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Evolution of artificial intelligence research in *Technological Forecasting and Social Change*: Research topics, trends, and future directions

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ABSTRACT

Artificial intelligence (AI) is a set of rapidly expanding disruptive technologies that are radically transforming various aspects related to people, business, society, and the environment. With the proliferation of digital computing devices and the emergence of big data, AI is increasingly offering significant opportunities for society and business organizations. The growing interest of scholars and practitioners in AI has resulted in the diversity of research topics explored in bulks of scholarly literature published in leading research outlets. This study aims to map the intellectual structure and evolution of the conceptual structure of overall AI research published in *Technological Forecasting and Social Change* (*TF&SC*). This study uses machine learning-based structural topic modeling (STM) to extract, report, and visualize the latent topics from the AI research literature. Further, the disciplinary patterns in the intellectual structure of AI research are examined with the additional objective of assessing the disciplinary impact of AI. The results of the topic modeling reveal eight key topics, out of which the topics concerning healthcare, circular economy and sustainable supply chain, adoption of AI by consumers, and AI for decision-making are showing a rising trend over the years. AI research has a significant influence on disciplines such as business, management, and accounting, social science, engineering, computer science, and mathematics. The study provides an insightful agenda for the future based on evidence-based research directions that would benefit future AI scholars to identify contemporary research issues and develop impactful research to solve complex societal problems.

1. Introduction

The rise of artificial intelligence (AI) as an enabling technology for economic growth and social empowerment has attracted researchers to systematically explore the current challenges and report the associated opportunities (Duan et al., 2019; Kopka and Grashof, 2022). The economic effects of AI have been well discussed in the past, where digital technologies such as AI and big data disrupt business models, enhance productivity, reduce waste, and enable firms to become agile to enhance stakeholder experience (Chauhan et al., 2022). However, the published literature on AI keeps shifting its disciplinary foci from being a general-purpose digital technology with transformative potential for key business processes to a technology of immense importance for humans, society, and the environment (Dwivedi et al., 2021; Kopka and Grashof, 2022). At its inception, the early research related to AI focused on the role of robots in manufacturing and the implications of robotization in industrial development and business transformation (Edler and Ribakova, 1994; Mori, 1989; Torii, 1989). Subsequently, the focus shifted to decision support systems that enabled data-driven decision-making from voluminous business data using AI-based techniques (Plant, 1993).

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Contemporary AI research focuses on shaping our daily lives, solving complex societal problems, and countering environmental issues to protect the global ecosystem and sustainability (Baabdullah et al., 2022; Dubey et al., 2019; Dwivedi et al., 2021; Wamba et al., 2021). The diversity and volume of AI literature confirm the multidisciplinary and interdisciplinary nature of research that covers various aspects related to the decision-making quality of organizations (Li et al., 2022), customer purchase decisions (Yeo et al., 2022), product and service personalization (Micu et al., 2022), healthcare (Huarng et al., 2022), clinical decision-making (Weerasinghe et al., 2022), managing electronic health records (Zuo et al., 2021), public sector (Di Vaio et al., 2022), sports (Schlembach et al., 2022) and many more.

Literature confirms that the term AI and AI-based systems came into existence in the 1950s (Duan et al., 2019). Subsequently, several decades of academic exploration in the field of AI in diverse social and organizational contexts have advanced various theories and concepts on managing the concerned societal challenges and business opportunities (Dwivedi et al., 2021). The societal aspects of AI include the adoption of related technologies for crisis management, economic empowerment, equality, justice, social inclusion, personal wellness, and health (Wamba et al., 2021). The business aspects of AI focus on organizational performance and productivity (Awan et al., 2021; Benzidia et al., 2021). The researchers in AI have widely disseminated their research findings in high-quality outlets so that potential researchers and practitioners can adapt the theories and concepts to develop more knowledge. In this way, an introspective evaluation of the well-articulated quality research on AI in various research outlets could suggest new avenues for future exploration. Such periodic retrospective evaluations of disciplines in specific outlets may expose impactful scholarly trends and propose future research directions (Sharma et al., 2022).

Technological Forecasting and Social Change (TF&SC) is a leading international peer-reviewed scientific journal that explores technological forecasting and innovations that lead social change and address the societal implications of technological innovations. *TF&SC* was introduced as *Technological Forecasting* in 1969 and was renamed to "*Technological Forecasting and Social Change*" in mid-1970. Currently, the Australian Business Deans Council (ABDC) Journal Quality List (JQL) 2019 classifies TFSC as an "A" category journal, while the Chartered Association of Business Schools (CABS) Academic Journal Guide (AJG) 2021 rates it with a rating of "3". The recent retrospective overviews of *TF&SC* (e.g., Sarin et al., 2020; Singh et al., 2020) have confirmed that topics like AI and big data have attracted a significant scholarly focus in the last few decades. However, the conceptual and contextual diversity in AI research is evident from the range of AI applications that are revolutionizing the end-user experience (Aw et al., 2022), transforming business firms' operations (Zeba et al., 2021), and addressing the most challenging social problems (Dubey et al., 2019). In addition, the socio-economic effects of AI have been documented well by *TF&SC* (Bag et al., 2021; Kopka and Grashof, 2022). Thus, the interdisciplinary nature of AI research published in *TF&SC* facilitates fragmentation and disintegration in the overall epistemological organization of the literature. Despite the proliferation of AI research published in *TF&SC,* there is a strong need for a comprehensive and cohesive understanding of how the well-acknowledged AI literature has evolved thus far and how it should advance knowledge to derive future-focused research opportunities. Hence, this study proposes that an integrative systematic review of the extant literature on AI published in *TF&SC* can fill the research gap by providing an integrated overview of the intellectual and conceptual structure of AI research. A data-driven and objective literature analysis can significantly facilitate identifying and analyzing dominant research topics from the vast knowledge base.

The current study provides a topic-based summary of the AI research published in the *TF&SC* by reviewing the relevant papers that exclusively advance AI research. Furthermore, to explore the diversity of research on the adoption of AI in the contemporary era of big data, Industry 4.0, Web 3.0, and circular economy, the study extracts and visualizes the key themes and topics for mapping the conceptual and theoretical development related to the adoption and implementation of AI technologies. Specifically, the current study aims to address the following research questions:

RQ1. What are the most dominant topics of scholarly interest on AI published in *TF&SC*?

