DIGITAL PLATFORMS, INDUSTRY 4.0, AND REGIONAL ECONOMIC RESILIENCE: RECOVERY PATHWAYS AND POLICY IMPLICATIONS FROM THE SYSTEMATIC LITERATURE REVIEW

Hang Thi Bich Tran
Department of Training Administration, Thuongmai University, Hanoi, 100000, Vietnam E-mail: tranbichhang@tmu.edu.vn, ORCID: 0000-0002-6411-1880

Thi Thuy Hang VU*
Faculty of Electronic Commerce, Thuongmai University, Hanoi, 100000, Vietnam, Email: vuthuyhang.tmdt@tmu.edu.vn, ORCID: 0000-0002-8961-2059

Xuan Lam Nguyen
Faculty of Electronic Commerce, Thuongmai University, Hanoi 100000, Vietnam, Email: lam.nx@tmu.edu.vn , ORCID: 0009-0000-6231-2710

*Corresponding Author: *Thi Thuy Hang VU, Email: vuthuyhang.tmdt@tmu.edu.vn*

ABSTRACT:
This study contributes to the growing body of literature on digital platforms, Industry 4.0, and regional economic resilience by systematically examining how digital transformation supports recovery pathways and policy responses in the post-pandemic era. Based on 78 Scopus-indexed documents published between 2020 and 2025, this research combines bibliographic analysis and systematic document review to map publishing trends, document types, influential countries, leading journals, highly cited publications, and thematic structures. The results show a steady increase in academic interest, with the number of publications rising from 1 in 2020 to 25 in 2025. Journal articles dominate the dataset, accounting for 74.4% of total publications, indicating the academic consolidation of this research field. Countries such as France, Australia, Israel, Greece, and Germany contribute significantly to this field, reflecting its international and interdisciplinary nature. Journals of Business Research, Educational Sciences, and Digital Society and Geography emerge as major publishing channels, while highly cited studies focus on remote work, online education, hyperlocal delivery, workplace behaviour, sustainability, marketing, and platform-based services. Thematic analysis identifies six main groups: human-centred digital competency formation; Digital marketing, social media, and sustainable platform-based markets; digitalisation, mobility, and development pathways in emerging contexts; digital innovation, online learning, and innovation efficiency; artificial intelligence (AI), blockchain, and platform-based crisis governance; and digital capabilities, urban adaptability, and the technological future. These findings demonstrate that regional economic resilience in the digital age is shaped by the interplay between human capabilities, platform-based market coordination, innovation systems, mobility and inclusion, intelligent governance, and place-based adaptation. This research advances a path-based understanding of digital resilience and offers policy implications for building comprehensive, adaptive, and sustainable regional development strategies. Future research should continue to examine regional differences through longitudinal, comparative, and context-specific empirical studies.
KEYWORDS: Digital platforms; Industry 4.0; Regional economic resilience; Sustainable Development; Systematic literature review.

1. INTRODUCTION

Recent global economic disruptions and structural transformations have underscored the uneven capacity of regions to absorb shocks and sustain long-term development, bringing regional economic resilience to the forefront of academic and policy debates. Rather than following uniform development trajectories, regions differ markedly in their ability to adapt, restructure, and transform economic activities in response to external pressures. These disparities have intensified scholarly interest in identifying recovery pathways and resilience-building mechanisms at the subnational level, particularly as an increasing share of global economic growth is generated within regional and urban clusters rather than at the national scale.

Within this evolving economic landscape, digital platforms have emerged as a critical component of contemporary production and coordination systems. Encompassing e-commerce ecosystems, digital payment infrastructures, online service platforms, and remote working technologies, digital platforms have fundamentally reshaped how economic activities are organised across space. Global e-commerce sales reached approximately USD 6.33 trillion in 2024, surpassing USD 6.86 trillion in 2025. Online retail accounts for 21% of worldwide retail sales in 2025, growing to 22.5% by 2028 (Go Global, 2025). These figures highlight that digital platforms are no longer peripheral tools but structural drivers of economic activity with far-reaching implications for regional resilience.

The diffusion of Industry 4.0 technologies, including artificial intelligence, big data analytics, cloud computing, and the Internet of Things, has further accelerated digital transformation across sectors. These technologies enable flexible production systems, data-driven decision-making, and industrial upgrading, contributing to the reconfiguration of regional industrial structures. According to the Insight Report (2024), regions that have actively invested in Industry 4.0-related technologies experienced productivity growth rates up to 2.5 times higher than regions with limited digital adoption. From a regional development perspective, the interaction between digital platforms and Industry 4.0 is pivotal in shaping adaptive capacity and long-term economic resilience.

The influence of digital platforms and Industry 4.0 on regional economic resilience is inherently spatial and uneven. Differences in digital infrastructure, human capital, institutional quality, and governance capacity significantly affect how regions harness digital technologies for economic renewal. OECD indicators show that digital adoption levels in high-performing regions exceed those in lagging regions by approximately 40%, reinforcing spatial inequalities in economic performance and resilience outcomes (OECD, 2024). These disparities suggest that resilience is not solely a function of technological availability but also of institutional environments and place-based policy frameworks.

In emerging and developing economies, digital platforms have also helped address long-standing infrastructure and accessibility challenges. In Southeast Asia, for example, digital transactions increased at an average annual rate exceeding 30% between 2020 and 2024, driven largely by mobile-based financial services and online platforms (ADB, 2025). Similarly, digital health and education platforms have improved service delivery in remote and underserved regions. These developments illustrate the potential of digital platforms and Industry 4.0 to support inclusive regional development, while also highlighting the importance of governance and policy alignment in shaping resilience outcomes.

Despite the rapid expansion of research on digital platforms, Industry 4.0, and economic transformation, existing studies remain fragmented in their treatment of regional economic resilience and recovery pathways. While empirical research has generated valuable insights into specific technologies, sectors, and regional cases, there is a lack of systematic synthesis that integrates technological, industrial, and institutional perspectives into a coherent understanding of resilience-building processes across regions.

To address this gap, this study conducts a bibliometric and systematic literature review to examine how digital platforms and Industry 4.0 are conceptualised in relation to regional economic resilience. By synthesising the literature, the study identifies dominant themes, recovery pathways, and policy-relevant insights that inform place-based strategies for strengthening regional economic resilience in the digital economy.

Accordingly, this study seeks to address the following research questions:

RQ1: How has scholarly attention to digital platforms, Industry 4.0, and regional economic resilience evolved from 2020 to 2025?

RQ2: Which countries, journals, and publications have contributed most significantly to this research field?

RQ3: What dominant thematic clusters and recovery pathways characterise the literature on digital platforms, Industry 4.0, and regional economic resilience?

RQ4: What policy implications emerge from the literature for strengthening regional economic resilience through digital platforms and Industry 4.0 technologies?

The remainder of this article is structured as follows. Section 2 describes the data sources and methodological approach. Section 3 presents the main findings, highlighting key research clusters, thematic trends, and influential contributions. Section 4 discusses the implications of these findings for regional development policy and economic resilience, and outlines directions for future research.

2. MATERIALS AND METHODS

Figure 1 illustrates a PRISMA flowchart, which outlines the systematic methodology employed for article selection in this study. The flowchart visually represents the process, detailing each stage, including identification, screening, eligibility evaluation, and final inclusion, all conducted according to predefined criteria.

