the forefront of international efforts to implement the **2030 Global Agenda** and the SDGs. The aim is to transform the EU into a modern, resource-efficient and competitive economy, with **no net emissions of greenhouse gases by 2050,** as targeted by its new post-2020 growth strategy, the **EU Green Deal**.[26] This approach has been further highlighted in the EU's new economic recovery plan, **NextGenerationEU,** announced in May 2020, which focuses on establishing an economy that works for people and the planet by taking action in the areas of economic stability, social fairness, environmental sustainability and productivity and competitiveness. These high level strategic objectives are reflected in various other EU policies, including, among others, the new **EU Industrial Strategy**[27], the new **EU SME Strategy**,[28] **Shaping Europe's Digital Future**,[29] and the new **Circular Economy Action Plan.**[30] The goal is to support industry in becoming greener, more circular and more digital, in order to remain competitive, resilient, and sustainable on the global stage. As stated in the **EC 2021 Work Programme**,[31] EC actions will remain guided by the 2030 Agenda and its SDGs, both internally and externally, as well as by the Paris Agreement.

Taking into account the 2030 Global Agenda, this chapter aims to provide brief insights from recent academic publications about the relationship between DX and its impact on the sustainability commitments of SMEs, discussed from economic, societal and environmental perspectives.

1.5.2 Relevance of the Fourth Industrial Revolution (4IR), Industry 4.0 and the Circular Economy to SDGs

4IR is the current era, in which multi-modal adoption of different advanced digital technologies and Key Enabling Technologies (KETs) are constantly evolving and merging with other new technologies (such as bioengineering, geoengineering, the Internet of Everything (IoE), neurotechnology, and new computing technologies) to connect the different digital, physical and biological spheres. The **digital sphere** includes 3D printing, AI, big data analytics, blockchain, cloud technology, digital twins, industrial IoT, quantum computing, robotics, and virtual/augmented reality (VR/AR). The **physical sphere** includes advanced/nano materials, nano devices, next-generation batteries, organ microchips, and wearables. The **biological sphere** includes bioinformatics, next-generation genomics, personalised medicine, stem cells, synthetic biology, and systems metabolic engineering.[32] The 4IR has been evolving at an exponential pace since the middle of the last century, with a unique velocity, scope, and systems impact, disrupting almost every industry globally by transforming entire systems of production, management, and governance, as defined by the World Economic Forum in its 4IR Initiative.[33]

The following **4IR technologies have been indicated as most relevant for environmental applications by the World Economic Forum's 'Fourth Industrial Revolution for the Earth' initiative**[34]: 3D Printing used in additive manufacturing; advanced materials (including nanomaterials); advanced sensor platforms (including satellites); artificial intelligence; biotechnologies; blockchain (and distributed ledger); drones and autonomous vehicles; energy capture, storage, and transmission; geoengineering; internet of things; neurotechnology; new computing technologies such as quantum computing and DNA-based solid state hard drives; robotics; virtual, augmented and mixed reality.

Likewise, in the discussion paper drafted by the **European Policy Center (ECP)** (Hedberg & Šipka, 2020), the following digital technologies and digitally enabled solutions are presented as having potential for bringing about various sustainability solutions: 3D printing or additive manufacturing; AI; applications or apps for computers,

26 https://ec.europa.eu/info/strategy/priorities-2019-2024/european-green-deal_en
27 https://ec.europa.eu/info/sites/info/files/communication-eu-industrial-strategy-march-2020_en.pdf
28 https://ec.europa.eu/info/sites/info/files/communication-sme-strategy-march-2020_en.pdf
29 https://ec.europa.eu/info/sites/info/files/communication-shaping-europes-digital-future-feb2020_en_3.pdf
30 https://ec.europa.eu/environment/circular-economy/
31 https://eur-lex.europa.eu/resource.html?uri=cellar%3A91ce5c0f-12b6-11eb-9a54-01aa75ed71a1.0001.02/DOC_1&format=PDF
32 https://www.pwc.com/ee/et/publications/pub/innovation-for-the-earth.pdf
33 https://www.weforum.org/agenda/2016/01/the-fourth-industrial-revolution-what-it-means-and-how-to-respond/
34 http://www3.weforum.org/docs/WEF_Harnessing_the_4IR_for_the_Earth.pdf

tablets and mobile devices; blockchain; cloud computing; data sharing built on barcodes, blockchain, quick response (QR) codes, radio frequency identification devices (RFIDs), and watermarks; digital twins; earth observation, satellite imagery, sensors, cameras, drones and robots; IoT and connected devices; and online platforms.

Even though the term **Industry 4.0** evolved simultaneously and is used interchangeably with 4IR, it actually originates from a strategic initiative in Germany (Industrie 4.0) within the ‘High-tech Strategy 2020’,[35] announced in 2010, aimed at making the German manufacturing industry more competitive. As a sub-domain of 4IR, Industry 4.0 has became a global term, along with other terms such as ‘Smart Factory/Industry’, ‘Smart Manufacturing’, ‘Intelligent Factory’, ‘Factory of the Future’, etc. All of these terms are used to describe more or less the same vision of modernisation of the manufacturing industry achieved through implementation of Industry 4.0. The term can be defined as the current trend for utilising automation and data exchange in manufacturing technologies by bridging the physical and digital worlds via cyber-physical systems enabled by Industrial IoT (IIoT), cloud computing and cognitive computing, allowing for personalisation/customisation of smart products (i-SCOOP, 2021).

Another focus of recent academic research is **the combined impact of 4IR digital technologies and the circular economy (CE) concept on SDGs.** The combination of 4IR technologies and CE, with its associated tools such as life cycle costing, life cycle impact assessment, materials passports, and circularity measurements, has been implemented in a number of sectors, in a variety of countries, in order to move away from a linear ‘take, make, and dispose’ model to a more circular model, with demonstrably positive results for the environment and economy. Three types of technologies can be used to transition into a CE and sustainable future: **Digital technologies** such as big data, blockchain, IoT, and RFID help enterprises track capital and manage excess capability and usage. **Physical technologies** such as 3D printing, energy recycling and processing, modular construction, nanotechnology, and robots, help businesses reduce manufacturing and product costs and minimise the environmental impact. **Biological technologies** such as bio-based materials, biocatalysts, bio-energy, hydroponics and aeroponics, help businesses move away from fossil fuels (Hoosainet al., 2020).

1.5.3 Impact of 4IR, Industry 4.0 and the Circular Economy on SDGs

Technological advances and innovative techniques have potential as powerful tools for achieving the UN SDGs (Chui et al., 2018), with some SDGs benefiting more than others. However, the impacts on SDGs are not always positive. There have also been studies showing negative impacts. For instance, a recent study (Vinuesa et al., 2020), reports that while AI might act as an enabler of technological improvement for 134 targets (79% of all SDGs), for 59 targets (35% of all SDGs) the impact might in fact be negative. In order to better understand if and how 4IR technologies can be used positively to address SDGs, various arguments concerning the positive and negative impacts will be briefly presented here.

The ‘Fourth Industrial Revolution for the Earth’ publication series produced by WEF in collaboration with PwC and the Stanford Woods Institute, groups emerging applications of 4IR technologies for the earth into 5 main categories that could address climate change: **clean power; smart transport systems, sustainable production and consumption; sustainable land use; smart cities and homes** (Herweijer & Combes, 2017). For instance, in terms of **clean power**, **smart grids,** connected via the cloud and utilising the IoT, big data analytics and ML, can significantly increase the **energy efficiency** of the existing grid. Enhanced predictability of demand and supply of renewables can also improve energy storage and load management and assist in the integration and reliability of renewables. The energy performance and affordability of renewables and battery storage solutions can also be increased using innovations such as nanobattery solutions, designer carbon, graphene applications and perovskite solar cell coatings (all of which are advanced materials), neural network controlled solar boost converters (AI), and 3D solar panels (3D printing). A distributed peer-to-peer grid, which leverages distributed renewables, can be facilitated through a fusion of AI, big data, blockchain, cloud and IoT.

Sustainable production and consumption involving adoption of IIoT, which combines smart machines, smart materials, and smart products across an entire industrial value chain, results in advanced production, optimised for the resource efficiency of energy, raw materials and water, while enabling connection with customer devices to optimise lifespan performance. Wider 4IR technologies incorporated into the IIoT platform to optimise smart

[35] https://ec.europa.eu/digital-single-market/en/blog/implementation-industry-40-strategy-german-plattform-industrie-40

product design include: energy efficient robotics, industrial big data analytics, intelligent machine applications, and sensor-driven computing and VR product simulators. IoT connected sensors and blockchain can revolutionise the ability to track and monitor products from origin to supply chains, ensuring increased transparency and accountability with regard to sustainable manufacturing and consumption.

In addition, the following 4IR technologies can be combined to provide five **game-changing climate solutions linked to SDGs 7 and 13** (Affordable and Clean Energy, and Climate Action) and thereby underpin a net zero emissions economy: **electrification of the transport system**, fusing AI, advanced materials, big data, cloud and IoT; **next generation distributed grid,** fusing AI, advanced materials, big data, blockchain, cloud and IoT; **smart and transparent land use management**, fusing AI, autonomous vehicles (drones), big data, cloud and IoT; **smart and automated road transport grid**, fusing autonomous vehicles, cloud, big data and IoT; **technology enabled urban planning and design**, fusing 3D printing, AI, advanced materials, autonomous vehicles, big data, cloud and IoT.

Despite all the potential benefits that can be gained by deployment of 4IR technologies to address climate change, particular attention should be given to the unintended consequences which might also ensue, since a number of 4IR technologies could have unintended negative consequences if not designed and scaled in a smart and sustainable way. Among the potential **negative impacts** are job displacements, infringements of data privacy, cyber security problems, and biotechnology 'bio errors'. In order for 4IR technologies to be used successfully for the planet and for society, innovators, industry and governments need to come together to shape flexible and robust national and international technology governance structures that will enable a 'responsible' 4IR (Herweijer & Combes, 2017).

The **Global Enabling Sustainability Initiative (GeSI)**[36] also defines **seven digital technologies** (digital access, fast internet, cloud, IoT, cognitive, digital reality (VR&AR), and blockchain) which have a **critical influence on the world**. In its 'Delivering A Smarter2030' report (GeSI & Deloitte, 2019), GeSI uses a framework of four '**impact functions**' to assess the link between these technologies and their impact on SDGs:

- **Connect & Communicate:** Connecting people to each other and to critical information;
- **Monitor & Track:** Real time, extensive observation of the world and its natural and built systems;
- **Analyse, Optimise and Predict:** The development of insights from data, and the use of those insights to drive process efficiency and infer the future;
- **Augment & Autonomate:** Provision of an 'active bridge' between digital and physical, from simulation through augmentation to the creation of autonomous systems.

The report uses this framework to establish links between each target and the seven digital technologies, and to categorise **how digital technologies can impact the SDGs**. It focuses on 103 of the total 169 SDG targets which are not primarily reliant on policy, financial support or non-digital interventions. Analysis across a range of SDGs estimates **an average acceleration of 22% in SDG progress** and a **23% mitigation of downward trends** by deploying existing digital technologies. However, while the increased adoption of digital technologies is expected to help close the gap in some of the 2030 targets, the performance of 8 out of the 25 indicators analysed is still expected to deteriorate.

Analysing the impact of digital technologies across **the three sustainability pillars of economy, environment/biosphere and society**, the report estimates the positive and negative impacts of DX for each pillar, as summarised in Table 2.

[36] https://gesi.org/

Table 2 Estimated positive and negative impacts of DX against major impact functions

Key Pillars	Major impact functions	Estimated positive impacts on SDGs	Estimated negative impacts on SDGs
Economy	• *Monitoring supply chains* accurately to create transparency in production • *Optimising processes* to increase productivity while reducing energy and material usage and emissions.	The global deployment of Industry 4.0 is estimated to have the potential to increase global manufacturing value added per capita from around $1,800 to over $2,700 in 2030, of which 22% of this increase can be attributed to Industry 4.0.	• Greater divide between developed and less developed economies • Increase in consumption as wealth increases • Increase in job displacements • Increase in system-wide risk from centralised control and cyber attacks.
Environment/ Biosphere	• *Monitoring and tracking* the state of the natural world (SDGs 6, 14, 15); • *Analysing and optimising* energy and material usage across sectors to minimise the impact of climate change (SDG 13); • *Augment and autonomate* to reduce emissions across agriculture, industry and manufacturing.	Adoption of digital technology is estimated to reduce CO2e by 668 metric tons, equivalent to 1.3% of global emissions in 2030, as a result of increased efficiency via process optimisations in agriculture, transportation, energy networks, manufacturing, and by managing water use through deployment of smart water infrastructures.	• Increase in emissions directly related to ICT technology deployment • Increase in extraction of scarce resources • Increase in e-waste, such as increased proliferation of IoT devices.
Society	• *Connecting* the unconnected and vulnerable to basic digital access, to enable financial inclusion, education and empowerment • *Analysing & predicting* to accelerate drug and crop developments by use of AI/ML and the computing power promised by the cloud. • *Monitoring, tracking and analysing* complex datasets to reduce poverty and hunger, disaster impact, education and health outcomes. • *Autonomating* machines to transform agriculture as well as city utilities, services, and security provisions.	Adoption of digital technologies is expected to have positive impacts across different areas, from sustainable and productive agriculture, skilled birth attendance, youth literacy, access to electricity, renewable energy consumption, air pollution, and reproductive rights.	• Increase in inequalities • Reduction in resilience of core society supporting systems unless cyber security is ensured • Spread of misinformation leading to lack of trust in society unless transparency and truth are ensured.

Source: Authors' interpretation of GeSI 'Delivering A Smarter2030' report (GeSI & Deloitte, 2019)

The previously mentioned impacts of DX on sustainability have also been highlighted by a number of other researchers. For instance, the emergence of the **internet of things (IoT)** has enabled the delivery of huge amounts of data, providing valuable information on managing natural resources more effectively and thereby avoiding natural disasters. IoT in Agriculture has provided valuable information generated by connected devices which analyse the soil to determine water needs for smarter irrigation.[37] Furthermore, **big data** can play a powerful role with regard to the **environment**, due to its ability to help companies understand and measure the **impacts of their operations on the environment** (Nardone, 2015). In addition, data has always been key to **assessing ecological risks**. Another added value of big data relates to its contribution to helping companies **optimise the usage of energy and other resources by** tracking data in real time through the deployment of new generation **smart meters and sensors** (Yifat, 2017).

A recent study (Corfe, 2020), focusing on the role played by **4IR technologies in improving the environment**, identifies a number of channels for tackling the environmental challenges associated with air pollution and global warming. These include: better monitoring of air quality by using affordable low power wide area networks (LPWANs); provision of more personalised advice on air pollution; use of emerging technologies (e.g. robotic

[37] http://digital-me-up.com/2017/05/05/the-impact-of-digital-innovation-on-the-planet/

trees, parasitic drones, air-cleaning buses and air separation plants) to remove pollution and carbon from the air; cleaning up transportation by shifting to electric and autonomous vehicles, car sharing, smart public transportation and dynamic road pricing; using big data and blockchain-based solutions to encourage environmentally friendly decision making by consumers and businesses by presenting the carbon emissions of their purchases at point of sale; decarbonising industry by using green commercial vehicle fleets, cloud computing, virtual and augmented reality and 3D printing.

Many more application areas of digital technologies and their various impacts on each SDG domain have also been mapped by Hoosain et al (2020) in their research on the use of digital technologies to address SDGs through circularity.

As reported in the UN SDG progress report, the **circular economy (CE)** holds particular promise for achieving multiple SDGs, particularly those connected with clean energy, economic growth, sustainable cities, responsible consumption and production, climate change, oceans, and life on land.[38]

Using 4IR technologies to achieve the goal of 'Responsible Consumption and Production' by adopting **circular innovation** could increase energy efficiency and reduce waste by putting re-use, remanufacturing, and recyclability at its core. Furthermore, accelerating circularity across global supply chains could generate over US$1 trillion annually by 2025 across the global economy (Herweijer & Combes, 2017), with the move from a linear model towards a more CE model generating as much as US$4.5 trillion globally by 2030 (Jose et al., 2020).

There has been a significant acceleration towards the CE by using 4IR digital technologies (Ramkumar, 2018). Although the CE applications are associated with SDGs (Mattero et al., 2018; Schroeder et al., 2018), the combined impacts of digital technologies and the CE on SDGs (Corfe, 2020) have only recently been the focus of research (Ellen MacArthur Foundation, 2019; Ghoreishi & Happonen, 2020)**.** Hoosain et al (2020) have investigated the relationship between DX and the CE in terms of achieving the SDGs. The 4IR technologies are viewed as enablers to enhance the CE across industries in three main ways**: through circular infrastructure optimisation; through building objects, parts, and components based on the circularity concept; and through the function of circular business structures**. The authors emphasise the importance of bringing together the concepts of 4IR digital technologies and the CE, in collaboration with international organisations and multiple stakeholders from politics, industry, academia and civil society, in order to have a positive impact on sustainability and achieving the SDGs.

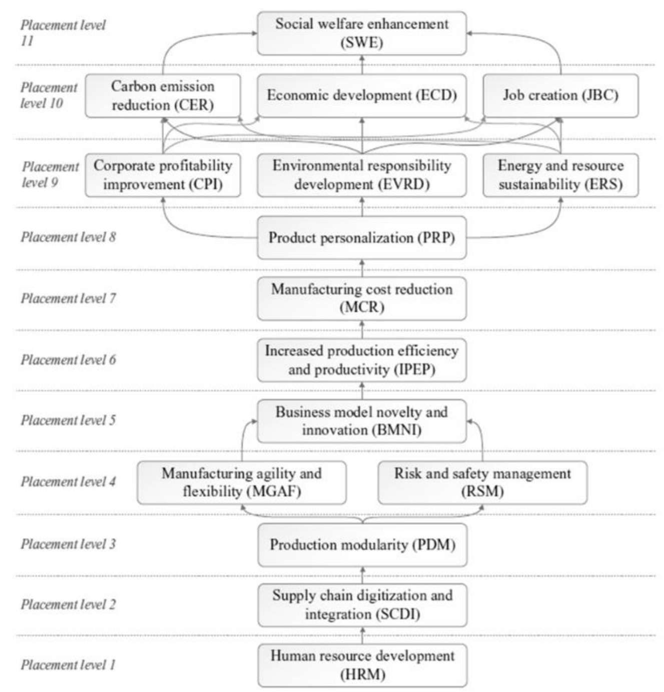
The role of **Industry 4.0 within the 4IR** has also became another research focus area. Further exploration is required regarding the impact of Industry 4.0 on sustainability as it grows exponentially, as well as its implications for sustainability in terms of economic, environmental, and social impacts. The digital connectedness and real time information development and sharing offered by Industry 4.0 may have contradictory impacts on SDGs (Lopes de Sousa Jabbour et al, 2018a; Lopes de Sousa Jabbour et al, 2018b). Digitalisation of manufacturing and business processes and the deployment of smart machines and devices may offer numerous advantages, such as increased manufacturing productivity, resource efficiency, and waste reduction (Tortorella & Fettermann, 2018). However, increased productivity due to industrial automation is also likely to be associated with higher resource and energy consumption as well as elevated pollution concerns (Beier et al., 2017; Liu & Bae, 2018). DX of the manufacturing industry using labour saving technologies (e.g. intelligent robots, autonomous vehicles, and cloud solutions) is also expected to severely disrupt labour markets by replacing the majority of low skilled jobs with new, highly skilled jobs, such as automation engineering, control system design, machine learning, and software engineering (Brougham & Haar, 2018; Frey & Osborne, 2017).

A recent study (Ghobakhloo, 2020) has attempted to develop an interpretive model of **Industry 4.0 sustainability functions** by explaining the processes of industrial digitalisation and the underlying **technology trends** (i.e. additive/advanced manufacturing, AR/VR, automation and industrial robotics, big data analytics, blockchain, cloud computing, cyber-physical production systems, cybersecurity, IIoT, Internet of People, Internet of Services, semantic technologies, simulation and modelling) and **design principles** (i.e. decentralisation, horizontal integration, interoperability, modularity, product and service individualisation, real time capability, smart products and factors, vertical integration, virtualisation) in order to assess their impact on SDGs. The study provides an explanation of ways in which the processes of Industry 4.0, including underlying technology trends

38 The Sustainable Development Goals Report 2018:
https://unstats.un.org/sdgs/files/report/2018/TheSustainableDevelopmentGoalsReport2018-EN.pdf

and design principles, can positively contribute to the achievement of SDGs. The modelled **Industry 4.0 sustainability functions** are expected to impact SDGs as illustrated in the figure below.

Figure 4 Impact of Industry 4.0 sustainability functions on a firms' SDG performance



Source: (Ghobakhloo, 2020)

The position paper published by the European Policy Centre (EPC) (Hedberg & Šipka, 2020) aims to show how digitalisation can support environmental protection and climate action, and how DX can be made more sustainable. In particular it looks at **greening ICT** and how digitalisation can enhance sustainable consumption and production (i.e. the circular economy), improve biodiversity, and make agriculture and mobility more sustainable. Digital solutions using innovative business models could be utilised for greening the economy, and improving the design of products. They could support people's right to repair, help improve resource and energy efficiency, reduce emissions, minimise waste and encourage dematerialisation (i.e. doing more with less materials). Digital solutions could also enhance governance, including the implementation and enforcement of relevant rules needed to protect biodiversity, and could boost the circular economy and help to achieve climate neutrality. On the other hand, concerns about the **negative impacts of 4IR technologies** have also been raised. These mainly concern the environmental footprint of the ICT sector itself (e.g. high consumption of energy and materials for data centres, digital devices and digital infrastructures; the waste created by the sector, etc.), along with an increase in wasteful consumption and energy- and transport-related emissions. In addition, there are negative implications for privacy, security (i.e. cyber attacks), health (i.e. radiation, hazardous substances), and potential job prospects, together with unwanted societal impacts, such as a rise in inequality. As a result, calls have been made for **responsible use of DX** by fully addressing the downsides of going digital in order to turn DX into a catalyst for creating a sustainable economy instead.

1.5.4 Linkages between SMEs, DX and SDGs

A sustainable economy includes **sustainable businesses**; therefore, understanding the drivers and measurement of a firm's successful transition to sustainability is necessary (Delmas, Lyon, & Maxwell, 2013).

Even though there is plenty of academic research which aims to explore the roadmap to sustainability (Eccles & Krzus, 2015; Gray & Stites, 2013; Joyce & Paquin, 2016; Nidumolu et al., 2009), there are still only limited studies available which provide empirical evidence explaining the link between the drivers of DX and sustainability and the impact of DX on the sustainability commitment of companies.

In a recent academic research paper (El Hilali et al., 2020), **the link with/impact of DX on a firm's sustainability** is investigated empirically, by studying Moroccan SMEs from different industries. The authors define five different hypotheses in the light of current literature and use a partial least squares structural equation model (PLS-SEM) to test (empirically) the **effect of DX on sustainability at firm level**. The hypotheses are based on four drivers linked to DX: **customers, competition, data,** and **innovation,** as explained below:

- **Customers** are at the heart of any DX and have a positive influence on companies' commitments to sustainability in the digital era;
- **Competition** in the digital era has a positive influence on companies' commitment to sustainability through publication of their carbon footprints. Additionally, the way that companies compete in the digital era has changed, as they frequently collaborate in order to learn from each other, while still remaining competitors;
- **Data** (i.e. data related to business processes, products or services, and customer data on both supply and demand side) as a strategic asset in the digital era, enhances both the relationship between company and customer, as well as the company's commitment to sustainability;
- **Innovation** in the digital era is a key driver of companies' commitment to sustainability, especially through **business model innovation** (Foss & Saebi, 2016; Zott & Amit, 2017), **digital social innovation** (Andrea, 2017) as well as innovations that lead to the emergence of **platform business models,** particularly **sharing economy solutions** (Porter & Kramer, 2011)**,** which benefit the environment by reducing the amount of goods produced and waste to be recycled following the **circular economy** concept. (Evans et al., 2017) Proposals which set out the foundational concepts for innovation in sustainable business models, such as sustainable value, should incorporate economic, social and environmental benefits as value forms; an innovative business model also requires the design of a new business purpose, value proposition and governance; in addition it requires the creation of a system of sustainable value flows that include all the stakeholders involved (Evans et al., 2017).

The **results** of the study of Moroccan SMEs affirm the **positive influence of customers, data and innovation on the quest of companies to reach sustainability**, whereas competition did not play a significant role. The authors conclude that on the road to achieving sustainability in the digital era, consideration should be given to adopting a **customer-centric approach** and building a culture that **embraces data**. Secondly, DX is not exclusive to large companies. SMEs could also adapt their business models, change the way customers are perceived, exploit data and rediscover innovation, not only for DX, but also to observe positive sustainability impacts (El Hilali et al., 2020).

In brief, DX is about using digital capabilities (such as big data, cloud computing and IoT) to revolutionise the customer experience, to outdo the competition and to create an innovative business model adapted to the digital era (Westerman, 2011). To link it with sustainability, a DX should help companies to increase their financial numbers and social footprint and reduce their negative externalities on the environment.

Since there is a constant symbiosis between the three elements of sustainability: **people** (social aspect), **planet** (environmental aspect) and **money** (economic aspect), these must be embedded into the business model and corporate report of the company. The latest literature assumes that the integration of sustainable goals into the **business model** can result in competitive advantage, increased company value, and a positive image and reputation for the business (Evans et al., 2017).

A sustainable mission statement should be translated into specific sustainable goals that the company will strive to achieve. The **environmental and social goals** are considered to be an integral part of the **economic logic** of the business. Frameworks such as the SDGs aim to help SMEs to understand the scope of the global sustainability issues, while providing a practical blueprint to guide companies in improving their economic, social and environmental performance. According to a study by the International Trade Centre (ITC) (2019), investing in SMEs in developing countries contributes to the SDGs through four main impact channels as follows: **employee impacts** (SDGs 1, 2, 3, 8); **business practice impacts** (SDGs 5, 8, 9, 10, 12, 13, 14, 15, 16); **sectoral impacts** (SDGs 2, 3, 4, 6, 7, 9, 11); and **national economy impacts** (SDGs 1, 8, 9, 10, 17). Through these channels, investments in SMEs can contribute to 60% of the 169 SDG targets. The two SDGs which stand out as benefiting most from strengthened SMEs are 'Decent Work and Economic Growth' (**SDG 8**) and 'Industry, Innovation and Infrastructure' (**SDG 9**). Further benefits arising from the key role played by SMEs in achieving various SDGs have been reported by Karlstorm (2018). These include: promoting inclusive and sustainable economic growth; promoting sustainable industrialisation and fostering innovation; improving health and well-being; and reducing income inequalities at local level by providing good quality jobs and working conditions. Malaquias et al. (2016) found a positive and significant relationship between the IT usage of SMEs in Brazil and the four categories of corporate social responsibility (CSR): economic, legal, ethical and discretionary. Jucan & Baier (2012) present the **implications of the use of ICT for CSR** activities in tourism businesses in emerging markets and also examine the relationship between e-sustainability and competitiveness. ICT-based services can improve the efficiency of processes and systems for multiple stakeholders (Lakatos et al., 2015; Santoro et al., 2018), and can support the **strategic** (improved customer relations), **tactical** (improved contract administration) and **operational** (improved data management) **sustainable benefits that SMEs can gain by using ICT tools**. **ICT can help to make CSR information** more easily available to stakeholders and create new possibilities for linking information on company impacts with other sources, providing easier access to information online that can be used to develop sustainable awareness (Jucan & Baier, 2012).

The business models of SMEs were compared **against a framework of social and economic SDGs** in a survey of 750 European SMEs in the food and beverage industry in **Western European** (Germany, Spain, UK) and **Central and Eastern Europe** (Croatia, Poland and Russia). The empirical results revealed that the **sustainable approach in Western and Eastern European countries was structured around the social and economic SDGs (1, 3, 4, 8, 11, 12, 16, 17) excluding environmental SDGs.** SMEs from both Western and Eastern European countries contributed to 'Good Health and Well-Being' (**SDG 3**) by providing healthy and safe working conditions and encouraging work-life balance. SMEs from Western Europe were more active in 'Responsible Consumption and Production' (**SDG 12**), implementing lean production to save resources, producing high quality products with minimal impact on the environment and providing full information about the origin of the product components on the packaging. They also tried to achieve 'Peace, Justice and Strong Institutions' (**SDG 16**) by meeting international standards and obtaining certificates on management standards, as well as by attaching great importance to recruiting and training local community members (**SDG 1 ‑ No Poverty and SDG 8 ‑ Decent Work & Economic Growth**). Eastern European SMEs formulated their ethical principles in cooperation with business partners; raised the awareness of their employees and customers about social and environmental issues and encouraged them to participate in sustainable activities (**SDG 4 ‑ Quality Education**); and communicated their commitment to socio-environmental activities to their stakeholders to encourage greater engagement (**SDG 11 ‑ Sustainable Cities & Communities**). Additionally, the survey findings indicate a positive relationship between the social responsibility strategy and ICT used by SMEs in all six countries. Engaging with the SDGs can provide a roadmap to business improvement and offer a way to stand out in the global arena. As a result of these empirical findings, combined with a literature review, the researchers conclude that the concept of **digitalisation can be an effective factor in the sustainable development of SMEs** (Belyaeva & Lopatkova, 2020)**.**

1.5.5 Drivers and challenges for SMEs to take sustainable actions using digital technologies

SMEs face the following drivers and challenges, which are both internal and external to their business, when taking sustainable actions by deploying digital technologies:

1.5.5.1 External drivers and challenges

The ICT sector plays a vital role as an **enabler** for a more sustainable economy and society via innovative business models that support the realisation of SDGs, particularly through CE practices, as previously explained. At the same time, the existing **negative side effects of the ICT sector** pose **key challenges** that need to be tackled, especially at a time of accelerated deployment due to the COVID-19 pandemic (Hoosain et al., 2020). Data centres, supercomputers, digital devices, IoT and digital infrastructures often require high levels of energy and resource consumption (i.e. initial mining of both abundant and rare materials and the impact of further activity across the value chain). The **waste created by the sector** is another growing problem, in addition to the implications for **privacy** (i.e. misuse of personal data due to data leaks and non-compliance with GDPR)**; security** (i.e. cyber attacks); **personal health** (i.e. radiation, hazardous substances); **job prospects;** and **growing inequalities** (GeSI & Deloitte, 2019; Hedberg & Šipka, 2020). The ICT sector currently accounts for around 2% of global greenhouse gas (GHG) emissions, which is comparable to the aviation sector (Avgerinou et al., 2017), and is expected to increase to more than 14% by 2040 (Belkhir & Elmeligi, 2018).

The survey of SMEs in the food and drink industry in a selection of Western and Eastern Europe countries reveals that a diverse mix of **emerging externalities** forms a special environment for the **development of sustainable business models**. Among the **analysed externalities**, the surveyed SMEs attributed the greatest importance to three factors: 1) the increased importance of intangible business assets, such as image or long-term relationships with customers to meet their constantly changing and increasing needs; 2) the increased level of competition based on sustainability; and 3) the development of ICT. There are many ways, including adoption of the tools of

Industry 4.0, that allow companies to update and create more innovative strategies in order to open up new opportunities for business development, as well as to impact social and environmental performance (Belyaeva & Lopatkova, 2020).

The positive impact of the **CE** on the transition to sustainability can be considered as a driver of sustainable actions by SMEs. However, since this transition to the CE is quite slow in low and middle-income countries compared to its fast acceleration in developed countries such as EU Member States, the CE cannot be seen as a meaningful driver in those countries which have yet to boost their performance on implementing the SDGs. Major differences exist in terms of the perception of whether the implementation of CE activities can make a meaningful contribution to economic growth, employment, and sustainable development (Wright et al., 2019). The shortfalls in implementation/contribution are associated with a lack of the following: government interventions and policies in the form of cross-departmental collaborations; business incentives; impact assessments on the economic, social, and environmental impacts on local communities; education; data required for monitoring and reporting; digital talent to improve existing technologies (Hoosain et al., 2020).

Another important factor that can be seen as both a driver and a challenge in terms of the formation of business sustainability is **standardisation.** Sustainability reporting is mainly defined by organisations such as the International Standardization Organisation (ISO)[39] and the Global Reporting Initiative (GRI), [40] among others. The aim is to define and unify **non-financial reporting (NFR)** as an indicator of efforts taken by firms to support UN SDGs (Bose, 2020). The **GRI** standards help organisations to understand their outward impacts on the economy, environment, and society by linking GRI standards with the SDGs and by providing a suite of tools to integrate SDGs into reporting. This increases the accountability of firms and enhances the transparency of their contribution to sustainable development. Under European Directive 2014/95/EU, large companies in EU Member States are required to provide a series of **environmental, social and governance (ESG) disclosures,** whereas this is a purely **voluntary requirement for SMEs.** What makes NFR challenging is the **lack of convergence in its definition between regulators, quasi-regulators and standard-setters**, as well as the **heterogeneity of NFR practices by leading sustainable firms** (Stolowy & Paugam, 2018). Likewise, **no generally accepted definition of this term exists** among academics (Tarquinio & Posadas, 2020). It is mainly referred to as **non-financial information** or by using underlying concepts such as 'social/environmental/human capital' or 'CSR reporting' instead (Erkens et al., 2015). Researchers find a positive association between ESG disclosure levels and firm value, suggesting that improved transparency, accountability and enhanced stakeholder trust play a role in increasing firm value (Li et al., 2018).

1.5.5.2 Internal Drivers and Challenges

Moore and Manring (2009) define various internal **drivers** which optimise SME sustainability, such as: i) to become a valuable **investment target for large firms,** since large firms aiming to venture into new sustainable markets and/or business segments find it less expensive to do so through investing in or acquiring SMEs; ii) by **creating highly competitive networks** of sustainable SMEs across the value chain that help to generate progress and provide financial and organisational efficiency towards sustainable development; iii) by becoming highly efficient **suppliers to global supply chains** by implementing sustainable practices.

The SMEs surveyed in the study of SMEs in the food and drink industry in Western and Eastern Europe reported the following benefits of taking sustainability actions: an increase in stakeholder loyalty and brand strength; improvement in staff motivation; and enhancement of financial indicators and sales. However, there were some differences in the perceived benefits reported by Western and Eastern European SMEs. Western European companies highlighted an increase in the loyalty of internal stakeholders, improved relations with the local community and more positive perceptions of investors (external stakeholders), whereas Eastern European SMEs highlighted improved financial indicators as a key benefit (Belyaeva & Lopatkova, 2020).

There seems to be a correlation between SMEs **using sustainable strategies** and the following business conditions: (1) **a sustainable company mission statement**; (2) **knowledge of CSR and SDG terminology**; (3) **country of origin** of SME; (4) **company usage of ICT and e-Commerce** (5) **level of Gross Domestic Product (GDP)** in the country in which the SME is located (i.e. the higher the GDP, the higher the number of SMEs implementing

[39] https://www.iso.org/news/ref2469.html
[40] https://www.globalreporting.org/about-gri/news-center/2021-01-21-enabling-companies-to-report-on-the-sdgs/

sustainability measures). The research findings indicate a **positive relationship between the social responsibility strategy and ICT used by SMEs in six Western and Eastern Europe countries**. Consequently, since **digitalisation is linked with sustainable development**, SMEs should be supported in achieving DX in order to realise these double benefits (Belyaeva & Lopatkova, 2020).

Non-financial reporting (NFR) is gaining global momentum, most notably in relation to environmental matters, as investors and the public at large ask for more relevant and reliable information to support investment decisions in the context of sustainable finance. Conducting business sustainably by integrating ESG objectives into the business model has more or less become mainstream for innovative companies and is seen as an opportunity for brand enhancement, attracting both talent and customers to the firm.[41]

In spite of the reported benefits, there are particular **challenges for SMEs** in implementing sustainable solutions which mainly leverage digital technologies. The main challenges are: **lack of access to finance for implementing sustainable changes**; **lack of knowledge, skills and capacity**, particularly regarding business development; **insufficient skills in marketing and strategic management; and lack of time** (Belyaeva & Lopatkova, 2020; Johnson & Schaltegger, 2016; Lessidrenska, 2019; Morioka et al., 2018). The biggest concern for SMEs is the return on investment, therefore it is crucial to recognise that interventions which reduce a business's negative impact can create long term value as well as save costs (Karlstorm, 2018).

1.6 *Policy recommendations*

As stated in the EC communication, '**Shaping Europe's Digital Future**',[42] the EU aims to turn the ongoing DX into a catalyst for creating a sustainable economy. This requires **alignment of the digital and green transitions** through recovery strategies that benefit from and contribute to greening the European economy by investing in the skills, sectors, products, services and digital technologies that can address climate, biodiversity and wider environmental challenges. The **European Green Deal** and its spinoff policy initiatives, along with the **EU Multiannual Financial Framework for 2021-27**, coupled with the **Next Generation EU - COVID-19 recovery package**, all aim to define these high level strategies and corresponding action plans to make this twin transition happen.

Based on this literature review, it is clear that DX comes with proven benefits as well as challenges for SMEs, while creating a **digital divide** between SMEs and LEs, smaller and bigger SMEs, and traditional and innovative SMEs, among others. Academics, along with organisations which support SMEs and sustainable development (e.g. the European Digital SME Alliance,[43] SME United,[44] the European Policy Centre (ECP),[45] OECD D4SME,[46] WEF 4IR4Earth,[47] GeSI[48] etc.) have made **key policy recommendations** through various position and research papers for supranational and national policymakers aimed at unlocking the full potential of sustainable DX, as highlighted below.

In terms of the various **internal and external challenges faced by SMEs in their DX journey** (e.g. lack of capacity and capability, time, funding, awareness, as well as digital security, data privacy, availability and accessibility, regulatory barriers, connectivity, interoperability, etc.) as elaborated in the previous sections (Thrassou, Uzunboylu, Vrontis, & Christof, 2020), there are various clusters of recommendations related to **digital technologies** (e.g. artificial intelligence, big data, blockchain ecosystems, cloud computing solutions, fintech, online platforms, etc.) and their impacts on the economy, society, climate, and environment, in addition to **cross-cutting domains**, all of which require that policy interventions be designed by taking into account the size, age and sector of SMEs (OECD, 2021).

Promoting **long term policy dialogue and cooperation among various stakeholder groups** in order to define and **set international standards and regulations for harmonisation** is viewed as a priority by D4SME. Likewise, to ensure that inclusive and sustainable global growth delivers the SDGs, it is crucial that **4IR digital technologies**

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[41] https://insights.nordea.com/en/sustainability/why-small-businesses-should-bother-about-esg/
[42] https://ec.europa.eu/info/sites/info/files/communication-shaping-europes-digital-future-feb2020_en_3.pdf
[43] https://www.digitalsme.eu/
[44] https://www.smeunited.eu/
[45] https://epc.eu/en/
[46] https://www.oecd.org/going-digital/sme/
[47] https://www.weforum.org/projects/fourth-industrial-revolution-and-environment-the-stanford-dialogues
[48] https://gesi.org/

and circular economy concepts be brought together by **global collaboration with multiple stakeholders** from international organisations, politics, industry, academia, and civil society.[49] Additionally, the need for an **integrated approach to policy making** in the digital age is underlined, since DX impacts many policy domains. The recently published OECD **'Going Digital Integrated Policy Framework'** defines its seven interrelated policy dimensions as: 1) **access to communication infrastructures, services and data**; 2) **effective use of digital technologies and data**; 3) **digital and data-driven innovation**; 4) **good jobs for all**; 5) **social prosperity and inclusion**; 6) **trust in the digital age**; 7) **market openness in digital business environments**. It also defines intersecting policy domains (e.g. data, digital government, skills and SMEs) which cut across several policy dimensions (OECD, 2020). **The complementarities which exist between various policies** aimed at addressing market failures impeding DX underline the benefits of taking **concerted action,** which can increase the benefits of reforms by 20% in the average OECD country. Based on OECD best practices, effective use of **monitoring and evaluation techniques, in combination with impact assessment techniques,** are also indicated as key elements in improving the **design, efficacy and agility of a policy mix aiming to achieve DX** (Sorbe, Gal, Nicoletti, & Timiliotis, 2019).

