Chapter

Digital Innovation and Sustainable Development: Two Sides of the Same Coin

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Abstract

Digital innovations and sustainable development are key words in the current agenda of worldwide policy makers. There are high expectations that digitalization will lead the world to more sustainable paths so that accomplishing net zero economies by 2050, as envisaged by policy packages, such as the Agenda 2030 by United Nations, and the European Green Deal by the European Commission. However, the scientific evidence reveals that this result is not taken for granted, and digital transformation may worsen and make more difficult the road to sustainable development whether the use of digital devices targets only economic performance. This chapter reviews the major evidence provided by the scientific literature and introduces how policymakers have been acting to make these two key words complementary to each other.

Keywords: innovation, digitalization, sustainable development, agenda 2030, twin transition

1. Introduction

This chapter of the book aims to illustrate the economic, political, and industrial context in which the ecological and digital transitions are developing. In particular, the two transitions will be analyzed from three main perspectives: the role of digital innovation in transforming society; a macro perspective of digitalization and sustainability; and finally, how digital innovations are expected to impact the territories.

2. The role of digital innovation in transforming the society

The challenges the economy and society have to face are several: the term "Great Challenges" refers to "specific critical barriers which, if removed, would help solve a major social problem with a high probability of global impact through widespread implementation" [1]. The United Nations has 17 Sustainable Development Goals including no poverty, zero hunger, good health and well-being, quality education, and gender equality [2]. Digital innovation can help to address the problems and criticalities connected to them, to the extent that new technological and scientific organizational approaches are adopted [3]. Digital innovation can, for example, support social action in favor of active aging: data from smart devices and home monitoring technologies can support individuals and families in tackling the challenges of aging at home [4, 5]. Data have become the central resource for the creation of value and for decision-making processes at every level (company, family, institution), therefore also for policies: this brings out several new questions on how data should and can be governed to achieve social beneficial innovations by avoiding or mitigating unwanted outcomes [6–8].

Data governance within and across organizations must be based on new approaches to manage and control data that is today distributed across organizations and ecosystems [9]. A huge mass of data can be interpreted in a biased way to serve the interests of one or a few parts of the social actors involved, therefore it is necessary to understand how the different parts collaborate or compete to manage data governance [10] in order to align diverse interests to address grand challenges through data-enabled innovations [11]. The risks of using big data go beyond cybersecurity or data interoperability [12, 13]. In fact, most of the data is located outside the proprietary boundaries of a company, therefore out of its control: they are located within infrastructures shared by collective actors, on digital platforms [13, 14]. It is very interesting to understand how companies manage data and seek their value at aggregate levels such as platforms, ecosystems, or inter-organizational networks [12].

The social challenges are therefore multiple, digital innovation can help to address the problems and criticalities connected to them, but how? What new organizational, technological, and scientific approaches need to be adopted to fully grasp its impact? Data is certainly the central resource for value-creation processes. Technological progress in the age of data, algorithms, and digital networks is based on 3 key characteristics: it is exponential, digital, and combinatorial [15]. From the economics of resource scarcity to the economics of critical resource abundance: data [15]: how to collect them at the aggregate level of digital platforms? How to use them safely and fairly?

The aim of the paragraph is to analyze the scientific debate on the potential for change of digital innovation for people, businesses, and institutions and to identify the new questions raised by the literature.

2.1 The digitization of society

Digital technologies are an integral part of the lives of people, organizations, and institutions [16] being applied in different fields such as food production ('precision farming'), electricity ('smart grids'), housing ('smart homes'), healthcare ('health apps'), mobility ('smart mobility'), peer-to-peer services ('sharing economy') and banking ('online payments') [16]. Against this background, European politicians have recently embraced the notion of a 'green digital transformation' based on the widespread use of digital technologies [17].

Data is the raw material of the information age, like land in the agricultural age and iron in the industrial age [18]. The digitization of cognitive processes, commercial exchange, of communication, has exponentially increased the potential and ability to collect data. Almost any good can be digitized, or converted into many bits that can be archived on a computer and sent on the net: this makes the goods transformed into data, very special since they develop an economy based on abundance rather than scarcity, to which the human being has always been used to [19]. The advancement of AI generates huge amounts of data. This phenomenon, widely called big data, refers to the integration of huge amounts of different digitized sources of complex data structures [20]. The term Big Data refers to this enormous mass of data that circulates on the internet infrastructure, which can be used to understand, analyze and predict phenomena and procedural developments in real time [21]. The real meaning of the concept of Big Data lies in the ability to process a huge amount of information in near real time so that it can be put to some use [19].

Big data drives value creation through the data generated by trading partners in upstream, downstream, and horizontal collaboration to investigate opportunities [22]. Big data and AI interplay everywhere: big data is the product of AI, and the advancement of big data also promotes AI's development [23]. Big data can alleviate decision-making cognitive biases, improving the adaptive response to problem occurrence. Despite a rapid increase in the number of studies on big data over the last 10 years, much research remains practice-driven, and academic-related research remains in its early stages [23].

The increases in data collection and the growth of processing power are two complementary elements: the more data is available, the more one invests in powerful computers and in plenty of memory to process them and process usable information. The more powerful computers are, the easier it is to collect large volumes of data and produce larger and more in-depth data sets. Big Data is evolving the process of collecting, managing, and processing data, thus generating new ways of accessing corporate information and new interpretative models [18].

The growing use of digital technology in the food, energy, health, and mobility sectors will increase the consumption of electricity and rare materials: it is not clear whether sustainable behaviors promoted by digital innovations will compensate for these extra costs. Digitalization, therefore, could be at odds with a transition toward sustainability unless the digital regime is refocused toward inclusive practices, democratic governance, and environmental regulation [16].

Over the past 10 years, AI has made enormous strides, thus making available a growing number of practical applications that are transforming the world [24]. In the academic literature, there is no unique and consensual definition of AI. AI-based solutions can be defined as systems with the ability to act intelligently, correctly interpreting external data, and using these objectives to execute particular tasks by a flexible configuration, even to the extent of reproducing human behaviors with cognitive, social, and emotional intelligence [25]. AI refers to machines performing cognitive functions usually associated with human minds, such as learning, interacting, and problem-solving [26]. Beyond the centrality of data for operating and competing in the age of AI [9, 27], the accessibility and ownership of organizational and customer data have been recognized as a fundamental advantage for firms to learn faster [27], and create innovation using AI [28]. Russell and Norvig [29] summarize the several definitions of AI systems into four categories along two dimensions: reasoning–behavior dimension and human performance–rationality dimension, that is:

1. systems that think like humans;

2. systems that act like humans;

3. systems that think rationally;

4. systems that act rationally.

AI systems should have the following capabilities: natural language processing to communicate in a natural language, knowledge representation to store information, auto-mated reasoning - the use of the stored information to answer questions and to draw new conclusions, and machine learning to adapt to new circumstances and to detect and extrapolate patterns [29, 30].

The fundamental accelerator of this progress is “deep learning”, that is, an AI technique based on multi-layered artificial neural networks: the basic principles of deep neural networks have been known for decades but the latest striking achievements have been made possible by the confluence of 2 long-lasting trends in information technology [24]:

1. the creation of immensely more powerful computers allowed, for the first time, neural networks to transform themselves into extremely efficient tools;

2. the immense mines of data that are now generated and collected through the information economy represent a decisive resource for teaching these networks to perform useful tasks. The availability of data on a hitherto unimaginable scale is in all likelihood the crucial factor in the astounding progress of AI. Deep neural networks suck up data to be exploited much like a huge whale feeds on krill.