RQ2. What are the avenues for future research? Which themes are showing an overall increasing trend of interest? Which topics are showing a declining trend? (Alternatively, have become stagnant?)

RQ3. What are the interesting interdisciplinary patterns in the intellectual structure of the overall AI research published in *TF&SC*?

RQ4. What is the disciplinary impact of the published research on AI in *TF&SC*?

The results of this study are significant for both academics and policy makers. This computer-assisted integrated review of extant AI literature makes a significant contribution to theory and practice by providing vital insights about the conceptual and intellectual structure of AI knowledge published in TF&SC. This study is well-timed given the rapid expansion of AI in business transformation, societal transfiguration, and evolution in human behavior (Duan et al., 2019; Dwivedi et al., 2021; Kopka and Grashof, 2022). The study reports the academic hotspots as a roadmap for future research endeavors that will advance the research on AI adoption and usage in the future.

This review paper is systematized into different sections. The next two sections provide a review of the literature and describe the methodology and data this work has used. The subsequent section reports the vital results from the topic modeling and disciplinary impact assessment. Next, a discussion of the results is provided in the following section. Lastly, this study offers implications for future studies and conclusions.

2. Literature review

This section offers a perspective of AI-based articles published in *TF&SC* and its earlier title named, *Technology Forecasting*. A deep dive into the articles published in *TF&SC* illustrates that AI has touched different aspects of human life, society, and business organizations. Broadly speaking, AI has equally disrupted organizations and individuals. At the organizational level, AI has transformed traditional manufacturing into intelligent and sustainable manufacturing (Bag et al., 2021; Chatterjee et al., 2021b; Zeba et al., 2021). The transformative implications of AI in manufacturing emphasize the role of intelligent agents, expert systems, big data analytics, blockchain, and IoT in the context of Industry 4.0 (Culot et al., 2020; Dwivedi et al., 2022). AI supports organizations at all four stages of innovation, i.e., idea generation, screening of idea, experimentation, and lastly, development & commercialization of an idea (Fredström et al., 2022; Trocin et al., 2021; Truong and Papagiannidis, 2022). Organizations have also started delegating their crucial functions, including decision-making, recruitment, and customer relationship management, to AI (Allal-Chérif, 2022; Ashaari et al., 2021; Chatterjee et al., 2021a; Dwivedi et al., 2023; Pietronudo et al., 2022; Zeba et al., 2021).

Pietronudo et al. (2022) mentioned that in the context of medical services, AI could anticipate problems and find ways to cope with unexpected situations. Likewise, Chatterjee et al. (2021a) documented that due to AI, organizations detect patterns in the voluminous data of consumers and provide them with the best possible solution to their queries. At the individual level, AI has influenced almost every service consumers use, including healthcare, retailing, and assisting the elderly and people with disability (Shareef et al., 2021; Vieira et al., 2022).

Recent work highlighted that human-like attributes and technological attributes of AI result in para-social interactions and smart-shopping perceptions among consumers (Aw et al., 2022; Dwivedi et al., 2023).

Likewise, Fruehwirt and Duckworth (2021) stated that advanced healthcare services are being provided through AI applications (Fruehwirt and Duckworth, 2021). However, the dark side of AI applications has also been a discussion point in literature. For example, scholars have recorded their concerns about how AI potentially negatively impacts the labor market, specifically unskilled employees (Gruetzemacher et al., 2020; Omrani et al., 2022; Walton and Nayak, 2021). Further, extreme labor displacement will happen in the future, forcing people to learn new skill sets. Also, due to the excessive use of AI, several ethical and trust issues, both at organizational and individual levels, are also emerging (Dwivedi et al., 2023). Shareef et al. (2021) suggested that to enhance the confidence of people in AI and technology in general, a clear regulatory framework and guidelines should be designed. Evidently, the literature consummately reports the significant development and adoption of AI in a wide range of personal, industrial, and social applications. However, there is a strong need to have an integrated view of the conceptual and intellectual structure of the knowledge to propose a future agenda discussing the impactful future implications of AI on humans, businesses, and society. The current study timely addresses this significant research gap and highlights opportunities for future research.

3. Methodology

3.1. Topic modeling and disciplinary impact assessment

This study exploits topic modeling to extract and visualize the key latent topics from the AI research published in *TF&SC*. The probabilistic generative model based on structural topic models (Roberts et al., 2019, 2016) is a recent statistical text analysis technique that can be used to extract, summarize and envisage the emerging themes from the research documents (Sharma et al., 2022, 2021b). Specifically, structural topic models (STM) can graphically visualize the temporal deviations in the topic prevalence in order to propose a prospective analysis by identifying promising research topics for future research endeavors (Baker et al., 2021). The STM-based topic modeling technique can extract latent research themes from a collection of research articles and identify specific emerging research themes. These emerging themes can be the academic hotspot that can be possibly further explored by potential researchers who want to contribute to these emerging fields and areas (Sharma et al., 2021b). Fig. 1 depicts the plate notation and Fig. 2 illustrates the algorithmic steps of STM.

A labeled node that performs a unique function in the probabilistic generative modeling process represents each variable in the plate notation. We provide a representation of observed variables of the model through shaded nodes, and the unshaded nodes represent latent variables. The data generation process involves extracting terms from documents and then generating topics from the semantically associated terms, which are co-occurring. A full description of STM is beyond the scope of this work, and readers may refer to Roberts et al. (2016) for a complete theoretical discussion and Roberts et al. (2019) for practical implementation. STM has been efficiently applied to uncover hidden topics within the information management literature (Sharma et al., 2021b) and a corpus of articles assessing investors' attention (Goodell et al., 2022).

