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Research article

The twin transition and flexible work arrangements: A systematic literature review

Luca Alfieri [a,b,*], Ilaria Mariotti [b], Federica Rossi [b]

[a] Politecnico di Milano- DAStU. Politecnico di Milano, Piazza Leonardo da Vinci, 32, 20133, Milano, Italy
[b] University of Tartu, School of Economics and Business Administration, Narva mnt 18, 51009, Tartu, Estonia

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ABSTRACT

The main idea behind the green and digital transition (twin transition) is to use technology to develop more efficient and productive systems, provide remote access to employment opportunities (Flexible Working Arrangements-FWAs), and broaden the structure of the labour market, while encouraging more sustainable production, workplaces, and society at large. Within this context, the paper systematically reviews literature on the interaction between FWAs and the twin transition (digital and green) using the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) framework, and paying special attention to their implications for the environment, society, and urban areas. This review fills a gap in the literature, showing how a growing but still limited number of scholars are approaching the topic. Most of the papers explore the impact of FWAs on energy use and the need for targeted policies to ensure a just transition that accounts for the social impact. Furthermore, the selected manuscripts place significant emphasis on the restructuring process of business models, on the complex and non-trivial relationship between digital tools and FWAs, and on the effects of work-life balance on employees. Many studies stem from the post-pandemic period, highlighting the Covid-19 pandemic as a catalyst for change. These findings underscore the emerging importance of FWAs in green and digital transition for a more resilient future.

1. Introduction

The ongoing advancements in ICT (Information and Communication Technology), automation, and artificial intelligence significantly impact society and work. Simultaneously, the environmental crisis necessitates more sustainable lifestyles (Andersen et al., 2021) and production systems. The central idea of the green and digital transition (hereafter, twin transition) is to use technology to create more effective and productive systems, offer remote access to job opportunities, and expand the labour market structure, while promoting more sustainable production, work environments, and society at large.

Flexible work arrangements (Table 1) – FWAs – (i.e., all potential agreements between employers and workers that deviate from regular full-time employment at the employer's premises) are rapidly spreading (Wheatley, 2021; Barrero et al., 2023; Eurofound, 2023). Shifrin and Michel (2022) argue that FWAs have two characteristics, precisely where the work is performed (flexplace) and when (flextime). A growing scholarly interest, especially after the COVID-19 pandemic, has emerged in the "flexplace" aspect of FWAs. Among these arrangements, we can refer to (i)[1] remote working (RW) when workers wholly or partially perform their tasks and duties from an alternative location to the default workplace (i.e., employer's/client's premises or public space) (ILO, 2020); (ii) "hybrid working", when workers just go to the workplace for a given number of days per week or month (Eurofound, 2023); (iii) "digital nomadism", when workers can work remotely and travel simultaneously, autonomously choose the location where to work, and visit at least three locations a year that are not their own or a friend's or family home (Cook, 2023). Several studies focus on the impact of FWAs on individuals (Kelly and Moen, 2020; Alfano et al., 2024; Barrero et al., 2023), organisations (Barrero et al., 2021), and territories (Ramani and Bloom, 2021; Delventhal et al., 2022; Gokan et al., 2022; Bond-Smith and McCann, 2022; Biagetti et al., 2024), while less attention is given to

* Corresponding author. Politecnico di Milano- DAStU. Politecnico di Milano, Piazza Leonardo da Vinci, 32, 20133, Milano, Italy
E-mail addresses: luca.alfieri@polimi.it (L. Alfieri), ilaria.mariotti@polimi.it (I. Mariotti), federicamaria.rossi@polimi.it (F. Rossi).

[1] The term remote working includes other flexible ways of working, such as teleworking, smart and agile working, as well as working from home (WFH) (ILO, 2020).

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Table 1
Flexible working arrangements and their definitions.

Flexible working arrangement	Definition
Remote working	Workers wholly or partially perform their tasks and duties from an alternative location to the default workplace (i.e., employer's/client's premises or public space) (ILO, 2020).
Teleworking	The work carried out remotely implies the use of technological devices (e.g., computers, tablets, mobile phones), and it is often limited to employees only (Messenger et al., 2017).
Working from home	The work is either entirely or partly done within the worker's home (ILO, 2020).
Smart and agile working	The work is partly carried out in the office and partly remotely to accommodate the need to balance work and family commitments (Weber et al., 2020).
Hybrid working	Workers go to their traditional workplace for a given number of days per week or month (Eurofound, 2023).
Digital nomadism	Workers can work remotely and travel simultaneously. They can autonomously choose the location where to work, and visit at least three locations a year that are not their own or a friend's or family's home (Cook, 2023).

the interplay between FWAs and twin transitions.[2]

Nevertheless, the twin transition not only reshapes industries through green and digital transformations but also demands a workforce equipped with new skill sets to navigate these shifts effectively (Beducci et al., 2024). Within the context of FWAs, the integration of digital technologies and sustainable practices has a profound impact on job roles, training requirements, and workforce adaptability. For example, RW and hybrid models inherently rely on proficiency with digital tools, while digital nomadism amplifies the need for self-management and adaptability to diverse environments. These arrangements further emphasise the importance of integrating sustainability skills into traditional STEM (science, technology, engineering and mathematics) subjects, allowing professionals to align digital innovation with upskilling needs (Cavallini and Soldi, 2023).

As organisations and individuals embrace flexible work structures, upskilling becomes essential to ensure that productivity gains from digital tools do not impair the environmental benefits of the green transition. Training programmes emphasising resilience skills, digital fluency, and specialised technical knowledge can bridge the gap between flexible working models and the broader goals of the twin transition (Hofmann Trevisan et al., 2024). Moreover, fostering an understanding of sustainable practices within digital workspaces—such as optimising energy use, minimising virtual carbon footprints, and promoting resource-efficient operations—can enhance the alignment between work modalities and green objectives (Vitti et al., 2024). These synergies underscore the critical role of human skills in ensuring that FWAs contribute positively to both digital innovation and environmental sustainability.

Within this context, the current paper aims to fill this gap in the literature by adding new insights into the link between FWAs and the twin transition. It systematically reviews and synthesises existing studies by using the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) framework (Hofmann Trevisan et al., 2024; Tahir et al., 2024; Panzarella et al., 2023; Page et al., 2021a; Page et al., 2021b; Pantelaki et al., 2021) to explore how FWAs intersect with the digital and green transitions, with particular attention to their environmental, social, and urban implications.

Furthermore, it is still unclear whether remote working and hybrid working can help reduce carbon emissions and energy consumption, or if they could potentially cause more harm than good to the environment. In addition, social aspects such as social isolation, negative impacts on careers, and potential increases in inequalities are issues to be considered as well. Some scholars suggest that the outcome of the potential benefits of FWAs from both a social and environmental perspective can depend on specific policies concerning urban planning and the organisation of workplaces. Specifically, the COVID-19 pandemic is seen as an accelerator of processes already in place (Amankwah-Amoah et al., 2021). Finally, digital nomadism and its intersection with the twin transition is still an unexplored area of research. The following research questions have been framed within this context: (i) To what extent can insights from the existing research on FWAs, digitalisation, and green transition inform our understanding of potential interactions among these three issues? (ii) What evidence does the literature provide regarding the potential environmental benefits or drawbacks of FWAs within the context of the twin transition? (iii) How do current studies describe the social and urban implications of FWAs in relation to the twin transition?

The paper is organised in four sections. Following Kraus et al. (2020), in section 2, we illustrate the theoretical background of this study. Section 3 presents data and methodology. The results of the systematic literature review through PRISMA are discussed in section 4. Conclusions and further research bring the paper to a close.

2. Theoretical background

In 2019, before the COVID-19 pandemic, the prevalence of RW in EU countries was very heterogeneous (Sostero et al., 2020). In northern Europe (Sweden, the Netherlands, Luxembourg, Finland and Denmark) 25 % of employees worked remotely on a regular basis or at least a few days per month. In contrast, in Italy, Cyprus, Romania and Bulgaria the percentages were much lower. This diversity can be traced to certain structural factors typical of each of the European economies, such as the size of enterprises, specialisation in both knowledge and innovation-intensive sectors, and organisational culture. Moreover, the different regulatory frameworks have a significant influence on the way companies manage work (Vargas Llave and Weber, 2020). The economic activities that are best suited to the RW model are professional, scientific, technical, finance and insurance, and public administration (Sostero et al., 2020; Baruffini and Rossi, 2024). The occupations best suited to the RW model are legislators, entrepreneurs, senior management; intellectual, scientific, and highly specialised professions; qualified professions in commercial activities and services; executive professions in office work (Mariotti et al., 2022). Nevertheless, RW is more related to the task content of occupations (e.g., the relevance of using a computer and the capacity to work from home) than to the workers' skills, since not all skilled workers can work from home, thus showing the increasing relevance of the so-called "task-based approach" (Vannutelli et al., 2022).

The pandemic marked a significant increase in RW in most EU countries. The survey conducted by Eurofound indicates that remote working decreased overall in spring 2022, with two out of three respondents working exclusively from the office (Eurofound, 2022). As pandemic restrictions were eased, many employees returned to their employers' premises, with a subsequent reduction in people working from home (12 % of employees worked entirely from home in spring 2022). Meanwhile, hybrid work (e.g., performed partly remotely and partly at the place of work) has gained ground (the percentage of employees engaged in hybrid work increased from 14 % in summer 2020 to 18 % in summer 2022), and the majority of EU workers have said that they prefer working from home several times a week in the long run. The FWAs, highlighted by the existing literature, are summarised in Table 1. This choice impacts the overall sustainability of the territories, and is part of the strategies promoting the twin transition. The reduction in the number of trips to the office affects traffic, congestion, and the

[2] The Horizon REMAKING project (https://remaking-project.eu/) focuses on these effects.

environment, as it reduces the amount of carbon emissions generated by transportation. According to a study by Global Workplace Analytics,[3] greenhouse gas emissions would be reduced by 54 million tonnes per year, if the US workforce worked from home only half of the time. The companies are also striving to become carbon-negative by 2030 through the promotion of remote and hybrid work. For example, Microsoft has pledged to remove more carbon from the atmosphere than it emits. Google has also committed to using 100 per cent renewable energy for its data centres and offices by 2030.

