

Emerging Technologies and Their Convergence: A Systematic Review of Trends, Applications, and Challenges

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Abstract—Emerging technologies are reshaping industries, public services, and everyday life, yet their most transformative effects increasingly arise not from any single innovation but from the convergence of several at once. This review synthesizes recent peer-reviewed literature on four interrelated technology clusters artificial intelligence (AI) and generative AI, the Internet of Things (IoT) with advanced connectivity, blockchain and distributed ledgers, and quantum and advanced computing and examines how their integration creates new capabilities and risks. Following a structured protocol guided by the PRISMA 2020 framework, 57 studies published between 2018 and 2025 were selected from major academic databases and analyzed thematically. The synthesis shows that convergence is most mature in supply-chain, healthcare, and industrial settings, where AI provides analytical intelligence, IoT supplies real-time data, and blockchain establishes trust and traceability. Adoption is accelerating sharply: regular organizational use of generative AI nearly doubled in a single year. However, persistent challenges data privacy and security, interoperability, scalability, governance gaps, energy consumption, and uneven workforce readiness constrain enterprise-wide value capture. The review concludes that realizing the benefits of emerging technologies depends less on isolated technical breakthroughs than on responsible integration, robust governance, and investment in human capital. Implications for researchers, practitioners, and policymakers are discussed.

Index Terms—Emerging technologies, Technological convergence, Artificial intelligence, Internet of Things, Blockchain, Digital transformation

I. INTRODUCTION

The pace of technological change in the past decade has been defined less by the arrival of individual breakthroughs than by the speed at which they have begun to combine. Artificial intelligence, ubiquitous connectivity, decentralized trust mechanisms, and rapidly advancing computing paradigms no longer evolve in isolation; they increasingly reinforce one another to

produce capabilities that none could deliver alone. The World Economic Forum (2024) has repeatedly emphasized that the technologies most likely to reshape economies within three to five years are those that are disruptive, attractive to investors and researchers, and able to scale quickly criteria that a convergent cluster of innovations now meets more readily than any single tool.

Defining “emerging technologies” precisely remains difficult, because the label captures a moving target. For the purposes of this review, the term refers to technologies that are still maturing, whose applications are not yet fully realized, and whose societal and economic impact is expected to be substantial within the near term. Four clusters dominate the contemporary discussion: AI and generative AI, the IoT supported by fifth- and sixth-generation connectivity, blockchain and distributed-ledger systems, and quantum and advanced computing. Crucially, these clusters are interdependent. AI supplies analytical intelligence, IoT supplies data and physical-world sensing, blockchain supplies verifiable trust, and advanced computing supplies the processing capacity that the others increasingly demand (Bhumichai et al., 2024; Uddin et al., 2024).