The current study adapts a social exchange model proposed by Nelson et al. (2017) that explores knowledge diffusion among research disciplines. This model is adapted to assess the magnitude of knowledge exchange between published research concerning AI and other scholarly disciplines classified by research databases. As depicted in Fig. 3, there is a reciprocity of knowledge flow between the other disciplines and research on AI published in TF&SC. This reciprocity of knowledge flow is assessable by analyzing the references and citations of articles (Sharma et al., 2022). The overall knowledge inflow is estimated from the references used in all AI articles reviewed in this study. The knowledge inflows from various individual disciplines are used to measure the disciplinary impact on published research concerning AI. The overall knowledge outflow is estimated from the citations generated by the articles. Hence, the knowledge outflows to various disciplines represent the disciplinary impact of the published AI research. Past studies suggest that Scimago, Scopus, and Web of Science databases provide a disciplinary classification of research journals that may be used to assess knowledge inflows and outflows (Sharma et al., 2021a). This study has used the Scopus database's disciplinary classification to assess AI research's disciplinary influence.

3.2. Data and text preprocessing

This study analyzes the overall intellectual evolution of AI in *TF&SC* from all the published research documents, including research articles and reviews. Fig. 4 depicts the data collection method to be used in the current study. All the keywords to extract the relevant papers on AI are carefully selected by reviewing the seminal papers that have contributed significantly to AI literature in different research contexts. Table 1 provides all the keywords with studies from which these are adapted. The keywords are grouped by logical operators (OR) to develop the search protocol for this study. The wildcard character (*) is used to select all combinations of the keywords, such as "*neural network*" will cover both "artificial neural network" as well as "neural networks".

This study has used the Scopus database as it provides more coverage of articles, as discovered in a previous study by Singh et al. (2020) that provided a bibliometric overview of *TF&SC* since its inception to 2020. The data collection steps of the current study are depicted in Fig. 4. The search protocol developed by the authors retrieved a total of 799 articles

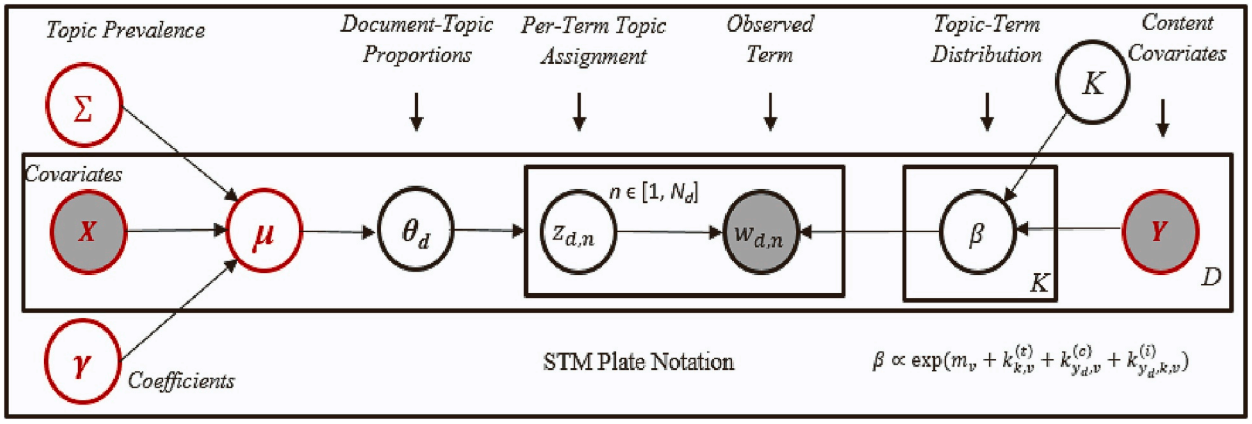

Fig. 1. Plate notation of STM.
(Adapted from Roberts et al. (2016).)

Given: Collection of indexed documents using vector $d \in \{1, 2, \ldots, D\}$ with metadata containing document-level covariates $X(Y)$-

1. Select the model parameter $\boldsymbol{\theta_d}$ (topic prevalence parameter) for a document d using the parameters: topic prevalence model's coefficients ($\boldsymbol{\Gamma}$), hyper-parameter ($\boldsymbol{\Sigma}$), and document-level covariates ($\boldsymbol{x_d}$).

$$\boldsymbol{\theta}_d \sim \text{LogisticNormal}_{k-1}(\boldsymbol{\Gamma}' \boldsymbol{x}_d, \boldsymbol{\Sigma})$$

2. For each topic k, indexed using vector $k \in \{1, 2, \ldots, K\}$ where K is the total number of topics, estimate the topic content parameter $\boldsymbol{\beta_k}$ using multinomial logit model for each vocabulary term indexed by vector $v \in \{1, 2, \ldots, V\}$

$$\boldsymbol{\beta}_{d,k,v} = \frac{\exp\left(m_v + k_{k,v}^{(t)} + k_{y_d,v}^{(c)} + k_{y_d,k,v}^{(i)}\right)}{\sum_v \exp\left(m_v + k_{k,v}^{(t)} + k_{y_d,v}^{(c)} + k_{y_d,k,v}^{(i)}\right)}$$

In the above representation, m is the baseline term distribution vector of length V. Further, $k_{k,v}^{(t)}$, $k_{y_d,v}^{(c)}$, and $k_{y_d,k,v}^{(i)}$ are topic specific deviation (t), covariate group deviation (c), and the interaction coefficient (i) respectively.

3. Estimate the per-document topic proportions using a multinomial distribution over $\boldsymbol{\theta_d}$ for a randomly selected document d with terms indexed by vector $n \in \{1, 2, \ldots, N_d\}$.

$$\boldsymbol{z}_{d,n} \sim \text{Multinomial}_{\text{K}}(\theta_d), \qquad \text{for } n = 1 \ldots N_d$$

4. Using a global parameter $\boldsymbol{B}$ which is a function of document-level covariates, sample a term from the vocabulary using multinomial distribution that provides per-corpus topic-term distributions -

$$\boldsymbol{w}_{d,n} \sim \text{Multinomial}_{\text{V}}(\boldsymbol{B}, \boldsymbol{z}_{d,n}), \qquad \text{for } n = 1 \ldots N_d$$

Fig. 2. Algorithmic steps of STM.
(Adapted from Roberts et al. (2016).)