Governments should seek to develop deeper understanding of the needs and challenges experienced by SMEs in digital adoption. They should also aim to **raise digital awareness** by sharing best practices, ideas, and interesting SME success stories about the benefits of digital technologies for addressing their specific business needs, in parallel with providing **incentives for digital deployment**. Furthermore, in order to foster digital adoption, it is crucial to provide **hands-on guidance and support services** which developing clear roadmaps, in combination with **financial support**. Financial instruments, tax benefits and targeted regulatory reforms can all improve **access to finance** (OECD, 2017)**. Supply side interventions** aimed at improving access to finance should include grants, loans and guarantee schemes. These types of interventions should involve investment and capital gains tax incentives for entities investing in young firms, along with co-investment funds and fund of funds (OECD, 2015). **Demand side interventions** should focus on shaping a strategic vision and improving awareness of available sources of finance. Such interventions should **leverage networks**, such as cluster organisations, incubators, accelerators, SME support associations, business angels, as well as matchmaking services, to help companies access finance. **Regulatory interventions** should target access to finance through effective and predictable insolvency regimes, improved market competition polices (aimed at freeing financial resources), easing the development of fintech solutions. Through the decentralised consensus recording of successful debt repayment or default, **Distributed Ledger Technologies (DLTs)** can allow high quality and low risk SMEs to credibly present their risk class to credit institutions, thereby reducing information asymmetries (Wang, Lin, & Luo, 2019; Benedikt & Weinhardt, 2019). Both **trade and supply finance** could benefit from more widespread use of **blockchain technology**, while blockchain-based smart contracts which define and automatically execute the terms and penalties of an agreement could support trust and reduce the administrative burden (Morris, 2019). The development of **knowledge brokers** could support DX by fostering the emergence of a digital ecosystem, reducing the skills gap through effective knowledge and resource sharing (Lin, Strahonja, & Plačko, 2019). **Digital Innovation Hubs (DIHs)**[50] often function as knowledge brokers. Their operation is associated with: a) incentivising cooperation between SMEs and large enterprises, establishment of collaboration networks and sharing of best practices in risk taking, training and use of financial resources; b) the emergence of novel forms of digital organisation and digital institutional infrastructure and building blocks, such as new standards and modules; c) better access to finance for SMEs; d) the formation and maintenance of networks of excellence, living labs, and platforms for learning and exchange of best practices; e) improved connectivity between research institutions, universities, SMEs and the public sector to address the lack of digital talent.

In parallel, particular attention should be paid to **skills and education** by promoting dialogue on how to upgrade workforce skills, and by redesigning education to reap the benefits of digitalisation (D4SME). **The development of training, mentoring and workshop services, as well as business advisory services** has demonstrated a positive effect on DX through upgrading the technical and managerial skills of the workforce (Sorbe, Gal, Nicoletti, & Timiliotis, 2019; OECD, 2017). For example, the EC-funded **DigitiliseSME** initiative[51] piloted a scheme for SMEs undergoing digital transformation. Each participant SME was temporarily paired with a digital enabler, who

[49] https://www.weforum.org/projects/fourth-industrial-revolution-and-environment-the-stanford-dialogues
[50] https://ec.europa.eu/digital-single-market/en/digital-innovation-hubs-dihs-europe
[51] More information relating to the initiative can be found here: https://digitalisesme.eu/about-digitalisesme/

assessed their specific needs in order to propose the most appropriate digital solutions. The outcomes were highly effective and useful, based on the testimonials of the beneficiary SMEs.[52]

The recommendations that are **directly linked to technologies** (e.g. digital infrastructure, including connectivity, data accessibility and data platforms, can be categorised as follows (D4SME, 1st and 2nd Roundtables):[53]

- **Digital infrastructure and platforms:** Ensure reliable, accessible and affordable connectivity, cybersecurity and fair access to data; acquire knowledge and develop and attract skills; develop effective e-government initiatives to stimulate SMEs to digitalise and to reduce red tape and regulatory burdens for SMEs; regulate digital platforms at international level in order to ensure fairness, access to data and fair taxation; make e-commerce platforms more affordable and remove regulatory constraints;
- **AI:** Better communication, education and training to raise SME awareness of the value of AI by highlighting the importance of infrastructure, data, software and talent in democratising AI; enable data partnerships and data sharing across the economy while addressing key concerns about privacy protection and accountability; coordination between national AI policies and global AI principles to guide new technology developments, including those related to ethics, cybersecurity and privacy; support international efforts to set global standards;
- **Blockchain and DLTs:** Develop **clear and effective regulation** in the short to medium term through targeted approaches such as establishing technology hubs; encourage SMEs to use blockchain in their processes by funding feasibility studies and incentivising pilot projects; ensure **global policy coordination** with regard to **setting international standards** to avoid **regulatory inconsistencies between countries;** foster dialogue between all stakeholders concerned; encourage firms to invest in blockchain solutions; **educate and bring together policymakers, regulators and entrepreneurs to increase awareness** about the technology, exchange best practices and discuss ways of accelerating its development; implement policies on developing **DLTs, focusing on governance, interoperability, privacy, security, transparency, scalability and accessibility;**
- **Fintech:** There is a need for more and better data to improve policy design, evaluation and adaptation. Although recourse to fintech services is still highly concentrated in a specific section of the SME population, namely high-growth firms with a global outlook, it is important for policymakers and regulators to consider how fintech developments can respond to the diverse needs of the wider SME population. A regulatory framework should be established that allows experimentation, while safeguarding consumers and investors, digital security and privacy, and increasing the financial literacy and skills development of SMEs. The push towards digitisation in 2020, especially in fintech, as a direct result of the COVID-19 pandemic, is expected to push fintech into a digital breakthrough in 2021.[54] Cloud computing is seen as a key strategic technology for the DX of the financial sector and **public cloud solutions** are becoming increasingly important due to their flexibility and scalability, as well as for their high quality security and resilience standards. The recent gathering together of European financial institutions into the '**European Cloud User Coalition**',[55] to strengthen the public cloud ecosystem for the entire financial industry, can be seen as an evidence of this approach.

In terms of **digital infrastructure and platforms** and the importance of affordable, **high speed internet connectivity for accelerating digital adoption** among firms, especially in remote (rural) areas (Sorbe et al., 2019), one solution for improving broadband coverage in rural areas would be to incentivise private investment, for example by offering special tax breaks, reduced spectrum costs or low interest loans. Alternatively, if private investment is not financially viable, another option would be direct government investment. Best practice, according to the OECD, should be to couple better access to affordable internet connectivity with technical enablers, such as 5G networks, and should also involve the introduction of pro-competitive reforms, such as encouraging the emergence of new industry entrants and enabling infrastructure sharing (OECD, 2017). Another related key recommendation is to ensure that the **digital infrastructure becomes more sustainable** by introducing requirements and financial incentives for **developing and deploying ICT equipment that utilises circularity and is energy-efficient, leading to fewer emissions and reduced material consumption**. Governance and economic instruments should be used to **reduce the climate footprint of data centres** by enhancing their

[52] https://digitalisesme.eu/resources-digitalisesme/
[53] http://www.oecd.org/going-digital/sme/,
https://www.oecd.org/cfe/smes/latestdocuments/D4SME%20First%20Roundtable%20Proceedings.pdf
[54] https://www.fintechsurge.com/news/10-fintech-predictions-from-our-experts-on-what-will-define-2021
[55] https://www.euroclear.com/newsandinsights/en/press/2021/2021-mr-02-european-cloud-user-coalition.html

energy efficiency and encouraging the use of renewable energy sources. For example, when the **European Data Space is established**, the European Policy Centre suggests **optimising the management and analysis of data relevant to climate action and the protection of the environment.** In addition, the ECP also recommends reducing barriers to the **free flow of information across value chains** to enable the development of a **sustainable circular economy** by keeping all stakeholders informed about the use, repair, recycling and disposal of products. Better coordination and exchange of information in value chains can enhance transparency, while creating the basis for **utilising** smart circular **concepts**, such as improved product environmental footprints and digital product passports (Hedberg & Šipka, 2020). Moreover, as underlined in the '**European Social Partners Framework Agreement on Digitalisation'**,[56] protecting both workers and business functions from the potential health and safety risks of new technologies should also be an important consideration within the relevant policy frameworks.[57] Additionally, because a crucial element of the digitalisation process for SMEs is the capability to work remotely and thereby continue their business activities online, **SMEUnited** suggests supporting SMEs to adopt **cloud-based teleworking** by providing channeled financial incentives such as the subsidising of digital hardware and software investments.[58]

In the '**Manifesto for Europe's Digital Future'**,[59] the **European Digital SME Alliance** formulates recommendations under priorities such as: introduction of a digital tax and ending tax inequalities; setting up a modern and fair market competition framework; unleashing the full potential of the data economy through public-private partnerships involving data, creation of data sharing pilot projects, open access to public sector data and enforcement of GDPR**;** reciprocity of access to public procurement markets; cutting down bureaucracy costs; strengthening the role of DIHs in supporting SMEs and boosting digital infrastructure to the next level; improving access to finance for risk prone projects; creation of geographic areas with conditions that are favourable to the development of new technologies (i.e. a 'sandbox environment') to ignite Europe-led innovation; unlocking standards by involving SME representation into the process; paving the way for EU-led AI; closing the digital skills gap; building a sustainable and inclusive digital Europe.

In order to achieve **sustainable DX,** ECP suggests developing and deploying **digital solutions to support and accelerate the greening of the economy and society**. This could be achieved by investing in digital solutions that could help to enhance biodiversity, climate neutrality, the circular economy, sustainable consumption and production and contribute to zero pollution as well as to the green transition, especially in agriculture, mobility, energy, and other industrial processes. Additionally, new requirements and financial incentives could be introduced for developing and deploying **circular and energy-efficient ICT equipment**, increasing product eco-design requirements, such as **recycled content quotas**, and implementing the **right to repair for smart devices**. Market-based tools could also be introduced, such as **public procurement for greener ICT** (Hedberg & Šipka, 2020).

The **European Digital SME Alliance** suggests addressing the remaining hurdles in a holistic manner by taking all **three components of a sustainable DX** into account: sustainable B2B digitalisation; green(er) technologies and a circular economy; and an innovation-enabling policy and regulatory framework that builds on an openness to achieving the green and digital (twin) transitions.[60]

In the report, **Digital with Purpose: Delivering a SMARTer2030** (GeSI & Deloitte, 2019), the authors envisage a **smarter and more sustainable world**, achieved via responsible, ICT-enabled transformation. They suggest developing and deploying digital technologies with positive societal impacts in mind, through a globally shared vision based on 3 pillars:

- **Commitments for all:** by embracing transparency and collaboration and by recommitting to the 2030 agenda and SDGs through harnessing the power of digital technologies to support these commitments;
- **Leadership by the ICT sector:** by mitigating negative impacts, operating responsibly and collaborating with the key or partner sectors involved in delivering the 2030 agenda, such as agriculture and fisheries, consumer and industrial products, energy, financial services, healthcare, transport, and public services;

[56] http://erc-online.eu/wp-content/uploads/2020/07/Final-22-06-20-with-signatures_Agreement-on-Digitalisation-2020.pdf
[57] https://www.smeunited.eu/admin/storage/smeunited/digital-for-smes-2nd-roundtable-agenda-3-4-february-2021.pdf
[58] https://www.smeunited.eu/news/smeunited-participates-in-oecd-roundtable-digital-for-smes
[59] https://www.digitalsme.eu/manifesto/
[60] https://www.digitalsme.eu/digital/uploads/Position-paper-Sustainable-Digital-Transformation_FINAL-2.pdf

- **Roles for each of the key stakeholder groups,** such as individual businesses and key business sectors, citizens, governments, institutional investors and NGOs.

Digital technologies will play a key role in helping the EU to achieve **climate neutrality** (i.e. a reduction of 55% in GHG emissions by 2030 and climate neutrality by 2050), in addition to strengthening its global competitiveness. For this reason, the **digital and green transitions should be mutually reinforcing.**[61] Meeting the EU's climate ambition will require industry to reduce CO2 emissions from industrial processes by increasing energy efficiency, as a result of transitioning to renewable energy and sustainable resources, and increasing circularity, among other solutions.[62] As reported by the **European Economic and Social Committee (EESC),**[63] stepping up Europe's 2030 climate ambition can only be achieved through a holistic approach and genuine participation and ownership by all actors at all levels, using the '**European Climate Pact'** stakeholder platform, which is based on inclusiveness and transparency principles, to ensure the transformation is just and fair.

Recently launched policies and regulations set out by the EC can be viewed as evidence of real commitment from the EU to achieving sustainable digital transformation throughout Europe. Some of the many examples include: the **Digital Markets Act,**[64] to ensure fair and open digital markets; the **Digital Services Act,**[65] to ensure a safe and accountable online environment; the **Data Governance Act,**[66] to establish European Data Spaces for sharing public data; the proposed **Climate Law**,[67] to achieve climate neutrality by 2050, mainly by cutting emissions and investing in green technologies; the new **Circular Economy Action Plan,**[68] for a cleaner and more competitive Europe; the new **EU Cybersecurity Act;**[69] the **FinTech Action Plan,**[70] the Pan-European **Blockchain Regulatory Sandbox**,[71] the **White Paper on AI**[72] and an updated version of the **Coordinated Plan on Artificial Intelligence**[73] to be announced in April 2021, which will ensure the responsible use of AI, including human oversight.

In order to achieve sustainable DX, the EC is also putting intensive effort into **digital skills development** aimed at reskilling/upskilling the current labour force, decreasing youth unemployment, elevating the digital skills literacy of European citizens, and bridging the digital skills gap between labour market needs and education/training providers, by defining sector specific curricula, among other approaches. The **European Pillar of Social Rights**[74] is one of the most important social strategies of the EU in terms of ensuring socially fair and just transitions to climate neutrality, digitalisation and equal opportunities/access to the labour market. The expected launch of the **Action Plan to implement the European Pillar of Social Rights** will take place in the first quarter of 2021. The EC is also encouraging Member States to include digital skills development actions in their national recovery plans when applying for financial support via the **Recovery and Resilience Facility.**[75] In addition, the **European Skills Agenda**[76] sets objectives across 12 action lines to be achieved by 2025. The goal is to develop more and better skills in order to achieve the twin transitions by strengthening **sustainable competitiveness** as defined in the **European Green Deal**; ensuring **social fairness** as the first principle of the **European Pillar of Social Rights**; and building **resilience** in responding to crises. The **Pact for Skills**[77] was recently launched by the EC as the very first action set out in the European Skills Agenda. It builds on other EU initiatives for multi-stakeholder cooperation such as the **Blueprint for Sectoral Cooperation on Skills**;[78] the **renewed European Alliance for Apprenticeships**;[79] and the **Digital Skills and Jobs Coalition**.[80] Additionally, **Centres of**

[61] Commission Communication Stepping up Europe's 2030 climate ambition.
[62] Circular Economy Action Plan (COM (2020) 98 final.
[63] https://www.eesc.europa.eu/en/about
[64] https://ec.europa.eu/info/strategy/priorities-2019-2024/europe-fit-digital-age/digital-markets-act-ensuring-fair-and-open-digital-markets_en
[65] https://ec.europa.eu/info/strategy/priorities-2019-2024/europe-fit-digital-age/digital-services-act-ensuring-safe-and-accountable-online-environment_en
[66] https://ec.europa.eu/digital-single-market/en/news/proposal-regulation-european-data-governance-data-governance-act
[67] https://ec.europa.eu/clima/policies/eu-climate-action/law_en
[68] https://ec.europa.eu/environment/circular-economy/pdf/new_circular_economy_action_plan.pdf
[69] https://ec.europa.eu/digital-single-market/en/eu-cybersecurity-act
[70] https://ec.europa.eu/info/publications/180308-action-plan-fintech_en
[71] https://ec.europa.eu/digital-single-market/en/legal-and-regulatory-framework-blockchain
[72] https://ec.europa.eu/digital-single-market/en/artificial-intelligence
[73] https://ec.europa.eu/digital-single-market/en/news/excellence-and-trust-ai-brochure
[74] https://www.socialplatform.org/what-we-do/european-pillar-of-social-rights/
[75] https://ec.europa.eu/info/business-economy-euro/recovery-coronavirus/recovery-and-resilience-facility_en
[76] https://ec.europa.eu/social/main.jsp?catId=1223&langId=en
[77] https://ec.europa.eu/social/main.jsp?catId=1517&langId=en
[78] https://ec.europa.eu/social/main.jsp?catId=1415&langId=en
[79] https://ec.europa.eu/social/main.jsp?catId=1147&intPageId=5234&langId=en
[80] https://ec.europa.eu/digital-single-market/en/digital-skills-and-jobs-coalition

Vocational Excellence (CoVEs)[81] have recently been established to bring together a wide range of local partners, such as providers of vocational education and training, employers, research centres, development agencies, and employment services, among others, to develop "skills ecosystems" that contribute to regional, economic and social development, as well as to innovation and smart specialisation strategies. The recently launched **Digital Education Action Plan** (2021-27)[82] outlines the EC's vision for high quality, inclusive and accessible digital education in Europe and is a call for action to achieve stronger cooperation at European level to make education and training systems fit for the digital age. There are also plans to develop an **EU Competence Framework for Green Skills**[83] which will define EU strategy for enhancing green skills and competences for all.

1.7 *Key takeaways*

First, it is key to better understand by all stakeholders what DX means along with potential benefits, negative and positive impacts before setting up policy and regulatory framework to unluck its full potential. Even though interchangeably used, it is a journey started with **digitisation** that enabled **digitalisation** and collectively lead towards **DX** over time. It is defined as a fusion of advanced technologies that integrates physical and digital systems and when combined with innovative business models and processes, leads to the creation of smart products, services and significant improvement of productivity by the EC. DX is not just about technology but about **transformative changes** that affect the way the value is created and captured inside a given company such as transforming the **customer experience** by building on data analytics, transforming **internal processes** as well as the **business model**. **Customer centricity, innovation capability, operational excellence using data capabilities and a competitive mind-set are** indicated as **key success factors** in transforming a firm digitally to remain competitive in the future.

4IR is the current era in which multi-modal adoption of different advanced digital and KETs are constantly emerging with the new ones such as bioengineering, new computing technologies, geo-engineering, neurotechnology and Internet of Everything (IoE) connecting digital, physical and biological spheres to one another. Even though the term **Industry 4.0** is evolved simultaneously and used interchangeably with 4IR, it can be defined as the automation and data exchange in manufacturing technologies by bridging the physical and digital world through cyber-physical systems enabled by IIoT, cloud computing and cognitive computing that allows personalization/customization of smart products. Over the past years, the use of **4IR and Industry 4.0 technologies** together with **CE** concept gained more importance for the transition from a linear towards more circular model, which has shown positive results on the environment and economy.

Key challenges that are internal to SMEs during DX can be grouped under three main categories as the lack of: awareness and availability of digital technology and tools required for DX due to lack of good connectivity, digital tools and services; capacity to engage in DX in terms of time and funding; capability to combine digital strategy with a concrete business model, integration with the existing technology and business processes, migration from previous systems and decommissioning old technologies. Thus, **SMEs are in need of technical support** for: defining their requirements; selecting the right products, technologies or suppliers; planning and initiating their DX; understanding the regulations in addition to **financial support** for implementation and **training to fill digital skills gap**. Lack of international standards, regulatory barriers, lack of affordable and accessible digital infrastructure, interoperability, cyber attacks, lack of availability and access to public data and digital platforms etc. are indicated among **key challenges external to SMEs.**

Major benefits brought by DX to SMEs are: an increase of financial performance by optimising revenue channels and reducing costs; productivity gains leading to greater efficiency through greater use of digital; access to new customers through expanded geographical reach; and more access to information and more productive processes that fosters innovation.

Connectivity, online presence, process digitalisation and automation, cloud-based services, collaboration and communication seem to be the **main purposes for SMEs to adopt digital technologies.** Under the **connectivity and online presence** where fixed and/or mobile broadband are the key enabler, on-line communication and

[81] https://ec.europa.eu/social/main.jsp?catId=1501
[82] https://ec.europa.eu/education/education-in-the-eu/digital-education-action-plan_en
[83] https://www.eesc.europa.eu/en/our-work/opinions-information-reports/opinions/towards-eu-strategy-enhancing-green-skills-and-competences-all-own-initiative-opinion

collaboration, e-commerce, internet-based solutions to reduce customer interactions, contactless payments, QR codes for direct ordering etc. are seen as common use cases. **Process automation and digitalisation** had a large spectrum of applications from e-signature to more sophisticated connected sensors and hardware ecosystems for reduction of contact processes to automation using connected devices with machine-to-machine communication under Industry 4.0. **Cloud-based services** makes it possible to access data and services (e.g. CRM, ERM, ERP, collaborative apps, workflow and management apps etc.) remotely from any place at any time through any internet-enabled device. When looked from **impact function** perspective, digital technologies mainly adopted for the following purposes: Connect and Communicate; Monitor and Track; Analyse, Optimise and Predict; Augment and Automate.

The global pandemic caused by **Covid-19** seem to add both complexity and opportunities to the SMEs. In general, SMEs are in a struggle for survival since **pandemic caused** drops in customer demand and fall in revenues, supply chain disruptions and challenges balancing employee capacity and welfare among others. **SME priorities shifted** from growing and resourcing business to finding new customers, managing business costs, streamlining business and staff, finding new revenue streams. Additionally, Covid-19 is expected to have profound implications on **progress towards the SDGs**, most of them to be impacted negatively while the impact on the ones related to life on land, below water, climate, and sustainable production and consumption are unclear at the moment.

With regards to the impact of **DX on SDG performance,** 4IR technologies when used responsibly in combination with CE concept are stated to bring sustainable solutions under Clean Power, Smart Transport Systems, Sustainable Production and Consumption, Sustainable land-use, Smart Cities and Homes as well as offering **game-changing climate solutions** around energy and to underpin a zero-net-emissions economy. However, a particular attention should be given against potential negative impacts that can vary from the impacts of automation on jobs, to data privacy, and cyber attacks. **Regarding the effect of DX at firm level sustainability**, adopting **customer-centric approach** and building a culture that **embrace data** and **innovation** seem to have a positive influence on companies' quest to reach sustainability. There is also a positive relationship between the social responsibility strategy and ICT used by SMEs and digitalisation.

There are **external challenges** such as **negative side-effects of the ICT sector** itself (e.g. data centers, computing, digital devices, IoT and digital infrastructures) requiring high levels of energy and resource consumption in addition to the **waste created by the sector** and other concerns around privacy, security; personal health; job prospects and growing inequalities that hampers the DX towards sustainability. However, if **circularity** measures are taken into account, the negative externalities of the sector can be turned into an opportunity and when combined with government interventions and policies in the form of cross-departmental collaborations, incentives towards businesses, assessments on the economic, social, and environmental impacts on local communities, education, data to monitor and report, talent to improve existing technologies, DX contributes to sustainability. The evolving field of non-financial and ESG reporting which is voluntary for the SMEs pose challenges to the firms to gather right data for reporting. Particular **challenges for SMEs to implement sustainable solutions by leveraging on digital technologies** are lack of access to finance for implementing sustainable solution, lack of knowledge, skills and capacity particularly regarding business development, insufficient marketing and strategic management skills, and lack of time.

Main drivers for SMEs to optimise sustainability solutions are indicated as becoming valuable investment targets for larger firms, creating highly competitive networks of sustainable SMEs, and becoming highly efficient suppliers in global supply chains by implementing sustainable practices. Regarding **benefits brought by taking sustainability actions** are reported as an increase in stakeholder loyalty and brand strength, improvement in staff motivation and enhancement of financial indicators and sales. Conducting business sustainably by integrating ESG objectives into the business model has seen as an opportunity for brand enhancement, attracting talent and customers by innovative SMEs.

As agreed by various stakeholders, meeting the '**Climate Neutrality**' as well as the '**Global 2030 Agenda**' operationalised through **UN SDGs** is possible if ongoing DX can be turned into **sustainable DX** and **used with purpose** to act as a catalyst to ensure the alignment between the **digital and green (twin) transitions** as targeted under the **EU Green Deal** and its spin-off policy initiatives. It requires a **holistic approach** and **continuous dialogue and collaboration between various stakeholder groups at the global level** especially by defining **international standards and regulations,** exchanging best practices, investing on skills, sectors, digital infrastructure, products, services and digital technologies that can address climate, biodiversity and wider environmental challenges.

Considering the key enabling role yet big gap on **accessible and affordable connectivity** issues observed, investing on **digital infrastructure** should be prioritised by the governments for boosting DX while reducing digital divide. It includes ensuring access to big data by establishing specific **data spaces** (e.g. EU Health Data Space) as well as ensuring **data accessibility across the whole value chain** by all relevant stakeholders through **regulated digital platforms** for **boosting circularity.** The digital infrastructure with strengthened public cloud is believed to accelerate the adoption of **blockchain and DLTs, Fintech** and other **cloud based-solutions for SMEs** particularly under **SaaS applications** (e.g. CRM, ERM, collaborative apps, workflow and management apps), **PaaS** and **IaaS** including **cloud-based tele-work solutions.** Ensuring **cybersecurity** and **data privacy** are key to ensure **trust and transparency** while increasing **security** on deployment of digital technologies against cyber attacks. When designing and investing, the **deployment of green(er) technologies** should be taken into consideration in order to **minimise the carbon footprint posed by the digital infrastructure** also by switching to the use of renewables and increasing energy efficiency particularly at the data centres as well as implementing CE concepts to reduce e-waste through recycle, re-use and repair. **Social dimension** is another key point to be considered in policy making in order to eliminate negative impact of digital on worker's health and wellbeing, impact on job transitions, and on growing digital divide.

As cross cutting policy areas: **raising awareness among SMEs** on benefits to be brought by specific technologies and sustainable DX; continuously **assessing their particular needs and challenges** to provide tailored **technical advisory support services in combination with financial support**; supporting **skills development** through mentoring, training, education and knowledge brokers such as Digital Innovation Hubs; setting up **fair competition** and market dynamics; removing **regulatory and administrative burdens**; developing **standards** in collaboration with SMEs; boosting **innovation**; rolling out **e-Government initiatives to boost SME DX**; incorporation of **green public procurement**; **evidence based policy making** by taking size, sector, age, location as well as differences between traditional vs innovative, manufacturing vs services SMEs into account; boosting collaboration between ICT and other key sectors such as energy, agriculture, healthcare, industrial processes by putting **circularity and bioeconomy** at the centre are among many other recommendations.

The **European Green Deal** and its spinoff policy initiatives, as well as the **EU Multiannual Financial Framework for 2021-27,** coupled with the **Next Generation EU - COVID-19 recovery package,** all aim to define high level strategies and to finance corresponding action plans to achieve the **twin transitions** required for a sustainable and inclusive future, not only in the EU, but globally, by taking a global leadership role and establishing global partnerships to realise the Global 2030 Agenda. The most recent policy and regulatory efforts undertaken by the European Commission in terms of achieving these goals fall into two distinct domains: **technology and sustainability** and **skills development**. The **Digital Markets Act,** the **Digital Services Act,** the **Data Governance Act,** the proposed **Climate Law,** the new **Circular Economy Action Plan,** the new **Cybersecurity Act,** the **FinTech Action Plan,** the **White Paper on AI**/updated **Coordinated Plan on AI,** and the Pan-European **Blockchain Regulatory Sandbox** all fit within the remit of **technology and sustainability** and are expected to become operational in 2021-22. In terms of **skills development,** current actions include the **Action Plan to implement the European Pillar of Social Rights**, the new **European Skills Agenda** and the recently launched **Pact for Skills**, which builds on other EU initiatives involving multi-stakeholder cooperation, such as the **Blueprint for Sectoral Cooperation on Skills**, **the renewed European Alliance for Apprenticeships** and the **Digital Skills and Jobs Coalition**. These multi-stakeholder partnerships boost skills across the fourteen industrial ecosystems defined in the new EU Industrial Strategy. Along with the launch of the **Digital Education Action Plan (2021-27)** to make education and training systems fit for the digital age, the setting up of **Centres of Vocational Excellence (CoVEs)** to develop skills ecosystems, and the plans for developing an **EU Competence Framework for Green Skills**, these initiatives can all be viewed as evidence of a real commitment from the EC to turning high level strategies into action for achieving sustainable digital transformation for Europe.

2 Business case studies

2.1 247TailorSteel (Netherlands)[84]

2.1.1 Introduction

247TailorSteel B.V. is a sheet metal company founded by Carel van Sorgen in 2007 in Varsseveld, Netherlands. The company specialises in providing industrial manufacturers with on-demand production and supply of tailored laser-cut metal sheets, tubes and bent products. 247TailorSteel leverages its use of advanced manufacturing technologies to supply added value to its clients in terms of convenience and customisation.

2.1.2 Digital Transformation activities

After growing and eventually selling his family's sheet metalworking company in 1998, Carel van Sorgen spent several years working in different industries. However, curious about how new digital technologies could be leveraged to modernise the steel industry, in 2003 he decided to start a new project: developing smart software for metal processing factories. Eventually, he decided to implement his vision for a networked smart factory himself.

Today, 247TailorSteel is at the forefront of the digital transformation of the steel sector. The company's business model is based on the on-demand production of tailored products through a digital and automated production process from design to delivery. To do so, the company relies on a software portal they developed in-house. The 'Sophisticated Intelligent Analyser' (SOPHIA®) works as an online platform and order processing system, as well as an online assistant for customers. SOPHIA® allows customers to design and upload their own 3D models and receive a quote for production price and delivery time within one minute, as well as offering the convenience of being able to place an order 24 hours a day. SOPHIA® is connected to the company's sophisticated machinery fleet, logistics and delivery system for production, restocking, transportation and delivery. Robots and automated guided vehicles have been implemented on the factory floor and software is used to plan efficient delivery routes. Thanks to the SOPHIA® portal, 247TailorSteel can deliver products within 48 hours of ordering, with a delivery reliability of 99.7 %. As an added bonus, the company has managed to significantly reduce its use of energy and raw materials.

Another significant metalwork industry innovation has been 247TailorSteel's launch of the Smart Bending Factory (SBF) Field Lab. This has enabled 247TailorSteel and eight key partner organisations to collaborate in sharing their know-how and resources, and to achieve scalable and flexible production capacities through the joint purchase and operation of machinery.

The company has experienced significant growth, from 100 employees in 2014 to more than 500 today. Their goal is to grow further by expanding internationally. In 2020, they opened a new production facility in Hilden, Germany, and have further plans to expand into a second German location. In order to fund these ambitions, 247TailorSteel now collaborates with the private equity fund, Parcom, which acquired a 60% stake in the company in 2019.

[84] Sources: https://www.247tailorsteel.com, Contributions from 247TailorSteel, A smart factory disrupting the production of sheet metal parts, WATIFY, 2017. Available at: https://ec.europa.eu/growth/tools-databases/dem/watify/boosting/communication-materials-support/smart-factory-disrupting-production-sheet-metal-parts, Unterfrauner, E., Case study: Smart Bending Factory – The customizing products plug-in company, MAKE-IT, 2017. Available at: http://make-it.io/2017/10/23/case-study-smart-bending-factory-the-customizing-products-plug-in-company/, Smart Industry Netherlands, Smart Bending Factory. Available at: https://smartindustry.nl/aan-de-slag/fieldlabs/smart-bending-factory, OP East Netherlands. Smart Bending Factory: The Plug-in Company Proj 00378. Available at: https://www.247tailorsteel.com/docs/default-source/documenten/170906-p17-020087-bpri---smart-bendig-a3-poster-drukwerk-ebook.pdf?sfvrsn=1d32f1b3_0, Parcom, Partner companies: 24/7 Tailor Steel. Available at: https://parcom.com/en/partner-companies/tailor-steel/?cn-reloaded=1, Borghuis, M., State-To-The-Art 247TailorSteel offers optimal delivery reliability. Available at: https://www.alurvs.nl/aluminium/nieuws/state-to-the-art-247tailorsteel-biedt-optimale-leverbetrouwbaarheid_11622/, Metals Consulting International, Dutch sheet processor expands in Germany. Available at: https://metals-consulting.com/tag/247-tailor-steel/

2.1.3 Support for Digital Transformation

The development of the SBF Field Lab was undertaken through the Smart Industry programme, the national Industry 4.0. initiative in the Netherlands, and was partially funded by the OP East Netherlands programme. The aim of this joint subsidy programme was to strengthen the economy in the provinces of Overijssel and Gelderland, with the goal of boosting the production of new products made by local SMEs.

2.1.4 Key Success Factors

Thanks to the SBF Field Lab, 247TailorSteel is also an ambassador for the Smart Industry initiative in The Netherlands.

The SBF Field Lab has been fundamental to the company's capacity to be a digital leader in the sector, creating a collaborative structure that allows them to share the high cost of machine ownership to achieve flexible and scalable production capabilities at very competitive prices.

Furthermore, 247TailorSteel attributes their successful scaleup and expansion ambitions to "knowing when to pass the torch" as the company puts it, by selling a 60% stake in 2019 to the private equity fund Parcom.

2.1.5 Key Challenges and Issues

The first challenge was the length of time it took for Carel van Sorgen and his small team of engineers to develop the concept and the software for a connected factory. In total, it took five years. The next challenge was that Varsseveld, the suburban town in which 247TailorSteel is headquartered, has a shrinking population and a lack of engineers.

However, the SBF Field Lab has acted as an innovation pole for the region and the educational institutions which are part of the collaboration – Graafschap College in Doetinchem and Anton Tijdink Technology College in Terborg – have established a Smart Industry education programme. Moreover, 247TailorSteel has contributed to the provision of training and the creation of interesting job opportunities that can help attract and retain young qualified people in the region.

2.1.6 Policy recommendations

The OP East Netherlands funding programme, from which the SBF Field Lab has benefited, achieved its policy objectives, since the initiative has contributed to the development of the local economy. The 247TailorSteel case study shows how innovative SMEs can become a digital transformation driving force and how adequate public support, in the form of project funding and public-private partnerships, can multiply the positive impacts of such schemes. Another policy-relevant lesson that may be drawn from this case is that innovative SMEs can also play a central role in promoting innovation support infrastructures.

2.2 Bächer Bergmann (Germany)[85]

2.2.1 Introduction

Bächer Bergmann GmbH (BB) is a small German carpentry business founded in 2010 by master carpenters Sebastian Bächer and Georg Bergmann. BB combines craftsmanship and innovation to provide precisely manufactured high-quality products with complex geometries to a broad array of clients from different industries, including major players such as Samsung, Porsche and DHL.

[85] Sources: https://digital.productions/, Contributions from Bächer Bergmann, Technological Transformation Success Story "Bächer Bergmann", WATIFY 2017. Available at: https://ec.europa.eu/growth/tools-databases/dem/watify/inspiring/watify-video-channel/watify-technological-transformation-success-story-b%C3%A4cher-bergmann.

2.2.2 *Digital Transformation activities*

Recognising the digital transformation potential in carpentry, the company adopted digital technologies at a relatively early stage so they could successfully meet new customer demands.

BB offers high added value carpentry services, producing high-quality, high-precision, complex and customised objects, such as sculptures, furniture and prototypes, combining traditional methods and tools with new technologies. These new technologies include Computer Numerical Control (CNC) milling machines, Computer-Aided Design (CAD) software, 3D printing, laser technology and robotics.

These new technologies have transformed and accelerated BB's production processes and helped to overcome the limitations of traditional carpentry. As a result, BB has expanded its portfolio of products and services, moving from traditional craftsmanship to digitally enhanced production. For example, for a medical school client, BB developed and fabricated larger than life-sized sculptures of the human body that were equipped with sensors in order to communicate with tablets and mobile phones. Other benefits of the modern technologies used by BB include increased operational flexibility and precision quality as well as reduced waste and energy consumption. BB's digital craftsmanship model has been essential to its business success and to the high quality of the products and services it provides to its customers.

BB's digital capabilities also enabled them to leverage their flexible manufacturing capabilities during the COVID-19 pandemic. They produced 80,000 face masks using 3D printing machines, which were sold on Veedelsretter, a local government funded e-commerce website set up to help small businesses in Cologne survive economically during the pandemic.

2.2.3 *Support for Digital Transformation*

BB has benefited from various forms of public support. Firstly, a partnership with the University of Cologne allowed them to experiment with and test the university's CNC milling machines before investing in their own. Additionally, German government funding for the introduction of energy efficient technologies helped to partially fund BB's digital transformation.

2.2.4 *Key Success Factors*

BB attributes their digital transformation success to combining digital technologies and know-how with creativity and craftsmanship. In order to optimise precision and quality, BB now uses CAD to design their products and CNC milling machines to manufacture them. However, traditional handcrafting is still used to put the finishing touches to each product.

2.2.5 *Key Challenges and Issues*

The key challenge for BB was identifying the specific digital technologies and tools to adopt. The opportunity to test and experiment with new technologies before investing in them was instrumental in overcoming this challenge.

2.2.6 *Policy recommendations*

Lack of access to expensive equipment and tools such as CNC milling machines for testing and experimentation could be a deterrent for SMEs wishing to digitalise. The case of BB therefore illustrates the importance of providing SMEs with connections to knowledge and to research & technology institutions, and also to the right infrastructures, including technology testing facilities. It also shows how synergies and cooperation between SMEs/entrepreneurs and technology institutions can be an essential factor in progressing from initial concept to reality.

Policymakers should help facilitate the replication of success stories like BB by actively encouraging and supporting knowledge and technology transfer and by putting in place public-private support mechanisms for digital transformation.

2.3 De Trog (Belgium)[86]

2.3.1 Introduction

Founded in 1970 in Bruges, De Trog is a bio-label bakery that produces high-quality, organic bread. The company combines traditional breadmaking with advanced manufacturing and digital technologies to improve the quality and efficiency of their production processes. The company has two different brands: *Bio De Trog* for B2C customers and *Pur Pain* for B2B clients.

2.3.2 Digital Transformation activities

The bakery initiated its digital transformation journey in 2013, and now relies significantly on automation and a range of technologies to digitalise its processes, such as custom robotic applications, big data, apps and augmented reality.

De Trog has also gamified the training of its employees. Using an app called 'Bakery Battle', employees can challenge each other to play 'knowledge battles', enabling them to maintain and update their professional knowledge in the process. The game format offers different levels, from easy to advanced, as well as different categories, such as 'My first day', warehousing, packaging, baking, etc. With its innovative training app, De Trog has ensured that its staff is skilled, well-informed and kept up-to-date on the company's quality and safety protocols.

De Trog's transformation has been widely recognised in the industry and has resulted in several awards, including the prestigious 'Factory of the Future' award on two occasions. In 2018, BNP Paribas Fortis acquired a minority stake in De Trog's parent group, Food Associates Group NV.

The efficiencies enabled by process automation, in combination with substantial investments in green infrastructure, have resulted in De Trog becoming the first bakery to be granted the CO2-Neutral label in Belgium.

De Trog has also recently announced a collaboration with Lokkal, an app-only fresh food supermarket, to deliver De Trog's fresh bread directly to their customers' homes.

2.3.3 Support for Digital Transformation

Although De Trog has relied on private finance for their digital transformation journey, the company has also benefited from a number of collaborations with public and public-private knowledge and support institutions and training centres, from which they have received advice and guidance on how best to approach the different stages of their transformation process.

In particular, De Trog has collaborated with the Flanders Agency for Innovation and Entrepreneurship and the Innovation Centre for the West-Vlaanderen region. The company has also benefited from knowledge exchange with public higher education institutions, including the University of Ghent and KU Leuven's Embedded and Artificially Intelligent Vision Engineering (EAVISE) Research Group.