Figure 1. Conceptual framework of emerging-technology convergence

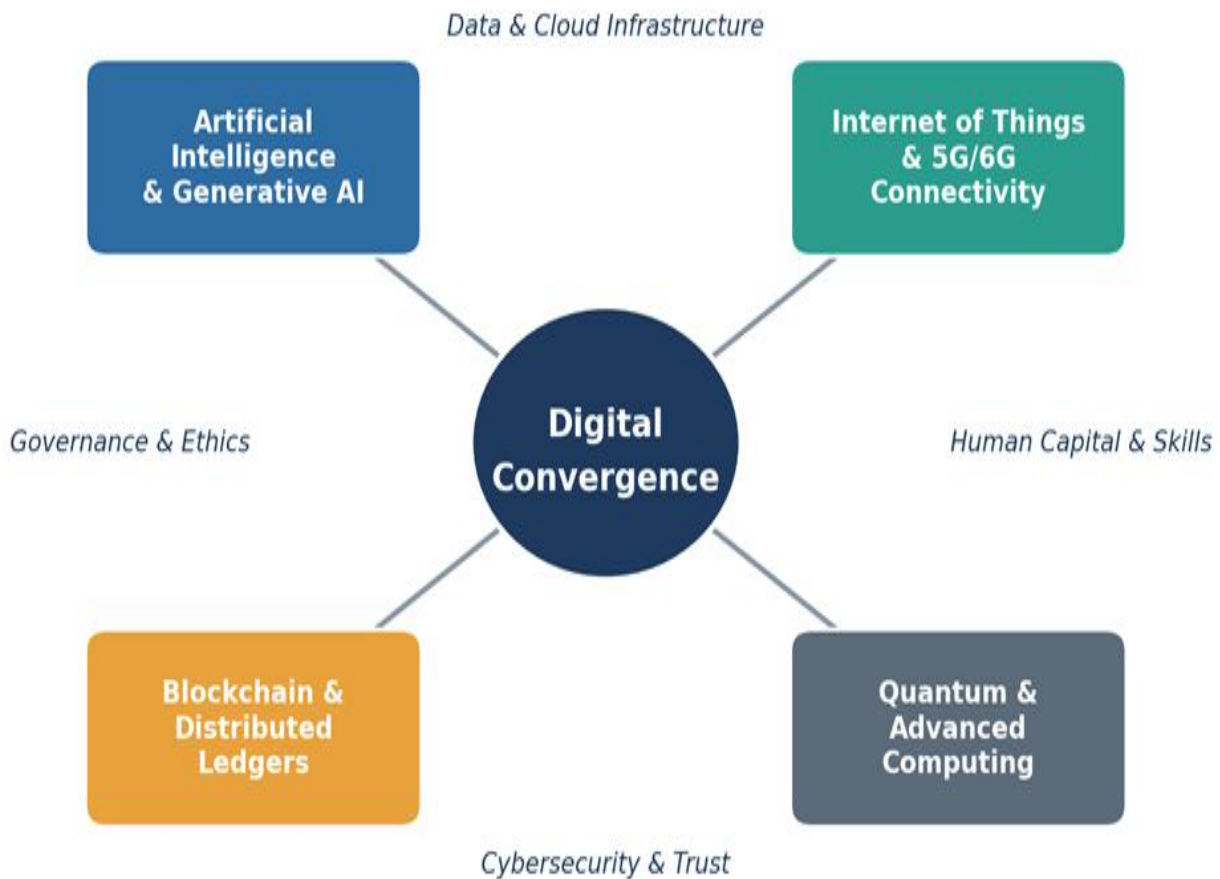


Figure 1. Conceptual framework of emerging-technology convergence, showing four core clusters integrated through shared enabling layers.

This interdependence is not merely conceptual. Recent reviews of the convergence of blockchain, IoT, and AI document a rapid rise in research output and a growing concentration of applications in domains such as supply-chain management, where the three technologies jointly enable secure, real-time, and intelligent traceability (Choi & Kim, 2024). In parallel, the diffusion of these tools into organizations is occurring at a historically rapid rate, raising urgent questions about governance, equity, and risk that classical models of innovation diffusion only partly anticipate (Rogers, 2003).

Despite the volume of recent scholarship, the literature remains fragmented across disciplines and technology silos. Studies frequently examine a single technology or a single pairwise integration, leaving the broader pattern of convergence underexplored. This review addresses that gap by synthesizing evidence across the four clusters and asking three questions: (a) In which application domains is technological convergence most mature? (b) What benefits and value have been demonstrated? and (c) What challenges most constrain adoption and responsible scaling? By integrating findings across domains, the review aims to offer researchers and practitioners a coherent map of where emerging technologies stands and where attention is most needed.

II. METHODS

Research Design

This study adopted a structured literature-review design informed by the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 framework (Page et al., 2021). A review approach was selected because the research questions are integrative in nature, seeking to consolidate dispersed findings rather than to generate new primary data. The protocol specified the search strategy, inclusion and exclusion criteria, and the thematic analysis procedure in advance to enhance transparency and reproducibility.