However, the results of previous studies were not conclusive. Indeed, there is a reduction in commuting (Morfeldt et al., 2023; Stermieri et al., 2023a), but workers might use private cars for leisure activities, shopping, etc. (E Silva and Melo, 2018; Bisello and Profous, 2022).

3. Methodology and data

3.1. Systematic review protocol

The systematic literature review follows the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines (Page et al., 2021a, 2021b), which provide a rigorous and transparent framework for identifying, screening, and synthesising academic literature.[4] It aims to investigate the relationship between FWAs and the twin transition.

3.2. Search strategy and literature identification

Key information concerning the study's inclusion and exclusion criteria is presented in Table 2.

The search for relevant records was conducted through two databases, namely Scopus and Science Direct,[5] checking the manuscripts' titles, abstracts and keywords. The first search phase process involved identifying the following keywords for constructing Boolean operators to be used in both Scopus and Science Direct.

- "remote work" OR "remote working" OR "telework" OR "teleworking" OR "hybrid work" OR "hybrid working" OR "working from home" OR "work from home" OR "digital nomad" OR "digital nomadism" OR "workation" AND "twin transition".

Table 2
Study inclusion and exclusion criteria.

Criteria	Description
C1	No time filter has been applied.
C2	Articles must come from peer-reviewed scholarly journals, books and book chapters in peer-reviewed books, with database searches conducted in Scopus and ScienceDirect.
C3	Data are identified through snowball sampling methodology.
C4	Works need to be written in English
C5	Works need to include both aspects of the Twin Transition (TT) and at least 2 mentions about flexible working arrangements in the text.

Notes: The data were collected from October to December 2023; publications in press in early 2024 are included.
Source: adopted from Reina et al. (2023).

[3] https://globalworkplaceanalytics.com/.
[4] Besides, elements coming from Reina et al. (2023) are considered.
[5] We did not include Google Scholar because it also captures technical reports, while strictly peer-reviewed databases such as Scopus and Science Direct do not (Grover et al., 2023).

Considering that some papers may focus more on one of the two transitions but still retain some relevant parts of the other one, we matched the same keywords[6] with digital transition and green transition as follows.

- for digital transition: "remote work" OR "remote working" OR "telework" OR "teleworking" OR "hybrid work" OR "hybrid working" OR "working from home" OR "work from home" OR "digital nomad" OR "digital nomadism" OR "workation" AND "digital transition";
- for green transition: "remote work" OR "remote working" OR "telework" OR "teleworking" OR "hybrid work" OR "hybrid working" OR "working from home" OR "work from home" OR "digital nomad" OR "digital nomadism" OR "workation" AND "green transition" OR "green transformation".

No filters were applied to searches. Both databases were requested to check for all the years, in all parts of the records, for any type of manuscripts (articles, contributions in books, books, etc.). The main idea was not to restrict the search only to a few years after the concept of twin transition was conceived but to, instead, identify possible past papers where issues of different FWAs relate to digital and green changes.

Scopus provided 148 records, and Science Direct 416, reaching a total of 564 records.

3.3. Selection process

During the selection process, duplicate records (85) were removed, and other records were excluded because they were clearly outside the scope of the research (316).

A second step in the selection process was the screening phase. Firstly, we checked the abstracts of the remaining 163 records to understand if they could potentially be of interest, considering the goal of the systematic literature review; 82 records were excluded through this step. The remaining 81 records were later assessed in the entirety of their texts for eligibility. The main criteria were the following.

- both aspects of the twin transition should be present, at least in part, in the text of the papers;
- at least one of the FWAs cited in the paper is mentioned at least twice. This excludes simple citations of the literature in the introduction or in the literature review, therefore not adding new insights on the topic.

Finally, overall 21 records were included in the systematic literature review. All the steps of the process are shown in Fig. 1.

The digitalisation process and FWAs are strictly connected in all papers, whereas the connection between twin transition and FWAs remains neglected by the literature. In Table 3, we show three examples of citations that helped in the last phase of screening. Table A1 in the Appendix shows the distribution of papers per journal and year. We can notice how most of the papers have been published between 2020 and 2023. The most relevant outlets for the subject are *Sustainability and Energy Research & Social Science*.

3.4. Data extraction framework

We create a thorough data extraction methodology that records both bibliographic and substantive information to methodically examine the chosen manuscripts. We retrieve important bibliographic information

[6] We dropped "workation" in the following queries because apparently neither of the two databases was able to properly recognise the word. Science Direct is able to identify 190 papers but none of them are about "workation" and most of them are duplicates of the previous queries.

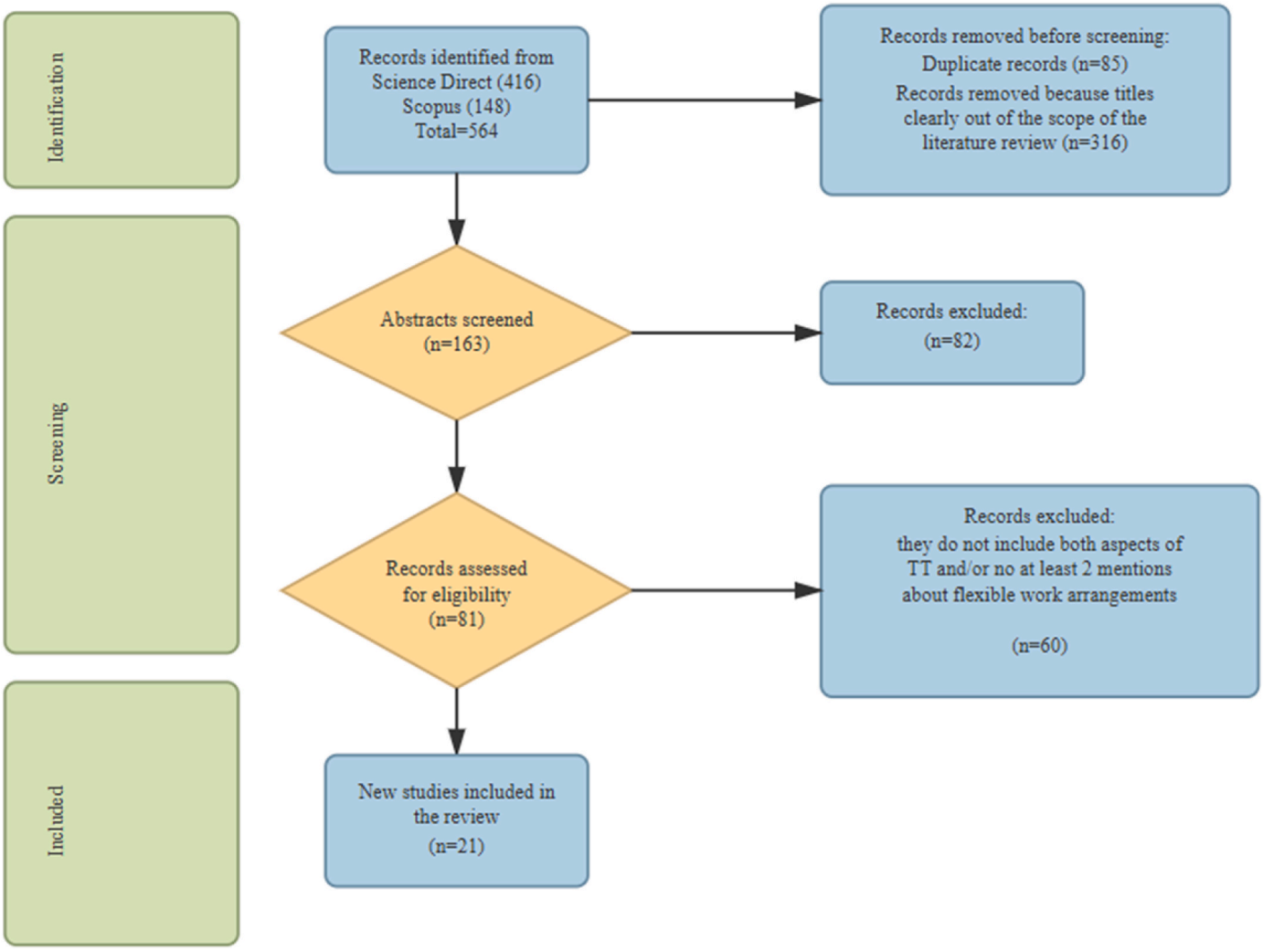

Fig. 1. PRISMA flow chart.

Table 3
Example of citations that provide information for the last screening.

