Complex Relationships Between Digital Transformation and Sustainable Development in the IT Sector. The Role of the IT Sector in Social and Circular Economies

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Abstract
The IT sector plays an essential role in shaping a sustainable future. It is important to address the sector's environmental and social impacts through innovation, responsible practices, and sustainable business models. The IT sector can drive positive change and support a more sustainable and equitable world by aligning with the Sustainable Development Goals. The presentation covers (I) how digital transformation relates to sustainable development and (II) a high-level evaluation of how the IT sector generates social and circular economies. (I) Digital transformation is one of the main preoccupations of the IT sector nowadays. It represents a holistic concept addressing all kinds of IT and energy-related sub-industries (hardware, software, AI, IoT, networking, energy, and many others) meant to transform the way of working into a faster and easier way. Thus, it presents both opportunities and challenges for sustainable development in the IT sector. While it can drive efficiency, innovation, and social inclusion, it also poses risks such as increased energy consumption, resource exploitation, and social inequality. Balancing these aspects through responsible practices, ethical governance, and inclusive policies is essential for leveraging digital transformation to support sustainable development goals. (II) Trying to evaluate social and circular economies generated by the IT sector, we can observe that it can help create a more inclusive, resource-efficient, and sustainable world by increasing digital inclusion, supporting social enterprises, and adopting circular economy principles. These efforts not only address pressing environmental and social challenges but also open up new business opportunities and enhance corporate responsibility

Keywords
Digital Transformation; Sustainable Development; SDGs; Circular Economy; Social Economy; Environmental Social Governance (ESG).

Introduction

In the context of the digital economy, digital transformation is considered an essential strategic choice for businesses to enhance sustainable development (Bai et al., 2023). According to Yingliang Su and Jiahua Wu (2024), digital transformation positively impacts a company's ability to innovate in technology, market, and management. This paper examines the impact mechanism of digital transformation on enterprise sustainable development, specific to the IT sector, from the dimensions of environmental impact, social impact, economic impact and governance and ethics impact (ESG). Discussions of ESG performance have shifted from the traditional financial perspective to a more sophisticated perspective of socio-economic outcomes (Wang et al., 2016). ESG information offers relevant information regarding the non-financial performance of a company. In addition, this study also combines some influencing factors of the enterprise other than itself, analyzing the impact of resource endowment, management motivation, external environment, and so on, on the sustainable development of the enterprise.

Methodological approach

This study employs a mixed-method approach to examine the impact mechanism of digital transformation on enterprise sustainable development within the IT sector. Based on two narrative literature reviews conducted to establish a theoretical framework. The narrative literature review is suitable for synthesizing existing knowledge, identifying patterns, and comprehensively understanding the investigated themes. The focus is on analyzing prior research, industry reports, and case studies. While a narrative literature review offers a broad view of the subject, it has some limitations. One of the most important is access to previous research. Also, there is a potential bias in literature selection due to the absence of a systematic analysis. It might also not always capture real-time industry trends, necessitating adding professional reports and investigations to the traditional theoretical body of knowledge.

The first narrative review links digital transformation to environmental, social, economic, governance, and ethical (ESG) impacts. The aim is to identify the main aspects that have a significant effect, and to connect these evolutions to specific SDGs. The second one takes a more practical lens, aiming to identify the key dimensions that demonstrate the relevance of the IT sector to the development of social and circular economies.

(I) Digital transformation and sustainable development

Digital transformation is a powerful tool for reshaping the business environment (Pînzaru, Zbuchea, & Viţelar, 2019). It is one of the main preoccupations of the IT sector nowadays. It represents a holistic concept addressing all kinds of IT and energy-related sub-industries (hardware, software, AI, IoT, networking, energy, and many others) meant to transform the way of working into a faster and easier way. Thus, it presents both opportunities and challenges for sustainable development in the IT sector being deeply embedded in organizational management in the digital era (Zbuchea & Vidu, 2018). While it can drive efficiency, innovation, and social inclusion, it also poses risks such as increased energy consumption, resource exploitation, and social inequality. Balancing these aspects through responsible practices, ethical governance, and inclusive policies is essential for leveraging digital transformation to support a just transition (Pînzaru et al., 2022) and sustainable development goals.

Opportunities are coming from innovation and green technologies, the creation of sustainable jobs, and economic growth through a circular economy, all of which are part of initiatives that will contribute to company growth. Sudi Apak and Erhan Atay (2015) stated that green energy is a term describing environmentally friendly, typically non-polluting sources of energy; some sources use it interchangeably with renewable energy. Green energy has mass appeal among consumers, investors, and manufacturers (Bohn, 2010, p. 36).