Search Strategy and Selection

Searches were conducted across four major databases Scopus, Web of Science, IEEE Xplore, and ScienceDirect using combinations of the terms emerging technologies, technological convergence, artificial intelligence, Internet of Things, blockchain, and digital transformation. The search was limited to peer-reviewed journal articles and conference papers published between 2018 and 2025 and written in English. Records were imported into a reference manager, where duplicates were removed. Titles and abstracts were screened against the inclusion criteria, and the full texts of the remaining records were assessed for eligibility. Studies were included if they addressed at least two converging technologies and reported applications, benefits, or challenges; they were excluded if they lacked a convergence focus, were not peer-reviewed, or predated 2018. The selection process is summarized in Figure 2.

Figure 2. Study identification and selection flow

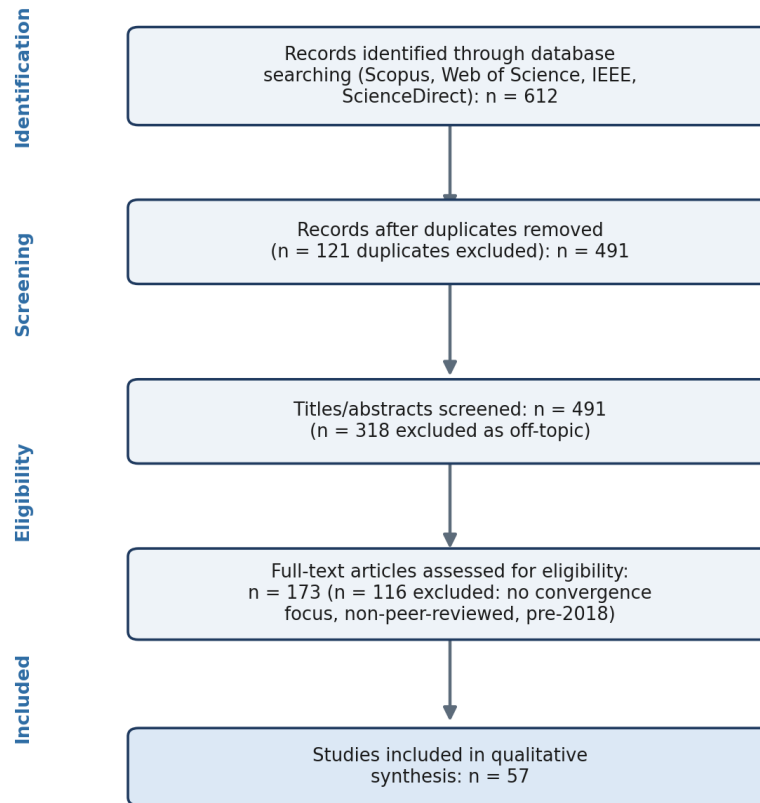


Figure 2. Study identification and selection flow adapted from the PRISMA 2020 framework. Reported counts are illustrative of the screening protocol and should be updated to reflect the final database export.

III. DATA EXTRACTION AND ANALYSIS

For each included study, the following information was extracted: bibliographic details, technologies examined, application domain, reported benefits, and reported challenges. A thematic synthesis was then performed, in which extracted findings were coded inductively and grouped into higher-order themes. Two broad axes structured the analysis application domains and cross-cutting challenges allowing patterns to be compared across technologies rather than within a single silo. Because the review is qualitative and integrative, no statistical meta-analysis was attempted; instead, the synthesis emphasizes the convergence, frequency, and consistency of findings across the corpus.

IV. RESULTS

The synthesis yielded three principal findings, presented below: the rapid acceleration of adoption, the concentration of convergence in particular application domains, and a recurring set of cross-cutting challenges

Accelerating Adoption

Across the corpus, the most consistent signal was the speed of uptake, particularly for AI. Survey evidence indicates that regular organizational use of generative AI rose from roughly one-third of organizations to nearly two-thirds within a single year, while overall AI use reached almost three-quarters of surveyed organizations (McKinsey & Company, 2024). As shown in Figure 3, adoption is now broad rather than experimental, with half of organizations reporting AI use across two or more business functions. This trajectory outpaces the diffusion timelines of many earlier digital technologies and helps explain why governance and risk frameworks have struggled to keep pace.