2.3.4 Key Success Factors

De Trog has relied heavily on knowledge exchange and collaboration with competence centres, leveraging these knowledge ecosystems to explore how best to approach their objectives and obtain the necessary support. Indeed, De Trog has collaborated with more than 20 organisations along its digital transformation journey.

[86] Sources: https://detrog.be/en/, Contributions from Food Associates Group NV, Combining craftsmanship & technology, WATIFY, 2017. Available at: https://ec.europa.eu/growth/tools-databases/dem/watify/inspiring/watify-success-stories/combining-craftsmanship-technology, WATIFY Technological Transformation Success Story "De Trog" - Combining craftsmanship & technology, 2017. Available at: https://ec.europa.eu/growth/tools-databases/dem/watify/inspiring/watify-video-channel/watify-technological-transformation-success-story-de-trog-combining, De Trog once again Factory of the Future, Gumption, 2019. Available at: https://www.gumption.eu/article/de-trog-once-again-factory-of-the-future, Our bank acquires a stake in Food Associates Group, BNP Paribas Fortis, 2018. Available at: https://companies.bnpparibasfortis.be/en/news?n=our-bank-acquires-a-stake-in-food-associates-group.

Furthermore, the company has not just focused on technology in its pursuit of success. The company also emphasises the importance of staff training, making significant efforts to ensure that its staff acquire the most appropriate professional skills and that they share the company's vision. The 'Bakery Battle' app has been instrumental in supporting this tailored in-house training.

2.3.5 Key Challenges and Issues

De Trog's goal was to scale up production without jeopardising the company's values and commitment to both tradition and sustainability. Identifying the best path to follow was therefore a crucial challenge. Establishing collaborations with key partners and gaining access to knowledge were essential elements in successfully overcoming this hurdle. By seeking external support and outsourcing digital solutions, De Trog has been able to maintain focus on their primary function: the production of high-quality bread.

The upskilling of De Trog's staff to use these new technologies was another important challenge, and one that is particularly prevalent in traditional industries, where employees may not be familiar with using digital tools in the workplace.

2.3.6 Policy recommendations

The case of De Trog illustrates how local support agencies for SME digitalisation, innovation and business transformation can help SMEs to achieve successful digital transitions. Facilitating access to these services as well as to digital skills training are concrete ways in which policymakers can support the digital transformation of SMEs. While advisory and training services could be provided and funded by either national or regional public institutions, there are also other ways in which access to such services could be facilitated. Examples include the provision of innovation vouchers to help pay for consulting services, public-private partnerships with competence centres and digital transformation support from Digital Innovation Hubs.

2.4 FYZOklinika (Czechia)[87]

2.4.1 Introduction

FYZOklinika is an SME located in Prague, Czechia. It was established as a small family business in 2011 by Zdenek and Iva Bilek and currently has 23 employees. It is a private health clinic offering physiotherapy and rehabilitation for the prevention and treatment of painful conditions of the musculoskeletal system, and in recent years has started to offer modern services to accelerate wound healing.

2.4.2 Digital Transformation activities

FYZOklinika aims to provide customised treatments specific to each patient. Historically, this type of health practice used a paper-based reservation system and archived paper-based medical documents. Over time, some of these health practices have modernised their record keeping using Excel and similar software tools. This was the situation when FYZOklinika started its business 10 years ago.

The company needed to find out more about exploiting digital solutions to further improve the efficiency of its management and its relationship with its clients. As a result, the company began to implement various IT solutions aimed at moving from a paper-based system to a digital database and so differentiating itself from its competitors.

Based on the digital transformation support described in the following section, the company deployed a technical solution which not only uses a modern database platform, but also a digital communication function based on Asterisk, an open source framework for building communications applications, allowing digital connection to clients/patients for the provision of customer care. Administrative staff are now able to communicate effectively and efficiently with clients before and after treatments.

[87] Sources: https://www.fyzioklinika.cz/en/, https://www.asterisk.org/, https://digitalisesme.eu/czech-health-company-receives-fruitful-support-for-its-digital-strategy-from-lithuanian-digital-enabler/, Interview with Mr. Zdenek Bilek on 13.01.2021.

FYZOklinika implemented all the suggested solutions, and plan to advance their digital transformation further, by continuing with the integration of state-of-the-art technologies such as Artificial Intelligence (AI) and the Internet of Things (IoT) into their systems and client services. They are currently researching how they might carry out and fund this digital modernisation.

FYZOklinika has already seen significant benefits. The staff responsible for customer care have reported increased effectiveness of communication and the ability to handle more calls per person on a daily basis. Furthermore, once an AI solution has been deployed, it should be possible to handle calls involving frequently asked questions by utilising machine learning.

2.4.3 Support for Digital Transformation

The company applied to the DigitaliseSME initiative, which matches the needs of applicants with an appropriate expert who can provide coaching in the specific digital solutions required. Sergey Matusevich, a digital expert from Lithuania, was assigned as their Digital Enabler to devise solutions for accelerating FYZOklinika's processes. After collaborating for 4 months, FYZOklinika was highly satisfied with the support provided by the Digital Enabler and the digital solutions he proposed.

2.4.4 Key Success Factors

The key success factor for FYZOklinika's digital transformation was finding a digital advisor with expertise in nonproprietary technologies, such as Asterisk and other open source technologies, since technology platforms designed for large companies are usually not affordable for smaller companies. Another critical success factor was the flexibility of gradual deployment of the new technologies.

2.4.5 Key Challenges and Issues

Currently, although it is not difficult to find smart digital technical solutions, it is difficult to find the right solution that can be implemented by a small company at an affordable cost. Once a suitable technological solution is found, the next challenge is to find professional support for its proper implementation.

2.4.6 Policy Recommendations

Based on its own experience, FYZOklinika would suggest to other SMEs seeking similar digital transformation solutions, that they should avoid large proprietary technology platforms and instead research more affordable, cost-effective nonproprietary options.

From a policy perspective, FYZOklinika would like to see continued roll-out of SME support services such as those offered by DigitaliseSME, whereby each SME can be assigned a specific Digital Enabler for a certain time period in which the company's needs can be assessed, and company and advisor can then collaborate on determining the most suitable digital transformation options.

2.5 Katty Fashion (Romania)[88]

2.5.1 Introduction

Katty Fashion is an innovative SME founded in 2003 in Iași, in the Nord-Est development region of Romania. It is a manufacturing company for the textile/fashion industry, with 40 employees, experienced in producing a wide range of women's outerwear, and specialising in short production runs and customised clothing. Katty Fashion is a member of the 'Romanian Textile Concept Cluster Bucharest' as well as the 'European Textile Platform for the Future of Textile and Clothing', from which it receives support in terms of news, ideas, funding opportunities, ecosystem and community, but not funding support. The company has been a successful exporter since entering

[88] Source: https://katty-fashion.com/, https://c-voucher.com/programme/, https://digitalisesme.eu/about-digitalisesme/, Interview with Ms Caterina Ailiesei and Ms Claudia Irimiea on 14.01.2021.

the textile market, collaborating with European partners as well as with suppliers, producers, regional development agencies, educational and research institutions from the local and regional markets.

Katty Fashion offers a wide spectrum of services, from original concept to the creation of new products, using computer aided (CA) pattern design and grading, sampling and prototyping, material sourcing, short production runs, technical support and quality control, and combining woven and jersey fabrics with very different fibre compositions and structures. The company has implemented the Quality Management System ISO 9001:2008 to maintain high quality standards for its products and services. In 2010, the company developed its own project, 'Concept of Eco-Chic Ethical Wear', to create highly fashionable collections using 100% organic materials. Their motivation was to comply with corporate social responsibility to protect the local and global environment, while producing stylish and environmentally friendly clothing.

The company offers production and garment development services to brands in contemporary and bridge market segments (mid to high quality and price point). They are currently providing these bespoke product development and manufacturing services to over 50 high end EU fashion brands with diverse and complex requirements.

2.5.2 Digital Transformation activities

Katty Fashion's decision to undertake digital transformation was based on the desire to improve overall efficiency, increase service diversification, gain a competitive advantage and consolidate customer loyalty.

Their main digital transformation journey started at the beginning of 2019 when they were awarded financial support through 'C-VoUCHER', an EU scheme funded through the H2020 Research and Innovation Programme. It is the first pan-European initiative to adopt the concept of the circular economy to redesign value chains, combining design and technology to help SMEs transition towards a circular economy.

During the course of the C-VoUCHER programme, Katty Fashion also applied for technical support from the 'DigitaliseSME' initiative, which assigns a Digital Enabler to applicant SMEs by matching their particular needs with the specific expertise of the advisor. The Digital Enabler assigned to Katty Fashion first undertook a needs assessment by evaluating the firm's activities, skills level and needs, in collaboration with the CEO. Together, they explored various opportunities and potential business directions for the company, broken down into short, medium, and long-term strategies, including the development of their own proprietary analytics platform powered by artificial intelligence (AI), which they named 'KARE', to showcase that they K(c)ARE about the impacts of today's actions on the next generations. Through workshops on various topics, the Digital Enabler proposed concepts for both rebranding and addressing various issues arising from the C-VoUCHER scheme. During a month-long collaboration with their Digital Enabler, Katty Fashion accomplished the following: they introduced more efficient practices for pattern development and fit management and developed a pattern library protocol; identified and transferred the library to the most suitable cloud storage solution; identified appropriate Product Lifecyle Management (PLM) software for the development of layouts, graphics and front-end forms; worked on their website, logo, imagery and web content for rebranding. Following this collaboration with their Digital Enabler, the company implemented Computer-Aided Design (CAD) and Computer-Aided Manufacturing (CAM) software upgrades and 3D licenses. Training of the team for implementation of the 2D CAD/CAM upgrades was included in the purchase contract through C-VoUCHER funding, while the suggested implementation and use of 3D licenses still requires additional help, study and follow-up.

The proposed solutions were assessed in a feasibility study conducted by an outside consulting company using funding from the European Bank for Reconstruction and Development (EBRD) Small Business initiative.

2.5.3 Support for Digital Transformation

As a result of the funding support received via the C-VoUCHER scheme, combined with technical support from the Digital Enabler assigned by DigitaliseSME, Katty Fashion was able to purchase new 3D and CAD/CAM licences. Thanks to this, the company is now able to provide the following new services: virtual prototyping, digital validation of designs and expected consumption of materials for production, online catalogues and on-demand manufacturing.

The addition of new features such as photo enabled pattern digitisation, pattern and fit development protocols and style history have improved the efficiency and speed of pattern development, while adopting 3D technology has the potential to reduce the number of samples required by half, which is expected to reduce the cost, waste and lead times of style development, while helping Katty Fashion to diversify its portfolio of services. Furthermore, the new website now includes better and more appropriate visual and written content, improving the company's attractiveness to top brands and thereby compensating for the higher production and development costs involved.

By adopting these new technologies, Katty Fashion has been able to start making the switch from a traditional business model towards a circular digitalised business model in line with its 10-year sustainable development strategy, developed in 2017-18. The company's aim is to lower their environmental footprint and to offer better working conditions and improved business solutions in order to make a vital paradigm shift in the fashion industry.

Currently, the company is aiming to develop and license their proprietary KARE digital platform to other companies and to create a KARE micro-factory/demo-lab, utilising the latest technologies and machinery.

Since the full implementation of all these new technologies is still ongoing and has been hampered as a result of the pandemic, it has not yet been possible to observe the full benefits, although the company has noticed an increase in labour productivity.

In order to progress further, Katty Fashion has applied for additional funding support from the Romanian national POR 1.2 programme and the Romanian regional RIS3 programme. Both applications are still pending.

2.5.4 Key Success Factors

The technical support and guidance received from the Digital Enabler was cited by Katty Fashion as a key success factor, along with continuous progress monitoring and the studying, testing and incorporation of proposed technology solutions into their workflow. Another factor mentioned was the firm's experience of more than a decade in the industry, and its in-house technical skills in terms of assessing, applying and comparing new technologies.

In October 2020, the company received an EIT Manufacturing Boost Up award for developing new solutions for sustainability, resiliency and creating social impact in manufacturing.

2.5.5 Key Challenges and Issues

The biggest challenge for Katty Fashion was finding the most appropriate solution for optimisation of its administrative processes, and also the amount of time needed for its development. After several weeks of market research to identify the best PLM solution, it was decided to develop from scratch an entirely cloud-based platform, accessible from any device, to integrate all administration processes, and to include a number of modules pertaining to the circular manufacturing model. The idea was to allow the company to address all of its process issues, while at the same time, adding unique value to their proprietary KARE platform in terms of its potential for being licenced to other companies, after identifying the needs and adaptations required. It was also challenging to work out how to integrate the PLM with CAD/CAM, front-end data input and an Enterprise Resource Planning (ERP) solution. A related challenge was how to avoid potential operational delays arising from the switchover to the company's new digitalised administration processes. To address this issue, the company decided to develop temporary online forms, which could also be used as the basis for the development of their digital platform.

At the present time, internal factors such as efficient management of production and challenges linked to the digitalisation of business processes are more pressing for Katty Fashion than external factors. One external challenge is a major increase in the number of low-cost manufacturers, particularly in the NE region, which has led to increased competition and therefore reduced profit margins. As a result, Katty Fashion is planning to diversify its services for higher added value by offering digital solutions and packages/toolkits for dissemination, replication and even franchising of the Katty Fashion business model which can be deployed by other SMEs operating in the textile sector. Their proprietary KARE platform will help the company to offer predominantly 360 Degree software to other garment and textile companies as part of their main business model. The company intends to add new modules to the platform over time, such as a PLM module for real-time progress tracking in the product manufacturing unit; a circular economy module for developing collaborative business models with other companies in the region and a collaborative 3D prototyping module.

The vision and efforts of the company are totally in line with the regional RIS3 strategies of the of NE Region, which are: the implementation of (1) high-tech processes and applications (industry 4.0) and (2) digital fashion.

2.5.6 Policy recommendations

Since the company benefited a great deal from the two support initiatives, C-VoUCHER and DigitaliseSME, they would highly recommend that similar initiatives be replicated EU-wide to provide hands-on technical support to SMEs in assessing their specific digitalisation needs, defining relevant solutions and supporting implementation financially. They would also suggest adding sectoral experts to future schemes, in addition to digital experts. This would avoid wasting time explaining sector specificities to digital experts in instances where the digital experts do not have this sectoral expertise.

2.6 Norteña de Aplicaciones y Obras (Spain)[89]

2.6.1 Introduction

Norteña de Aplicaciones y Obras, located in Aranda de Duero, provides specialised services in roof waterproofing. They operate in Castile and León and neighbouring regions with a small core team of seven people, although they rely on collaborations with multiple freelancers to support their technical activity.

2.6.2 Digital Transformation Activities

Jorge Bermejo, Norteña's CEO, started the company in 2006, just before the financial crisis hit the Spanish construction sector. In order to survive, Norteña redirected its business model by focusing on the needs of local companies. It soon became apparent that digitalisation was going to be an essential tool in terms of offering the high-quality services the market demanded. In 2015, Jorge Bermejo decided to start with digitalising workers' daily worksheets, which to that point had involved a cumbersome and time-consuming process: worksheets were completed by hand on the construction site every day, and then had to be scanned or introduced into an MS Excel spreadsheet again at the office. However, thanks to the implementation of Enterprise Resource Planning (ERP) and Customer Relationship Management (CRM) digital tools, workers were able to start filling their worksheets directly into their tablets and smartphones.

Over the course of several years, Norteña has digitalised most of its processes, which has allowed them to significantly enhance management and decision-making, as well as to offer high added value services to their clients, based on transparency and traceability.

Internally, they have implemented an integrated system with several modules to closely monitor the company's activity at all levels. Apart from fully managing clients and stock using the CRM and ERP systems, different modules also allow for faster worksite incident management, real-time cost control of different projects, real-time cost control per department and employee, digital management of invoices and payments and much more. All this information is displayed on a dashboard, from which the team can monitor the company's finances in real time and control whether the budgets for all the projects and for the company overall are being implemented as planned, and then leverage this knowledge for better-informed business decisions.

Norteña has applied its digital capacities to come up with innovative ways to cater to clients' needs. For example, when they realised that clients would often misplace important documents for projects that had been finished a long time ago, they pioneered the inclusion of a QR code in their roofs. All their clients can now scan the code and immediately gain access to all documents related to that roofing contract whenever needed, from

[89] Sources: https://www.nortena.es/, La empresa arandina Norteña, premiada por su 'software' de gestión empresarial, El Norte de Castilla, 2017. Available at: https://www.elnortedecastilla.es/economia/empresas/empresa-arandina-nortena-20171027140324-nt.html?ref=https:%2F%2F, Norteña gana el premio CEPYME, El diario de Burgos, 2019. Available at: https://www.diariodeburgos.es/noticia/z8853a5d1-0a4f-a83a-c9a3f9abdf80cec7/nortena-gana-el-premio-cepyme, Interview with Jorge Bermejo, CEO of Norteña, 18th November 2020.

guarantees to permits, annual revision reports or maintenance manuals. Clients also receive a daily automatic email informing them of daily progress on ongoing projects, along with pictures of the site. Other client services relying on the company's digital capabilities include automatic notifications sent to clients when their guarantees are about to expire, giving them the option to contract maintenance work, and the ability to check the resolution of incidents online.

As a consequence of their digital strategy, the company has cut the time required by workers to complete paperwork by 80 % and reduced the cost of budget control by 77 %. From 2011 to 2019, company turnover grew by an impressive 450 %, a performance that its CEO attributes to Norteña's digital capabilities and innovative mindset.

Jorge Bermejo also highlights the positive impact this transformation has had in terms of cost savings on paper and construction materials.

2.6.3 Support for Digital Transformation

In 2017, Norteña received public financial support for the development of its ERP system from the regional government of Castile and León. However, Jorge Bermejo describes his experience with regional digital transformation support programmes as quite unsatisfactory.

According to Norteña's CEO, in practice, accessing public support for digital transformation can often prove to be too complicated and time-consuming for the scarce resources of SMEs.

After some unfruitful attempts to obtain more public funding, he has decided to rely only on the company's own funds in the next stages of the company's digital transformation plan.

2.6.4 Key Success Factors

Norteña's case has been widely recognised as a success and has won seven awards for innovation and excellence in management since 2017, including the Award for the Best SME Digital Transformation in 2019, granted by the Spanish Association of SMEs (CEPYME).

Among its key success factors, Norteña emphasises digitalisation and continuous improvement as a core part of its business and brand. Despite operating in a traditional sector, the company strives to cultivate a startup mentality and has been very active in promoting its story: they often apply for digital transformation and management awards, participate in local conferences, forums and associations to share their digital transformation journey, and have been featured in the local and national press.

A second factor highlighted by Norteña is the involvement and commitment of the staff to the digitalisation process. Norteña's team is not only aligned with the company's digital strategy, but is also closely involved in defining it. Jorge Bermejo points out that they all share a passion for realising the potential of digitalisation for Norteña, and that having everyone fully on board has been crucial for success.

2.6.5 Key Challenges and Issues

The first step – going paperless at the construction site – was a big challenge at the time. It was unclear how CRM and ERP technologies could be integrated into the process and the costs of these digital tools were high. Overcoming these initial obstacles ultimately required significant dedication and major financial efforts for a small company like Norteña. As digital tools helped to increase efficiency, the reinvestment of savings was used for further digitalisation steps.

As the company's transformation has been incremental, module integration has been an important challenge. Norteña are currently working out how to refine the communications between modules to take on their next objective: the automation of part of their financial control system.

As with many other businesses, Norteña has faced challenges during the COVID-19 crisis. However, they highlight how being a digital company has helped them in dealing with the effects of the pandemic. Thanks to data-based decision making and digitalised processes, they expect to finish 2020 with the same turnover as last year.

Furthermore, since 2012, Norteña's office team has teleworked, benefiting from the company's digital capabilities. Consequently, Norteña was fully prepared for the measures required to control the COVID-19 pandemic.

2.6.6 Policy Recommendations

Streamlining application processes should be a priority in all programmes targeting SMEs. Bureaucratic procedures and complicated eligibility conditions can discourage application and put a strain on the limited resources of SMEs. Policymakers at both regional and national level, who are aiming to promote the digital transformation of SMEs, should make efforts to avoid unnecessary complexity and limit the administrative burden on applicants, thus encouraging them to apply.

Additionally, more emphasis should be placed on the once-only principle when it comes to administrative documents and information. It is still not uncommon for companies to be required to provide the same information repeatedly when applying for support.

2.7 Royal snc (Italy)[90]

2.7.1 Introduction

Royal snc is a family-owned SME managing a number of hotels in the North East of Italy. It was established in 1985 and currently has 50 employees. It is a service company focused on the delivery of hotel and catering industry services.

2.7.2 Digital Transformation activities

Royal snc recognises the importance of digitalisation for ensuring future success, and decided to deploy relevant digital technologies in order to stay up-to-date. In particular, they felt that data collection and analytics would be key to increasing their market outreach and improving the internal management of their hotels.

For this reason, the company sought support for the identification and deployment of the most suitable digital tools to help them with market expansion, improvement of management capacity and energy storage and efficiency, in order to create a sustainable business model.

They started with leveraging online data insights to gain better understanding of consumer profiles and behaviours, their competitors and their competitors' offerings, and options for marketing communications, using digital tools from the main digital platforms, such as Google's Keyword Planner, Facebook IQ, etc. The company also collects guest information in compliance with General Data Privacy Regulation (GDPR) from the moment their guests check-in until they finally check-out.

The company aims to make business decisions based on the customer insights generated by web analytics. By studying guest data, they hope to spot the trends and expectations of various customer segments (based on age, gender, cultural origin, etc.) and adapt their marketing strategy accordingly. Once they have accomplished this, the company plans to improve their search engine marketing, site user experience, email, and social media marketing.

Royal snc is also in the process of implementing automation of their beach umbrellas. A digital device powered by photovoltaic panels will automatically open and close beach umbrellas at the hotel's private beach area, in order to benefit from solar energy. This automation of operations will also allow the company to minimise maintenance activities and optimise staffing levels by using the Internet of Things (IoT) together with information technology (IT) and operational technology (OT).

[90] Sources: https://www.baiadelmar.com/, https://digitalisesme.eu/about-digitalisesme/, https://digitalisesme.eu/digitalisesme-matching-series-italian-hotel-company-expands-its-market-outreach-thanks-to-maltese-digital-enabler/, Interview with Ms Krista Boschian on 14.01.2021.

2.7.3 *Support for Digital Transformation*

Royal snc applied to the DigitaliseSME initiative, which matches the needs of applicants with an appropriate expert who can coach the company in the development of digital solutions. Trevor Buhagiar, a digital expert from Malta, was assigned to Royal snc as a Digital Enabler, thanks to his expertise in integrating digitalisation tools into customer management to improve market outreach.

The suggestions made by their Digital Eabler included the deployment of various digital solutions for both internal and external use, in order to transform the traditional hotel experience to follow global hospitality and tourism market standards, in line with the trending needs and preferences of guests. The following digital solutions were suggested:

- A software application to handle goods requests, ordering and consumption, in order to eliminate traditional manual form filling processes and identify trends in usage and consumption of goods, incorporating an alert system to send notifications of major changes and/or shortages.
- A housekeeping quality control system to contribute to the maintainance of the company's brand quality promise.
- Digital energy consumption monitoring for energy conservation and cost reductions.
- A Building Management System (BMS) to provide enhanced control of the technical plant of the hotel (such as automated start-stop of equipment, provision of alerts to the operator and maintenance personnel) to improve provision of essential services such as air-conditioning and hot water supply.
- A Guest Room Management System (GRMS) to both enhance the guest experience and support the energy management and conservation strategy of the hotel.
- A digital menu ordering system to enhance the guest experience while providing a record of ordering trends to improve menu planning and food procurement.
- Voice activated controls within the guest rooms to provide a better experience for guests while also branding the hotel as innovative and future looking.
- A guest services application to provide a platform for the hotel owner to interact and better engage with guests in order to improve the experience of each guest throughout their stay, and also to provide a communication channel for digital marketing.
- A chat interface on the company's website to allow customers to interact with the hotel reservation personnel in real-time, in order to increase customer confidence and thereby enhance the purchasing decision process.

Royal snc was highly satisfied with the support provided by their Digital Enabler. The company is now looking into further funding opportunities, including the EU recovery fund, to help implement the digital solutions suggested.

2.7.4 *Key Success Factors*

Royal snc identified a number of success factors in their digital transformation journey. Personal curiosity, motivation, vision and the entrepreneurial skills of management were all viewed as being key, along with taking a step-by-step approach to deployment. As a result of their experience with DigitaliseSME, Royal snc feel that their motivation has greatly increased, thanks to the fruitful exchanges with their Digital Advisor, and the contacts they have made with the digital world on both a human and knowledge-based level.

Another key success factor mentioned was staff training. In order to maximise the benefits of digitalisation, the company needed to train employees in specific skills to understand the functionality of the software and its applications. Having a thorough familiarity with concepts like relational databases has allowed staff to manage the data appropriately.

2.7.5 Key Challenges and Issues

Krista Boschian, Royal snc's Project Manager, believes there is not enough support and funding for the digital transformation of SMEs, even though digitalisation has been widely recognised as providing immense potential for increasing productivity, improving efficiency, and empowering improved decision-making. SMEs are already burdened by the costs of internal management and taxation, so they are unable to cover all the necessary investment on their own. As a result, Ms Boschian underlined that the high infrastructure and organisational costs incurred in implementing digital solutions present a major challenge for SMEs.

Another key challenge is general lack of interest from SMEs in undertaking digital transformation. This is the impression Ms Boschian came away with after having presented Royal snc's experiences at the final conference of the 'DigitaliseSME' initiative in Brussels, when she learned that the scheme had attracted fewer applicants than expected, indicating either lack of interest and/or lack of awareness among SMEs.

2.7.6 Policy recommendations

National governments need to introduce appropriate digital policies accompanied by support instruments for SMEs. Only then will SMEs be able to fully utilise new technologies to improve business performance.

Specific short and long-term policies which make the costs of digital transformation sustainable need to be identified in order to encourage investment by SMEs.

Ms Boschian emphasised the growing gap between the skills possessed by employees and the digital skills required by the labour market. As a result, policy measures are required to bridge this gap, as well as to ensure that education and corporate training opportunities are boosted to equip more people with the digital skills needed to meet market demand.

Finally, Ms Boschian stressed the importance of ensuring cybersecurity, both at firm level, in terms of helping firms acquire the technical skills necessary for implementation, as well as at policymaking level, in terms of defining the the most effective cybersecurity strategies, policies, and programmes.

2.8 Skill Software GmbH (Germany)[91]

2.8.1 Introduction

Skill Software GmbH is an innovative micro SME which develops digital solutions. It was founded 30 years ago by Edgar Reh, a nuclear physicist, in Frankfurt am Main in Germany, and has 8 employees.

Skill Software focuses on software development and distribution, specialising in mobile B2B solutions using a cloud server database. The company provides radical simplification of complex business processes for use on smartphones and tablets, enabling the transfer of important data to and from mobile working places, and managing the on-site collaboration of teams and of main and sub-contractors. It offers Industry 4.0 solutions for construction and building management, energy and technology, and customer and visitor flow. Another focus area is project-oriented Customer Relations Management (CRM), particularly for the construction industry, involving digitally supported customer acquisition and customer management.

2.8.2 Digital Transformation activities

Skill Software has been digitalising customer processes since it was founded 30 years ago. For its first project, it connected 15 advisors at Henkel to the Henkel head office with small mobile computers, networked customer services and set up a solution database for product problems.

[91] Sources: https://skillsoftware.de/, https://digitalisesme.eu/about-digitalisesme/, https://digitalisesme.eu/cs/digitalisesme-matching-series-german-software-company-expands-it-market-outreach-with-the-support-of-czech-digital-enabler-6/, https://www.bmbf.de/de/kmu-innovativ-ressourcen-und-energieeffizienz-612.html, Interview with Mr Edgar Reh on 05.01.2021.

This led the company increasingly into customer acquisition and support, later known as 'Customer Relationship Management' (CRM). The next step was to connect BlackBerry mobile phones to CRM software, which led to the development of its first cloud-based CRM solution.

When Skill Software's largest CRM customer, Häfele, asked whether the company could digitalise planning and management documentation processes for the construction sector, the company developed **BauDoc** for tablet PCs and now smartphones.

Another customer, KMW, wanted to digitalise the technical service management of freezers, so Skill Software developed **TechDoc**, and for energy consumption, **EnergyDoc**, using the Internet of Things (IoT).

In 2018-2020, in collaboration with KMW and va-Q-tec (a major provider of temperature-controlled thermal containers for global distribution of the Covid-19 vaccine), Skill Software developed a freezer that uses only 50% of the usual energy requirements.

Skill Software has also created a software suite called **PropertyDoc** comprised of: **Skill Project CRM** to help their customers increase sales through customer relatonship management; **BauDoc** for all construction management control and documentation tasks involved in the building and construction industry; **EnergyDoc** for energy savings using mobile energy management software with integrated sensors and alarm functions; **TechDoc** for delivery of important technical information to mobile workplaces to allow the undertaking of technical services and preventative maintenance, all in support of CO2 reduction.

2.8.3 Support for Digital Transformation

Mr Reh has taken part in the 'DigitaliseSME' initiative as both a Digital Enabler and also as a beneficiary. He first participated as a Digital Enabler, helping an SME in Breda, the Netherlands, to digitalise the vehicle approval process for special types of vehicles such as trucks, caravans, and trailers. For another SME, in Karlovy Vary, Czechia, Mr Reh helped develop an energy management system for their customers. The concept was due to be implemented in 2020 but was halted by Covid-19 and the ensuing lockdowns.

By this time, Mr Reh realised that he needed professional advice from a Digital Enabler with different expertise to his own, specifically on market analysis and digital marketing, with a view to expanding his market reach across Europe. As a result, he registered his company with DigitaliseSME and was matched with the Czech Digital Enabler, Veronika Kobylková, who has exactly the kind of knowledge and skills he needed. Through this collaboration, Skill Software received digital marketing and sales support to enable it to expand into the Eastern European B2B market, especially in Czechia and Poland. Following this support, Skill Support has introduced several aspects of market analysis and digital marketing into the German market but has not yet done so for the Czech and Polish markets.

Learning how to introduce new digital marketing and sales processes in a scalable and globally applicable way has been a fascinating experience for Mr Reh. The company is now in the process of expanding its business into the Netherlands and the United Kingdom.

In terms of funding support, Skill Software benefited from an innovation fund provided by the State of Hesse and also from EU Regional Funds, which covered half the development costs of EnergyDoc. For the development of the low energy freezer, the company benefited from the 'KMU Innovativ' funding initiative run by the German Federal Ministry of Education and Research.

The company is also connected to some B2B networks and clusters in Germany, such as BVMW, and cooperates with two universities.

2.8.4 Key Success Factors

Mr Reh pinpoints being open minded towards digitalisation as a key success factor. To this end, the company have attended a number of startup workshops, participated in networks and associations and cooperated with various specialists in different areas of digitalisation via LinkedIn and Xing marketing, Facebook, Instagram, YouTube, internet forums, search engine optimisation, etc. As a result, they have worked out a modular strategy that has been tested and proven step-by-step. Based on the lessons they have learned, the company's main success driver has been to focus on the quality of their products as the best way of increasing the number of their business leads.

2.8.5 Key Challenges and Issues

Skill Software is developing software solutions in difficult domains such as construction, the least innovative sector in Germany. The key challenge identified by Mr Reh is that when companies learn and develop on their own, based on trial-and-error, the process is expensive, since it takes a long time to develop new solutions. He recommends taking a step-by-step approach by monitoring success, and by networking with other parties who are also digitalising their processes.

2.8.6 Policy recommendations

From a policy perspective, Mr Reh highlighted the importance of financial support for the digitalisation of SMEs as a key recommendation. However, he also highlighted that financial support on its own is not enough, it needs to be accompanied by technical support. Therefore, he recommends the roll-out of support initiatives such as 'DigitiliseSME', which should be made easily accessible to SMEs aiming to digitalise. Bringing together digital experts and SMEs to collaborate on digital solutions to meet their needs and expectations triggers cross-fertilisation of ideas which is highly beneficial for the SMEs concerned.

Another key recommendation made by Mr Reh, is to raise awareness of the benefits of digitalisation by sharing digitalisation success stories across as many communication channels as possible.

Mr Reh also drew attention to the way in which the recent COVID-19 lockdowns have acted as a powerful incentive to most companies to accelerate digitalisation in order to continue doing business. This momentum should continue to be supported during the pandemic and beyond.

2.9 Van Den Borne Aardappelen (Netherlands)[92]

2.9.1 Introduction

The Van Den Borne family farm, founded in Reusel (North Brabant) in 1952, consists of roughly 550 hectares of land, devoted primarily to potato crops, but also maize, wheat and sugar beet. Thanks to the innovative spirit of brothers Jacob and Jan Van Den Borne, it has now evolved into one of the most digitally advanced farms in the Netherlands, gaining industry recognition for its innovative practices, including a nomination in 2019 from the magazine 'Future Farming' as one of the 10 most innovative arable farms worldwide.

2.9.2 Digital Transformation activities

In 2006, the Van Den Borne brothers initiated the farm's digital transformation journey with the aim of increasing the efficiency and quality of their crop yields through precision agriculture.

The farm is now an agricultural leader in the application of a wide range of precision farming technologies. GPS, drones and sensor technologies have been deployed to monitor soil health and accurately determine cultivation requirements. The management of field operations is further supported by crop monitoring tools and software that provide real-time data and key insights to help ensure maximum efficiency and productivity. The data collected helps the Van Den Borne brothers to make better informed decisions on irrigation and fertiliser use.

[92] Sources: https://www.vandenborneaardappelen.com/, Contributions from Van Den Borne Aardappelen, Smart precision farming, WATIFY, 2017 https://ec.europa.eu/growth/tools-databases/dem/watify/inspiring/watify-success-stories/smart-precision-farming, Jacob Van Den Borne. Flagship Farmers, McDonalds, 2017 https://www.flagshipfarmers.com/en/profile/jacob-van-den-borne/#tab3, Koerhuis, R. Precision farming technology as a management tool. Future Farming, 2019. https://www.futurefarming.com/Smart-farmers/Articles/2019/9/Precision-farming-technology-as-a-management-tool-463666E/.

This digital transformation has enabled the farm to increase crop yields, reduce the use of inputs such as water, fertilisers and fuel, and to increase revenue.

2.9.3 Support for Digital Transformation

The farm has received public financial support from local, regional and national SME innovation and rural economic development programmes to help finance the farm's digital transformation ambitions. These support programmes have included the Noord-Brabant subsidy scheme for SME innovation stimulation, the Regional Economic Action Programme (REAP) of the province of Noord-Brabant and the Rural Development Programme POP3 Brabant 2014-2020. Over the years, the farm has also participated in a long list of publicly supported R&D and innovation projects. Additionally, the farm has received financial support for investment in precision farming equipment from the 'Programma Precisie Landbouw' (Precision Farming Programme), co-funded by the Netherlands government and the agricultural industry.

2.9.4 Key Success Factors

The Van Den Borne farm is an important example of how a rural SME from a traditional sector, supported over time with various public funding programmes, can lead the way in smart farming. Because of these funding schemes, the Van Den Borne brothers have been able to take risks in terms of the investments and experiments required to achieve their digital transformation goals.

The success of their approach is based on running initial test trials and use cases, followed by scaling up the most successful trials company-wide. This has led to other farmers making the necessary investments in their own farms, after having observed the results of the scaling up and company-wide introduction of these novel technologies.

Aside from the practical deployment and adoption of technical equipment, the Van Den Borne farm has also benefited from collaboration with knowledge institutions and other companies. This collaboration has been a mutual learning curve; for the institutions it has provided an opportunity to get closer to real-world challenges, while for the Van Den Borne brothers, it has been key to keeping up-to-date with new technologies and identifying their future potential for the farm.

Being able to leverage collaboration and public funding opportunities has been key to defining and funding the Van den Borne brothers' vision for the farm.

Furthermore, the efforts of the Van Den Borne brothers to share their knowledge and experience of smart farming have played a major role in raising the farm's recognition and profile in the agriculture industry.

2.9.5 Key Challenges and Issues

The journey towards precision farming has been long but rewarding for the Van Den Borne brothers. Exploring the possibilities offered by smart farming initially required a significant investment in time and money to research the technologies available and to test use cases.

2.9.6 Policy recommendations

To replicate success cases like this, it is essential that SMEs which are interested in what novel technologies can do for their business but are unsure where to start – as was initially the case for the Van Den Borne brothers – receive both financing and guidance/training, as well as the means to test technologies and ideas. Training programmes, innovation vouchers and Digital Innovation Hubs also play an important role here.

Digital transformation support programmes that are tailored to the specific needs of rural SMEs would not only help to transform traditional sectors but would also boost local economies and address depopulation in rural areas.

2.10 Z-Application (Belgium)[93]

2.10.1 Introduction

Z-Application is a Belgian micro SME established in 2013 by Francis Appels after the firm for which he had previously worked for 25 years closed down. He established Z-Application with his own funding and runs it as a sole entrepreneur utilising his educational background and expertise in electronics and informatics. The company specialises in the production of barcode scanning applications for warehouses, as well as customised warehouse logistics solutions for existing customers. The company's warehousing and e-commerce customers are located mainly in France but also across Europe and other parts of the world, including the USA, Mexico, and South Africa. It has also recently partnered with an Australian company to cover distribution in the Asia-Pacific region.

2.10.2 Digital Transformation activities

Z-Application offers web-based client/server solutions, and utilises JavaScript/HTML5/CSS3 for user interfaces. It aims to help companies by offering custom development of Dolibarr open source Enterprise Resource Planning (ERP) software solutions as well as providing Dolibarr implementation support such as installation support, problem solving, and data migration from other systems such as Sage/Ciel for automated stock management purposes.

Mr Appels has developed a ready-to-use modular base product which eliminates the need to develop independent business solutions for each customer, requiring only customisation to suit their specific business needs. The base product uses the open source Dolibarr ERP system since it is easy to manage and install on any platform and has all the standard features a business needs. The base product is being continuously developed to add new features. The Z-Application 'Mobilid' app is a mobile Dolibarr warehouse application with a built-in barcode scanning feature for order collection and inventory counting, which can be installed on smartphones, tablets and next generation industrial handhelds.

Improving the automation of their online sales process using digital technologies was important for Z-Application. As a result, following the digital transformation support which Mr Appels received (as detailed in the next section), the company developed a new website with an integrated Search Engine Optimisation (SEO) tool. The website includes a blog and a page of trusted business partners to attract more customers. It also links to the Mobilid product website for ease of product ordering and to track product interest. Mobilid is also marketed via the Dolibarr 'Dolistore' e-marketplace platform.

Z-Application has already started to see significant benefits in terms of being able to understand its customers better and to be able to profile them. It is expecting to increase its sales as a result.

Currently, the company has implemented most of the suggested digital transformation solutions and is now looking for additional support for the online branding and marketing of its products.

2.10.3 Support for Digital Transformation

When first setting up the company, Mr Appels received financial aid from the Flemish SME e-wallet training support scheme, which helped him to upskill on mobile app development.

Recently, the company applied to the DigitaliseSME initiative, which matches the needs of applicants to a relevant expert who can coach the company in the development of digital solutions. Bogdan Dumitrasconiu, a digital expert from Romania, was assigned to Z-Application as a Digital Enabler to suggest solutions for improving the automation and digitalisation of the sales process. After collaborating for two weeks, Mr Appels was highly satisfied with the support provided by his Digital Enabler.