On the other hand, challenges to sustainable development are now recognized worldwide. Three dimensions are relevant: the interaction among culture, structure, and technology; the approaches of optimization–improvement–renewal; and the parties involved. Renewal of systems requires new ways of searching and designing exploration processes comprising human needs as a starting point, backcasting as a method and

jumps in eco-efficiency to measure orientation towards innovation. This implies a strategic approach to innovation and breakthroughs in which trans-disciplinarity is key to obtaining viable results. Dutch experiences (Jansen, 2003) reveal that innovation options can be identified and innovation paths can be paved. Support conditions were identified; to ensure the availability of sufficient capacity, strong efforts must be made in the (higher) education system. A proposal is made for a European policy to strengthen and spread the system's renewal approach in interaction with educational renewal.

For the relationship between digital transformation and sustainable development of the IT sector, this study looks specifically at the environmental, social and economic impact and the governance and ethical implications of digitization impacting the citizens.

This assessment covers some high-level positive and negative impacts in the areas mentioned:

1. Environmental impact

Energy savings have a positive impact because digital transformation can increase them through the use of smart technologies, Internet of Things (IoT) devices, and advanced analytics. For example, smart grids and smart buildings can optimize energy use, reducing overall consumption and greenhouse gas emissions. On the other hand side, the growth in data generation and processing demands more energy-intensive data centers. The proliferation of digital devices also increases the overall energy footprint. Efforts to transition data centers to renewable energy sources are crucial to mitigating this impact.

Dematerialization of products/goods enables the dematerialization of products and services, reducing the need for physical materials. E-books, digital documents, and online services decrease the demand for paper and physical transportation, contributing to resource conservation. However, the production of digital devices and the infrastructure supporting digital services still require significant material resources, including rare earth metals, which can have environmental and social implications if not sourced responsibly.

Considering the impact on SDGs, digital transformation and the IT industry might align with SDG 7 (Affordable and Clean Energy), SDG 12 (Responsible Consumption and Production), and SDG 13 (Climate Action). IT development and the extensive implementation of digital technologies might support SDG 7 through smart grids, IoT-enabled energy management, and AI-driven energy optimization, thereby enhancing energy efficiency and reducing carbon emissions. Smart meters and AI-powered energy analytics support energy conservation and integrate renewable energy sources effectively. Digital transformation fosters the dematerialization of products, reducing reliance on physical materials and thereby contributing to SDG 12. Other technologies associated with the IT Sector, such as cloud computing and digital documentation, minimize paper waste, supporting responsible production and consumption patterns. The ever-increasing IT sector, nevertheless, could impact SDG 13 both ways. While digital transformation aids through energy-efficient solutions, increased data generation and the demand for cloud services raise concerns about carbon footprints. Policies promoting green computing and transitioning data centers to renewable energy sources can help balance these impacts.

2. Social impact

Digital inclusion and equity. Digital transformation can enhance social inclusion by providing greater access to information, education, and services. E-learning platforms, telemedicine, and online banking can reach underserved populations, bridging the digital divide. Conversely, if not appropriately managed, digital transformation can exacerbate inequalities (Imran, 2022). Disparities in access to digital infrastructure, skills, and technologies can leave certain groups behind, particularly in rural or economically disadvantaged areas, as well for old population.

The labor market and employment are influenced by creating new job opportunities and by driving economic growth through the development of new industries and services. Upskilling and reskilling programs can help workers transition to digital economies. However, automation and AI-driven processes can lead to job displacement (Tennin et al., 2022), particularly in sectors susceptible to automation. Ensuring that the workforce is prepared for these changes and that social safety nets are in place is critical.

SDG 4 (Quality Education), SDG 8 (Decent Work and Economic Growth), and SDG 10 (Reduced Inequalities) are deeply interconnected and foundational for creating inclusive and sustainable societies. Their goals relate to one another, especially in the context of social enterprises, tech for good, and sustainable development.

3. Economic impact

Digital transformation raises innovation, leading to new business models and revenue streams. The sharing economy, entertainment economy, and digital platforms have emerged as significant economic drivers. These models can promote resource efficiency and sustainability (Gilchrist et al., 2022). On the other hand, these new business models can also disrupt traditional industries and employment structures, creating economic instability for some workers and communities. It is easier to assess how technology shapes the demand for skills and changes production processes than to estimate its effect on job losses. Technology is changing the skills being rewarded in the labor market. The premium is rising for skills that robots cannot replace- general cognitive skills such as critical thinking, and socio-behavioral skills, such as managing and recognizing emotions that enhance teamwork. Workers with these skills are more adaptable in labor markets. Technology is also disrupting production processes by challenging traditional firm boundaries, expanding global value chains, and reshaping the geography of jobs. Finally, technology is changing how people work, giving rise to the gig economy in which organizations contract with independent workers for short-term engagements.

