Digital Transformation as a Structural Driver of ESG Performance: Empirical Evidence from Indian Capital Markets

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Abstract:

Digital transformation is increasingly a structural determinant of corporate sustainability strategies in emerging economies. This research investigates the impact of digitalization on Environmental, Social, and Governance (ESG) performance among Indian firms listed on the BSE 500 between 2022 and 2024. Utilizing a novel text-mining approach to quantify digital intensity followed by panel regression analysis, the study explores the mechanisms through which technological adoption enhances corporate accountability. The findings reveal a robust positive correlation between digital transformation and ESG outcomes, with the most significant impact observed within the governance dimension. This suggests that digitalization facilitates financial sustainability by reducing information asymmetry and enhancing regulatory compliance. The study provides critical insights for policymakers and investors in transitional economies regarding the strategic integration of digital reforms to achieve long-term ESG resilience.

Keywords: digital transformation; ESG; structural reforms; panel data; text mining.

JEL Classification: G30; O33, M14; C33; Q56.

Introduction

The escalating risk of global climate change is an unparalleled challenge and jeopardizes ecological sustainability, economic stability, and societal welfare (Bai et al., 2023; Kehler & Birchall, 2023; Dai et al., 2024; Dai, 2025). Consequently, at the global level, corporations have been emphasizing the integration of ESG factors with their operational and strategic framework and adopting Digital Transformation (DT) to facilitate long-term sustainability and competitiveness (Yin et al., 2024; Liu et al., 2025; Omonijo & Zhang, 2025). ESG has come forth as a critical parameter for assessing corporate sustainability. ESG practices upgrade long-term corporate value, enhance stability and promote sustainable growth, while providing strategic

understanding for risk evaluation and investment decisions. Therefore, promoting the improvement of ESG outcomes has become a key objective for corporate success (Pedersen et al., 2021; Bhidayasiri et al., 2024). However, discrepancies in ESG ratings can disrupt stakeholders' decision-making (Ren, 2025). DT can drastically affect ESG outcomes and is crucial to accelerate the advancement of ESG practices (Li et al., 2023; Zhao et al., 2025).

Digital transformation has become a strategic necessity for companies to compete. In this digital age, enterprises require strategic DT to sustain leadership status and attain sustainable development (Rammal et al., 2023). DT empowers corporations to strengthen ESG practices through disclosure transparency, data management and regulatory compliance. It contributes to timelier and more comprehensive ESG disclosures while streamlining management processes, which enhances aggregate operational efficacy (Zhao & Cai, 2023).

In recent years, the interconnection of DT and ESG Performance (ESG_perf.) has gained scholarly and practical attention, signifying the need to understand how digital tools transform sustainable practices in the corporate environment. However, this relationship is context-dependent, owing to heterogeneity in digital maturity and institutional environment across advanced and emerging economies (Kwilinski et al., 2023). Existing literature investigating the effect of DT on ESG_perf. in the Indian context is sparse. ESG practices have emerged as a key consideration in India due to rising global ESG assets, investor focus on ESG_perf., regulatory pressure, and ongoing foreign direct investment (KPMG, 2021a; KPMG, 2021b; Maji & Lohia, 2023). Sequential regulatory reforms, including the Business Responsibility Report in 2012 and the Business Responsibility and Sustainability Report in 2021, highlight the progressive development of ESG in India's economy (Maji & Lohia, 2023). Further, the Digital India initiative has accelerated the pace of DT in the country. These unique attributes of India with respect to ESG and digital environment yield distinct implications, calling for further investigation to assess the interaction between DT and ESG_perf. in the Indian context.

The present work contributes to addressing this literature gap by (i) assessing the impact of DT on ESG_perf. of the Indian listed firms, (ii) using BSE 500 listed firms from April 1, 2022, to March 31, 2024, as a sample, this study estimates the DT score using a novel text mining and word frequency approach, and (iii) underscores the significant role of DT for strengthening ESG_perf. This enriches the understanding of the association between DT and ESG_perf. and offers policy-oriented implications for regulators and policymakers. Thus, the present study hypothesizes:

H1: Digital transformation significantly enhances ESG performance.