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[93] Sources: http://www.z-application.com/, https://www.dolistore.com/en/modules/407-Connector-for-Mobilid-Mobile-app.html, https://www.mobilid.eu/, https://www.vlaio.be/nl/andere-doelgroepen/flanders-innovation-entrepreneurship/subsidies-entrepreneurs/subsidies, https://digitalisesme.eu/digitalisesme-matching-series-belgian-company-providing-solutions-to-warehouses-aims-to-increase-sales-with-the-help-of-a-romanian-digital-expert/, Interview with Mr. Francis Appels on 01.11.2021.

2.10.4 Key Success Factors

Mr Appels considers his key success factors to be a strong product combined with personalised support. As he explained, there are many similar and cheaper products on the market, but none of them offer a customised product with customer support. Customers have the option of purchasing basic features with lifetime support or can purchase additional features with varying support options. Mr Appels mainly offers the direct support option to end customers. He also partners with trusted ERP integrators/resellers which buy and re-sell his product, since Z-Application does not carry out ERP integration and training. This allows customers in need of ERP support to receive it from his trusted partners instead.

Further success factors mentioned by Mr Appels were his personal passion for digital technologies and a mindset which does not see digital transformation as a challenge. He also considers his home-based teleworking strategy to be a success factor, viewing it as more efficient, productive and environmentally-friendly, since it has entirely eliminated office commuting. As a result he has avoided many of the challenges faced by other companies in adapting to the new pandemic working conditions since, as the sole proprietor of a self-funded company, he has always carried out his business this way.

2.10.5 Key Challenges and Issues

Responding to multilingual requests from his international customer base, and undertaking digital marketing are the main challenges faced by Z-Application. Mr Appels is currently on the lookout for a reliable communication and translation company which offers a seamless e-translation solution that can be embedded into the existing website. This way, requests could be automatically and correctly translated, while also supporting online branding and marketing in various languages on a variety of e-commerce websites.

2.10.6 Policy recommendation

Mr Appels is happy with the current regulatory and policy framework in Belgium, as well as across the EU, in terms of being able to provide business solutions cross-border via e-commerce throughout the EU.

3 Policy case studies

3.1 France Num - France

3.1.1 Introduction

France Num is a government policy initiative led by the 'Direction Générale des Entreprises'. It was officially launched in October 2018, based on the National Digital Council's recommendations for supporting the digital transformation of SMEs, particularly VSEs with fewer than 10 employees. The programme was developed in partnership with the 'Régions de France' organisation, the French regions and a number of professional organisations, with the aim of bringing together under one umbrella all the public services which support SME digital transformation.

There are two strands to the France Num 'brand': 'Advisor France Num' for the public and private partners of the programme and 'Enterprise France Num' for SMEs seeking support for digital transformation. The overall France Num brand brings together under one banner all the actions carried out by the government and France Num stakeholders to support the digital transformation of SMEs at national and regional levels (e.g. the France Num web platform, the community of advisers and partners, specific regional programmes, events, training, etc.).

The high-level mission of the initiative is to mobilise stakeholders around a strong brand in order to provide support to SMEs for their digital transformation. The goal is to provide a tailored solution for each company by raising their digital awareness via the France Num website, and by the provision of online tools such as a digital maturity assessment, as well as search engines for finding funding opportunities, special events, and advisors (based on specific digital technology needs/industrial sector/location).

There is also an extranet space within the France Num portal, reserved for public and private advisers, partners and government agencies, so they can share and promote relevant information and arrange collaborations aimed at providing digital support services and events for SMEs.

3.1.2 Digital Transformation Support Services

In a study carried out in 2019 by the Confédération des Petites et Moyennes Entreprises (CPME) and the software company, SAGE,[94] only 34% of VSE managers stated that digital transformation was already deployed or was in the process of being deployed in their company. According to the study, digital transformation services such as website creation, digitalisation of business processes, and stock and order management processes were among those most highly requested by SMEs to meet their specific needs.

France Num offers tailored services based on three types of company profile: companies new to digital, companies which have already implemented digitalisation of some kind, and companies at an advanced level of digitalisation. A variety of services are on offer to enterprises: information about the benefits of digital technologies; website creation; online marketing via social networks; use of e-commerce platforms to improve and increase sales; digital solutions for the organisation of business processes/automation of tasks/finding new customers/improving customer relations; and cyber resilience advice, for example, to help protect the company against cyber attacks and data leaks. Most recently, within the scope of the Recovery Plan established by the European Union to help repair the economic and social damage caused by the coronavirus pandemic, two new measures have been added to the existing initiative to accelerate the digital transformation of all enterprises. The first measure is the introduction of an Artificial Intelligence (AI) Booster. The objective is to assess the needs of SMEs and mid-caps from all sectors, which have already acquired a basic level of digital maturity, in order to support them in implementing various AI solutions. The second measure aims to provide support to manufacturing SMEs and mid-caps planning to invest in advanced Industry 4.0 manufacturing technologies (e.g. robotics, additive manufacturing, cyber-physical systems, sensors, production management software, etc.) in order to modernise their manufacturing processes.[95]

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[94] https://www.sage.com/fr-fr/blog/transformation-digitale-tpe-etude/
[95] https://www.economie.gouv.fr/plan-de-relance/maitrise-diffusion-numerique

A multi-phase implementation schedule is ongoing. During the 4th quarter of 2020, SMEs were given access to free diagnostics, a callout for the selection and mobilisation of training providers was introduced, and France Num loans were launched. An ongoing awareness raising campaign about the benefits of digitalisation will continue with the online training course, "Ma TPE a rendez-vous avec le numérique" ('My VSE has an appointment with digital technology'). Finally, from the second quarter of 2021, the France Num website will be further upgraded to provide direct access to new features.[96]

3.1.3 Observed/Expected Impacts on SME Digital Transformation

France Num aims to support every SME that wants to initiate the digitalisation process, with the goal of enabling 1 million SMEs to benefit from a digital diagnostic over the 3-year period of the initiative. When it launched in 2018, it comprised 25 partners and 900 advisors. By 2019, more than 1,500 advisors had partnered with the initiative to support VSEs/SMEs in their digital transformation.

Based on the testimonials of SMEs that have already used the France Num platform, SMEs are generally satisfied with the services and guidance they have received. As a result of being matched with an advisor with specific expertise in the digital technology field appropriate for their business sector and needs (e.g. developing real estate digital platforms), SMEs have gained confidence and trust in the scheme, and in the recommendations of their advisors for transforming their business appropriately.[97]

The impacts of digitalisation on SMEs have differed depending on the sector involved and the digital actions implemented. The pandemic lockdowns have also created different impacts. For example, utilising social network marketing has led to greater business visibility for some SMEs, while the adoption of online booking platforms has opened up new revenue sources for some SMEs and helped them to develop services for their local customers. Overall, the main impacts of digitalisation have been to provide companies with an improved online presence, new means of connecting with customers,[98] and the ability to work with simple and easily accessible digital tools (email, phone, payment methods), all of which have allowed SMEs to remain competitive. Data from the scheme show that the larger the SME, the more likely it is to adopt digital transformation (43% of companies with 10-19 employees and 53% of those with 20-49 employees). [99]

Although originally the main goal of France Num was to enable all French SMEs to launch their digital transformation within 3 years, the Covid-19 crisis has hampered progress of this aim. However, the European Union's Recovery Plan is expected to help mitigate this challenge, enabling France to mobilise EU funding of EUR 400 million until 2022 to help French companies recover and become more resilient through the adoption of digital technologies.

3.1.4 Key Success Factors

Access to finance for digitalisation activities is a major challenge for most SMEs. As a result, the France Num platform provides a search engine for digitalisation funding opportunities specifically dedicated to SMEs and VSEs. It covers national and regional public funding instruments, such as digital vouchers, loans and guarantees, equity capital and other funding sources such as crowd sourcing platforms.[100] Developing digital skills while at work is another important factor in increasing competitiveness and accelerating the business potential of SMEs. France Num therefore provides an online resource on its website which defines the 12 digital skills of the future,[101] along with another online resource, aimed at the construction sector, which outlines the four advantages of digitalisation for businesses: to increase the visibility and responsiveness of the company and thereby boost competitiveness; to improve the customer experience; to introduce more efficient, time-saving

[96] https://www.economie.gouv.fr/plan-de-relance/profils/entreprises/aides-francenum-transformation-numerique
[97] https://www.francenum.gouv.fr/comprendre-le-numerique/plugimmo-une-nouvelle-plateforme-immobiliere-numerique-concue-pour-les-2
[98] https://www.francenum.gouv.fr/comprendre-le-numerique/un-primeur-developpe-son-commerce-de-proximite-avec-deux-applis-commande-en
[99] https://www.gouvernement.fr/les-actions-du-gouvernement/economie-et-finances/comment-propulser-mon-entreprise-dans-le-numerique
[100] https://www.francenum.gouv.fr/financer-son-projet
[101] https://www.francenum.gouv.fr/comprendre-le-numerique/quelles-sont-les-competences-numeriques-de-demain

administrative management and communication with suppliers; and to increase the overall productivity of the business by moving towards new digital forms of work organisation.[102]

Other key factors in the success of the France Num initiative include being responsive to the specific needs of SMEs, and taking an active role as the intermediary between SMEs, digital advisors and all other stakeholder groups involved in the initiative. Also key to success is continually improving the scheme as a result of feedback from stakeholders and beneficiaries. A final success factor is the identification and promotion of companies which have successfully achieved digital transformation, as examples of best practice to inspire other SMEs.

3.1.5 Key Challenges and Issues

It is essential to start by identifying the precise needs of SMEs in taking their first step into the digital world. France Num has pinpointed four obstacles to digital transformation: lack of digital awareness; lack of understanding of digital technologies; lack of in-house digital skills; and lack of financial resources. All of these obstacles are addressed by the policy actions developed by the government.[103]

To avoid confusing SMEs, it is important that all the digital transformation support on offer from national/regional/local support institutions is made available in one place, in this case, under the France Num banner. For this reason, the France Num initiative is conducted jointly by the government and the regions, through committees organised around the Association of French Regions, the Minister for the Economy and Finance, and the Secretary of State to the Prime Minister in charge of the Digital Agenda. Other stakeholders (public and private-public partnerships, professional bodies working closely with SMEs, chartered accountants and banking networks) have also been encouraged to get involved in order to ensure the success of this policy.[104]

3.1.6 Recommendations for roll-out as a best practice

It is essential to centralise resources for SMEs so they can save time finding the information they need, quickly implement the most appropriate digital solutions, and thereby achieve a fast return on their time/money investments. A centralised platform allows SMEs to obtain online recommendations, find advisors in their region, identify relevant events and training, assess their digital maturity and find funding opportunities. Further recommendations include the establishment of government guaranteed loans, which can be a crucial factor in facilitating the transition to new technologies, and taking a collaborative approach which involves government, regions and local partners, to ensure the effectiveness of the actions taken.

3.2 Fund for Artificial Intelligence, Blockchain and IoT (Fondo per Artificial Intelligence, Blockchain e IoT) - Italy

3.2.1 Introduction

The National Fund for Artificial Intelligence, Blockchain and IoT was announced in the 2019 Italian budget.[105] Managed by the Italian Ministry of Economic Development through its in-house agency, Infratel,[106] it was endowed with EUR 45 million for the period 2019-2021 (EUR 15 million per year). Although the fund is not yet operational, its pilot project was launched in 2019. Subsequently, the 'Simplification Decree',[107] published in July 2020 and converted into law in September 2020[108], established a new regulation simplifying administrative procedures for the allocation of public funding, which requires the Ministry of Economic Development and the

[102] https://www.francenum.gouv.fr/comprendre-le-numerique/quels-outils-numeriques-pour-les-entreprises-du-batiment
[103] https://www.economie.gouv.fr/files/files/PDF/DP_FranceNum.pdf p. 8
[104] https://www.economie.gouv.fr/files/files/PDF/DP_FranceNum.pdf p. 8-9
[105] Budget Law number 145/2018, published in the Official Gazette, number 302 of 31/12/2018: https://www.gazzettaufficiale.it/eli/gu/2018/12/31/302/so/62/sg/pdf
[106] Infrastrutture e Telecomunicazioni per l'Italia S.p.A.: https://www.infratelitalia.it/
[107] Law Decree number 76/2020, published in the Official Gazette, number 178 of 16/07/2020: https://www.gazzettaufficiale.it/eli/id/2020/07/16/20G00096/sg
[108] Law number 120/2020, published in the Official Gazette, number 228 of 14/09/2020: https://www.gazzettaufficiale.it/eli/id/2020/09/14/20G00139/sg

Ministry of Economy and Finance to define clear criteria for assigning resources. To what extent this will impact the operation of the fund is not yet known.

The main scope of the fund is to pursue the digital and innovation growth of the country by leveraging emerging technologies and vertical applications in deep technology, such as Artificial Intelligence (AI), blockchain and the Internet of Things (IoT). The targeted beneficiaries are SMEs which could benefit from the integration of new solutions developed in these technology domains.

The establishment of the fund is in line with an overall national strategy that since 2018 has pursued the development of emerging technologies and the uptake of applications in vertical sectors. The first step taken by the Italian Parliament in 2019 was to create the legal definitions of 'Distributed Ledger Technologies' and 'smart contracts'. Subsequently, two groups of national experts were established to support the Italian Ministry of Economic Development in devising national strategies for the promotion of AI and blockchain applications in Italy. One group of experts developed a national strategy proposal for AI. The other group developed a national strategy proposal for blockchain, which was put out to public consultation until July 2020. These proposals will act as guidelines for the development of a national roadmap in these two fields.

3.2.2 Digital Transformation Support Services

The National Fund for Artificial Intelligence, Blockchain and IoT was launched with the purpose of promoting:

a) research and innovation projects to be carried out in Italy by public and private entities, including foreign actors, in national strategic areas, for the development of AI, blockchain and IoT, to increase the country's competitiveness in these fields;
b) competitive challenges and new opportunities for the achievement of specific technological objectives and applications;
c) the transfer of the resulting digital transformations to Italian businesses and specifically to SMEs.

3.2.3 Observed/Expected Impacts on SME Digital Transformation

The National Fund for Artificial Intelligence, Blockchain and IoT is not yet operational. Therefore, there are no data available on its implementation and impact. However, other data, available at national level, show that investments in blockchain are growing in Italy, doubling between 2018 and 2019 to a total of EUR 30 million. The main applications of blockchain are in supply chain traceability, digitalisation of processes, authentication and certification, tokenisation, marketplaces, data sharing, data integrity and security, digital identity management and smart contracts. The aim of most of these examples is to improve customer experience, avoid counterfeiting and promote and protect 'Made in Italy' products.

In 2019, the Ministry of Economic Development launched a pilot project in partnership with IBM and a number of Italian textile and high fashion companies. The goal was to support the development of a case study to exploit the blockchain potential for 'Made in Italy' product protection and, more specifically, to prevent counterfeiting by increasing traceability within the textile sector. In 2020, the pilot resulted in a feasibility plan for the scalability of the project.

As a result of the COVID-19 pandemic, blockchain solutions were also developed in 2020 to monitor and trace the evolution of the epidemic and to authorise actions to reduce infection risks.

Finally, in September 2020,[109] a study was published, conducted by the OECD and funded by the Ministry of Economic Development, which provides an overview of the development of the blockchain ecosystem in Italy. It reviews ongoing projects and applications and their impact on Italian businesses, in particular, on SMEs, highlighting that many of these ongoing projects and applications are specifically aimed at SMEs. Most of the blockchain applications are focused on ensuring traceability, durability and transparency. The range of possible target sectors is broad, including agri-food, manufacturing and financial services.

[109] https://www.oecd-ilibrary.org/economics/blockchain-per-le-pmi-e-gli-imprenditori-in-italia_bdbbb4ea-it

3.2.4 Key Success Factors

Even though it is not yet operational, one of the key success factors behind the National Fund for Artificial Intelligence, Blockchain and IoT is the Italian innovation ecosystem, made up of skilled research teams and young startups offering solutions based on emerging technologies. Another key success factor is the rise in Italian Venture Capital funds[110] dedicated to companies offering solutions in these technology domains. The Iconium VC fund, established in 2018, is one such example, investing specifically in blockchain startups. Additionally, in recent years, various incentives and support measures have boosted digitalisation and backed startups and innovative SMEs which offer advanced solutions in deep tech fields. One such example is the Italian government's 'Smart&Start' incentive scheme,[111] which targets startups active in the blockchain field. A final success factor relates to the entry of Italy into the European Blockchain Partnership in 2019. This has led to Italy's participation at an international level in the blockchain domain and has resulted in the establishment of strategic partnerships to enable further dissemination of digital technologies to citizens and businesses.

3.2.5 Key Challenges and Issues

The main challenges that may hinder the uptake of deep tech by SMEs include lack of a digital culture and lack of internal skills and competencies. However, there are other issues that could also inhibit the adoption of emerging technologies, such as difficulties in identifying tangible benefits, allocating adequate financial resources and accessing available funds or support initiatives.

In the blockchain field, for example, according to a survey conducted in 2019 by the 'Blockchain and Distributed Ledger Observatory' of the School of Management, Polytechnic University of Milan,[112] only 20 % of SMEs had sufficient knowledge of technology applications and only 3 % considered that these technologies would have an impact on their business in the next five years. In addition, only 1 % of SMEs had carried out projects focused on the development of technology applications.

3.2.6 Recommendations for roll-out as a best practice

Similar policy initiatives, starting from a strategic approach to operational implementation, have already taken place in other EU countries, so this type of policy approach has already proved successful (for example, in Germany, with its national blockchain strategy). In the case of Italy, the broad consultation process undertaken by the Italian government, involving a group of 30 experts selected from different public and private organisations, has helped to identify the challenges, needs and requirements in the key technology domains which are specific to Italy. These identified factors will guide the development of a national strategy that will be turned into specific action lines which the Fund for AI, Blockchain and IoT will target. In this way, financial resources addressing the real needs of the beneficiaries can be most effectively channeled to projects and make a tangible impact on the target beneficiaries. In addition, establishing a legal definition of some of the major aspects of these technologies, such as Distributed Ledger Technology (DLT) and smart contracts, will contribute to the consolidation of knowledge and set up a framework for additional policy interventions and instruments in the field.

3.3 Fit 4 Digital Packages - Luxembourg

3.3.1 Introduction

'Fit 4 Digital Packages' is a national policy initiative developed and offered jointly by the General Directorate for Small and Medium-Size Enterprises of the Ministry of Economy, the House of Entrepreneurship of the Chamber of Commerce, and Luxinnovation, the national agency responsible for the promotion of innovation in Luxembourg.[113] It was first launched in 2019 for retail and services and in 2020 was extended to the HoReCa (hotel/restaurant/café) industry, the skilled crafts industry, architects, and consulting engineers, all of which play

[110] https://www.iconium.it/en/home-en/
[111] https://ec.europa.eu/growth/tools-databases/regional-innovation-monitor/support-measure/centro-i/smartstart-italy
[112] https://www.osservatori.net/it/ricerche/osservatori-attivi/blockchain-distributed-ledger
[113] https://www.houseofentrepreneurship.lu/actualites/detail/le-programme-fit-4-digital-packages-elargit-son-perimetre/

an important role in Luxembourg with regard to employment and SMEs.[114] The initiative will continue supporting SMEs throughout 2021.

Fit 4 Digital Packages is a digitalisation aid programme which has been designed specifically to support Very Small Enterprises (VSEs) with fewer than 50 employees in their digital transformation efforts. The economic fabric of Luxembourg is made up mainly of VSEs and therefore their impact on the local economy is significant. While bigger companies have already largely adopted digital solutions, VSEs are still struggling, particularly in terms of internal competencies and finding expert digital know-how and financial resources.

The programme provides VSEs with a preliminary needs assessment, help with implementation of digital marketing tools, and financial support. It is aimed at VSEs which are hesitant about deploying a digitalisation strategy, and which lack knowledge about how to evaluate the work and costs involved. VSEs which implement one of the recommended packages at an investment level of EUR 6,650 - EUR 10,000, excluding value added tax (VAT), receive financial support of EUR 5,000 from the Ministry of the Economy's General Directorate for Small and Medium-Size Enterprises.[115,116]

A parallel initiative, Fit 4 Digital Transition,[117] aims to provide similar support services to all size classes of SMEs. SMEs can either apply for financial support of EUR 5,000, as with VSEs, or, alternatively, after digital implementation they can apply for a subsidy of up to 50% of the costs incurred.

3.3.2 Digital Transformation Support Services

Several types of support services are provided to VSEs during their digital transformation journey. The Fit 4 Digital Packages offer is built around the results of the preliminary analysis carried out by the House of Entrepreneurship of the Chamber of Commerce, which identifies the specific needs of each VSE and the corresponding solutions, such as digital marketing (development of website/social media), customer relationship management (CRM software) or organisational management (i.e. specialised business software appropriate to the specific industry needs of the VSE). Once agreed, the implementation of the digital tool is carried out with the support of an approved service provider.[118] The service providers are chosen and accredited by Luxinnovation, and selected from providers who demonstrate specific digital competencies.[119]

Since the Covid-19 pandemic, with its impact on many business activities, there has been an increase in the number of VSEs enquiring about digitalisation, due to the necessity of finding new ways of doing business (for example, in the HoReCa industry, by switching from restaurant catering to take-away services).

3.3.3 Observed/Expected Impacts on SME Digital Transformation

VSEs seem, in general, to be highly satisfied with the initiative based on the testimonials received.[120] Receiving customised support through an independent scheme, rather than one affiliated to proprietary software companies, has had a positive impact on VSE satisfaction levels, because it has allowed VSEs to define their specific needs and evaluate different solutions that make sense for their business. As a result, many entrepreneurs and VSE employees have learned about the different types of digital technologies and have also increased their digital skills. The greatest impact of the Fit 4 Digital Packages has been in the sectors of commerce, crafts, HoReCa and architecture. In the 3 months between the launch of the initiative in October 2019 and the end of the same year, a total of 30 companies participated in the initiative, while more than 180 companies took part in 2020.[121]

Although VSEs with fewer than 50 employees and a turnover of less than EUR 10,000,000[122] are eligible for the programme, in practice, VSEs with 1-10 employees (i.e. micro SMEs) comprise the majority of applicants. Specific

[114] https://www.cc.lu/actualites/detail/le-programme-fit-4-digital-packages-elargit-son-perimetre/
[115] https://paperjam.lu/article/fit4-digital-packages-elargit-
[116] https://www.luxinnovation.lu/fit-4-digital-packages/
[117] https://www.luxinnovation.lu/fit-4-digital-transition/
[118] https://www.cc.lu/actualites/detail/le-programme-fit-4-digital-packages-elargit-son-perimetre/
[119] https://www.luxinnovation.lu/fr/fit-4-digital-packages-prestataires/#prestataires
[120] https://www.luxinnovation.lu/fit-4-digital-packages/
[121] Information provided by the House of Entrepreneurship, 15/12/20
[122] Interview with Luxinnovation 28/11/2020

operational changes within these companies have occurred as a direct result of the initiative, and, following the initial support, some VSEs have also proceeded further with their digitalisation process. By targeting additional sectors, key to the national economy, the objective of this policy initiative is to enable the largest possible number of VSEs to benefit from digitalisation. Thanks to the financial support on offer, VSEs have been able to consider undertaking digital transformations that would not have been possible without it.

3.3.4 Key Success Factors

The Covid-19 crisis has reinforced the need for many VSEs to redefine both their way of working and their business models. Indeed, businesses which were inititally reluctant to digitalise, have been encouraged to digitalise their activities and processes to ensure the continuity of their businesses, thanks to the awareness and skills development programme for entrepreneurs set up by the House of Entrepreneurship.

Another key success factor has been simplifying the digitalisation steps required. On average, the duration of each project is around three months. The process of software installation seems to be efficient, with skilled technical support provided by recognised partners, and some VSEs expressing their desire to digitalise further after the programme has ended.

A further success factor has been the establishment of regular and effective communication between beneficiaries, external service providers and the three institutions behind the Fit 4 Digital Packages initiative.

3.3.5 Key Challenges and Issues

During the digitalisation process, one particular challenge regularly mentioned by SMEs is the difficulty of finding employees with the requisite digital qualifications. Consequently, digital training needs are high. VSEs also experience difficulty in finding the most appropriate digital solutions by themselves, as well as in accessing the necessary funding. The assistance provided by Fit 4 Digital Packages takes care of these three needs, by providing customised support, a network of affiliated experts, and financial aid supplied by the Ministry of the Economy in the form of a digital voucher.[123]

One of the lessons learned from the Fit 4 Digital Packages initiative is the importance of supporting VSEs technically as well as financially. One of the challenges faced by the initiative itself is the high number of requests received from VSEs due to the economic crisis caused by the pandemic, which has made it challenging to process all the applications and support them in a timely manner.[124]

3.3.6 Recommendations for roll-out as a best practice

As VSEs represent a large proportion of businesses in the EU-27 Member States, it is essential to continue to promote awareness of the benefits of digitalisation by guiding and advising VSEs on the steps to be taken and, above all, by reassuring them about best practices.[125] Many CEOs of smaller companies do not always know where to start their digitalisation process. For this reason, the introduction of simplified procedures enables VSEs to quickly implement new technologies. Furthermore, a fast procedure allows quick payment of the grant, thus facilitating the cash flow management of VSEs. Allowing VSEs to test their digital maturity is also key to ensuring that the advice they receive is as appropriate for their needs as possible.

In order to ensure the effectiveness of schemes such as Fit 4 Digital Packages, another key essential is that government agencies and any external partners involved maintain high standards of communication and collaboration with each other. Furthermore, well-chosen trusted external service providers can play an important role in improving the visibility of this type of initiative and enhancing its effectiveness.

A further recommendation is that the administrative roles in the initiative should be clearly defined. In the case of Fit 4 Digital Packages, for example, the initial needs assessments are carried out by the House of Entrepreneurship of the Chamber of Commerce, service provision is handled by Luxinnovation via external

[123] https://meetanentrepreneur.lu/en/video/fit-4-digital-packages/
[124] Interview with Luxinnovation 28/11/2020
[125] https://www.cc.lu/actualites/detail/lancement-du-programme-de-digitalisation-des-pme-porte-par-le-ministere-de-leconomie-la-chambre-de/

service providers, and financial support is the remit of the General Directorate for Small and Medium-Size Enterprises of the Ministry of Economy.

3.4 Iniciativa Nacional Competências Digitais e.2030 (Portugal INCoDe.2030) - Portugal

3.4.1 Introduction

One of the main factors hindering the digital transformation of SMEs is the shortage of digital skills. Indeed, the New Industrial Strategy for Europe[126] points out that 7 out of 10 companies cannot find employees with the relevant skills. To tackle this issue, 120 million Europeans will have to upskill or reskill in the next five years alone. In Portugal, several studies have highlighted the scarcity of IT expertise,[127] with 8 out of 10 companies facing difficulties in finding specialised IT talent. According to IT industry stakeholders, universities do not produce enough technicians and engineers to meet the existing needs of Portuguese SMEs.[128]

In this context, the Portuguese National Government launched the National Digital Competences Initiative, 'Portugal INCoDe.2030', in 2017. It commenced formally in 2018 with the publication of the Resolution of the Council of Ministers 26/2018 of 8 March 2018.[129] The ultimate goal of the initiative is to improve Portugal's position and competitiveness worldwide in terms of digital proficiency. More specifically, Portugal INCoDe.2030 [130]aims to:

- Ensure digital literacy and inclusion for the whole population
- Stimulate employability, professional training and specialisation in digital technologies and applications
- Ensure strong participation in international R&D and digital knowledge networks.

Both public and private stakeholders are participating in the initiative: from national and regional public administrations and municipalities to trade associations, SMEs, educational and vocational institutions, foundations, etc.

The promotion and coordination of the initiative involves three permanent bodies:

1. The National Forum for Digital Competences, responsible for gathering and coordinating a broad range of private and public stakeholders to ensure widespread mobilisation for the initiative.
2. The INCoDe.2030 Coordination Structure, which oversees the initiative as a whole and promotes and coordinates the activities in each action line.
3. The INCoDe.2030 Technical Secretariat, which monitors, records and reports on the implementation of all the planned activities.

3.4.2 Digital Transformation Support Services

The implementation of Portugal INCoDe.2030 is structured in five axes / action lines:

1. Inclusion: measures to ensure that the whole population has equal access to digital technologies.
2. Education: measures to ensure the education of the younger population by stimulating and reinforcing digital literacy and digital competences at all levels of schooling and as part of lifelong learning.
3. Professional qualifications: measures to upskill the working population by providing the knowledge required to become part of a labour market that relies heavily on digital competences.

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126 https://ec.europa.eu/info/sites/info/files/communication-eu-industrial-strategy-march-2020_en.pdf
127 https://www.robertwalters.pt/hiring/hiring-advice/81-por-cento-empresas-com-dificuldades-para-encontrar-talento-tecnologico.html
128 https://www.jornaldenegocios.pt/negocios-iniciativas/detalhe/o-drama-dos-recursos-nas-tecnologias-escassez-e-falta-de-competencias
129 https://dre.pt/web/guest/pesquisa/-/search/114832288/details/maximized
130 https://www.incode2030.gov.pt/sites/default/files/incode2030_en.pdf

4. Specialisation: measures to promote specialisation in digital technologies and applications to improve employability and create higher added value in the economy.
5. Scientific research: measures to ensure conditions are in place for the production of new knowledge and active participation in international R&D networks and programmes.

3.4.3 Observed/Expected Impacts on SME Digital Transformation

Even though it is currently too early to assess the impact of the initiative on SMEs, some outcomes/results can already be highlighted, based on the Progress Report presented at the 2nd Permanent Forum for Digital Competences[131]:

Table 3 Examples of outputs/results

Axes / Action lines	Outcomes / Results
Inclusion	Creation of 10 Creative Communities for Digital Inclusion with 750 direct beneficiaries, including 22 certified female mentors
Education	Over 200 primary schools integrated ICT in their curricula
	The 'Programming and Robotics in Basic Education' project was implemented in nearly 200 schools, reaching over 10,000 students
Professional qualification	Over 12,500 participants in digital skills training courses
	649 participants have benefited from 40 courses focusing on programming, information security, data science, digital marketing and similar topics
Specialisation	Creation of several Higher Professional Technical Courses in direct cooperation with polytechnic schools and private companies
Scientific research	Launch of the Portuguese strategy on Artificial Intelligence

The following table includes the SME-related indicators selected to measure the impact of the initiative:

Table 4 Current situation vs Expected results

SME-related Indicator	Current (2015)	Expected/targeted		
		2020	2025	2030
% of ICT specialists in employment	2.3	3	5	8
% of SMEs with a high level of digital intensity	17.7	20	30	40
Business enterprise R&D (BERD) expenditure as percentage of GDP	0.6	1	1.5	2

3.4.4 Key Success Factors

Portuguese industry considers the INCoDe.2030 initiative to be an important tool for promoting the digital transformation of the private sector.[132] However, the involvement of all levels of government and society is necessary, particularly in connection with digital literacy, for the initiative to be successful.

3.4.5 Key Challenges and Issues

Improving the digital skills of the Portuguese population is an enormous challenge in all dimensions: political, economic, cultural and social. For this reason, the Portuguese government has established a set of goals covering different factors, including social inclusion and digital literacy, the physical and cognitive access of the entire population to digital services, and the intensive use of ICT in lifelong education. Another challenge facing the initiative is related to the various stakeholders involved. Portugal INCoDe.2030 is structured as an integrated

[131] https://www.incode2030.gov.pt/sites/default/files/incode.2030_relatorio_de_progresso_12122018.pdf
[132] https://ec.europa.eu/information_society/newsroom/image/document/2019-32/country_report_-_portugal_-_final_2019_0D313AC4-9C8E-F45B-AA1BFF19CC713C17_61218.pdf

programme for Portugal, to be promoted through the collaboration of all stakeholders, with their different experiences and knowledge, from a variety of public and private organisations. Consequently, the different priorities of the various stakeholders could affect the implementation of the initiative. Therefore, the continuous and active support of all stakeholders is needed in order to achieve the 2030 targets, for which there is a strong commitment.[133]

3.4.6 Recommendations for roll-out as a best practice

The INCoDe.2030 initiative was developed to adapt to the specificities of the Portuguese context and relies on stakeholders from both the private and public sectors. This specificity, combined with existing differences within the EU-27 in terms of digital skills, regulations, culture and economic structures, could therefore prohibit replication of the initiative in other EU Member States.

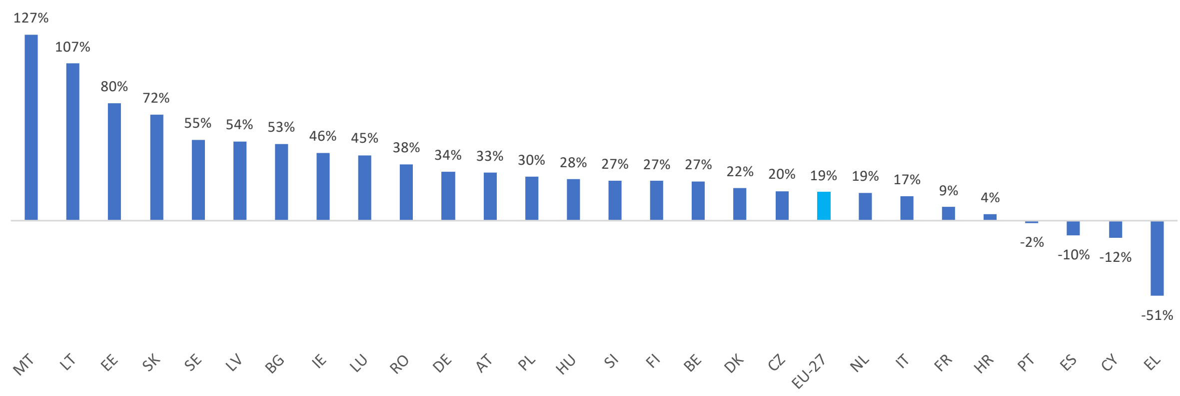
[133] https://www.incode2030.gov.pt/sites/default/files/2019-incode2030-hlrc-finalreport_6.pdf

4 The drivers of the performance of EU-27 SMEs from 2008 to 2016

4.1 Introduction

Cumulative growth from 2009 to 2016[134] in value added generated by EU SMEs in the NFBS varies greatly across Member States (Figure 5). The present chapter assesses empirically the factors which could explain these differences across Member States of the growth of SME value added from 2010 (i.e. from the post-great financial crisis year) to 2016 (i.e. the last year before major structural breaks occur in the SBS database[135]).

Figure 5 Cumulative growth from in SME value from 2009 to 2016



Source: Eurostat, National Statistical Offices, DIW Econ

4.2 Empirical approach

The variable of interest is the annual growth rate of value added by SMEs in the NFBS reported in Eurostat's Structural Business Statistics database[136]. The explanatory variables include potential determinants of growth in value added by SMEs. These can be classified as structural or cyclical factors. Structural factors include:

- A country's competitiveness, defined by the World Economic Forum (WEF) as the "set of institutions, policies, and factors that determine the level of productivity of a country" (Schwab and World Economic

[134] Because of structural breaks in the SME data, the end year of the analysis is 2016. According to Council Regulation (EEC) No 696/93 of 15 March 1993 an enterprise is the smallest combination of legal units that is an organisational unit producing goods or services, which benefits from a certain degree of autonomy in decision-making, especially for the allocation of its current resources. An enterprise carries out one or more activities at one or more locations. An enterprise may be a sole legal unit. However, in past years, NSOs could not implement this definition of an enterprise due to a lack of data. Each legal unit used to be recorded as a separate enterprise in the SBS database. However, over the past few years, NSOs of a number Member States have started to report to Eurostat enterprise data reflecting the 1993 enterprise definition. Legal units (which are part one organisational unit, according to the definition above) are now recorded as a single enterprise in the SBS database instead if several SMEs. As a result, in the year in which the data are reported for the first time according to the correct enterprise defintion, the total number of SMEs decreases and the total number of large enterprises increases in the SBS database, which also implies a decrease in SME value added and employment (in contrast to an increase for large companies). Such a structural break is observed in 2017 in the case of FR and IT, and in 2018 for AT, BE, DE, ES, LV, PL and SE.

[135] According to Council Regulation (EEC) No 696/93 of 15 March 1993 an enterprise is the smallest combination of legal units that is an organisational unit producing goods or services, which benefits from a certain degree of autonomy in decision-making, especially for the allocation of its current resources. An enterprise carries out one or more activities at one or more locations. An enterprise may be a sole legal unit. However, in past years, NSOs could not implement this definition of an enterprise due to a lack of data. Each legal unit used to be recorded as a separate enterprise in the SBS database. However, over the past few years, NSOs of a number Member States have started to report to Eurostat enterprise data reflecting the 1993 enterprise definition. Legal units (which are part one organisational unit, according to the definition above) are now recorded as a single enterprise in the SBS database instead of several SMEs. As a result, in the year in which the data are reported for the first time according to the correct enterprise defintion, the total number of SMEs decreases and the total number of large enterprises increases in the SBS database, which also implies a decrease in SME value added and employment (in contrast to an increase for large companies). Such a structural break is observed in 2017 in the case of FR and IT, and in 2018 for AT, BE, DE, ES, LV, PL and SE.

[136] Eurostat (n.d.).

Forum, 2016), and measured by the WEF's Global Competitiveness Index (GCI)[137]. The GCI ranges from 1 to 7 and has a broad scope: it is based on over 100 indicators[138] which fall under 12 categories (or "pillars"), ranging from institutions to innovation. It is expected that growth in value added by SMEs is higher in more competitive economies.[139]

- A country's score for starting a business[140] – one of the 11 topics that are the focus of the World Bank's (WB) *Doing business* project. The score accounts for the number of procedures typically carried out to start and run a limited liability company, the time and cost associated with these procedures, as well as the paid-in minimum capital requirement (*Doing business*, n.d.b). It is expected that higher scores are associated with higher business birth rates, which in turn are likely to increase overall value added by SMEs.

- A country's score for resolving insolvency[141] – also from the WB's *Doing business* project. This indicator captures the "recovery rate" or the proportion of a secured creditor's unpaid claim that can be recovered through insolvency proceedings (taking into account the time, cost and outcome of these proceedings), as well as the strength of an economy's legal framework for judicial liquidation and reorganization proceedings (*Doing business,* n.d.c).[142]

- The share of SMEs in high and very high R&D intensity industries,[143] based on Eurostat's Structural Business Statistics database[144]. It is expected that SMEs in economies with relatively important R&D-intensive industries – as measured by the share of SMEs in these industries – will benefit from greater knowledge spillovers and therefore grow faster.