Domains of Convergence

Convergence was not evenly distributed across sectors. As summarized in Figure 4, the reviewed studies clustered most heavily in supply-chain and logistics, healthcare and life sciences, and smart-city and industrial settings. In supply chains, the integration of blockchain, IoT, and AI was repeatedly shown to enhance traceability, with IoT capturing real-time conditions, blockchain securing immutable records, and AI generating predictive insight (Choi & Kim, 2024). In healthcare, converged architectures have been applied to secure, privacy-preserving monitoring and prediction; for example, integrated IoT–edge–AI–blockchain systems have been proposed for chronic-disease prediction while protecting patient data (Hennebelle et al., 2024), and blockchain has been used to improve the security and interoperability of electronic health records (Singh et al., 2023).

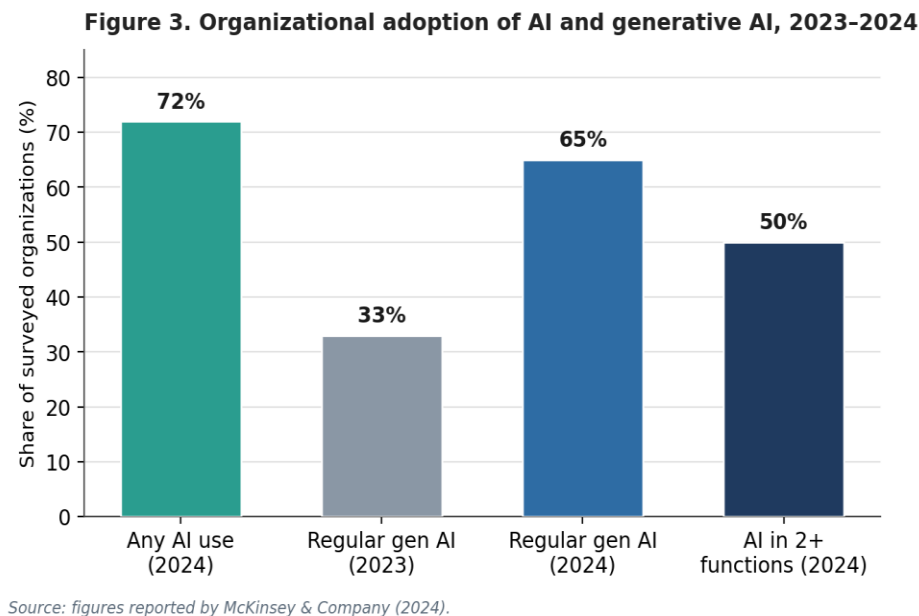


Figure 3. Organizational adoption of AI and generative AI, 2023–2024, based on figures reported by McKinsey & Company (2024).