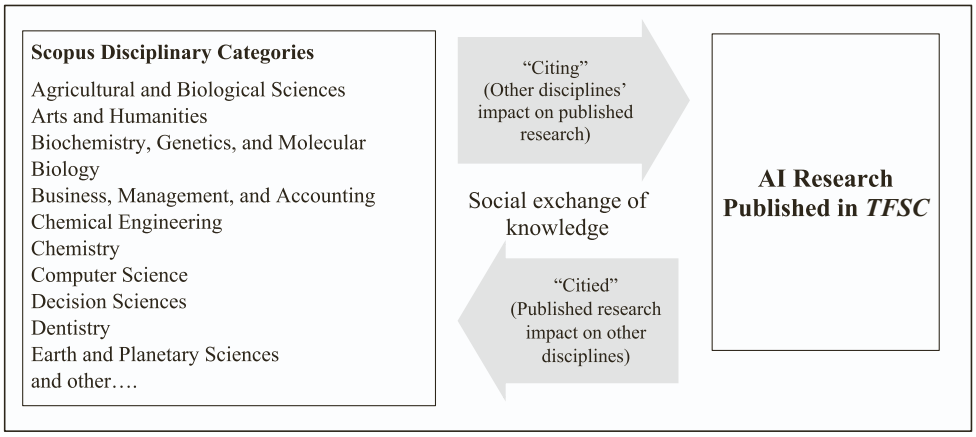

Fig. 3. Social exchange model of knowledge diffusion.
(Adapted from source: Nelson et al., 2017.)

from the entire corpus of *TF&SC*. These articles were independently screened by two different co-authors, and non-relevant articles were filtered out, which resulted in the final document set of 608 articles exploring different aspects of AI.

The text corpus for the STM-based topic modeling was organized by concatenating the title, abstract, and keywords of each research paper, which is a standard method for similar work (Sharma et al., 2021b). The text preprocessing for topic modeling involved the removal of stop words, non-English characters, numbers, publisher information, and punctuation. The most frequent bi-grams and trigrams were discovered using an n-gram tokenizer developed by the authors using the ngram package in the R programming environment, which were concatenated to preserve their semantic association. This study used the STM package in R to perform the topic modeling (Roberts et al., 2019). The STM package supports evaluating multiple topic models with a varying number of topics and finding the optimal number of topics based upon a tradeoff between held-out likelihood and semantic coherence (Roberts et al., 2016; Sharma et al., 2021b). Fig. 5 shows that a model of eight topics can be used for the corpus prepared from the final document set of 608 articles.

4. Results

4.1. Growth and progress of AI research

The growth and progress of AI research are evident in Fig. 6 where scholarly interest has significantly shifted in the last ten years toward AI. Table 2 reports the top 10 articles as per the total number of Scopus-indexed citations. Most of the highly cited articles are related to technology future analysis, technological forecasting, and technology

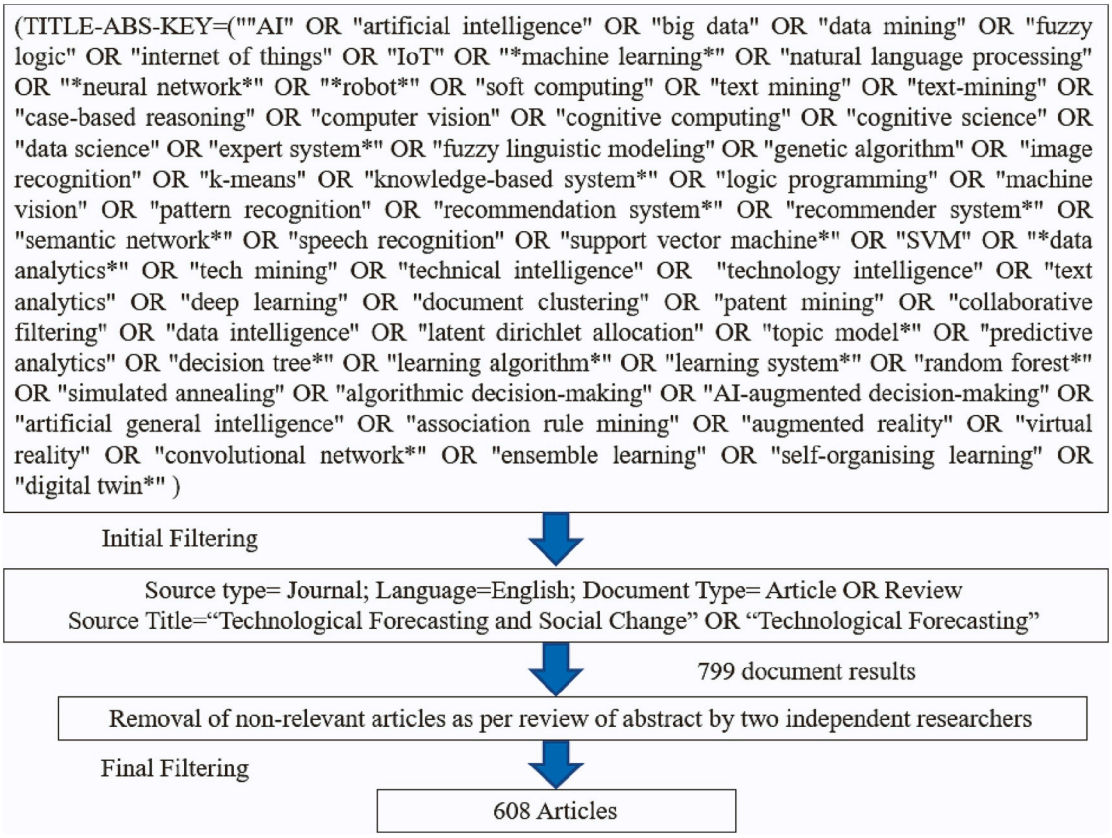

Fig. 4. Search protocol with articles inclusion and exclusion criteria.

Table 1
Theoretical support for each keyword used in search protocol.