- The annual change in the structural balance of general government excluding interest, as a percentage of potential GDP at current prices, sourced from the AMECO database[145]. The change in the structural balance of general government is a measure of fiscal policy. A negative value indicates fiscal expansion, which is expected to stimulate the economy and promote growth in SME value added.[146]

In addition, a number of cyclical factors were also included in the model specification:[147]

- The output gap sourced from the AMECO database and lagged by one year[148]. It is measured as the gap between actual GDP and estimated trend GDP, and expressed as a percentage of trend GDP at constant prices. The output gap quantifies the difference between aggregate supply and demand. For example, a negative output gap indicates that aggregate demand is lower than what the economy is capable of producing when resources are used optimally (the latter is often referred to as "potential" output and, in this instance, measured through trend GDP) (see for instance Ladiray et al., 2003). It is expected that

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[137] World Economic Forum (2018).
[138] These indicators are based on existing datasets (e.g. statistical data from the IMF, World Bank etc.) as well as a primary data collection exercise: the WEF's Executive Opinion Survey (Schwab and World Economic Forum, 2016).
[139] The 12 pillars are: institutions, infrastructure, macroeconomic environment, health and primary education, higher education and training, goods market efficiency, labour market efficiency, financial market development, technological readiness, market size, business sophistication, and innovation (Schwab and World Economic Forum, 2016). For a detailed overview of the methodology for constructing the GCI, see for instance Schwab and World Economic Forum (2016).
[140] Doing business (n.d.a).
[141] Doing business (n.d.a).
[142] In order to utilize a broader measure of regulations and their enforcement, the use of the overall ease of doing business score was considered. However, because the computation of indicators within several topics was subject to methodological changes, this analysis focuses on the two topics which did not undergo substantial methodological revisions.
[143] As classified in Muller et al. (2019).
[144] Eurostat (n.d.).
[145] AMECO (2020a).
[146] Additional variables were also considered. For instance, in order to account for the possible impact of specific problems faced by SMEs, the inclusion of variables denoting the incidence of various problems (e.g. access to finance, availablity of skilled staff or experienced managers etc.) faced by enterprises (based on the survey on the access to finance of enterprises) was also considered. However, the causal relationship between these variables and the dependent variable would be unclear. Indeed, certain problems may hinder growth, but they may also be a result of high growth (e.g. a lack of skilled staff may prevent firms from scaling up their activities, but may also be a result of increased workload from rapid expansion). Therefore, these variables were not included in the analysis.
[147] These also include a variable capturing monetary policy, which is a key tool for managing cyclical changes in output. It should also be noted that some of these variables – growth in exports and inflation – include both a structural and cyclical component, so these variables are not purely 'cyclical'.
[148] AMECO (2020b).

the output gap in the previous period is negatively correlated with contemporaneous growth in value added, as a result of an economy's adjustment towards its long-run equilibrium.

- The annual growth in exports of goods and services (nominal), sourced from Eurostat[149]. This proxy for foreign demand growth is expected to be positively associated with growth in value added by SMEs.

- The annual change in the short-term interest rate (nominal), taken from the AMECO database[150]. This variable is a proxy for monetary policy: a fall in the short-term interest rate indicates a monetary expansion, and is likely to ease SMEs' access to financing, thereby allowing them to grow their activities. Therefore, the change in the short-term interest rate is expected to be negatively correlated with growth in SME value added.

- Inflation, as measured by growth in the average annual Harmonised Index of Consumer Prices (HICP), taken from Eurostat[151]. Inflation can be distortionary when it is unexpected, thereby hindering economic activity and therefore value added growth. However, growth in value added incorporates changes in prices, meaning that higher growth in value added is likely to be associated with higher inflation.[152]

The analysis dataset is an almost perfectly balanced panel of 26 EU Member States and the estimation period ranges from 2011 to 2016.[153] Table 5 presents summary statistics of the variables described above.

Table 5 Summary statistics – analysis variables

	Count	Mean	Standard deviation
Growth in SME value added (%)	154	3.4	6.4
Share of SMEs in high- and very high-R&D intensity industries (% of NFBS population)	154	25.8	5.7
Starting a business score (WB Doing business)	154	87.0	5.7
Resolving insolvency score (WB Doing business)	154	67.4	14.9
Global Competitiveness Index	154	4.7	0.5
Δ Structural balance of general government excluding interest (% of potential GDP at current prices)	154	0.5	1.3
Δ Nominal short-term interest rate	154	-0.3	0.6
Lagged gap between actual and trend GDP (% of trend GDP)	154	-2.0	2.5
Growth in the annual average HICP index (%)	154	1.3	1.6
Growth in exports of goods and services (%)	154	5.4	5.7

Note: The above statistics are based on the estimation sample. Δ denotes the first-difference operator.
Source: Eurostat, National Statistical Offices, DIW Econ, AMECO, WEF, World Bank

The model is fit using the Ordinary Least Squares (OLS) estimator. In order to check the robustness of results, variants of the model include country and/or year fixed effects. The former are intended to account for unobservable time-invariant country-specific factors, while the latter are included to control for EU-wide shocks

[149] Eurostat (2020a).
[150] AMECO (2020b).
[151] Eurostat (2020b).
[152] Inflation is also a key control variable, accounting for the potentially confounding effect of price-level variation on the relationship between the dependent variable and certain explanatory variables such as nominal growth in exports.
[153] Malta and Croatia enter the estimation sample in 2012. In recent years, Ireland has seen an increase in "globalisation activities" of multinational corporations (e.g. transfers of intangible assets for tax purposes) (see for instance Central Statistics Office, n.d.; European Commission, 2016; OECD, 2016; Regan, 2016; Beesley, 2017). This has impacted GDP – most notably in 2015, when it rose by over 25%. Although these sometimes-large changes in GDP resulting from "globalisation activities" of multinational corporations do not reflect developments in actual economic activity, they create structural breaks in several variables used in the analysis. For this reason, data on Ireland is not included in the analysis.

to growth in SME value added. As unobservable factors may be correlated within countries and across time, standard errors are clustered at the country level.

4.3 Empirical Results

The regression results in Table 6 provide some evidence that structural factors are associated with SME value added growth. The coefficient on the GCI achieves statistical significance at the 5% level and displays a positive sign in two of the specifications. Furthermore, the coefficient on the score for resolving insolvency is positive and statistically significant at the 10% level in one of the models. These results, however, are not robust to the addition of country fixed effects (or time fixed effects, in the case of the score for resolving insolvency), and should therefore be interpreted with caution. The relationship between fiscal policy and growth in SME value added is more robust to the inclusion of fixed effects. Indeed, the differenced structural balance of general government displays a negative and statistically significant[154] relationship with the dependent variable in all specifications, suggesting that expansionary fiscal policies are associated with higher growth of SMEs.

Among cyclical factors, growth in exports displays the most robust relationship with the dependent variable as its coefficient estimate is positive and statistically significant in all specifications.[155] The results also provide some evidence that SME economic activity has a tendency to adjust and revert back to its long-run equilibrium after actual GDP has deviated from potential GDP.[156] Indeed, the coefficient on the lagged output gap is negative and statistically significant in two of the specifications.[157]

Table 6 Regression results

	(1)	(2)	(3)	(4)
Share of SMEs in high- and very high-R&D intensity industries (% of NFBS population)	-0.0728	-0.153	-0.102	-0.448
	(0.563)	(0.680)	(0.420)	(0.341)
Starting a business score (WB Doing business)	0.00433	0.146	-0.0286	0.0846
	(0.969)	(0.409)	(0.789)	(0.641)
Resolving insolvency score (WB Doing business)	-0.0985	0.211*	-0.0984	0.188
	(0.173)	(0.0515)	(0.141)	(0.165)
Global Competitiveness Index	4.054**	10.51	4.391**	8.065
	(0.0379)	(0.148)	(0.0241)	(0.234)
Δ Structural balance of general government excluding interest (% of potential GDP at current prices)	-1.584***	-0.537*	-1.381***	-0.439*
	(0.000443)	(0.0597)	(0.000356)	(0.0873)
Δ Nominal short-term interest rate (%)	0.0640	0.881	0.0631	0.278
	(0.920)	(0.123)	(0.951)	(0.740)
Lagged gap between actual and trend GDP (% of trend GDP)	-0.282	-0.489*	-0.407	-0.691**
	(0.371)	(0.0715)	(0.188)	(0.0103)
Growth in the annual average HICP index (%)	-0.355	-0.565	0.781	-0.453
	(0.341)	(0.144)	(0.326)	(0.439)
Growth in exports of goods and services (%)	0.432***	0.409***	0.442***	0.282*
	(5.06e-06)	(0.000663)	(0.00170)	(0.0886)
Constant	-9.111	-70.80**	-11.95	-43.56
	(0.344)	(0.0456)	(0.217)	(0.262)
Country fixed effects	NO	YES	NO	YES
Year fixed effects	NO	NO	YES	YES
Observations	154	154	154	154

Note: Δ denotes the first-difference operator. P-values in parentheses *** p<0.01, ** p<0.05, * p<0.1

Source: Eurostat, National Statistical Offices, DIW Econ, AMECO, WEF, World Bank

[154] At the 10% level, and 1% level when country fixed effects are not included.

[155] At the 1% level in most models, and 10% level when both country and year fixed effects are included.

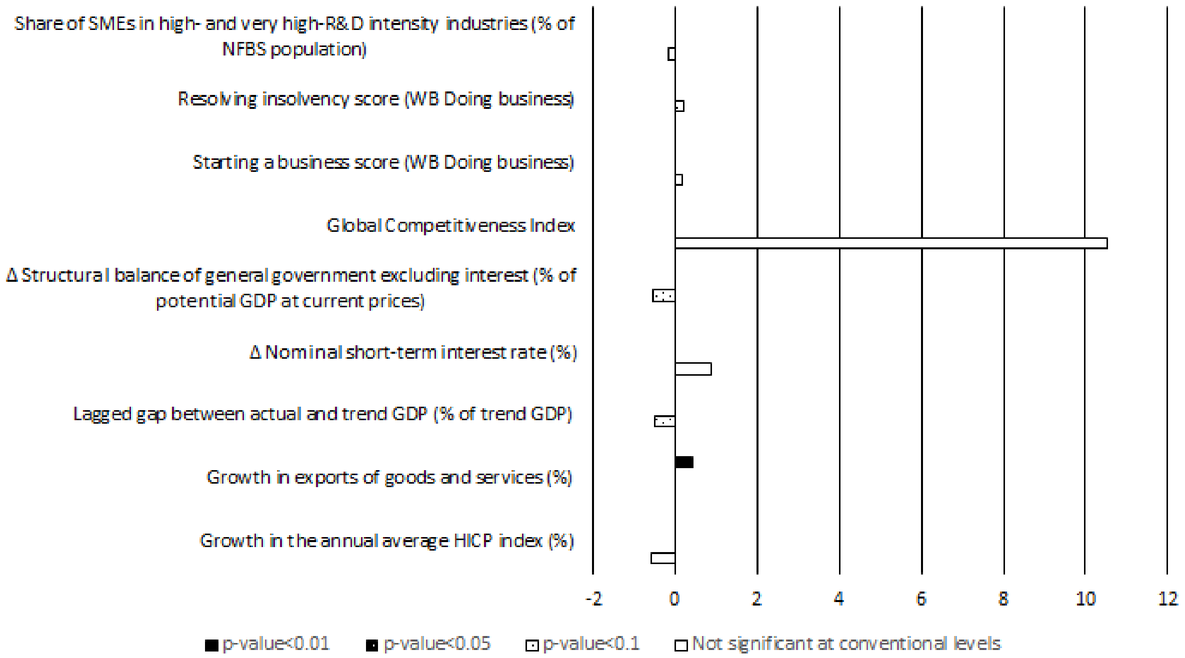
[156] It should be noted, however, that the output gap is computed at the level of the economy as a whole, whereas the dependent variable is restricted to the population of SMEs in the NFBS. Therefore, the estimated relationship between both variables cannot perfectly capture the equilibrium adjustment process.

[157] At the 5% and 10% level.

Coefficients from model (2) are presented graphically in Figure 6. For greater comparability, these coefficients are also presented in standardized form in Figure 7, where each bar represents the change in SME value added growth associated with a one standard deviation increase in a given explanatory variable (expressed as standard deviations of SME value added growth).

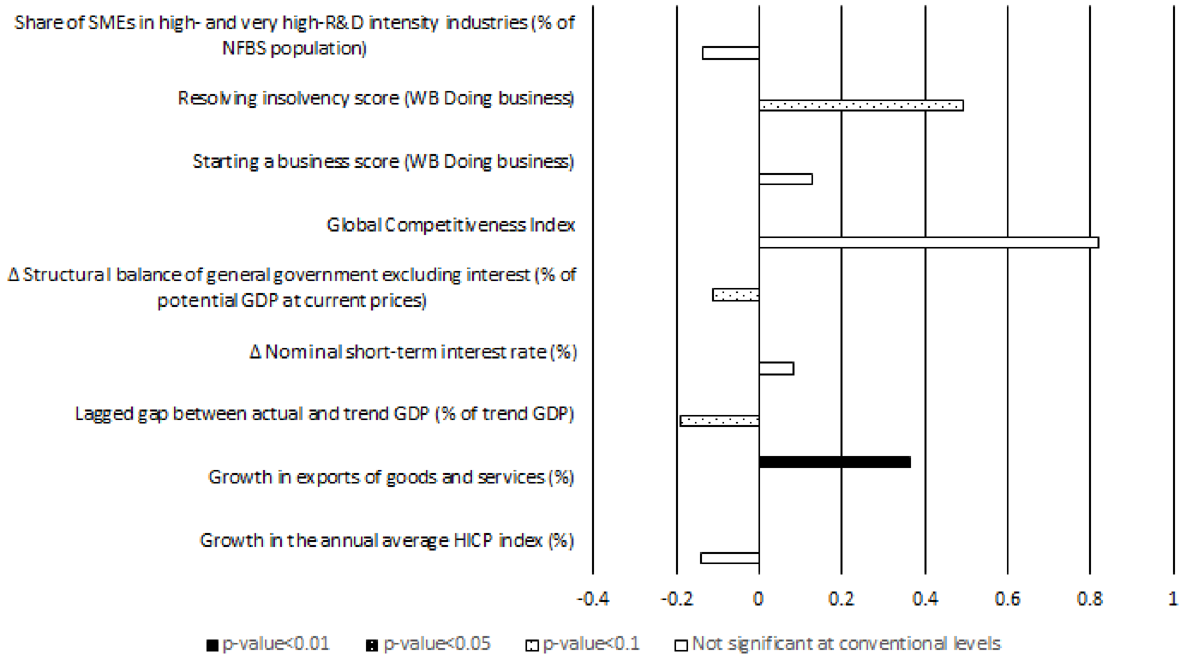
Figure 7 suggests that a one standard deviation increase in the score for resolving insolvency is associated with half of a standard deviation increase in the dependent variable. The standardized coefficient on the annual growth in exports of goods and services is roughly similar in magnitude albeit lower. A one standard deviation increase in the output gap in the previous period is associated with 0.2 of a standard deviation decline in the dependent variable. Finally, a one standard deviation increase in the differenced structural balance of general government is associated with a 0.1 standard deviation decrease in SME value added growth.

Figure 6 Regression results (based on fixed effects model)



Note: Δ denotes the first-difference operator.
Source: Eurostat, National Statistical Offices, DIW Econ, AMECO, WEF, World Bank

Figure 7 Regression results – standardized (based on fixed effects model)

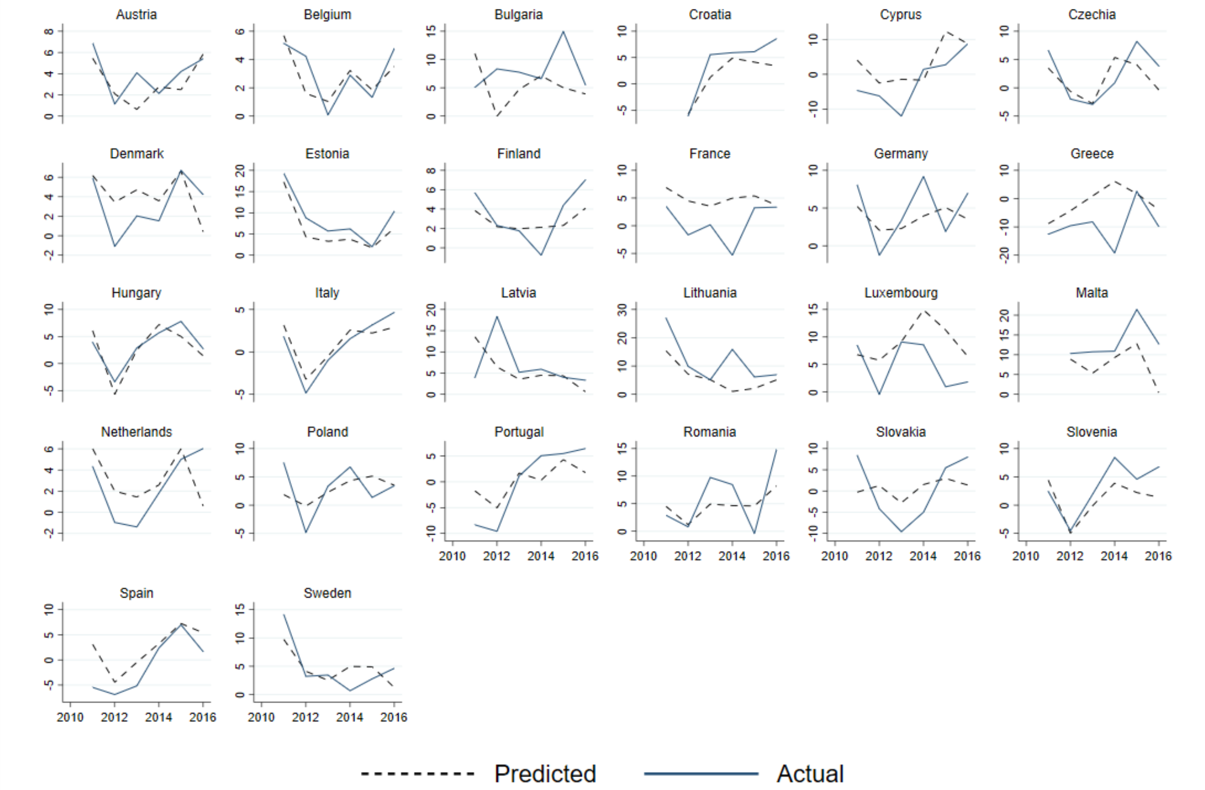


Note: Δ denotes the first-difference operator.
Source: Eurostat, National Statistical Offices, DIW Econ, AMECO, WEF, World Bank

4.4 Model predictions

Coefficient estimates can be used to produce 'fitted' or 'predicted' values of the dependent variable – the annual growth rate of SME value added. The accuracy of the models' predictions can be assessed visually in Figure 8 and Figure 9, which plot actual growth in SME value added across time for each Member State, along with fitted values based on models (1) and (2). Both models' predictions appear to follow actual growth rates reasonably well.

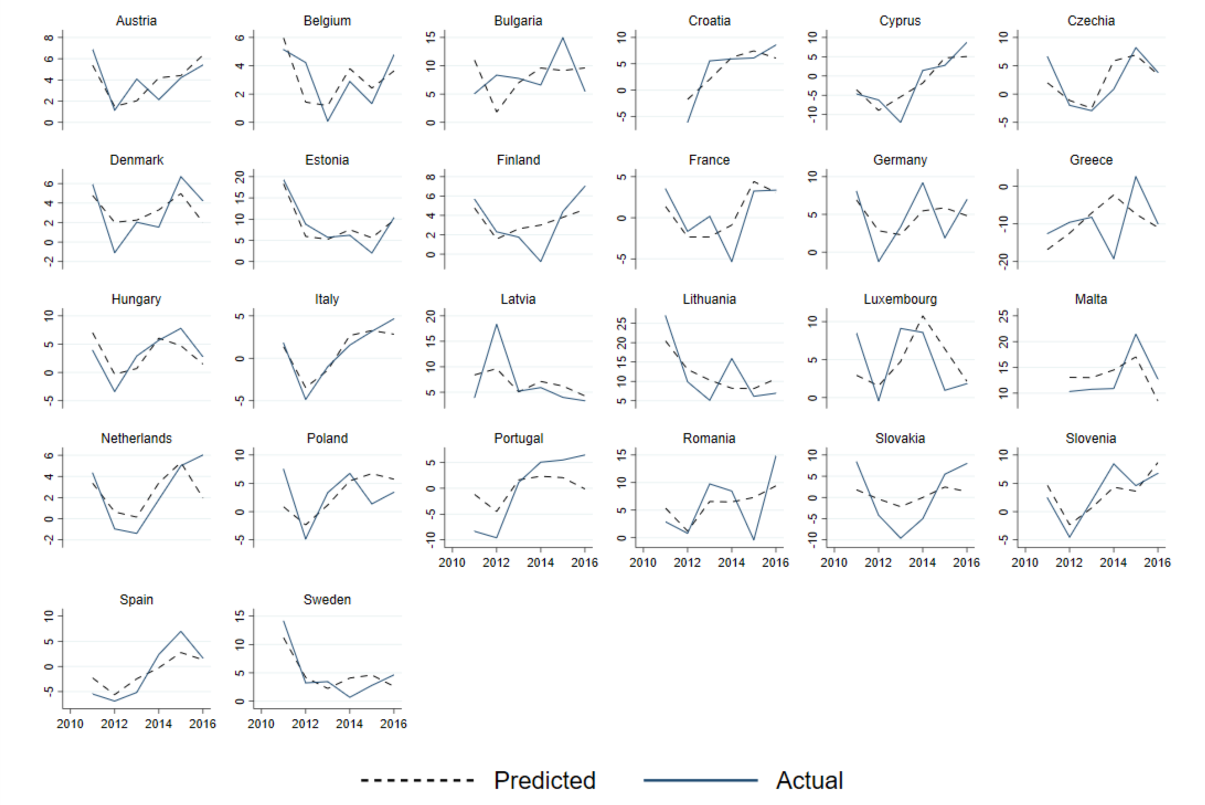
Figure 8 Actual and predicted annual growth rates in SME value added in % between 2011 and 2016 (based on pooled OLS model)



Note: predicted growth estimated through an OLS model.

Source: Eurostat, National Statistical Offices, DIW Econ, AMECO, WEF, World Bank

__Figure 9 Actual and predicted annual growth rates in SME value added in % between 2011 and 2016 (based on fixed effects model)__

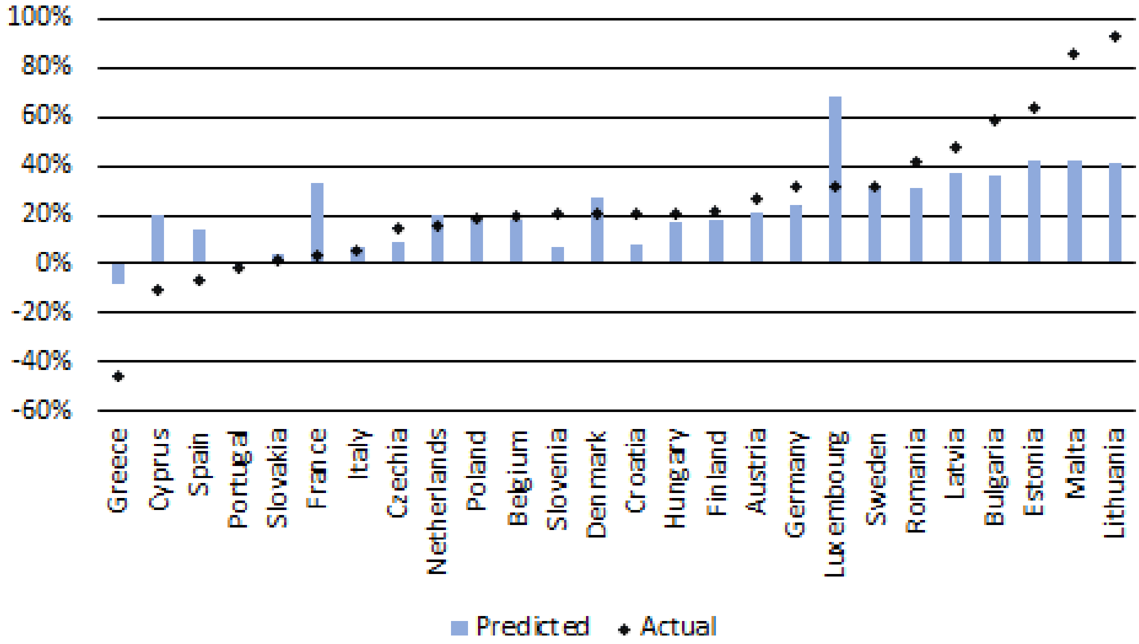


Note: predicted growth estimated through a country fixed effects model (country-specific effect included in the fitted values)
Source: Eurostat, National Statistical Offices, DIW Econ, AMECO, WEF, World Bank

Figure 10 and Figure 11 focus on the percentage change in SME value added between 2010 and 2016.[158] The accuracy of growth predictions based on the fitted values from the OLS model varies markedly across countries. In contrast, predicted growth based on the fitted values from the fixed effects model is fairly accurate for all countries. This indicates that the introduction of country-specific intercepts, which capture time-invariant determinants of the dependent variable in each Member State, are important in predicting growth.[159]

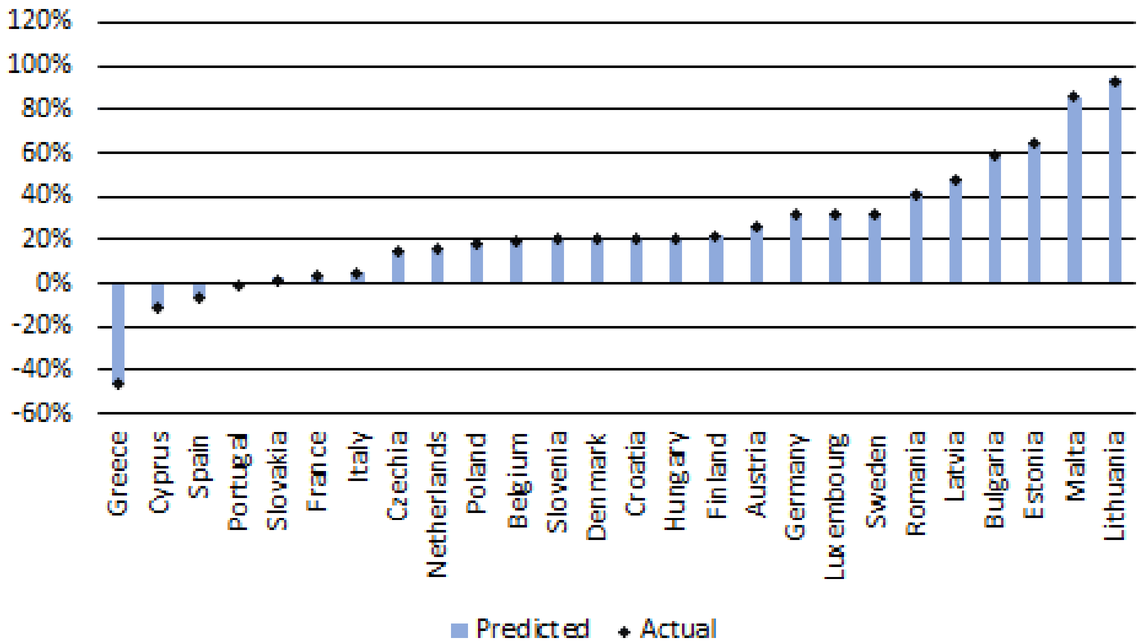
[158] This is calculated using the following formula: $\left[\prod_{t=2011}^{2016}(1+g_t^i)\right]-1$, where g_t^i is actual or predicted annual growth in SME value added in country i and in year t.
[159] Results based on models (3) and (4) (not shown) are very similar to those based on models (1) and (2) respectively.

Figure 10 Actual and predicted growth between 2010 and 2016 (based on pooled OLS model)



Note: predicted 2010-2016 growth estimated through an OLS model. Growth in Croatia and Malta relates to the period 2011-2016.
Source: Eurostat, National Statistical Offices, DIW Econ, AMECO, WEF, World Bank

Figure 11 Actual and predicted growth between 2010 and 2016 (based on fixed effects model)



Note: predicted 2010-2016 growth estimated through a country fixed effects model (country-specific effect included in the fitted values). Growth in Croatia and Malta relates to the period 2011-2016.
Source: Eurostat, National Statistical Offices, DIW Econ, AMECO, WEF, World Bank

5 Analysis of Flash Eurobarometer 486 survey on 'SMEs, start-ups, scale-ups and entrepreneurship'

5.1 Introduction

Digitalisation is one of the main challenges that European small and medium-size enterprises (SMEs) face today[160]. SMEs can benefit from digitalisation by entering the data economy which in turn can improve business intelligence and consumer research, engendering further innovation, more effective marketing and improvements in customer satisfaction[161]. Data generated by SMEs also provides the opportunity for stock optimisation based upon consumer behavioural models.

To assess what support could be most effective for SMEs, this section will analyse a number of characteristics which may encourage or deter SMEs to adopt digital technology. The data used for this analysis is sourced from the **Flash Eurobarometer 486 on Entrepreneurship, Start-ups and Scale-ups**. Overall, the Eurobarometer response sample comprised 16,365 responses. For the purpose of the analysis in this report, the following survey responses were excluded: a) 3,750 responses from survey participants located in countries outside of the EU-27; b) 633 responses from survey respondents locacted in the EU-27 with 250 or more employees; c) 116 responses from survey participants located in the EU-27 who did not provide information on the number of their employees; d) 1,225 responses from survey respondents who indicated that they had closed their business; and, e) 239 responses from survey respondents who reported that the age of their business was '9999'. As result, the response sample used in the analysis of the digitalisation of SMEs comprised 10,402 responses.

Section 5.2 sets out the research question and rationale for the selection of indicators and section 5.3 presents the results of the econometric analysis.

5.2 Indicator selection

To accurately measure the drivers of technology adoption amongst SMEs we utilized responses from the Flash Eurobarometer on Entrepreneurship, Start-ups and Scale-ups survey. Participants of the survey were asked to **indicate which of the following options best describes your enterprise's approach to digital technologies?** The respondents could choose one of the following options:

1) Your enterprise has adopted or is planning to adopt basic digital technologies such as email or a website but not advanced digital technologies;
2) There is a need to introduce advanced digital technologies but your enterprise does not have the knowledge or skills or financing to adopt them;
3) There is a need to introduce advanced digital technologies and your enterprise is currently considering which of them to adopt;
4) There is a need to introduce advanced digital technologies and your enterprise has already started to adopt them;
5) Your enterprise does not need to adopt any digital technologies;
6) Other;
7) None;
8) DK/NA.

For the purposes of this study, those SMEs which choose answer 1 and answer 4 are of interest, this is because in both cases enterprises have either adopted digital technologies or are planning to adopt digital technologies rather than simply considering or recognising the need for adoption.

The most common response for SMEs overall is that the enterprise has adopted or is planning to adopt **basic digital technologies** such as email or a website but **not advanced digital technologies**. The answer to this

[160] European Commission (2019). *Cybersecurity, Internet of things and big data for small and medium-size enterprises* [online]. Available at: https://op.europa.eu/en/publication-detail/-/publication/82aa7f66-67fd-11ea-b735-01aa75ed71a1/language-en (Accessed: 17th December 2020)

[161] European Commission (2019). *Supporting specialized skills development: Big Data, Internet of Things and Cybersecurity for SMEs* [online]. Available at: https://op.europa.eu/en/publication-detail/-/publication/bb5c6c09-6285-11ea-b735-01aa75ed71a1/language-en (Accessed: 17th December 2020)

particular question varies upon the size of SMEs whereby the adoption of advanced digital technologies is most prevalent among medium-sized SMEs, small SMEs are split between basic and advanced digital technologies and micro SMEs are more focused on basic digital technologies.

Table 7 Frequency distribution (in %) of Q 22: Please indicate which of the following options best describes your enterprise's approach to digital technologies? (Single answer)

Answer no.	Which of the following options best describes your enterprise	All SMEs	Micro SMEs	Small SMEs	Medium-sized SMEs
1	Your enterprise has adopted or is planning to adopt basic digital technologies such as email or a website **but not advanced digital technologies**	33.13	36.76	29.35	26.74
2	There is a need to introduce advanced digital technologies but your enterprise does not have the knowledge or skills or financing to adopt them	7.89	8.2	8	6.65
3	There is a need to introduce advanced digital technologies and your enterprise is currently considering which of them to adopt	10.40	8.55	12.5	13.37
4	There is a need to introduce advanced digital technologies and your enterprise has already started to adopt them	25.23	19.68	29.35	37.69
5	Your enterprise does not need to adopt any digital technologies	16.92	19.97	14.78	9.84
6	Other	1.12	1.17	0.96	1.18
7	None	4.16	4.49	4.11	3.12
8	DK/NA	1.15	1.17	0.96	1.41
	Total	**100**	**100**	**100**	**100**

Note: Overall, the Eurobarometer response sample comprised 16,365 responses. For the purpose of the analysis in this report, the following survey responses were excluded: a) 3,750 responses from survey participants located in countries outside of the EU-27; b) 633 responses from survey respondents located in the EU-27 with 250 or more employees; c) 116 responses from survey participants located in the EU-27 who did not provide information on the number of their employees; d) 1,225 responses from survey respondents who indicated that they had closed their business; and, e) 239 responses from survey respondents who reported that the age of their business was '9999'. As result, the response sample used in the analysis of the digitalisation of SMEs comprised 10,402 responses
Source: LE Europe analysis of Eurobarometer data

To ensure the consistency of respondents, we noted which specific technologies were adopted by SMEs who answered 1 or 4 to the above question. As per the table below, a number of enterprises who said that they were planning to adopt basic digital technologies have actually already adopted advanced digital technologies. Similarly, some businesses who said they had adopted advanced digital technologies failed to identify any specific advanced technologies they have adopted.

Table 8 Summary of technologies adopted by enterprises (Q 23, multiple answers allowed)

Technology	Total Frequency	Percentage	Answered 1 to Q 22	Answered 4 to Q 22
Artificial intelligence, e.g. machine learning or technologies identifying objects or persons, etc.	651	6.26	127	332
Cloud computing, i.e. storing and processing files or data on remote servers hosted on the internet	4,741	45.58	1,358	1,750
Robotics, i.e. robots used to automate processes for example in construction or design, etc.	815	7.84	158	375
Smart devices, e.g. smart sensors, smart thermostats, etc.	2,615	25.14	688	1,032
Big data analytics, e.g. data mining and predictive analysis	1,285	12.35	259	610
High speed infrastructure	3,244	31.19	909	1,229
Blockchain	299	2.87	73	141

None of these	3,513	33.77	1,361	329
DK	151	1.45	54	24

Note: Overall, the Eurobarometer response sample comprised 16,365 responses. For the purpose of the analysis in this report, the following survey responses were excluded: a) 3,750 responses from survey participants located in countries outside of the EU-27; b) 633 responses from survey respondents locacted in the EU-27 with 250 or more employees; c) 116 responses from survey participants located in the EU-27 who did not provide information on the number of their employees; d) 1,225 responses from survey respondents who indicated that they had closed their business; and, e) 239 responses from survey respondents who reported that the age of their business was '9999'. As result, the response sample used in the analysis of the digitalisation of SMEs comprised 10,402 responses
Source: LE Europe analysis of Eurobarometer data

Whilst the survey identified cloud computing as an advanced digital technology, we categorise it as a basic technology due to its widespread use and adoption. We have grouped basic and advanced technology adopters as follows:

- Basic digital technology adopters are those firms that:
    - Noted they have adopted basic technologies in Q22 and have not adopted any of the advanced technologies in Q23;
    - Noted they have adopted basic technologies in Q22 and have only adopted cloud computing and/or high speed infrastructure in Q23;
    - Noted they have adopted advanced technologies in Q22 and have not adopted any of the advanced technologies in Q23;
    - Noted they have adopted advanced technologies in Q22 and have only adopted cloud computing and/or high speed infrastructure in Q23;
- Advanced digital technology adopters are those firms that:
    - Noted they have adopted basic technologies in Q22 and have adopted cloud computing, high speed infrastructure and one or several of the advanced technologies in Q23;
    - Noted they have adopted basic technologies in Q22 and have not adopted cloud computing or high speed infrastructure but have adopted one or several of the advanced technologies in Q23;
    - Noted they have adopted advanced technologies in Q22 and have adopted cloud computing, high speed infrastructure and one or several of the advanced technologies in Q23;
    - Noted they have adopted advanced technologies in Q22 and have not adopted cloud computing or high speed infrastructure but have adopted one or several of the advanced technologies in Q23;

Table 9 Model specification

Variable	Question	Comment	Value
Dependent 1	22	Firms which have adopted basic digital technologies as per the definition above	1; 0
Dependent 2		Firms which have adopted advanced digital technologies as per the definition above	1; 0
Independent variables			
Age	1		Continuous
Size	2b	The size will correspond the definitions used in the report.	Micro; Small; Medium;
Scale up	5	This dummy will equal 1 where respondents answered that their company was found prior to 2015 and which have grown turnover by at least 30% since 2016[162].	0;1

[162] This is consistent with the Eurobarometer definition for 'scale-ups' - enterprises founded prior to 2015, that have achieved significant growth since 2016 (thus in the last three years) in employment and/or turnover. Growth in turnover must have been at least 30% to qualify

Gazelle		This dummy will equal 1 where respondents answered that their company is less than 5 years old and which have grown turnover by at least 30% since 2016[163].	0;1
City	8	This dummy will equal 1 where respondents answered that the enterprise is in a large town or city and 0 otherwise.	0;1
GVC	9	This dummy will equal 1 where respondents identified as *not* being part of a global value chain (option 5)	0;1
External funds available	10	This dummy will equal 1 where respondents said that they could probably or definitely obtain external financing in case of need (option 1 and option 2)	0;1
Exporter	11	This dummy will equal 1 where respondents said that they export (option 2 – 8)	0;1
Independent	13	This dummy will equal 1 where respondents answered that their enterprise **is solely owned by one person; owned by more than one person** or **predominantly family owned** (option 1, option 2 and option 7) and 0 otherwise	0;1
Innovation	19	This dummy will equal 1 where respondents said that they engaged in innovative activity (option 1 – 7)	0;1
Country	-	Country will be used as a dummy variable (EU27 only)	0;1
Sector	-	Sector will be included at the highest level only due to data limitations	0;1
Barriers to digitalisation			
Lack of financial resources	21	This dummy will equal 1 where respondents said that a lack of financial resources represented a barrier to digitalisation (option 1)	0;1
Lack of skills, including managerial skills		This dummy will equal 1 where respondents said that a lack of skills, including managerial skills represented a barrier to digitalisation (option 2)	
Lack of information technology infrastructure, such as high speed internet connection		This dummy will equal 1 where respondents said that a lack of information technology infrastructure, such as high speed internet connection represented a barrier to digitalisation (option 3)	
Regulatory obstacles		This dummy will equal 1 where respondents said that regulatory obstacles represented a barrier to digitalisation (option 4)	
IT security issues		This dummy will equal 1 where respondents said that IT security issues represented a barrier to digitalisation (option 5)	
Uncertainty about future digital standards		This dummy will equal 1 where respondents said that uncertainty about future digital standards represented a barrier to digitalisation (option 6)	
Internal resistance to change		This dummy will equal 1 where respondents said that internal resistance to change represented a barrier to digitalisation (option 7)	

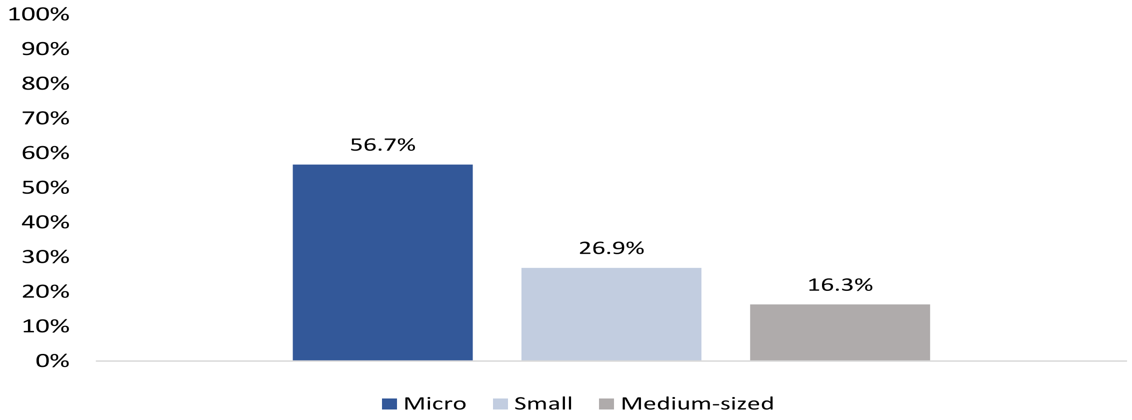
Source: LE Europe analysis of Eurobarometer data

The majority of SMEs in the sample are micro SMEs (Figure 12), within this group, a total of 16.9% of enterprises are either gazelles or scales-ups (Figure 13). Gazelles are overrepresented within micro SMEs representing 4.6% of micro enterprises as opposed to 3.7% of enterprises overall (Figure 13). Similarly, small SMEs have a high proportion of scale-ups (20.2%) compared to SMEs overall (15.7%), however, given that small enterprises are only 26.9% of the sample, there are a higher number of scale-ups which are micro SMEs in this particular dataset (Figure 14).

on a turnover basis. To qualify as a scale-up on the basis of employment, there must have been a growth of a t least 30% in the case of firms with 10 or more employees, or, in the case of micro firms, an increase of at least 3 employees.