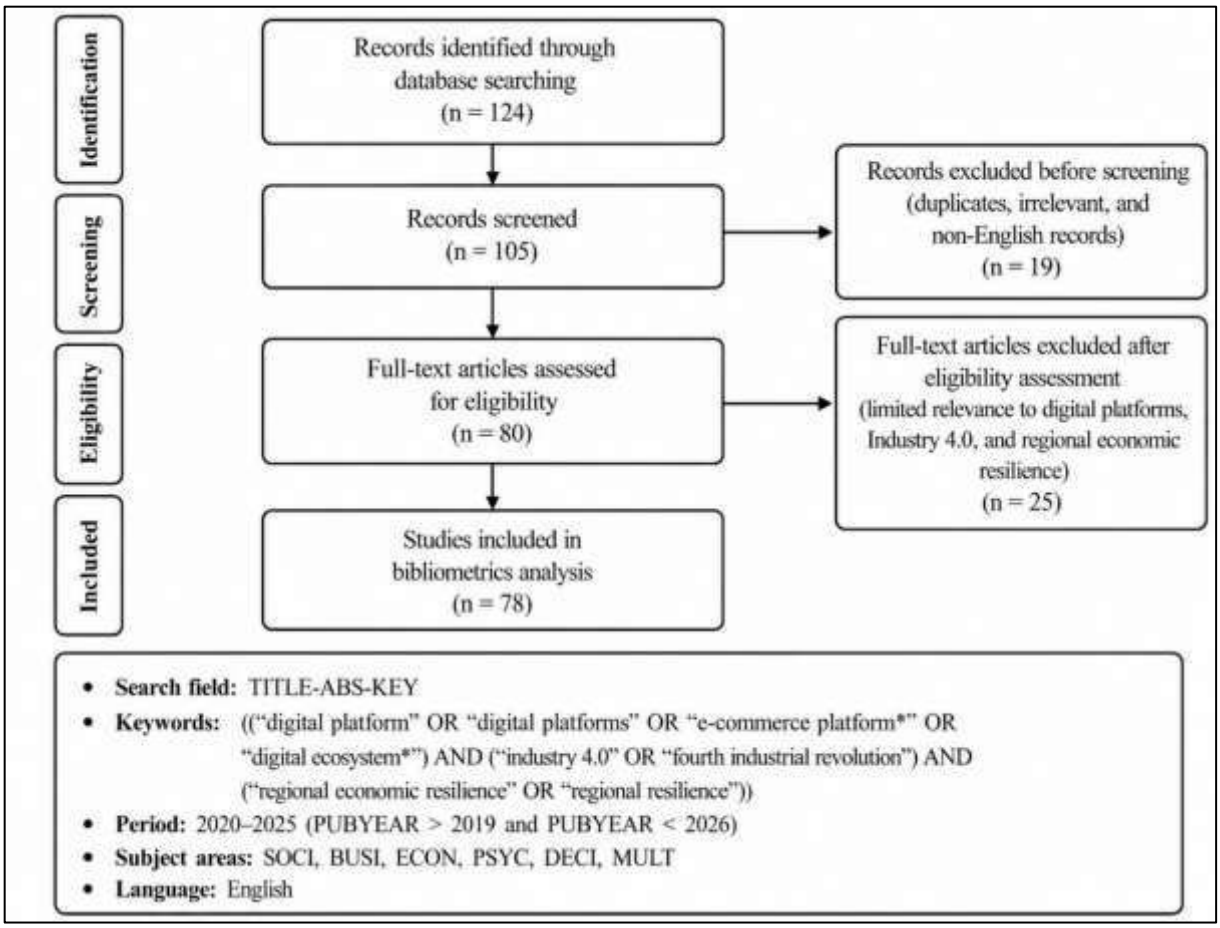

Figure 1. PRISMA diagram
Source: Authors

2.1. Selection of review and bibliometric approach

This study adopts a systematic literature review combined with bibliometric analysis to examine the intellectual structure of research on digital platforms, Industry 4.0, and regional economic resilience. Bibliometric analysis is widely used to identify influential publications, authors, countries, journals, and thematic clusters within an evolving research field (Naveen Donthu et al, 2021). It is particularly useful for synthesizing fragmented literature and revealing research trends, conceptual linkages, and emerging directions across a large body of publications. In the context of this study, the combined approach enables both a structured selection of relevant studies and a quantitative mapping of recovery pathways and policy-related themes in the literature (Pritchard, 1969).

2.2. Selection of tools

VOSviewer (version 1.6.19) is a widely recognized software tool for bibliometric analysis (Eck & Waltman, 2009). It is designed to visualize and explore bibliometric data, with a focus on co-authorship networks, keyword co-occurrence, and citation mapping (Bouyssou & Marchant, 2011; El Archi et al., 2023). In this study, VOSviewer was utilized to visualize citation relationships among scholarly articles, identify research hotspots through keyword co-occurrence analysis, and generate visual representations of research collaboration networks. Additionally, Microsoft Excel, a versatile spreadsheet tool, was employed for data management and analysis purposes.

2.3. Selection of databases

The study retrieved relevant articles from Scopus, a widely recognized academic database frequently used in bibliometric analyses (Asif & Fazel, 2024). Several factors contributed to the selection of Scopus: (1) it is one of the largest and most comprehensive databases available; (2) it serves as a primary platform for reference data in literature reviews; (3) it offers ease of access; (4) it provides built-in data visualization and analysis features; (5) it allows multiple file formats for downloading samples; and (6) it offers a diverse range of data (Brzezinski, 2015; Guz & Rushchitsky, 2009; El Archi et al., 2023).

2.4. Search strategy and keyword identification

To capture the intersection of digital platforms, Industry 4.0, and regional economic resilience, the study developed a search string for use in the title, abstract, and keyword fields of the Scopus database. The search

focused on publications from 2020 to 2025 in order to capture recent developments in digital transformation, technological adaptation, and resilience-related debates. The search string was formulated as follows:
TITLE-ABS-KEY (("digital platform" OR "digital platforms" OR "e-commerce platform*" OR "digital ecosystem*") AND ("industry 4.0" OR "fourth industrial revolution") AND ("regional economic resilience" OR "regional resilience") AND PUBYEAR > 2019 AND PUBYEAR < 2026 AND (LIMIT-TO (SUBJAREA , "SOCI") OR LIMIT-TO (SUBJAREA , "BUSI") OR LIMIT-TO (SUBJAREA , "ECON") OR LIMIT-TO (SUBJAREA , "PSYC") OR LIMIT-TO (SUBJAREA , "DECI") OR LIMIT-TO (SUBJAREA , "MULT")) AND (LIMIT-TO (LANGUAGE , "English")).
To improve topical relevance, the search was further refined by subject areas related to the aims of the study, including Business, Management and Accounting; Economics, Econometrics and Finance; Social Sciences; Decision Sciences; and multidisciplinary studies where relevant. This strategy enabled the study to identify literature that explicitly addressed technological transformation and resilience processes from a regional or place-based perspective.

2.5 Data extraction, screening, and analysis techniques

The initial Scopus search yielded 124 documents. Following the PRISMA procedure, duplicate, irrelevant, and non-English records were excluded, and the remaining studies were screened for their relevance to digital platforms, Industry 4.0, and regional economic resilience. After this process, a final dataset of 78 documents was retained for analysis. The selected documents were then imported into VOSviewer for bibliometric analysis. The study examined annual publication trends, citation patterns, co-authorship networks, and the contributions of countries, institutions, and journals. In addition, keyword occurrence and co-occurrence analyses were conducted to identify major themes and emerging research directions. The results were subsequently interpreted through a systematic literature review lens in order to synthesise the main recovery pathways and policy implications discussed in the literature.

3. FINDINGS

3.1. Response to RQ1

Figure 2 presents the annual distribution of publications on this topic from 2020 to 2025. Research activity began at a very modest level in 2020, with only one publication. In 2021, the number of documents rose sharply to 7, a sevenfold increase from the previous year. This upward trajectory continued in 2022, when the volume reached 12 publications, followed by 15 in 2023 and 18 in 2024. The most notable expansion occurred in 2025, with the number of documents climbing to 25, the highest level recorded during the observed period. Overall, the dataset includes 78 publications, indicating a clear and sustained increase in scholarly attention to the role of digital platforms in post-pandemic economic recovery. Although the annual growth rate varied across years, the overall pattern indicates that this topic has gained strong, consistent academic momentum.