Keywords for filtering relevant articles	Adapted from studies
AI, artificial intelligence, big data, data mining, fuzzy logic, internet of things, IoT, *machine learning*, natural language processing, *neural network*, *robot*, soft computing, text mining, text-mining	Mustak et al. (2020)
case-based reasoning, computer vision, cognitive computing, cognitive science, data science, expert system*, fuzzy linguistic modeling, genetic algorithm, image recognition, k-means, knowledge-based system*, logic programming, machine vision, pattern recognition, recommendation system*, recommender system*, semantic network*, speech recognition, support vector machine*, SVM	Duan et al. (2019)
data analytics	Bag et al. (2021); Iqbal et al. (2020)
tech mining, technical intelligence mining, technology intelligence mining, text analytics	Zhang et al. (2014)
deep learning	Xu et al. (2019)
document clustering	Kostoff et al. (2007)
patent mining, collaborative filtering	Park and Yoon (2017)
data intelligence	Eachempati et al. (2021)
latent dirichlet allocation, topic model*	Kim and Geum (2021)
predictive analytics	Dubey et al. (2019)
decision tree*, *learning algorithm*, random forest*	Butticè et al. (2019)
simulated annealing	Amer et al. (2019)
algorithmic decision-making, AI-augmented decision-making	Keding and Meissner (2021)
artificial general intelligence	Goertzel et al. (2017)
association rule mining	Kim et al. (2017)
augmented reality, virtual reality	Allal-Chérif (2022)
convolutional networks	Zhu and Motohashi (2022)
ensemble learning, self-organising learning	He et al. (2022)
digital twin*	Kamble et al. (2022)

opportunity analysis. The analysis of the context of these articles reveals interesting patterns in the business and society-related contexts where AI-related techniques and interventions have been used.

4.2. Topic modeling results

The topic modeling results provide the top words associated with each latent topic and a document-topic mapping in which we can map the top documents that are semantically associated with each topic (Sharma et al., 2021b). Thus, topic modeling is an excellent application of text analytics to organize, understand and summarize the key latent topic from the extant literature. The current study explores the key latent topic using STM from the AI research published in *TF&SC* and discovers that the extant literature mainly focuses on eight latent topics. Table 3 provides the top words as per the highest occurrence probability measure and frequency exclusivity score (FREX). The FREX score highlights those words which are more frequent in a topic but are exclusive or less frequent in other topics (Sharma et al., 2021b). The topic labels are generated using the top frequent words from each topic. Being a variant of probabilistic topic models, STM also estimates the proportion of each topic in the entire corpus as topic prevalence. Table 2 indicates that the most dominant topics are Topic 2-Patent Data Mining for Technology Roadmapping and Topic 4-Big Data Analytics for Circular Economy and Sustainable Supply Chain. Future researchers may explore exemplary studies to understand each topic and explore the conceptual structure of AI research.

4.2.1. Topic 1 - AI and Robotics in Manufacturing

Topic 1 (AI and Robotics in Manufacturing) addresses research issues related to the role of smart automation, robots, IoT, and advanced techniques based on AI and ML for digital manufacturing (Zhou et al., 2021) and related activities like production logistics scheduling (Yue et al., 2021), optimizing supply chains (Soni et al., 2022), and

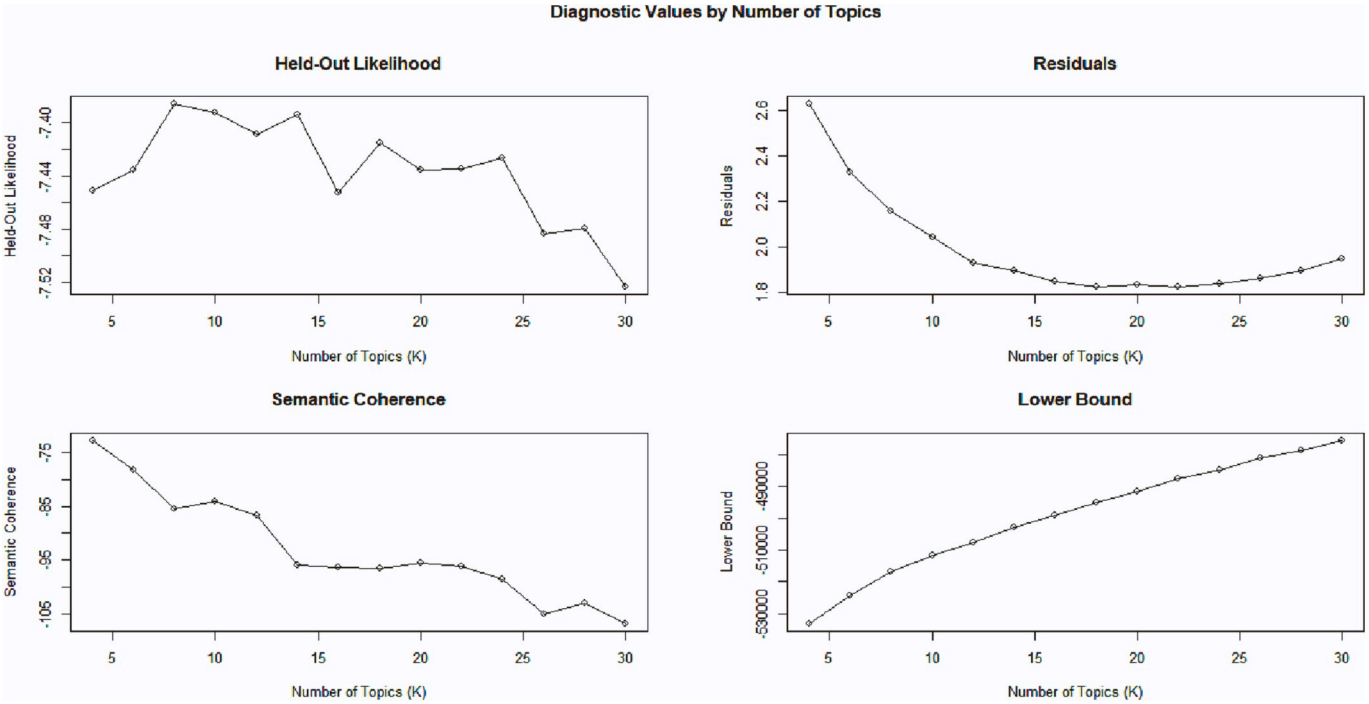

Fig. 5. Selection of the number of topics.

