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DECARBONIZATION IN THE DIGITAL AGE: A CRITICAL LITERATURE REVIEW OF ECONOMIC GROWTH AND SUSTAINABILITY TRADE-OFFS

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Abstract:

The growth of the global digital economy has made it more important to understand whether digitalisation is aiding decarbonisation or generating new environmental pressures. While the empirical research is growing, evidence in the existing studies is conflicting and seldom combine the efficiency-enhancing and resource-rebound perspectives into a single conceptual framework. This research carries out a systematic and critical literature review of the digital-sustainability nexus via Scopus using PRISMA. This review summarises peer-reviewed literature from 2022 to 2026, including 14 empirical studies and five methodological and foundational references. This survey surveys evidence from corporate governance, energy markets, smart-city systems, digital trade, and macroeconomic policy. Studies were rated for quality against criteria relating to internal validity, transparency of data, rigour of analysis and, for review articles, transparency of search and inclusion procedures. The results indicate that digital technologies can enhance energy efficiency, optimise the allocation of resources and reduce carbon intensity. However, these gains can be offset by rebound effects, growing demand for electricity and resource use associated with digital infrastructure. The review's main contribution is a conceptual synthesis that integrates the Ecological Modernisation Theory and the Jevons Paradox to account for the conditional, rather than uniformly positive or negative, environmental impacts of digitalisation. Governance, fiscal policy, green finance, renewable-energy deployment and corporate digital-

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decarbonisation maturity are highlighted as important conditions to align digital transformation with decarbonisation in the review. The resulting framework provides an evidence-based basis for future empirical research and for designing digital transformation strategies that maximise environmental benefits, while limiting unintended rebound effects.

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Keyword:

Digital Economy, Decarbonization, Economic Growth, Sustainable Development, Systematic Literature Review

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Introduction

The world's digital economy is experiencing a fundamental shift that is becoming more and more intertwined with the global drive for decarbonisation. Thus, countries face a double transition, where the digital transformation and the ecological transition need to be followed simultaneously, while maintaining a long-term economic performance (Alvi et al., 2025; Meseguer-Sanchez et al., 2024). This alignment raises the question: what conditions might allow digital technologies to foster lower-carbon economic development, rather than exacerbate environmental pressures? Digital technologies are increasingly embedded in international supply chains, smart-city systems, and national energy infrastructures, where they can improve the allocation of resources and contribute to the Sustainable Development Goals (SDGs) (Barut et al., 2023; Deka et al., 2025; Di Vaio et al., 2024; Sharifi et al., 2024). Simultaneously, the proliferation of data networks, computing infrastructure and digitally enabled production can increase electricity demand and resource use, creating important macroeconomic and environmental trade-offs (Gupta & Monika, 2025; Wen et al., 2026).

The debate is framed around the digitalisation-sustainability nexus, which is defined here as the multi-dimensional and potentially non-linear relationship between digital adoption, productivity, resource use and environmental outcomes. Digitalisation can help improve the efficiency of energy systems by leveraging applications such as artificial intelligence (AI), Internet of Things (IoT) technologies, digital payment systems and data-driven energy management (Alvi et al., 2025; Tibrewal et al., 2025). However, data centers, smart systems and blockchain-based networks may increase electricity demand and related environmental pressures (Gupta & Monika, 2025; Madkhali et al., 2024; Wen et al., 2026). These effects are entangled with wider socioeconomic factors such as urbanisation, trade openness, fiscal capacity and the cost of renewable-energy transition, which can shape the distribution of costs

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and benefits across countries and sectors (Goforth et al., 2024; Nica et al., 2026; Sabuz & Tasnim, 2025).

Digital technologies are being adopted at a rapid rate, but the evidence on whether digitalisation accelerates decarbonisation or exacerbates environmental degradation remains inconclusive. The literature is also divided along lines of technological efficiency, energy demand, corporate sustainability, and trade and macroeconomic policy perspectives. Existing reviews tend to focus on these dimensions separately, and few studies combine the efficiency-enhancing mechanisms of digitalisation with the resource and production rebound mechanisms related to the Jevons Paradox. Moreover, evidence is still sparse for developing, fragile and Global South economies and little attention has been paid to how governance, green finance, urbanisation and digital trade policy together influence the digital-sustainability nexus (Emenekwe et al., 2022; Sabuz & Tasnim, 2025; Wang et al., 2022).

This critical review therefore aims to review and critically evaluate the competing mechanisms linking digital economic expansion, economic growth and de-carbonisation. The review is motivated by three interrelated objectives: (i) to identify the mechanisms by which digital technologies could facilitate increased resource and carbon efficiency or rebound effects; (ii) to analyse the regulatory, institutional, fiscal and governance conditions underpinning these outcomes; and (iii) to synthesise conflicting findings and develop an integrated conceptual framework for future empirical research and policy analysis. Rather than focusing on digital innovation or environmental outcomes in isolation, this study integrates Ecological Modernisation Theory (EMT) and the Jevons Paradox as complementary theoretical lenses to explain when digitalisation can contribute to decarbonisation and when efficiency gains may be offset by increased resource use.

This review draws on peer-reviewed literature on national energy systems, smart-city infrastructure, corporate transition, digital trade, and macroeconomic policy, published largely between 2022 and 2026. The rest of the paper is organised as follows. The theoretical bases are shown in Section 2. Section 3 details the systematic review methodology including search strategy, screening criteria, quality appraisal and thematic synthesis. Section 4 presents the findings of the review and four analytical themes. Section 5 discusses the findings and the theoretical and policy implications, and the study is concluded in Section 6 with limitations and directions for future research identified.