Technology is disrupting the demand for three types of skills in the workplace. First, the demand for nonroutine cognitive and socio-behavioral skills appears to rise in advanced and emerging economies. Second, the demand for routine job-specific skills is declining. And, third, payoffs to combinations of different skill types appear to be increasing. These changes show up not just through new jobs replacing old ones but also through the changing skill profiles of existing jobs (World Development Report, 2019).

SDG 9 (Industry, Innovation, and Infrastructure), SDG 11 (Sustainable Cities and Communities), and SDG 17 (Partnerships for the Goals) focus on building the systems,

structures, and partnerships needed for inclusive and sustainable development. They lay the foundation for long-term transformation by emphasizing innovation, resilience, collaboration, and infrastructure.

4. Governance and ethical issues

Data privacy and security. Digital transformation enables better data management and security practices, protecting individuals' privacy and promoting trust in digital systems. Privacy-preserving technologies are the workhorse that enforces the protection of digital assets, whether personal or corporate. In particular, such technologies are instrumental in implementing privacy and data protection by design. Due to its legal framework and expertise in information technologies, Europe is very well placed to take the lead in innovation on privacy-preserving technologies and establish a common understanding of digital society notions across disciplines (van de Hoven et al., 2022). However, the increased collection and use of data raise concerns about privacy, surveillance, and data breaches. Ethical data governance and robust cybersecurity measures are essential to address these challenges. Excessive data collection may abuse of dominance in the era of big data (Robertson, 2020).

AI and automation can drive efficiency and innovation, contributing to sustainable development. For instance, AI can optimize supply chains, reducing waste and emissions, thus reducing the carbon footprint (MD Rokibul Hasan and all, 2024). Ethical considerations around AI include biases in algorithms, transparency, and the potential for misuse. Ensuring that AI systems are developed and deployed responsibly is crucial for sustainable development. Biases can be unintentionally embedded in algorithms through biased training data or decision-making processes. Implementing robust bias-detection mechanisms and diverse datasets that accurately represent the real-world population is critical to mitigating these biases. Transparency is also a key ethical consideration in AI implementation. Lack of transparency can lead to distrust among users who cannot understand or challenge algorithmic decisions affecting their lives. By providing explanations for algorithmic outcomes and making the decision-making process transparent, users can gain insights into how decisions are made and hold AI systems accountable. (Benneh Mensah, 2023)

SDG 5 (Gender Equality) and SDG 16 (Peace, Justice, and Strong Institutions) are human rights-centered goals essential for building equitable, safe, and inclusive societies. They support not only social progress but also economic development and democratic resilience.

Table 1 summarizes the dimensions of digital transformation based on the previous literature review, mapping them to environmental, social, economic, governance, and ethical impacts, along with the relevant SDGs. This table encapsulates the multidimensional implications of digital transformation, as discussed in the text, and highlights how it relates to sustainable development and the SDGs.

Table 1. The impact of digital transformation on sustainable development

Dimension	**Focus Areas / Impact**	**SDGs mapped**
Environmental Impact	- Energy saving via smart tech, IoT, advanced analytics - Transition to renewable energy	SDG 7 (Affordable & Clean Energy) SDG 12 (Responsible

	sources for data centers - Dematerialization (digital docs, e-books) reducing physical resource use - Challenges include increased energy demand from data growth and production of digital devices with material resource use	Consumption & Production) SDG 13 (Climate Action)
Social Impact	- Digital inclusion and equity in access to information, education, health, banking - Risks of the digital divide, especially in rural, old populations - Impact on the labor market: new jobs, reskilling, job displacement	SDG 4 (Quality Education), SDG 8 (Decent Work), SDG 10 (Reduced Inequality)
Economic Impact	- Innovation, new business models (sharing, digital platforms) - Disruption of traditional industries and employment - Changing skills demand: rise in cognitive & socio-behavioral skills, decline in routine skills - Growth in the gig economy and global value chains	SDG 9 (Industry, Innovation & Infrastructure) SDG 11 (Sustainable Cities) SDG 17 (Partnerships)
Governance & Ethical Issues	- Data privacy, security, and responsible management - Risks of surveillance, data breaches, abuse of data - Use of AI & automation: efficiency gains vs. biases, transparency, potential misuse	SDG 5 (Gender Equality), SDG 16 (Peace, Justice, Strong Institutions)