The present paper is structured as follows: Section 1 presents the literature review. The overview of data and methodological procedure is described in section 2. Section 3 reports the results and discussions. The final section concludes results and provides implications and future directions.

1. Literature Review

Firm DT initiatives have played a considerable role in advancing ESG_perf. (Zhong et al., 2023; Su et al., 2023; Kwilinski et al., 2023). Digital transformation initiatives integrated with Sustainable Development Goals (SDGs) have strengthened corporates' sustainability outcomes over time (Alojail & Khan, 2023).

The relationship between DT and ESG can be understood through several theoretical lenses. According to stakeholder theory, DT raises an enterprise's ability to foster confidence among stakeholders by facilitating transparent information, access to larger markets,

interacting with socially responsible consumers, and effectively conveying sustainability goals (Osmonbekov et al., 2002; Di Vaio et al., 2023; Sahu et al., 2023; Martínez Peláez et al., 2023). Further resource-based view theory posits that DT facilitates enterprises to realize a sustainable competitive advantage, which arises from innovative digital assets and dynamic capabilities (Ellström et al., 2022; Willie, 2025).

A considerable body of research has concentrated on DT and ESG_perf. association lately. Li et al. (2025), drawing on resource-based view and stakeholder theory, have constructed and tested an analytical structure to capture both direct and indirect channels through which digital trade has influenced ESG outcomes of Chinese listed companies from 2010 to 2022. The findings demonstrated that digital trade has brought notable enhancements in ESG outcomes, with more pronounced improvement in environmental (E) and social (S) pillars. Additionally, technological innovations have been the most prominent mediator, indicating that digital proficiencies have promoted the advancements of sustainable innovations.

DT has positively affected ESG_perf. Digital innovations have elevated ESG_perf. by fostering dynamic capabilities, including sustainability-driven innovations, strategic operations, and responsible practices (Su et al., 2023). Digital resources, organizing digital assets, adoption of digital technologies, firm competitiveness and management of digitalization have indirectly contributed to ESG_perf. among Chinese small and medium enterprises through the mediating role of market performance (Wang & Esperança, 2023). Additionally, digital finance has significantly improved equitable industrial carbon emission (EICE) in 276 Chinese cities from 2011 to 2022. Eastern regions and areas with more advanced internet infrastructure have shown a stronger impact (Lu & Wu, 2025).

Technology empowerment has exerted a significant and positive influence on ESG performance in corporates. Larger enterprises have experienced more substantial enhancements in ESG outcomes. Further, DT and corporate carbon performance have served as a mediating mechanism in the relationship between technology empowerment and ESG outcomes. Through the promotion of DT and improved carbon emission management, technology empowerment has contributed to improved ESG performance (Zhao et al., 2025). To capture the strategic edge of DT comprehensively, corporations should proactively embrace and widen the deployment of digital technologies. Leadership integrating advanced digital tools into strategic choices and routine operations could have enhanced efficiency and further supported superior ESG_perf. (Su et al., 2023).

DT has been propelled through minimizing the tendency of managers to prioritize immediate gains, fostering transparency in the dissemination of internal information and boosting innovation-driven technology in firms (Zhong et al., 2023). The DT has enhanced ESG_perf. with a notable spatial spillover effect in EU countries from 2008 to 2020. Significant favourable effects from digital public services for corporates and citizens have underscored the crucial role of DT in advancing ESG outcomes. Additionally, technological innovation has been a vital mechanism through which DT has translated into strengthened ESG_perf. (Kwilinski et al., 2023).

