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Regional misalignment in twin transition: coping with a double perspective on green and digital transformations[1]

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Abstract: Many voices in the policy debate concur on the need to accelerate the green and digital transitions of businesses to build sustainable and competitive regional economies. Academic research on the topic is still in its early stages and the twin transition remains ill-defined.
Using novel data on the food sector in an Italian region, the paper provides insights into the barriers that a twin transition perspective may encounter at both the firm and systemic levels to become a means to support new sustainable development trajectories.
The analysis highlights that a weak twin transition evolution is due to the peculiarities of how green and digital perspectives are normally addressed and operationalized within Small and Medium-sized Enterprises (SMEs) and along their network of local support.
We maintain that triggering an effective and more impactful twin transition regional path requires aligning more strategically the green and digital initiatives within the companies. Moreover, we maintain that surrounding systems of stakeholders and policymakers need to develop supporting strategies and initiatives informed by a thorough understanding of local SMEs characteristics, sectoral specificities, and peculiar problems of misalignment.

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Keywords: twin transition; misalignment; Small and Medium-sized Enterprises, food industry; regional development

JEL Classification Numbers: 014; 033; R11

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1. Introduction

The concepts of green and digital transformation are becoming increasingly intertwined, leading to the common adoption of the term 'twin transition' in political and academic circles. The twin transition refers to a concurrent process of green and digital transformation that, when combined, can accelerate progress toward shared societal and sustainable objectives (European Commission 2022, p. 7). Thus, this term emphasizes the mutually reinforcing nature of the two transitions, to mitigate the crises we face today, and redirect economic activities toward innovative sustainable development pathways.

In recent years, several studies documented the significant role of digital technologies in supporting sustainable development and re-routing (e.g. Bellandi et al., 2020; De Propris & Bailey, 2020). After an initial focus on digital technologies (Götz & Jankowska 2017; Reischauer, 2018; Coco et al., 2024), as a means to re-route manufacturing Small and Medium-sized Enterprises (SMEs), the urgency of the environmental crisis called policy-makers and analysts to factor in environmental and social innovations when envisioning economic development paths (Ghobakhloo, 2020; Khan et al., 2021). Thus, scholars started inquiring about the intertwined effect of digital and green when discussing regional recovery to provide policy provisions and orientation with supporting evidence (e.g., Sharma et al., 2022).

While some recent studies on twin transition come from the business literature and focus on innovation, with some attention to firms' business model redefinition (Denicolai et al., 2021; Montresor & Vezzani, 2023; Rehman et al., 2023), others come from transitional and regional geography literature and focus mainly on the role of the regional structural characteristics and ecosystem in setting new opportunities. Recent special issues in related journals are evidence of a new emerging interest from scholars in those branches of literature.[2]

While growing, the pace of academic research needs to consolidate validated knowledge that might contribute to effective policies in front of uncertain scenarios and heterogeneous contextual specificities and industrial structures. Moreover, SMEs, compared to large companies, have limited resources (Colapinto & Finotto, 2024) to dedicate to both

[2] See the special issue 2023 vol. 30 (7) in Industry and Innovation on 'The twin (digital and green) transition: handling the economic and social challenges'. The recent special issues in Regional Studies 'The regional dimension of the twin transition: new insights on joining green and digital transformations' and in Technology and Society 'Twin transitions: unravelling the interplay between green and digital in socio-technical transformation processes'.

transformations. Understanding how the green and digital perspectives are addressed in SMEs may help to understand which are the barriers that can be encountered in envisioning a twin transition supporting sustainable local path development in regions where the SMEs' population remains the principal contributor to the local economy.

The paper aims to contribute to this emerging stream of research by looking at how green and digital transitions are approached by SMEs within a specific sector and a specific region. Within this context, we will provide insights into the barriers that a twin transition perspective may encounter locally to become a means to support new sustainable development trajectories.

Empirically we focus on SMEs located in a specific region in Italy: the Veneto region in which the population of traditional SMEs has still an important economic weight. This approach aims to offer valuable insights into the stages of transition undertaken by an economy that remains rooted in local traditional foundations (Plechero & Grillitsch, 2023).

We will then look specifically at SMEs within the agri-food sector which is one of the crucial targets of the European Green Deal (European Commission, 2019) and an important sector in terms of sheer contribution to climate change (Poore & Nemecek, 2018). Its embeddedness in territories makes it a critical industry to dig into for understanding local development or rerouting. First, different productions are possible in different geographical and climatic settings. Second, the specificities of the sector motivate very localized value chains, since many agricultural products and intermediate items need to be transformed close to their loci of production, those local stakeholders and supplier networks are crucial (Annosi et al., 2019; 2021; Capobianco et al., 2022; Dicken, 2015).

Section 2 will illustrate the current debate and the theoretical background; section 3 will provide general information on the contextual setting and will introduce the research design. Section 4 will discuss the empirical findings, while section 5 will conclude by drawing some policy implications.

2. Theoretical background

The twin transition is currently receiving significant attention in policy debates (European Commission 2021; 2022). This attention is primarily driven by the pressing need to achieve the United Nations' Sustainable Development Goals (SDGs) outlined in the Agenda 2030, as well as the target of attaining zero carbon emissions by 2050. While the focus of the twin transition lies predominantly in its environmental implications (e.g., Bianchini et al.,

2023), economic geographers and innovation business scholars are increasingly acknowledging its crucial role in facilitating business renewal and redirecting economies (Bachtrögler-Unger et al., 2023; Moşteanu, 2020; Diodato et al., 2023; Rehman et al., 2023; Montresor & Vezzani, 2023; Findik et al., 2023).

The policy debate has helped bridge together the two green and digital perspectives. However, there remain unresolved issues regarding how these perspectives can be effectively aligned within firms and local economies, particularly when it comes to pursuing undefined goals lacking a consciously formulated unified vision. To restructure industrial specializations, aligned changes should be addressed at both the systemic and firm levels (Isaksen et al., 2020). On the one hand, the twin perspective necessitates combined regulatory and more nuanced policy considerations that should take account of the specific contextual conditions. On the other hand, it requires companies and entrepreneurs to deal differently with their peculiar procedures and network relations to address a correct twin perspective that can steer them and their networks toward new competitive renewed trajectories.