Authors	Citations
Stermieri et al. (2023a)	*"[…] any gains in emissions attained by the reduction of commuting and energy demand for transport and the energy savings achieved in the tertiary sector are offset by the increase in the residential heating demand. This highlights the need for a holistic assessment of teleworking. For example, an increase in teleworking days should be complemented by incentives for investing in new technologies and renovation practices in old buildings." (p.15)*
Khanna et al. (2023)	*"Telecommuting has gained wider acceptance since the COVID-19 pandemic but the impacts on economy-wide energy use are not straightforward. A review confirmed that 26 out of 39 studies show energy reduction - by as much as 77 % - from teleworking, while 8 studies suggest that teleworking increases or has a neutral impact on energy use." (p.7)*
Baldassa et al. (2023)	*"Specifically, telework and MaaS are negatively related, since individuals showing a low willingness to telework in the future are likely to commute a lot; therefore, their likelihood to subscribe MaaS for its use is higher than for teleworkers, who tend to travel less frequently than the former." (p.7)*

from each of the 21 chosen articles, such as the authors, the year of publication, and the journal or book where the work was published. In addition to these core indicators, we record the methodology used in each study, acknowledging that the relationship between FWAs and twin transition has been investigated using a variety of research methodologies, from qualitative case studies to quantitative modelling exercises. We also evaluate the relevance of COVID-19 to each study, noting whether it was a relevant factor or not, given the temporal concentration of publications that followed the pandemic.

Finding important information about FWAs in the context of the twin transition is the main goal of our extraction framework. We created a topic categorisation framework iteratively through preliminary reading of the chosen manuscripts to enable systematic synthesis across various research. Three primary categories of impacts are distinguished under this paradigm. We started by determining the environmental impacts. Second, we classified social impacts, such as shifts in the balance between work and life. Third, we looked at territorial and urban impacts.

Given that much research falls into more than one category, we can systematically label each paper based on whether and how it addresses environmental, social, and urban dimensions using this categorisation methodology. During the review process, the framework was improved to ensure it included the essential ideas pertinent to our research objectives, and was adaptable enough to account for the many viewpoints and conclusions in the chosen literature.

3.5. Descriptive characterisation of the studies

To provide a comprehensive understanding of the research landscape at the intersection of FWAs and twin transition, we conducted a

descriptive characterisation of the selected literature corpus. This analysis situated our findings within the broader academic discourse, revealing patterns on how this emerging field is being studied. We looked at how chosen manuscripts are distributed among subjects. Since many journals cover a variety of topics, we took these overlaps into account in our study, realising that interdisciplinary publication venues are especially crucial for this new field.

Understanding the evolution of scholarly attention to this topic, especially in light of significant disruptions like the COVID-19 epidemic, required an understanding of the temporal distribution of publications. To find patterns in research output across time, we thus examined the year of publication (based on online publishing dates). In addition to this temporal analysis, we looked at the methodological strategies used in the chosen studies, making a distinction between mixed-method designs, which combine several research strategies, qualitative techniques like case studies and interviews, and quantitative techniques like modelling and statistical analysis. This methodological analysis shed light on the kinds of evidence being used to address issues related to twin transition and FWAs.

Lastly, by looking at author affiliations across the articles, we examined the geographic distribution of research activities. The research communities and national contexts that were most actively addressing the relationship between FWAs and sustainability transitions were identified by this analysis. We could gain a better understanding of how local policy frameworks, labour market structures, and cultural factors may be influencing research goals in this field by finding concentrations of scholarly activity in specific nations or regions. When taken as a whole, these descriptive analyses offered crucial background information for understanding the findings in section 4.

The results of the selection process are presented in Table 4, showing (i) the authors of the papers/chapters; (ii) the year of publication; (iii) the name of the journal or book, and the title of the paper/chapter; (iv) the methodology used; (v) if COVID-19 is a very relevant part of the research; (vi) insights and/or results related to FWAs in the context of the twin transition.

In Fig. 2, the selected literature exhibits strong methodological skew toward qualitative approaches, with 12 papers (57 %) employing qualitative methods, 7 papers (33 %) using quantitative methods, and 2 papers (10 %) adopting mixed methods. This distribution likely reflects the exploratory nature of twin transition research and the limited availability of systematic data on the intersection of FWAs with both environmental and digital indicators. The prevalence of case studies, particularly concentrated in specific European contexts, raises questions about generalisability.

Fig. 3 shows that Continental European authors (61) substantially outnumber Anglo-Saxon authors (16).[7] This geographic pattern contrasts with much management and organisational literature, which typically shows Anglo-American dominance. Several factors may explain this pattern. First, the European Commission's strong policy emphasis on both digital and green transitions, formalised in policy frameworks and funding mechanisms, creates incentives for European researchers to investigate these topics. Second, certain European countries experienced more dramatic digital transformation during the pandemic due to lower pre-pandemic digitalisation baselines (European Commission, 2020), making the phenomenon more salient for researchers in these contexts. Italian institutions appear in four papers for author affiliations, Swiss institutions in three papers, while Romanian and Polish institutions appear in only one paper each. This concentration may reflect varying digital infrastructure readiness before the pandemic (European Commission, 2020), and differential policy emphasis on environmental issues (European Commission, 2023a; European Commission, 2023b, 2024).

Fig. 4[8] shows the number of articles published by different universities. Publications are more or less equally distributed per university, with almost all of them counting one publication, and only two exceptions with 2 manuscripts. This confirms the infancy of the subject where no university can claim to be a main centre of studies of FWAs and twin transition. Instead, Fig. 5 shows the type of research institutions working on FWAs and twin transition. Most of the studies are conducted by academics (77 %), and 14 % by researchers from public institutions that are not a university. The last 9 % is produced by private research institutes. These results are not surprising as the subject can be more easily related to public interest than to private interest.

4. Results and discussion on the results

4.1. Thematic analysis

The systematic review of 21 manuscripts reveals distinct thematic patterns in how scholarly literature addresses the intersection of FWAs and the twin transition. This section presents a rigorous thematic analysis organised around three subsections, precisely digital transition and FWAs; green transition and FWAs; twin transition and FWAs.

4.1.1. Digital transition and FWAs

Digital transformation emerges as the foundational enabler of contemporary FWAs across all selected manuscripts. The analysis reveals that digitalisation is not merely a technical prerequisite but fundamentally reshapes the conceptualisation and implementation of flexible work arrangements. All 21 manuscripts acknowledge the critical role of digital infrastructure and technologies in facilitating remote and hybrid work arrangements, though they approach this relationship from different analytical perspectives.

The enabling dimension of digital transition manifests in multiple ways. Through their model using a very large dataset of countries (185) from 1990 to the pre-Covid-19 period, Liu et al. (2023) demonstrate how increased internet penetration stimulates more efficient solutions, including remote working, virtual meetings, and smart technologies. Fouquet and Hippe (2022) provide historical context using data from major European economies starting from 1850, showing that digitalisation has fundamentally increased the ability of much of the workforce to work remotely. This was essential during the pandemic. The technological infrastructure—ranging from high-speed internet connectivity to collaborative software platforms—created conditions under which organisations can rapidly scale FWAs when physical distancing is necessary.

Beyond mere enablement, digital transition drives profound organisational transformations. Table 5 shows the different types of impacts in the selected manuscripts. Among papers examining social impacts (18 manuscripts, 85.7 % of the total), a large part of them explicitly discusses how digital technologies need business model restructuring and human resource management innovations. Böttcher et al. (2024) argue that digital technology transcends simple optimisation of logistics or enabling of remote work; rather, it integrates sustainability aspects as an integral component of organisational identity and business model logic. This finding suggests that digitalisation facilitates essential workplace redesign rather than simply relocating existing work practices to new settings.

The relationship between digitalisation and work organisation extends to emerging employment forms. Liu et al. (2023) establish connections between digital platforms and the gig economy, noting that gig economy workers demonstrate a higher propensity to rely on flexible working arrangements. Storey (2023) examines digitalisation's impact on the mining sector, especially in Canada and Australia, during a period of 15 years, revealing that automation, data availability, and improved

[7] Australia, Canada, UK, and USA.

[8] This figure is based on a similar one in Fernández (2023).

Table 4
Results of the selection process.