Contemporary research acknowledges the pivotal role of DT in enhancing ESG_perf. (Wang & Wang, 2025; Zhao et al., 2025). Despite the expanding literature, empirical research concerning the relationship between DT and ESG_perf. in India is relatively limited. This gap serves as a motivation for the present study.

2. Research Methodology

Sample and Data Sources

The present research employed an initial sample of BSE 500 listed firms from April 2022 to March 2024. Firms' ESG performance data have been obtained from CRISIL ESG ratings, firms' digital transformation scores have been determined through textual analysis of annual reports available on the BSE website and financial data of corporates have been obtained from the CMIE PROWESS database. Due to the modification of the CRISIL ESG rating framework from the financial year 2022-23 and the availability of ESG scores, the study confined the analysis to the preceding two years, which ensures comparability across sample firms and avoids the unbalanced panel problem.

In line with prior literature (Mendiratta et al., 2023; Naaraayanan & Wolfenzon, 2024), the final sample was determined by using multiple criteria as represented in Table 1. The resulting final sample consisted of 301 firms with 602 firm-year observations.

Table 1: Sampling Criteria (Final Sample Firms: 301)

	Criteria	No. of Firms
	Initial sample of BSE 500	500
Less:	Financial firms	81
Less:	Central and State Government firms	44
Less:	Firms have not been a consistent constituent of the BSE 500 index within the sample period	55
Less:	Firms having a financial year-end other than March 31	13
Less:	Firms merged or acquired during the span of the study period	3
Less:	Firms with missing data	3

Source: Authors' own work.

Dependent Variable

Firms' ESG performance is taken as the explained variable. Crisil ESG rating is utilized as a proxy for ESG performance. Crisil rate on a 0-100 scale, where 0-40 category indicates weak firms, 41-50 reflects below average firms, 51-60 indicates Adequate firms, 61-70 represents Strong firms and 71-100 reflects leadership.

Independent Variable

Digital transformation of corporates is an explanatory variable in the study. The planning and execution of digital transformation can be precisely observed from the information contained in the listed companies' annual reports. The study has employed Wu et al. (2022) text mining methodology to create a DT score. Python software has been employed to quantify the frequency of keywords from corporate annual reports in six dimensions, including artificial intelligence, big data, cloud computing, blockchain, applications, and automation and platforms, to indicate the DT level.

Significant terminology from industry reports and scholarly studies has been identified to refine the keyword list that quantifies digital transformation. Additional relevant words for digital transformation have been added after analysing the Indian corporate financial reports. Figure A1 in the Appendix depicts DT keywords. The retrieved word frequencies have been summarized to create a DT score. To determine the overall DT indicator, the data have been processed logarithmically since it exhibits a "right bias" feature. Higher frequency represents to greater level of digital transformation (Jing & Fan, 2024; Wang & Hou, 2024; Wibowo et al., 2024).

Control Variables

Drawing upon prior research, the empirical model has incorporated a set of control variables, including Return on Assets (ROA), Leverage (LEV), Firm Size (FS), Board Size (BS) and proportion of Independent Directors (IND), with description in Table 2.

Table 2: Variable Description

Panel	Variable Name	Variable	Variable Description
Dependent Variable	ESG Performance	ESG_perf.	▪ Crisil ESG ratings
Independent Variable	Digital Transformation	DT	▪ Log-transformed DT score based on text mining and word frequency
Control Variable	Return on Assets	ROA	▪ $\dfrac{\text{Net income}}{\text{Total assets}}$
	Leverage	LEV	▪ $\dfrac{\text{Total liabilities}}{\text{Total assets}}$
	Firm Size	FS	▪ Logarithm of firms' total assets
	Board Size	BS	▪ Logarithm of the total board size
	Independent director proportion	IND	▪ $\dfrac{\text{Number of independent directors}}{\text{Total number of directors}}$

Source: Authors' own work.