(II) Role of IT sector in social and circular economies

By evaluating the social and circular economies generated by the IT sector, we can observe that it can help create a more inclusive, resource-efficient, and sustainable world by increasing digital inclusion, supporting social enterprises, and adopting circular-economy principles. These efforts not only address pressing environmental and social challenges but also open up new business opportunities and enhance corporate responsibility. Hammam Ahmed Hammam Al Kezmazy (2019) introduced a new concept regarding social entrepreneurship, social problems, and development projects. The concept assumes that we must go through three distinct paths in parallel when solving our pressing problems. These ways include leveraging our previous experiences, drawing on others' successful applied projects, and continuously following new technologies under development.

For the evaluation of the social and circular economies generated by the IT sector, the current work tries to look at the potential initiatives and their impact related to digital

inclusion and accessibility, social enterprises and tech for good, related to social economy and sustainable product design, e-waste management, and innovative business models related to circular economy.

A. Social economy and the IT Sector

The social economy focuses on organizations and enterprises prioritizing social objectives over profit. These entities often address social needs and aim to enhance social welfare, equity, and inclusion.

1. Digital inclusion and accessibility

Digital inclusion and accessibility are crucial pillars in the modern world, ensuring that everyone has equal access to digital technologies regardless of background or ability. The IT industry plays a paramount role in providing this desiderate, primarily by bridging the digital divide and using assistive technologies.

a. Bridging the digital divide:

- Initiatives: The IT sector is instrumental in closing the digital divide by providing affordable internet access, digital literacy programs, and low-cost devices to underserved communities. Companies like Google and Facebook have invested in global connectivity projects to bring the internet to remote areas.
- Impact: Improved access to digital tools and the internet enables disadvantaged groups to participate more fully in the economy, access education, and improve their quality of life.

b. Assistive technologies:

- Initiatives: IT companies develop assistive technologies that support people with disabilities. Examples include screen readers, voice recognition software, and adaptive hardware.
- Impact: These technologies enhance the ability of people with disabilities to access information, perform tasks, and engage in social and economic activities.

2. Social enterprises and Tech for Good

Social Enterprises and Tech for Good often intersect, aiming to address social and environmental issues through innovative, sustainable means. A social enterprise is an organization that applies commercial strategies to maximize improvements in human and environmental well-being. These enterprises prioritize social impact over profit, though many operate with a profit model to ensure sustainability. Tech for Good refers to using technology to address social, environmental, and economic challenges. It spans startups, nonprofits, and large companies using digital tools to create positive change.

a. Social enterprises:

- Initiatives: Social enterprises leverage IT to address social issues—for instance, the use of technology to facilitate micro-lending to entrepreneurs in developing countries.

- Impact: These initiatives empower individuals by providing financial services, education, and other resources, contributing to economic development and social well-being.

b. Tech for Good:

- Initiatives: The "Tech for Good" movement encourages IT companies to develop solutions that tackle societal challenges, such as healthcare, education, and environmental protection. Examples include mobile health apps and educational platforms.
- Impact: These technologies can improve health outcomes, educational attainment, and environmental sustainability, benefiting society as a whole.

B. Circular economy and the IT sector

The circular economy aims to minimize waste and make the most of resources by creating closed-loop systems where products and materials are reused, refurbished, remanufactured, and recycled. The circular economy and the IT sector are increasingly converging as the world seeks more sustainable, efficient, and ethical ways to manage technology's lifecycle.

1. Sustainable product design

Sustainable product design is the practice of creating products with the least possible negative impact on the environment and society throughout their entire life cycle – from raw materials to disposal or recycling. It combines innovation, ethics, and environmental responsibility and is a core element of circular economy thinking.

a. Eco-friendly materials:

- Initiatives: IT companies are increasingly using sustainable materials in their products. For example, smartphone manufacturers use recycled aluminum and rare earth elements in their devices.
- Impact: This reduces the environmental footprint of products by conserving resources and reducing the need for virgin materials.

b. Modular and repairable designs:

- Initiatives: Designing products for durability, repairability, and upgradability extends their lifecycle. Few (only a few) smartphone manufacturers create smartphones with modular components that users can easily replace.
- Impact: This approach reduces electronic waste and the demand for new devices, promoting resource efficiency.