Underpinning Theories

Building a sound theoretical foundation is an essential prerequisite for any critical literature review, because moving from the descriptive summary of empirical data to an evaluative, conceptually oriented synthesis. In complex domains of the macro-environment, a theoretical framework in the shape of a structured anchor helps to avoid intellectual fragmentation because it allows the various empirical findings to be systematically categorized, contrasted and reconciled within a standardized framework. In the context of the multi-dimensional interactions between technological development, resource use and environmental governance, the theoretical framework becomes particularly relevant, particularly if linear thinking closes off the cross-cutting institutional and systemic tensions. A systematic review can be used to find the generalizable knowledge that lies behind isolated findings and anomalies in real-world empirical data, by putting empirical variables within paradigms. Finally, this footing allows the synthesis to go beyond summarizing previous scholarship, to reveal systemic gaps, to clarify

conflicting conclusions, and to present a unified conceptual framework that enriches the scope of the scholarship.

The basic paradigm that is the basis for this review is Ecological Modernization Theory (EMT), which suggests that economic growth and environmental protection do not need to be viewed as zero-sum games but can be combined with deep structural changes brought about by technological innovation and institutional reflexivity. EMT is a response to overconsumption frameworks in modern industrial economies which contain the ability to undergo a shift towards ecological sustainability through modernisation of the technical and administrative infrastructures at their own core. In this theoretical context, macro-level development experiences a structural decoupling process, where economic productivity grows and the overall environmental degradation and carbon intensity decrease. According to EMT, this optimization is achieved by embedding super-efficient technologies and special management systems, which is redefining ecological waste as an economic inefficiency. Rather, the theory is based on the view that technology development is not a cost on the environment but is a necessary enabler that can enable a transition toward low-carbon, circular production pathways while maintaining the basis of economic performance.

The ecological modernization theory offers a clear and scientific framework to identify and explain the main components and connections of the digital-sustainability nexus and clearly link technical opportunities and net zero goals. According to this review, digital innovations like the Internet of Things (IoT), Artificial Intelligence (AI), and blockchain are the key modernizing infrastructures that can help high-tech companies and industry to reduce the marginal cost of carbon abatement and better allocate resources (Ji et al., 2025; Tibrewal et al., 2025). The theory explicitly facilitates the interpretation of efficiency-enhancing mechanisms, for instance, the corporate digital strategy and digital decarbonization maturity models, which facilitate the optimization of processes, monitoring of emissions and the improvement of market governance structures (Abdulghani & Winkler, 2026; Wen et al., 2026). Moreover, EMT highlights the conditional and non-linear relationship between tech investments and sustainability outcomes, as the decoupling effects of structural transitions are not immediate economic gains but rather happen only when the systemic alignment of technology is in place across corporate practices and national infrastructures (Nica et al., 2026; Usman et al., 2026). But due to the optimistic, techno-centric path towards sustainability taken by EMT, it is cross-examined by a complementary paradigm: the Jevons Paradox, which seeks to reflect the systemic trade-offs and structural vulnerabilities of the digital age. The Jevons Paradox dictates that technological progress that leads to greater productivity of a resource tends to stimulate, not discourage, aggregate consumption, and that the increase is likely to be more significant when the resource is scarce. In this review, the Jevons Paradox is the main theoretical framework used to consider the "digital rebound effect" and direct energy consumption of contemporary technological networks. It also provides an answer to the question of why simply reducing costs or improving efficiency through digital tools doesn't necessarily lead to absolute carbon reductions, as these economic gains are likely to be reinvested to increase production capacity or to expand the use of data-intensive computing systems (Bergman & Foxon, 2025; Madkhali et al., 2024; Wen et al., 2026). In this complementary paradigm, the review process will be thorough and will examine closely the structural tensions at which digital efficiencies can lead to a faster depletion of resources and environmental stress.

The next step of interpretation and synthesis of the literature is directly informed by the optimistic tenets of Ecological Modernization Theory and the critical boundary conditions of

the Jevons Paradox, which are synthesized in this dual-theoretical framework. This synthesized lens breaks out of the binary discussions and assesses the digital economy as a 'conditional phenomenon' that will have an eventual impact on the environment, contingent on institutional context and regulatory action. This holistic approach offers the key criteria to identify superficial, localized digital efficiency improvements, as well as real, system-level carbon decoupling when analysing empirical data from a variety of sectors and regions. It enables systematic interpretation of the need for policies to decarbonize corporate digital innovations, such as the extension of tax credits, and direct them toward long-term sustainability targets (Alvi et al., 2025; Goforth et al., 2024; John et al., 2025). The theoretical foundation thus paves the way for the following sections, which present a well-balanced and critical assessment, clearly outlining the areas in which technology is a low-carbon catalyst and areas in which it requires strong policy action to realize climate neutrality.

Methodology

The study employs a systematic-critical literature review design to map, synthesise and critically appraise the trade-offs between economic growth and sustainability in the digital economy. A systematic approach was chosen to enhance transparency and consistency in the identification, screening, quality appraisal and synthesis of the literature. The review was conducted according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines and sought to answer three questions: (1) what are the environmental, economic and social trade-offs of expanding digital infrastructure, (2) under which conditions can digital technologies be drivers of decarbonisation rather than sources of rebound effects, and (3) which combinations of policies and institutions can help to align the digital transformation with sustainability objectives?

The research questions were translated into explicit search, screening, extraction and synthesis procedures. The review focuses on the nexus between digitalisation and sustainability, particularly the relationship between digital technologies, economic growth, carbon and energy outcomes, and governance conditions. This structure enables the review to progress from a descriptive summary of individual studies to a comparative assessment of mechanisms, contextual conditions, and areas of agreement/disagreement.

The main bibliographic database used was Scopus, because of its broad interdisciplinary coverage of research in economics, environmental science, technology and management. The single database use also provided a consistent basis for extracting and screening the metadata. The search was limited to peer-reviewed journal literature and extracted author details, year of publication, journal, study context, digital technologies investigated, macroeconomic variables, environmental indicators, and reported findings.