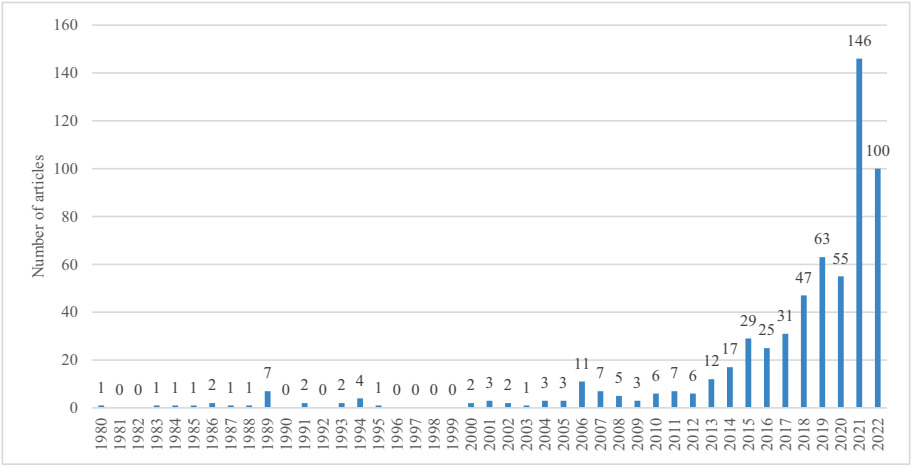

Fig. 6. Number of AI articles published during 1980–2022.

technological transformations under Industry 4.0 (Culot et al., 2020). The early research published on *TF&SC* on AI during the years from 1985 to 1995 focused on assessing the impacts of industrial robots and robotization on the performance and competitiveness of manufacturing industries in contemporary industrializing countries such as Japan (Mori, 1989), Korea (Torii, 1989), and Germany (Edler and Ribakova, 1994). The computer-integrated manufacturing based on industrial robots paved the way for industrial development and growth that deeply impacted the structure of employment and other macroeconomic factors (Saito and Nakamura, 1989). However, in the subsequent period, the emergence of technological innovations such as cloud, big data analytics, data mining, machine learning, metaverse and AI drastically changed all the aspects related to intelligentization of manufacturing (Dwivedi et al., 2022a; Liu et al., 2020). The technological revolution in Industry 4.0 facilitated by the proliferation of robotics, AI, ML, and big data-based techniques, has successively replaced manual processes by automation to improve performance and enhance productivity. The digital transformation led by AI and robotics has boosted industrial productivity. However, the concerns about its impact on workforce, community, and environment have scholarly relevant implications (Ballestar et al., 2021).

4.2.2. Topic 2 - Patent Data Mining for Technology Roadmapping and Trend Analysis

Topic 2 (Patent Data Mining for Technology Roadmapping) represents the scholarly literature employing data mining, ML, AI, and NLP-based approaches for technology opportunity discovery from patents (Lee et al., 2022), technology roadmapping (Zhang et al., 2021), R&D trend analysis from mining patent data (Han et al., 2021), and tracking innovation diffusion from large scale patent data (Fredström et al., 2021). The process of technology opportunity discovery requires analyzing voluminous data using high-precision methods to recognize and assess promising technology opportunities for achieving growth driven by technological innovations (Lee et al., 2022). AI and ML-based

Table 2
Top 10 articles as per the number of Scopus citations (as of June 2022).

SL	Authors	Title	Citations	AI technique	Context
1	Wang et al. (2018)	Big data analytics: Understanding its capabilities and potential benefits for healthcare organizations	640	Big data analytics	Healthcare
2	Bryant and Lempert (2010)	Thinking inside the box: A participatory, computer-assisted approach to scenario discovery	275	Data mining	Scenario planning
3	Santoro et al. (2018)	The Internet of Things: Building a knowledge management system for open innovation and knowledge management capacity	271	IoT	Knowledge management
4	Porter et al. (2004)	Technology futures analysis: Toward integration of the field and new methods	271	Forecasting	Technology futures analysis
5	Tseng et al. (2002)	Combining neural network model with seasonal time series ARIMA model	251	ANN	Machinery industry
6	Kostoff et al. (2004)	Disruptive technology roadmaps	242	Text mining	Literature-based discovery
7	Hengstler et al. (2016)	Applied artificial intelligence and trust-The case of autonomous vehicles and medical assistance devices	237	AI in autonomous vehicle	Medical assistance
8	Martino (2003)	A review of selected recent advances in technological forecasting	235	Data mining	Technological forecasting
9	Gordon and Pease (2006)	RT Delphi: An efficient, "round-less" almost real time Delphi method	216	AI and NLP	Decision making
10	Boon and Park (2005)	A systematic approach for identifying technology opportunities: Keyword-based morphology analysis	209	Text mining	Technology opportunity analysis

Table 3
Main topics in AI research, topical content, and prominent articles.