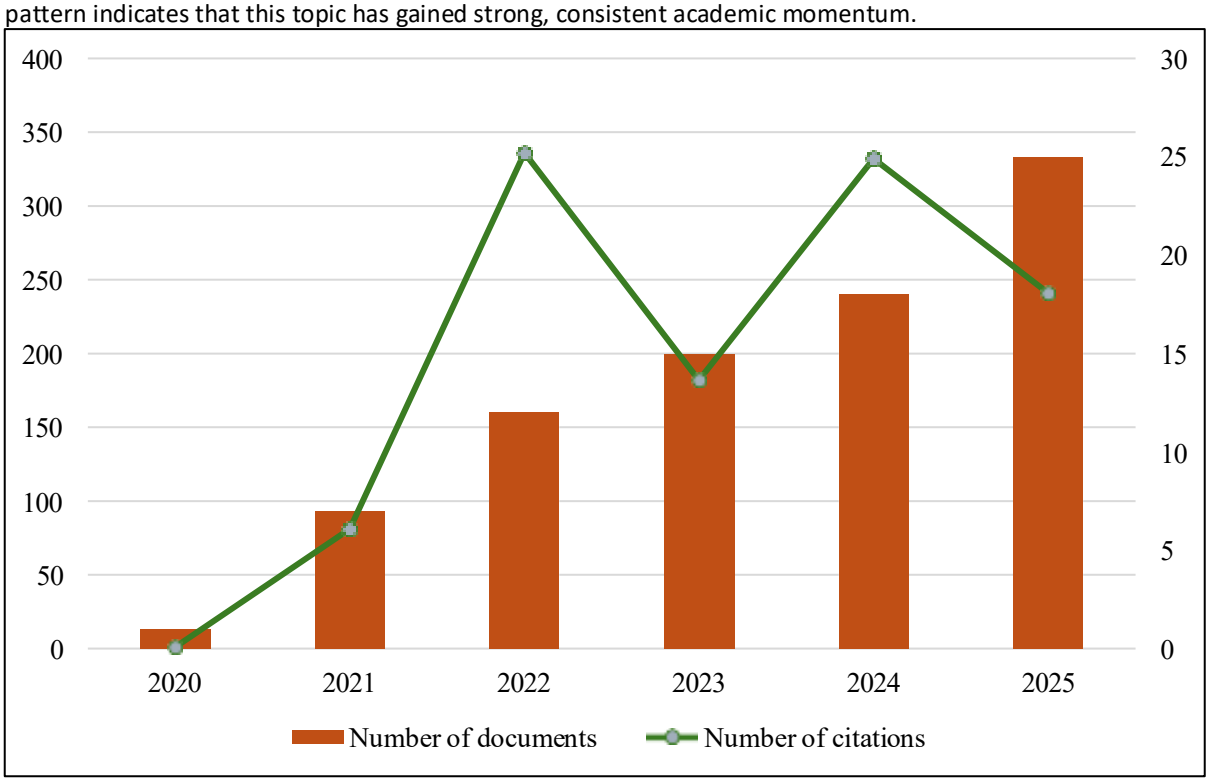

Figure 2. Number of publications by year and citation

Source: Authors

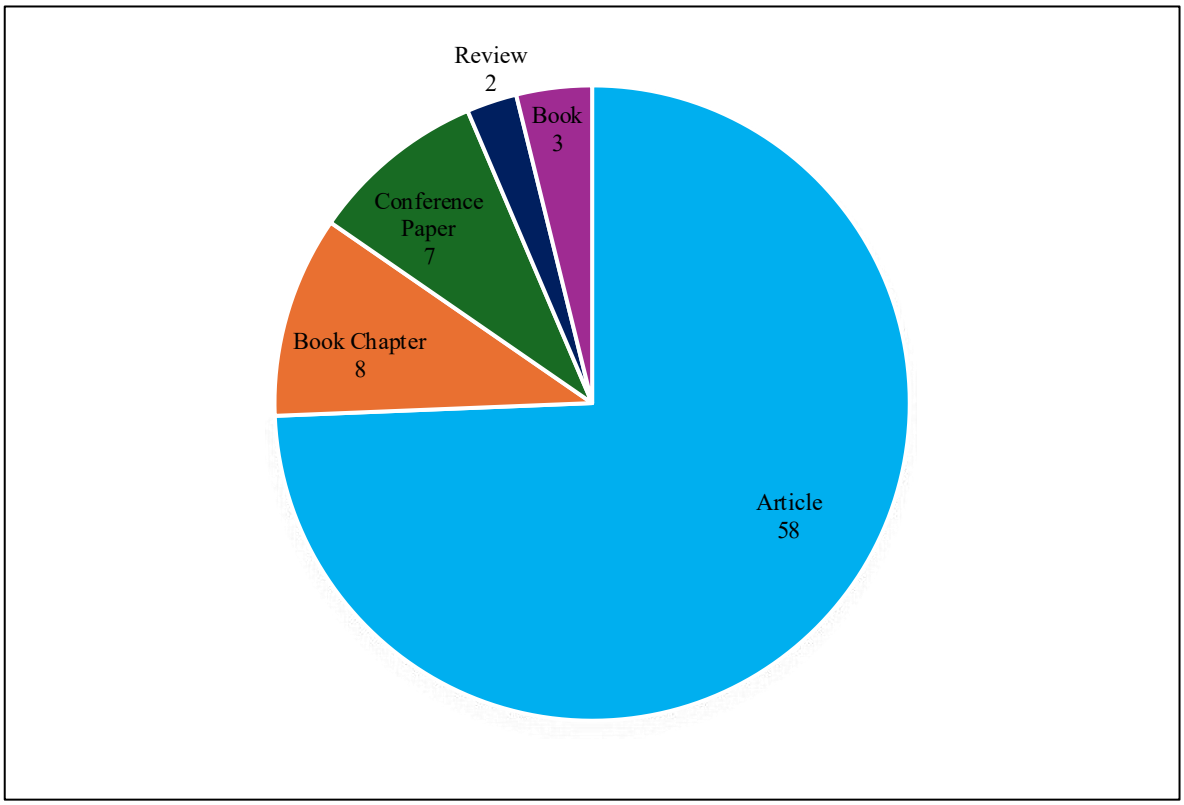

Figure 3. Number of documents by type

Source: Authors

Figure 3 illustrates the distribution of 78 documents by type. The most significant portion of the chart comprises articles, with 58 (74.4%). Book chapters account for eight documents (10.3%), followed by conference papers with seven documents (9.0%). Books are less common, with only three documents (3.8%), while reviews are the least frequent, comprising just two documents (2.6%). Figure 3 highlights the dominance of articles in the dataset, demonstrating a strong preference for journal publications over other types of academic documents.

3.2. Response to RQ2

Table 2 highlights the most significant authors on the topic, identified based on the number of citations in their publications.The analysis highlights the global scope of research on digital platforms and their role in post-pandemic economic recovery. Influential studies have emerged from countries such as Spain, the UK, India, Israel, the US, Greece, and Austria.

The most cited publication is by Saura et al. (2022) from Spain, 'Exploring the challenges of remote work on Twitter users' sentiments: From digital technology development to a post-pandemic era,' published in the 'Journal of Business Research'. This study, which has received 140 citations, investigates the socio-emotional implications of remote work in the context of rapidly evolving digital technologies during and after the pandemic. Its high citation count reflects its relevance across business management, sociology, and digital media disciplines.

The second-ranked document, authored by Peimani & Kamalipour (2021), is titled 'Online Education in the post-COVID-19 Era: Students' Perception and Learning Experience'. It was published in Education Sciences and cited 56 times. The paper focuses on the transformation of education post-pandemic and emphasizes the importance of understanding challenges and opportunities in this new framework. In third place, Guru et al. (2023) explore hyperlocal delivery models in their paper, 'Assessing the feasibility of hyperlocal delivery model as an effective distribution channel' published in 'Management Decision'. Cited 42 times, this study provides critical insights into post-COVID-19 supply chain management and consumer behaviour, particularly in distribution strategies. Reizer et al. (2022)'s fourth-most cited document examines the psychological impact of the pandemic. Their study, 'Examining the relationship between fear of COVID-19, intolerance for uncertainty, and cyberloafing: A mediational model' published in the 'Journal of Business Research' with 40 citations, offers valuable contributions to understanding workplace behaviours under uncertainty.

Other notable works include Yadav et al. (2022)'s study of CEOs' business orientation and Sustainable Development Goals during the pandemic (34 citations) and Tzavara et al. (2023)'s study of personal learning environments before, during, and after the pandemic (25 citations). These studies explore the intersections between leadership, sustainability, and educational technology in the post-pandemic era. Additional influential

contributions include Sheth (2022) on post-pandemic marketing (23 citations), Carrigan & Jordan (2022) on social media's role in universities (20 citations), and Ecker & Strüver (2022) on digital platforms in food delivery (20 citations). These documents further emphasize the significance of social and technological transformations driven by the pandemic.

The diversity of topics and geographical distribution among the leading contributors underscore the interdisciplinary and global nature of the role of digital platforms in economic recovery and development during and after the pandemic. Studies range from remote work and education to supply chain management, marketing, and social dynamics, reflecting the multidimensional impact of digital platforms. The high number of citations demonstrates the resonance of these works in their respective fields, pointing to the role of digital platforms in shaping ongoing discussions. The association of authors from many countries also suggests more collaborative, cross-cultural investigations to address common challenges.

Table 2. Most influential authors of the top 9 most cited articles

Rank	Author(s)	Authors' countries	Article title	Journal	TC
1	(Saura et al., 2022)	Spain	Exploring the challenges of remote work on Twitter users' sentiments: From digital technology development to a post-pandemic era	Journal of Business Research	140
2	(Peimani & Kamalipour, 2021)	United Kingdom	Online education in the post covid-19 era: Students' perception and learning experience	Education Sciences	56
3	(Guru et al., 2023)	India	Assessing the feasibility of hyperlocal delivery model as an effective distribution channel	Management Decision	42
4	(Reizer et al., 2022)	Israel	Examining the relationship between fear of COVID-19, intolerance for uncertainty, and cyberloafing: A mediational model	Journal of Business Research	40
5	(Yadav et al., 2022)	India	How does entrepreneurial orientation and SDG orientation of CEOs evolve before and during a pandemic	Journal of Enterprise Information Management	34
6	(Tzavara et al., 2023)	Greece	Using Personal Learning Environments before, during and after the Pandemic: The Case of "e-Me"	Education Sciences	25
7	(Sheth, 2022)	United States	Post-pandemic marketing: when the peripheral becomes the core	Journal of Research in Interactive Marketing	23
8	(Carrigan & Jordan, 2022)	United Kingdom	Platforms and Institutions in the Post-Pandemic University: a Case Study of Social Media and the Impact Agenda	Postdigital Science and Education	20
9	(Ecker & Strüver, 2022)	Austria	Towards alternative platform futures in post-pandemic cities? A case study on platformization and changing socio-spatial relations in on-demand food delivery	Digital Geography and Society	20

Note: TC: Total citations
Source: Authors

3.3. Response to RQ3

The answers to RQ3 are reported in Tables 3 and 4, illustrating the top 10 contributing countries and top 11 journals concerning digital platforms in economic resilience post-pandemic, respectively. These tables provide critical metrics, including total citations (TC), number of articles (NoA), total link strength (TLS), and average citations (AC), offering a comprehensive perspective on the impact and collaboration in this domain.

The analysis of 43 nations highlights considerable progress in the field, with Spain emerging as the top contributor. Spain secured the highest rank in co-authorship, with 148 citations across four documents, reflecting its robust academic influence and a notable average citation rate (AC) of 37. Despite a relatively low TLS (1) and few links,

its work has significantly impacted research. Bolivia follows closely in second place with 140 citations from a single article, the highest average citation rate (AC 140) among all countries. This singular yet highly influential contribution underscores Bolivia's substantial impact in this research area, although it has limited collaborative connections (TLS 1). India ranked third and stands out for its many articles (9), accumulating 134 citations. With a strong TLS of 5 and multiple links, India demonstrates substantial collaboration and influence within the research community. Other noteworthy contributor countries include the United Kingdom (118 citations, AC 14.75) and the United States (86 citations, AC 8.6), both of which exhibit co-authorship (TLS 3 and 5, respectively), reinforcing their leadership in international collaborations (Figure 4).

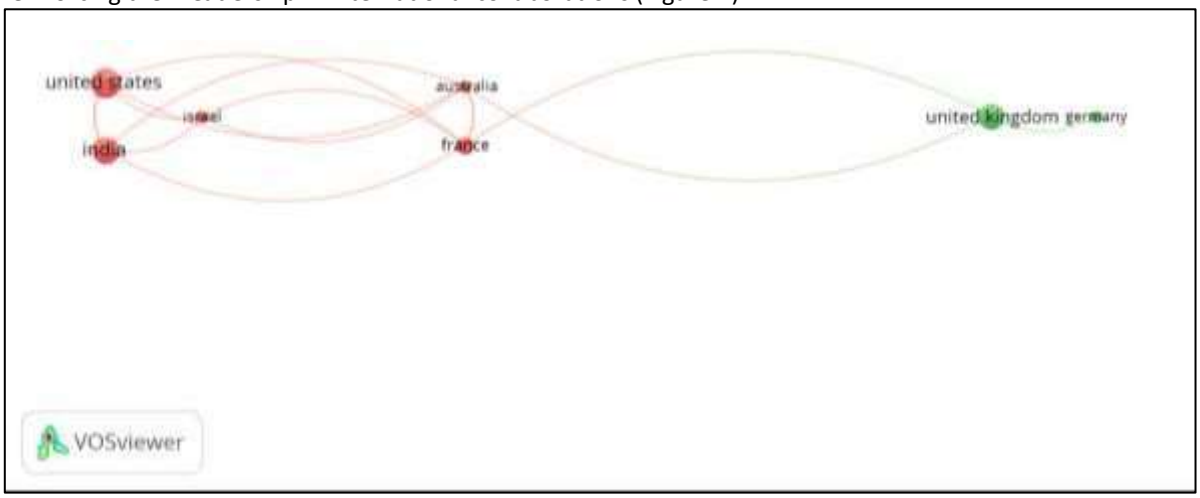

Figure 4. Scientific output distribution of countries

Countries such as France, Australia, Israel, Greece, and Germany contribute significantly, reflecting diverse global participation. For instance, Australia and Israel share an AC of 21 and demonstrate substantial co-authorship strength (TLS 6 and 4). France, Australia, Israel, Greece, Germany, Australia and Israel.