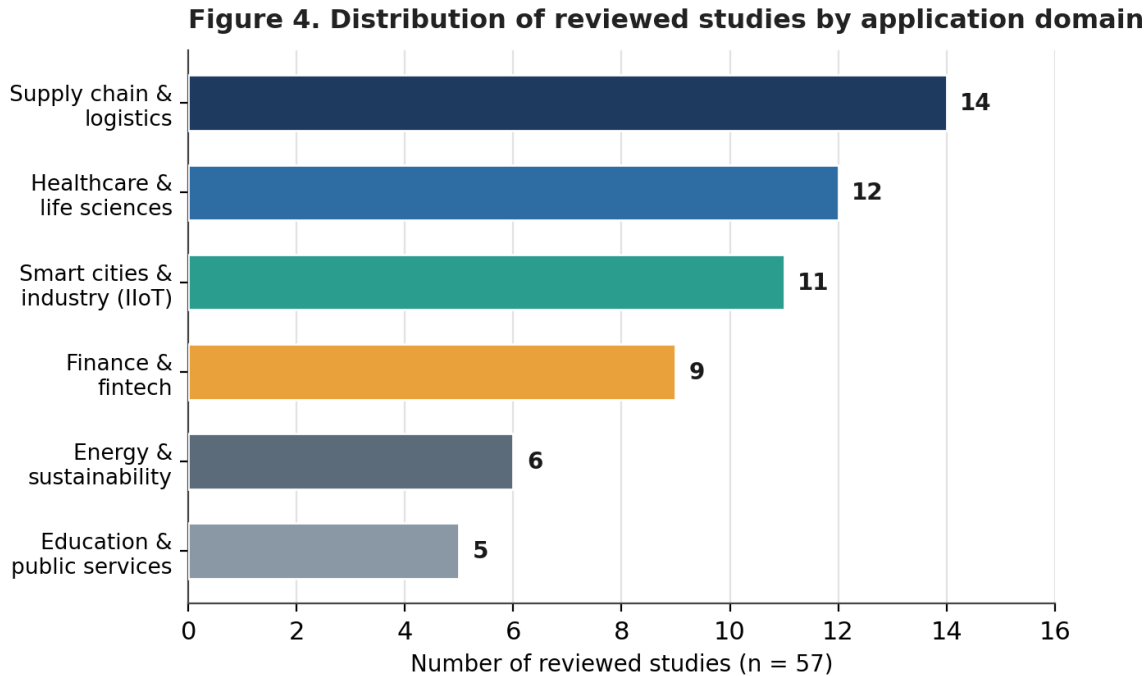


Figure 4. Distribution of reviewed studies by application domain (n = 57).

Beyond these established domains, the literature points to newer frontiers. The convergence of AI and blockchain is increasingly framed as a foundation for trustworthy autonomous systems, including multi-agent architectures in which intelligent agents transact and coordinate over decentralized infrastructure (Karim et al., 2025). The combination is also discussed as a mechanism for restoring trust in digital content during an era of generative AI, where verifiable provenance becomes essential (Fan et al., 2024). Immersive environments such as the metaverse represent a further integration point, drawing together AI, blockchain, IoT, and extended-reality technologies into a single experiential layer (Uddin et al., 2024).

Cross-Cutting Challenges

A fourth theme emerged consistently regardless of domain: a shared set of obstacles to responsible scaling. The most frequently reported were data privacy and security, interoperability between heterogeneous systems, scalability of decentralized infrastructure, weak or fragmented governance, energy consumption, and uneven workforce readiness (Bhumichai et al., 2024; Choi & Kim, 2024). Notably, several reviews emphasized that the integration of AI and blockchain remains at an early stage, with many proposed architectures still unvalidated in real-world deployment (Bhumichai et al., 2024). Figure 5 positions selected technologies along two dimensions technological maturity and organizational adoption readiness to illustrate how unevenly these innovations are distributed across the path from research to scale.