Topic	Top-10 most frequent terms	Top-10 terms as per FREX score	Expected prevalence	Prominent articles
Topic 1- AI and Robotics in Manufacturing	Robot, Impact, Production, Industry 4.0, Manufacturing, Technology, Economic, Innovation, Artificial Intelligence, Knowledge	SMEs, Industry 4.0, Robotization, Automobile, Competitiveness, Technological Innovation, Productivity, Additive Manufacturing, Efficiency, Production	11.86 %	(Ballestar et al., 2021; Huo and Chaudhry, 2021; Kong et al., 2017; Liu et al., 2020; Zhou et al., 2021)
Topic 2- Patent Data Mining for Technology Roadmapping	Technology Roadmapping, Research, Patent Analysis, Text Mining, Data Mining, Knowledge Discovery, Innovation, Invention, Technological Development, Trend	Patent Analysis, Tech Mining, Morphology, Technical Intelligence, Link Prediction, Technology Convergence, Patent Data, Trademark, Technology Lifecycle, Emerging Technology	20.57 %	(Choi et al., 2022; Fredström et al., 2021; Lee et al., 2022; Zhang et al., 2021; Zhu and Motohashi, 2022)
Topic 3- Machine Learning for Healthcare	Healthcare, Twitter, Medical, Social Media, Policy, Web, Online, Information, Machine Learning, Sentiment Analysis	Twitter, Destination, Covid, Tourist, Machine Learning, Health, Medical, Wearable, Pandemic, Social Media	9.55 %	(Abdel-Basset et al., 2021; Caselli et al., 2021; Huarng et al., 2022; Nanath et al., 2022; Weerasinghe et al., 2022; Zuo et al., 2021)
Topic 4- Big Data Analytics for Circular Economy and Sustainable Supply Chain	Big Data, Internet, IoT, Big Data Analytics, Decision Making, Supply Chain, Circular Economy, Sustainable Supply Chain, Circular Supply Chain, Analytics Capabilities	Circular Economy, IoT, Supply Chain, Big Data Analytics, Agility, Capability, Ambidexterity, Data Science, Recycling, Supply Chain Management	15.53 %	(Awan et al., 2021; Bag et al., 2021; Benzidia et al., 2021; Chauhan et al., 2022; Dwivedi et al., 2022; Han and Trimi, 2022; Kamble et al., 2022; Xuan, 2022; Yu et al., 2021; Zeba et al., 2021)
Topic 5- Adoption of AI by Consumers	Artificial Intelligence, Robotics, Smart, Consumer, Innovation, Augmented Reality, Technology, Product, Service, Retail	Consumer, Retail, Perception, Brand, Augmented Reality, Virtual World, Consumption Behavior, Service Quality, Technology Acceptance Model, Personality	10.93 %	(Aw et al., 2022; Baabdullah et al., 2022; Batat, 2021; Frank et al., 2021; Manthiou and Klaus, 2022; Ponzoa et al., 2021; Rabassa et al., 2022; Roe et al., 2022; Wang et al., 2022; Yeo et al., 2022)
Topic 6- AI, Open Innovation, and Innovation Management	Artificial Intelligence, System, Open Innovation, Automation, Technological Change, Innovation Management, Knowledge Management, Digital Technologies, Work, Trust	Emergency Management, Employee, Labor Market, Expert Systems, Automation, Innovation Management, Technological Change, Open Innovation, Climate Change, Energy Efficiency	11.32 %	(Arias-Pérez and Vélez-Jaramillo, 2022; Gruetzemacher et al., 2021; Haefner et al., 2021; Jabeur et al., 2022; Johnson et al., 2022; Kimpimäki et al., 2022; Llopis-Albert et al., 2021; Rossi et al., 2022; Santoro et al., 2018; Walkowiak, 2021)
Topic 7- Forecasting and Classification using AI	Forecasting Model, Data, Artificial Neural Network, Machine Learning, Performance, Optimization, Classification, Algorithm, Time Series, Deep Learning	Time Series, Crude Oil, Stochastic, Neural Network, Inference, Scenario Discovery, Forecasting Model, Ensemble Model, Parameter, Prediction	12.85 %	(Biswas et al., 2022; Gan et al., 2020; Jabeur et al., 2021; Jeon et al., 2020; Li et al., 2021; Manickavasagam et al., 2020; Sharifi et al., 2019; Sohrabpour et al., 2021; Yakubu and Kwong, 2021; Zhukov et al., 2022)
Topic 8- AI for Decision-Making and Risk Management	Machine Learning, Artificial Intelligence, Decision Making, Credit, Platform, Business, Algorithm, Risk Management, Risk Assessment, Ecosystem	Credit Rating, Crowdfunding, Decision, Platform, Default, Risk Management, Decision Support System, Banking, Transformation, Innovation Ecosystem	7.37 %	(Carayannis et al., 2018; Daim et al., 2018; Heidary Dahooie et al., 2021; Keding and Meissner, 2021; Li et al., 2020; Mahmud et al., 2022; Rodríguez-Espíndola et al., 2022; Tang et al., 2019; Wang et al., 2020; Yalcin et al., 2022)

big data analytics methods, such as deep learning and topic modeling, can process large volumes of data and discover precise insights for emerging technologies (Chung and Sohn, 2020). Similarly, technology assessment and roadmapping involve the evaluation of technology before its acquisition as well as the impact assessment of an acquired technology to understand the status quo from an applications perspective (Zhang et al., 2021). The data analysis and visualization methods supported by AI, ML, text mining, and NLP can be effectively leveraged

to understand the current status of research and development and forecast the future technological trends related to potential opportunities for scientific advancement (Chung and Sohn, 2020; Li et al., 2019). Furthermore, the same methods can also detect technology convergence patterns where the hybridization of multiple technologies enables the emergence of novel innovative technologies (Zhu and Motohashi, 2022).

4.2.3. Topic 3 - Machine Learning for Healthcare

Topic 3 (Machine Learning for Healthcare) mainly focuses on innovative applications of data analytics, machine learning, knowledge discovery, and other related techniques in the healthcare domain and medical industry. The increasingly diversified applications of these techniques are bringing together various insular disciplines for the diagnosis of diseases, such as cervical cancer screening (Lee et al., 2021), management of electronic health records (Zuo et al., 2021) and medical information (Woo et al., 2015), monitoring health and well-being using smart devices (Papa et al., 2020), mental health indexing (Nanath et al., 2022), and development of expert systems that can perform literature-related knowledge discovery to categorize causes of chronic and infectious diseases (Kostoff and Patel, 2015). A significant number of scholarly contributions also explore the widespread adoption of big data analytics and specific techniques, such as machine learning, in assessing the emotional well-being of people (Durahim and Coşkun, 2015) and mental health issues (Nanath et al., 2022). Moreover, AI and related technologies have also become increasingly prevalent in healthcare administrative activities as well where intelligent automation may efficiently execute the tasks of a healthcare professional such as clinical decision-making (Weerasinghe et al., 2022). It is well discussed in the literature that AI-based wearable noninvasive healthcare devices have eased the processes related to collecting and disseminating personalized health information (Papa et al., 2020). However, researchers report that these devices raise ethical issues such as economic burden, accountability, transparency, permission, and data privacy that need further exploration in the future (Huarng et al., 2022).