The blockchain is a technology based on the logic of the distributed database, i.e. a database in which the data is not stored on a single computer but on multiple devices connected to each other and connected to the network, which works through a communication protocol. The distributed network or Distributed Ledger (DLT) refers to “a set of systems conceptually characterized by the fact that they refer to a distributed ledger, governed in such a way as to allow access and the possibility of making changes by multiple nodes of a net” [31]. BCT has been described as a promising and disruptive technology, which, through its mechanisms, is able to change how value is extracted and delivered [32]. BCT is one of the technologies underpinned by the Industry 4.0 paradigm [33], defined as “a digital, decentralized and distributed ledger in which transactions are logged and added in chronological order with the goal of creating permanent and tamperproof records” [34] and refers “to a fully distributed system for cryptographically capturing and storing a consistent, immutable, linear event log of transactions between networked actors” [35].

Blockchain technology is based on decentralization and the uncontrollability of the system [36]. However, it has been realized how essential the need to authorize transactions is [37]: nodes need acceptance to become part of the network. Blockchain technology continues to operate in a decentralized way, supporting the system under authorization and authentication, eliminating the privacy issue [38]. BCT records information concerning the nature, quality, quantity, location, and ownership in ledgers [39]. Given the characteristics of this technology, BCT represents a useful tool to facilitate data sharing, enhancing its transparency, accountability, efficiency, safety, and traceability [40, 41] and protecting it from tampering, deletion, and revision [42]. Just as HTML has become the standard language for the web, the blockchain may have the technological ingenuity that will make it the protocol for trusted transactions. The web was essentially made from HTML. The great innovation consisted in making the web something visible, accessible, and easily navigable, thus allowing other innovations to stratify on this platform. The blockchain makes trusted transactions the protocol upon which much more can be built [18].

The introduction of blockchain would allow the sharing of information in a reliable and secure environment while ensuring its immutability. Every actor in a supply chain would no longer need to use paper documents or rely on central entities or third parties to certify the various information and documents produced during the process [43].

2.2 The change potential of digital innovation for people, businesses, organizations, and institutions

2.2.1 Digital innovation and transformation is reshaping society

A lively scientific debate is underway on the impact of digital innovations on the lives of individuals, organizations, and the environment: the subjects of investigation naturally stand out as big data analytics, artificial intelligence, and blockchain. Digital transformation (DT) can be defined as a disruptive process where organizations change value-creating processes by adopting digital technologies in response to changes in the business environment [44]; it stimulates innovation as it requires the acquisition of new knowledge and skills, leads to a new way of collaborating within the organizations, promotes the development of new business models [45].

DT also catalyzes the transformation of governance, HR, and IT functions in organizations [46]. Previous studies identified the positive impact of digital transformation on all three pillars of sustainability; however, it is more evident in evaluating sustainability's economic and environmental aspects [47–49]. According to Maguire and Winthereik [50] digitalization changes the dynamics of systems and renders components and performance visible in new ways. It has significant potential to monitor environmental change and to facilitate the uptake of low-carbon and energy-saving technologies [51].

2.2.2 Smart industry 4.0, IoT

Manufacturing is living a very lively changing with the smart production systems Industry 4.0 is already a reality in many medium-to-large companies [52, 53]. Smart manufacturing, [54], represents integrated systems that respond in real-time to the demand of the factory, the supply network, and the customer. The Internet of Things (IoT) will assist companies in measuring their operational performance by implementing connected sensors to track most of their activity [55].

Suppliers and society: The evolution of the Internet of Things (IoT) coupled with AI to form intelligent cyber-physical systems will also bring new implications for our daily lives [56]. As artificial intelligence grows in its knowledge and intelligence, algorithms will be able to optimize people's daily lives in unimaginable ways. The most interesting phenomenon to study will concern the forms of integration between IoT and AI.

2.2.3 Artificial intelligence

The impacts of AI-based digital innovation are reflected in multiple aspects of society [24]: economy (industry, services, transport, agriculture, etc.), work, energy, collective security (cyberattacks), information (fake news), social media (confusion and manipulation of public opinion), privacy, justice, weapons.

Robots are machines capable of handling complex series of actions that interact, communicate and provide services to an organization or customers [57, 58]. Many studies in the literature investigate the use of AI robots, especially in the context of services, and their implications for society. There are emerging studies discussing hypotheses that, in the near future, the use of AI robots could become dysfunctional and cause mental disorders and other psychiatric problems in humans [57, 59]. Many researchers argue that the use of artificial intelligence robots can have a huge impact on society, not only because they will be more integrated into service meetings, but they can also put themselves and humans at risk, become able to perform tasks creatively (i.e. leave nothing to humans) and achieve the same level of intelligence as humans [57, 59].

The development of artificial intelligence (AI) and machine learning (ML) offers organizations the possibility of radical changes in products, services, innovation processes, business models, and in the very nature of business activities in industrial ecosystems: indeed, a growing number of studies have endorsed the value of incorporating AI and ML to develop products that effectively address the deepest and most complex customer needs and satisfaction [27, 60]. According to Ford [24] AI is a flexible resource capable of applying cognitive abilities to practically any problem, similar to electricity that can be activated with a simple switch: this new resource will be able to analyze data, make decisions, solve complex problems, and give test your creativity. What will be the future implications of AI? Is it to be understood as a specific innovation or as an extraordinarily scalable technology? Will AI be a resource capable of generating value for people, businesses, and institutions and how?

AI can influence several aspects of society: law and regulations, organizations, diagnostic medicine, industry manufacturing, transportation, marketing, social media, government, etc. [61]. The impact of AI on organizations brings together the impact of AI on different aspects and processes such as [62]: work [63], highlights the critical skills for employees in organizations that use AI and their contribution to solving problems, and stimulates curiosity to create new knowledge; Kolbjørnsrud, et al. analyzes the employee-machine relationships [64]; forecasting, [65]; manufacturing (AI contribution to customizing [66, 67] and to optimizing quality [68]; decision supports, [69]; risk management [70, 71]; problem-solving [72], marketing and social media [73, 74].

In terms of management, AI can be categorized broadly into two different applications within organizations: automation and augmentation [19, 75, 76]. Automation refers to machines taking over human tasks, whereas augmentation implies that humans work in close collaboration with machines to perform a particular task [77]. The scientific community is debating whether 'robots', through automation, will make human workers and certain skills redundant, or whether AI will primarily be assistants or collaborators doing basic jobs, such as data collection, systematization, analysis, and recommendations, thus increasing process performance and human capabilities and preparing people to make more informed decisions [78].

Loureiro [62] analyzes how AI can affect society as a whole in a broader sense, how it affects organizations, what types of systems have been used, and what methodologies are employed; they highlight that, among the different impacts that AI has, one of the major impacts of AI will be seen on governance. Empowering governance using AI-based algorithms poses major challenges to top management as they decide which areas to prioritize and to what extent of delegation. Mele et al. [61] explore how AI and other forms of cognitive technology can influence value co- creation: the authors find that choice architectures and nudges affect value co-creation by widening resource accessibility dynamically, extending engagement, and augmenting human actors' agency.