Table 3. Most contributing countries (top 10 out of 43) based on co-authorship analysis

Rank	Country	TC	NoA	TLS	Links	AC
1	Spain	148	4	1	0	37
2	Bolivia	140	1	1	0	140
3	India	134	9	5	4	14.8
4	United Kingdom	118	8	3	3	14.75
5	United States	86	10	5	4	8.6
6	France	43	4	6	5	10.75
7	Australia	42	2	6	5	21
8	Israel	42	2	4	4	21
9	Greece	30	4	0	0	7.5
10	Germany	23	2	1	1	11.5

Note: TC: Total citations, NoA: Number of articles, TLS: Total link strength, AC: Average citations
Source: Authors

The bibliographic coupling analysis of 65 journals ranks the top 11 based on their TC, NoA, TLS, and AC. The Journal of Business Research, published by Elsevier Inc., tops the list with 180 TC from two articles and a TLS of 2, indicating its central role in advancing research on digital platforms and economic resilience. The second-ranking journal, Education Sciences (MDPI), contributed three articles and accumulated 82 citations. Its focus on educational technologies and learning paradigms post-pandemic makes it an essential publication in this research area. Digital Geography and Society (Elsevier Ltd.), with 53 citations from four articles and the highest TLS (4), ranks third, emphasising spatial and digital dynamics in economic resilience. Other prominent journals include Management Decision and Journal of Enterprise Information Management, published by Emerald Group, which contribute insights into managerial strategies and enterprise-level transformations.

Table 4. Most contributing journals (top 11 out of 65) based on bibliographic coupling

Rank	Journal	Publisher	TC	NoA	TLS
1	Journal of Business Research	Elsevier Inc.	180	2	2
2	Education Sciences	MDPI	82	3	1
3	Digital Geography and Society	Elsevier Ltd	53	4	4
4	Management Decision	Emerald Group Publishing Ltd.	42	1	0
5	Journal of Enterprise Information Management	Emerald Group Publishing Ltd.	34	1	1
6	Sustainability (Switzerland)	MDPI	32	4	2
7	Journal of Research in Interactive Marketing	Emerald Group Publishing Ltd.	23	1	0
8	Postdigital Science and Education	Springer International Publishing AG	20	1	3
9	Resilience, Authenticity and Digital Heritage Tourism	Taylor and Francis Ltd	13	1	1
10	Forum Scientiae Oeconomia	WSB University	13	1	0
11	Qualitative Market Research	Emerald Group Publishing Ltd.	13	1	0

Note: TC: Total citations, NoA: Number of articles, TLS: Total link strength, AC: Average citations
Source: Authors

The findings underscore the research's collaborative and multidisciplinary nature in digital platforms and economic resilience. Spain, India, and the United Kingdom emerge as key contributors, while journals like the Journal of Business Research and Education Sciences drive impactful academic discourse. These contributions highlight the importance of international collaboration and the role of key journals in shaping future research directions.

3.4. Response to RQ4

This network analysis provides valuable insights into predicting future research trajectories. Figure 5 illustrates the co-occurrence analysis of keywords in the dataset, applying a threshold of at least two occurrences. Out of 477 keywords, 42 met the specified threshold, underscoring their significance in the literature. The visualization reveals six distinct clusters, each representing a central thematic or research area, suggesting that closely related concepts have garnered substantial scholarly attention. These clusters are visually differentiated by colour: red, green, blue, yellow, purple, and cyan.

The analysis identifies 206 connections between keywords, reflecting the intricate relationships among various topics and ideas. This interconnectedness suggests that researchers frequently explore multiple dimensions simultaneously, emphasizing these subjects' complex and interrelated nature. Additionally, the total association strength of 259 further highlights the centrality of specific topics, indicating their pivotal role in shaping the core of the research and their ability to attract greater academic interest due to their strong correlations with other concepts.

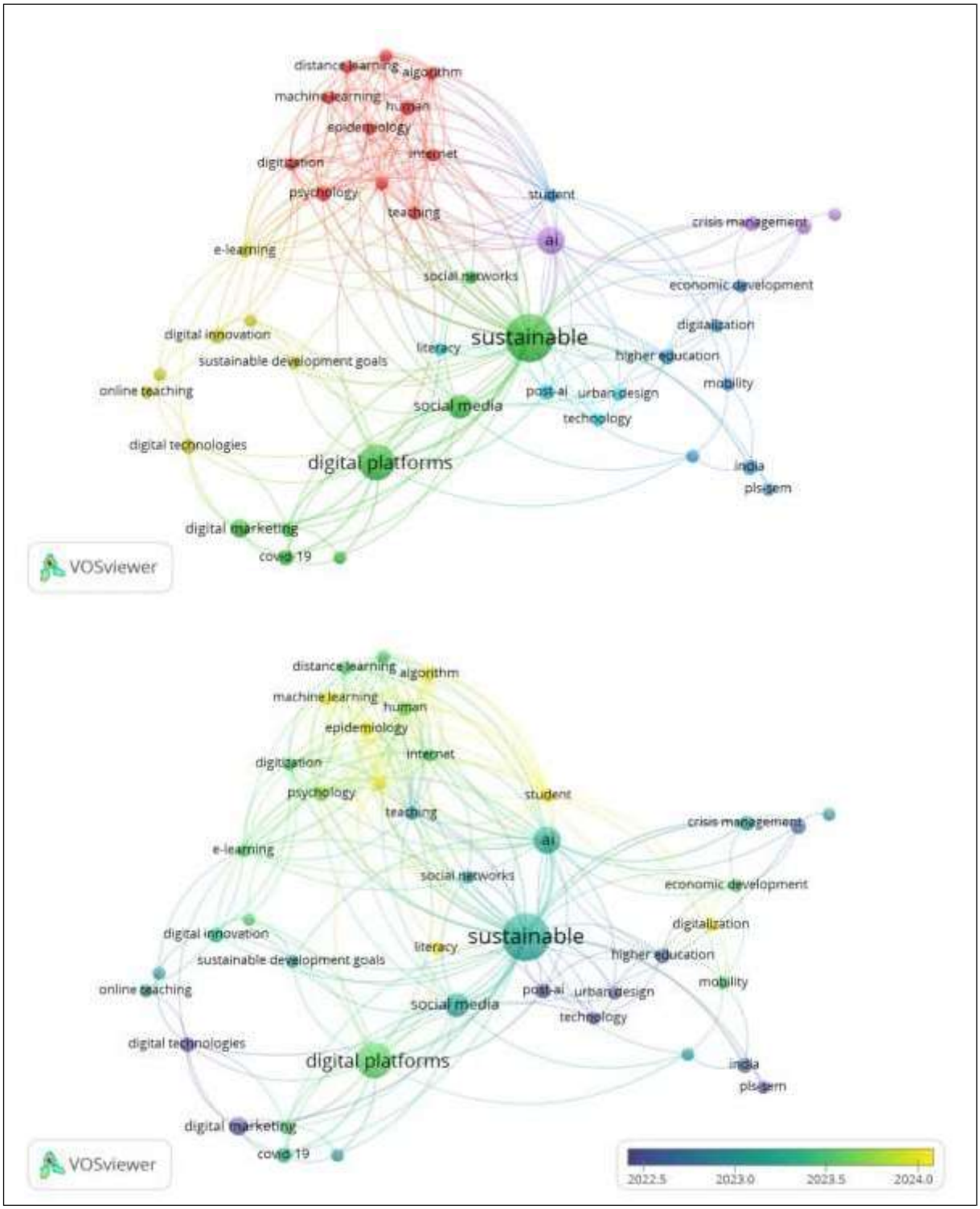

Figure 5. Visualization of keywords co-occurrence analysis
Source: Authors

Cluster 1. Human-Centred Digital Capability Formation (Red Cluster)

The red cluster brings together keywords such as algorithm, machine learning, psychology, distance learning, medical education, teaching, and human, indicating that this research branch places humans at the centre of the digital transformation process. Instead of viewing digital platforms and technology as neutral tools, this research emphasises that the effectiveness of digitalisation strongly depends on the capacity for technology adoption, learning ability, psychological adaptability, and skill restructuring of individuals and organisations. Therefore, this cluster is not just about online education or digital healthcare, but rather about how digital human capital is formed in the context of, and after, crises. In the network map, the red cluster is located quite close to central nodes such as digital platforms, sustainable development, and AI, showing that this is a crucial micro-platform for

larger recovery mechanisms to operate (Dwivedy et al., 2025). Simultaneously, on the overlay time map, many nodes in this cluster are turning yellow, such as algorithm, machine learning, student, and distance learning, indicating a recent shift in academic interest from describing initial adaptation to more sophisticated questions about digital competence, learning assessment, and AI-powered decision enhancement (Valiati & Möller, 2025). In terms of content, studies in this cluster show that the pandemic acted as a catalyst, forcing education, vocational training, and healthcare to shift to digital platforms at an unprecedented pace. This gives rise to three key issues. First, the link between psychological stress and digital adaptability: online learning and working maintain continuity but also exacerbate digital fatigue, social isolation, and cognitive stress; these factors directly impact the productivity, engagement, and resilience of the local workforce. Secondly, disparities in access to and use of technology, especially in education and healthcare, lead to uneven accumulation of human capital across regions. Thirdly, the rise of machine learning and algorithmic support for diagnosis, forecasting, and decision optimisation opens the possibility of improving service quality while simultaneously raising concerns about algorithmic bias, privacy, and labour surveillance on platforms. From a regional economic resilience perspective, this cluster suggests that regional resilience depends not only on digital infrastructure but also on the ability of education, healthcare, and labour markets to translate technology into human capabilities. Recent findings also reinforce this interpretation, indicating that digitalisation and remote work can enhance business and local resilience, but the impact is only truly sustainable when accompanied by retraining and organisational adaptation (Latuheru et al., 2025).