2.1 Twin transition, systemic perspective, and re-routing

Until recently, studies adopting a systemic perspective from the transitional and regional evolutionary economic geography literature have primarily focused on analysing green and digital transformations as separate entities, without focusing too much on their intertwined role and effect in re-routing. Indeed, the role of digitalization in sustainable transitions has received little attention in the literature on socio-technical systems until a few years ago (e.g., Andersen et al., 2021). From an economic geography perspective at the regional level, studies looking at possible new regional trajectories for local economies have also predominantly conducted distinct research on digital and green pathways. The latter path has been sometimes considered the outcome influenced by the former and not one of the transformations that coupled with digitalization can lead to sustainable re-routing (e.g., Sareen & Haarstad, 2021).

However, current works in this field, such as Mäkitie et al. (2023), try to provide a theoretical clarification of the concept of twin transition at a systemic level, identifying different types of couplings that can occur between the green and digital spheres. In particular, the authors argue that only radical innovation in the two spheres can be considered a twin transition that can create substantial structural changes/reconfigurations of a system. All in all, in general, with the latter contributions in the field there is an increase in the tentative to clarify that transitions are ways to provide key impact to new regional industrial path developments more

than the outcomes to which we should look at (Chlebna et al., 2023, p. 227).

Although not explicitly mentioning a twin transition perspective, some regional studies (e.g. Bellandi et al., 2020; Ramirez, 2020) within the framework of Industry 4.0+[3] and regional development, have highlighted the need to better align digital and green fields of actions. The regional case studies investigated by those authors in Sweden and Italy provide the idea that when different technological/green transitions are in place there is a need to strengthen mutual alignments between different technical and social elements of a territorial system, supply chain relations, business networks, and knowledge bases. These contributions have also strengthened the idea that place-based policy plays a crucial role in facilitating and directing the alignment of different perspectives, ultimately fostering positive path development. Studies on the digital transition of local systems of SMEs exhibit already the tensions that are inherent in how EU policies are locally devised and deployed.[4] Other recent regional studies have then shed light on some fundamental regional factors, such as income, skills, infrastructure, and efforts which partly determine the extent to which green and digital investments can contribute to drive future economic growth in specific regions (e.g., Maucorps et al., 2023). While regions like the one investigated in this paper show good performances in several of those factors, such analyses fail to adequately capture the influence of the characteristics of the local business community and specializations as well as the importance of alignment in the local network of strategic stakeholders to grasp the possibility for re-routing.

2.2 Digital and green transitions in SMEs: benefits and key barriers

The significance of the twin transition concept in the current policy debate (European Commission, 2021; 2022) is not completely matched by a comprehensive theorization in business studies as well. In fields such as management, strategy, and innovation, the literature has primarily focused on considering the potential benefits for the organizations of the two transitions independently. Only recently there has been a growing interest in examining their

[3] Industry 4.0+ is meant as the 'deployment of all the technologies of the FIR [last generation of digital technologies] that will trigger a transformational shift in the techno- socioeconomic paradigm attuned to a green economy and society transformational shift' (De Propris and Bailey 2020).

[4] For instance, in their account of regional-scale projects aimed at mentoring SMEs into the digital transformation, Coco, Colapinto, and Finotto (2023) document how European and National policy schemes, given the pressure to support local economic development, tend to replicate best practices; on the other hand, SMEs in given places and based on their sectoral specialization might perceive general policy-templates ill-adapted to the local context.

interactions, mainly aimed at investigating the relationship between digital solutions and sustainable performance (De Sousa et al., 2018; Montresor & Vezzani, 2023).

General reviews of the interaction between digital technologies- specifically industry 4.0 solutions - and sustainable performances that can be employed also in SMEs have attempted to single out discrete solutions enhancing sustainable business models, such as circular economy ones (Ortega-gras et al., 2021). Several digital tools have the potential to lead firms to transition toward new business models, drastically reducing their environmental footprint thanks to the regeneration of materials and products. Just to name a few: Big Data analytics and Internet of Things (IoT) allow to promptly monitor consumption of energy and materials and intervene selectively. Robotics and artificial vision, thanks to their superior performance in sorting items, materials, and products along production lines, increase firms' effectiveness in regenerating and integrating inputs. Addictive manufacturing can support eco-design, allowing to prototype and test the results of the injection of regenerated materials in existing products or new ones.

Along with fine-grained analyses of the intersection between digital technologies and ecologically sound business models and practices, further literature pointed to the role digital and green solutions play in sustaining competitive advantage (Rehman et al., 2023)[5]. In general, digital technologies are framed in the extant literature as harbingers of increases in productivity, process efficiency, flexibility, environmental sustainability, and novel configurations of business models (Bauer, 2016; Liao et al., 2017; Raj et al., 2020). Attention has been paid also to the role digital technologies may play in enabling a 'servitization' path for SMEs (Plechero et al., 2023), one wherein the reliance on intangible assets may be considered better to capture sustainable values (González Chávez et al., 2021). In turn, shifting away from traditional business models based on material assets to more technologically driven ones might contribute to the sustainability of entire sectors (Rymaszewska et al., 2017) and green re-routing.

While the entanglement of digital technologies and green practices is conducive to better environmental and economic firms' performances in principle, the transition towards strategies capitalizing on both in SMEs is often troublesome. Montresor and Vezzani (2023),

[5] Rehman et al. (2023) find, for example, that IOT influences technological innovation positively, thus making green innovations a key element to building sustainable competitive advantage. Similarly, they find that green human resource management practices incorporating green imperatives and sensitivities are conducive to innovations –technological and organizational– that might make a competitive advantage unfold. Finally, they find that investment in environmental management at the plant level, since it is conducive to higher levels of innovation in processes and products, affects a firm's ability to obtain a competitive advantage.

analysing firms in the Italian context note that the relationship between digital technologies and eco-innovation is weaker in SMEs.

One well-known obstacle SMEs face is represented by the lack of resources, namely financial, making complex for organizations to innovate or catch up rapidly (Coleman et al., 2016). Competence and cultural barriers are also some of the main recognized limits. There may be barriers of organizational culture, leadership, and transformation in the skillset of SMEs, that might be perceived as daunting to be developed or changed (Isensee et al., 2020). SMEs might face issues of sheer numbers since their talent pool is limited, and they might not have key specialists among their employees. More generally, digital and green transitions require widespread dissemination of novel competencies among human resources that might be perceived as too expensive in terms of time (i.e. not easy to access rapidly) and financial resources to bring in (Coleman, 2016; Gabrielli & Balboni 2010; Pelletier & Cloutier, 2019).