The implications of a hybrid working environment are humans and AI systems working together and changing how managers and owners need to act to ensure a healthy working balance between multiple different needs [79]. Today, companies are already using AI systems to help managers decide who to hire. A more distant future trend may arise from the use of brain-computer interfaces to enhance cognitive skills for both managers and employees.

What is becoming clear is that, based on its ability to process more ecosystem information, AI is enhancing some business and marketing processes; leading to the reconfiguration and shaping of existing ecosystems and the formation of new ones, through the integration and sharing of more data; and it's leading to more real-time interactions and the possibility of developing a more systemic market vision [62]. If the potential of AI is to be realized, organizations must understand, consider, and engage their customers and employees in the reshaping of the whole value co-creating process [30]. AI is now being applied within enterprises for customer selection, HR, risk assessment in banking and insurance, advertising, scheduling, and routing [79–81].

The analytical skills and expanded knowledge made available by big data and artificial intelligence allow organizations to be supported in all decision-making processes [23]. This point highlights how AI is linked to cultural and social contexts, far beyond just the business aspects. Viewed from a more macro (i.e. social) level, the implementation of AI raises profound ethical questions [82]. For example, Bostrom and Yudowsky have emphasized three important ethical considerations: transparency, accountability, and fairness [83].

As AI continues to develop, it shows the potential to disrupt also the job market and the broader economy on a possibly unprecedented scale. According to Iansiti and Lakhani [27], AI will affect almost every job function. Long before the advent of AI, there were fears that automation and robotization would make humans redundant, assuming that there is only a certain amount of work, and if it is automated then there is less for humans to do [84]. It was concluded that most jobs consist of tasks and routines that could be automated, thus automation could create more opportunities for humans to work more closely with upcoming technological advancements, providing more time to use human capabilities and innate human skills, as machines would take over more of the predictable activities of a normal work day [85]. Basically, everything that can be delegated to software is exposed to the risk of being automated. It can wipe out many jobs but also make products and services available to more people. Manual work, on the other hand, while being replicable, requires very expensive robots: this, paradoxically, could stimulate a potential re-evaluation of craftsmanship. Any job of a routine and predictable nature (i.e. any role where the worker is faced with similar problems) can be fully or partially automated. The greatest risk concerns low-level unskilled jobs, routine professional activities (such as accountants and lawyers), and intellectual work following standard procedures. There are many questions that the change generated by these technologies stimulates: will new non-automatable jobs be created in sufficient measure to absorb all those who have lost their routine jobs? Will workers have the skills and abilities and personal attributes necessary to transition effectively into these new roles?

People work increasingly under the control of algorithms that monitor or scan their activities, practically treating them like robots. Many new opportunities are located in the so-called gig economy where workers are not guaranteed anything in terms of wages and working hours: all this can increase inequalities and risk dehumanizing the living conditions for a growing part of our workforce [24]. A vibrant market economy depends on large numbers of consumers being able to buy products and services: if they have no jobs and therefore no income how will they create the demand needed to sustain continued economic growth? Just as a transition of employment from the primary sector to the industrial sector actually took place during the industrial revolution, one could hypothesize a similar transition in the occupational composition of the current labor market. However, at the moment it is difficult to hypothesize which new spaces in the labor market artificial intelligence will be able to create in order to develop replacement opportunities for more routine and standardized jobs.

Machine learning algorithms will be constantly working to figure out how to automate many of the work and repetitive tasks so almost all types of routine and predictable work will eventually vanish and this could make the challenge for the workers best suited to this type of job very difficult [30]. Just as human beings AI agents are influenced by their experience when developing their creative ideas. AI agents will have more power to learn from their human ancestors to develop new creative and innovative concepts that may be applied in the workplace. This can also contribute to the creation of smart workplaces as AI systems could assist in providing safer working conditions and convenience due to a better understanding of patterns of task fulfillment and creative processes. This opens the door to a concept of qualitative, not just quantitative, transition of work.

In the first round of AI impact on work, creative jobs are projected to be safe from AI replacement. In fact, some researchers argue that AI will always fail to recognize and use human creativity [86] and that a new type of Feeling Economy (based on emotions, empathy, and interpersonal relations) will drive job creation [30]. Actually, the threat does not only concern less educated workers but also clerical jobs focused on routine analysis, manipulation, extraction, or communication of information. The risk becomes greater as the automation of these roles does not require expensive machinery, a good software is enough.

2.2.4 Blockchain

Blockchain technology expresses multifaceted applicability in different sectors, therefore it can unfold very broad and deep innovation potential [43]. The execution of transactions in near real-time makes the BC a technology for the execution of contracts without intermediaries and for archiving data, with unprecedented levels of security and efficiency, in multiple areas of economic activity [87]. The applications of the BCT are the subject of studies in the literature on three macro-areas [87]:

1. studies on cryptocurrencies, from which derive applications of the BCT divided into financial and non-financial [88];

2. studies on the evolution of blockchain in three waves [89], the advent of cryptocurrency (Bitcoin), smart contract platforms (Ethereum and Hyperledger), and the third wave describing a programmable society [90];

3. Zheng et al. [91], finally, identify five main areas of blockchain applications, namely finance, Internet of Things (IoT), public and social services, reputation systems, and finally security and privacy.

This approach is expanded upon by Casino et al. [87], who provide a more detailed list of applications of blockchain focusing on specific areas of economic activity such as health, education, governance, data management, and specific business processes and operations such as supply chain management. Research on BCT is in a developmental phase and spans three broad themes: organizational issues, the competitive environment and the effect it will have on firms and industries, and technology design [92]. If we observe the application of BCT in general terms within the company's value creation process, it is possible to place this technology in the context of supply chain management, production, financial, marketing processes, etc. According to Sheel and Nath [93], BCT can also support supply chain management in reducing production lead times and improving the frequency of new product development, allowing the business to better integrate procurement, transport, and the pre- and post-sales service process.

The BCT can intervene in particular on various critical aspects emerging in the agro-food supply chain, especially regarding the responsibility, origins, and processing of agri-food products, access to the market for small producers, and international standards of work [94]. Naturally, the main reference lies in the concept of traceability of food along the entire value chain, from primary production to the arrangement on the shelves of the points of sale; the BCT intervenes to support the quality certification process as it provides certification bodies with greater accessibility to the necessary information. By leveraging these elements that guarantee transparency, the agri-food company can build or nurture relational trust with its market.

Accessibility to correct and truthful information allows the actors of the agri-food value chain, production, processing, distribution companies, and consumers, to evaluate the alternatives and to effectively decide on the acquisition and management of the resources. - arose and, at the same time, increased the level of food security [95, 96]. The adoption of BCT may also have a social impact thanks to the creation of new business models, the reorganization of existing models, the introduction of new systems, and new skills. In fact, the adoption of the BCT presupposes the involvement of the various players in the supply chain who will operate according to a virtuous cycle by engaging in peer-to-peer operations, reducing corruption and increasing responsibility, and creating value for businesses and local communities.

The BCT can also positively influence the reduction of the environmental impact, as, through better traceability and transparency of the entire production process to guarantee the consumer, it can induce producers to limit or avoid the widespread use of pesticides and fertilizers. The transparency of the BCT and therefore, its ability to trace especially agri-food products along the entire supply chain offers the opportunity to identify all and only the contaminated products in time, consequently recalling from the market not the entire production but only the batches of potentially dangerous goods. In this way, it is possible to reduce food waste, transport costs to the market, and vice versa, and, ultimately, reduce the use of natural resources and the related harmful environmental effects. Finally, a BCT-based system helps both employers and employees to be legally protected and avoid various risks related to contractual arrangements [97]. Ultimately, the BCT reaps several advantages but some limitations persist regarding regulations, relationships between actors, data ownership, scalability, etc. [98].