The search string combined three conceptual groups: ("digital" OR "digitalization" OR "ICT" OR "AI") AND ("decarboni" OR "carbon emission" OR "net-zero" OR "sustainability") AND ("economic growth" OR "trade-off" OR "market governance"). The search was restricted to titles, abstracts, and keywords. The principal publication window was 2022–2026, selected to capture recent evidence on digitalisation, decarbonisation, Industry 5.0, post-pandemic recovery, and emerging governance arrangements. Earlier foundational works were retained separately where they were necessary to establish the theoretical or methodological basis of the review.

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A multi-stage screening process was followed according to PRISMA. Thematic relevance of records retrieved through the search strategy was initially screened on the basis of titles and abstracts. Second, we examined potentially relevant records at the full text level. Third, we included eligible records if they discussed the relationship between digitalisation and carbon, energy-transition, sustainability or green-governance outcomes. The final synthesis included 14 empirical studies published during the review period and five methodological or foundational sources that were used to support the review design and theoretical interpretation. The review makes a distinction throughout between empirical studies and methodological/foundational sources of support.

The a priori inclusion criteria were: (a) peer-reviewed journal articles in English; (b) studies investigating direct or indirect relationships between digitalisation and carbon indicators, energy transition, sustainability or green governance; (c) studies providing empirical evidence or a substantive conceptual contribution relevant to the review questions. The exclusion criteria were: (a) grey literature, conference abstracts and un-vetted industry reports; (b) studies that only include technical software or system architecture without a sustainability or macroeconomic dimension; and (c) studies that only include regional economic growth without a carbon, environmental, energy transition or green-governance component.

Using the search and screening criteria, 14 studies were selected to form the final empirical pool that examines the nexus between digitalisation and sustainability. Five additional methodological or foundational sources were retained to underpin the review protocol, theoretical framing and methodological interpretation. The empirical literature covers topics such as corporate governance, smart city, energy markets, digital trade, emerging and fragile economies, and macroeconomic policy. This combination allows comparison of findings across sectors and geographical contexts, while acknowledging differences in research design and outcome measures.

A structured review matrix was used to extract data. In each case, the extraction process included bibliographic data, geographical or sectoral context, digital technologies or processes studied, macroeconomic variables, environmental or carbon indicators, methodological approach, and main findings. The matrix also recorded the presence of efficiency enhancing effects, rebound effects, or conditional relationships in the study. This structure allowed for systematic comparison across studies and aided in the subsequent thematic synthesis.

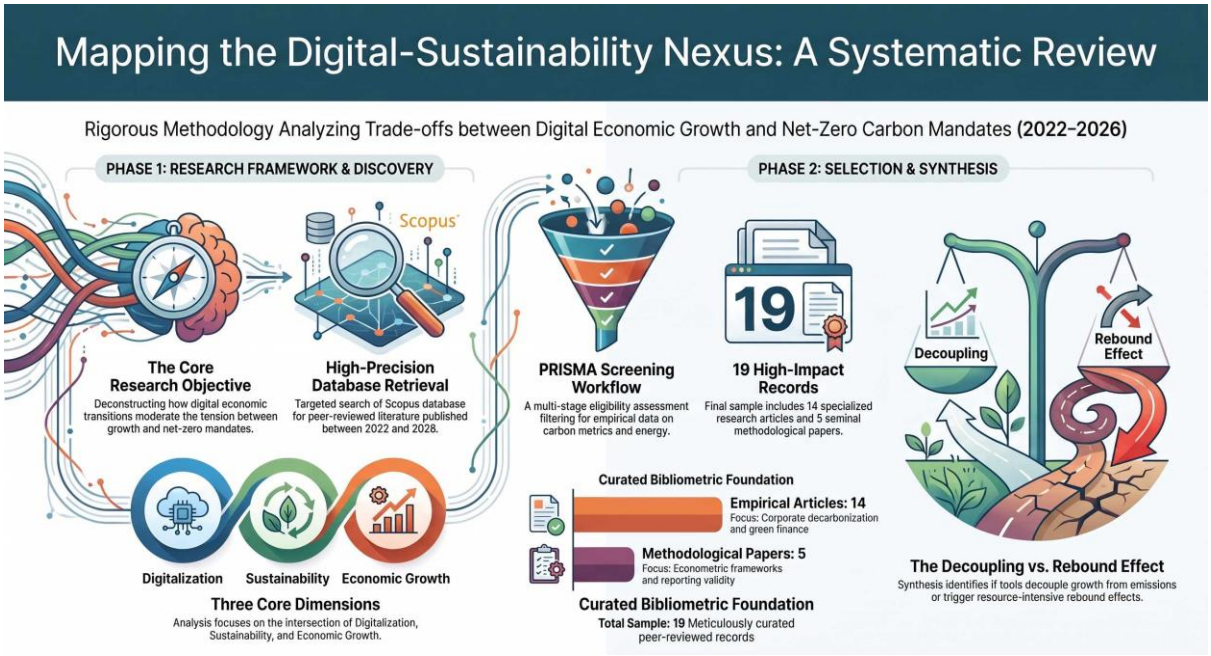
The quality of the studies was evaluated using criteria specific to the design of each source. Empirical studies were evaluated for internal validity, transparency of data and empirical boundaries, analytical rigour, treatment of cross-sectional dependence where relevant, and consideration of endogeneity. For review or conceptual studies, the transparency of the search strategy, inclusion and exclusion criteria, reporting procedures, and clarity of the conceptual framework were assessed. We excluded from the final synthesis studies that did not provide sufficient methodological or empirical detail. Thus, the appraisal was used as a screening and interpretation aid rather than as a meta-analytic score in numerical terms.