Due to the lack or the scarcity of resources and competences, SMEs look often at stakeholders for support in both the transitions and depend on local ecosystems of service suppliers and institutions (Journeault et al., 2021; Plechero & Grillitsch, 2023). In their study of policies for the digital transition, Coco et al., (2024) document then the mismatch between how policymakers, entrepreneurs and technology vendors frame technologies and their benefits delay SMEs' adoption of updated solutions. More specifically, there might be clashes between how strategic priorities are set: SMEs, often domain specialists, are pressured by day-by-day competitive forces and operational issues and look at technologies as means to obtain quick fixes; on the other hand, digital technologies, especially those synergistically operating with green solutions, open perspectives related to strategic innovation on the long term (Coco et al., 2024; Coskun-Setirek & Tanrikulu, 2021). The work of Coco et al., (2023) highlights how the impacts in terms of the granular understanding of the logic of different spheres depend on the specificities in which they are settled and the actors that are involved.

3. Context and Method

3.1 An introduction to the contextual setting

The Veneto Region boasts significant traditional manufacturing roots and a lively population of SMEs in several sectors (Plechero & Grillitsch 2023). In 2021, the manufacturing processing and productive part related to the agri-food industry of the region alone contributed

to 1.8% of the total Italian GDP (Ismea, 2023). [6] The region stands particularly out as a key contributor to Italian food production, particularly in meat and grain-related products. Veneto is also among the leading Italian regions in terms of the quality of its food products (Salpina & Pagliacci, 2022). The Venetian Geographical Indication (GI) economy (which also includes the beverage industry) represents an impressive 48% of the regional sector, more than double that of the national one (21%) (Ismea-Qualivita, 2023). The industry is pivotal for the flourishing of other key sectors: first, it transforms, sustains, and adds value to the products of agriculture that generates 2.2% of the Italian Value Added, one of the largest relative shares in Europe (Ibiden). Second, the sector is also key for shares of the tourism industry, especially when enogastronomic destinations are considered, and third, is also key for the development of the regional mechanic and mechatronic sectors which produce a key part of the dedicated food machinery that are employed in the local food specializations.

When one considers the twin transition, the food sector of the region needs to face new challenges. As an effort to green the European economy, the sector is called to reduce its impact on climate and to move towards more sustainable business models and strategies, as per the European Green Deal and the Farm to Fork Strategy. Digital technologies and more up-to-date strategic and operational models enabled by the likes of industry 4.0 and similar solutions, are playing a crucial role in increasing the competitiveness of firms in the sector that are, in the Region on average very small in size.[7] Reduced size is associated to the lack of resources to invest in transitions that might be either capital–intensive (as the application of digital technologies to production processes) or competence–intensive and demanding (as the re-engineering of processes and end-to-end processes in supply chain to increase sustainability performances).

Despite the recognized quality of local food production, uncertainties stemming from the Covid-19 pandemic, current geopolitical tensions, and recent restructuring in the global value chain pose significant threats to the future sustainability of the regional small businesses.

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[6] In 2022, in the region, there were approximately 63 thousand farms and 3,544 beverage and food companies. (Ismea, 2023). Together the value added of the food and beverage sector based in Veneto represents the 13.8% of the total value added of the Italian sector (Ismea, 2023; Sistema Statistico Regionale, 2023). The exports in 2022 amounted to 6,812 million Euros, although the market is still not fully exploited and remains primarily European (79% of total exports), and mainly related to the German market.

[7] According to ISTAT (Italian official statistics) related to the year 2021 the firms active in the food industry (NACE code 10), were 77.5% micro firms (with less than 10 employees), 18.5% small firms (10-49 employees), 3.55% medium firms (50 to 249 employees) and only less than 0.5% large firms.

The challenges are also exacerbated by notable increases in 2022 in energy prices (92%), fertilizer prices (164%), and agricultural commodities (48%), which are currently demanding firms to become more efficient (Ismea 2023). In this uncertain and dynamic scenario, Veneto manufacturing food SMEs need some important restructuring to be able to cope with those current challenges and be able to meet at the same time EU green goals. Notably, cost pressures and disruptions in value chains over the recent period, coupled with a growing focus on environmental concerns, make urgent the pursuit of green and digital transformations as means to support more sustainable long-terms paths. Critical for local food SMEs is not only embracing both transformations to enhance efficiency but also to rethink their traditional business models and align with global new consumer trends and the ongoing transformation of the global food system.

3.2 Research method and data

The main data used for the paper were collected through the annual survey of an Italian university center focusing on basic and applied research on the agri-food sector. One of the center's goals is to disseminate its research results in the form of actionable knowledge for local SMEs to improve their business models and to exploit technological, organizational, and strategic innovations. Since 2020, the research center has conducted annual desk research on the region's food SMEs marketing and strategic choices via a systematic desk analysis of their digital communication and surveys to company decision-makers aimed at understanding the determinants and impacts of choices related to strategic and technological innovation. Although all the information collected through annual desk research and surveys has served for this paper as a background, we specifically elaborated the data collected in 2022, based on a regional population of 385 firms[8]. The 2022 survey focused, among other aspects, on SMEs' decisions and activities related to digitalization and sustainability. To that end, the survey contained questions aimed at understanding if firms adopted a series of digital technologies and related practices (e.g. technologies for automation, additive manufacturing, cloud services, data analytics, internet of things; cybersecurity, traceability, forecasting, e-commerce and SCM systems); if they acted according to internal strategies, and if they adopted sustainable practices

[8] The population concerns all food capital firms belonging to the NACE codes from 10.1 to 10.8 present in 2022 the Bureau Van Djik's AIDA database having more than 10 and less than 250 employees, possessing productive and transformation processes. From the population agricultural farms', cooperatives, consortia and beverage companies have been excluded.

(e.g. green packaging; waste management/valorisation; energy efficiency systems or systems for the emission reduction; use of renewable energy, monitoring sustainability of the supply chain) or had specific green certifications or specific figures within the companies in charge of those practices.

Due to the low response rate reached after COVID-19, the data points were not sufficient for a robust quantitative analysis conducive to sound generalizable conclusions[9]. Therefore, we decided to conduct interviews to deepen our insights into the green and digital transition occurring within the companies, while looking for further evidence validating or contrasting the inferences, we made on the survey available data.