3. Digitalization and sustainability: a macro perspective

3.1 The digitalization-sustainability relationship

Sustainability and digitalization stand as macro-trends shaping the current economy and society, thus urging major transitions [99, 100]. First, the two mega-concepts must be defined. Even though there is no univocal definition of the concept of 'sustainability', the most widespread definition is that was developed by the UN Brundtland Commission in 1987, which defined it as a "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" [101, 102]. Rapid and continuous technological progress has marked the birth of a digital age which is changing society and economy [103]. Given the breadth of the topic, the consensus on the conceptualization of digitization and its derivatives, such as digital technology, big data, digital transformation, artificial intelligence, and cloud computing, has appeared imprecise in literature [104]. Gregori & Holzmann [105] argue that, on one hand, digitalization entails an emerging digital logic that has distinct relationships with logics of sustainability, but on another hand, implies a supporting logic for the development of value propositions that include the three key aspects of sustainable development: economic, environmental, and social value. However, the distinction between digitization and the digital transition has to be kept in mind: digitization means the translation of business processes into digital language so that they can be managed automatically; digital transition, in contrast, has economic, psychological and social dimensions, that is it does not only include the tools adopted by the company, but also and especially the organizational system and the digital knowledge of people.

Bleicher and Stanley [106] define digital transition as a major driver of growth and sustainability. At the base of sustainable change, it is argued that a more digitally oriented corporate culture has to be established before the implementation of technologies. Among the elements that play in such favor, Information and Communication Technologies (ICTs) and the Internet of Things (IoTs) have a fundamental role in advancing sustainability and in improving transparency or assessment abilities thanks to the contribution of big data analysis and management [100, 107]. Furthermore, a high level of development enhances entrepreneurial attitudes through various support policies that promote the digital transition [108, 109]. According to Ferreira et al. [110], entrepreneurial attitudes can have a positive impact on both the digital transition and the environmental transition. The digital transition of companies can be triggered through increased awareness in identifying opportunities and entrepreneurial abilities, without ignoring the complex environment in which these are inserted [111–113]. Entrepreneurship should be seen as a vehicle of economic, social, and digital transformation. In business terms, the two concepts of sustainability and digital transformation could converge into the so-called 'digital sustainability', which can unify the two strategic objectives to drive positive societal and environmental changes [114]. This chapter aims to better analyze and explore all these topics.

3.2 Twin transitions: Consequences of Covid-19 on European policies

Recently, economic, health and social emergencies have raised awareness of the environmental crisis (started in the 1970s) and have confirmed that digital transformation is one of the main enablers for building more sustainable economies and societies. The importance of technology is visible in the ability of a country to respond to a crisis: it was demonstrated that countries with a more developed communications infrastructure, with more advanced digital technology systems, are better placed to preserve economic activities and jobs [115]. Although defined as two different topics, the environment, sustainable mobility, infrastructure, technological innovation, artificial intelligence (AI), blockchain, Big Data, Internet of Things (IoT), etc. are all closely interrelated; The ecological and digital transitions represent the new production paradigms of our society, as they are a source of growth and economic competitiveness that result in more innovative and sustainable industries and businesses, thanks to the development of new technologies. These reasons lead to defining the two transitions as 'twin transitions' as well as 'two sides of the same coin': sustainability cannot be achieved without technology; they must be studied and examined jointly. As mentioned by Veugelers et al. [116], the COVID-19 crisis has led to wider recognition of the importance of sustainable and digital transformation, which are global, profound, and irreversible transformations that have become two key targets of economic recovery. Modern digital innovations, such as machine learning techniques or AI, have seen exponential growth in their value, estimated to add around 14% to the global economy by 2030 [114, 117]. The containment from coronavirus and the need to provide a recovery of the world economy have confirmed the increasing role of new technologies and the importance of a required transition towards a more digital economy and society [115].

From a political point of view, the ecological transition and digital transition are crucial points in the current EU strategies, such as the EU's Digital Strategy and European Green Deal, which are the promotors of the recovery plan for Europe. Combined with the National Recovery and Resilience Plans (NRRP) for each EU member state, the initiatives are seen as a unique opportunity to transform the EU economy, making it both greener and more digital in a twin transition [116]. These transitions are also envisaged by several European macro-policies, in particular by the Next Generation EU (NGEU), through which the Recovery and Resilience Facility (RRF) has the ambitious goal of restructuring the entire European socio-economic system and providing substantial economic resources amounting to €68.9 billion in grants and €122.6 billion in loans, of which 37.5% of the plan will support climate objectives and 25.1% of the plan will support the digital transition [118]. At this point, it is necessary to give a definition of both transitions.

The green transition is an opportunity to put Europe on a new path of sustainable and inclusive growth, which also aims at reducing the dependence on fossil fuel imports and at improving the energy and resource security of the Union. From the general perspective of tackling climate change with the European Green Deal including the 'Fit for 55' package, the European Union needs to increase the annual yearly investments by more than 500 billion euros, compared to the previous one and other additional investments. The principle of equity will be a central pivot for these policies. The European Green Deal was launched by the Commission in December 2019; to this end, during one periodical meeting, the European Council stated that "The transition to climate neutrality will bring significant opportunities, such as potential for economic growth, for new business models and markets, for new jobs and technological development" [119]. The Fit for 55 package accelerates Europe's climate change challenge plan and contains 13 legislative proposals on energy and climate, which have the common aim of putting the European Union on track to meet the target of reducing greenhouse gas emissions by 55% by 2030 as set out in the Climate Act.

The coronavirus pandemic has accelerated the digital transition of our societies and highlighted the importance of digital technologies for Europe's future economic growth. To set out the Union's digital targets for 2030 and achieve these ambitions, the European Commission proposed "The Digital Compass", which requires stepping up investments in key digital technologies, including cyber security, cloud computing, artificial intelligence, data spaces, blockchain and quantum computing, and semiconductors, as well as in the relevant skills. To foster the digital transition, also in this case, the European Union needs to increase annual yearly investments by more than 100 billion euros. According to the Commission, the digital transition will also contribute to the green objectives, with synergies in many areas of a smart circular economy, ensuring equity and aiming at increasing the innovation and productivity of the EU economy, offering new and equal opportunities for people and businesses [120]. EU's digital strategy leverages the potential of ICT technologies to facilitate innovation, progress, and economic growth and aims primarily at developing the digital single market. The Digital Decade policy program, with concrete targets and objectives for 2030, will guide Europe's digital transformation with Skills, Digital transformation of businesses, Secure and sustainable digital infrastructures, and Digitalisation of public services. The Commission will pursue the EU's digital ambitions for 2030 through concrete terms and projected trajectories at the EU and national level, with key performance indicators to track progress towards the digital targets and an annual cooperation cycle to monitor and report on progress multi-country projects combining investments from the EU, Member States and the private sector [121].