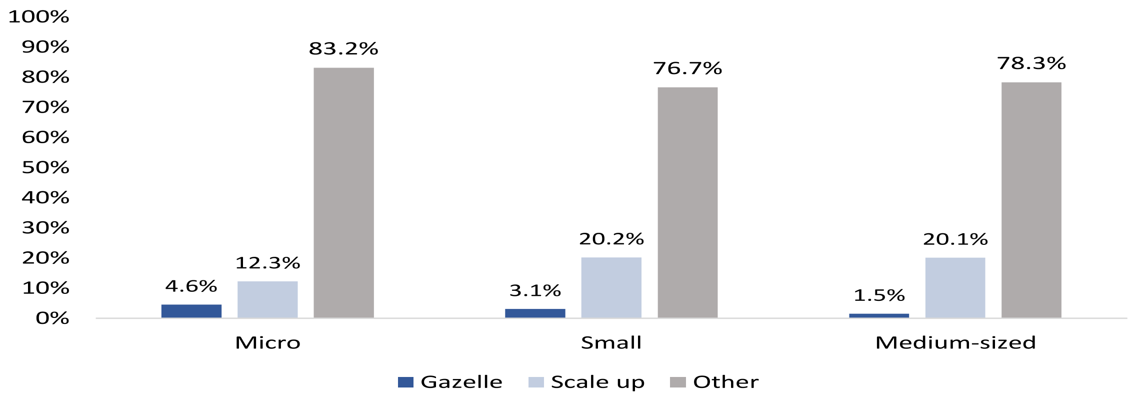
[163] According the Eurostat a gazelle is a high growth enterprise that is up to 5 years old where high growth is defined as growth in number of employees greater than 10 % per year over a three-year period and having at least 10 employees in the beginning of the growth.

Figure 12 Total distribution by SME size



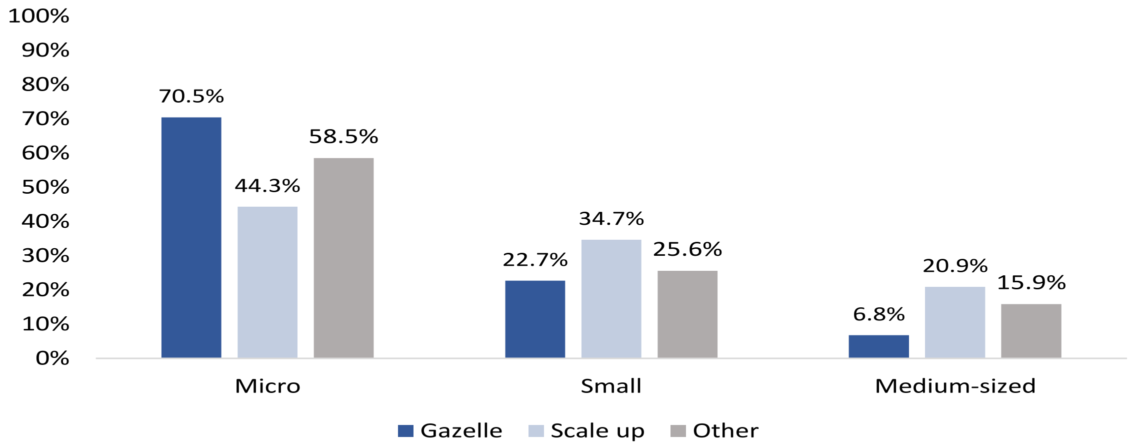
Source: LE Europe analysis of Eurobarometer data

Figure 13 Distribution by SME size and type



Source: LE Europe analysis of Eurobarometer data

Figure 14 Distribution of gazelles and scale-ups according to SME size

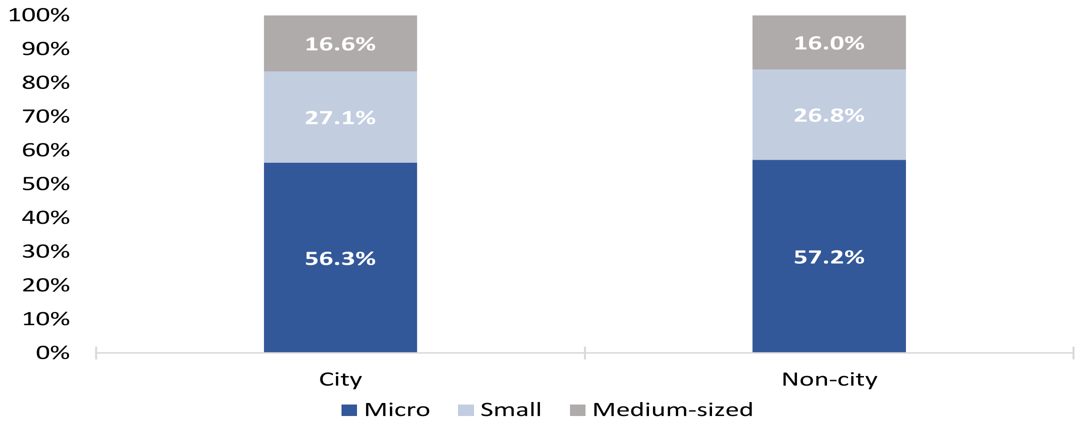


Source: LE Europe analysis of Eurobarometer data

City

Respondents were asked whether their enterprise is located in a large town/city, a rural area, industrial area or a small town or village. As shown in the Figure 15 below, firms located in a city have a slightly higher proportion of small and medium-sized SMEs.

Figure 15 Distribution of SMEs in city and non-city locale

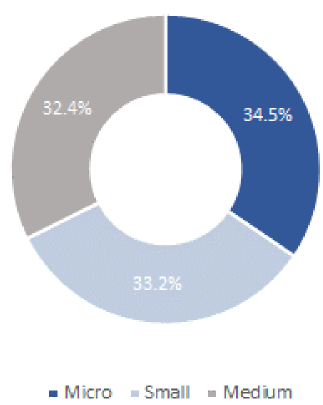


Source: LE Europe analysis of Eurobarometer data

Global Value Chain (GVC)

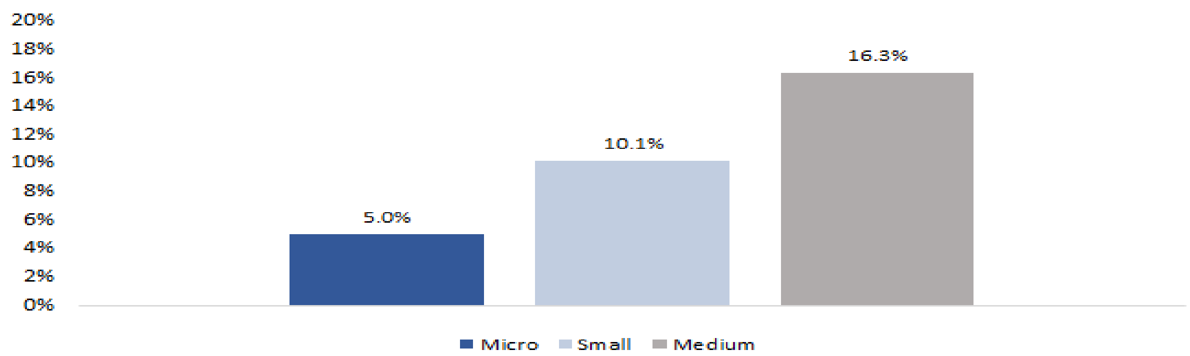
A global value chain (GVC) is when different stages of a production process take place in different countries. These processes all contribute to the manufacturing of a good or service. Approximately 8% of SMEs identified as being part of a GVC. As shown in Figure 16 below, nearly 35% of those enterprises that are part of a GVC are micro SMEs. However,Figure 17 shows that only 5% of micro SMEs said that they are part of a global value chain but this figure increases to 10.1% and 16.3% with small and medium-sized SMEs respectively.

Figure 16 Distribution of SMEs which are part of a global value chain



Source: LE Europe analysis of Eurobarometer data

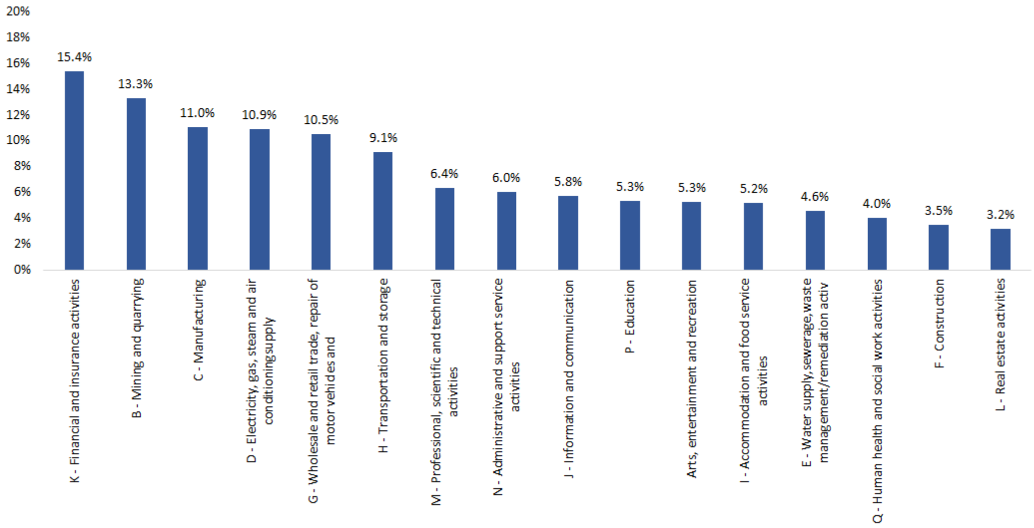
Figure 17 Respondents who identified as being part of global value chain, by SME size



Source: LE Europe analysis of Eurobarometer data

The share of respondents who identified as being part of a GVC is below 10% in the majority of sectors. The real estate activities sector had the lowest GVC participation 3.2% and financial and insurance activites had the highest participation rate at 15.4%.

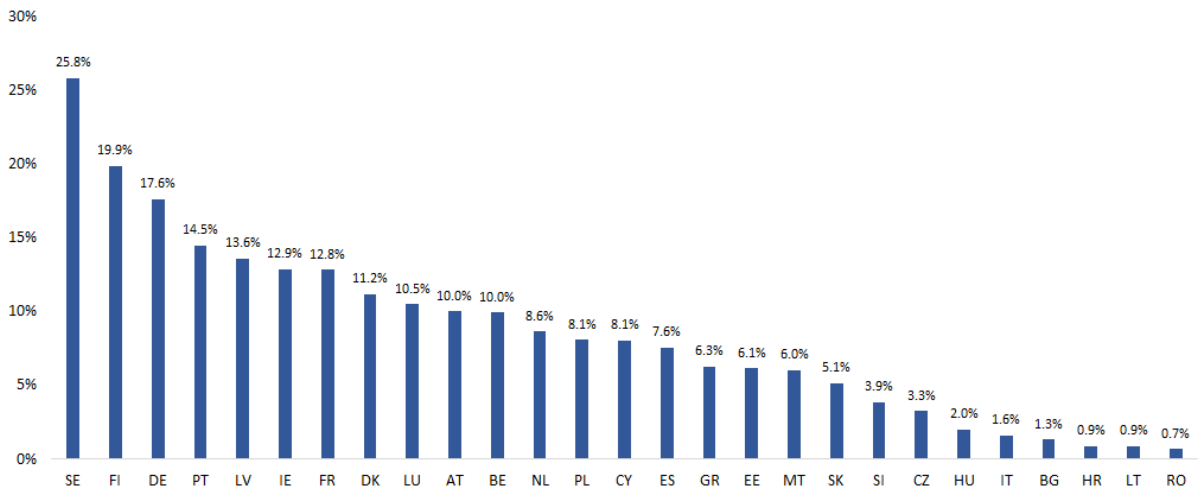
Figure 18 SME respondents who identified being part of a global value chain, by sector



Source: LE Europe analysis of Eurobarometer data

Less than 1% of SMEs in Croatia, Lithuania and Romania identified as being part of a global value chain. SME participation in GVCs is low throughout EU Member States with Sweden being the only country where participation is above 20%.

Figure 19 SME respondents who identified as being part of a global value chain, by county

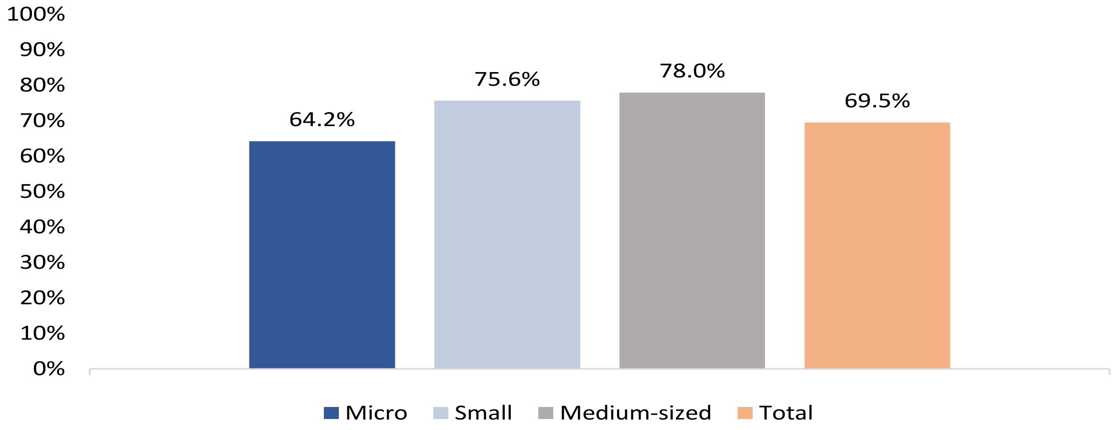


Source: LE Europe analysis of Eurobarometer data

External funds available

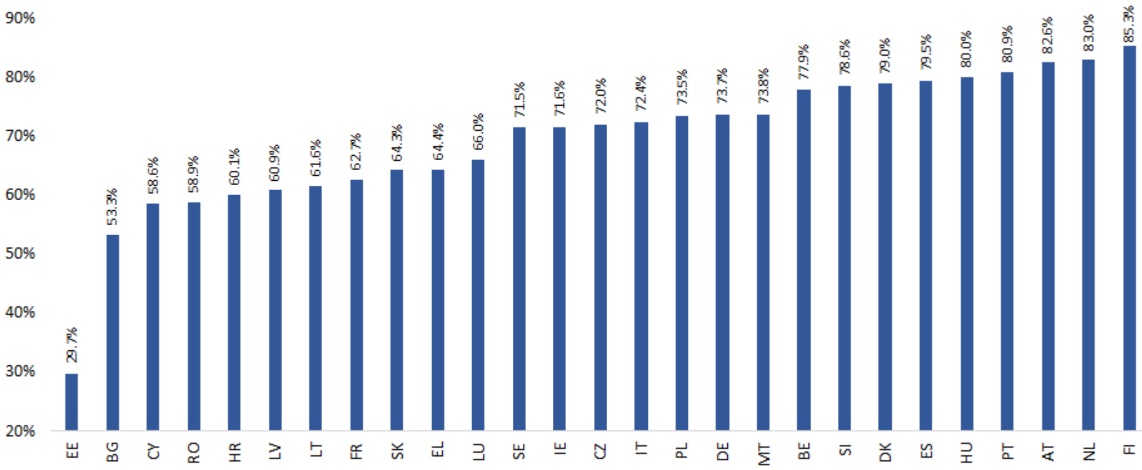
Almost 70% of enterprises noted that their enterprise would definitely be able or probably be able to obtain external financing in case of need. The proportion of firms able to obtain external financing differs upon the firm size and the Member State in which the firm is located. According to respondents, medium-sized SMEs have much greater access to external funds than micro SMEs. Similarly, 85.3% of SMEs located in Finland said they had access to external funds compared to just 29.7% in Estonia.

Figure 20 Availability of external funds, by SME size



Source: LE Europe analysis of Eurobarometer data

Figure 21 Availability of external funds for SMEs, by Member State

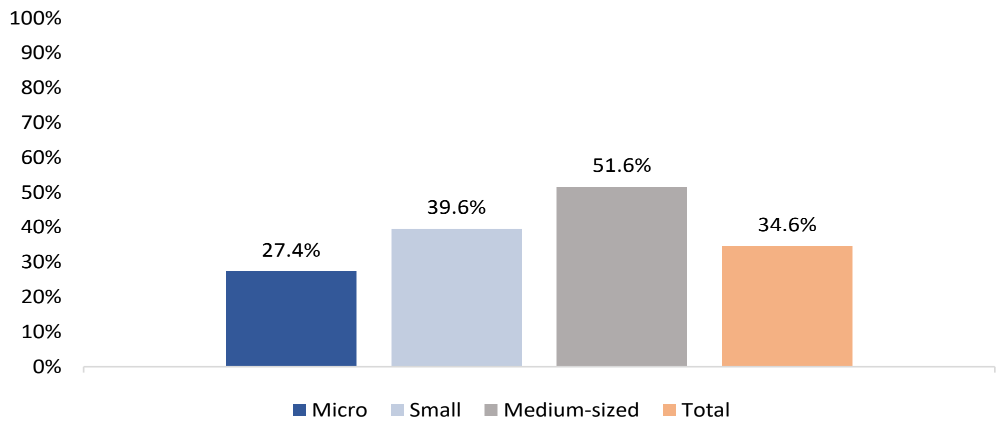


Source: LE Europe analysis of Eurobarometer data

Exporter

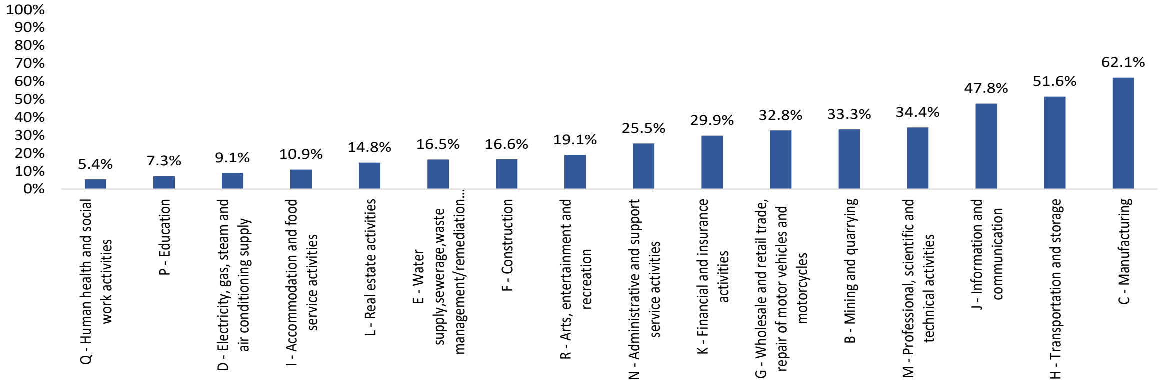
The share of exporters amongst SMEs overall equates to 34.6% of the population (Figure 22). The largest share of exporters is amongst medium-sized SMEs where just over half of enterprises noted that they exported goods or services in 2019. This falls to 39.6% amongst small SMEs and 27.4% amongst micro SMEs. Naturally, the level of exporting varies greatly by sector. Manufacturing has the largest share of exporting SMEs at 62.1% and human health and social work activities has the smallest share of exporting at just 5.4%.

Figure 22 Firm exporting by SME size



Source: LE Europe analysis of Eurobarometer data

Figure 23 SMEs exporting across sectors



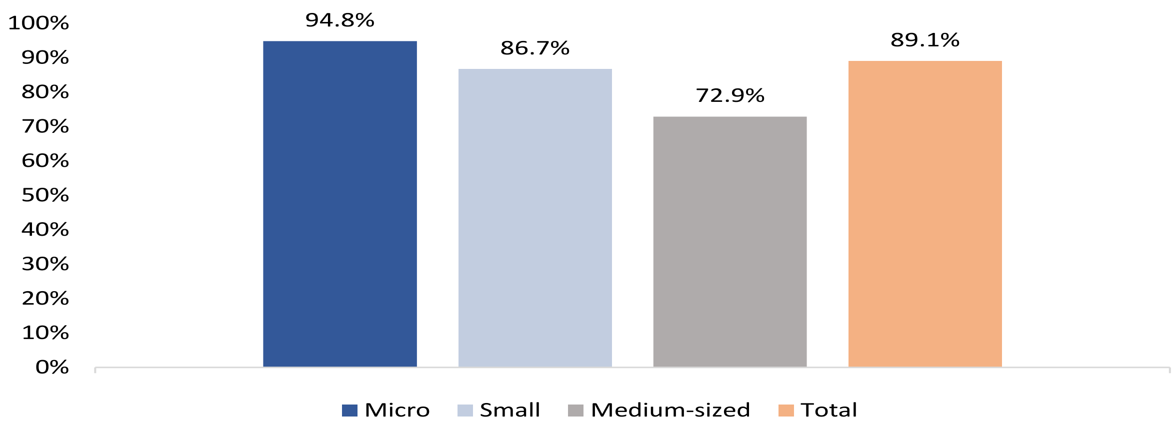
Source: LE Europe analysis of Eurobarometer data

SME independence

Participants were asked about the ownership structure of their enterprise and whether it is solely owned by one person, owned by more than one person, part of a national or international enterprise group, co-owned by a public entity, co-owned by venture capital firm, co-owned by business angel, predominantly family owned, jointly owned by its members (e.g. cooperative, mutual society).

The vast majority of firms in the dataset are independent firms i.e. solely owned by one person, owned by more than one person or predominantly family owned. In fact, only 10.9% of firms are not independent (Figure 24). Firm independence seems to decrease with size whereby 94.8% of micro SMEs are independent, 86.7% of small SMEs and 72.9% of medium-sized SMEs.

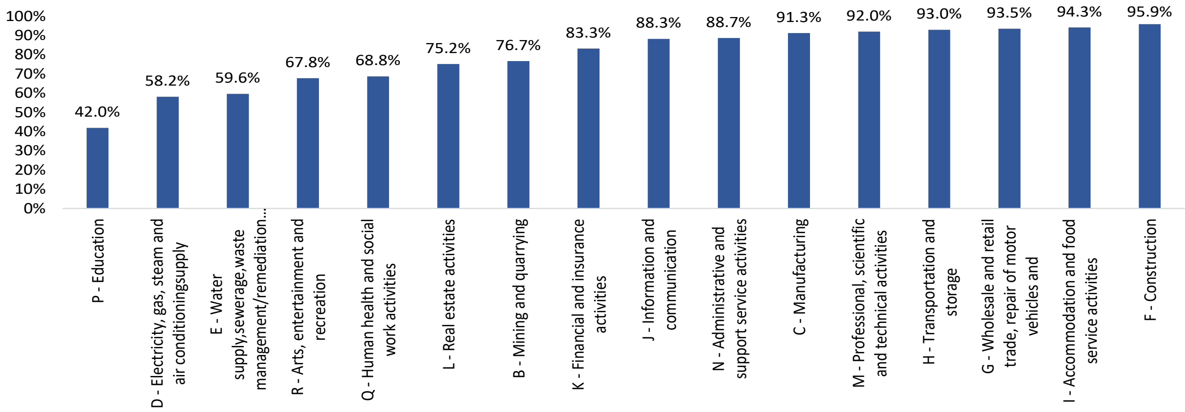
Figure 24 SME independence by SME size



Source: LE Europe analysis of Eurobarometer data

Firm independence varies greatly depending on which sector the enterprise is in. While less than half of SMEs in education are independent, over 95% of those SMEs in construction are independently owned (Figure 25).

Figure 25 Independent SMEs across sectors



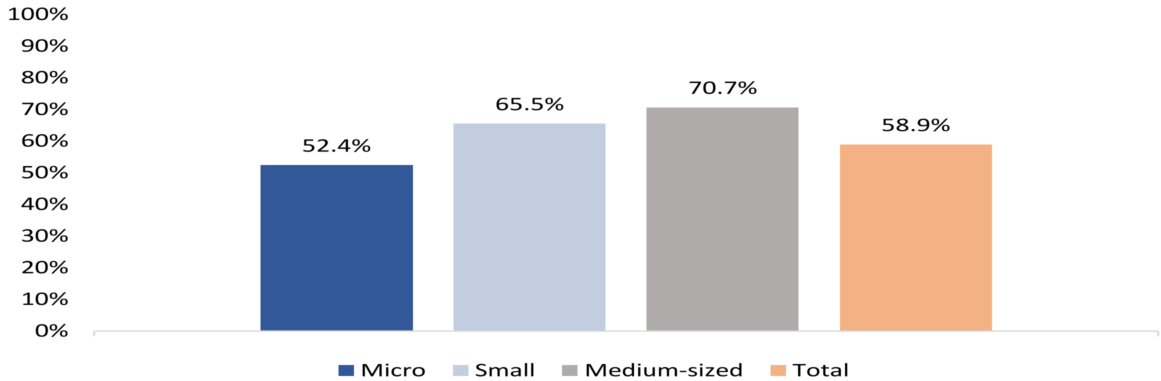
Source: LE Europe analysis of Eurobarometer data

Innovation

The Eurobarometer survey asked SMEs whether their enterprise introduced new innovations in the last 12 months. Innovations included improved production process, products or services, a new business model or method of selling goods and services or social and environmental innovations such as products or services which are more energy efficient or which improve society.

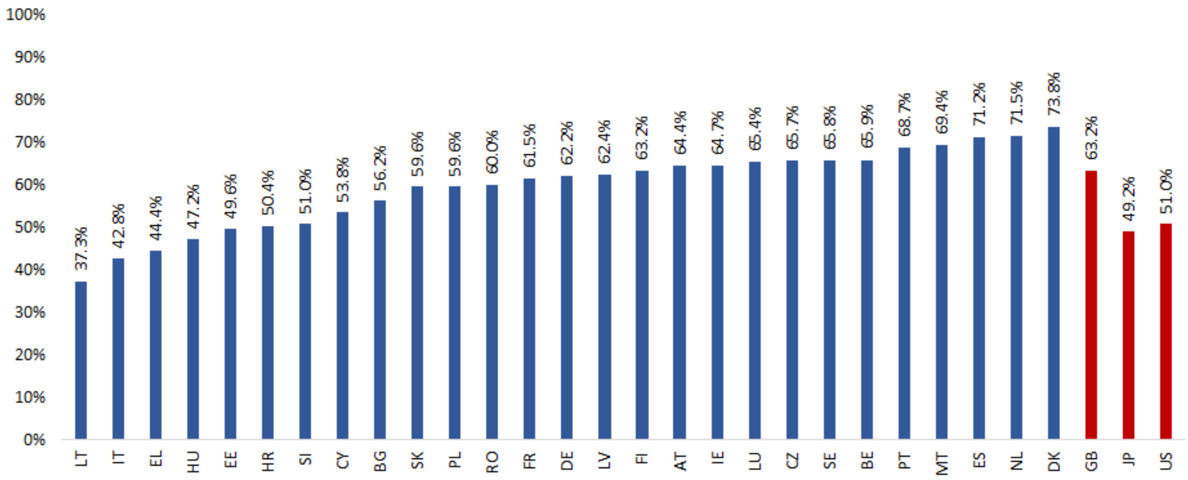
The proportion of firms which engaged in innovation differed by firm size and Member State. Medium size SMEs had the highest proportion of innovators at 70.7% (Figure 26). Small SMEs had the second highest level of innovation at 65.5% and micro SMEs had the lowest proportion of innovators at 52.4%. As shown in Figure 27, over 70% of SMEs located in Spain (71.2%), Netherlands (71.5%) and Denmark (73.8%) engaged in innovation. The lowest level of innovation was found in Lithuania where 37.3% of SMEs engaging in innovative activities. Just under half of EU Member States have a higher proportion of SME innovation than Great Britain, 23 Member states have higher innovation than Japan and 21 Member states have higher levels of innovation amongst SMEs than the United States.

Figure 26 Enterprise innovation by SME size



Source: LE Europe analysis of Eurobarometer data

Figure 27 SME innovation by country

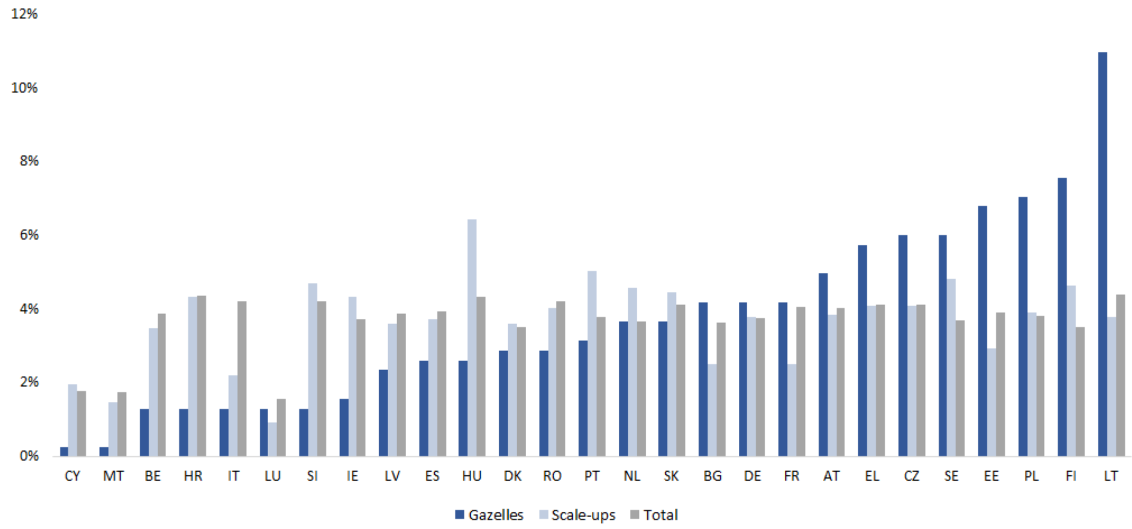


Source: LE Europe analysis of Eurobarometer data

Country

The distribution of SMEs in the data is relatively consistent across Member States (Figure 28). The largest concentration of gazelles are in Lithuania (11%) and are overrepresented in comparison to the proportion of all SMEs (4.4%) and scale-ups (3.8%) in Lithuania. Hungary has the highest proportion of scale ups out of all member states which represent 6.4% of all scale-ups.

Figure 28 Distribution by country



Source: LE Europe analysis of Eurobarometer data

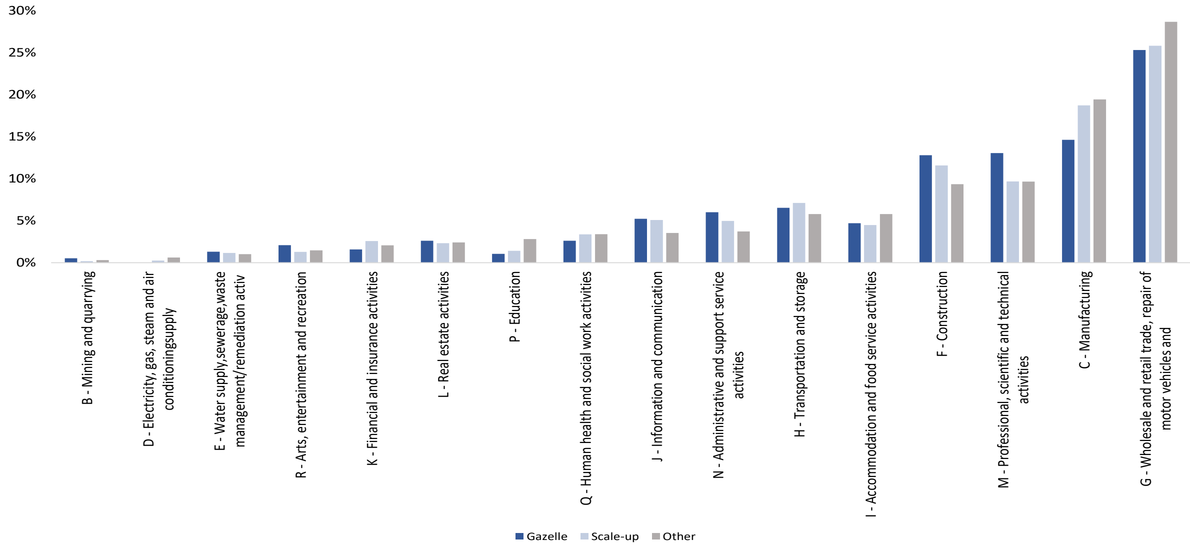
Sector

The largest proportion of SMEs in the dataset are from the wholesale and retail trade, repair of motor vehicle sector. However, gazelles and scale-ups are underrepresented in this sector relative to SMEs overall. Similarly, the manufacturing; electricity, gas, steam and air conditioning supply; accommodation and food service activities and education sectors have a lower concentration of gazelles and scale-ups compared to the number of enterprises overall.

Gazelles and scale-ups are both over-represented in construction; administrative and support service activities; information and communication; transportation and storage; and water supply, sewerage, waste management/remediation activities.

Gazelles are dominant in the professional, scientific and technical activities; administrative and support service activities; arts, entertainment and recreation and mining and quarrying sectors. Finally, human and social work activities and finance and insurance activities are dominated by scale-ups.

Figure 29 Sector breakdown



Source: LE Europe analysis of Eurobarometer data

Barriers to digitalisation

As shown in Table 10 below, SME characteristics and barriers to digitalisation vary by country. Estonia and Italy have the largest number of SMEs who have adopted or are planning to adopt **basic** digital technology and a relatively low proportion of SMEs who have started to adopt advanced digital technologies. While 1.1% of SMEs are considered gazelles in Italy, 6.4% of SMEs in Estonia are considered gazelles. Both countries have a low level of SME participation in GVCs and cite access to finance as the largest barrier to digitalisation.

Sweden and the Netherlands have the highest levels of advanced technology adoption amongst EU Member States. Additionally, Both Member States have a high proportion of scale ups, in the Netherlands scale-ups represent 19.6% of SMEs whilst in Sweden the percentage is even higher at 20.6%. Lack of skills, including managerial skills and internal resistance to change are the most common barriers to digitalisation in Sweden and the Netherlands respectively. Interestingly, SMEs in Sweden have the highest level of GVC participation amongst all Member States.

France had the highest proportion of SMEs citing access to finance; lack of skills including managerial skills; regulatory obstacles and IT security as barriers to digitalisation. Changes to digital standards and internal resistance to change is most prevalent in Spain. Finally, 38.3% of SMEs in Denmark cited technology infrastructure as a barrier to digitalisation, the highest proportion across Member States.

Table 10 Characteristics by country

							Barriers to digitalisation						
Country	Total obs. per country	Basic digital tech adoption	Advanced digital tech adoption	Gazelles	Scale up	Not part of GVC	Access to finance	Lack of skills	Tech infrastructure	Regulatory obstacles	IT Security	Changes to digital standards	Internal resistance
AT	419	37.9%	27.4%	4.5%	15.0%	90.0%	10.7%	16.2%	18.9%	15.5%	18.1%	24.1%	16.9%
BE	402	32.1%	27.9%	1.2%	14.2%	90.0%	19.2%	24.9%	13.9%	25.9%	22.1%	21.1%	26.6%
BG	377	34.5%	19.6%	4.2%	10.9%	98.7%	27.1%	13.5%	9.0%	8.8%	17.5%	22.0%	9.8%
CY	186	35.5%	18.3%	0.5%	17.2%	91.9%	25.8%	12.9%	9.1%	3.2%	8.1%	11.3%	9.7%
CZ	429	26.8%	18.9%	5.4%	15.6%	96.7%	24.0%	24.5%	17.0%	14.7%	20.3%	21.4%	19.1%
DE	392	33.9%	25.0%	4.1%	15.8%	82.4%	20.2%	26.3%	38.3%	30.9%	32.7%	34.9%	20.9%
DK	366	24.6%	26.5%	3.0%	16.1%	88.8%	25.4%	30.3%	12.0%	22.1%	13.1%	24.3%	23.5%
EE	407	55.0%	19.9%	6.4%	11.8%	93.9%	12.8%	6.1%	3.7%	1.7%	2.0%	3.2%	2.0%
ES	410	27.1%	24.6%	2.4%	14.9%	92.4%	29.0%	31.5%	22.9%	31.7%	25.1%	36.6%	32.2%
FI	367	33.2%	36.2%	7.9%	20.7%	80.1%	24.3%	23.2%	7.9%	11.2%	11.4%	19.3%	22.1%
FR	421	38.5%	19.0%	3.8%	9.7%	87.2%	31.6%	38.0%	28.0%	34.0%	34.9%	31.8%	31.6%

							Barriers to digitalisation						
Country	Total obs. per country	Basic digital tech adoption	Advanced digital tech adoption	Gazelles	Scale up	Not part of GVC	Access to finance	Lack of skills	Tech infrastructure	Regulatory obstacles	IT Security	Changes to digital standards	Internal resistance
EL	430	31.9%	23.5%	5.1%	15.6%	93.7%	20.7%	11.9%	18.6%	7.7%	7.4%	13.3%	6.3%
HR	454	44.1%	18.5%	1.1%	15.6%	99.1%	21.6%	10.8%	17.8%	5.3%	8.4%	7.5%	6.8%
HU	451	28.6%	22.6%	2.2%	23.3%	98.0%	12.6%	12.6%	10.2%	9.1%	6.2%	11.3%	6.2%
IE	388	26.3%	30.7%	1.5%	18.3%	87.1%	25.8%	36.9%	30.7%	29.9%	24.2%	29.9%	31.2%
IT	439	61.0%	10.7%	1.1%	8.2%	98.4%	13.9%	10.5%	5.9%	11.4%	4.6%	7.1%	8.0%
LT	456	35.3%	13.6%	9.2%	13.6%	99.1%	24.3%	10.3%	3.9%	4.4%	5.0%	6.4%	6.8%
LU	162	30.2%	31.5%	3.1%	9.3%	89.5%	23.5%	30.2%	12.3%	22.8%	30.2%	17.9%	30.9%
LV	404	33.4%	24.3%	2.2%	14.6%	86.4%	30.4%	23.5%	10.1%	20.0%	15.3%	27.2%	21.0%
MT	183	39.9%	22.4%	0.5%	13.1%	94.0%	18.0%	31.1%	13.1%	16.9%	24.0%	19.1%	26.2%
NL	382	34.6%	38.0%	3.7%	19.6%	91.4%	11.8%	23.0%	14.4%	20.2%	20.2%	18.8%	28.3%
PL	396	33.6%	23.0%	6.8%	16.2%	91.9%	27.5%	8.3%	17.7%	26.5%	22.5%	26.0%	18.7%
PT	393	33.8%	23.4%	3.1%	20.9%	85.5%	24.4%	14.2%	10.9%	22.1%	22.1%	31.6%	24.4%
RO	438	17.1%	17.6%	2.5%	15.1%	99.3%	29.0%	7.8%	6.8%	19.6%	4.6%	4.3%	7.8%
SE	383	35.2%	35.8%	6.0%	20.6%	74.2%	22.2%	30.8%	9.1%	13.8%	24.0%	24.5%	26.4%
SI	439	34.2%	29.8%	1.1%	17.5%	96.1%	13.2%	13.7%	9.3%	6.6%	10.3%	11.4%	11.4%
SK	428	33.4%	21.0%	3.3%	17.1%	94.9%	20.6%	11.4%	11.0%	7.5%	8.2%	6.1%	7.2%

Source: LE Europe analysis of Eurobarometer data

The issues faced by SMEs differ by enterprise size. Micro SMEs, the most common enterprise size within the sample[164], have the largest proportion of enterprises which have adopted or are planning to adopt basic digital technology. Additionally, micro SMEs also have the lowest proportion of enterprises which have started to adopt advanced digital technologies.