We selected 20 cases out of the regional firm population. The selection aimed for variety, in terms of sub-sectors (each food sub-sector represented by the two-digit NACE code classifications we considered in the analysis[10]), positions in the value chains (looking for both firms selling directly to consumers or operating in business-to-business environments), geographical area, size (measured as number of employees). We looked for significant cases from the point of view of the main phenomena we investigated. Being interested in decisions and strategies related to digitalization and sustainability and their intersections, we singled out firms that might give us empirical material to interpret. We thus used their online presence - intended as the heterogeneity of digital channels used - as a proxy for their familiarity with digital technologies at large; we then considered the presence of content related to sustainability on their websites as a proxy for their commitment to sustainable practices or strategies. Table 1 reports the firm codes, primary subsector (*NACE, activity*), province (*area*), and size in terms of employees (*SIZE*).

All the interviews followed a common protocol elaborated by the research team. All the interviews lasted around one hour and were recorded and transcribed. One of the researchers who was not present during the interviews analysed the transcripts and classified them following a thematic grid decided beforehand. The 20 cases were classified according to the presence of changes (i.e. transitions) related to digitalization processes (D), or sustainability aspects (S) or both (DS). In particular, the researcher reconstructed narratives of the steps taken by firms in both the transitions (digital and sustainable) or lack thereof based on the information

[9] We obtained 52 responses, which corresponds to a 13.5% response rate.

[10] NACE codes from 10.1 to 10.8 concern: the processing and preserving of meat and production of meat products; fish, crustaceans, and mollusks; fruit and vegetables; manufacture of vegetable and animal oils and fats; dairy products; grain mill products, starches, and starch products; bakery and farinaceous products; and other food-related products.

provided by the informants. The detailed analysis of the verbatim transcriptions allowed the researcher to categorize discrete claims of respondents as signals of the presence of instantiations of digital and/or sustainable transformations; then, and more to the point, the transcripts and the iteration between them and the material on the firms collected during the desk phase and survey, together with the researcher's expertise in the topics at hand, allowed to draw inferences on the maturity of each firm's digital, sustainable or combined twin transition.[11] Thus, the twin transition was categorized as being lacking, in progress, weak or strong. The procedure, informed by extant academic and grey literature on the two transitions, allowed to determine the degree of interconnection among D, S aspects (unbalanced, aligned, misaligned), the positioning of the firm in relation to D and S themes (i.e. operational or strategic), and the presence of other involved actors.[12]

A second researcher, that was present during the interviews, processed the colleague's coding to validate her categorization and to spot inconsistencies and anomalies in the interpretation. The two agreed on the way the first researcher classified all firms but one. The two researchers then met and discussed the issue, converging to a common vision also of this last case. This procedure was chosen to ensure at the same time objectivity (granted by the lack of contextual knowledge by the first researcher) and accuracy (granted by the situated knowledge acquired by the second researcher during interviews).

[11] The categories used to capture the relative position of each firm synthesized both the complexity of the transitions pursued by the firms (interrelated transformations such as, for instance, digitalization of upstream processes and the front-end with customers; integrated sustainability-oriented transformations such as the design of green packaging and the re-use of byproducts, their intensity in terms of commitment and invested resources (by assessing, for instance, financial resources and dedicated human resources), the prospects of the aforementioned transitions (whether they were a response to a discrete threat or occasion or if they were inserted in organic and long-term plans).

[12] In essence, through the category of alignment, we were looking for evidence of orchestrated and interdependent efforts integrating the digital and the green transition, vis-à-vis a prevalent focus on one of the two or a mismatch between the two when pursued together. Moreover, the strategic/operational categorization of the collected evidence allowed the researcher to grasp the strategic orientation of the interventions, being for example a proactive or prompt response to changes in regulation or to the sudden restructuring of the market and industry or an adaptive answer related to day by day routines or operations.

4. Empirical evidence and findings

According to the data collected through the survey, the interviews, and other available official data (i.e. from Veneto Unioncamere - the regional union of Chamber of Commerce), firms in the agri-food sector of the region have only recently begun to invest more systematically in digitalization[13].

In 2019, almost half of SMEs in the regional industry were still not adopting any enabling Industry 4.0 technologies (Unioncamere data), primarily focusing on those considered basic ones like cybersecurity, robotics and automation, and cloud services. Investments in more advanced digital tools such as the Internet of Things and data analytics were instead still quite limited.

The data from the University research center reveals that around 1 out of 4 food companies started their digital transformation journey for the first time only in 2020. If then the recent crises (pandemic and the geopolitical tensions caused by the Ukraine and Russia war) have been an incentive within the industry to invest more efficiently in the downstream processes, particularly strengthening the presence of the firms on the web and social media, the investment in upstream technologies helping to radically transform firms' business models is still weak. In 2022, based on the survey results, the 4.0 digital investments made by companies have been mainly in Machinery and equipment (67% of sample firms), Cloud services (60%), and Cybersecurity and business continuity (46%). The interviews conducted have confirmed this trend and unveiled the technologies have been primarily aimed at enhancing some operational efficiency, as well as bolstering e-commerce-related downstream processes, rather than pursuing key strategic objectives. We could also observe that the digital transformation has not been accompanied by an adequate investment in human resources. Numerous SMEs opted to rely on external consultancy, agencies, and technology suppliers when dealing with the internal digital transformation. While over 70% of survey firms have stated that they have engaged these organizations to support their digital transformation efforts, 40% declared that have relied exclusively on them for implementing transformative processes. Consequently, suppliers of technologies and agencies dedicated to helping firms in digital transformation have assumed a pivotal role in steering the development and growth capabilities of these SMEs.

In the realm of sustainability, data from desk research and the survey depicted a similar

[13] The national plan 4.0 since 2017 to support SMEs in their digitalization advancements (Ministero dello Sviluppo Economico 2018) played a first crucial role in pushing SMEs to invest in digital technology by providing fiscal and funding incentives for the acquisition of 4.0 machinery, equipment, and related software.

trend. This trend highlights recent positive steps in sustainability investments, primarily focusing again on improving downstream communication and operational efficiency, rather than pursuing organic investments involving shared strategies within the local supply chain. For instance, only 38.5% of firms have declared their commitment to sustainable practices in their supply chain operations.

Even though only approximately 15% of the surveyed food firms in 2022 incorporated sustainability information on the homepage of their websites, one out of two survey firms invested in sustainable packaging practices that can enhance communication to the target. A significant percentage of firms have also initiated the adoption of waste reduction practices (77% of the sample firms), invested in renewable energy sources (69% of the sample firms), or developed more efficient energy systems (around 63% of the sample firms).

One-third of the firms have then declared the presence of internal figures with a role in addressing environmental issues. However, from the conducted interviews, this seems primarily driven by regulatory obligations, particularly in response to the pursuit of specific certifications which are becoming mandatory by law. Indeed, about 31% of the firms have stated to have already a certification linked to sustainability issues.