Cluster 2: Digital marketing, social media, and sustainable platform-based markets for regional resilience (Green Cluster)

The green cluster, which illustrates how digital platforms, social media, and digital marketing have developed from short-term crisis tools into longer-term mechanisms for sustainable market adaptation and regional economic resilience, is the review's most direct and policy-relevant thread. This cluster, which is based on the keywords "commerce," "digital marketing," "digital platforms," "social media," "social networks," "labour market," and "sustainable," demonstrates that the post-pandemic literature no longer views digital platforms as just an emergency means for preserving business continuity. Rather, they are increasingly seen as infrastructures for sustainable market coordination, allowing businesses, employees, and consumers to stay linked while reorganising production, communication, and exchange in ways that are more resource-efficient and adaptable (Mehra et al., 2025). While the overlay visualisation indicates that this stream gained significant momentum during the 2023–2024 period, when the debate shifted from the immediate COVID-19 response to more durable questions of digital competitiveness, platform governance, and sustainability-oriented transformation, the co-word map's green colour highlights the cluster's strong internal coherence (Nguyen & Son Dinh, 2025).

The role of digital platforms as facilitators of sustainable commerce is the cluster's first key theme. In many situations, businesses relied on platform-mediated transactions both during and after the epidemic to maintain client relationships, minimise physical restrictions, and maintain market access. But more and more research indicates that these platforms' benefits extend beyond only recuperation. Digital platforms facilitate more adaptable and possibly sustainable business models, especially for small businesses and local entrepreneurs, by cutting transaction costs, decreasing reliance on physical intermediation, and broadening market reach. Research on the use of mobile platforms in retail and digital adaptation in post-pandemic business environments shows that companies' continued use of these systems is influenced not only by necessity but also by perceived utility, behavioural control, and the increasing understanding that digital channels can improve long-term competitiveness and continuity (Jena, 2022; Rammal et al., 2023). In this perspective, rather than portraying digital commerce as a short-term replacement for ofline interaction, the cluster portrays it as a resilience pathway through market continuity, efficiency, and adaptive reconfiguration.

The emergence of social media and digital marketing as sustainable engagement methods is the subject of a second theme. The prominence of social media and social networks in this cluster suggests that the ability of businesses and individuals to foster trust, visibility, and interaction in digital environments is just as important to resilience as having access to technology. According to research, social media platforms are rapidly serving as an inexpensive marketing infrastructure that helps companies maintain customers' attention, build communities, and adjust their branding strategies at unpredictable times. In post-pandemic labour and product marketplaces, where visibility and responsiveness frequently defined survival, research on personal branding, online interaction, and digital marketing indicates that these techniques became extremely valuable (Machado et al., 2024). This is important from a sustainability standpoint, since digital marketing can foster more ongoing, data-driven client relationships, increase opportunities for micro and small businesses, and reduce reliance on resource-intensive promotional channels. However, the literature does not portray this shift as intrinsically advantageous. It also draws attention to the dangers of content saturation, algorithmic visibility disparities, platform dependence, and authenticity pressures. This cluster thus suggests a more nuanced conclusion: social

media-driven digital marketing only helps sustainable adaption when it enhances long-term relational value rather than just short-term promotional intensity (Strickland & Ratten, 2024).

The green cluster's third line of debate concerns platformization's effects on the labour market, which are crucial to understanding sustainability from a broader socioeconomic perspective. The labour market's inclusion alongside commerce and digital platforms indicates that the literature is increasingly considering resilience from both employment restructuring and business continuity perspectives. Platform-based ecosystems generate new types of work, branding, broking, and digital intermediation, but they also unevenly increase competition and spread risk. Research on urban platformization and post-pandemic labour transitions demonstrates that while platforms can offer workers and businesses adaptive options, these advantages are often accompanied by precarity, institutional conflict, and unequal control over visibility and data (Kuttler, 2023). Because of this, the cluster's sustainability dimension should not be limited to corporate expansion or environmental effectiveness. Instead, it represents a more comprehensive view of sustainable development that encompasses social inclusion, economic continuity, and more equitable involvement in digital marketplaces. According to this perspective, social media and digital platforms can significantly contribute to regional resilience only when they are supported by governance frameworks that safeguard working conditions, promote digital competency, and shield users from platform-mediated risks.

When combined, the green cluster can be considered the study's central sustainability cluster, as it connects digital platforms to both the long-term restructuring of communication, exchange, and livelihood systems and commercial recovery. Its conceptual contribution is in demonstrating how platform-based ecosystems, where social media exposure, digital marketing capabilities, and sustainable commercial adaptation interact, are increasingly mediating regional economic resilience. Because it directly addresses management, digital transformation, and the socioeconomic aspects of sustainability while also providing policy implications for more equitable and long-lasting regional development, the cluster is particularly pertinent to the journal's purpose. More precisely, research indicates that resilience-oriented policy should support sustainable digital marketing strategies that foster social well-being and competitiveness, responsible platform governance, and the development of digital capabilities for workers and SMEs. In this regard, the green cluster highlights a key recovery pathway in the literature: when digital platforms and social media are integrated into sustainable systems of market communication, participation, and value creation beyond commerce, areas become more resilient.

Cluster 3. Digitalisation, Mobility, and Developmental Pathways in Emerging Contexts (Blue Cluster)

The blue cluster includes digitalisation, economic development, higher education, mobility, India, students, and theoretical study. Compared to cluster 2, which focuses on the platform market, cluster 3 reflects a research direction that emphasises the development trajectory of digitalisation in transitional contexts, especially in emerging economies. The simultaneous emergence of economic development, mobility, and higher education shows that this is not a narrow cluster about education, but rather one describing how digitalisation permeates fields directly related to the movement of opportunities, access to resources, and the upgrading of regional development capacity (Ben Youssef, 2025). On the overlay map, many keywords in this cluster are highlighted in dark blue, including higher education, mobility, technology, and India, indicating they belong to an earlier research class from the 2022–early 2023 period. Consequently, this cluster shows that digitalisation is perceived as a development enabler, particularly by expanding learning capabilities, social mobility, and cross-border connectivity. However, studies within the cluster also show that the impact of digitalisation does not occur automatically. In higher education, digital platforms can expand learning experiences, increase interactivity, and support internationalisation, but these benefits are strongly conditioned by institutional quality, the availability of infrastructure, and digital pedagogical capacity (Jun et al., 2025). In urban and service spaces, mobility and logistics platforms are restructuring the relationship between the state, platforms, and workers. In emerging economies, digitalisation is not just about adopting technology, but about reshaping development paths. When digitalisation is linked to education, mobility, and institutional support, it can enhance a region's long-term resilience (Le-Dinh et al., 2025); however, if it occurs within a weak institutional environment, the impact may be more divergent than convergent. Recent evidence also suggests that the digital industry, digital infrastructure, and digital economy can improve regional resilience through structural upgrades, innovation, and spatial effects, but the extent of the impact varies considerably between regions.

Cluster 4. Digital Innovation, E-Learning, and Innovation Performance (Yellow Cluster)

The yellow cluster comprises digital innovation, digital technologies, e-learning, online teaching, innovation performance, opportunity, and sustainable development. While Cluster 1 emphasises human capacity to adopt technology, Cluster 4 focuses on how technology is organised and deployed to create innovation performance at the organisational and ecosystem levels (Diniță et al., 2025). The yellow colour of the cluster on the network map is linked to several nodes on the left half of the map, where e-learning, digital innovation, and online teaching

connect with digital platforms and Sustainable Development Goals. On the overlay, these nodes tend to shift from green to yellow, indicating a theme that has evolved significantly over time: from digitalisation being used only to maintain teaching and business during the pandemic to being seen as a driver of innovation and performance in the post-crisis context (Hang Vu & Nguyen, 2026). From a holistic perspective, this cluster shows that innovation is no longer understood simply as creating new products, but as the ability to recombine technology, knowledge, and operating models to maintain and upgrade operations. In education, e-learning and online teaching open up opportunities for personalisation, increased engagement, and expanded accessibility, but also place very high demands on learning material design, instructor digital skills, and connectivity infrastructure. In the business sector, especially SMEs and innovative businesses, digital innovation is closely linked to the ability to restructure processes, reach new customers, and shift from reactive to growth. This cluster is also closest to the spirit of Industry 4.0, as it shifts the focus from adoption to innovation performance and opportunity capture. Recent studies on the digital economy in the Industry 4.0 environment and on digital interventions for business resilience reinforce the argument that digital innovation is not just a short-term response but is becoming a long-term component of resilience (Bandrova et al., 2025; Nsir et al., 2025).

Cluster 5. AI, Blockchain, and Platform-Based Crisis Governance (Purple Cluster)

This cluster, though small, is noteworthy for bringing together keywords with high technological content: AI, blockchain, crisis management, and platforms. Structurally, it's a fairly concentrated cluster positioned between economic development topics and central nodes such as sustainable and digital platforms. This indicates it's not the largest cluster within the study, but it plays a crucial role in connecting discussions about new technologies with crisis management and platform governance issues. In the overlay map, AI and its connections are primarily colored from turquoise to violet, meaning they've grown rapidly recently but are still in their formative stages rather than fully stable (Van Wyk, 2025). This aligns with the broader academic context: since the pandemic, AI and blockchain have increasingly been seen as tools to enhance predictive capabilities, tracing, information coordination, and trust-building in vulnerable systems (Domina et al., 2025). The content of this cluster represents a shift from “digital transformation” to “algorithmic and distributed governance.” AI supports pattern recognition, risk forecasting, and decision optimisation under uncertainty; blockchain provides a transparent infrastructure for data retrieval and validation; and platforms create a space for coordination among multiple stakeholders (Corallo et al., 2025). However, this cluster is also where policy implications become clear: alongside the prospect of improved crisis management efficiency are questions about algorithmic transparency, data power asymmetry, digital exclusion risks, and governance costs. Therefore, this cluster demonstrates that the region's resilience in the Industry 4.0 era stems not only from having new technologies but also from the capacity to manage them (Widaningsih et al., 2025).