In addition, as stated by Seele and Lock [122] digital technologies can considerably contribute to sustainable development goals. In an ever-changing and increasingly digitalized world, indeed, it is necessary to analyze the role that the technology development can play in achieving a more equitable society, in line with the 17 Sustainable Development Goals set in 2015 by the UN in the 2030 Agenda and with the integrated vision of the three dimensions underpinning the concept of sustainability: economic, social and environmental [102]. For instance, the development of smart systems connected to the Internet of Things or the development of digital tools useful to generate, use, transmit, or source electronic data for organizational activities, can generate unique opportunities to strategically address challenges associated with the United Nations Sustainable Development Goals (SDGs), ensure at the same time an equitable, environmentally sustainable, and healthy society [100, 123, 124]. These new tools that contribute to achieving specific targets could be defined in literature with the concept of "Digital Sustainability", defined by Mondejar, M. E. et al. [124] as "the effort of developing and deploying smart technologies to secure sustainable economic growth while considering and integrating the SDGs".

3.3 The role of digital transition in guaranteeing sustainable development from a macro-perspective

The digital revolution represents a huge opportunity to increase productivity, innovation, and employment, ensure wider access to education and culture and reduce territorial disparities; it represents a great social and environmental opportunity also because it is a source of access to an Integrated network of New big data [124, 125]. The digital marketplace allows for efficient transactions by ensuring financial gains for the producers despite offering reasonable prices, thus, merging socio-environmental and economic value [105].

However, the biggest open question in the literature and on policymakers' agendas is how the two transitions should be balanced. Indeed, the amount of pollutant emissions resulting from the increasing use of new technologies is often underestimated. To clarify. It is well known that new technologies are created to improve energy efficiency, to ensure a better allocation of resources and to give impulse to the circular economy, to foster decarbonization but also to reduce pollution and the loss of biodiversity, or to launch highly automated and intelligent production and business processes, etc.; however, it should not be forgotten that there are no technologies with zero impact on the environment currently (there are technologies with low or minimal impact on the environment, but not "zero impact"). Computers, data centers, the ever-growing connectivity of electronic devices, and simultaneous data sharing require continuous and increasing consumption of electricity, that if not generated from renewable sources emits greenhouse gases, especially CO_2 emissions [126]. For example, according to a study by the Royal Society reported by the World Economic Forum, a single user who uses e-mail for work (with an average mail consumption) emits around 135 kilos of CO_2 per year, which denotes that digital technologies contribute between 1.4 and 5.9% of the total to annual global emissions - impressive numbers when one considers that all international air traffic is responsible for just 2% of the total [127]. A turnaround is urgently needed. According to the Global e-Sustainability Initiative (GESI), the turning point is the increasing ability to generate, capture and transmit digital data and to analyze them in order to put them at the service of sustainability goals.

A recent study [124] has explored how digitalization can assist in attaining SDGs in the following five sectors, demonstrating how benefits can be achieved in each of them: food-water-energy nexus, industry, citizens' health and wellbeing, climate change, and biodiversity protection. For instance, digital technologies are up-scaling sustainable agricultural land and resources management and strengthening the associated productivity, services, and livelihood security worldwide (1st and 2nd SDGs- No poverty, Zero hunger); big data, advanced automated controls and the integration of the internet of things play an essential role in ensuring accessible water for all citizens, reducing energy consumption and enhancing energy efficiency and provide sustainable alternatives (6 and 7 SDGs -Clean water and sanitation, Affordable and clean energy); Digitalization contributes in decreasing CO2 emissions associated to transportation systems (11th SGD -Sustainable cities and communities); In climate research, multi-spatial–temporal climatic data form a baseline to understand climate variability and future projections, and to know how to preserve impacts on biodiversity (13th SDG - Climate action,); Sustainable and smart manufacturing, one of the key aspects of Industry 4.0, is secured by computer control and machine-to-machine communication (9th SDG- Industry, innovation and infrastructure); Digital tools play a vital role in promoting well-being and improving quality of life through facilitating access to health care, e.g. with Telemedicine or Implementation and normalization of e-Health system (3rd SGD- Good health and wellbeing). Thus, the interconnection of SDGs to Digital transition is undeniable. In all the areas just listed, it is required that the workforce be highly skilled in the use of digital technologies; that is why the digital transition - which pursues this end - can be the unique process that will transform the economy and make it sustainable. "The benefits of big data integration in our daily lives can promote quality of life and drastically assist humanity towards the sustainable challenges to ensure human, biodiversity, and earth resilience" [124]. Governments can also track the recovery and facilitate research on policy effectiveness more promptly through the analysis of Big Data captured by digital payments.

Del Río Castro et al. [100] wrote another recent study regarding the use of digital technologies towards the achievement of the UN Sustainable Development Goals (SDGs); however, the authors largely ground their study on extra academic literature, with an explicit focus on the SDGs. This issue has led to the writing of a new scientific article "Sustainability through digital transformation: A systematic literature review for research guidance" [104] focused on analyzing the nexus between digitalization and sustainability. This relation emerged as extremely fragmented to the author regarding sectors, functions, and even methodologies, thus calling for unified perspectives and overarching theoretical frameworks in the future developments of the topic; however, as mentioned by the author, the academic environment has drastically worked in picking up on the relationship between sustainability and digitalization, especially after the outbreak of the COVID-19 pandemic, and the number of published articles is continuing to rise. Not surprisingly, as mentioned in the previous paragraph (3.2), all policymakers' agendas and government agreements intend to pursue sustainable and digital growth paths by 2030 (e.g. the National Recovery and Resilience Plan in Italy is mostly based on two major missions: Mission 1 - Digitalisation, innovation, competitiveness and culture', i.e. digital transition, and Mission 2 - Green revolution and ecological transition [see 125]. These stimulate researchers to study these topics and create new literature.

Until now, as Guandalini I. states "Looking at the organizational types discussed on the relation between digitalization and sustainability, a first dramatic line can be drawn between 'business' and 'government'" [104]. The first line of research will be addressed in the following paragraph (3.4), but on the second line, it can be argued that the main themes involve policy development [123], support to specific stakeholders, or administrative sustainable optimization through digital technologies [128–130]. Consequently, the technology sector should provide data to enable monitoring of energy consumption and carbon emissions; regulators should develop guidelines on the energy proportionality of digital applications; political leaders should outline new rules to neutralize the negative consequences of uncontrolled digitization. With increasing regulations and environmental awareness of the government, the approach to innovation from the macro perspective has a huge impact on society: the macro-level approach, which consists of environmental and social factors like government and policies [131] provides new solutions that add environmental and social value, and that push firms to invest in new sustainable and digital solutions [132–135]. Finally, attention should be paid to the use of big data: cybersecurity of strongly interconnected systems through the cloud should be reinforced by institutions, while simultaneously attempting to close the digital poverty gap between countries. According to several authors [123, 136–138] big data represents the 'new oil' of the digital with their contribution to monitoring sustainability on a large scale and to sustainable IoT in relation to the concept of Industry 4.0 and digital manufacturing.