Author(s) and year	Journal/Book	Title	Methodology/timeframe/Region or country/ies of interest	Relevance of COVID-19	Insights/results
Lovelace and Philips (2014)	Geoforum	The 'oil vulnerability' of commuter patterns: A case study from Yorkshire and the Humber, UK	Case study/quantitative Spatial microsimulation model; data from 2001 surveys. Yorkshire and the Humber, UK.	no	Policies encouraging telecommuting need to be more targeted on different workers' typologies.
Elliot et al. (2020)	Environmental and Resource Economics	Suggestions for a Covid-19 Post-Pandemic Research Agenda in Environmental Economics	Policy analysis/qualitative, 2020; international framework.	yes	Negative and positive effects of WFH. Post-pandemic green transition needed greater cultural, social, and political changes.
Elavarasan et al. (2021)	Sustainable Cities and Society	A hover view over effectual approaches on pandemic management for sustainable cities – The endowment of prospective technologies with revitalization strategies	Policy and scenarios analysis/SWOT analysis/qualitative; Covid-19 period (but issues related to other pandemics in 1918 and 2003 considered); international framework.	yes	The pandemic brought larger collaboration via RW among experts thanks also to social media connections. Economic growth in the upcoming years must pay attention to middle and low-income earners and RW plays a role.
Mihai et al. (2021)	Sustainability	The Challenges of the Green Economy in Romania. Scientific Literature Review	Systematic literature review/ qualitative; literature considered from 2007 to 2021, country of interest: Romania	no	Twin transition can increase social exclusion. Telework has two opposing effects on an individual's well-being (paradox): autonomy and work-life balance, but detrimental impact on professional relationships and career.
Noussan and Jarre (2021)	Energies	Assessing commuting energy and emissions savings through remote working and carpooling: Lessons from an Italian region	Quantitative, metrics' calculations; data used from the origin and destination (OD) matrix published by the Lombardy region; authors used updated OD 2020 version. ODs collected from 2015; region of interest; Lombardy.	no	The potential contribution of RW to lower the GHG emissions is strongly connected to the diffusion of this arrangement across commuting trips. Increasing the amount of RW would bear more significant results if applied non-homogeneously across workers and, specifically, if based on commuting distance.
Angelidou et al. (2022)	Technological Forecasting & Social Change	Emerging smart city, transport and energy trends in urban settings: Results of a pan-European foresight exercise with 120 experts	Survey/Qualitative, Delphi questionnaire submitted by 120 field experts; data collected from November to December 2020; international framework (mostly European experts).	no	RW can remove the advantages of economies of scale related to mass public transport or organized working environments.
Babapour Chafi et al. (2021)	Sustainability	Post-pandemic office work: perceived challenges and opportunities for a sustainable work environment	Case study/Qualitative, workshop with 53 people in total; data collection from November 2020 to May 2021; country of interest Sweden.	yes	Hybrid work is preferable. Employers are expected to provide support and re-design the physical and digital workplaces for the employees. No clear relationship between energy consumption and RW.
Fouquet and Hippe (2022)	Energy Research & Social Science	Twin transitions of decarbonisation and digitalisation: A historical perspective on energy and information in European economies	Quantitative, historical data analysis; data from 1850 to 2019; countries of interest: selection of major European economies.	no	Digitalisation has increased the ability of much of the workforce to work remotely during the pandemic. The pandemic has enhanced housing relocations outside urban centres, with both positive and negative impacts on transport use and associated energy consumption.
Isensee et al. (2022)	Sustainability	Exploring the Use of Mobile Apps for Fostering Sustainability-Oriented Corporate Culture: A Qualitative Analysis	Qualitative, 16 expert interviews plus literature review and analysis of 4 apps available in German language; interviews conducted between May and July 2021; international framework, in principle, but based on German language.	no	During the pandemic, businesses had to reorganise their processes and manage the new digital work environment (e.g., increasing the RW share). Collaboration and cooperation between leadership and employees on sustainability. Use of Apps that help to foster a sustainability culture. Blue-collar workers might be neglected in the implementation of digital tools, home office opportunities and culture development.
Roberto et al. (2023)	Contribution of the book "Intelligent Environments - Advanced Systems for a Healthy Planet"	Smart working and flexible work arrangements: opportunities and risks for sustainable communities	Qualitative, analysis of various kinds of literature (not only academic) and legal framework; timeframe; last decades from the 1990s till the end of 2020; European level analysis with some specific considerations to Italian cases.	no	Working remotely is not necessary for everyone. Teleworking is requested by both employees and employers but for different reasons. Workloads, longer and non-routine working hours can be a negative side of telework if the firm requires high performance from the employees. Risk of isolation due to

(*continued on next page*)

Table 4 (*continued*)

Author(s) and year	Journal/Book	Title	Methodology/timeframe/Region or country/ies of interest	Relevance of COVID-19	Insights/results
					RW. Redevelopment initiatives should include coworking spaces. The debate on energy consumption and telework still open. Possible issues on gender and social inclusion should be considered.
Baldassa et al. (2023)	Case Studies on Transport Policy	Telework and MaaS adoption in a post-pandemic scenario. Evidence from municipal employees of Padua, Italy	Case study/mixed method, mixed logit model and questionnaires to the employees of the municipality of Padua, Italy; data collection between October 2020 and January 2021; Place of interest: Padua municipality.	yes	Very high increase in telework after the pandemic in Italy. The diffusion of telework can negatively impact the decision to adopt MaaS (Mobility-as-a-Service). The number of people who work from home in a certain location should be considered in preliminary research regarding the possible diffusion of MaaS.
Cassetti et al. (2023)	Energy	The interplay among COVID-19 economic recovery, behavioural changes, and the European Green Deal: An energy-economic modelling perspective	Quantitative, scenario forecasting exercise with two large scale energy-economy models; data of the models updated till the year 2019; EU countries.	yes	COVID-19 potential long-term consequences on EU citizens lifestyles (WFH included). Behavioural changes required to achieve a net-zero transition involve a wide range of sectors and modes. An increase in carbon prices may be alleviated by lifestyle changes, such as WFH and less air travel.
Khanna et al. (2023)	Energy Research & Social Science	Conceptualizing demand-side technological and social innovations in modeling pathways to carbon neutrality	Qualitative, specific analytical framework; timeframe considered depending on the different technological innovation: rule applied; <~10 years since market introduction and/or <~15 % market share in their conceptualisation of early adopters and digitalisation innovation; international framework.	no	Significant shifts towards telecommuting and e-commerce during the pandemic shutdowns. To reach carbon neutrality, lifestyle modifications (e.g., telecommuting) and altered urban forms will be required in addition to technology alternatives for transformation. Innovations still face technological, sociocultural, economic, and institutional barriers to be overcome to ensure wider adoption.
Liu et al. (2023)	Frontiers in Environmental Science	Examining the role of digitalisation and gig economy in achieving a low carbon society: an empirical study across nations	Quantitative, two-way fixed effects model; data from 1990 to 2019; international framework based on 185 countries.	no	Increased Internet penetration stimulates more efficient and environmentally friendly solutions (e.g., RW, virtual meetings, and smart technologies), which can result in energy savings and reduced emissions. Gig economy workers are more likely to rely on flexible working arrangements. More research is required to evaluate the net environmental impact of telecommuting.
Morfeldt et al. (2023)	Communications Earth & Environment	Emission pathways and mitigation options for achieving consumption-based climate targets in Sweden	Scenario analysis/quantitative, forecasting exercise; data from 2007 to 2019; country of interest: Sweden.	no	Increased RW can reduce commuting and the need for office space, but policies are required to encourage these behavioural shifts and prevent spillover effects that could raise greenhouse gas (GHG) emissions from the supply chain.
Stermieri et al. (2023a)	Energy Strategy Reviews	Impacts of digitalisation and societal changes on energy transition: a novel socio-techno-economic energy system model	Quantitative/case study; socio-techno-economic energy system model; data between 2010 and 2021; country of interest: Switzerland.	yes	In Switzerland, teleworking lowers the demand for commuting by 10 %. The savings on transport costs can then be used to fund the purchase of clean and efficient home technologies, which will offset the increased demand for energy in the home brought on by WFH. Teleworking has a net positive effect on energy consumption.
Stermieri et al. (2023b)	Energy Research & Social Science	Quantifying the implications of behavioural changes induced by digitalisation on energy transition: A systematic review of methodological approaches	Systematic literature review/ qualitative, only peer-reviewed academic journals and conference proceedings are included; manuscripts between 2010 and 2022; international framework.	no	Teleworking households are able to minimise the number of trips and miles driven. Time saved due to a reduction in commuting can be reused by households to perform other activities. Since coworking spaces are typically found in residential neighbourhoods, people should use bicycles, public transportation, or

(*continued on next page*)

Table 4 (*continued*)

Author(s) and year	Journal/Book	Title	Methodology/timeframe/Region or country/ies of interest	Relevance of COVID-19	Insights/results
					walking rather than driving their own vehicles to reach the workplace.
Storey (2023)	The Extractive Industries and Society	From FIFO to LILO: The place effects of digitalisation in the mining sector	Qualitative literature review (not only academic) plus 16 semi-structured interviews with experts; between 2007 and 2022; international framework but special attention to the Canadian and Australian situation.	no	New higher-skill-demanding jobs will be created with the introduction of new technologies, many of which can be performed remotely. When the supply chain is impacted by digitalisation, people who work in indirect service and supply sector jobs will also feel similar effects. For the first time, more data mining activities can now be done remotely as a result of automation, data availability, and improved connectivity.
Trinchini and Baggio (2023)	First Monday	Digital sustainability: Ethics, epistemology, complexity and modelling	Qualitative, epistemological analysis; most literature cited from 2015 to 2023; international framework.	yes	RW will eventually transform urban economies through diverse ways of travelling, teaching, learning, and living. Not all job types had the same possibility of accessing WFH, with certain noticeable restrictions and sociopsychological problems arising from remote working. Similar concerns about the detrimental consequences on work-life balance, the digital divide between industries and among employees (as not all occupations are "remotable"), surveillance, and productivity are being raised by the current WFH trend.
Böttcher et al. (2024)	Information Systems Journal	Digital sustainable business models: Using digital technology to integrate ecological sustainability into the core of business models	Qualitative, creation of a taxonomy of digital sustainable business models; data collection around 2021 (estimation considering the submission of the paper to the journal); international framework: selection of 31 start-ups.	no	Digital technology does not only optimise logistics or enable RW but implements sustainability as an integral part of the core logic of the organisation (business model) and its identity.
Wojnicka-Sycz et al. (2024)	Innovation: The European Journal of Social Science Research	From adjustment to structural changes – innovation activity of enterprises in the time of COVID-19 pandemic	Mixed method, econometric analysis, interviews, surveys; countries of interest: timeframe of the interviews from June 2020 to December 2020; Italy, Germany, Austria, Poland, the Czech Republic and Russia.	yes	Reducing the costs associated with office space may be another reason for sustaining distant work. RW increased from 1.2 % before the pandemic to 8.8 % during the lockdown, and stayed at 5.3 % afterwards in Italy. 54 % of Russian enterprises switched to partial or full RW. RW may decrease the need for mobility and promote less-dense living, which may contribute to lower pollution levels.

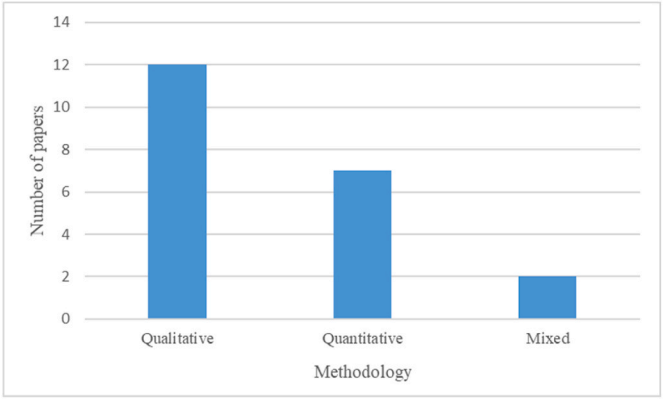

Fig. 2. Methodologies of the selected papers.