Advanced technology adoption increases with enterprise size, 73.8% of small SMEs and 83.3% of medium-sized SMEs have adopted advanced digital technologies. While access to finance is the greatest barrier to digitalisation for micro SMEs, a lack of skills including managerial skills is cited as a more pressing issue for small and medium-sized SMEs. Interestingly,

[164] Micro SMEs represent 56.7% of the sample population, small SMEs represent 26.9% of the sample population and medium-size SMEs represent 16.4% of the sample population.

internal resistance to change is the most common barrier to digitalisation identified by medium-sized SMEs which may be due to the greater adoption of advanced digital technologies as opposed to basic digital technologies.

Table 11 Characteristics by SME size

							Barriers to technology digitalisation						
SME size	**Total enterprise**	**Basic digital tech adoption**	**Advanced digital tech adoption**	**Gazelle**	**Scale up**	**Not part of GVC**	**Access to finance**	**Lack of skills**	**Tech infrastructure**	**Regulatory Barriers**	**IT security**	**Changes to digital standards**	**Internal resistance to change**
Micro	5903	38.7%	17.7%	4.6%	12.3%	95.0%	22.0%	16.6%	13.4%	15.6%	14.0%	17.6%	12.1%
Small	2801	31.8%	26.8%	3.1%	20.2%	89.9%	21.4%	21.8%	15.3%	17.1%	17.7%	20.4%	21.3%
Medium-sized	1698	24.6%	39.9%	1.5%	20.1%	83.7%	21.2%	23.9%	15.7%	17.4%	18.9%	20.3%	28.0%

Source: LE Europe analysis of Eurobarometer data

5.3 Econometric analysis

This section outlines the results of the empirical analysis which identifies the probability of an SMEs adopting basic or advanced digital technologies based upon a number of characteristics.

5.3.1 Approach

Using a cross-sectional econometric model such as a probit model we can identify the likelihood of adopting digital technologies based on a number of key characteristics provided by the Flash Eurobarometer on Entrepreneurship, Start-ups and Scale-ups survey. The empirical properties of each indicator included in the econometric analyses are assessed against the conventional statistical significance threshold (i.e. up to a statistical significance level of 10%).

The results of pairwise correlation analysis are presented as a first step in understanding the relationships between variables. The results of the econometric analysis are then presented.

5.4 Results

5.4.1 Pairwise correlation

Pairwise correlations provide an initial sense of the indicators' relationships with the dependent variable. Prior to conducting the pairwise correlation for all of the variables, we checked the correlation between gazelles and scale ups. Due to their overlap in characteristics of having high growth and being relatively young enterprises there is a concern that gazelles and scale ups are highly correlated. Surprisingly, the analysis shows that gazelles and scale-ups have a small negative association, significant beyond the 1% level. As the variables are not highly correlated we can include both of them in our econometric model.

Table 12 Pairwise correlations of gazelle and scale-ups

Indicator	Gazelle	Scale up
Gazelle	1	
Scale up	-0.0844 * (0)	1

Note: * p<0.1

Source: LE Europe analysis of Eurobarometer data

In the interest of identifying any differences in the adoption of technology due to enterprise size, we first conducted the analysis on all SMEs and then ran separate analysis for micro, small and medium-sized SMEs below.

The table below provides the pairwise correlations between the dependent variables measuring the adoption of digital technology and firm level characteristics. Almost all of the independent variables show different coefficient signs in the adoption of basic versus advanced digital technologies, this is intuitively correct as the characteristics of firms adopting basic digital technology are expected to be different than firms adopting advanced digital technology. Age is an exception showing a positive and statistically significant association with both basic and advanced digital technologies. In the case of micro SMEs, age has a positive association with basic digital technologies and a negative association with advanced digital technologies. In contrast, age has the opposite association with basic and advanced technology adoption for medium-size firms.

SMEs which identify as scale-ups, have external funds available, export and innovate show positive associations with advanced digital technology adoption and negative associations with basic digital technology adoption. In contrast, SMEs that identify as not being part of a global value chain show a positive association with basic digital technology adoption and a negative association with advanced digital technology adoption.

Gazelles show a positive association with advanced digital technology adoption and a negative association with basic digital technology adoption however, this relationship reverses in the case of medium-sized SMEs. Independent SMEs exhibit a positive association with basic digital technology adoption and a negative association with advanced digital technology adoption, the opposite is true for small and medium-sized SMEs although the association is not significant.

The majority of the barriers to digitalisation have a negative statistically significant association with basic digital technology adoption and a positive statistically significant association with advanced digital technology adoption. Lack of financial resources is the only barrier to digitalisation which has a negative association to the adoption of both basic and advanced digital technologies. Disaggregating the results by firms size, we find that a lack of financial resources in the case of small SMEs show a negative statistically significant association with basic digital technology adoption and a positive statistically significant association with advanced digital technology adoption.

The associations with the dependent variables differ across industries. Additionally, the only industries which show consistent associations regardless of form size are the Information and communication; and professional, scientific and technical industries. In general, manufacturing; electricity, gas, steam and air conditioning supply; and water supply, sewerage, waste management/remediation activities show a positive association with advanced digital technology adoption and a negative association with basic digital technology adoption.

Table 13 Pairwise correlations for all SMEs

Variables	Basic digital technology adoption	Advanced digital technology adoption
Age	0.0168*	0.0365*
	0.0859	0.0002
Scale-up	-0.0531*	0.0755*
	0	0
Gazelle	-0.0251*	0.0023
	0.0104	0.8156
City	0.0026	-0.0087
	0.7876	0.3744
Not part of a global value chain	0.0654*	-0.1162*
	0	0
External funds available	-0.0539*	0.1145*
	0	0
Exporter	-0.0706*	0.1235*
	0	0
Independent	0.0303*	-0.0543*
	0.002	0
Innovation	-0.0988*	0.1893*
	0	0
Lack of financial resources	-0.0572*	-0.0175*
	0	0.0735
Lack of skills, including managerial skills	-0.0740*	0.0407*
	0	0
Lack of information technology infrastructure, such as high speed internet connection	-0.0285*	0.0218*
	0.0036	0.026
Regulatory obstacles	-0.0751*	0.0805*
	0	0
IT security issues	-0.0617*	0.0681*
	0	0
Uncertainty about future digital standards	-0.0617*	0.0525*

Variables	Basic digital technology adoption	Advanced digital technology adoption
	0	0
Internal resistance to change	-0.0744*	0.0826*
	0	0
AT	0.0145	0.0176*
	0.1379	0.0723
BE	-0.0105	0.0192*
	0.2862	0.0502
BG	-0.0004	-0.0189*
	0.971	0.0536
CY	0.0026	-0.0174*
	0.7915	0.0752
CZ	-0.0339*	-0.0239*
	0.0006	0.0149
DE	-0.0027	0.0057
	0.7854	0.5643
DK	-0.0401*	0.0122
	0	0.2136
EE	0.0868*	-0.0184*
	0	0.0606
ES	-0.0319*	0.004
	0.0011	0.6799
FI	-0.0053	0.0559*
	0.5861	0
FR	0.0169*	-0.0231*
	0.0851	0.0187
EL	-0.0118	-0.0014
	0.2276	0.8831
HR	0.0426*	-0.0265*
	0	0.0069
HU	-0.0267*	-0.0058
	0.0064	0.5516
IE	-0.0343*	0.0318*
	0.0005	0.0012
IT	0.1169*	-0.0645*
	0	0
LT	0.0033	-0.0512*
	0.7352	0
LU	-0.0114	0.0227*
	0.2436	0.0204
LV	-0.0049	0.0022
	0.6188	0.8196
MT	0.015	-0.0043
	0.1268	0.6584

Variables	Basic digital technology adoption	Advanced digital technology adoption
NL	-0.0001	0.0650*
	0.9949	0
PL	-0.0041	-0.0038
	0.6745	0.7016
PT	-0.003	-0.0017
	0.7571	0.859
RO	-0.0769*	-0.0306*
	0	0.0018
SE	0.0028	0.0550*
	0.7763	0
SI	-0.0018	0.0299*
	0.8565	0.0023
SK	-0.005	-0.0134
	0.6067	0.1715
B - Mining and quarrying	0.0024	0.0079
	0.809	0.4233
C - Manufacturing	-0.0394*	0.0449*
	0.0001	0
D - Electricity, gas, steam and air conditioning supply	-0.0223*	0.0309*
	0.0227	0.0016
E - Water supply, sewerage, waste management/remediation	-0.0291*	0.0113
	0.003	0.2511
F - Construction	0.0236*	-0.0395*
	0.0163	0.0001
G - Wholesale and retail trade, repair of motor vehicles and motorcycles	0.0122	-0.0419*
	0.2129	0
H - Transportation and storage	-0.0148	-0.016
	0.1313	0.102
I - Accommodation and food service	0.0158	-0.0257*
	0.1071	0.0089
J - Information and communication	-0.0297*	0.0492*
	0.0024	0
K - Financial and insurance	-0.0048	0.0289*
	0.6269	0.0032
L - Real estate	0.01	0.0096
	0.308	0.3254
M - Professional, scientific and technical	0.0239*	0.0067
	0.0149	0.4913
N - Administrative and support service	0.0033	0.0012
	0.7374	0.901
P - Education	0.0109	0.0053
	0.2677	0.588
Q - Human health and social work	0.0105	0.0075

Variables	Basic digital technology adoption	Advanced digital technology adoption
	0.2845	0.4434

Note: * p<0.1

Source: LE Europe analysis of Eurobarometer data

Table 14 Pairwise correlations for micro SMEs

Variables	Basic digital technology adoption	Advanced digital technology adoption
Age	0.0656*	-0.0355*
	0	0.0064
Scale-up	-0.0270*	0.0471*
	0.0378	0.0003
Gazelle	-0.0476*	0.0238*
	0.0003	0.0675
City	-0.0011	-0.02
	0.9325	0.1245
Not part of a global value chain	0.0467*	-0.0769*
	0.0003	0
External funds available	-0.0277*	0.1016*
	0.0335	0
Exporter	-0.0372*	0.0967*
	0.0042	0
Independent	0.0134	-0.0277*
	0.3027	0.0334
Innovation	-0.0573*	0.1577*
	0	0
Lack of financial resources	-0.0791*	-0.0042
	0	0.7445
Lack of skills, including managerial skills	-0.0679*	0.0204
	0	0.1179
Lack of information technology infrastructure, such as high speed internet connection	-0.014	0.0148
	0.2828	0.2565
Regulatory obstacles	-0.0733*	0.0814*
	0	0
IT security issues	-0.0475*	0.0634*
	0.0003	0
Uncertainty about future digital standards	-0.0492*	0.0511*
	0.0002	0.0001
Internal resistance to change	-0.0440*	0.0378*
	0.0007	0.0036
AT	0.0055	0.018
	0.6746	0.1676
BE	-0.001	0.0254*

	0.938	0.0508
BG	-0.0096	-0.017
	0.4597	0.1927
CY	0.0126	-0.0260*
	0.334	0.0457
CZ	-0.0434*	-0.0209
	0.0008	0.1091
DE	-0.0266*	0.0084
	0.041	0.5206
DK	-0.0620*	-0.0042
	0	0.7467
EE	0.0953*	-0.0247*
	0	0.0581
ES	-0.0211	-0.0012
	0.1049	0.9241
FI	0.0121	0.0245*
	0.3535	0.0599
FR	0.0192	-0.016
	0.1394	0.2192
EL	-0.0451*	0.0221*
	0.0005	0.089
HR	0.0382*	-0.0169
	0.0033	0.1939
HU	-0.0453*	0.0154
	0.0005	0.2372
IE	-0.0172	0.0270*
	0.1875	0.0378
IT	0.1241*	-0.0570*
	0	0
LT	-0.0181	-0.0574*
	0.1645	0
LU	-0.0191	0.0178
	0.1428	0.172
LV	0.0068	-0.0042
	0.602	0.7464
MT	0.0187	-0.0105
	0.1506	0.4195
NL	0.0238*	0.0662*
	0.0679	0
PL	-0.0006	-0.0066
	0.9648	0.6137
PT	0.0047	-0.0032
	0.7153	0.8085
RO	-0.0952*	-0.008
	0	0.5402
SE	0.0298*	0.0486*

	0.0221	0.0002
SI	-0.0028	0.0388*
	0.8295	0.0029
SK	0.0001	-0.0189
	0.9941	0.1467
B - Mining and quarrying	-0.0043	0.0046
	0.7389	0.7223
C - Manufacturing	0.0038	0.0002
	0.7721	0.9899
D - Electricity, gas, steam and air conditioning supply	-0.0290*	0.0331*
	0.0261	0.0109
E - Water supply, sewerage, waste management/remediation	-0.0116	-0.0069
	0.3731	0.5953
F - Construction	0.016	-0.0135
	0.2182	0.2995
G - Wholesale and retail trade, repair of motor vehicles and motorcycles	0.0067	-0.0392*
	0.6066	0.0026
H - Transportation and storage	-0.0218*	-0.0244*
	0.0941	0.0613
I - Accommodation and food service	-0.0037	-0.0082
	0.7741	0.5284
J - Information and communication	-0.0295*	0.0570*
	0.0234	0
K - Financial and insurance	0.001	0.0214*
	0.9397	0.0998
L - Real estate	0	0.0182
	0.9985	0.161
M - Professional, scientific and technical	0.0131	0.0306*
	0.3137	0.0188
N - Administrative and support service	-0.007	-0.007
	0.5934	0.5901
P - Education	0.0077	-0.003
	0.5545	0.8171
Q - Human health and social work	0.01	0.0175
	0.4429	0.1782

Note: * p<0.1

Source: LE Europe analysis of Eurobarometer data

Table 15 Pairwise correlations for small SMEs

Variables	Basic digital technology adoption	Advanced digital technology adoption
Age	0.0552*	0.0051
	0.0035	0.7865
Scale-up	-0.0621*	0.0817*
	0.001	0

Variables	**Basic digital technology adoption**	**Advanced digital technology adoption**
Gazelle	-0.012	0.0076
	0.5272	0.6866
City	0.0095	0.0166
	0.6156	0.3791
Not part of a global value chain	0.0367*	0.0874*
	0.0523	0
External funds available	-0.0473*	0.0889*
	0.0123	0
Exporter	-0.0415*	0.0774*
	0.0281	0
Independent	-0.0073	0.0003
	0.7012	0.9859
Innovation	-0.1086*	0.1836*
	0	0
Lack of financial resources	-0.0407*	0.0193
	0.0314	0.3075
Lack of skills, including managerial skills	-0.0456*	0.0233
	0.0158	0.217
Lack of information technology infrastructure, such as high speed internet connection	-0.0460*	0.0108
	0.0149	0.5681
Regulatory obstacles	-0.0616*	0.0721*
	0.0011	0.0001
IT security issues	-0.0581*	0.0630*
	0.0021	0.0009
Uncertainty about future digital standards	-0.0630*	0.0248
	0.0008	0.1887
Internal resistance to change	-0.0457*	0.0618*
	0.0156	0.0011
AT	0.0450*	0.0017
	0.0173	0.9301
BE	-0.0219	0.0289
	0.2458	0.1265
BG	0.0057	0.0202
	0.7623	0.2844
CY	-0.0087	0.0185
	0.6472	0.3286
CZ	-0.021	0.0116
	0.2663	0.5406
DE	0.0117	0.0014
	0.5346	0.9417
DK	-0.0095	0.0022
	0.6138	0.9073

Variables	Basic digital technology adoption	Advanced digital technology adoption
EE	0.0701*	0.0046
	0.0002	0.8061
ES	-0.0350*	0.015
	0.064	0.4276
FI	0.0001	0.0753*
	0.9963	0.0001
FR	0.0168	0.0297
	0.3731	0.1165
EL	0.0271	0.0216
	0.1522	0.254
HR	0.0390*	0.0341*
	0.039	0.0709
HU	-0.016	0.0417*
	0.3965	0.0271
IE	-0.0475*	0.0485*
	0.0119	0.0102
IT	0.0836*	0.0646*
	0	0.0006
LT	0.0036	0.0295
	0.8503	0.1187
LU	-0.0059	0.0328*
	0.7565	0.0828
LV	-0.0271	0.0104
	0.1519	0.5823
MT	0.014	0.0175
	0.4588	0.3551
NL	-0.004	0.0591*
	0.8344	0.0018
PL	-0.0062	0.0235
	0.7415	0.2129
PT	-0.0142	0.0144
	0.454	0.4459
RO	-0.0533*	0.0586*
	0.0048	0.0019
SE	-0.0271	0.0782*
	0.1519	0
SI	-0.0007	0.0211
	0.9715	0.2642
SK	-0.0132	0.0037
	0.4853	0.8455
B - Mining and quarrying	0.0128	0.0107
	0.4969	0.57

Variables	Basic digital technology adoption	Advanced digital technology adoption
C - Manufacturing	-0.0352*	0.0127
	0.0626	0.502
D - Electricity, gas, steam and air conditioning supply	-0.0187	0.0107
	0.3236	0.57
E - Water supply, sewerage, waste management/remediation	-0.0268	0.0083
	0.1564	0.6606
F - Construction	0.0318*	0.0657*
	0.0923	0.0005
G - Wholesale and retail trade, repair of motor vehicles and motorcycles	-0.028	0.0202
	0.1382	0.2846
H - Transportation and storage	-0.0084	0.0036
	0.658	0.8498
I - Accommodation and food service	0.0515*	0.0499*
	0.0064	0.0083
J - Information and communication	-0.0399*	0.0614*
	0.0347	0.0011
K - Financial and insurance	0.0155	0.0154
	0.4135	0.4156
L - Real estate	0.0358*	0.0044
	0.058	0.814
M - Professional, scientific and technical	0.0217	0.0061
	0.252	0.7481
N - Administrative and support service	0.0049	0.0143
	0.7962	0.4485
P - Education	0.026	0.011
	0.1686	0.5589
Q - Human health and social work	-0.0128	0.0098
	0.4978	0.6056

Note: * p<0.1

Source: LE Europe analysis of Eurobarometer data

Table 16 Pairwise correlations for medium-sized SMEs

Variables	Basic digital technology adoption	Advanced digital technology adoption
Age	-0.0335	0.036
	0.1679	0.138
Scale-up	-0.0614*	0.0529*
	0.0114	0.0292
Gazelle	0.018	-0.0134
	0.4587	0.5816
City	0.0125	0.0231

Variables	Basic digital technology adoption	Advanced digital technology adoption
	0.6081	0.341
Not part of a global value chain	0.0816*	-0.1158*
	0.0008	0
External funds available	-0.0863*	0.0845*
	0.0004	0.0005
Exporter	-0.1133*	0.0947*
	0	0.0001
Independent	-0.0063	0.0146
	0.7967	0.547
Innovation	-0.1494*	0.1732*
	0	0
Lack of financial resources	-0.0081	-0.0457*
	0.7398	0.0597
Lack of skills, including managerial skills	-0.0978*	0.0495*
	0.0001	0.0416
Lack of information technology infrastructure, such as high speed internet connection	-0.0322	0.0315
	0.1846	0.1939
Regulatory obstacles	-0.0955*	0.0806*
	0.0001	0.0009
IT security issues	-0.0833*	0.0431*
	0.0006	0.0761
Uncertainty about future digital standards	-0.0867*	0.0744*
	0.0003	0.0022
Internal resistance to change	-0.1185*	0.0729*
	0	0.0027
AT	0.0087	0.029
	0.719	0.2328
BE	-0.0235	-0.0139
	0.3334	0.5679
BG	0.0202	-0.0174
	0.4047	0.4726
CY	-0.017	0.0131
	0.4846	0.5905
CZ	-0.0197	-0.0540*
	0.4161	0.0261
DE	0.0709*	-0.0121
	0.0035	0.6195
DK	-0.0028	0.0474*
	0.9086	0.0508
EE	0.0660*	-0.0141
	0.0065	0.5623
ES	-0.0677*	-0.0007

Variables	Basic digital technology adoption	Advanced digital technology adoption
	0.0053	0.9775
FI	-0.0830*	0.1202*
	0.0006	0
FR	-0.0104	-0.0138
	0.6699	0.5707
EL	0.0460*	-0.0415*
	0.0581	0.0875
HR	0.0606*	-0.0358
	0.0125	0.1409
HU	0.0249	-0.0044
	0.3047	0.856
IE	-0.0564*	0.0005
	0.0202	0.982
IT	0.1160*	-0.0587*
	0	0.0155
LT	0.0787*	-0.0496*
	0.0012	0.0409
LU	0.0104	0.0177
	0.6675	0.4658
LV	-0.0267	0.022
	0.2714	0.365
MT	0.0154	-0.0338
	0.5252	0.1645
NL	-0.0594*	0.0574*
	0.0143	0.0181
PL	0.0135	-0.0017
	0.5774	0.9453
PT	-0.0351	0.0396
	0.1484	0.1029
RO	-0.0522*	-0.0520*
	0.0316	0.0322
SE	-0.0568*	0.0507*
	0.0193	0.0368
SI	-0.0063	0.029
	0.7967	0.2319
SK	-0.0032	-0.0229
	0.8955	0.3448
B - Mining and quarrying	0.0121	-0.008
	0.6171	0.7434
C – Manufacturing	-0.0678*	0.0336
	0.0052	0.1665
D - Electricity, gas, steam and air conditioning supply	0.001	0.0326

Variables	Basic digital technology adoption	Advanced digital technology adoption
	0.9671	0.179
E - Water supply, sewerage, waste management/remediation	-0.0435*	0.0163
	0.073	0.5028
F – Construction	0.0256	-0.0573*
	0.292	0.0182
G - Wholesale and retail trade, repair of motor vehicles and motorcycles	-0.0061	0.0058
	0.8013	0.811
H - Transportation and storage	-0.006	-0.0135
	0.8035	0.5782
I - Accommodation and food service	0.0157	-0.0221
	0.5169	0.3622
J - Information and communication	-0.0299	0.0368
	0.2175	0.1299
K - Financial and insurance	-0.0332	0.0375
	0.1711	0.1225
L - Real estate	-0.0057	0.0258
	0.8134	0.2884
M - Professional, scientific and technical	0.0085	0.0283
	0.7263	0.2444
N - Administrative and support service	0.0456*	-0.0073
	0.0601	0.7635
P – Education	0.0331	-0.0055
	0.1728	0.8208
Q - Human health and social work	0.0916*	-0.0692*
	0.0002	0.0044

Note: * p<0.1

Source: LE Europe analysis of Eurobarometer data

5.4.2 Probit model estimation

SMEs which are categorised as **scale-ups**, have **external funding available, export** or **innovate** are more likely to adopt advanced digital technologies and less likely to adopt basic digital technologies, regardless of the firm size. These results are intuitively correct, high growth firms such as scale-ups may need to adopt advanced digital technologies in order to continue growing. Firms which have access to external funding may want to invest that funding in advanced digital technologies which can engender efficiency gains. Exporting firms are competing on a global stage, as such, the adoption of advanced digital technologies may be in an effort to stay competitive or to become more competitive. Similarly, innovative firms may adopt advanced technologies to create new products or enhance existing products or work processes.

Similar to scale-ups, SMEs which are categorised as gazelles show a positive relationship with advanced technology adoption and a negative relationship with basic digital technology adoption. This result fails to hold for medium-sized SMEs, however this is not statistically significant.

SMEs that are not part of a **GVC** are less likely to adopt advanced digital technology and more likely to adopt basic digital technology..

It is expected that independent firms may find it harder to obtain financing, making the investment in digital technology difficult. The aggregate results show that firms which are independent are more likely to adopt basic digital technology and less likely to adopt advanced digital technology. This result fails to hold for small and medium-sized SMEs whereby independent firms are more likely to adopt both basic and advanced digital technologies, although the results are not statistically significant.

Firms who cite uncertainty about future digital standards as a barrier to digitalisation were more likely to adopt advanced digital technology. This result may be due to reverse causality whereby those firms that have adopted advanced digital technologies may be concerned about future digital standards but basic digital technology adopters may not take digital standards into consideration. Contrary to the aggregate result, small SMEs show a negative relationship between future digital standards and the adoption of basic and advanced digital technologies, the result is not statistically significant.

SMEs which cite internal resistance to change as a barrier to digitalisation are less likely to adopt basic digital technologies but more likely to adopt advanced digital technologies. Again, this may be as a result of reverse causality, whereby internal resistance to change arises when companies start implementing advanced digital technologies but not when basic digital technologies are being adopted. The same reasoning could be used to explain regulatory obstacles and IT security issues, only firms adopting advanced digital technologies will encounter these barriers. Interestingly, IT security issues act as a barrier to basic and advanced technology adoption for medium-sized SMEs, although the relationship is not statistically significant.

A lack of financial resources and a lack of skills including managerial skills reduce the likelihood of adopting basic and advanced digital technology. These findings hold for micro and small SMES but fail to hold for medium-sized SMEs.

The mining and quarrying; electricity, gas, steam and air conditioning supply; information and communication; financial and insurance activities and real estate activities industries are more likely to adopt advanced digital technologies and less likely to adopt basic digital technologies, regardless of firm size. Similarly, the manufacturing; water supply, sewerage, waste management/remediation activities; professional, scientific and technical activities and administrative and support service industries have a positive relationship with advanced digital technology adoption and a negative relationship with basic digital technology adoption. These results hold at the aggregate level and for small and medium-sized SMEs but fail to hold for micro SMEs.

Amongst medium-size firms, all sectors apart from human health and social work activities have a positive relationship with the adoption of advanced digital technologies and a negative relationship with the adoption of basic digital technologies. For small SMEs, two industries have a negative relationship with advanced technology adoption, accommodation and food service; and construction. Interestingly, construction also has a negative relationship with basic digital technology adoption. In the case of micro SMEs, over half of the industries have a negative relationship with advanced digital technology adoption.

Austria, Belgium, Bulgaria, Estonia, Finland, Luxembourg, Latvia, the Netherlands, Sweden and Slovakia show positive relationships with the adoption of both basic and advanced digital technology. These results are generally consistent across firm sizes with a few exceptions. Firms located in Cyprus, France, Hungary, Italy, Lithuania, Malta and Poland are less likely to adopt advanced technologies and more likely to adopt basic digital technologies. Czechia, Spain and Romania are the only Member States where firms are, in general, less likely to adopt both digital and advanced technologies. Germany, Denmark, Greece and Portugal fail to show a consistent pattern of technology adoption across different firm sizes.

Table 17 Probit model results for all SMEs

Variables	Basic digital technology adoption	Advanced digital technology adoption
Age	0.00107	0.000881
	(0.111)	(0.225)
Scale-up	-0.124***	0.149***
	(0.000887)	(8.08e-05)
Gazelle	-0.197***	0.0261
	(0.00661)	(0.732)
City	0.00267	-0.0378
	(0.923)	(0.204)

Variables	Basic digital technology adoption	Advanced digital technology adoption
Not part of a global value chain	0.205***	-0.261***
	(8.18e-05)	(1.91e-07)
External funds available	-0.0498*	0.230***
	(0.0909)	(0)
Exporter	-0.139***	0.242***
	(5.29e-06)	(0)
Independent	0.0958**	-0.111**
	(0.0368)	(0.0173)
Innovation	-0.140***	0.437***
	(4.52e-07)	(0)
Lack of financial resources	-0.0960***	-0.0947***
	(0.00413)	(0.00905)
Lack of skills, including managerial skills	-0.103***	-0.0504
	(0.00510)	(0.194)
Lack of information technology infrastructure, such as high speed internet connection	0.0126	-0.000644
	(0.752)	(0.988)
Regulatory obstacles	-0.138***	0.189***
	(0.000452)	(2.54e-06)
IT security issues	-0.0676*	0.0705*
	(0.0931)	(0.0899)
Uncertainty about future digital standards	-0.0544	0.0288
	(0.149)	(0.469)
Internal resistance to change	-0.125***	0.114***
	(0.00123)	(0.00353)
AT	0.195**	0.106
	(0.0313)	(0.287)
BE	0.0418	0.132
	(0.652)	(0.191)
BG	0.0372	0.0284
	(0.689)	(0.785)
CY	0.0525	-0.0383
	(0.648)	(0.771)
CZ	-0.164*	-0.160
	(0.0721)	(0.113)
DE	0.118	0.0251
	(0.210)	(0.809)
DK	-0.162*	0.0154
	(0.0959)	(0.880)
EE	0.545***	0.0988
	(1.37e-09)	(0.335)
ES	-0.0423	-0.0136
	(0.652)	(0.893)
FI	0.0856	0.389***
	(0.362)	(9.61e-05)
FR	0.275***	-0.141
	(0.00262)	(0.174)
EL	-0.0316	0.154
	(0.727)	(0.123)
HR	0.288***	-0.0514
	(0.000991)	(0.606)
HU	-0.141	0.124
	(0.117)	(0.209)

Variables	Basic digital technology adoption	Advanced digital technology adoption
IE	-0.134	0.244**
	(0.163)	(0.0157)
IT	0.677***	-0.346***
	(0)	(0.00155)
LT	0.0299	-0.155
	(0.736)	(0.137)
LU	0.0219	0.240*
	(0.859)	(0.0593)
LV	0.0894	0.0495
	(0.327)	(0.621)
MT	0.254**	-0.0252
	(0.0264)	(0.840)
NL	0.102	0.375***
	(0.275)	(0.000160)
PL	0.125	-0.0432
	(0.175)	(0.672)
PT	0.112	-0.0595
	(0.225)	(0.558)
RO	-0.523***	-0.0437
	(6.40e-08)	(0.666)
SE	0.187**	0.329***
	(0.0448)	(0.000942)
SI	0.0446	0.282***
	(0.618)	(0.00343)
SK (omitted)	-	-
B - Mining and quarrying	-0.133	0.304
	(0.615)	(0.297)
C - Manufacturing	-0.205*	0.103
	(0.0694)	(0.405)
D - Electricity, gas, steam and air conditioning supply	-0.602***	0.678***
	(0.00667)	(0.00138)
E - Water supply, sewerage, waste management/remediation	-0.547***	0.275
	(0.00175)	(0.124)
F - Construction	-0.107	0.0188
	(0.355)	(0.883)
G - Wholesale and retail trade, repair of motor vehicles and motorcycles	-0.103	-0.0330
	(0.353)	(0.787)
H - Transportation and storage	-0.189	-0.0208
	(0.118)	(0.876)
I - Accommodation and food service	-0.0998	0.0193
	(0.409)	(0.885)
J - Information and communication	-0.309**	0.306**
	(0.0157)	(0.0248)
K - Financial and insurance	-0.131	0.140
	(0.353)	(0.356)
L - Real estate	-0.0621	0.214
	(0.647)	(0.147)
M - Professional, scientific and technical	-0.0127	0.0878
	(0.913)	(0.489)
N - Administrative and support service	-0.150	0.137
	(0.233)	(0.322)
P - Education	0.0740	0.202

Variables	Basic digital technology adoption	Advanced digital technology adoption
	(0.585)	(0.170)
Q - Human health and social work	0.0246	0.138
	(0.848)	(0.327)
Constant	-0.373***	-1.117***
	(0.00853)	(0)
Observations	**10,402**	**10,402**

Note: *** p<0.01, ** p<0.05, * p<0.1, ++ p<0.2, + p<0.25

Source: LE Europe analysis of Eurobarometer data

Table 18 Probit model results for micro SMEs only

Variables	Basic digital technology adoption	Advanced digital technology adoption
Age	0.00353***	-0.00312**
	(0.000782)	(0.0231)
Scale-up	-0.0239	0.0615
	(0.656)	(0.296)
Gazelle	-0.240***	0.0284
	(0.00620)	(0.765)
City	-0.0404	-0.0544
	(0.262)	(0.198)
Not part of a global value chain	0.213**	-0.236***
	(0.0109)	(0.00585)
External funds available	-0.0103	0.219***
	(0.784)	(1.41e-06)
Exporter	-0.0870**	0.249***
	(0.0346)	(9.53e-08)
Independent	0.0453	-0.0775
	(0.575)	(0.380)
Innovation	-0.0601*	0.399***
	(0.0943)	(0)
Lack of financial resources	-0.170***	-0.0679
	(0.000113)	(0.188)
Lack of skills, including managerial skills	-0.150***	-0.0679
	(0.00336)	(0.247)
Lack of information technology infrastructure, such as high speed internet connection	0.0939*	-0.0560
	(0.0790)	(0.368)
Regulatory obstacles	-0.162***	0.219***
	(0.00227)	(0.000156)
IT security issues	-0.0453	0.0855
	(0.413)	(0.160)
Uncertainty about future digital standards	-0.0135	0.0752
	(0.792)	(0.197)
Internal resistance to change	-0.0732	0.0187
	(0.201)	(0.768)
AT	0.0286	0.241
	(0.815)	(0.105)
BE	0.0380	0.250*
	(0.757)	(0.0911)
BG	-0.0468	0.0981
	(0.701)	(0.518)
CY	0.0614	-0.0845
	(0.690)	(0.682)

Variables	Basic digital technology adoption	Advanced digital technology adoption
CZ	-0.263**	-0.0807
	(0.0303)	(0.588)
DE	-0.139	0.128
	(0.284)	(0.413)
DK	-0.430***	-0.0252
	(0.00129)	(0.871)
EE	0.550***	0.0757
	(3.22e-06)	(0.609)
ES	-0.0442	0.0321
	(0.720)	(0.831)
FI	0.141	0.315**
	(0.251)	(0.0324)
FR	0.218*	-0.0477
	(0.0687)	(0.751)
EL	-0.319**	0.369**
	(0.0113)	(0.0128)
HR	0.176	0.102
	(0.128)	(0.486)
HU	-0.328***	0.331**
	(0.00664)	(0.0212)
IE	-0.0891	0.327**
	(0.493)	(0.0334)
IT	0.623***	-0.200
	(7.59e-08)	(0.197)
LT	-0.0937	-0.247
	(0.419)	(0.115)
LU	-0.161	0.308
	(0.349)	(0.109)
LV	0.0874	0.0705
	(0.461)	(0.631)
MT	0.223	-0.000649
	(0.152)	(0.997)
NL	0.179	0.536***
	(0.159)	(0.000308)
PL	0.0720	-0.0122
	(0.575)	(0.939)
PT	0.0597	0.0233
	(0.614)	(0.873)
RO	-0.653***	0.126
	(2.63e-07)	(0.383)
SE	0.258**	0.437***
	(0.0333)	(0.00240)
SI	-0.0441	0.404***
	(0.704)	(0.00348)
SK (omitted)	-	-
B - Mining and quarrying	-0.318	0.112
	(0.482)	(0.835)
C - Manufacturing	-0.0278	-0.0978
	(0.854)	(0.573)
D - Electricity, gas, steam and air conditioning supply	-0.665*	0.643**
	(0.0523)	(0.0404)
E - Water supply, sewerage, waste management/remediation	-0.326	-0.108

Variables	Basic digital technology adoption	Advanced digital technology adoption
	(0.215)	(0.725)
F - Construction	-0.0280	-0.0340
	(0.855)	(0.847)
G - Wholesale and retail trade, repair of motor vehicles and motorcycles	-0.0162	-0.151
	(0.912)	(0.368)
H - Transportation and storage	-0.129	-0.190
	(0.421)	(0.308)
I - Accommodation and food service	-0.137	-0.0125
	(0.391)	(0.946)
J - Information and communication	-0.210	0.194
	(0.210)	(0.300)
K - Financial and insurance	-0.0692	0.0651
	(0.720)	(0.764)
L - Real estate	-0.0562	0.196
	(0.749)	(0.325)
M - Professional, scientific and technical	0.0398	0.0296
	(0.793)	(0.865)
N - Administrative and support service	-0.0685	-0.108
	(0.682)	(0.581)
P - Education	0.0700	-0.0307
	(0.716)	(0.891)
Q - Human health and social work	0.107	0.138
	(0.558)	(0.505)
Constant	-0.402**	-1.126***
	(0.0444)	(1.30e-06)
Observations	**5,894**	**5,903**

Note: *** p<0.01, ** p<0.05, * p<0.1, ++ p<0.2, + p<0.25

Source: LE Europe analysis of Eurobarometer data

Table 19 Probit model results for small SMEs only

Variables	Basic digital technology adoption	Advanced digital technology adoption
Age	0.00297**	-0.000385
	(0.0176)	(0.774)
Scale-up	-0.166**	0.198***
	(0.0118)	(0.00268)
Gazelle	-0.0992	0.0524
	(0.512)	(0.729)
City	0.0347	-0.0325
	(0.522)	(0.562)
Not part of a global value chain	0.0527	-0.152*
	(0.557)	(0.0842)
External funds available	-0.0679	0.213***
	(0.269)	(0.00132)
Exporter	-0.0264	0.0743
	(0.651)	(0.214)
Independent	0.00146	0.0395
	(0.986)	(0.653)
Innovation	-0.211***	0.462***
	(0.000129)	(0)
Lack of financial resources	-0.0495	-0.0599
	(0.453)	(0.381)

Variables	Basic digital technology adoption	Advanced digital technology adoption
Lack of skills, including managerial skills	-0.0271	-0.0875
	(0.686)	(0.206)
Lack of information technology infrastructure, such as high speed internet connection	-0.136*	0.0311
	(0.0726)	(0.691)
Regulatory obstacles	-0.0738	0.149**
	(0.323)	(0.0445)
IT security issues	-0.103	0.115
	(0.170)	(0.127)
Uncertainty about future digital standards	-0.118	-0.0503
	(0.101)	(0.494)
Internal resistance to change	-0.0188	0.0849
	(0.783)	(0.217)
AT	0.412**	-0.0670
	(0.0161)	(0.708)
BE	-0.0317	0.175
	(0.861)	(0.328)
BG	0.210	-0.158
	(0.261)	(0.419)
CY	0.0360	-0.179
	(0.861)	(0.402)
CZ	-0.0103	-0.143
	(0.953)	(0.420)
DE	0.271	-0.0507
	(0.122)	(0.779)
DK	-0.000359	0.00335
	(0.998)	(0.986)
EE	0.539***	0.172
	(0.00243)	(0.360)
ES	-0.0470	0.0227
	(0.793)	(0.897)
FI	0.149	0.446**
	(0.412)	(0.0139)
FR	0.299*	-0.254
	(0.0812)	(0.165)
EL	0.275*	-0.0472
	(0.0885)	(0.779)
HR	0.388**	-0.230
	(0.0224)	(0.210)
HU	0.0187	-0.216
	(0.912)	(0.225)
IE	-0.124	0.237
	(0.479)	(0.162)
IT	0.588***	-0.490**
	(0.00106)	(0.0191)
LT	0.0481	-0.00616
	(0.787)	(0.974)
LU	0.100	0.209
	(0.638)	(0.317)
LV	0.0458	-0.0276
	(0.807)	(0.882)
MT	0.292	0.0773
	(0.175)	(0.726)