Model Specification

To analyse the influence of DT on ESG, the following standard fixed-effect panel regression model has been employed:

$$ESG_{it} = \beta_0 + \beta_1 \times DT_{it} + \beta_j \times Z_{it} + \lambda_i + \varepsilon_{it}$$

where, ESG_{it} is the ESG score of firm i in the year t, DT_{it} is the digital transformation score of firm i in the year t, β_0 is the intercept, β_1 and β_j are the coefficients corresponding to the explanatory variable and each control variable, Z_{it} refers to the control variables of firm i in the year t, λ_i denotes the individual fixed effect and ε_{it} is the random error term.

As the dataset of this paper covers a short time span, it is justifiable to assume that unobserved heterogeneity remains constant over time (Millimet & Bellemare, 2023). Accordingly, time fixed effect is not included in the benchmark regression equation.

3. Findings and Discussions

Data Characteristics

Table 3 exhibits descriptive metrics for all variables in the present research. The ESG performance has an average value of 56.571 with a standard deviation of 5.601, respectively, indicating little variation (CV = 9.9%) in firms' *ESG_perf.* Meanwhile, the average value and standard deviation of DT are 3.491 and 0.97, respectively, highlighting moderate variations (CV = 27.8%) in the extent of firm DT.

Table 3: Descriptive Statistics

	DT	ESG_perf.	ROA	LEV	FS	BS	IND
Count	602	602	602	602	602	602	602
Mean	3.491	56.571	0.084	0.448	11.226	2.341	0.515
Std.	0.97	5.601	0.096	0.824	1.235	0.253	0.107
Min	1.099	37	-0.902	0.004	8.485	1.792	0

	DT	ESG_perf.	ROA	LEV	FS	BS	IND
25%	2.773	53	0.043	0.251	10.368	2.197	0.455
50%	3.332	56	0.085	0.376	11.026	2.303	0.5
75%	4.073	59.75	0.127	0.523	11.938	2.485	0.571
Max	6.5	77	0.353	14.609	16.077	3.135	0.833
CV	0.278	0.099	1.142	1.84	0.11	0.108	0.208

Source: Authors' own work.

Correlation and Regression Analysis

Table 4 represents correlation matrix of all study variables. DT exhibits a moderate positive and significant correlation with *ESG_perf.* (r = 0.539), indicating a greater extent of firm DT yields elevated *ESG_perf.* ROA demonstrates a positive and significant correlation with *ESG_perf.* (r = 0.217). In contrast, LEV represents a negative association (r = -0.037). FS is also positively and significantly associated with *ESG_perf.* (r = 0.233), while BS demonstrates a very weak positive association (r = 0.063). IND has a positive and significant association with *ESG_perf.* (r = 0.102). In aggregate, the correlation estimates among explanatory and control variables are relatively low. Further variance inflation factor (VIF) analysis validates no evidence of multicollinearity, as all VIF values are under 5. These outcomes imply that the independence of explanatory and control variables upholds the robustness of regression estimates.

Table 4: Correlation Matrix

	DT	ESG_perf.	ROA	LEV	FS	BS	IND
DT	1						
ESG_perf.	0.539***	1					
ROA	0.036	0.217***	1				
LEV	0.061	-0.037	-0.652***	1			
FS	0.293***	0.233***	-0.031	-0.013	1		
BS	0.085**	0.063	0.123***	-0.112***	0.361***	1	
IND	0.052	0.102**	0.109***	-0.062	-0.036	-0.014	1

Note: ***, ** and * signify significance at the 1%, 5% and 10% level, respectively.
Source: Authors' own work.

Table 5 outlines the outcomes of pooled OLS, random effect and fixed effect regressions, where *ESG_perf.* is the outcome variable and DT is the explanatory variable. Across all the estimation techniques, the results uniformly suggest that a greater level of DT significantly increases *ESG_perf.*, consequently, hypothesis 1 is accepted. The F-test and Hausman test validate that the fixed effect (FE) model provides the best fit. Within this specification, the parameter estimate of DT is 1.0255, which is statistically significant at 1% level. The empirical findings make evident the significant positive impact of DT on *ESG_perf.* Put differently, corporates can strengthen their *ESG_perf.* through an augmented extent of DT.