While some progress has been made in both digital and sustainable directions by the firms, the analysis of the interviews highlights how both perspectives have been addressed within companies. When we intertwine the role of digital and green transformation, only in a few cases, the interviewees associated the digitization process with sustainability activities. Both practices were primarily seen as specific and separate activities, often driven by external forces, rather than a systematic approach where the different factors supporting both transitions were managed to achieve common strategic goals. For example, digital tools that could support some sustainability practices have been used indeed mainly as a means of improving efficiency through cost reduction or of improving communication.

Table 1 presents the main outcomes of our qualitative analysis, in which we feature the main perspective to the twin transition that we identified within the companies.

Tab 1 – Cases classification and twin transition perspective

Code Case	**Main Activity** NACE classification	**Area** NUTS 3	**SIZE** Number of employees	**Twin transition perspective**
r	10.5 Cheesemaking processes	VR	14	***Lack of D and S transitions***
u	10.5 Cheesemaking processes	TV	18	***Lack of D and S transitions***
j	10.1 Meat processing	PD	86	***Lack of D and S transitions***
a	10.2 Fresh products	VE	27	***Difficult to accomplish DS*** (Both transitions not yet there; p weak digital side: mainly dependent on suppliers of technolog
d	10.7 Baked goods	VI	27	***Unbalanced DS transition*** (Internal-external support for D re green S transition there were no strategic aims (with mainly e
f	10.6 Grain processing	VI	11	***Unbalanced DS transition*** (Mainly S - green-energy effic accompanied by an aligned 4.0 transformation)
m	10.7 Baked goods & flour-based products	TV	86	***Unbalanced DS transition*** (More D than green S focus and market; fragmented D and S visions)
o	10.1 Cured meats	PD	10	***Unbalanced DS transition*** (Mainly green S downstream trans transition also constrained by a lack of strategic vision and int
c	10.5 Fresh cheeses	TV	245	***Misaligned DS transition*** (green and digital objectives not y figures for digital and sustainability)
h	10.7 Baked goods	TV	52	***Misaligned DS transition*** (large dependence on external acto two areas; operational focus, i.e. problem to align in packagin
b	10.8 Sweet and candies	PD	45	***Weak twin transition*** (fragmented and with artisan charac different external actors and drivers)
e	10.6 Millings, flour, cereals	TV	14	***Weak twin transition*** (downstream and adaptive – operatio energy)
k	10.1 Meat processing	PD	42	***Weak twin transition*** (limited in scope, e.g. IoT for energy ef
s	10.8 Snack productions	VR	11	***Weak twin transition*** (limited in scope, e.g. packaging led by

l	10.6 Grain processing	PD	27	***Weak twin transition*** (limited in scope e.g. packaging; energy saving and still unbalanced towards digitalization, but as a future opportunity to exploit; the transitions are not so externally dependent, the organization is detecting opportunities to accomplish it through also activities of business intelligence)
g	10.8 Frozen ready meals	TV	14	***Not yet twin transition but possible*** (the alignment seems to be possible in the future due to a more strategic attitude towards the digital and green thematic - customized consulting activities based on own firms' needs)
i	10.8 Roasting	TV	22	***Twin transition in progress*** (derived mainly from 4.0 investments in logistics and packaging (recycling purpose); vision jointly shared with local service providers; eco-patent)
q	10.3 Fresh products		15	***Twin transition in progress*** (limited in scope, e.g.. energy saving; waste reduction but with a strategic vision in relation to the future; outcome in progress: sustainability report)
t	10.6 Grains	TV	32	***Twin transition in progress*** (strategic vision – although consultants' activities are key, internal conscious approach to changes; leadership)
p	10.4 Cereals, oils and animal feed	VI	130	***Twin transition in progress*** (internal awareness; strategic vision)

Source: own elaboration based on interview cases

In three out of twenty firms, we identified a lack of D and S transitions (cases r, u, j). Despite some online activities being reported by these firms, there have been no significant efforts made operationally or strategically to initiate both transitions. One company (case a) instead began investing in digitalization and environmental sustainability but failed to achieve profitable solutions, partly due to its typical reliance on external technological providers. After attempting to launch direct B2B e-commerce without a proper organizational structure or adequate involvement of internal staff and ownership, it abandoned the initiative in favor of a simpler but less profitable alternative (i.e. the use of a third-party platform). Sustainability activities were then primarily focused on basic logistics solutions but were insufficient to be effectively combined with internal profitable investments in B2B activities. The interviewee mentioned that, given the nature of its activities, internal transitions were challenging to accomplish, and thus, no significant investments were really made in this regard.

For four companies (d, f, m, o), unbalanced transitions were evident, indicating a focus of the firms on either improving digital strategies or enhancing sustainable practices. In these cases, we observed a general lack in coordination, creating the impression that without a shared vision on both green and digital sides of investments, the initiatives could only remain fragmented. Within these investigated cases, the imbalance between internal and external forces (local consultants and agencies versus internal employees and dedicated figures) was also well evident.

In the case of Firm d, for example, while there has been a stronger push for digital transformation, both in the production processes and in digital communication, this has not been accompanied by a similar push in the sustainability sphere. The entrepreneur did not see sustainability investments as a potential lever to improve the firm's competitive capacity. Moreover, even if the firm had an internal environmental engineer in charge of sustainability duties, its role remained mainly linked to solving regulative aspects and managing operations. He did not affect strategies or the path toward sustainability. External services then were fragmented and not uniquely perceived. The entrepreneur stated:

‘Concerning external partners, if we talk about solar energy, there are those who specialize in solar energy. If we talk about the environment and purification, there are those who handle that aspect. When it comes to disposals and recycling, we need to deal with several suppliers.’ (Own English translation)

Within the ‘unbalanced transitions’ cases, we observed a general difficulty in coordinating activities, especially in Firm m, where we noticed a tendency to approach transitions with a rather adaptive attitude. One of the directors of the company stated:

‘For instance, we have [4.0] machines that were bought, delivered, and assembled but are still inactive…. The procurement and maintenance of these machines require different timelines compared

to machines that previously lacked sensors and technological components [the firm does not deal internally with that].' (Own English translation)

Fragmentation was also evident in companies c and h, primarily stemming from a lack of strategic alignment. In both cases, initiatives aimed to incorporate both digital and environmentally friendly aspects were reported, but without a distinct and fully developed strategic DS approach. For instance, in the case of Firm h, there was an investment in 4.0 packaging machine supported by an external technological provider, without considering the type of raw material needed and its sustainability implications. Similarly, some sustainability activities suffered from a similar lack of integration. The external technological provider lacked comprehensive knowledge of the company's production processes and capabilities. Consequently, the project failed to achieve the expected results and slowed down the transition. In both cases c and h, the firms had a heavy reliance on external agencies and consultants, specializing separately in green or digital domains, further exacerbating the fragmentation of initiatives.