3.4 The digital transition in a sustainable corporate landscape

Improving the sustainability of enterprises has become the winning strategy to address the particular environment that the COVID-19 pandemic and geopolitical conflict have led in these years. UN Sustainable Development Goal 9 aims to develop a resilient infrastructure, increase internet access to the least-developed countries, improve technological capabilities, and promote the integration of small-scale industries and enterprises into global value chains [139]. Indeed, the coronavirus pandemic led many firms to cut investments and postpone their further plans. However, there is growing awareness that its recovery could thus be a shock that accelerated the corporate sector's twin green and digital transformation, contributing to a more sustainable and resilient post-pandemic economy. Investments in digital technologies, indeed, are key drivers of the green transition and these motivate twin transitions. Nowadays, as a result of the studies, the biggest challenge of entrepreneurship is its contribution to achieving environmental and digital transitions [140, 141]. Indeed, a huge number of scientific articles explicitly address digital opportunities for sustainability as part of a business strategy in a new era of scientific and technological progress [47, 142]; for instance, Chen and Kamal [143] and Lee et al. [144] recognize that digitalization in the manufacturing sectors has a positive effect on sustainability development if challenges of technological and social changes are addressed.

Digital innovation and digital transformation enable companies to a dual aim: i) to achieve greater flexibility and efficiency, optimize production processes, generate value propositions for innovation ecosystems, and respond to market needs [145–147] and ii) to enable them to maintain market competitiveness and staying at the forefront of technological innovation [148]. The process of digital transformation manifests in new institutional arrangements, bringing about novel values, practices, and structures, for example accepted and customizable digital modules - ERP systems- or standard-setting digital infrastructures like product platforms and blockchain technology [149]. Digital transformation can have a strong potential in facilitating internationalization, e.g. with knowledge, leadership, digital servitization, and technological factors [150] or it may also bring out negative effects, e.g. the lack of technological knowledge and cultural factors, the inability of technological infrastructure in some international contexts, the new security risks associated with these technologies and the personality traits that limit participation, perception, learning and optimal use of these tools [151]. From a social perspective, for instance, digitalization changes labor market conceptions significantly [152], while from an ecological perspective, the increase in energy consumption can be enormous [153]. However, these negative effects on internationalization encourage firms to use smart digital channels to develop improved and efficient strategies [139]. As reported in the annual survey "EIB" [154], the percentages of firms that adopted advanced digital technologies in 2021, are 62% for EU and 66% for US firms, of which 46% of EU firms and 59% of the US have adopted steps to make investments more digital. However, the response from these firms was rather uneven with digital technology-leading firms forging ahead and US firms being more responsive [116]. Veugelers et al. [116] find that EU and US firms that have adopted advanced digital technologies are more likely to invest to tackle the physical and transition risks from climate change because more probably to have already invested or have further plans in Green technologies investments.

To sum up, although there are several studies in the literature on the evaluation of sustainable development and management ability in enterprises [155–157] there is a lack of further exploration into how to improve corporate sustainability from the perspective of digital transformation. Furthermore, it has been shown that those who adopt better management practices for technology adoption and firm performance have more possibility to twin green and digital technologies and track environmental, social, and corporate governance (ESG) metrics through these new technologies [158]. Thus, enterprises must continue to accelerate along this road with the help of their governments. For example, the adoption of investment in R&D to develop or introduce new products, processes and services, and innovative strategies, is relevant to the development of policies that will help move firms that are not green and not digital towards more sustainable investment decisions and expand and train their workforce; to avoid the twin transition leading to a twin polarization, policymakers should remove the barriers that trap the firms in persistent inactivity [116]. Ji et al. [103] state that "governments must realize that digital transformation is an important means to improve corporate sustainability". Moreover, as stated by Feliciano-Cestero et al. [139], Digital transformation can imply the use of digital technologies in many areas of business strategy, such as digital platforms, digital services [151, 159–162], digital ecosystems, internet technologies [163–168] and information and communication technology [143, 162, 169], among the use of other advance technologies, as automation, artificial intelligence and big data analytics [147, 148, 167, 170–174].

From a territorial perspective, the Ministry of Enterprise and Made in Italy [175] has provided for an aid scheme to support new innovative and sustainable business investments in Italy, known as 'Sustainable Investments 4.0'. The measure provides for the granting and disbursement of subsidies in favor of investment programs proposed by micro, small, and medium-sized enterprises that comply with the current principles of environmental protection and high technological content, consistent with the Transition 4.0 plan, with priority given to those capable of making a particular contribution to the sustainability objectives defined by the European Union and to those aimed, in particular, encouraging the transition of enterprises towards the circular economy paradigm. Entrepreneurship has been considered a potential solution to big social and environmental challenges such as climate change and social inequalities [176–178]. According to recent studies, digital technologies enable the development of novel business models and entrepreneurial opportunities; they can be supportive of tackling the challenges sustainable entrepreneurs face [114, 149, 179–181]. As mentioned by Ferreira et al. [110], the environmental transition should serve as a driver of competitive advantage, while the digital transition needs to reach beyond the conviction that companies can resolve all their issues through an injection of technology but rather through constant updating and continuous staff training so that this transition does not emerge as an obstacle.

In the literature, there is an interest in the relationship between sustainability and digitalization and mapping the potential of digitalization benefits for sustainability issues of companies [182]. Several authors contribute to the theoretical development of sustainable entrepreneurship by presenting the concept of "value spillover" with captures the socio-environmental value (e.g., education and raising awareness). Accurately, as stated by Gregori and Holzmann "value spillover coupled with the role of digital technologies for enabling the formation of communities, co-creation activities, and broader stakeholder integration offers new perspectives on entrepreneurial value creation for sustainability" [105]. To summarize, entrepreneurship represents a path towards securing both the environmental transition and the digital transition [110].

4. How digital innovations are expected to impact the territories

4.1 Digital innovation's state of art at the territorial level

Many European Commission's documents are turning the spotlight on digital innovation, stressing the importance of technologies in changing daily life attitudes thanks to their pivotal role for people, the competitiveness of the market, and an open and democratic society. Bearing in mind its powerful influences, European Commission is also picking out the right way to lead the digitization process towards more sustainable solutions which are resource-efficient, circular, and climate-neutral arguing that "It requires that every citizen, every employee, every businessperson has a fair chance, wherever they live, to reap the benefits of our increasingly digitized society" [183].

4.1.1 Territorial distribution

Although at its peak, technologies appear to be patchily distributed. As a matter of fact, there is a significant divide between rural and urban areas in terms of fast and ultra-fast coverage of digital infrastructures. Even if broadband connectivity was already almost universally developed in 2019 (99.9%), fast or ultra-fast connectivity coverage, a prerequisite for using the latest available technologies and services, is uneven [184]. This divergence is also detectable across European regions and the rural-urban divide in users' digital skills. Looking at European data, just over one quarter (26%) of the EU population aged 16–74 years revealed above-basic overall digital skills in 2021, whose 33 percent is of people living in cities, while a lower proportion of people living in towns and suburbs 24 per-cent and in rural areas 20 percent. European Commission has also been committed to analyzing the E-Government rate in European countries, concluding that the shortage of e-services available to citizens is present at both regional and local levels and is unlikely to create a pull effect in promoting digital competencies. Shedding light on e-Government, it refers to the state of play within online Government services across Europe, continually improving the platforms for citizens, businesses, tourists, and expat communities. Specifically, the European top seed countries in e-Government are with 97% score Malta, followed by Estonia (92%), Austria, and Latvia (87%). The following countries are Denmark (84%), Lithuania (83%), and Finland (83%). Regarding progress, Luxembourg, Hungary, and Slovenia have made the most incredible advances in the last 2 years, rising by 20, 19, and 18 percentage points, respectively (reaching scores of 79, 63, and 72%). The last European countries, occupying the last places with a rate under 50%, are Serbia and Romania respectively, growing with a rate of 5 and 7%, thus slightly lowering the gap between front runners and laggards [185].