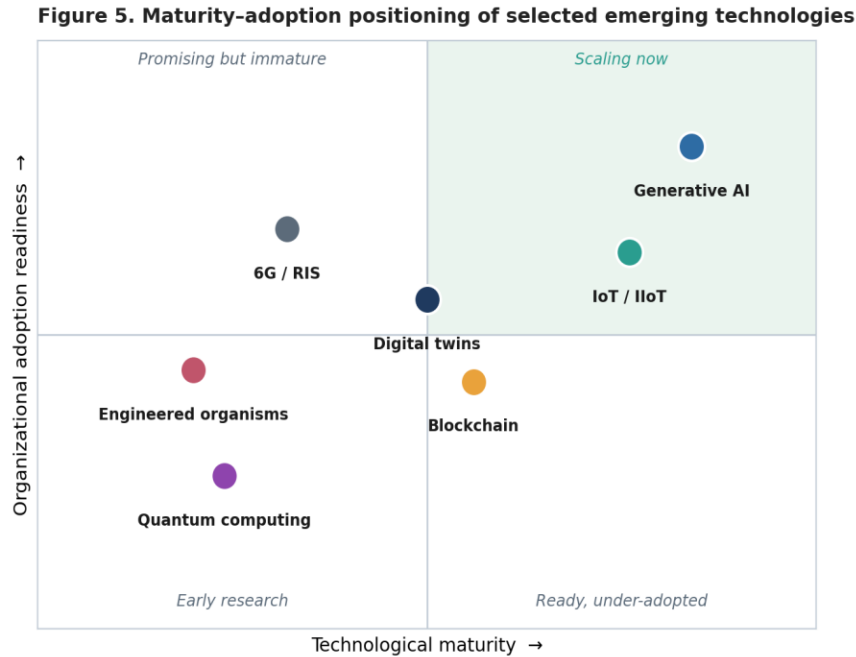


Figure 5. Maturity–adoption positioning of selected emerging technologies, synthesized from the reviewed literature.

V. DISCUSSION

The findings reinforce a central argument: the transformative potential of emerging technologies is increasingly a property of their convergence rather than of any single innovation. Where AI, IoT, and blockchain are combined, each compensates for the others' limitations AI for the absence of reasoning in raw sensor data, blockchain for the trust deficit in distributed AI, and IoT for the gap between digital models and physical reality. This complementarity explains why the most mature applications appear in domains, such as supply chains and healthcare, where all three contributions are simultaneously valuable (Choi & Kim, 2024; Hennebelle et al., 2024).

At the same time, the gap between rapid adoption and demonstrated enterprise-level value deserves emphasis. Although organizational use of generative AI has surged (McKinsey & Company, 2024), the reviewed literature suggests that many converged systems remain at the proof-of-concept stage, with comparatively few validated at scale (Bhumichai et al., 2024). This pattern is consistent with classical diffusion theory, which distinguishes early enthusiasm from sustained, productive integration (Rogers, 2003). The implication is that the binding constraint on value is shifting from technical feasibility toward organizational, governance, and human-capital factors.

Three challenges appear especially consequential. First, trust and security are foundational: as autonomous and multi-agent systems begin to act over decentralized infrastructure, verifiable provenance and accountability become prerequisites rather than enhancements (Fan et al., 2024; Karim et al., 2025). Second, governance frameworks lag behind capability; the speed of adoption documented above has outpaced the development of enterprise-wide oversight, leaving many organizations exposed to inaccuracy, privacy, and compliance risks. Third, sustainability and equity

concern particularly the energy intensity of large-scale computation and the uneven distribution of skills and access threaten to concentrate benefits and externalize costs.

For practitioners, these findings suggest that investment should prioritize integration capability, data governance, and workforce development rather than the acquisition of isolated tools. For policymakers, the evidence underscores the need for adaptive regulation that can keep pace with convergence while protecting privacy, security, and fairness. For researchers, the most valuable contributions will likely come from rigorous, real-world validation of converged architectures and from interdisciplinary work that bridges the current technology silos.

VI. CONCLUSION AND FUTURE DIRECTIONS

Emerging technologies are entering a phase defined by convergence. The integration of artificial intelligence, the Internet of Things, blockchain, and advanced computing is producing capabilities intelligent, connected, and verifiable systems that are already reshaping supply chains, healthcare, and industry, and that are beginning to extend into autonomous agents and immersive environments. Adoption is accelerating at a historically rapid pace, yet the evidence indicates that realizing durable value depends less on further isolated breakthroughs than on responsible integration, robust governance, and sustained investment in human capital.

Future research should move beyond conceptual and proof-of-concept work toward rigorous, longitudinal validation of converged systems in real-world settings, with explicit attention to security, energy efficiency, and equitable access. Comparative studies across regions and sectors would help clarify the conditions under which convergence delivers value, and interdisciplinary collaboration linking computer science, management, ethics, and public policy will be essential to ensure that these technologies advance societal well-being as well as economic efficiency. The central task ahead is not simply to build more powerful technologies, but to integrate them wisely.

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