Variables	Basic digital technology adoption	Advanced digital technology adoption
NL	0.134	0.203
	(0.427)	(0.223)
PL	0.206	-0.247
	(0.225)	(0.154)
PT	0.115	-0.226
	(0.555)	(0.267)
RO	-0.276	-0.398**
	(0.138)	(0.0424)
SE	0.00697	0.363*
	(0.971)	(0.0513)
SI	0.123	0.147
	(0.492)	(0.417)
SK (omitted)	-	-
B - Mining and quarrying	-0.00356	0.388
	(0.993)	(0.361)
C - Manufacturing	-0.231	0.0948
	(0.275)	(0.673)
D - Electricity, gas, steam and air conditioning supply	-0.542	0.306
	(0.197)	(0.444)
E - Water supply, sewerage, waste management/remediation	-0.479	0.0521
	(0.134)	(0.872)
F - Construction	-0.0414	-0.115
	(0.848)	(0.622)
G - Wholesale and retail trade, repair of motor vehicles and motorcycles	-0.179	0.0808
	(0.390)	(0.715)
H - Transportation and storage	-0.156	0.0426
	(0.502)	(0.861)
I - Accommodation and food service	0.128	-0.183
	(0.569)	(0.453)
J - Information and communication	-0.391	0.366
	(0.111)	(0.144)
K - Financial and insurance	0.0393	0.144
	(0.884)	(0.611)
L - Real estate	0.159	0.0669
	(0.554)	(0.815)
M - Professional, scientific and technical	-0.0115	0.0545
	(0.958)	(0.816)
N - Administrative and support service	-0.127	0.183
	(0.597)	(0.467)
P - Education	0.140	0.0821
	(0.565)	(0.752)
Q - Human health and social work	-0.0757	0.0294
	(0.749)	(0.906)
Constant	-0.320	-1.125***
	(0.221)	(3.65e-05)
Observations	**2,801**	**2,801**

Note: *** p<0.01, ** p<0.05, * p<0.1, ++ p<0.2, + p<0.25

Source: LE Europe analysis of Eurobarometer data

Table 20 Probit model results for medium-sized SMEs only

Variables	Basic digital technology adoption	Advanced digital technology adoption
Age	-0.000980	0.000262
	(0.522)	(0.847)
Scale-up	-0.164*	0.0560
	(0.0799)	(0.493)
Gazelle	0.0539	-0.127
	(0.843)	(0.622)
City	0.0999	0.0733
	(0.192)	(0.292)
Not part of a global value chain	0.0701	-0.170*
	(0.525)	(0.0689)
External funds available	-0.150*	0.152*
	(0.0726)	(0.0609)
Exporter	-0.253***	0.153*
	(0.00565)	(0.0618)
Independent	0.136	0.0272
	(0.116)	(0.734)
Innovation	-0.258***	0.387***
	(0.00105)	(2.71e-07)
Lack of financial resources	0.0209	-0.166**
	(0.817)	(0.0430)
Lack of skills, including managerial skills	-0.109	0.00855
	(0.248)	(0.918)
Lack of information technology infrastructure, such as high speed internet connection	-0.0310	0.0928
	(0.768)	(0.321)
Regulatory obstacles	-0.291***	0.206**
	(0.00620)	(0.0237)
IT security issues	-0.0777	-0.0227
	(0.463)	(0.803)
Uncertainty about future digital standards	-0.122	0.0642
	(0.219)	(0.459)
Internal resistance to change	-0.199**	0.0569
	(0.0290)	(0.472)
AT	0.351	0.162
	(0.138)	(0.464)
BE	0.0197	0.0701
	(0.939)	(0.763)
BG	0.305	0.0661
	(0.205)	(0.778)
CY	-0.0879	0.364
	(0.811)	(0.263)
CZ	-0.113	-0.258
	(0.642)	(0.265)
DE	0.568**	-0.0443
	(0.0171)	(0.847)
DK	0.247	0.260
	(0.301)	(0.243)
EE	0.568**	0.0581
	(0.0193)	(0.808)
ES	-0.202	-0.0709
	(0.476)	(0.759)

Variables	Basic digital technology adoption	Advanced digital technology adoption
FI	-0.450	0.715***
	(0.157)	(0.00350)
FR	0.235	-0.0199
	(0.387)	(0.937)
EL	0.417*	-0.0873
	(0.0794)	(0.711)
HR	0.591**	-0.0856
	(0.0123)	(0.710)
HU	0.375	0.0835
	(0.119)	(0.713)
IE	-0.303	0.0504
	(0.254)	(0.828)
IT	0.960***	-0.332
	(0.000132)	(0.194)
LT	0.649***	-0.201
	(0.00571)	(0.393)
LU	0.334	0.287
	(0.333)	(0.371)
LV	0.127	0.177
	(0.616)	(0.448)
MT	0.401	-0.260
	(0.167)	(0.349)
NL	-0.270	0.329
	(0.327)	(0.167)
PL	0.380	0.0775
	(0.108)	(0.727)
PT	0.138	0.241
	(0.609)	(0.308)
RO	-0.277	-0.161
	(0.277)	(0.491)
SE	-0.148	0.292
	(0.591)	(0.215)
SI	0.257	0.267
	(0.293)	(0.239)
SK (omitted)	-	-
B - Mining and quarrying	-0.218	0.122
	(0.739)	(0.839)
C - Manufacturing	-0.442	0.267
	(0.118)	(0.371)
D - Electricity, gas, steam and air conditioning supply	-0.585	0.948**
	(0.195)	(0.0287)
E - Water supply, sewerage, waste management/remediation	-0.895**	0.514
	(0.0192)	(0.153)
F - Construction	-0.336	0.141
	(0.256)	(0.649)
G - Wholesale and retail trade, repair of motor vehicles and motorcycles	-0.268	0.212
	(0.350)	(0.480)
H - Transportation and storage	-0.415	0.200
	(0.176)	(0.529)
I - Accommodation and food service	-0.205	0.228
	(0.513)	(0.494)
J - Information and communication	-0.531	0.573*

Variables	Basic digital technology adoption	Advanced digital technology adoption
	(0.126)	(0.0907)
K - Financial and insurance	-0.157	0.235
	(0.659)	(0.494)
L - Real estate	-0.274	0.460
	(0.453)	(0.196)
M - Professional, scientific and technical	-0.119	0.383
	(0.700)	(0.228)
N - Administrative and support service	-0.280	0.370
	(0.373)	(0.251)
P - Education	-0.0135	0.498
	(0.966)	(0.140)
Q - Human health and social work	0.102	-0.00127
	(0.734)	(0.997)
Constant	-0.188	-1.061***
	(0.589)	(0.00229)
Observations	**1,698**	**1,698**

Note: *** p<0.01, ** p<0.05, * p<0.1, ++ p<0.2, + p<0.25

Source: LE Europe analysis of Eurobarometer data

An additional area of interest would be to run the analysis for digital and non-digital sectors, however the data is not granular enough to achieve this.

6 The digitalisation of SMEs and its link to GHG emissions

According to a recent narrative, digitalisation may not only increase businesses´ competitiveness and productivity but may also enhance their sustainability by reducing greenhouse gas (GHG) emissions. The digitalisation of SMEs could thus contribute to achieving the overall goal of emission neutrality in 2050 set by the European Commission.[165]

Digitalisation may increase productivity through improvements in supply chain management, which may lead to higher energy efficiency (substitution effect). The production of the same output can thus be achieved with lower GHG emissions. The potential for improvements in productivity and resulting reductions in GHG emissions is particularly high for SMEs for two reasons. First, SMEs account for a large share of economic activity in most countries. Second, SMEs are generally less productive than large firms: across the EU27, SME productivity was about EUR 40 000 in 2020, compared to EUR 66 300 for large companies.[166]

However, higher productivity also enables firms to produce more cost-efficiently and to lower prices, thereby incentivizing higher consumption and production (income effect). An increase in the total level of production thus leads to a "rebound effect" in GHG emissions. Theoretically, it is not clear which of two opposing effects - the reduction in GHG emissions due to an increase in energy efficiency or the increase in GHG emissions due to higher output - prevails.

This chapter provides an empirical analysis of how digitalisation paths across different industries impact GHG emissions and whether the impact on overall GHG emissions depends on the share of SMEs in an industry. Descriptive statistics indicate that GHG intensity of companies depends more on the sector than on the country. A regression analysis leads to the conclusion that industries with higher digitalisation levels may show significantly lower levels of overall GHG emissions but only in sectors with a lower share of SME employment. In sectors with a higher share of SME employment, higher digitalisation levels are associated with higher GHG emissions. The latter must be vetted against the finding that a higher share of SMEs in a sector in general indicates lower GHG emissions.

6.1 Research overview

The counteracting effects outlined above are reflected in mixed findings in the emerging field of research linking digitalisation and sustainability. On the one hand, studies find or forecast that digitalisation has or will have a positive impact on sustainability through its impact on productivity, resulting in a decrease in GHG emissions. The GLOBAL e-SUSTAINABILITY INITIATIVE, for example, estimated in their SMARTer 2030 report that ICT enabled solutions offer the potential to reduce GHG emissions by 20 % until 2030 (GeSI, 2015). However, other studies come to the opposite conclusion. They find that ICT can also adversely affect sustainability depending on country characteristics and the level of ICT, leading to an increase in GHG emissions. Salahuddin et al. (2016), for example, found that a 1% increase in internet usage results in a rise of 0.16% in GHG emissions across OECD countries.

Higon et al (2017) analysed the impact of ICT on CO_2 emissions for a panel of 142 countries over the period from 1995 to 2010. They found that rising ICT levels lead to a reduction in CO_2 emissions in developed countries, whereas the opposite holds for developing countries. The authors concluded that the relationship between ICT and CO_2 is best described as an inverted U-shape. Similarly, Khan et al (2020) showed that ICT reduces emissions in developed countries and increases emissions in developing countries. However, for the full sample of 91 countries, ICT reduces emissions. In contrast, Park et al. (2018) concluded that more usage of ICT led to higher CO_2 emissions for a panel of 23 EU Member States.

Empirical research focusing on environmental effects across industries, instead of countries as a whole, is scarce. Bernstein & Madlener (2008) analysed the impact of ICT capital on electricity intensity, not GHG emissions, in five major European industries. To measure ICT capital, they used data from the EU-KLEMS-dataset and combined it with data from EUROSTAT on electricity intensity. The key finding of the panel analysis with cross-section fixed effects was that the effect of computer and hardware on electricity-intensity is sector-specific. In contrast, communication technologies were found to have an energy-saving effect in all industries. Similarly,

[165] https://ec.europa.eu/info/strategy/priorities-2019-2024/european-green-deal_en
[166] Source: SME PR 2020

Collard et al. (2005) found that electricity intensity decreased with a rise in communication devices in French service sectors, whereas electricity intensity of production increases with computers and software.

The explicit link between digitalisation in SMEs and GHG emissions has not been intensively studied yet. Isensee et al. (2020) proposed, after conducting an extensive literature review, that SMEs should adopt green digitalisation tools to improve their sustainability. However, the authors themselves regard the available data linking SMEs, digitalisation and GHG emissions as insufficient. In the following, we aim to fill this research gap by linking the SME PR 2020 database with macro data on digitalisation and industry-level GHG emissions over the period from 2008 to 2016.

6.2 Database

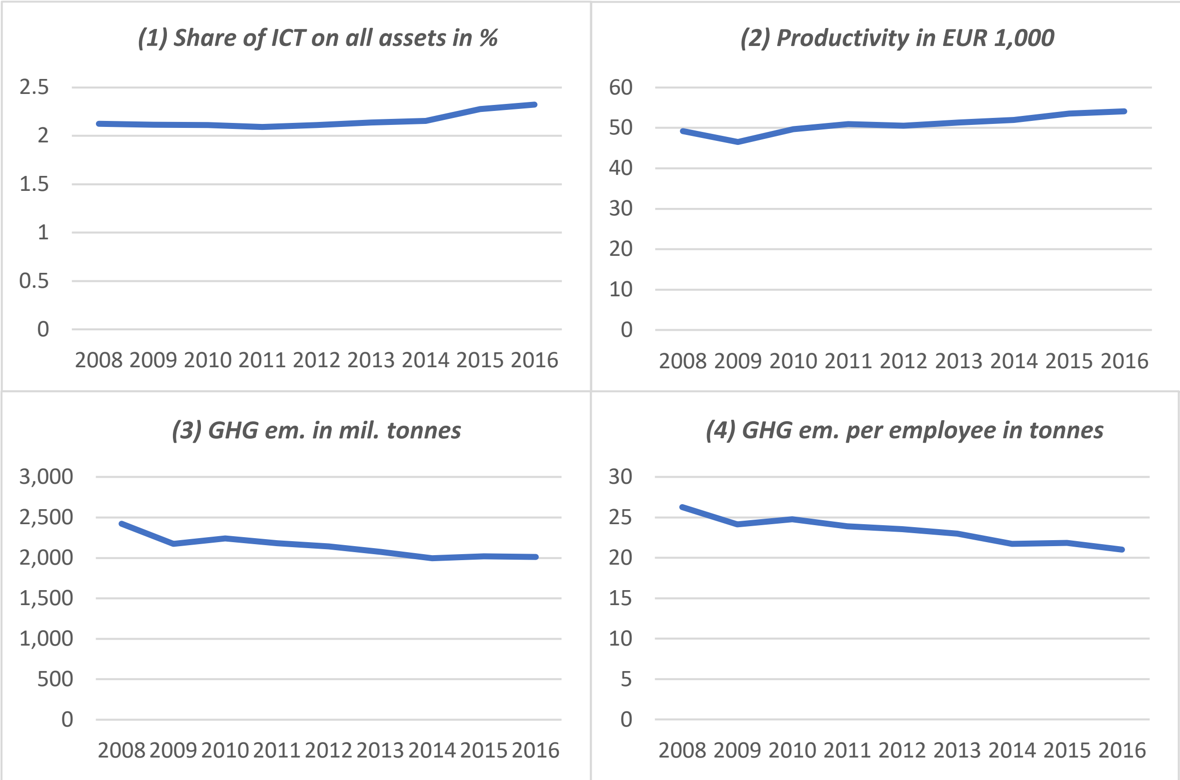
The dataset used in the following analysis covers 16 countries and 12 sectors of the non-financial business economy for the years 2008 to 2016. Following the approach of Berstein & Madlener (2008), the current state of digitalisation across industries is measured by data from the EU-KLEMS data set on the capital net stock[167] of the capital types computer and hardware (IT), telecommunication equipment (CT) and software and databases (Soft_DB).[168] In the following, these variables are abbreviated as ICT. The data for GHG emissions have been taken from air emissions accounts, published by EUROSTAT. GHG emissions are reported as CO_2-equivalent for 64 industries according to the NACE classification.[169] Air emissions accounts follow the residential principle, i.e. regardless of where the emissions take place geographically, emissions are assigned to the country where the operator causing the emissions resides.[170] To link digitalisation and GHG emissions with SMEs, the data are merged with the information from the 2021 SME PR database. The *professional activities* (M) and the *administrative activities* (N) sectors are aggregated as specified by EU-KLEMS. Not all countries of the SME PR database could be included in the analysis due to missing data within the EU-KLEMS or EUROSTAT database. In 2016, the countries included in the analysis represented 88.2 % of value added and 78.4 % of employment in the EU27.

6.3 Descriptive evidence

The following figure describes the development of digitalisation, productivity, absolute GHG emissions and GHG emissions per employee aggregated across all 16 countries and all 12 sectors from 2008 to 2016.

[167] Capital net stock: "The stock of assets surviving from past periods and corrected for depreciation is the net (or wealth) capital stock. The net stock is valued as if the capital good (used or new) were acquired on the date to which a balance sheet relates." https://www.oecd-ilibrary.org/economics/national-accounts-at-a-glance-2009/net-capital-stock_9789264075108-23-en;jsessionid=J3Op_e-QonnGsnHDRTizlj1u.ip-10-240-5-21
[168] https://euklems.eu/download/
[169] https://ec.europa.eu/eurostat/web/climate-change/data/database
[170] https://ec.europa.eu/eurostat/statistics-explained/index.php/Greenhouse_gas_emissions_by_industries_and_households#Greenhouse_gas_emissions

Figure 30 Development of central indicators from 2008 to 2016



Note: The share of ICT is weighted by the respective net capital of all assets in (1).
Source: EUROSTAT (3) + (4), EU-KLEMS (1), SME PR (2)+(4)

Figure 30's first panel depicts the share of ICT capital of the overall net capital stock. The share of ICT capital – also referred to as ICT intensity in the following analysis - stagnated between 2008 and 2014 at a level of about 2.1 % and grew in 2015 and 2016 to about 2.3 %. The development of productivity, defined as value added per employee, is displayed in panel (2) of Figure 30. Until 2012, productivity growth was strongly affected by the global financial crisis and the following European debt crises. However, from 2012 onwards, productivity grew from EUR 50 600 to EUR 54 100 per employee in 2016.

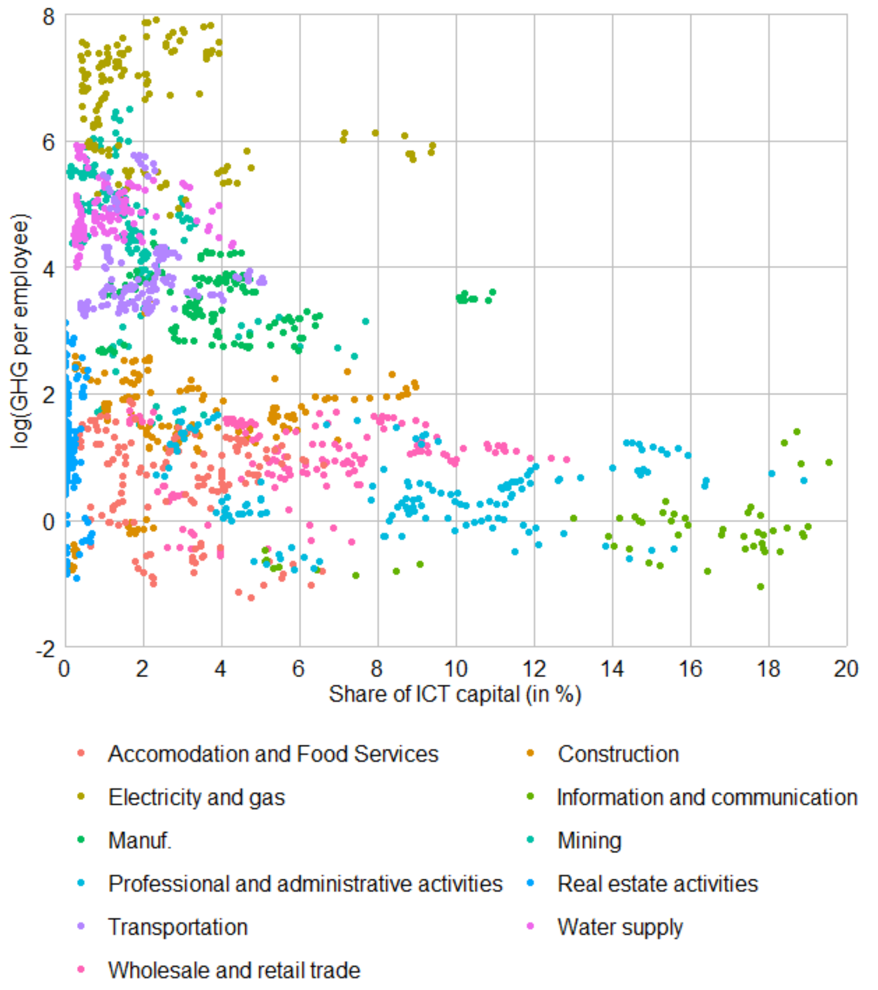
Panel (3) displays the path of the absolute amount of GHG emissions in million tonnes of CO_2 equivalent. Emissions fell from 2 400 million tonnes in 2008 to 2 000 million tonnes in 2014 and stagnated from then on. CO_2 emissions per employee, depicted in Figure 33, followed a similar trend. In 2008, the average employee emitted 26.2 tonnes in CO_2 equivalent. The value dropped to about 21 tonnes per employee in 2016.

However, one should be cautious to draw any conclusions on the relationship between ICT capital, productivity and GHG emissions based on these aggregated data. There is substantial variation in ICT capital and GHG emissions across industry sectors and countries which is masked in the aggregate data. The following plots take a closer look at the relationship between GHG intensity and ICT capital both within and across sectors and countries.

Figure 31 shows the relationship between GHG emissions per employee and the share of ICT net capital on all assets[171]. Each dot represents an observation for a sector within a country for a certain year and the different colours mark the different sectors.

[171] GHG emissions are displayed in logs (logarithmic scale), a common practice for skewed variables.

Figure 31 Share of ICT capital in % vs. GHG emissions in tonnes per employee (in logs) by sector

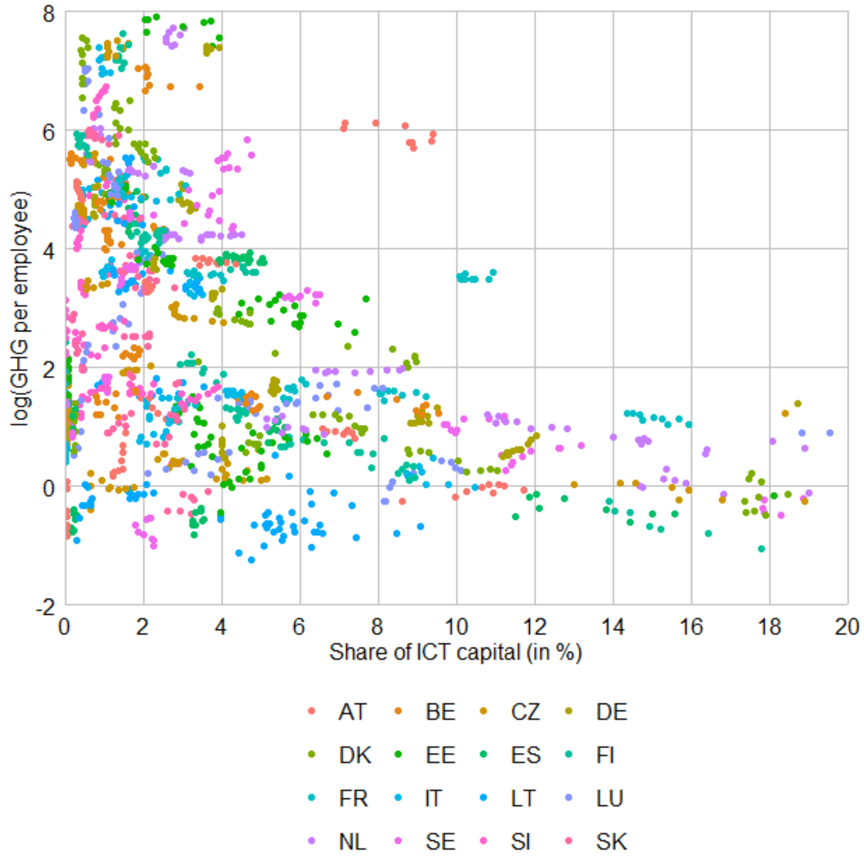


Note: The information and communication sector has very high shares in ICT net capital with maximum values larger than 60 %. However, for illustration purposes, the graph is cut at the 20 % threshold.

Source: EU-KLEMS, EUROSTAT

First, it is notable that the observations are clustered by industries. Sectors tend to have similar levels of ICT capital and GHG emissions per employee across countries and periods. Additionally, there seems to exist an overall negative correlation between digitalisation and emissions per employee. However, this correlation seems to be driven by variation of GHG emissions across sectors with different levels of ICT capital rather than by variation in ICT capital within sectors. As expected, the *electricity and gas* sector and the *water supply*, *manufacturing* and *transportation* show the most GHG emissions per employee. The least GHG emissions per employee are emitted by service sectors. Within sectors the dots are horizontally distributed, indicating that there is no correlation between ICT capital per employee and GHG emissions if one compares GHG emissions in the same sector across different countries or periods.

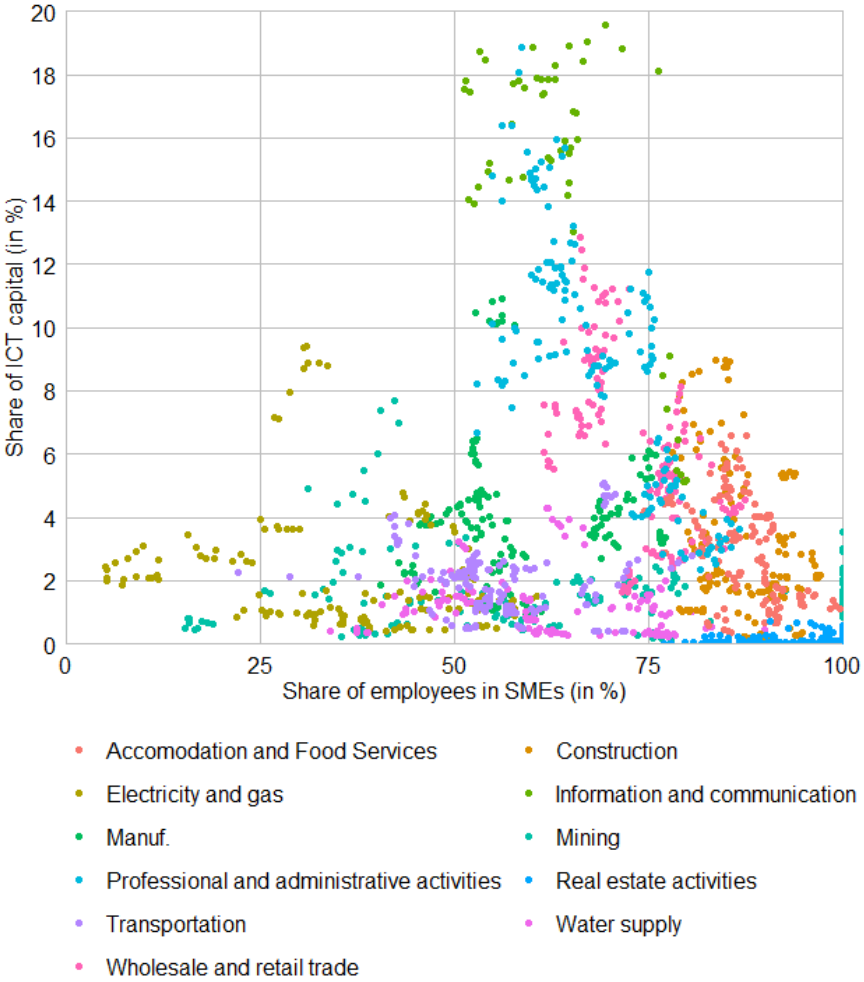
Figure 32 Share of ICT capital in % vs. GHG emissions in tonnes per employee (in logs) by country



Note: The information and communication sector has very high shares in ICT net capital with maximum values larger than 60 %. However, to remain informative, the graph is cut at the 20 % threshold.
Source: EU-KLEMS, EUROSTAT, SME PR

Figure 32 depicts the same data as Figure 31 but differentiated by countries. It illustrates the challenges in analysing the impact of ICT capital on GHG emissions on the country level. Each country's economy is characterised by a different composition of sectors. Figure 31 has shown that ICT capital stock and GHG emissions differ systematically and significantly across sectors. Therefore, when analysing the relationship between ICT intensity and GHG emissions in a country over time, shifts in the sectoral distribution should be taken into account. A country shifting from an industry-oriented to a more service-oriented economy will experience an increase in the share of ICT capital mainly because service sectors tend to have more ICT capital. If GHG emissions decrease during the shift, the reduction in emissions should be attributed to the shift in the sectoral distribution of the economy rather than the digitalisation paths of companies within a sector.

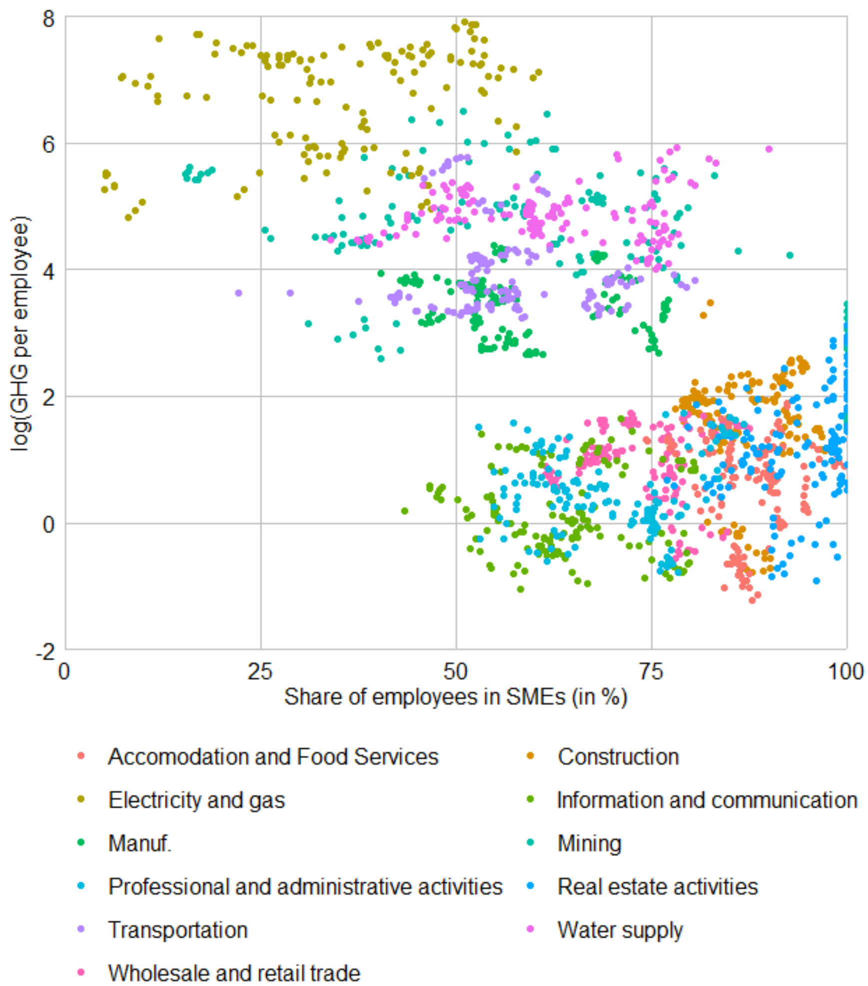
Figure 33 Share of employees in SMEs in % vs. share of ICT in % by sector



Note: The information and communication sector has very high shares in ICT net capital with maximum values larger than 60 %. However, to remain informative, the graph is cut at the 20 % threshold.
Source: EU-KLEMS, SME PR

Figure 33 plots the share of employees in SMEs and ICT intensity within a sector in a country in a certain year. Again, the data points are clustered by sectors. The graph does not reveal any clear relationship between the share of employees in SMEs and ICT intensity. While for sectors with a share of employees in SMEs below 75 percent, a slightly positive correlated may be detected, the relationship seems to become negative for companies with a high share of employees in SMEs above 75%. There are some sectors with particularly high shares of employees of SMEs and low shares of ICT capital, including the *real estate activities* sector, the *accommodation and food services sector* and the *construction* sector. There is also no clear relationship between the share of employees in SMEs and ICT intensity within sectors.

Figure 34 Share of employees in SMEs in % vs. GHG emissions in tonnes per employee (in logs) by sector



Note: The information and communication sector has very high shares in ICT net capital with maximum values larger than 60 %. However, to remain informative, the graph is cut at the 20 % threshold.
Source: EU-KLEMS, SME PR

Finally, the share of employees in SMEs is plotted against GHG emissions per employee across sectors. Once again, the data are clustered by sector: Sectors tend to have similar shares of employees in SMEs and GHG emissions across countries and periods. Strikingly, sectors with high shares of SMEs tend to have lower GHG emissions per employee. However, within sectors, no clear relationship between the two variables is observable.

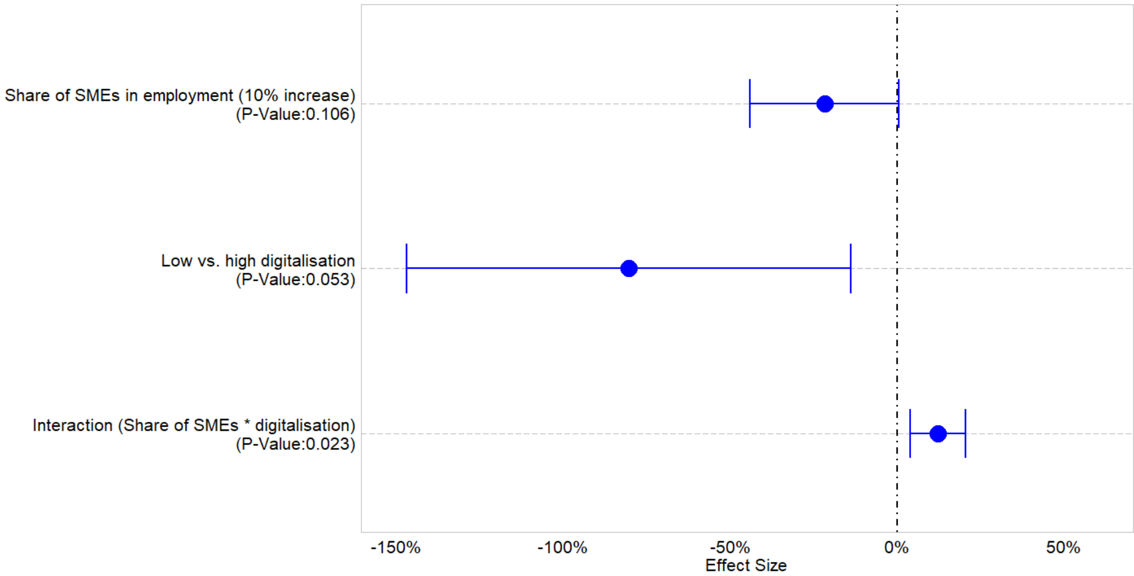
6.4 Regression analysis

The graphical analysis revealed that differences across sectors account for a large portion of the observed variation in ICT capital, GHG emissions and the share of SMEs across countries and time periods. To investigate the impact of digitalisation paths of companies on GHG emissions, this variance across sectors should thus be explicitly controlled for in the following regression analysis.

The regression analysis aims to estimate the impact of SMEs and ICT on absolute GHG emissions and GHG emissions per employee. To construct an experiment-like setting, the whole sample was divided into observations with a relatively high share and those with a relatively low share of ICT capital. A dummy variable takes the value 1 if the observation – i.e. the value of ICT capital in a sector in a country in a particular year - is among the highest three deciles of ICT intensity within a sector and year. The dummy takes the value 0 when the observation is amongst the lower 3 deciles.[172] The dependent variable, GHG emissions, is included in logs to simplify the interpretation of the estimated effects in percentages.

The explanatory variables of interest in the regression are the share of employees working in SMEs, ICT-intensity and an interaction of the share of employees in SMEs and ICT-intensity. The interaction term allows investigating in how far the effect of digitalisation on GHG emissions depends on the share of SME employment in the sector. Additionally, the regression model controlled for time (years), sectors and countries. The standard errors are clustered at the sector level.

Figure 35 Coefficients of Regression of GHG Emissions on Digitalisation and Share of SMEs



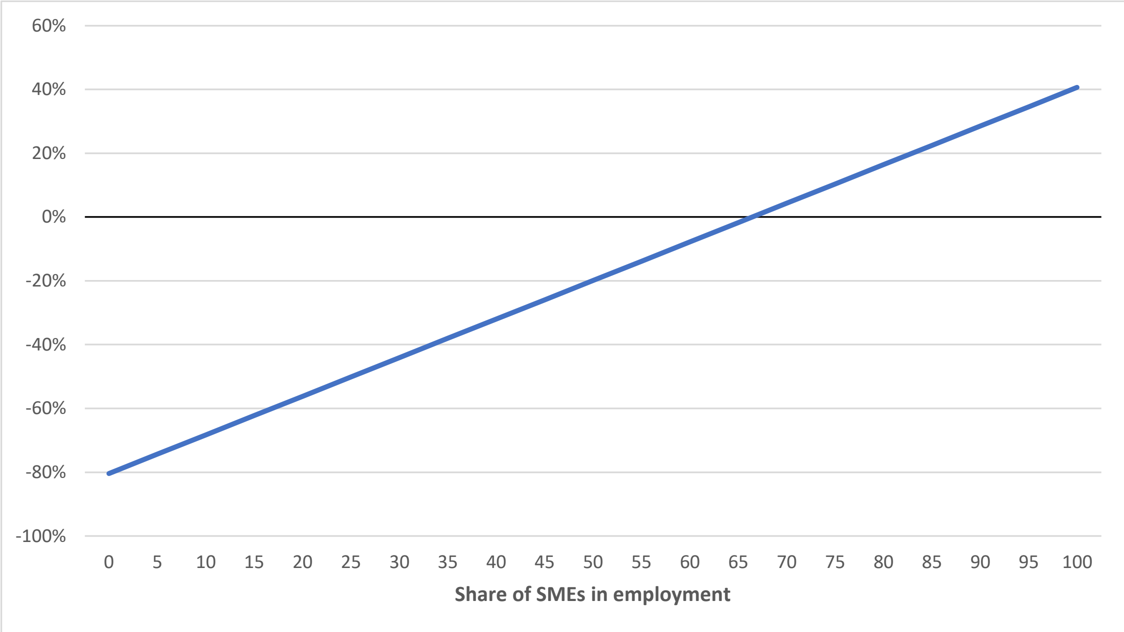
Note: N = 1,107, regression with industry-clustered standard errors, controlling for time, country and industry, 90%-significance level confidence interval. Own calculations.
Source: EU-KLEMS, EUROSTAT, SME PR

Figure 35 focuses on the regression results with GHG emissions as dependent variable[173], showing the effect size and the corresponding p-value of the main variables of interest. Both the coefficient of SME employment and the digitalisation dummy are estimated to be negative, indicating a reducing effect on GHG emissions. However, to correctly interpret the effect of both variables, the interaction term must also be taken into account. The coefficient of the interaction is estimated to be positive, implying that the decreasing effect of digitalisation on GHG emissions is weaker the higher the share of SME employment in a sector.

Figure 36 illustrates how the estimated effect of digitalisation varies with the share of SME employment. While the effect of a sharp increase in the share of ICT capital (i.e. digitalisation dummy equal to 1) is estimated to be negative for sectors with a low share of SME employment, it turns positive at a threshold SME employment share of around 66%. For example, at a SME employment share of 60%, a sharp increase in digitalisation is estimated to reduce emissions by around 8%; whereas at an SME employment share of 70%, digitalisation is estimated to increase emissions by around 4%.

[172] A transition from 0 to 1 may be interpreted as a treatment of digitalisation. Observations that fall in-between the status of "treated" and "untreated" are not covered by the regression approach.
[173] The regression with GHG emissions per employee as dependent variable showed no significant results.

Figure 36 The effect of a sharp increase in digitalisation on GHG emissions dependent on the share of SME employment



Note: N = 1,107, pooled regression with industry clustered standard errors, controlled for time, country and industry. Own calculations.
Source: EU-KLEMS, EUROSTAT, SME PR

However, it should be emphasised that – despite the positive interaction effect – the overall effect of the share of SME employment on GHG emissions is estimated to be negative. For sectors with a high level of digitalisation, an increase in SME employment of 1%-point reduces GHG emissions by an estimated 2.2%, compared to a reduction of around 1% for sectors with high levels of digitalisation.

6.5 Conclusion

The above analysis provided several insights into the relationship of digitalisation, the share of SMEs and GHG emissions across sectors. First, all three variables – the ICT capital stock, the share of SME employment and GHG emissions – differ significantly and systematically across sectors. Therefore, any empirical analysis should control for the type of sector. Second, the regression analysis has shown that the effect of digitalisation depends on the share of SME employment. For sectors with low shares of SME employment, digitalisation is estimated to reduce emissions; this effect changes direction when the sectoral SME employment share exceeds 66%.

However, one should be cautious to interpret the presented results causally. More research is needed to identify the causal relationship between digitalisation paths of SMEs and GHG emissions. In particular, the above analysis highlighted the challenges in analysing the relationship of digitalisation and GHG emissions at an aggregate level. Future research would thus benefit from disaggregated, company-level data on digitalisation paths and GHG emissions.

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