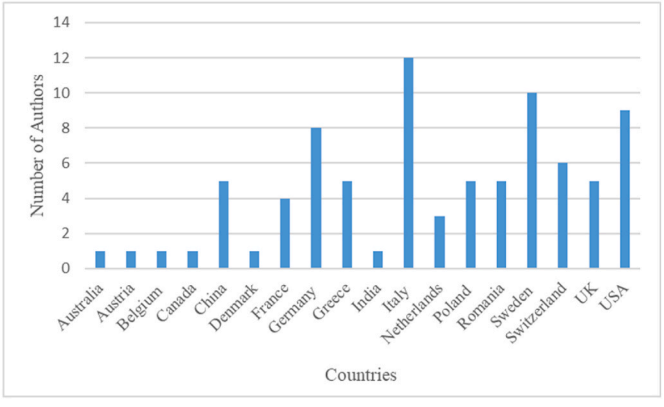

Fig. 3. Number of Authors per country considering their affiliation.

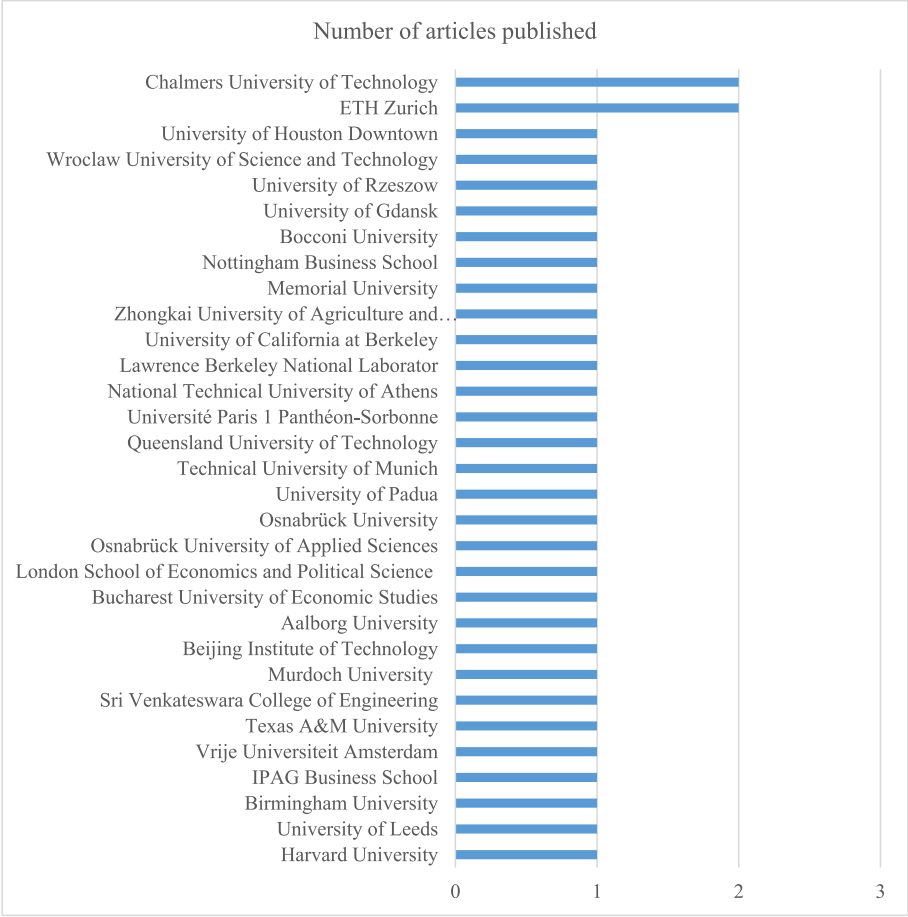

Fig. 4. Production per university in the topic.

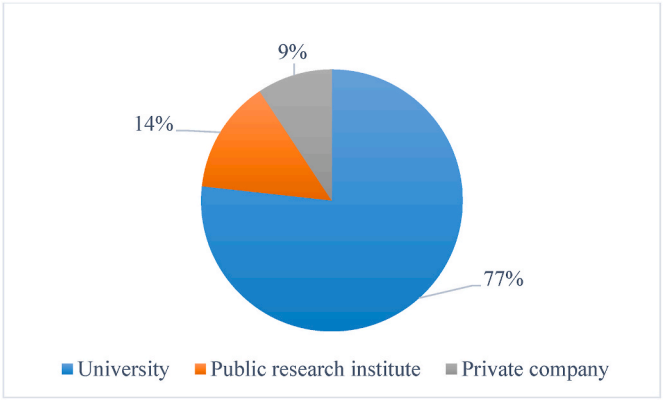

Fig. 5. Type of research institution involved in the subject.

connectivity enable mining activities to be performed remotely for the first time, creating new, higher-skill-demanding jobs. These transformations ripple through supply chains, affecting not only direct employees but also workers in indirect service and supply sector positions.

However, the selected literature also reveals significant tensions and inequalities within the digital transition. The digital divide emerges as a persistent concern across multiple studies. Trinchini and Baggio (2023) emphasise in their epistemological analysis that not all job types have equal possibilities for working from home, highlighting noticeable restrictions and sociopsychological problems arising from remote working. They raise concerns about detrimental consequences on work-life balance, and the digital divide between industries and among employees, noting that not all occupations are "remotable." Similarly,

Table 5
– Typology of impacts related to FWAs mentioned in the selected manuscripts.

Author(s) and year	Environmental impacts	Social impacts	Urban impacts
Lovelace and Philips (2014)	No	Yes	No
Elliot et al. (2020)	Yes	Yes	No
Elavarasan et al. (2021)	No	Yes	No
Mihai et al. (2021)	Yes	Yes	No
Noussan and Jarre (2021)	Yes	No	Yes
Angelidou et al. (2022)	Yes	No	No
Babapour Chafi et al. (2021)	Yes	Yes	No
Fouquet and Hippe (2022)	No	Yes	No
Isensee et al. (2022)	No	Yes	No
Roberto et al. (2023)	Yes	Yes	Yes
Trinchini and Baggio (2023)	Yes	Yes	Yes
Böttcher et al. (2024)	Yes	Yes	No
Cassetti et al. (2023)	Yes	Yes	No
Khanna et al. (2023)	Yes	No	No
Liu et al. (2023)	Yes	Yes	No
Morfeldt et al. (2023)	Yes	Yes	Yes
Stermieri et al. (2023a)	Yes	Yes	No
Stermieri et al. (2023b)	Yes	Yes	Yes
Storey (2023)	No	Yes	No
Trinchini and Baggio (2023)	No	Yes	No
Wojnicka-Sycz et al. (2024)	No	Yes	No

Khanna et al. (2023) identify technological, sociocultural, economic, and institutional barriers that demand-side innovations face in achieving wider adoption, suggesting that digital transformation proceeds unevenly across sectors and populations.

Isensee et al. (2022) provide specific evidence of digital exclusion patterns, warning that blue-collar workers might be neglected in the implementation of digital tools, home office opportunities, and culture development initiatives. This observation points to a critical paradox, namely that while digital technologies democratise access to certain work arrangements, they simultaneously risk creating new forms of stratification based on occupational categories, digital literacy, and access to necessary infrastructure.

The organisational dimension receives substantial attention. Indeed, many selected papers address business model transformations. In their analysis of the literature, policies and legal European framework in the last decades, Roberto et al. (2023) note that, during the pandemic, businesses had to reorganise their processes and manage the new digital work environment, including increasing the remote work share. This reorganisation required collaboration and cooperation between leadership and employees. The use of mobile applications to foster sustainability culture exemplifies how digital tools can serve integrative functions, though implementation remains uneven across organisational hierarchies.

In their analysis, which also considers previous pandemics (Spanish flu and severe acute respiratory syndrome, also known as SARS), Elavarasan et al. (2021) highlight how the pandemic brought larger collaboration via remote working among experts, facilitated by social media connections, thus suggesting that digital platforms can enhance knowledge sharing and professional networks in ways that transcend physical boundaries. However, the authors stress how this benefit should not be a privilege of high-earner workers, and say that low and middle-income workers should receive special attention.

The temporal dimension proves significant. Publications accelerated dramatically from 2020 onwards, with only one pre-pandemic study (Lovelace and Philips, 2014) compared to 9 studies in 2023 alone. This pattern suggests that while digital technologies enabling FWAs existed before COVID-19, the pandemic functioned as a catalyst that made these arrangements both necessary and visible to researchers, prompting systematic investigation of their implications.

4.1.2. Green transition and FWAs

The relationship between FWAs and environmental sustainability is the most contested domain in the selected literature, characterised by contradictory findings, methodological debates, and ongoing uncertainty about net environmental impacts. Among the 21 selected manuscripts, 14 papers (66.7 %) examined environmental dimensions (Fig. 6), with 12 of these (85.7 % of environmental papers, 57.1 % of all papers) focusing specifically on energy consumption (Fig. 7).

The energy consumption debate reveals fundamental divisions. Proponents of FWAs' environmental benefits emphasise reduced commuting emissions. Stermieri et al. (2023a) demonstrate through quantitative modelling that in Switzerland, teleworking lowers commuting demand by 10 %, producing net positive effects on energy consumption when transport savings are reinvested in clean and efficient home technologies. In their study on Lombardy in the pre-Covid-19 period, Noussan and Jarre (2021) calculate that the potential contribution of remote working to lowering greenhouse gas emissions is strongly connected to its diffusion across commuting trips, suggesting that increasing remote working would yield more significant results, if applied non-homogeneously across workers, specifically targeting those with longer commuting distances.