Table 5: Benchmark Regression Results

Model	ESG_perf.		
	OLS Model	RE Model	FE Model
DT	2.8156***	2.1401***	1.0255***
	(12.511)	(8.7465)	(2.9823)
ROA	16.043***	5.3590**	-0.1063
	(3.3832)	(1.9717)	(-0.0508)
LEV	0.7706**	0.1215	0.0152
	(2.1393)	(0.5139)	(0.0125)
FS	0.5306**	0.4811**	0.0547
	(2.5051)	(1.9771)	(0.0658)
BS	-0.9026	0.7108	1.6920*
	(-1.0350)	(0.9152)	(1.8862)
IND	2.9919	1.2905	1.0730
	(1.6289)	(0.9140)	(0.5578)
Observations	602	602	602
R2	0.35	0.31	0.17
Log Likelihood	-1761.8	-1150.6	-915.19
F test			2.9592***
LM test		24745950.04***	
Hausman test			18.56***
Industry	Control		

Note: ***, **, and * indicate significance at the 1%, 5%, and 10% levels; t-values are reported in ().
Source: Authors' own work.

In addition to aggregate *ESG_perf.* score, the present research has analysed the implications of DT on Environmental (E), Social (S), and Governance (G) independently. Table 6 exhibits pillar-level regression analysis.

Table 6: Pillar-Level Regression Results

Model	E	S	G
DT	1.2267	0.3393	1.4022***
	(1.5382)	(0.4904)	(3.790)
ROA	-2.7053	-1.3864	5.1973**
	(-0.5645)	(-0.2464)	(2.1524)
LEV	-6.6641**	7.7539***	1.1452
	(-2.3705)	(3.5052)	(0.7000)
FS	1.4150	-1.2490	-1.0101
	(0.9401)	(-0.7966)	(-0.9524)
BS	2.0172	1.5559	1.3286
	(1.1949)	(0.8826)	(1.2340)
IND	2.4074	2.3097	-0.6469
	(0.6692)	(0.7294)	(-0.5363)
Observations	602	602	602
F test	2.3227**	2.3252**	3.7792***
Industry	Control		

Note: ***, **, and * indicate significance at the 1%, 5%, and 10% levels; t-values are reported in ().
Source: Authors' own work.

The findings from Table 6 uncover that DT significantly enhances G pillar, which has a coefficient of effect at 1% level. Conversely, E and S pillars demonstrate no significant results. This indicates that technological improvements associated with G are the key driver of *ESG_perf.* in the sample, while E and S dimensions potentially take longer to materialize.

Robustness Test

The robustness analysis validates the stability and reliability of the estimation model and variables when subject to alternative specifications. To ensure the reliability of outcomes, this study performed two robustness tests using FE model, consistent with the benchmark model. First, benchmark model was re-evaluated by including time fixed effects with firm fixed effects. The findings remain positive and significant. Table 7 shows the test outcomes. The parameter estimate of DT is 0.8359 and is significant at 5% level.

Table 7: Robustness Test- Including Time Fixed Effect

Model	ESG_perf.
	FE Model
DT	0.8359** (2.3337)
ROA	0.6262 (0.3206)
LEV	0.9572 (0.8428)
FS	-1.1579 (-1.2059)
BS	1.4360 (1.6127)
IND	0.8897 (0.4697)
Observations	602
F test	2.1299**
Industry	Control
Time	Control

Note: ***, **, and * indicate significance at the 1%, 5%, and 10% levels; t-values are reported in ().
Source: Authors' own work

Second, the model was re-evaluated without control variables. This test assesses whether the identified impact of DT on *ESG_perf.* depends on the selection of control variables. The results remain consistent in both direction and significance. Table 8 demonstrates test outcomes. The coefficient of effect of DT is positive and significant at 1% level with a one-way FE (firm fixed effect), and in the two-way FE model (firm fixed effect + time fixed effect), the DT coefficient of effect is positive and significant at 5% level.