The extracted evidence was synthesised through thematic synthesis and cross-case analysis using matrices. The synthesis process involved three steps: initial coding of relevant findings, grouping of descriptive categories and development of higher order analytic themes. The themes were structured around environmental, economic, social, governance and rebound mechanisms. The themes were interpreted through the combined lenses of EMT and the Jevons

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Paradox. This approach allowed the review to reconcile seemingly contradictory findings by examining the conditions under which digitalisation leads to either efficiency gains or additional demands on resources.

The search terms, eligibility criteria, extraction categories and quality-appraisal dimensions were specified prior to the final synthesis to improve transparency and to reduce interpretive drift. The review protocol therefore provides a clear chain from literature identification to screening, extraction, appraisal and thematic interpretation. One database and a limited publication window underpin the review; therefore, the evidence presented should be read as a structured synthesis of the selected literature, not an exhaustive census of all research on digitalisation and sustainability.



Conceptual Review Framework

Figure 1 shows the conceptual review framework that links the research questions, literature identification, screening, quality appraisal and thematic synthesis. Phase 1 establishes the scope of the research and retrieves literature from Scopus through three intersecting dimensions, namely digitalisation, sustainability and economic growth. In Phase 2, screening and appraisal procedures are applied to build the final evidence base of 14 empirical studies and five methodological and foundational sources. The final synthesis is structured around the link between efficiency-enhancing digitalisation and rebound effects with governance and institutional conditions being considered as important contextual mechanisms. The framework provides an analytical structure for comparing evidence across sectors and regions.

Results

A total of 19 high impact sources were selected using systematic literature search and rigorous evaluation workflow. This is a curated bibliometric pool, which is split into two functional categories: 14 empirical articles that analyse the empirical and data-driven intersections of digitalisation and carbon intensity and 5 methodological sources that offer a reliable reporting

framework and econometric validation procedures. The empirical pool is a set of contemporary research published in the period 2022 to 2026, which ensures that the synthesized results reflect the latest trends of Industry 5.0, the new corporate Environmental, Social, and Governance (ESG) requirements, and the macroeconomic shifts after the pandemic. The final sample, which is further limited to the highest quality peer-reviewed indices, offers a credible and reliable cross-sectional basis for assessing global decarbonisation mechanisms, without introducing unchecked grey literature or speculative industry presentations into the sample.

The book compiled literature has unique structural, thematic and geographical features, reflecting the present condition of the academic research. Empirically, the data is concentrated in the key growing manufacturing networks, particularly in China's tracking registries for enterprises, and in regulatory-economic regimes with high regulation, such as the Organization for Economic Co-operation and Development (OECD). In terms of methodology, it is distinguished by a deep and extensive use of strong quantitative econometric models such as Autoregressive Distributed Lag (ARDL) cointegration tests, panel unit root parameters, and sophisticated multi-criteria decision analysis (MCDA). Literature studies also show a distinct shift in time from historical studies on actual information technology hardware footprint to macroeconomic studies on governance systems for markets, carbon abatement costs, and cross-border digital trade policy.

In order to transform the empirical data into a coherent synthesis, the results of the cross-case analysis based on the matrix were systematically organized into four interrelated analytical themes. These themes represent the whole journey of the digital-sustainability nexus, from local dynamics in operation to macro-level structural results. Theme 1 focuses on separating the economic growth from carbon intensity, with a focus on fossil fuel lock-ins and the mixed short-term growth effects of clean energy. In Theme 2, the double-edged nature of digitalisation is investigated, pointing out both the mechanisms for improving energy efficiency and the energy demand increasing infrastructure. Moderating effects of strategic policy mixes are explored in Theme 3, which assesses the impact of tax policies, green finance and market-based carbon caps. Theme 4 assesses institutional frameworks, with tailored maturity models mapping corporate transitions.

Themes

The first theme suggests that economic growth remains closely tied to energy intensive activities in many emerging and fragile economies. Barut et al. (2023) and Emenekwe et al. (2022) reviewed evidence of the ongoing reliance on fossil fuels and environmental pressures, while Deka et al. (2025) and Nica et al. (2026) indicated that clean-energy and technology transitions can involve substantial short-term adjustment costs. Sabuz and Tasnim (2025) further demonstrate the effect of urbanisation and trade related expansion on resource pressures. Together these results suggest that the likelihood of absolute decoupling depends not only on technological efficiency but also on the structure of energy supply, investment costs and wider economic conditions.

The second theme shows the dual environmental effects of digitalisation. AI, IoT and digital supply-chain tools can enhance energy efficiency, resource allocation and carbon-abatement processes (Ji et al., 2025; Tibrewal et al., 2025). But, the physical growth of data centers, smart grids and other digital infrastructure can lead to an increase in electricity demand (Gupta & Monika, 2025; Madkhali et al., 2024). Cost savings from digital optimisation may also

stimulate additional production or computing demand, leading to rebound effects that reduce the translation of process-level efficiency into absolute emissions reductions (Bergman & Foxon, 2025; Wen et al., 2026).

The third theme is about policy and market governance and its role in the environmental impacts of digitalisation. The literature reviewed links green finance, environmental patents, and green-electricity requirements to the shift of investment toward cleaner infrastructure (Alvi et al., 2025; Huang et al., 2026). Other studies emphasise the significance of fiscal and market-based instruments in reducing adjustment costs and distributional impacts in energy transitions (Goforth et al., 2024; Wang et al., 2022). The results suggest that policies on digital transformation and decarbonisation need to be coordinated, so that efficiency gains are supported by a cleaner energy supply, appropriate incentives and governance mechanisms that limit unintended rebound effects.