Wojnicka-Sycz et al. (2024) observe that remote working may decrease mobility needs and promote less-dense living patterns, potentially contributing to lower pollution. In Italy, they document increases in remote work from 1.2 % pre-pandemic to 8.8 % during lockdown, stabilising at 5.3 % afterwards, with similar patterns in Russia where the

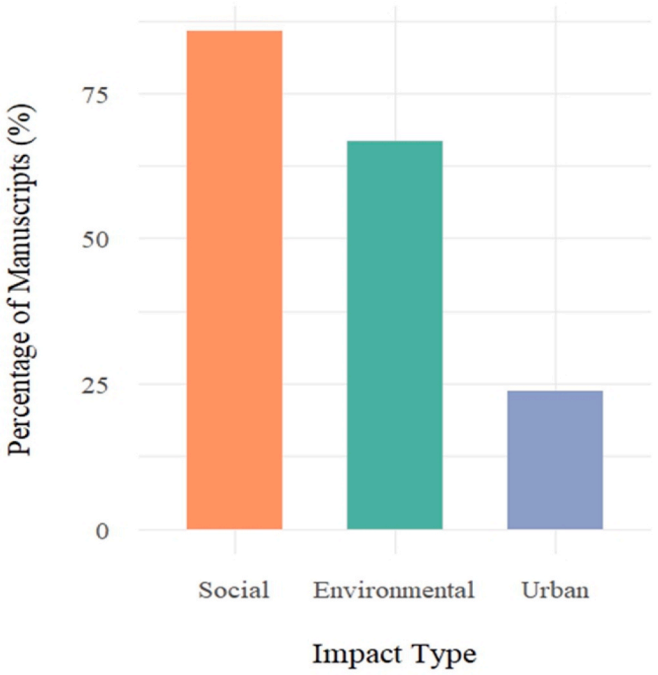

Fig. 6. Percentage of selected manuscripts that cover topics related to social, environmental and urban impacts.

majority of enterprises switched to partial or full remote working. These behavioural shifts, combined with reduced office space requirements, which may motivate sustaining distant work for cost reasons, suggest potential for substantial emission reductions at scale.

However, sceptics and those advocating a more nuanced assessment present compelling counterarguments. Angelidou et al. (2022) caution that remote working can remove advantages of economies of scale related to mass public transport or organised working environments, potentially leading to higher per-capita energy consumption through fragmented, individualised consumption patterns. Their study is quite relevant, considering that it is also based on a Delphi questionnaire submitted to a large number of international experts in the field (120). Babapour Chafi et al. (2021) note that no clear relationship exists between energy consumption and remote working, highlighting measurement challenges and contextual variability.

As shown in Fig. 7, the rebound effect emerges as a critical concern in 41 % of energy-focused papers. Using Swiss data, Stermieri et al. (2023a) explicitly address this phenomenon, noting that gains in emissions from reduced commuting and office energy demand can be offset by increased residential heating demand. They emphasise the need for holistic assessment and complementary policies, including incentives for investing in new technologies and renovation practices in old buildings. In their study on Sweden, Morfeldt et al. (2023) reinforce this concern, arguing that while increased remote working can reduce commuting and office space needs, policies are required to encourage behavioural shifts and prevent spillover effects that could raise greenhouse gas emissions from the supply chain.

The complexity deepens when considering household behaviour changes. Khanna et al. (2023) note that time saved due to reduced commuting can be reused by households to perform other activities, which may or may not be environmentally beneficial. The literature review they conduct reveals that 26 out of 39 previous studies show energy reduction—by as much as 77 %—from teleworking, while 8 studies suggest teleworking increases or has a neutral impact on energy use. This divergence underscores methodological challenges and contextual dependencies in assessing net environmental effects.

Several papers emphasise that environmental outcomes critically

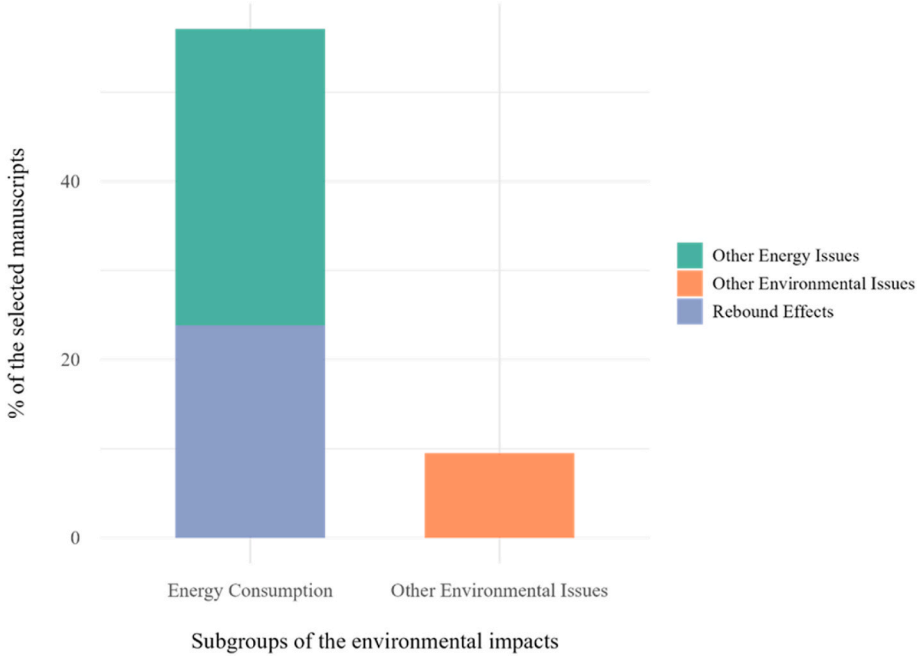

Fig. 7. – Subgroups of topics related to environmental impacts.

depend on complementary policies and urban planning decisions. Elliott et al. (2020) argue that post-pandemic green transition requires greater cultural, social, and political changes beyond simple adoption of remote working. Cassetti et al. (2023) demonstrate through energy-economic modelling that behavioural changes required to achieve net-zero transition involve wide-ranging sectors and modes, with lifestyle changes such as working from home and reduced air travel potentially alleviating increases in carbon prices.

Khanna et al. (2023) conceptualise demand-side technological and social innovations in pathways to carbon neutrality, arguing that lifestyle modifications, including telecommuting and altered urban forms, will be required in addition to technological alternatives for transformation. They emphasise that innovations still face technological, sociocultural, economic, and institutional barriers, which need to be systematically addressed to ensure wider adoption.

The geographic and infrastructural context proves significant. Fouquet and Hippe (2022) observe that the pandemic enhanced housing relocations outside urban centres, with both positive and negative impacts on transport use and associated energy consumption. This spatial redistribution complicates simple calculations about commuting reductions, as it may generate new travel patterns, longer-distance occasional commuting, and changes in local infrastructure demands.

A small subset of papers (9.5 % of all manuscripts) considers environmental impacts beyond energy consumption, including air quality improvements and broader ecological effects. However, these remain understudied when compared to the dominant focus on energy and emissions.

The methodological landscape reflects this uncertainty. Among the 14 papers examining environmental impacts, 7 employ quantitative approaches (often modelling and scenario analysis), 6 use qualitative methods (case studies and policy analysis), and 1 adopts mixed methods. While enriching the evidence base, this methodological diversity also contributes to divergent findings based on different assumptions, system boundaries, and contextual factors.

4.1.3. Twin transition and FWAs

The integration of digital and green transitions with FWAs reveals complex interdependencies, policy challenges, and social implications that are not the mere sum of the two transition effects. This subsection examines how manuscripts addressing both dimensions simultaneously identify emergent properties, unintended consequences, and necessary conditions for achieving mutually reinforcing outcomes.

Table 5 shows that the social dimension dominates the discussion on twin transition, with 18 papers (85.7 %) examining social impacts. Among these, work-life balance emerges as a central concern in 75 % of cases (Fig. 8), reflecting both opportunities and risks. Mihai et al. (2021) identify a fundamental paradox, namely that telework simultaneously offers autonomy and improved work-life balance, while potentially causing detrimental impacts on professional relationships and career progression. This dual nature creates winners and losers, with benefits and harm distributed unevenly across occupational categories, demographic groups, and organisational contexts.

Babapour Chafi et al. (2021) advocate for hybrid work as preferable to purely remote arrangements, arguing that employers must provide support and redesign both physical and digital workplaces for employees. This position suggests that optimal outcomes require intentional organisational design rather than the mere adoption of technology-enabled flexibility. Roberto et al. (2023) emphasise that working remotely is neither necessary nor appropriate for everyone, noting risks of isolation alongside benefits. They advocate for redevelopment initiatives that include coworking spaces.

The equity and inclusion dimension receives substantial critical attention. Roberto et al. (2023) and Isensee et al. (2022) both highlight the risk that blue-collar workers and those in non-remotable occupations may be neglected in digital tool implementation, home office opportunities, and organisational culture development. Trinchini and Baggio (2023) elaborate on sociopsychological problems arising from remote working inequality, raising concerns about detrimental consequences on work-life balance and the digital divide between industries and among employees. These observations suggest that twin transition, without careful management, may exacerbate existing inequalities rather than ameliorate them.