Table 8: Robustness Test- Excluding Control Variables

Model	ESG_perf.	
	FE Model	
DT	1.1087*** (3.3947)	0.8477** (2.4001)
Observations	602	602
F test	11.524***	5.7603**
Industry	Control	Control
Time		Control

Note: ***, **, and * indicate significance at the 1%, 5%, and 10% levels; t-values are reported in ().
Source: Authors' own work.

Conclusion

The present research aims to assess the implications of DT on the *ESG_perf.* of Indian listed firms. The coefficient of effect of DT has a significant positive value, indicating that the deployment and integration of digital tools within the firm's environment have notably contributed to enhanced firm *ESG_perf.,* primarily through governance mechanisms. Robustness tests have confirmed the reliability of the results. These outcomes highlight the pertinence of DT as a driving mechanism for sustainable growth. Digitally enabled tracking of ESG practices serves as a structural reform for Indian corporate governance. Technology-driven ESG systems reinforce accountability and curtail information asymmetry among corporations, stakeholders, and regulators through improving information transparency, data accessibility, and continuous monitoring (Jolly, 2025; Baplawat et al., 2025). This corroborates more robust enforcement of governance mechanisms in the Indian corporates.

This study could broaden the scholarly literature on digital transformation and ESG. Practically, the study underscores that managers and policymakers should emphasize the need to expedite digitalization for achieving environmental accountability, sustained social value and improved governance benchmarks. This study is limited in reflecting the long-term impact of DT on *ESG_perf.* due to a short time period. Future research could expand the time span and sample range to account for prolonged dynamics of digital transformation and ESG performance.

Credit Authorship Contribution Statement

The authors contributed to this work in various capacities. Sharma, M. contributed to supervision, conceptual guidance, methodology, validation, writing through review and editing, and critical review of the manuscript. Radhika contributed to conceptualization, methodology, data curation, formal analysis, writing the original draft, and visualization.

Conflict of Interest Statement

The authors declared no conflict of interest related to the publication and/or authorship of this study.

Data Availability Statement

The firm-level data used in this study were obtained from secondary data sources, including Prowess and Crisil. The text-mining scripts used for assessing digital transformation score are available from the corresponding author upon reasonable request. No conflicts of interest or external funding influenced data collection or analysis.

Ethical Approval Statement

Ethical approval was waived due to the use of secondary data sources and the retrospective nature of the study. All data used were either publicly available or derived using custom text-mining scripts, and no human participants were involved.