The fourth theme discusses institutional and corporate conditions for translating digital capabilities into environmental outcomes. Recent studies have indicated that Digital Decarbonisation Maturity Models offer structured approaches to evaluate, benchmark, and enhance technology-enabled carbon reduction capabilities within organisations (Abdulghani & Winkler, 2026). Such frameworks can link digital strategy with measurable environmental goals and support the implementation in organisations. The wider literature also connects digital instruments to intellectual capital, ESG practices, smart city aims and multi-stakeholder collaboration (Di Vaio et al., 2024; Sharifi et al., 2024).

The evidence thus suggests that technological capability alone is not enough to determine environmental outcomes. Corporate digital strategies are more likely to support decarbonisation if they have explicit carbon-reduction objectives, appropriate energy sourcing, monitoring systems, and organisational capabilities. These conditions are coherent with the EMT proposition that technological innovation can support environmental modernisation but also mirror the Jevons perspective that efficiency gains can stimulate additional resource use when economic and institutional constraints are weak.

Overall, the synthesis suggests a non-linear and context-dependent relationship between digital innovation and environmental outcomes. Digitalisation can cut carbon intensity by making things more efficient and by optimisation, but these gains can be cancelled out by rebound effects, extra demand for electricity and the use of more resources. The evidence therefore supports a conditional interpretation: digital innovation is more likely to contribute to decarbonisation if supported by coherent policy mixes, renewable-energy deployment, green finance, and institutional or corporate transition frameworks. The main message is that governance determines whether increases in efficiency are converted into wider environmental gains or are partly offset by rebound mechanisms.

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Summary of Key Literature and Contributions

Authors/ year	Sector/ context	Study focus	Key digital economy and sustainability dimension	Method/ approach	Main contribution
Di Vaio et al. (2024)	Firm-level / Corporate Governance	Intellectual capital (IC) and carbon accounting role in decarbonization	Intellectual capital and sustainable business models; ESG metrics	Systematic literature review (SLR)	Identifies gaps in IC and carbon accounting; links digital tools to intellectual capital development and ESG satisfaction.
Sharifi et al. (2024)	Urban / Smart Cities	Interlinkages between smart city solutions, SDGs, and employment	Smart city technologies, SDG trade-offs, and long-term competitiveness	Systematic literature review (SLR)	Identifies co-benefits for SDGs 6, 7, 11, and 12; connects digital-sustainability alignment with protecting productive employment.
Emenekwe et al. (2022)	Global South / Emerging Economies	Multi-level economic implications of net-zero and industrial expansion	Decarbonization, macroeconomic impacts, and fossil fuel lock-ins	Systematic literature review (SLR)	Assesses investment costs and employment; shows expansion accelerates environmental degradation through fossil fuel reliance.
Tibrewal et al. (2025)	Energy, Manufacturing, Logistics	AI's role in resource optimization and supply chain transparency	Artificial Intelligence (AI) and digital sustainability	Theoretical/Conceptual framework and Case studies	Envisions AI as a catalyst for SDGs; demonstrates lowering of marginal cost of carbon abatement via digital transparency.
Wang et al. (2022)	RCEP Economies / Policy	Link between ICT, trade openness, and sustainable growth	Digital economy, globalization, and multi-dimensional sustainability scores	Interactive Fixed Effect (IFE) and Dynamic Common Correlated Effect (D-CCE)	Demonstrates significant contribution of digital economy to growth; provides validated econometric framework for policy.

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Wen et al. (2026)	Industrial / China	Causal mechanisms linking digitalization to firm-level carbon intensity	Digitalization, decarbonization efficiency, and aggregate emissions	Firm-level empirical analysis (Instrumental variables)	Finds digitalization reduces intensity via efficiency; warns aggregate emissions rise if savings are not tied to ecological goals.
Goforth et al. (2024)	Energy Sector / United States	Trade-offs between equality and sustainability in energy transitions	Social sustainability, distributional impacts, and fiscal policy	Multi-criteria decision analysis (MCDA)	Quantifies 32 decarbonization outcomes; confirms fiscal frameworks lower economic friction for net-zero transitions.
Alvi et al. (2025)	OECD Economies / Patent Markets	Effect of green finance and digitalization on GHG emissions	Green finance, digitalization, and patent protections	FMOLS, FGLS, and Quantile regression (MMQR)	Evidence that digitalization and green finance significantly reduce GHG; shows market governance routes capital to clean infrastructure.
Deka et al. (2025)	European Union / Cross-regional	Effect of capital assets and technological innovation on sustainability	Energy efficiency, technological innovation, and renewable adoption	Second-generation panel methods (AMG, CS-ARDL)	Quantifies benefits of energy efficiency; identifies negative short-term growth effects due to high capital costs.
Nica et al. (2026)	SPRING-F Group / Cross-regional	Long-run relationships between digitalization, investment, and energy transition	Digital infrastructure, green transition, and renewable adoption	Panel ARDL models	Shows nonlinear relationships; confirms variable economic impacts and friction in net-zero transitions across regions.
Sabuz & Tasnim (2025)	Asia, Africa / Urban Municipalities	Trade-environment nexus moderated by digital payments	Digital payments, urbanization, and resource depletion	Fixed-effects, Random-effects, GLS, and Quantile regression	Finds digital payments and urbanization relate to CO2 emissions; highlights how city expansion