2. E-Waste management

E-waste (electronic waste) management is one of the digital age's most urgent environmental and social challenges. With rapid technological advancement and shorter product life cycles, managing discarded electronics responsibly is critical for sustainability, health, and resource conservation. E-waste refers to discarded electronic

and electrical devices – including computers, smartphones, TVs, batteries, cables, printers, etc.

a. Buy-back and recycling programs:

- Initiatives: Many IT companies have established buy-back and recycling programs. For instance, computer manufacturers allow consumers to return old electronics for responsible recycling.
- Impact: Proper e-waste management prevents hazardous materials from entering the environment and recovers valuable resources for reuse.

b. Circular supply chains:

- Initiatives: Implementing circular supply chains involves reusing components and materials from returned products. IT companies are increasingly adopting these practices to create more sustainable supply chains.
- Impact: Circular supply chains reduce the environmental impact of production and contribute to a more sustainable resource management system.

3. Innovative business models

Innovative business models are transforming how organizations create, deliver, and capture value – often with a strong focus on sustainability, technology, and social impact. These models are especially relevant for startups, social enterprises, and tech-for-good initiatives that want to solve real-world problems in new ways.

a. Product-as-a-Service:

- Initiatives: The Product-as-a-Service model involves offering products on a subscription or rental basis rather than selling them outright. For example, some companies provide managed print services where customers pay per page printed.
- Impact: This model encourages companies to produce durable, high-quality products and to take responsibility for their lifecycles, thereby promoting sustainability.

b. Refurbishment and Remanufacturing:

- Initiatives: Some companies have refurbishment and remanufacturing programs that restore used equipment to like-new resale conditions.

Impact: Refurbishing and remanufacturing extend product lifespans, reduce waste, and make high-quality technology more accessible.

Table 2 explains the role of the IT sector in social and circular economies, mapped according to the dimensions from the above narrative literature review.

Table 2. The role of the IT sector in the social and circular economies

Economy Dimension	**Role of IT Sector / Initiatives**	**Impact / Goals**
Social Economy		
Equity & Inclusion	Use of IT for micro-lending, financial services, education, health, and employment support	Empowers individuals, promotes social well-being, and supports economic development
Social Impact	Digital tools (mobile health apps, educational platforms) improve health, education, and environmental awareness	Benefits society by enhancing health outcomes, educational attainment, and sustainability
Community Development & Poverty Reduction	Tech-enabled microfinance, online resources, and digital education platforms	Improves access to resources, reduces inequalities, and fosters inclusive growth
Circular Economy		
Sustainable Product Design	Eco-friendly materials, modular/repairable products	Reduces environmental footprint, conserves resources, and extends product lifespan
E-Waste Management	Buy-back schemes, responsible recycling, circular supply chains	Prevents hazardous waste, recovers valuable resources, promotes resource efficiency
Innovative Business Models	Product-as-a-Service, refurbishment, remanufacturing	Extends product life, reduces waste, promotes sustainable consumption and production

Table 2 shows how the IT sector enables social and circular economies, emphasizing sustainable impact and innovation aligned with responsible resource management and social well-being. Theefore, it might contribute to sustainable development in a significant way.

Conclusions

Integrating circular economy principles within the IT sector significantly advances sustainable development by promoting resource efficiency, waste reduction, economic growth, environmental protection, and social equity. By aligning with the sustainable development goals, the IT sector can create a more sustainable and equitable future through digital transformation, innovation, and responsible practices.

Digital transformation drives both opportunities and challenges for sustainable development. Digital transformation is a double-edged sword for sustainable development. It opens up unprecedented opportunities to accelerate progress across all 17 UN Sustainable Development Goals (SDGs), but it also introduces new risks and inequalities that must be carefully managed. But digital transformation is not inherently

sustainable — it must be made so. Policies, education, design thinking, and equitable access must work in tandem to ensure that digital progress advances the SDGs rather than undermining them.

Economic impacts are shaped by the rise of new business models and job creation, but also disruption in traditional industries. The economic implications of digital transformation and innovation are both transformative and disruptive. While new business models and technologies unlock job creation, entrepreneurship, and global competitiveness, they also challenge traditional industries, reshape labor markets, and raise concerns about inequality and worker protection.

The IT sector can significantly impact sustainable development and other sectors, but it must also ensure its own sustainable development. The circular economy within the IT sector promotes resource efficiency and sustainability. The IT sector is a critical enabler of sustainable development across industries, but it must also address its environmental and social footprint. Embracing circular economy principles is essential to ensure the sector's long-term sustainability, resilience, and alignment with global goals such as the UN SDGs.

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