Cluster 6. Digital Literacy, Urban Adaptation, and Technology Futures (Cyan Cluster)

The cyan cluster comprises literacy, technology, urban design, and post-AI. Despite having only four keywords, this cluster is not weak; on the contrary, it reflects emerging and dispersed topics. The combination of literacy and urban design shows that this is not simply a matter of individual skills, but rather of designing an institutional–spatial–cognitive environment in which technology becomes useful and inclusive (Sergei & Miroslav, 2025). The keyword post-AI appears infrequently and at the network's edge. This suggests that the concept is not yet theoretically stable. On the overlay map, this cluster is mainly in the blue-turquoise region, meaning it is emerging but has not yet reached the academic depth of clusters related to digital commerce or digital education. This cluster emphasises the foundational conditions for long-term adaptability, including digital literacy, the ability to understand and use technology, and the integration of technology into urban planning. This is particularly important for regional economic resilience, as the future resilience of a region will depend not only on having AI platforms, but also on whether citizens, businesses, and governments have sufficient literacy to use them effectively, the design capabilities to integrate them into living spaces, and the institutions to mitigate external impacts (Truong et al., 2025). New research on AI in regional development and on the integration of AI, blockchain, and digital twins for smart resilience shows that regional development policy is gradually shifting from supporting digital infrastructure to an ecosystem of digital capabilities and adaptive design capabilities (Hang Vu et al., 2026).

4. DISCUSSION AND CONCLUSIONS

4.1. Discussion of findings

The systematic review results show that research on digital platforms, Industry 4.0 technologies, and regional economic resilience has grown rapidly in the post-pandemic period. The annual publication trend shows a clear and continuous increase from 2020 to 2025. Research activity was relatively modest in 2020, with only 1

publication, but increased sharply in subsequent years, reaching 7 publications in 2021, 12 in 2022, 15 in 2023, 18 in 2024, and 25 in 2025. This trend indicates that research topics have shifted from an emerging approach in the early stages of the COVID-19 crisis to a more stable research stream focusing on digital-based recovery, adaptation through digital platforms, and long-term transformation at the regional level. This steady increase also reflects the growing awareness that digital platforms and Industry 4.0 technologies are not merely temporary crisis-response tools but are becoming crucial structural elements of economic resilience in the post-pandemic context.

The document type structure further reinforces the assessment of the academic development of this topic. Of the 78 documents, journal articles accounted for the largest proportion, with 58 publications (74.4% of the dataset). This indicates that academic discussions on digital platforms and the region's economic resilience are primarily developed through peer-reviewed scientific journal research, rather than through conference papers, books, or book chapters. Book chapters and conference papers also contribute to this area, but to a more limited extent, while the number of review articles remains relatively low. The scarcity of comprehensive reviews indicates that while empirical and conceptual studies on digital platforms, Industry 4.0, and resilience have increased, systematic meta-analysis remains lacking. This also underscores the need for current research to systematise scattered evidence, identify recovery pathways, and highlight key policy implications in the literature.

Geographically, the results show that this research area attracts interest from many countries. Countries such as France, Australia, Israel, Greece, and Germany have made significant contributions, reflecting the international and multi-contextual nature of digital platforms and economic resilience in the region. Notably, the collaboration between Australia and Israel, with an AC score of 21 and a relatively prominent level of co-authorship, demonstrates that this topic has fostered cross-national academic connections. This is significant because the economic resilience of a region is highly context-dependent. Each country and territory has different institutional conditions, digital infrastructure, technological capabilities, and socio-economic characteristics. Therefore, the diversity of countries enriches the field of research by providing evidence from multiple development contexts.

The analysis at the journal level also reveals the field's interdisciplinary development. The Journal of Business Research leads in total citations, demonstrating its central role in driving discussions on digital platforms, business transformation, remote work, and post-pandemic economic adaptation. Education Sciences is also a significant publication source, reflecting the role of online learning, educational technology, and digital competency formation in broader discussions of resilience. Meanwhile, Digital Geography and Society contributes spatial perspectives, particularly in connecting digitalisation with location-based development, platform economics, and regional transformation. Other journals, such as Management Decision and Journal of Enterprise Information Management, offer perspectives on governance, corporate strategy, and organisational transformation. Overall, the prominent publications show that the field is not confined to a narrow discipline, but is shaped by contributions from business, education, geography, governance, information systems, and research and development.

The most-cited publications continue to demonstrate the multifaceted nature of the research literature. The study by Saura et al. (2022) is the most cited, focusing on remote work and Twitter user sentiment in the post-pandemic context. The high number of citations for this study highlights the importance of considering the social, emotional, and organisational impacts of digitally-based work models. The study by Peimani and Kamalipour (2021), the second most-cited, analyses online education in the post-COVID-19 era and emphasises the role of learner experience in digital transformation. Guru et al. (2023) contribute to the discussion of hyper-local delivery models, demonstrating how platform-based distribution systems can support supply chain adaptation and maintain consumer accessibility. Reizer et al. (2022) added behavioural and psychological perspectives to their analysis of the relationship between COVID-19 fear, uncertainty, and distracting behaviour in the digital workplace. Other influential publications address leadership, sustainability, educational technology, marketing, social media, and food delivery platforms. This diversity shows that resilience is not just an economic issue, but also a social, behavioural, organisational, and spatial phenomenon.

Figure 6 synthesises these findings within an integrated framework. The figure shows six thematic clusters that form the knowledge base for explaining the relationship between digital platforms, Industry 4.0 technologies, and regional economic resilience. This framework illustrates that the impact of digital transformation is mediated by regional and organisational capabilities, including strategic leadership, digital skills and understanding, innovative learning, data and AI infrastructure, partnerships, ecosystems, and adaptive institutions. These capabilities are translated into resilient outcomes through integrated mechanisms such as human-centred capacity building, sustainable digital market coordination, mobility-based inclusion, innovation diffusion and e-learning, AI/blockchain-based coordination, and urban adaptation and future forecasting. At the same time, this framework acknowledges that digitalisation may be limited by adverse feedback conditions, including the digital divide, skills shortages, platform dependence, data and privacy risks, infrastructure asymmetry, and governance fragmentation.

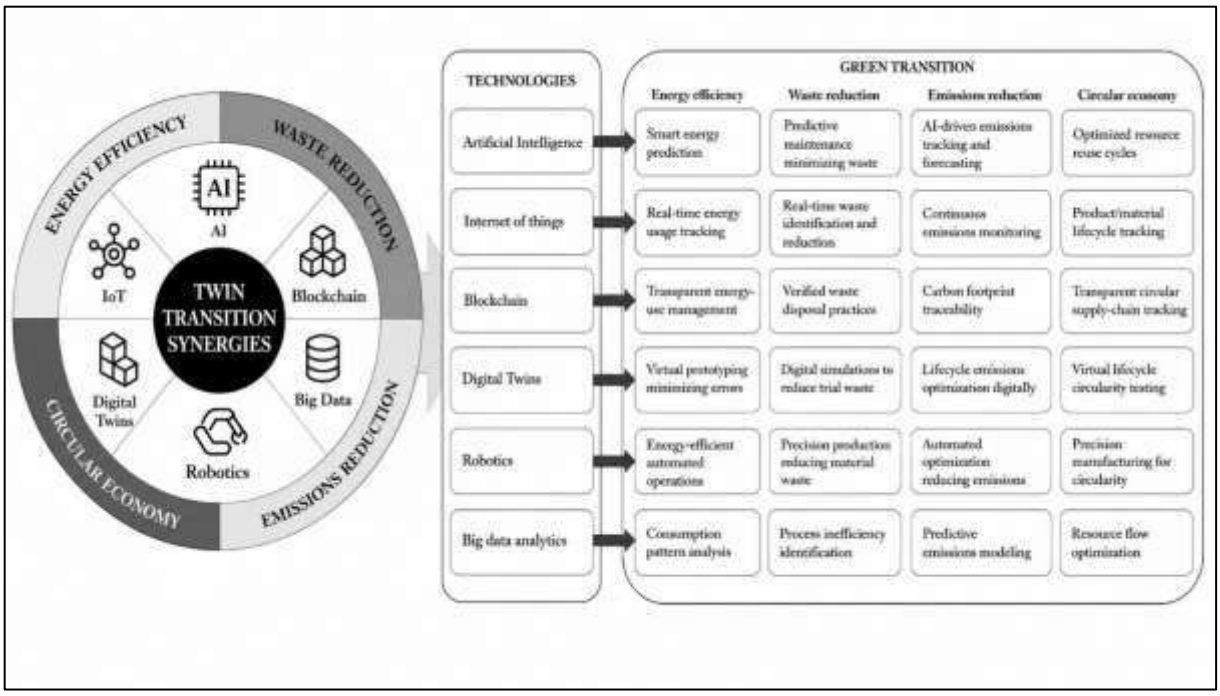

Figure 6. Digital Resilience Synthesis Framework
Source: Authors

Key findings suggest that regional economic resilience in the digital age should be understood as a capacity- and ecosystem-based process. Digital platforms and Industry 4.0 technologies can support recovery and transformation, but their contribution depends on how these technologies are integrated with human capabilities, organisational processes, governance institutions, market systems, and regional development strategies. This research area also exhibits a distinctly interdisciplinary character, as evidenced by the diversity of journals, influential publications, document types, and contributing countries.