Mihai et al. (2021) explicitly state that twin transition can increase social exclusion, a finding that contradicts optimistic narratives about technology-enabled democratisation of work opportunities. Storey (2023) demonstrates sector-specific patterns in the mining industry, where digitalisation creates higher-skill-demanding jobs that can be performed remotely, potentially displacing workers unable to acquire

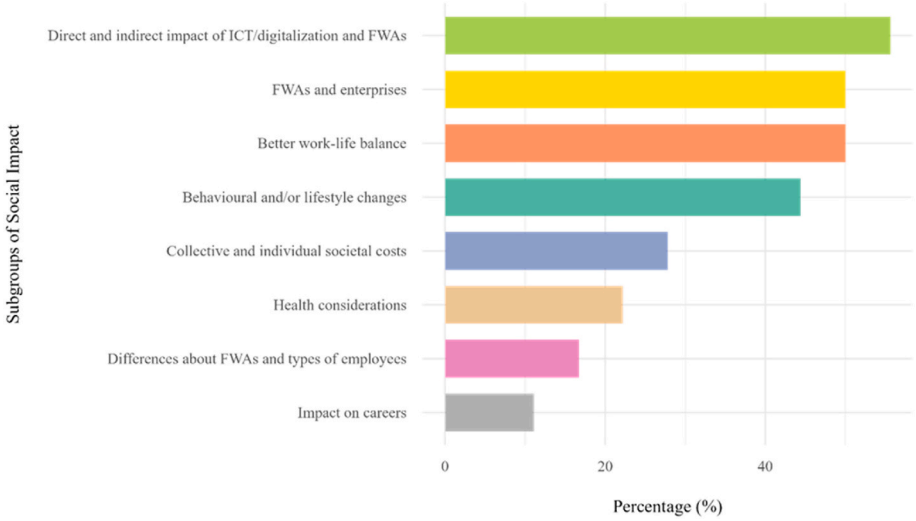

Fig. 8. – Subgroups by topic on social impacts. Note: The percentages are calculated based on the total number of selected studies that consider social impacts. Each paper may cover more than one topic.

necessary competencies.

Behavioural and lifestyle changes constitute another critical theme, emphasised by 66.7 % of social impact papers. Elliott et al. (2020) argue that the negative and positive effects of working from home require a post-pandemic green transition to involve greater cultural, social, and political changes. Cassetti et al. (2023) model how COVID-19 may have potential long-term consequences on the lifestyle of EU citizens, including working from home. They demonstrate that behavioural changes required to achieve net-zero transition involve wide-ranging sectors and modes.

The policy imperative clearly emerges across multiple studies. Lovelace and Philips (2014) emphasise that policies encouraging telecommuting need to be more targeted on different worker typologies, recognising heterogeneity in commuting patterns, housing situations, and job characteristics. Morfeldt et al. (2023) argue that without policies to encourage behavioural shifts and prevent spillover effects, potential environmental benefits may not materialise or may be offset by unintended consequences. Baldassa et al. (2023) demonstrate specific policy trade-offs, showing that telework diffusion can negatively impact the adoption of Mobility-as-a-Service (MaaS), suggesting that the number of people working from home in a given location should be considered in preliminary research regarding possible MaaS diffusion.

Elliott et al. (2020) call for a comprehensive framework of policies necessary to make flexible work arrangements and other societal changes effective while mitigating inequalities. This holistic perspective recognises that isolated interventions may produce suboptimal or contradictory outcomes, requiring coordinated approaches across transportation, housing, labour regulation, environmental policy, and digital infrastructure domains.

Urban reorganisation constitutes a smaller but significant literature stream, with 5 papers (23.8 %, Table 5) addressing territorial and urban impacts. Roberto et al. (2023) and Stermieri et al. (2023b) both identify coworking spaces as potentially playing crucial roles in twin transition. Stermieri et al. (2023b) argue that coworking spaces, typically located in residential neighbourhoods, encourage the use of bicycles, public transportation, or walking rather than driving personal vehicles to reach workplaces, thereby reducing transportation-related emissions while maintaining some social and professional interaction benefits.

Roberto et al. (2023) emphasise how coworking spaces can contribute to urban area regeneration, thus benefitting broader populations beyond the upper classes. They argue that redevelopment initiatives should deliberately include coworking spaces as part of sustainable urban planning. Conversely, they warn that lack of spatial reorganisation can be detrimental to green transition goals, as dispersed home working without supportive infrastructure may generate inefficient travel patterns and resource use.

Fouquet and Hippe (2022) document how the pandemic enhanced housing relocations outside urban centres, with both positive and negative impacts on transport use and associated energy consumption. This spatial redistribution creates new challenges for urban and regional planning, potentially undermining traditional assumptions about transportation infrastructure needs, service provision, and community development.

The COVID-19 pandemic functions as a critical watershed across the twin transition literature. Approximately 40 % of selected manuscripts (8 papers) place significant emphasis on the pandemic as catalyst for change. Elavarasan et al. (2021) observe that the pandemic brought larger collaboration via remote working among experts, facilitated by social media connections, and argue that economic growth in upcoming years must pay attention to middle and low-income earners, with remote working playing a role in inclusive development.

The temporal distribution of publications provides striking evidence of the pandemic's catalytic effect. Only one study (Lovelace and Philips, 2014) pre-dates 2020, with publications accelerating from 4 in 2021 to 11 in 2023. This pattern suggests that while underlying technological and environmental trends pre-existed COVID-19, the pandemic made their intersection with FWAs both urgent and visible, prompting scholarly investigation that continues to intensify.

The integration of digital and green transitions with FWAs reveals that neither transition proceeds independently, and their interaction produces emergent challenges requiring coordinated policy responses, organisational innovations, and social adaptations. The literature emphasises that achieving sustainable and equitable outcomes requires moving beyond technological determinism to embrace holistic frameworks addressing behavioural, institutional, spatial, and distributional dimensions simultaneously.

4.2. *Discussion on the results*

Our finding that 85.7 % of environmental impact papers focus on energy consumption aligns with literature on broader sustainability transitions by emphasising energy systems as central to decarbonisation (Fouquet and Hippe, 2022). However, this concentration leaves other environmental dimensions understudied, including biodiversity impacts, material consumption, waste generation, and water use associated with dispersed work patterns.

The contested findings on net environmental benefits echo long-standing debates in transport geography and environmental economics about rebound effects and behavioural compensation (E Silva and Melo, 2018). Our synthesis reveals that the debate remains unresolved, depending on system boundaries, contextual factors, and methodological approaches. This divergence suggests the need for standardised assessment frameworks that Stermieri et al. (2023b) call for in their methodological review.

The social equity concerns identified across 85.7 % of papers examining social impacts resonate with critical scholarship on digital divides and uneven sustainability transitions (Rodríguez-Pose and Bartalucci, 2024). Our finding that 75 % of social impact papers emphasise work-life balance paradoxes aligns with Mihai et al. (2021) but carries the discussion further by showing how these paradoxes interact with environmental and digital transformation dynamics.

The emphasis on business model transformation in 75 % of social impact papers connects to broader innovation literature on digital sustainable business models (Böttcher et al., 2024). However, our review reveals that transformation literature rarely integrates environmental assessment with organisational change analysis, suggesting siloed scholarly conversations that would benefit from integration.

Several significant gaps emerge from our analysis. Territorial and regional impacts receive limited attention. The few existing studies (Noussan and Jarre, 2021; Baldassa et al., 2023; Roberto et al., 2023) provide highly localised case studies without broader comparative frameworks. Studies examining twin transition and FWAs at regional scales, particularly at NUTS3 level as suggested by our analysis, would enable us to understand how different geographic conditions shape outcomes.

Digital nomadism remains conspicuously absent despite its growing prominence (Cook, 2023; Pettas and Avdikos, 2023). None of the selected papers examine this increasingly visible form of FWA in the twin transition context, despite its potentially significant environmental footprint and complex relationship with digital infrastructure and sustainable development.

Energy poverty receives no mention in selected manuscripts despite its critical importance for just transitions. The literature on energy poverty emphasises the risk that low-income households unable to access adequate energy consumption may be further disadvantaged by digital or twin transitions (Baruffini and Rossi, 2024; Aoun et al., 2021). Baruffini and Rossi (2024) emphasises the importance of specific digital tools and policies to provide citizens with the means to address the challenges of twin transition, but this perspective remains absent from the FWA-focused literature we reviewed.

Literature on third places remains underdeveloped, with only Roberto et al. (2023) and Stermieri et al. (2023b) substantively addressing coworking spaces. Several public policies in Europe promoted by municipalities (i.e. Milan and Bologna in Italy), regions (Emilia Romagna in Italy) and countries - (Ireland's National Connected Hubs Network, and "Tiers Lieux" in France) allow both public and private employees to work remotely in Third places (i.e., coworking space, innovation hubs) near home (Mariotti and Tagliaro, 2024). Therefore, empirical research on how these interventions shape twin transition outcomes is urgently needed.

Moreover, temporal dynamics receive insufficient attention. Most studies provide cross-sectional snapshots or short-term assessments of the immediately post-pandemic situation. Longitudinal research examining how relationships between FWAs and twin transition evolve as arrangements stabilise, technologies mature, and policies adapt would provide critical insights for long-term planning.

Intersectional analysis remains rare. While some papers note differential impacts by occupation, education, or gender, few systematically examine how multiple dimensions of inequality intersect in shaping who benefits and who suffers from twin transition combined with FWAs. Roberto et al. (2023) mention gender and social inclusion issues, but do not develop a detailed intersectional analysis.

5. Conclusions

During and after the pandemic, there has been an increase in studies exploring the effects of FWAs on individuals (Kelly and Moen, 2020; Alfano et al., 2024; Barrero et al., 2023), organisations (Barrero et al., 2021), and territories (Ramani and Bloom, 2021; Delventhal et al., 2022; Gokan et al., 2022; Bond-Smith and McCann, 2022; Biagetti et al., 2024), while less attention has been focused on the interaction between FWAs and twin transition.