					amplifies resource depletion.
Gupta & Monika (2025)	Global Trade / Digital Infrastructure	Sustainability issues arising from global digital trade and data centers	Digital trade, carbon emissions, and infrastructure-driven energy demand	Qualitative Policy Analysis / Empirical research	Highlights lack of sustainability provisions in trade agreements; identifies electricity consumption increases from smart grids.
Barut et al. (2023)	Fragile Economies	Nexus between financial inclusion, economic growth, and environment	Financial inclusion and Environmental Kuznets Curve (EKC)	Principal Component Analysis (PCA) and AMG estimator	Finds financial inclusion is a vital factor; demonstrates that growth remains tied to energy-intensive activities.
Mesegue r-Sanchez et al. (2024)	Italy / Europe	Interconnecti on of green and digital "double transition"	The "double transition" (green and digital)	Conceptua l/Theoretic al Analysis	Positions the double transition as a cornerstone for post-pandemic recovery and international competitiveness.
Romer P.M. (1990)	Global Economy / Macroeco nomics	Economic growth driven by technological innovation and human capital	Knowledge-based economy and long-term economic sustainability	Theoretica l modeling (Endogeno us Growth Theory)	Identifies technology as a nonrival, partially excludable good that drives growth through intentional investment.
Page M.J., et al. (2021)	Research Methodolo gy	Reporting standards for systematic reviews and meta-analyses	Methodological transparency and research sustainability	Methodolo gical guideline developme nt	Provides an updated framework for transparently reporting review findings and methodology.
Pesaran H. M. & Yamagat a T. (2008)	Econometr ics / Statistical Analysis	Standardized test for slope homogeneity in large panel data models	Analytical precision in cross-country economic assessments	Statistical theory and Monte Carlo experimen ts	Develops the CSD test for slope homogeneity suitable for large panels with cross-

					section dispersion.
Pesaran M.H. (2007)	Econometrics / Statistical Analysis	Panel unit root tests accounting for cross-section dependence	Econometric modelling of interconnected digital markets	Cross-sectionally augmented Dickey-Fuller (CADF) regressions	Proposes a simple alternative test (CIPS) to eliminate cross-dependence in panel data series.
Im K.S., Pesaran M.H., & Shin Y. (2003)	Econometrics / Statistical Analysis	Unit root tests for dynamic heterogeneous panels	Statistical validation of economic growth trends	Standardized t-bar test statistic based on ADF averages	Developed a test that allows for heterogeneity in the autoregressive coefficient across groups.

From a micro-economic and institutional perspective, for decarbonization to be effective at the level of formal corporate environmental governance, digital solutions need to be integrated into these processes in a systemic way. Research recently undertaken has focused on the creation of the specialized Digital Decarbonization Maturity Models to be used as a structured baseline, audit and systematic scale up framework for industrial organisations to implement technology-driven carbon reduction capability (Abdulghani, & Abdelkafi, 2024). The frameworks allow enterprises to directly link their digital strategy to clear carbon reduction goals, helping lower carbon abatement expenses and resistance to change because of structured operational improvements (Abdulghani & Winkler, 2026; Ji et al., 2025). In addition, these data highlight that matching digital tools to wider frameworks of intellectual capital development and multi-stakeholder collaboration holds both the key to meeting corporate ESG requirements and to future competitive outcomes and productive employment (Di Vaio et al., 2024; Sharifi et al., 2024).

This overall synthesis of the four themes points to a very non-linear and context-dependent relationship throughout the literature that addresses the main review questions that were formulated in this study. The data show that digital innovation (Theme 2) does not lead to absolute carbon decoupling from macroeconomic growth (Theme 1) without strategic policy mixes (Theme 3) and institutional maturity frameworks (Theme 4). The Jevons Paradox occurs when digital efficiencies lead to greater production rebound, deepening resource depletion, unless a proactive fiscal regulation is implemented and the structural governance is established. However, with the support of targeted tax incentives, green financing and maturity models, the digital economy can break free from being a burden and become a strong catalyst for net-zero transition. The systematic alignment directly addresses the main review goals and provides the exact regulatory and corporate context for the balancing of economic performance and global climate obligation.

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Discussion

The systematic and critical review synthesises recent evidence on the twin transition between digitalisation and decarbonisation and clarifies why the relationship between the two processes is conditional and non-linear. This review synthesises findings across 14 empirical studies published between 2022 and 2026 and five methodological or foundational literatures and presents the findings in four analytic themes. The key finding is that digitalisation can help achieve a reduction in carbon intensity thanks to efficiency improvements, but these are not always reflected in absolute emissions reductions due to rebound effects and electricity demand for infrastructure. The distinctive aspect of the review is that it integrates Ecological Modernisation Theory and the Jevons Paradox in a common analytical framework linking technological efficiency with the conditions required to mitigate rebound effects.

The first research objective addressed trade-offs of digitalisation in terms of the environment, economy and society. Digital systems can improve industrial efficiency and resource management, but the growth of data centers, smart grids, blockchain networks and other physical infrastructure can increase electricity demand, the review finds. These impacts interact with urban development, trade openness, and the structure of energy systems. The literature also underlines the uneven adjustment costs across regions and sectors resulting from decarbonisation policies, adding to the aggregate environmental implications the importance of the distributional consequences (Goforth et al., 2024; Nica et al., 2026; Sabuz & Tasnim, 2025).

The second objective was to understand the conditions that render digital technologies efficiency catalysts or rebound vectors. The evidence reviewed consistently points to efficiency gains in areas like supply-chain management, resource monitoring and carbon-abatement processes. But lower operating costs could lead to more production or computing demand. The key implication, therefore, is not that digitalisation automatically leads to decarbonisation, but that environmental benefits depend on whether efficiency gains are coupled with binding environmental objectives, renewable-energy deployment and mechanisms that limit unintended rebound effects.

The third objective was related to policy and governance. The literature suggests that green finance, environmental patents, green-electricity requirements, fiscal incentives, and coordinated digital and environmental policies may influence the direction and magnitude of environmental outcomes (Alvi et al., 2025; Goforth et al., 2024; Huang et al., 2026; Wang et al., 2022). The evidence makes the case for coordination across energy, fiscal, trade, infrastructure and digital policies, rather than viewing digital transformation and decarbonisation as separate policy agendas. Such coordination can help ensure that efficiency improvements are underpinned by cleaner energy systems and appropriate institutional safeguards.