Cluster analysis expands the bibliographic findings by identifying key content directions within the field. Cluster 1 – Human-Centred Digital Capability Formation – emphasises the foundational role of digital skills, human capital, organisational learning, and inclusiveness. This cluster shows that digital transformation only truly contributes to resilience when individuals and organisations have the capacity to use, interpret, and adapt to digital technologies. Cluster 2 – Digital marketing, social media, and sustainable platform-based markets for regional resilience – shows how digital platforms help businesses maintain market access, engage with customers, and stabilise regional demand during periods of disruption. This is particularly significant for small and medium-sized enterprises (SMEs), which rely heavily on digital channels to maintain their presence and expand their market reach. Cluster 3 – Digitalisation, Mobility, and Developmental Pathways in Emerging Contexts – reflects the spatial and developmental dimensions of digital transformation. This cluster shows how digital infrastructure, connectivity, and mobility-related technologies can support more inclusive development pathways, especially in emerging contexts or in resource-constrained regions. Cluster 4 – Digital Innovation, E-Learning, and Innovation Performance – emphasises the role of digital learning, knowledge transfer, and innovation capacity in enhancing resilience. This cluster shows that resilience is not just about returning to pre-crisis states, but also includes the capacity to innovate, experiment, and restructure existing practices. Cluster 5 – AI, Blockchain, and Platform-Based Crisis Governance – highlights the growing role of advanced technologies in crisis monitoring, coordination, transparency, and data-driven decision-making. AI can support predictive analytics, risk assessment, and resource allocation, while blockchain can enhance traceability, trust, and accountability in platform-based systems. However, these technologies also raise issues related to data governance, privacy, cybersecurity, and institutional readiness. Cluster 6 – Digital Literacy, Urban Adaptation, and Technology Futures – broadens the discussion by linking citizens' digital capabilities to urban adaptation, smart urban development, and future-oriented thinking. This cluster emphasises that resilient regions are not only those that adopt technology, but also those that prepare citizens, organisations, and urban systems for continuous technological change.

4.2. Recovery pathways enabled by digital platforms and Industry 4.0

Based on findings from the bibliographic analysis and the system overview, it can be seen that digital platforms and Industry 4.0 technologies do not affect the economic resilience of regions in a single direction. Instead, they create multiple recovery pathways through a combination of digital capabilities, integration mechanisms, organisational capabilities, institutional capabilities, and the development conditions of each region. These

pathways reflect how regions, businesses, and organisations use digital technology to maintain operations, adapt to disruption, restructure markets, and move towards long-term transformation.

Figure 7 presents an integrated framework explaining how the six main thematic clusters are transformed into regional economic recovery mechanisms. This framework shows that the research clusters do not exist in isolation but are linked through two important intermediate layers: regional capabilities and organisational capabilities, as well as technology-market-governance integration mechanisms. Specifically, capabilities such as strategic leadership, digital skills and knowledge, data/AI infrastructure, innovative learning, partnerships, and adaptive institutions act as intermediaries for digital technologies to generate resilient outcomes. Through integrated mechanisms such as human-centred capacity building, sustainable digital market coordination, mobility-based inclusion, innovation diffusion and e-learning, AI/blockchain-based collaboration, as well as urban adaptation and future forecasting, digital platforms and Industry 4.0 technologies can create impact at both enterprise and regional levels.

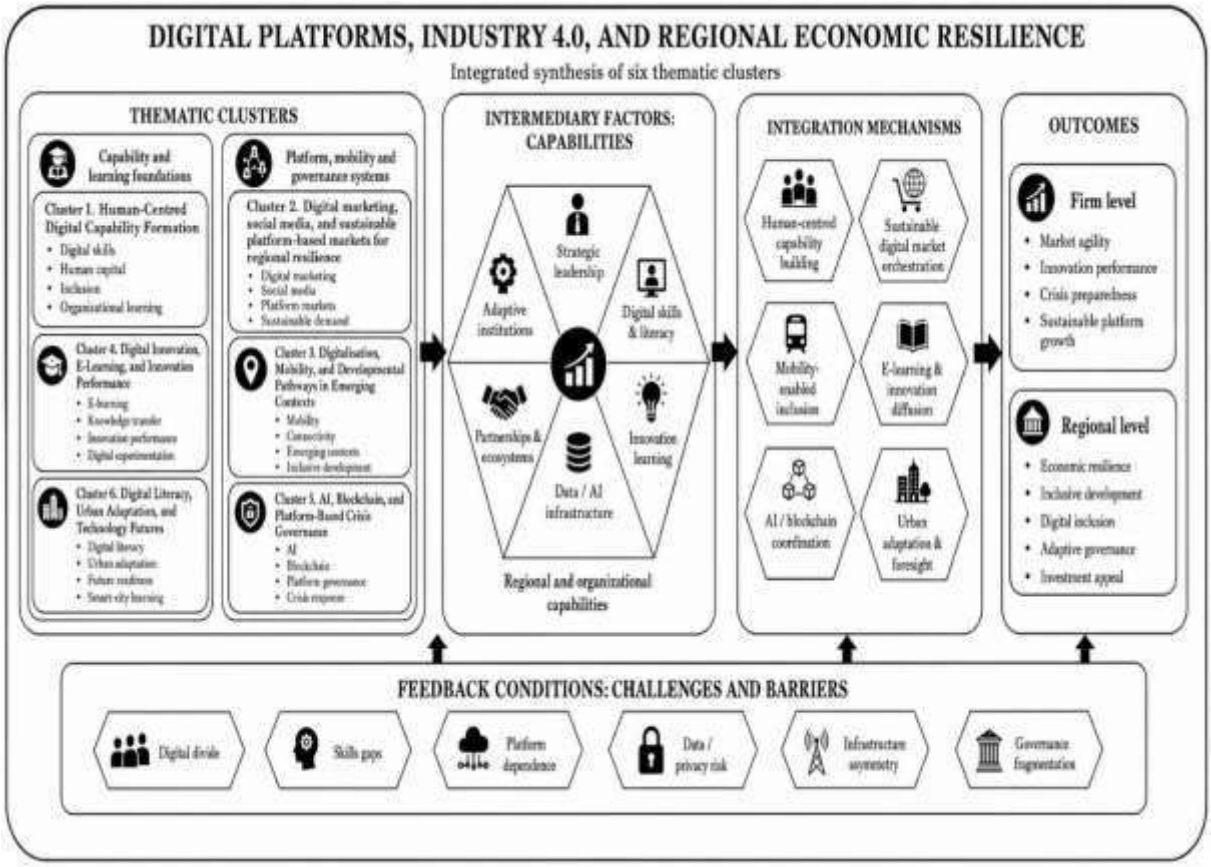

Figure 7. Platform-Enabled Recovery Pathways
Source: Authors

The first recovery path is the development of human-centred digital capabilities. Results from Cluster 1 show that digital skills, human capital, organisational learning capacity, and inclusiveness are fundamental to enabling regional actors to adapt to change. Digital platforms and Industry 4.0 technologies can only be effective when workers, managers, businesses, and local communities have sufficient capacity to access, use, and leverage these technologies. Therefore, regional economic recovery should not be understood simply as an investment in technology, but rather as a process of upgrading human and organisational capabilities. This path is particularly important for developing regions, where the digital skills gap and inequality in access to technology can undermine the effectiveness of digital transformation.

The second recovery path is the development of a sustainable digital market based on platforms. Cluster 2 shows that digital marketing, social media, and online marketplace platforms play a crucial role in helping businesses maintain customer engagement, expand distribution channels, and stabilise demand amidst disruption. For small and medium-sized enterprises (SMEs), digital platforms can help reduce reliance on traditional physical markets, expand customer reach, and increase responsiveness to market changes. However, this path also raises issues of platform dependence, disparities in digital marketing capabilities, and uneven access among businesses. Therefore, digital marketplaces only truly support regional resilience when combined with platform trust, data governance capabilities, fair competition, and a sustainable development orientation.

The third recovery path is inclusive and interconnected development through digitalisation and mobility. Cluster 3 emphasises the role of digitalisation, connectivity, and mobility-supporting technologies in expanding access to services, markets, and development opportunities for emerging or resource-constrained regions. Digital platforms can help connect peripheral areas with broader economic flows, improve access to services, and support more resilient development models. However, the positive impact of this path strongly depends on the quality of digital infrastructure, logistics infrastructure, inter-local coordination capacity, and the inclusiveness of regional development policies. Without proper governance, digitalisation can exacerbate spatial inequality between regions with good infrastructure and those with weak connectivity.

The fourth recovery path is to sustain learning and innovation and enhance the efficiency of innovation through digital technology. Cluster 4 shows that e-learning, digital collaboration tools, and technology-based innovation systems can sustain knowledge flow during a crisis. This is a crucial mechanism that helps businesses and organisations not only recover lost operations but also enhance their capacity for experimentation, restructuring, and innovation in operating models. At the regional level, digital learning and digital innovation help form new knowledge networks, supporting technology diffusion and enhancing long-term competitiveness. Therefore, this path shows that resilience is not only linked to short-term recovery but is also directly related to the capacity for continuous learning and innovation.

The fifth recovery path is AI- and blockchain-based crisis management on digital platforms. Cluster 5 reflects the increasingly clear role of advanced technologies in monitoring, forecasting, coordinating, and transparentizing socio-economic activities during a period of great uncertainty. AI can support big data analysis, trend detection, risk forecasting, and resource allocation optimisation. Blockchain can enhance traceability, trust, and accountability in transaction systems, supply chains, and public services. Digital platforms also facilitate rapid collaboration between businesses, governments, and communities. However, this path requires data governance capabilities, cybersecurity, ethical standards, and institutional trust. Without these conditions, the application of AI and blockchain could give rise to new risks related to privacy, surveillance, digital exclusion, or governance fragmentation.