Having ascertained that disparity, it raises the necessity to understand the hindering factors to a homogeneous digital innovation. Given the diversity of rural areas in Europe, including their different degree of peripherality, and the fact that the digital divide is shrinking globally [186], it can be argued that the issue of digitization of rural areas may be intended as a classic one of geography. That is why it can be related to the differences in access to specific goods due to geographical location. Geographical location, also in terms of access to ICTs, affects the social and economic vitality of rural areas. For instance, Grimes [187] underlines that precisely peripheral rural areas, which largely do not participate in the development process, can benefit most from digitization. It is a fact that digital innovation can overcome the state of isolation of these areas by strengthening the linkage with urban centers, that is, the distance that could only be reduced to a limited extent physically (e.g., by improving transport accessibility to such areas). Another positive impact can be the easy access to some goods and services, which, in case of the lack of access, especially to the Internet, are more easily accessed in cities than in the countryside. Finally, access to Information and Communication Technologies (ICTs) supports participation in all interactions between people, which could be less frequent in the countryside because of a lower population density [188]. The following section will deeply analyze the potential impact digital innovation can have on rural territories, also known as marginalized, isolated, and inner areas.

4.2 The impact on the inner areas

4.2.1 The concept of "inner areas"

Before analyzing the possible impacts of digital innovation, it is necessary to clarify what the concept "inner areas" refers to. This article will embrace the Agency of Territorial Cohesion definition to identify those areas far away, at least 40 kilometers from public services. Moreover, this definition has been crossed with the EUROSTAT association of inner areas with rural areas since their distance from the urban cluster (where urban cluster means contiguous grid cell groups of 1 km^2 with a density of at least 300 inhabitants/km^2 and a population of at least 5000 inhabitants) [189].

4.2.2 Inner areas' condition

The high political bodies' interest in Inner areas is due to their drawback conditions since these territories are affected by different problems such as the demographic drop, the high average age of the population, the low digitalization level, the low education level, and the distance from essential services to the point to stay in a situation of marginalization in comparison with urban centers [190]. This disease is also relapsed in the social paradigm, falling back into a situation of passivity, stationary development, and absence of absorptive capacity for innovation to the point of not benefiting from the global innovation process. Although this stagnant situation, the inner areas still have the potential for future development, thanks to their material and immaterial heritage richness, as natural and historical, cultural, and architectural resources [191]. Considering the above aspects, the institutions and academic literature are looking for new triggering pathways for the long-term sustainable development of inner areas. Within the toolbox, digitalization appears to have positive impacts on sustainability in terms of community prosperity and greater environmental control. On the other hand, it can also have disruptive effects, w since the possible outmatching with the specific socio-economic characteristics of the domain. So, it is important to mitigate negative impacts to maximize the potential positive effects. The following sections will deal with the positive and negative impacts of digital innovation on territories.

4.2.3 Deep glance at digital innovation impacts

The pivotal role of digitalization in rural reality is in the rural development strategy of the Organization for Economic Co-operation and Development (OECD), which emphasizes the importance of digitalization for sustainable development. Its report, "Rural Well-Being: Geography of Opportunities", emphasizes the potential of digitalization for overcoming the disadvantages of remoteness in rural regions by reducing distances and increasing location independency.

As Ferrari et al. [192] argued the impact is multidimensional since it embraces different aspects. As a matter of fact, digital innovation can have the following:

- Socio-cultural impacts;
- Socio-economic impacts;
- Socio-political impacts;
- Environmental impacts.

4.2.3.1 Socio-cultural impacts

It deals with the expected impacts on the community. These effects are threefold since they refer to the social and relational aspects, the quality of life, and education. Regarding the first aspect, digital innovation can raise the inclusion of rural areas into society significantly and improve the attractiveness of rural areas. Quality of life can also become better because of a lower relief from heavy work that can give access to more free time, but also to the possibility of accessing goods from distant areas through online purchases. The availability of distance learning and the increasing need to learn the technology itself can also positively affect the educative aspects. Looking at the other side of the coin, digitalization also comes with its negative impacts, such as the exclusion of those subjects who cannot keep up with technological change, but also the distance from nature since computers and robots increasingly mediate the relationship between fields, workers, and animals. In addition, instant access to distant learning can lead to the closing of local schools. Furthermore, digital automation can raise farmers' reliance on data analysis and decision-making systems to the extent of losing their expertise and intuition.

4.2.3.2 Socio-economic impacts

The socio-economic impacts of digitalization can be defined in four main aspects that affect workers, business owners, and the community. Regarding labor, digital innovation can replace repetitive and seasonal labor, favor novel job opportunities associated with the usage of new technologies, and the possibility of exploiting the network to gain access to a skilled workforce and decentralizing the work structure. From the management standpoint, the large business owners are the primary beneficiaries since they can achieve better control at a larger scale, optimize their resources and processes, and deal with production irregularity thanks to the improved measurability granted by the sensing and monitoring technologies as well as the farm management platforms. The availability of online booking services and the birth of novel energy-related services, for example, renewable sources can also create better market conditions. Despite this roundup of positive effects, negative implications can happen too. For example, there is the possibility of unemployment and the need to cope with the change in work profiles. Regarding management aspects, rural communities have to face up with the need to deal with changes in production models and terms involved with stakeholders. Moreover, the development of online booking services and the birth of novel energy-related services can be particularly harmful to small business owners, with the closing of local businesses that cannot compete in the global market. The increased performance inequality concerning prominent players who can profit from technology, and the creation of monopolies, as a tendency towards these types of centralized market models, characterizes the digital world.

4.2.3.3 Socio-political impacts

In contrast to the previous aspects, the socio-political impacts are all related to positive effects. They involve the following stakeholders: business owners, for what concerns aspects related to data, their value and control; the community and institutions, with improved legality thanks to mechanisms that facilitate transparency and regulatory compliance (e.g., block-chain, dematerialization, process standardization).

4.2.3.4 Environmental impacts

Forecasting is the reduction of human impacts and carbon emissions, and the improvement of animal welfare preannounces a positive affection regarding the environmental aspect. No risks were explicitly discussed by the experts.

4.2.4 Taking final stock of the digital innovation impacts

The majority of effects related to social and economic dimensions are dominating the scene. Considering the managerial sphere, the replacement of manual activities with automatic ones can allow business owners to improve productivity by better managing their processes and lowering labor costs. Moreover, large business owners can also benefit from the economies of scale facilitated by technological infrastructures. Conversely, the trend of small businesses is the opposite since they risk being ruled out by a market in which they cannot compete or be incorporated by larger companies. Consequently, a negative impact can affect communities, which can suffer from these phenomena with the closing of local businesses and unemployment. So, a disparity between small and big players, accompanied by the risk of inequitable development, can rise highly [193–194]. From the socio-cultural side, positive expected impacts affect rural communities with an increase in inclusion, driven mainly by connectivity, and greater well-being thanks to more free time and less heavy work. In this sense, a smart community, manages innovative technologies and infrastructures, enabling the evolution of relational dynamics that go from the individual to the entire community. The harmonious use of ICTs causes an increase in social capital (ranking, followers, how, etc.), which can be easily measurable [195]. It can certainly be said that the Smart Community, in fact, favors new models of territorial development, which, starting from the citizen and his needs, exploit digital technologies, thus stimulating collective digital creativity, from the definition of planning processes to the sharing of information. Strictly related to this concept, a need for a new inner area's community emerges, which means a capillary network of places and people (smart village, smart cultural heritage, smart communities, slow tourism, agricultural wellness, etc.) that favors the unified management of these territories even during the health emergency [196]. The use of ICTs technologies such as platforms and infrastructure, as well as social media, mainly linked to leisure and tourist, and sporting activities, can represent an opportunity for new forms of development. That is why smart tourism and smart living can be engines for the development of these areas. Smart tourism is therefore intended as a new technological frontier for the services sector and a container of innovative technologies for tourist use. It embodies the cultural and economic revolution of living in all facets, even the immaterial structure of cities and management methods. It can be conceived as the result of traditional tourism's recent evolution in which technological innovations and consumer orientations dialog according to new logic'from dreaming to sharing'. The result is a new tourism model resulting from web and social networks and improving its efficiency [197, 198].