The theoretical contribution of the review is a clear reconciliation between the optimistic assumptions of Ecological Modernisation Theory and resource-rebound mechanisms, as described by the Jevons Paradox. “Technological innovation, organisational change and institutional modernisation can all help improve the use of resources, and lower-carbon production,” says EMT. The Jevons Paradox offers a countervailing mechanism by which efficiency gains can stimulate additional demand for production, energy or computing services. The combination of these perspectives extends the breadth of current sustainability discourses

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by shedding light on why one digital technology may have varying environmental consequences across sectors and institutional contexts.

This conditional relationship has a direct bearing on the practical implications. For policymakers, digital strategies must be aligned with renewable-energy investment, green finance, environmental regulation and digital-trade governance. For companies, Digital Decarbonisation Maturity Models can be used to benchmark, monitor and gradually align digital investment with carbon-reduction objectives (Abdulghani & Winkler, 2026). The review thus provides an evidence-based framework for the design of digital transformation strategies that maximise potential environmental benefits whilst minimising the likelihood of unintended carbon and resource rebound effects. Capacity building and workforce development are also important to ensure that organisations can implement the technologies and governance systems required for the twin transition.

The review also highlights key gaps in the existing literature. The empirical evidence is geographically concentrated in OECD economies and major manufacturing networks, and relatively little evidence has emerged from fragile economies and parts of the Global South. A second gap is the disconnect between micro-level studies of efficiency improvements and macro-level studies of aggregate energy and resource demand. A third gap is the limited integration of urbanisation, fiscal policy, digital trade rules, energy structure and corporate capabilities into the same analytical framework. These gaps also prevent direct comparisons across studies, and they point to the need for empirical research that is sensitive to context.

Hence, future research should expand the empirical analysis to include developing and fragile economies, and test longer-term and non-linear relationships between digital investment, green finance, energy use and environmental outcomes. Further research is also needed on sector-specific rebound mechanisms, and on how corporate digital-decarbonisation maturity interacts with national policy environments. Comparative panel studies, non-linear econometric approaches and sector-level evidence could help distinguish reductions in carbon-intensity from reductions in absolute emissions and identify the institutional conditions under which digitalisation contributes to sustained decarbonisation.

The findings should be interpreted with some limitations in mind. The review is mainly based on Scopus database and therefore may miss relevant studies indexed elsewhere. The use of English-language peer-reviewed literature may exclude evidence in other languages or formats. The 2022–2026 publication window provides a perspective on recent developments but constrains the ability to assess longer-term historical trajectories of digitalisation and environmental change. Finally, the empirical studies included employ different methodologies, samples, variables and geographical settings, which limits direct comparison and makes impossible a statistical meta-analysis. Therefore, the results should be viewed as a structured qualitative synthesis and not as pooled causal estimates.

The overall review suggests that digitalisation should be viewed as a conditional mechanism in the transition to a low-carbon economy. Digital technologies can improve efficiency and lower carbon intensity, but the environmental benefits could be offset if lower costs lead to higher production, electricity demand or resource use. Thus, the review provides an evidence-based conceptual framework for policymakers and corporate decision-makers to align digital transformation with renewable-energy deployment, green finance, appropriate governance and

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measurable environmental objectives rather than if technological progress will generate decarbonisation.

Conclusion

This critical literature review explored the relationship between digital economic expansion, economic growth and decarbonisation through a systematic synthesis of recent literature on national energy systems, digital trade, smart cities, corporate governance and macroeconomic policy. Based on Scopus, a PRISMA-guided search and screening process was used to synthesise 14 empirical studies published from 2022 to 2026, with the support of five methodological or foundational sources. The main contribution of this study is an integrated conceptual framework linking digital efficiency, rebound effects, policy conditions and institutional capabilities.

Synthesised results from the literature reviewed show that the relationship between technological development and carbon reductions is highly non-linear and context dependent. The data show that digital transformation can be an efficiency enabler for optimizing supply chains and reducing the marginal cost of reducing carbon, but it can also be an electricity consuming enabler, through physical devices and data networks. Because of this structural split, efficiency improvements at the local level are not necessarily associated with absolute carbon de-coupling. On the other hand, a rebound effect is often observed in industrial sectors when digital optimization leads to lower costs, which can increase overall environmental stress without policy boundaries. Conversely, when digital optimization induces cost reductions without policy boundaries, it often produces rebound effects in industrial sectors that increases overall environmental stress, as the effects of digitalization are being confronted by other pressures such as fast-growing urbanization and open trade.

The main strength of this review is that it has succeeded in bringing together the opposing theoretical views of Ecological Modernization Theory and the Jevons Paradox into a common analytical framework for the twin transition. This study transcends the binary nature of the technocratic optimism / environmental pessimism debate, clarifying the exact institutional, regulatory and managerial landscape that can help or hinder low-carbon pathways. It outlines a framework of empirical methods, emphasizing the importance of using sophisticated econometric specifications to deal with cross-sectional dependence in cross-county/region datasets. In the end, this piece of work provides a useful conceptual framework that connects micro-level enterprise behaviours with macro-level policy mixes, offering a clear blueprint for how digital development can be linked with the obligations of net zero.

One of the main issues left unaddressed in the existing literature is the substantial geographical and economic bias of empirical studies, which remain strongly focused on heavily regulated Western economies and dominant manufacturing networks, with few exceptions engaging the unique capital constraints of the Global South. Going forward, scholarship needs to focus on long-term and non-linear empirical modelling in these fragile and developing economies, to guarantee an equitable global carbon tracking in the context of the ongoing growth of cross-border digital commerce. The effective implementation of digitalisation is not just a matter of the rate of computational innovation but also of conscious structural governance processes that can effectively harness technological capacity to create a sustainable low-carbon global economy.