In a quarter of the cases (b, e, k, s, l), we observed the presence of a weak twin transition, also here primarily characterized by adaptiveness and external dependency. For instance, the case b, highlighted how dependency on external suppliers is typical for companies with an artisanal character. In this case, the firm primarily invested downstream (in sales and communication) but with varying types of support for digitalization and sustainability (an e-commerce agency on one side, and suppliers of packaging material on the other). In Case l, external dependence was less pronounced compared to other cases and more initiatives seemed to have been undertaken due to the organization's efforts to identify new opportunities through business intelligence activities. However, some sustainability activities remained anyway underexplored, likely due to the leadership's limited understanding of what sustainability can entail. Addressing this challenge would probably necessitate additional external support capable of aligning new sustainability objectives with the existing digital initiatives already in place.

Indeed, across all five mentioned cases, it's evident that certain initiatives have been undertaken on both digital and sustainability fronts, highlighting a transition albeit with limited scope. These initiatives typically focused on enhancing specific operations. For instance, in the case of Firm k, investments in the Internet of Things were made to improve energy efficiency. Similarly, other companies have developed sustainable and digital activities aimed at enhancing packaging and communication. However, these efforts remain somewhat isolated and do not fully integrate digitalization and sustainability into the broader organizational strategy.

Case g, while not fully engaged in a twin transition, has been classified as 'possible' due to the leadership's clear intention to progress in both digital and green directions. The potential for

alignment is attributed to a more strategic approach toward digital and sustainability themes compared to previous cases. This strategic attitude involves customized consulting activities tailored to the firm's specific needs and requests and a more proactive stance toward integrating digitalization and sustainability into the organizational strategy.

For the remaining four cases (i,q,t,p), we labeled the twin transition perspective detected as a 'twin transition in progress'. Although these initiatives are still limited in scope, such as addressing logistics, waste, or energy issues, they have begun proactively within the companies. Despite relying on external support, the internal leadership in these cases demonstrated some strategic vision for the future, envisioning better intertwining of digital and green investments. The more formal approach of these companies to practices suggests that they may coordinate the various operational initiatives that have recently started to be undertaken.

Despite some innovations resulting from digitalization and sustainability investments, such as those implemented in Case i, facilitated by a key consolidated external support network, it's crucial to highlight that none of the investigated companies have demonstrated a robust and fully aligned twin transition. This absence of a comprehensive twin vision has hindered the ability to change business models or position the companies in new more transformative niches in the market.

In summary, our analysis reveals a widespread deficiency in strategic twin vision among most companies, where the integration of green and digital aspects often falls short. This deficiency is exacerbated by limited internal competencies within SMEs, which impede a seamless intersection of activities in the green and digital domains. The confluence of digital and environmental sustainability is primarily evident in addressing energy-related issues and sustainable packaging, highlighting the restricted scope of initiatives within the investigated companies.

The interviews conducted further emphasized that SMEs, especially in the digital sphere, heavily depend on specialized support from external partners, including agencies, local consultants, and technological providers. While the role of consultants is crucial, integrating both digital and green aspects seamlessly poses a challenge. The local external support network of those companies includes a variety of actors typically specialized in specific tasks such as communication, marketing, or machinery functions, and they primarily remain operating within their main domain of specialization.

5. Conclusion and policy implication

As the political debate and literature on transition have recently highlighted, green and digital transformation may be powerful tools when strategically intertwined to expedite the achievement of grand societal challenges and reinforce economic resilience. In this paper, we argue that these transitions can also pave the way for the potential rerouting of traditional economies. However, we

highlight that this is not an automatic process and misalignment at firms and at the level of local support are important barriers to overcome.

Our research reveals that the SMEs in the food sector of the Veneto region have yet to fully embrace the potential of a twin perspective. Across various cases we analysed, a very weak evolution stage emerges, revealing a general lack of local awareness regarding the transformative potential of integrating digital and green transformations.

We have observed that the twin transition in those SMEs is for now mainly adaptive and the current lack of strategic vision by the firm leadership and lack of internal resources play for sure a pivotal role in the misalignment within the population of SMEs. However, this misalignment extends to the local private network of SMEs support (consultants, agencies, technological providers), which, at present, demonstrates the ability to perform narrow and specialized tasks in digital and green directions due to the limitation of the main prevalent knowledge domains in which they operate. External providers often offer standardized solutions without considering the specific needs of the company. Relying too heavily on those providers without a reasoned path toward transformation can lead to failures and slowdowns of possible strategic rerouting.

The weakened evolution stage of the twin transition undertaken by the SMEs we observed could hinder their ability to pursue more positive and innovative future trajectories. Investment in digital and green transformations should extend beyond targeting specific environmental goals, such as energy efficiency and reducing food waste. To support the rerouting of firms in the local system, digital and green transformations should lead to innovation in business models, facilitating the adoption of digital technologies and green practices that enable alternative production methods and experimentation with innovative practices, creating new value that can be shared in the territory.

Addressing these misalignments requires raising awareness among key local stakeholders (institutional actors, policymakers, universities) regarding the dual perspective of green and digital transformations and their potential for inducing innovative change. For instance, consider the role that regional universities, research centers, and educational institutes could play in training firms and their local network of support, in developing new laboratories focused on a specialized place-based twin perspective, and in defining new common regional innovative scenarios. Additionally, intermediate organizations may play a role in identifying the need for new expertise and capabilities within local food systems. This will be achievable if the twin transition becomes a pursued and shared local government priority. Local policymakers should support new initiatives that promote collaborative projects within the local food specializations and create incentives for local collaborations (also among consultants) to expand the scope of expertise and share good practices regionally. This requires alignment across various intervention levels, including coherence in goals,

regulatory frameworks, and public interventions, as well as modifications to system level assets (Isaksen et al., 2020) that could support the intertwined nature of green and digital aspects in regional innovation strategies.