Within this scenario, technologies can represent an opportunity to reactivate and innovate the old local production systems [199] of agriculture, food, and craft. It can empower sustainable tourism (cultural, religious, naturalistic) as a lever for development through the promotion of internal areas in increasingly complex circuits and schedules. ICT can also allow the reorganization of work in territories, especially in the tertiary sector, by introducing the formula of remote working in its declinations of teleworking and smart working.

4.3 What are the barriers to digitalization process of these territories?

Ferrari et al. [192] have also detected the barriers to the digital processing of these territories. In that sense, also barriers have been analyzed with a multi-dimensional approach. That's why the authors have deemed socio-cultural, technical, economic, and institutional barriers. Many obstacles are linked to the social tissue of these zones, which are lagging in a state of isolation. It is a fact that the population is old, with a low density, and sparsely populated because of the presence of seasonal works. This state of demography certainly means brain drain [200], fear of changes, roots to traditions, and lack of competencies. Besides, the implementation of the internet has technical issues too. Deeply explaining, rural territories must develop connectivity since they lack infrastructure. Moreover, they have to keep pace with current connections by developing an easily accessible digital connection. On the other side, economic barriers refer to the shortage of financial resources to be invested in technological solutions. It is a fact that technology implementation has costs related to ICTs, the modernization of the physical infrastructure of farms, and the development of digital skills.

4.4 What are the drivers to the digitalization process of these territories?

The drivers have been categorized in the same way as barriers by Ferrari et al. [192]. That is why it is possible to distinguish between socio-cultural, technical, economic, and institutional drivers. The first typology mainly includes all those aspects related to the social needs of rural communities and the typical inclinations and tendencies of stakeholders. It embodies the repair of isolation through better communication that can identify and strengthen the links between needs and potential supply; moreover, it refers to the demand for lighter work, as automation is expected to reduce the manual labor typical of rural activities. It also includes new cultural tendencies whose main features are the spirit of cooperation and solidarity of small communities, the need for inclusion in the "local vibe", also the interest that technology can create. Besides social aspects, technical drivers emerge too, even though in a limited quantity. The first driver of technology is its quality in terms of simplicity, reliability, efficiency, and specialization. These aspects allow for a more straightforward response to rural areas' peculiarities, convincing rural community members to accept digital solutions. Additionally, Digitalisation can be encouraged by the availability of new types of data about plants and crops that can be exploited for better monitoring and control. Regarding the economic side, technology facilitates the collection of market demands, collecting drivers from customers' requests for healthy food and market trends, such as the need for a "green" and transparent image. In that sense, the market is raising the demand for organic products and healthy food. Collecting data from which to develop a new product can be a means to get higher market shares and profits. Technologies also support the birth of collective forms of organization, such as cooperatives that can facilitate small players. Moreover, it allows the development of technology hubs and intermediary roles, facilitating learning and access to technology. It is not to underestimate the effects on business needs, such as process optimization, which means more efficiency for the farm and firms. Also, financial aspects are present, such as collecting phenomena related to the cost of assets and expected benefits. As advanced technology becomes less expensive, more subjects can be at risk of being experimented with technologies. Lastly, labor-related drivers are twofold. On the one hand, technology can tackle seasonal work and low scarce population, and on the other hand, the cost of manual labor can become lower. Many environmental drivers encourage digital innovation implementation in these territories since it is conceived in a sustainable view. As a matter of fact, ICTs are associated with the reduction of impact and the rise of control of environmental conditions such as the improvement of animals' health and the prevention of natural disasters. The last category is related to the institutional side since institutions are the most potent factors in fostering digital innovation in these zones. The first type of drivers dealt with regulatory restrictions, such as new regulations, taxes, and constraints associated with undesired behaviors (e.g., excessive use of nitrogen for fertilization). Also, economic incentives (e.g., subsidies, incentives for the adoption of sustainable technologies, funding programs, and economic support for cooperation with digital players) can play a relevant role in the digital transition. Moreover, developing educational courses (e.g., training programs, technical mentorship) to facilitate the circulation of digital knowledge and the creation of digital innovation centers can lead to digital transition. Lastly, the promotion of digitalization with campaigns and dissemination results of success stories can encourage the digital process [201, 202].

5. Conclusions

In conclusion, the challenge brought about by the current energy crisis, ongoing geopolitical conflict, climate change, environmental impact, and limited natural resources solicits the production of new technological solutions and new and innovative tools compared to traditional ones. The twin transition (in ecological and digital sectors) goes parallel. It should be seen as a big challenge, i.e., as a considerable effort to tackle and solve a problem with a high societal impact, to assess the risks involved, to explore the different possibilities and technological options presented, and to try to make rapid progress towards the triple aim of energy security, decarbonization, and energy efficiency [203]. It is no longer possible to separate digital trends from sustainability ones. It is time to rethink the concept of sustainability and update it in light of the development of digitalization and the potential of this phenomenon. Digitalization is becoming essential to business [182]. Furthermore, there is no doubt that solving such a major challenge requires a joint effort, first by scientists, researchers, politicians, officials, and journalists, of an extensive public-private partnership, at the EU and national level and the general public's consensus [203].

Equally, greater personal responsibility is needed by citizens, businesses, and institutions to minimize and mitigate the negative effects of digital innovation on social relations, the size and quality of employment, and the environment, thus ensuring that it becomes the driving force of sustainable development.

Finally, a double effort by public institutions (universities and governments) is required: firstly, to deploy communication infrastructure, improve regulatory frameworks and enhance access to the Internet and digital services, some additional efforts are still necessary from all countries [204]; secondly, education and training systems must be better equipped to deliver digital skills and transversal skills, which are necessary for people to benefit from digital transformation and adapt to changing circumstances throughout their life [205, 206]. Only by taking all these factors into account, by equating risks and opportunities, the twin transition will be pursued efficiently. With these factors into account, by equating risks and opportunities, the twin transition will be pursued efficiently.

All this transition process must be taken leveraging the multi-dimension of the local drivers and the hindering factors. In that sense, efficiency, automation of processes, and better linkage between distant areas will quickly pull the transition process of territories. However, the presence of an elderly population, a low digitally skilled workforce, and the huge cost of technologies lead to a digital pitchy development, where inner and isolated areas are the most disadvantaged. That is why institutions at different levels must plan and apply the digitalization process in line with the territory's profiles and guarantee continuous support to the less experienced and endowed, reaching multi-scaled governance [207].

Conflict of interest

The authors declare no conflict of interest.

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