The results of this systematic literature review allow us to provide an answer to the research questions: (i) To what extent can insights from the existing research on FWAs, digitalisation, and green transition inform our understanding of their potential interactions among these three issues?

(ii) What evidence exists in the literature regarding the potential environmental benefits or drawbacks of FWAs within the context of the twin transition? (iii) How do current studies describe the social and urban implications of FWAs in relation to the twin transition?

The importance of digital infrastructure and technology in supporting distant and hybrid work arrangements is acknowledged in all 21 manuscripts from different analytical perspectives. The structured literature review uncovers intricate relationships, difficult policy issues, and societal ramifications resulting when digital and green transitions are combined with FWAs. These issues reach beyond the sum of the two transition effects alone. Hence, it is clear that neither transition happens on its own, and that their interaction creates new problems, which call for coordinated organisational innovations, social adaptations, and legislative solutions. The research highlights the need to abandon technical determinism and adopt holistic frameworks that concurrently address behavioural, institutional, geographical, and distributional aspects to achieve sustainable and equitable results.

As concerns research question 2, the literature about the potential environmental benefits or drawbacks of FWAs is mixed. Such an arrangement would reduce CO2 emissions, thus facilitating the transition to a low-carbon society (Fouquet and Hippe, 2022). However, new patterns of work and living could offset these savings, such as increasing expenditure on office supplies and furnishings to keep functional workplaces at home, or raising the interior home temperature, thus consuming more energy. Moreover, the "rebound effect" plays a role in increasing emissions for non-commuting purposes (E Silva and Melo, 2018). A few papers argue that, without policies to encourage behavioural shifts and prevent spillover effects, potential environmental benefits may not materialise or may be offset by unintended consequences (Morfeldt et al., 2023).

The literature review allows to disentangle the social and urban implications of FWAs in relation to the twin transition. About 86 % of the studies underline the relationship between digital inequalities, uneven sustainability transitions, and social equity issues. Most of the papers focusing on social impact have a strong emphasis on business model change, which ties in with the innovation literature on digital sustainable business models (Böttcher et al., 2024). During the pandemic, businesses had to reorganise their processes and manage the new digital work environment, including increasing the remote work share, as well as collaboration and cooperation between leadership and employees. Attention is especially focused on the relationship between digitalisation and work organisation, thus involving the emerging forms of employment, and the effects of FWAs on the work-life balance and satisfaction of individuals, reflecting both opportunities and risks (Mihai et al., 2021). The studies also reveal significant tensions and inequalities within the digital transition. This points to a critical paradox, namely that while digital technologies democratise access to certain work arrangements, they simultaneously risk creating new forms of stratification based on occupational categories, digital literacy, and access to necessary infrastructure (Isensee et al., 2022).

The policy imperative clearly emerges across multiple studies, emphasising that policies encouraging telecommuting need to be more

targeted on different worker types, recognising heterogeneity in commuting patterns, housing situations, and job characteristics (Lovelace and Philips, 2014).

Finally, the evidence on territorial and urban impacts is scant. The few studies researching this topic (Baldassa et al., 2023; Roberto et al., 2023; Noussan and Jarre, 2021) focus on case studies, thus lacking more comprehensive comparison frameworks. This highlights the need for broader, more geographically diverse research to improve our understanding of territorial implications.

The structured literature review underlined limitations of the analysed studies, as for instance, the exploratory nature of twin transition research and the limited availability of systematic data on the intersection of FWAs with both environmental and digital indicators. While the dominance of qualitative case studies is valuable for exploratory research, it limits the ability to assess net effects, identify causal mechanisms, and generalise findings. Future research would benefit from the following methodological advances. The development of standardised metrics and system boundaries for environmental assessment would enable comparison across studies and contexts. The divergent findings on energy impacts partly reflect inconsistent methodological choices regarding what gets measured and how system boundaries are drawn. Moreover, longitudinal designs tracking the same organisations, workers, and communities over extended periods would illuminate temporal dynamics and adaptation processes currently obscured by cross-sectional designs.

Mixed-method approaches combining quantitative assessment of environmental and economic outcomes with qualitative investigation of social processes and equity implications would provide a deeper understanding than either approach alone. Comparative research across diverse geographic, economic, and institutional contexts would identify scope conditions, shaping when and how FWAs support or undermine twin transition objectives. In addition, natural experiments and quasi-experimental designs exploiting policy variations or technological rollouts could provide stronger causal evidence than currently available observational studies.

Finally, participatory and action research approaches engaging workers, communities, and policymakers as co-researchers could generate both scholarly insights and practical innovations, addressing the frequent disconnect between academic research and policy implementation.

It is worth noting that analyses of digital nomadism are conspicuously absent in the existing literature. Given the rising prominence of digital nomadism and its potential impact on society and the environment (Pettas and Avdikos, 2023), further exploration and research are warranted to help policy makers to manage this phenomenon. Addressing these gaps will be crucial for developing a more nuanced and better understanding of the multifaceted dynamics associated with the twin transition and FWAs.

Lastly, little evidence has been provided about the role of third places like coworking spaces in enhancing near-working strategies that reduce commuting to the workplace, thus decreasing congestion and pollution in central areas, and promoting the geographical redistribution of activities. Few countries are promoting these strategies through specific public or private initiatives. In Italy, the municipalities of Milan (Comune di Milano, 2022) and Bologna (Smart Bo project), and the Emilia Romagna region[9] allow public administration employees to work in coworking spaces near homes, in urban and peripheral areas. In Ireland, the National Connected Hubs Network[10] belonging to the Rural Development Policy 2021–2025, specifically, to Ireland's National Remote Work Strategy, promotes remote working in rural Ireland by facilitating workers' or employers' relocation away from large urban centres. In France, the national association of third places "Tiers Lieux"[11] is supported by the government to enhance near working, thus reducing commuting, congestion, and pollution in large cities.

Strategies promoting the twin transition will have to also consider the dynamics generated by remote and hybrid work, both at institutional (i.e., National Integrated Energy and Climate Plan) and industrial levels (Mariotti and Rossi, 2023). Companies need to consider the increasingly frequent requests of workers to perform their work-related tasks remotely to guarantee a better work-life balance (Barrero et al., 2023; 2025). Regulatory frameworks in European countries address FWAs and the right to disconnect (Sanz de Miguel et al., 2023).

Furthermore, the twin transition together with working arrangements could effectively reinforce regional capabilities for productivity and innovation of demographically declining and left-behind areas by increasing their attractiveness and accessibility to labour market opportunities. However, as argued by Rodríguez-Pose and Bartalucci (2024), less developed and rural regions are more exposed to the economic side effects linked to the green transition, with the threat of leaving already left-behind regions further behind.

A recent Horizon project (MOBI-Twin[12]) aims to investigate whether the twin transition can provide a novel paradigm for territorial cohesion by better balancing spatial mobility patterns through the redefinition of regional attractiveness. While the digital transition can offer remote access to job opportunities and expand the labour market structure, the green transition can help left-behind areas innovate more by recombining their existing assets and resetting their productivity structure. However, urban/rural divides may widen as a result of inadequate infrastructure and limited access to digitalisation (Cavallaro and Dianin, 2022). Thus said, twin transition may give rise to new patterns of spatial mobility in which areas that were previously deemed to be "original" areas may become "destination" regions as a result of shifting factors that contribute to regional appeal, such as sectoral structure, living standards, and environmental conditions. Further research should also focus on this aspect. Finally, the paper only analyses academic studies according to a typical academic structured literature review, ignoring policy reports and grey literature. Further research should consider a wider range of documents in order to enrich the debate.

CRediT authorship contribution statement

Luca Alfieri: Writing – review & editing, Writing – original draft, Visualization, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Ilaria Mariotti:** Writing – review & editing, Writing – original draft, Validation, Supervision, Investigation, Funding acquisition, Formal analysis, Conceptualization. **Federica Rossi:** Writing – review & editing, Writing – original draft, Validation, Supervision, Investigation, Formal analysis, Conceptualization.

Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests:

Luca Alfieri reports financial support was provided by Horizon Europe. Ilaria Mariotti reports financial support was provided by Horizon Europe. Federica Rossi reports financial support was provided by Horizon Europe. If there are other authors, they declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

[9] See Piano integrato delle attività di organizzazione 2023–2025.

[10] Guidance for the Development of Hubs and Remote Working Facilities (https://www.connectedhubs.ie/files/CH-GuidanceDocForDevelopmentOfHubs.pdf); Hubs Classification System (https://www.connectedhubs.ie/files/AECHubsClassificationSystem-Master.pdf).

[11] https://francetierslieux.fr.

[12] https://mobi-twin-project.eu/.

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Appendix

Table A1
Studies by source (articles and year)

Journal	2014	2020	2021	2022	2023	2024	total
Case Studies on Transport Policy					1		1
Communications Earth & Environment					1		1
Energies			1				1
Energy					1		1
Energy Research & Social Science				1	2		3
Energy Strategy Reviews					1		1
Environmental and Resource Economics		1					1
FIRST MONDAY					1		1
Frontiers in Enviromental Science					1		1
Geoforum	1						1
Information Systems Journal						1	1
Innovation: The European Journal of Social Science Research						1	1
Sustainable Cities and Society			1				1
Sustainability			1	2			3
Technological Forecasting & Social Change			1				1
The Extractive Industries and Society					1		1
total papers	1	1	4	3	9	2	20

Notes: Table based on Reina et al. (2023). Roberto et al. (2023) is not present because it is a contribution to a book.

Data availability

Data will be made available on request.

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