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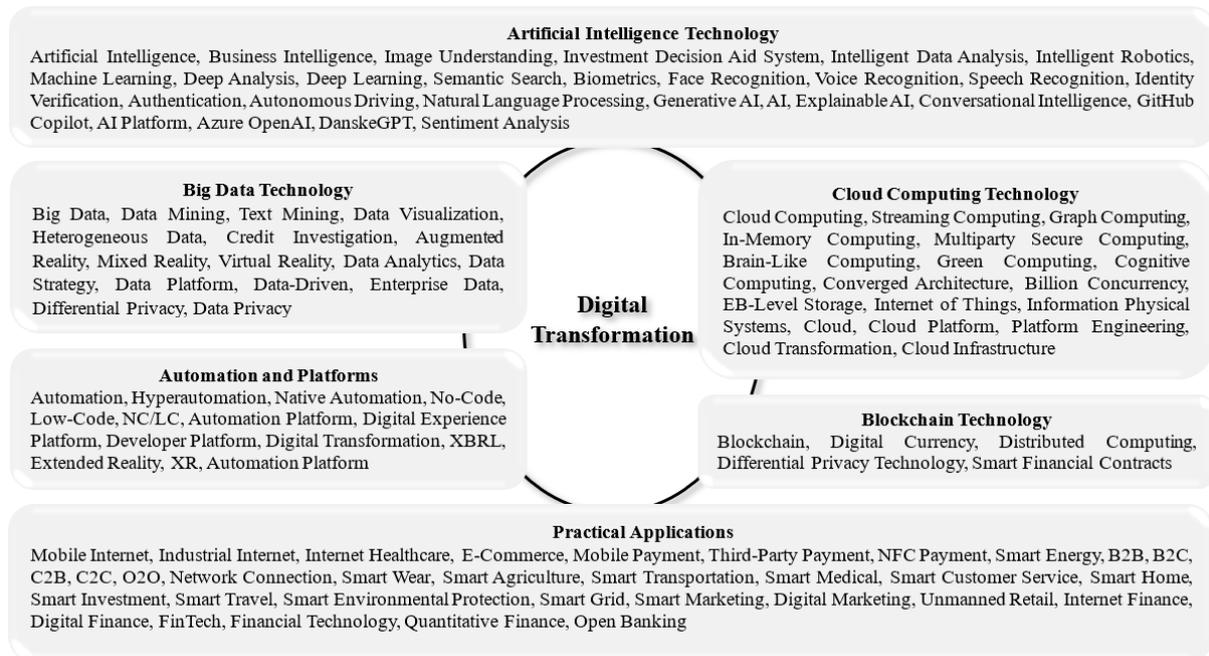
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APPENDIX

Figure A1: Digital Transformation Keywords

Artificial Intelligence Technology
Artificial Intelligence, Business Intelligence, Image Understanding, Investment Decision Aid System, Intelligent Data Analysis, Intelligent Robotics, Machine Learning, Deep Analysis, Deep Learning, Semantic Search, Biometrics, Face Recognition, Voice Recognition, Speech Recognition, Identity Verification, Authentication, Autonomous Driving, Natural Language Processing, Generative AI, AI, Explainable AI, Conversational Intelligence, GitHub Copilot, AI Platform, Azure OpenAI, DanskeGPT, Sentiment Analysis

Big Data Technology
Big Data, Data Mining, Text Mining, Data Visualization, Heterogeneous Data, Credit Investigation, Augmented Reality, Mixed Reality, Virtual Reality, Data Analytics, Data Strategy, Data Platform, Data-Driven, Enterprise Data, Differential Privacy, Data Privacy

Digital Transformation

Cloud Computing Technology
Cloud Computing, Streaming Computing, Graph Computing, In-Memory Computing, Multiparty Secure Computing, Brain-Like Computing, Green Computing, Cognitive Computing, Converged Architecture, Billion Concurrency, EB-Level Storage, Internet of Things, Information Physical Systems, Cloud, Cloud Platform, Platform Engineering, Cloud Transformation, Cloud Infrastructure

Automation and Platforms
Automation, Hyperautomation, Native Automation, No-Code, Low-Code, NC/LC, Automation Platform, Digital Experience Platform, Developer Platform, Digital Transformation, XBRL, Extended Reality, XR, Automation Platform

Blockchain Technology
Blockchain, Digital Currency, Distributed Computing, Differential Privacy Technology, Smart Financial Contracts

Practical Applications
Mobile Internet, Industrial Internet, Internet Healthcare, E-Commerce, Mobile Payment, Third-Party Payment, NFC Payment, Smart Energy, B2B, B2C, C2B, C2C, O2O, Network Connection, Smart Wear, Smart Agriculture, Smart Transportation, Smart Medical, Smart Customer Service, Smart Home, Smart Investment, Smart Travel, Smart Environmental Protection, Smart Grid, Smart Marketing, Digital Marketing, Unmanned Retail, Internet Finance, Digital Finance, FinTech, Financial Technology, Quantitative Finance, Open Banking

Source: Authors' own work