The sixth recovery pathway is urban adaptation and preparation for the technological future. Cluster 6 shows that citizens' digital capabilities, urban adaptability, and technological foresight are crucial elements for long-term resilience. Resilient regions and cities are not only those that adopt technology rapidly, but also those that can prepare their citizens, organisations, and infrastructure for continuous technological change. Digital literacy enables citizens to access digital services, participate in the digital economy, and adapt to new forms of work, learning, and consumption. Meanwhile, urban adaptation and foresight enable regional governments to be more proactive in infrastructure planning, risk management, and the development of inclusive smart-city models.

The integrated framework in Figure 7 also shows that the recovery pathways do not operate independently. They are interconnected through mediating capabilities and are influenced by feedback conditions. Barriers such as the digital divide, skills shortages, platform dependence, data and privacy risks, infrastructure asymmetry, and governance fragmentation can undermine the positive impact of digital technologies. This implies that recovery strategies based on digital platforms and Industry 4.0 need to be comprehensively designed, combining technology investment, human capacity building, infrastructure improvements, adaptive institutional development, and fostering public-private sector collaboration.

Recovery pathways driven by digital platforms and Industry 4.0 technologies include: building human-centred digital capabilities, developing sustainable digital markets, enhancing connectivity and inclusive development, sustaining learning and innovation, improving technology-based crisis governance, and promoting future-oriented urban adaptation. These pathways demonstrate that a region's economic resilience depends not only on the level of technology adoption but also on how technology is integrated into the region's ecosystem, market structure, organisational capacity, governance institutions, and long-term development strategies.

4.3. Theoretical implications

The research findings offer several important theoretical implications for explaining the relationship between digital platforms, Industry 4.0 technologies, and regional economic resilience. First, the literature review shows that this research area has moved beyond its initial focus on immediate post-pandemic recovery. In the early stages of COVID-19, many studies viewed digital platforms as tools for maintaining operations, enabling education, healthcare, labour, services, and market transactions to continue functioning under severe disruptions. However, the current thematic structure of the literature reveals that digital platforms and Industry 4.0 technologies are increasingly seen as long-term supporting factors for knowledge sharing, industrial upgrading, organisational adaptation, institutional coordination, and the restructuring of regional development. This shift has significant theoretical implications as it alters the understanding of regional economic resilience. Resilience should not be understood merely as the ability to absorb shocks or return to pre-crisis states. Instead, the document shows that resilience is a proactive and uneven process of socio-economic transformation based on technology, in which regions must continuously reorganise, adapt, and innovate their economic systems.

According to this approach, digital transformation is no longer a short-term response to a crisis, but becomes part of the foundational structure of regional recovery and development.

The second theoretical implication is the need to shift from a technology-centric approach to a capacity- and ecosystem-based approach. Research clusters on human-centred digital capacity building, digital innovation, e-learning, and innovation effectiveness show that the impact of digital platforms and Industry 4.0 technologies does not depend solely on technology availability. More importantly, this impact depends on the capacity of individuals, businesses, organisations, and local institutions to adopt, utilise, and transform technology into value. Therefore, capacity building can be seen as an intermediary mechanism between technological transformation and regional resilience. Regions with better learning systems, more adaptable institutions, and higher digital capabilities will be able to transform technological and market shocks into opportunities for upgrading, innovation, and restructuring.

A third theoretical implication concerns the role of digital platforms in market coordination and in building sustainable resilience. Research on digital marketing, social media, and platform-based markets shows that digital platforms are not merely transaction channels or communication tools, but also market coordination infrastructures. Through these platforms, businesses can maintain customer relationships, expand market awareness, stabilise demand, and adjust commercial strategies in an uncertain environment. However, the document also shows that digital resilience is truly sustainable only when platform-based adaptation not only helps businesses survive commercially but also supports equitable participation, long-term inclusiveness, suitable working conditions, and sustainable connectivity within regional economic ecosystems.

The fourth theoretical implication is that the research field is entering a new phase, which can be called intelligent resilience and governance orientation. The emergence of topics related to AI, blockchain, algorithms, platform governance, and the post-AI context shows that academic discussion is shifting from the question of "whether to adopt technology" to "how technology is governed." In this phase, resilience is not only linked to technology adoption or the use of digital platforms, but also to the ability to control algorithmic systems, ensure reliable data flow, support predictive decision-making, and address the institutional consequences of AI-based coordination. This expands the understanding of resilience to issues such as data power, algorithmic inequality, accountability, digital trust, digital labour governance, and technological regulatory capacity in different territorial contexts.

This study contributes theoretically in two main directions. First, it shifts the focus from describing digital responses in the post-pandemic period to identifying the socio-economic and technological pathways through which digital transformation shapes regional resilience. Second, it helps connect three relatively fragmented streams of literature: research on digital platforms, Industry 4.0, and regional development. Previous studies often examined individual technologies, industries, platforms, or crisis impacts separately. In contrast, the recovery-oriented approach shows that resilience is formed from the interaction between digital infrastructure, labour systems, platform markets, local institutions, and the specific development conditions of each region.

4.4. Policy implications

The research findings also suggest several important policy implications. First, policies aimed at strengthening regional economic resilience need to move beyond a focus solely on digital infrastructure investment. Internet connectivity, data infrastructure, cloud services, and technology platforms are necessary but not sufficient conditions for creating resilience. The overall results show that the effectiveness of digital platforms and Industry 4.0 technologies strongly depends on digital skills, organisational capacity, learning ability, and institutional adaptability. Therefore, regional policies should combine infrastructure investment with digital capacity-building programmes for workers, small and medium-sized enterprises, teachers, local administrators, and public organisations.

Second, policies should recognise digital platforms, social media, and digital marketing as essential components of the regional market ecosystem, rather than merely as supplementary communication tools or sales channels. For many businesses, especially SMEs, platform-based channels have become crucial mechanisms for maintaining demand, engaging with customers, increasing market awareness, and responding quickly to fluctuations. Therefore, business support programs should include training and consulting on digital marketing, platform participation, online branding, customer data analysis, and market expansion through digital channels. These supports can help businesses reduce vulnerability to crises and participate more effectively in domestic and international digital markets.

Thirdly, policies need to focus on the sustainability and inclusiveness of platform-based adaptation. Digital markets can help businesses maintain operations and expand opportunities, but they can also create new risks, such as dependence on large platforms, unequal visibility, unstable digital working conditions, and disparities in data access. Therefore, digital resilience should not be assessed solely through operational efficiency or online sales growth. Consideration must be given to whether platform-based transformation fosters equitable participation, sustainable employment, long-term competitiveness, and inclusive regional development. This

requires policy to balance innovation, competition, labour protection, and equitable access to digital opportunities.

Fourth, the rise of AI, blockchain, and platform-based crisis governance highlights the urgent need for stronger data and technology governance frameworks. As intelligent technologies become increasingly integrated into regional economic systems, policy needs to address data privacy, cybersecurity, algorithmic accountability, data transparency, digital identity, and trust in platform-based coordination. AI and blockchain can improve forecasting, traceability, resource allocation, and crisis response, but they also require ethical standards, regulatory capacity, and appropriate institutional oversight mechanisms. Without these conditions, intelligent technologies could create new forms of exclusion, over-monitoring, algorithmic bias, or fragmentation in governance.

Fifth, digital resilience policies need to be designed based on local specificities. Resilience is spatially uneven, as regions differ in infrastructure, human capital, industry structure, institutional quality, platform readiness, and business capacity. The same technology can produce vastly different results between a developed urban area, a transitioning industrial region, and a peripheral area with limited connectivity. Therefore, policies applied uniformly to all regions risk increasing rather than narrowing inequalities in resilience. Policies for developing digital resilience need to be tailored to the infrastructure conditions, industry strengths, labour market characteristics, and institutional capacity of each region.

Finally, policies need to promote multi-stakeholder coordination mechanisms involving the state, businesses, educational institutions, technology platforms, and local communities. Regional economic resilience cannot be created by a single entity or a single policy tool. It requires a combination of technology investment, skills development, business model innovation, data governance, labour protection, infrastructure upgrades, and the building of adaptive institutions. Therefore, regional digital recovery and transformation programs should be designed as ecosystem strategies in which policies on technology, education, business, labour, urbanisation, and regional development are interconnected. This approach will help regions not only recover from crises but also enhance their long-term adaptive and transformative capabilities amid increasingly profound digitalisation.

4.5. Limitations and future research directions

This study has certain limitations. First, the dataset was collected from the Scopus database. While Scopus has broad coverage of peer-reviewed scientific publications, the study may have missed some relevant documents indexed in Web of Science, Google Scholar, or regional databases. Further studies could expand the data source to provide a more comprehensive view of this field.

Second, the study only considered publications in English. This may exclude some local or regional studies published in other languages, particularly those reflecting the experience of digital transformation and economic recovery in specific national contexts. Therefore, future studies could utilise a multilingual dataset to better clarify regional and national specificities.

Third, the study used systematic bibliographic analysis and literature reviews. These methods are suitable for identifying publication trends, thematic clusters, and conceptual connections, but they do not permit direct testing of the causal relationship among digital platforms, Industry 4.0 technologies, and the region's economic resilience. Therefore, further studies could develop quantitative models or comparative case studies to test the impact of each digital technology on the region's recovery and adaptation outcomes.

Fourth, the study's dataset focuses on the 2020–2025 period, which was heavily impacted by the COVID-19 pandemic and the post-pandemic recovery process. Meanwhile, digital platforms, AI, blockchain, and Industry 4.0 technologies continue to develop rapidly. Therefore, future research needs to regularly update data to identify emerging topics, especially those related to AI governance, platform dependence, data inequality, digital labour, and smart regional transformation.

Finally, further research should pay more attention to interregional differences. The same digital technology can produce very different outcomes depending on the infrastructure, institutional quality, human capital, industry structure, and policy capacity of each locality. Therefore, more sectoral, regional, and cross-country comparative studies are needed to explain why some regions benefit more from digital transformation, while others risk being left behind.

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Informed Consent Statement: Not applicable.

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