The paper contributes theoretically to understanding the dark side of transitions by considering different types of misalignments (e.g. misalignment in the business network, in the system of support, and in how the different perspectives are addressed in firms). It also explores the combined role of firm-level and system-level agency and conditions in the process of structural changes (Grillitsch et al., 2022). This work supports recent research that views transitions as a means for new regional industrial path developments rather than outcomes themselves (Chlebna, Martin, and Mattes 2023). Furthermore, it contributes to theoretical developments that consider the diversity of regional economic fabrics in Europe to develop evidence-based policy initiatives.

Like other studies relying on primary data analysis, this paper has limitations that could be addressed in future studies by adding other longitudinal or comparative analyses. Further research is needed to explore how local public stakeholders, beyond the private network of support, are addressing digital and sustainable transitions at the regional level. Future studies could also investigate the agency roles played by various key actors in the local value chain, going beyond local consultants, and analyse how their interests can be aligned to drive successful twin transitions.

Bibliography

Andersen, A.D, Frenken, K., Galaz, V., Kern, F., Klerkx, L., Mouthaan, M., Piscicelli, L., Schor, J.B., & Vaskelainen T. (2021). On digitalization and sustainability transitions. *Environmental Innovation and Societal Transitions,* 41, 96– 98.

Annosi, M. C., Brunetta, F., Bimbo, F., & Kostoula M.. (2021). Digitalization within food supply chains to prevent food waste. Drivers, barriers and collaboration practices. *Industrial Marketing Management* 93, 208-220.

Annosi, M.C., Brunetta, F., Monti, A., & Nati. F. (2019). Is the trend your friend? An analysis of technology 4.0 investment decisions in agricultural SMEs. *Computers in Industry* 109, 59– 71.

Bachtrögler-Unger, G., Balland, P-A., Boshma, R., & Schwab. T. (2023). *Technological capabilities and the twin transition in Europe Opportunities for regional collaboration and economic cohesion.* Bertelsmann Stiftung Report.

Bauer, H., Baur, C., Mohr, D., Tschiesner, A., Weskamp, T., Alicke, K., & Wee. D. (2016). *Industry 4.0 After the Initial Hype – Where Manufacturers are Finding Value and How They Can Best Capture It*. McKinsey Digital. Available at: https://www.mckinsey.com.

Bellandi, M., Santini, E. , Vecciolini C. & De Propris L. (2020). Industry 4.0 Transforming local productive systems in the Tuscany region. In *Industry 4.0 and Regional Transformations,* edited by L., De Propris and D. Bailey, D. London: Routledge.

Bianchini, S., Damioli, G. & Ghisetti C.. (2023). The environmental effects of the "twin" green and digital transition in European regions. *Environmental & Resource Economics,* 84 (4), 877–918. doi: 10.1007/s10640-022-00741-7.

Capobianco Uriarte, M.d.L.M., Cravero, R.A., Alfredo Regodesebes Urrutia, A., Grabois, M., & Casado Belmonte M.d.P. (2022). Research Trends and Innovation Perspectives about Sustainability and Agri-Food 4.0". In *Agri-Food 4.0* edited by Mor, R.S.,Kumar, D., & Singh A., Advanced Series in Management, volume 27, Emerald Publishing Limited, Bingley, pp. 1-15. doi: 10.1108/S1877-636120220000027001

Chlebna, C., Martin, H., & Mattes J. (2023). Grasping transformative regional development – Exploring intersections between industrial paths and sustainability transitions. *Environment and Planning A: Economy and Space*, 55(1), 222–234. doi: 10.1177/0308518X221137346

Coco, N., Colapinto, C. & Finotto V.. (2023). Bridging conflicting frames in policies for digital transformation. *Science and Public Policy* scad068. Doi: 10.1093/scipol/scad068

Coco, N., Colapinto, C. & Finotto V. (2024). Fostering digital literacy among small and micro-enterprises: digital transformation as an open and guided innovation process. *R&D Management* 54, 118– 136. doi: 10.1111/radm.12645.

Coleman, S., Göb, R., Manco, G., Pievatolo, A., Tort- Martorell, X., & Reis M.S. (2016). How can SMEs benefit from big data? Challenges and a path forward. *Quality and Reliability Engineering International,* 32 (6), 2151–2164.

Coskun-Setirek, A., & Tanrikulu Z. (2021). Digital innovations-driven business model regeneration: A process model, *Technology in Society* 64. doi:10.1016/j.techsoc.2020.101461.

de Sousa Jabbour, A.B.L., Jabbour, C.J.C., Godinho Filho, M., & Roubaud, D. (2018). Industry 4.0 and the circular economy: a proposed research agenda and original roadmap for sustainable operations. *Annals of Operations Research,* 270 (1), 273– 286.

Denicolai, S., Zucchella, A., & G. Magnani. (2021). Internationalization, digitalization, and sustainability: are SMEs ready? A survey on synergies and substituting effects among growth paths. *Technological Forecasting and Social Change* 166, 120650. doi: 10.1016/j.techfore.2021.120650

De Propris, L., & Bailey D. (2020). Disruptive Industry 4.0 +: key concepts. In *Industry 4.0 and Regional Transformations* edited by L. De Propris and D. Bailey. London: Routledge. doi: 10.4324/9780429057984.

Dicken, P. (2015). *Global Shift: Mapping the Changing Contours of the World Economy*. 7th edition. Guilford Press

Diodato, D., Huergo, E., Moncada-Paternò-Castello, P., Rentocchini F., & Timmermans B., (2023). Introduction to the special issue on 'the twin (digital and green) transition: handling the economic and social challenges' *Industry and Innovation,* 30(7), 755– 765. doi:10.1080/13662716.2023.2254272.

European Commission. (2019). *A European Green Deal*, available at: https://ec.europa.eu/info/ strategy/priorities-2019-2024/european-green-deal_en.

European Commission. (2021). *A Green and Digital Transformation of the EU*. Ministerial Declaration. DigitalDay2021.

European Commission. (2022). Joint Research Centre, Muench, S., Stoermer, E., Jensen, K., et al. *Towards a green & digital future: key requirements for successful twin transitions in the European Union*, Publications Office of the European Union. doi:10.2760/977331

Eurostat (2023). *Key figures on the European food chain*. Luxembourg: Publications Office of the European Union.

González Chávez, C.A, Holgado, M., Öhrwall Rönnbäck, A., Despeisse, M., & Johansson B. (2021). Towards sustainable servitization: A literature review of methods and frameworks. Procedia CIRP 104, 283-288. doi: 10.1016/j.procir.2021.11.048.

Götz, M., & Jankowska B. (2017). Clusters and Industry 4.0–do they fit together? *European Planning Studies,* 25(9), 1633– 1653.