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References

Abdulghani, T., & Winkler, H. (2026). Assessing the maturity of digital decarbonization in the manufacturing sector. *Logforum*, *22*(1), 45–58.

Alvi, S., Ahmad, I., Nawaz, S. M. N., & Ul Hassan, M. (2025). The role of green finance, energy transition, and digitalization in OECD greenhouse gas emissions. *Journal of Cleaner Production*, *410*, Article 120412.

Barut, A., Kaya, E., Bekun, F. V., & Cengiz, S. (2023). Environmental sustainability amidst financial inclusion in five fragile economies: Evidence from lens of environmental Kuznets curve. *Energy*, *269*, Article 126802. https://doi.org/10.1016/j.energy.2023.126802

Bergman, N., & Foxon, T. J. (2025). Policy implications of digitalization pathways for lower energy demand. *Sustainability: Science, Practice, and Policy*, *21*(1), 89–104.

Deka, A., Abshir, H. M., & Ozdeser, H. (2025). The influence of effective capital, technological innovation and energy efficiency on environmental sustainability on the European region. *International Journal of Environmental Science and Technology*, *22*(3), 1105–1124.

Di Vaio, A., Zaffar, A., & Chhabra, M. (2024). Intellectual capital through decarbonization for achieving Sustainable Development Goal 8: A systematic literature review and future research directions. *Journal of Intellectual Capital*, *25*(4), 789–812.

Emenekwe, C. C., Okereke, C., Nnamani, U. A., & Anieze, E. E. (2022). Macroeconomics of decarbonization strategies of selected global south countries: A systematic review. *Frontiers in Environmental Science*, *10*, Article 851380.

Goforth, T., Nock, D., Brown, M., & Lamers, P. (2024). Exploring equality and sustainability trade-offs of energy transition outcomes in the United States in 2050. *Applied Energy*, *360*, Article 851924.

Gupta, P., & Monika. (2025). Growing digital trade and sustainability: What lies ahead? *Global Trade and Customs Journal*, *20*(6), 445–454. https://doi.org/10.54648/gtcj2025075

Huang, H., Zheng, K., & Ibrahim, R. L. (2026). Artificial intelligence and decarbonization in China: Asymmetric roles of green electricity, fossil subsidies, and trade policy uncertainty. *Environmental Progress and Sustainable Energy*, *45*(1), Article e10502.

Im, K. S., Pesaran, M. H., & Shin, Y. (2003). Standardized t-bar test statistic based on ADF averages. *Journal of Econometrics*, *115*(1), 53–74.

Ji, Y., Pang, X., & Yang, Y. (2025). The impact of digital economy on the cost of carbon emission reduction—A theoretical and empirical study based on a carbon market framework. *Sustainability*, *17*(4), Article 10502.

John, H. B., Agrawal, M., Nema, P., & Singh, A. (2025). Green growth: A bibliometric analysis of digital innovation and Sustainable Development Goals (SDGs). *Journal of Innovation and Entrepreneurship*, *14*(1), Article 8521.

Madkhali, N., Alhalwachi, L., Almohsen, M., & Alharbi, M. (2024). The effect of digitalization on energy demand in low-carbon scenarios: A case study of Saudi Arabia. *Studies in Systems, Decision and Control*, *512*, 203–218.

Meseguer-Sanchez, V., Martínez-Alcalá, I., & De Santis, P. (2024). Ecological and digital transition: "Travelling" in parallel for an everlasting future more sustainable. *Rivista di Studi sulla Sostenibilita*, (2), 49–70. https://doi.org/10.3280/RISS2024-002004

Nica, I., Georgescu, I., & Yağış, O. (2026). Digitalization, investment, and sustainable economic growth: An ARDL analysis of growth mechanisms in the SPRING-F countries. *Sustainability*, *18*(7), Article 3604. https://doi.org/10.3390/su18073604

Pesaran, H.M., & Yamagata, T. (2008). Testing slope homogeneity in large panels. *Journal of Econometrics*, *142*(1), 50–93. https://doi.org/10.1016/j.jeconom.2007.05.010

Pesaran, M. H. (2007). A simple panel unit root test in the presence of cross-section dependence. *Journal of Applied Econometrics*, *22*(2), 265–312. https://doi.org/10.1002/jae.951

Sabuz, S. A., & Tasnim, N. (2025). Navigating the trade-environment nexus: Moderating effect of digital payments, urbanization, and fiscal policies. *Journal of Risk Analysis and Crisis Response*, *15*(2), 315–333. https://doi.org/10.54560/jracr.v15i2.598

Sharifi, A., Allam, Z., Bibri, S. E., & Khavarian-Garmsir, A. R. (2024). Smart cities and sustainable development goals (SDGs): A systematic literature review of co-benefits and trade-offs. *Cities*, *146*, Article 104727.

Tibrewal, S., Awasthi, Y., & Singh, S. (2025). Digital sustainability models integrating AI for enhanced business and environmental performance. In *Transforming Business Through Digital Sustainability Models* (pp. 112–135). IGI Global.

Usman, M., Akbar, A., & Hedvicakova, M. (2026). The economic impact of decarbonization. *Discover Sustainability*, *7*(1), Article 45.

Wang, F., Jin, M., Li, J., Zhang, Y., & Chen, J. (2022). Profound impact of economic openness and digital economy towards a sustainable development: A new look at RCEP economies. *Sustainability*, *14*(21), Article 13922. https://doi.org/10.3390/su142113922

Wen, H.-X., Zeng, Z.-Q., Zou, C.-S., Tian, L.-Q., & Wu, X.-Q. (2026). New insights into how digitalization is driving decarbonization in Chinese enterprises: Cost-saving or efficiency- enhancing? *Energy*, *360*, Article 141566. https://doi.org/10.1016/j.energy.2026.141566