Grillitsch, M., Asheim, B., Isaksen, A., & Nielsen, H. (2022). Advancing the treatment of human agency in the analysis of regional economic development: Illustrated with three Norwegian cases. *Growth and Change*, 53, 248–275.

Isaksen A, Langemyr Eriksen E, & Rypestøl JO. (2020). Regional industrial restructuring: Asset modification and alignment for digitalization. *Growth and Change*, 51, 1454–1470.

Isensee, C., Teuteberg, F., Griese, K. M., & Topi C. (2020). The relationship between organizational culture, sustainability, and digitalization in SMEs: A systematic review. *Journal of Cleaner Production*, 275, 122944.

Ismea (2023). *Rapporto sull'agroalimentare italiano*. Roma.

Findik, D., Tirgil, A. & Özbuğday, F. C. (2023). Industry 4.0 as an enabler of circular economy practices: Evidence from European SMEs. *Journal of Cleaner Production,* 410, 137281.

Gabrielli, V. and B. Balboni. (2010). SME practice towards integrated marketing communications. *Marketing Intelligence & Plannin,g* 28, 275–290.

Ghobakhloo, M. (2020). Industry 4.0, digitization, and opportunities for sustainability. *Journal of Cleaner Production,* 252.

Journeault, M., Perron, A. & Vallières L.. (2021). The collaborative roles of stakeholders in supporting the adoption of sustainability in SMEs. *Journal of Environmental Management,* 287. Doi: 10.1016/j.jenvman.2021.112349.

Khan, S. A. R., Razzaq, A., Yu, Z., & Miller S. (2021). Industry 4.0 and circular economy practices: A new era business strategies for environmental sustainability. *Business Strategy and the Environment,* 30(8), 4001-4014.

Liao, Y., Deschamps, F., Loures, E..F.R., & Ramos L.F.P. (2017). Past, present and future of industry 4.0 – a systematic literature review and research agenda proposal. *International Journal of Production Research*, 55, 3609– 3629. doi:10.1080/00207543.2017.1308576.

Mäkitie, T., Hanson, J., Damman, S., & Wardeberg M. (2023). Digital innovation's contribution to sustainability transitions. *Technology in Society*, 73. doi: 10.1016/j.techsoc.2023.102255.

Maucorps, A., Römisch, R., Schwab, S., & Vujanović N.. (2023). The Impact of the Green and Digital Transition on Regional Cohesion in Europe. *Intereconomics,* 58(2), 102– 110.

Ministero dello Sviluppo Economico (2018). *Piano nazionale industria 4:0*. https://www.mise.gov.it/images/stories/documenti/guida_industria_40.pdf.

Montresor, S., & Vezzani A. (2023). Digital technologies and eco-innovation. Evidence of the twin transition from Italian firms. *Industry and Innovation*, 30(7), 766– 800. doi: 10.1080/13662716.2023.2213179

Morisson, A., & Pattinson M. (2021). *Clusters Drivin the Green and Digital Twin Transitions.* Lille: Interreg Europe Policy Learning Platform. Policy Brief.

Moşteanu, N.R. (2020). Green Sustainable Regional Development and Digital Era. In *Green Buildings and Renewable Energy, Innovative Renewable Energy* edited by *A.,* Sayigh, 181-97. Cham: Springer. doi:10.1007/978-3-030-30841-4_13.

Nomisma. (2020). L'industria alimentare italiana oltre il Covid-19. Competitività, impatti socio-socio-economici, prospettive. Egea

Ortega-Gras, J.-J., Bueno-Delgado, M.-V., Cañavate-Cruzado, G., & Garrido-Lova J. (2021). Twin Transition through the Implementation of Industry 4.0 Technologies: Desk-Research Analysis and Practical Use Cases in Europe. *Sustainability,* 13, 13601.doi:10.3390/su132413601.

Pelletier, C. & Cloutier, L.M. (2019). Conceptualising digital transformation in SMEs: an ecosystemic perspective. *Journal of Small Business and Enterprise Development,* 26 (6/7), 855–876.

Plechero M., & Grillitsch M.. 2023. Advancing innovation in manufacturing firms: knowledge base combinations in a local productive system. *European Planning Studies,* 31(6), 1247– 1269. doi:10.1080/09654313.2022.2122705.

Plechero, M., Santini, E., & Corò G. (2023). Through firms' eyes: How SMEs define technological spaces and trajectories in the digital era. Department of Management, Università Ca' Foscari Venezia Working Paper No. 9. https://ssrn.com/abstract=4656191

Poore, J., & Nemecek, T. (2018). Reducing food's environmental impacts through producers and consumers. *Science,* 360, 987– 992. doi:10.1126/science.aaq0216

Raj A., Dwivedi G., Sharma A., de Sousa Jabbour A.B.L., & Rajak S. (2020). Barriers to the adoption of industry 4.0 technologies in the manufacturing sector: An inter-country comparative perspective. *International Journal of Production Economics,* 224

Ramirez, P. (2020). Sustainable manufacturing Creating a regional forest- based bio-economy. In *Industry 4.0 and Regional Transformations* edited by L. De Propris and D. Bailey. London: Routledge. 97-111.

Rehman, S.U. , Giordino, D., Zhang, Q. & Alam G.M. (2023). Twin transitions & industry 4.0: Unpacking the relationship between digital and green factors to determine green competitive advantage. *Technology in Society*,73.

Reischauer, G. (2018). Industry 4.0 as policy-driven discourse to institutionalize innovation systems in manufacturing. *Technological Forecasting and Social Change*, 132, 26– 33. doi:10.1016/j.techfore.2018.02.012.2

Rymaszewska, A., Helo, P., & Gunasekaran A. (2017). IoT powered servitization of manufacturing– an exploratory case study. *International journal of production economics* 192, 92– 105.

Salpina, D., & Pagliacci, F. (2022). Are We Adapting to Climate Change? Evidence from the High-Quality Agri-Food Sector in the Veneto Region. *Sustainability*, *14*, 11482. doi:10.3390/su141811482

Sareen, S., & Haarstad, H. (2021). Digitalization as a driver of transformative environmental innovation *Environmental Innovation and Societal Transitions* 41, 93– 95.

Sharma, R. de Sousa, L. Jabbour, A. B.,Vranda, J., & Anjali S. (2022). The role of digital technologies to unleash a green recovery: pathways and pitfalls to achieve the European Green Deal. *Journal of Enterprise Information Management* 35 (1), 266– 294.