4.2.4. Topic 4 - Big Data Analytics for Circular Economy and Sustainable Supply Chain

Topic 4 (Big Data Analytics for Circular Economy and Sustainable Supply Chain) concerns the role of big data analytics in developing a green and sustainable supply chain to reduce, reuse, and recycle materials to achieve a circular economy. AI-driven big data analytics transform the voluminous transactional data into strategically important business insights that can improve managerial decision-making related to several aspects of the business, including integrating supply chain processes, developing circular economy capabilities in the supply chain, improving environmental efficiency to create a sustainable supply chain, and achieving better operational flexibility (Awan et al., 2021; Bag et al., 2021; Gupta et al., 2019; Yu et al., 2021). Hence, exploring the interplay among big data analytics, circular economy capabilities, circular economy performance, green supply chain collaboration, and supply chain integration has gained significant attention from academicians and practitioners in the recent past.

Gupta et al. (2019) provided a stakeholder perspective describing the potential of big data analytics in data-driven decision-making, collaboration, coordination, and integration that is significant for implementing sustainable business practices related to the circular economy. Further, Bag et al. (2021) discovered that the adoption of big data analytics and AI has a significant impact on the development of circular economy capabilities in firms manufacturing automobile and automotive components in South Africa. Moreover, Awan et al. (2021) assessed the role of big data analytics capability on the circular economy performance of manufacturing firms and discovered that decision-making quality depends on big data analytics capability, which ultimately improves productivity and efficiency under the circular economy. Specifically, the role of big data analytics in developing integrated supply chains (Yu et al., 2021) and green supply chain collaboration (Benzidia et al., 2021) has well-fascinated scholars and practitioners in recent years due to the increasing pressure on firms to improve environmental performance and operational flexibility. Hence, the adoption of emerging digital advancements in big data analytics and AI can enable business firms to adopt a circular economy and shift to a sustainable supply chain (Chauhan et al., 2022; Choi and Chen, 2021).

4.2.5. Topic 5 - Adoption of AI by Consumers

Topic 5 (Adoption of AI by Consumers) encompasses research related to AI-enabled technological disruptions in consumable products and services. Business organizations have already started exploiting AI to offer AI-empowered products and services to understand customers' requirements, support consumers in purchase activities, provide a personalized experience with products, enhance the quality of services, and manage post-purchase services to ensure long-term relationships with customers. However, the adoption of AI-based products and services by consumers and the resultant behavior remains an important focus area of *TF&SC*. The predominant research on assisting consumers in the purchase and post-purchase-related activities discusses the role of AI-powered virtual personal assistants such as chatbots (Baabdullah et al., 2022) and digital voice assistants (Aw et al., 2022; Rabassa et al., 2022). However, other than services, firms have also started offering tangible AI products like self-driving vehicles and smart home devices such as AI-based home appliances and care robots (Frank et al., 2021; Shareef et al., 2021). Even the experience economy sectors such as fashion, tourism, and hospitality have started tapping the huge benefits of AI-based products and services that include applying augmented reality (AR) to enhance customers' dining experiences in restaurants (Batat, 2021), employing AI-powered technologies to influence the fashion product purchase decisions (Yeo et al., 2022), and using robots as a tour guide in robotic tourism (Manthiou and Klaus, 2022) and many others. Thus, the adoption of AI-enabled products and services, assessment of the delivered customer value by these disruptive technologies, and the resultant experience and satisfaction are likely to remain a key focus area of *TF&SC* in the future, given their increasing penetration in the market (Khaksar et al., 2016; Ponzoa et al., 2021; Shin et al., 2018).

4.2.6. Topic 6 - AI, Open Innovation, and Innovation Management

Topic 6 (AI, Open Innovation, and Innovation Management) mainly represents the research related to adopting AI by business firms in their innovation processes to gain competitive advantage by increasing efficiency and innovativeness. The early research on this theme discusses the advancements related to industrial automation, such as automobile assembly by robots (Arai, 1989) and the use of computer-based expert systems for resource management (Plant, 1993). In the subsequent contemporary studies, researchers have explored various factors related adoption and implementation of AI in innovation, research, and development processes by firms (Johnson et al., 2022). Business firms may exploit AI to understand the complex, volatile, and dynamic business environment and proactively act intelligently amid competition (Haefner et al., 2021). New disruptive AI-based technologies, such as the Internet of Things (IoT), are innovating internal knowledge management practices in firms, resulting in enhanced innovation capacity (Santoro et al., 2018). Business firms are developing new business models and reconfiguring their existing business models to exploit the potential of AI-enabled complex digital systems such as IoT (Rossi et al., 2022). Concerning AI and its application to innovation and innovation management, the managers in business firms need to assess AI readiness levels to identify the barriers to be overcome (Haefner et al., 2021) and build smarter capabilities to exploit the entrepreneurship opportunities created by big data driven innovations (Jabeur et al., 2022). The transformation capabilities of AI argue that it can radically transform businesses and society. However, the uncertainties related to AI safety and AI governance remain the key challenge to resolve (Gruetzemacher et al., 2021).

4.2.7. Topic 7 - Forecasting and Classification using AI

Topic 7 (Forecasting and Classification using AI) mainly represents the applied AI research concerning the development of AI and ML-based models for prediction and classification problems. The early research on this theme focused on developing forecasting models for time-series data analysis, and optimization of the forecasting performance was the key objective of researchers (Black et al., 1994; Tseng et al., 2002). The subsequent studies exploited several AI-based forecasting models in different contexts, such as the multilayer perceptron model for predicting research and development performance in Europe (de la Paz-Marín et al., 2012), machine learning based ensemble model to forecast demand of a new product before it's actual launch (Lee et al., 2014), and adaptive neuro-fuzzy inference system (ANFIS) to predict the natural gas demand (Azadeh et al., 2015) and many other. Contemporary scholars have focused on other AI-based techniques, such as genetic programming to develop an export sales forecasting model (Sohrabpour et al., 2021), fuzzy rough set time series forecasting to predict the importance of product attributes from online reviews (Yakubu and Kwong, 2021), gradient boosting decision trees (CatBoost) for corporate failure prediction (Jabeur et al., 2021) to name a few. Many contemporary scholars have adapted the existing machine learning and AI-based models to develop hybrid ensembles that work better than the non-ensemble methods. For example, Jeon et al. (2020) have developed a hybrid machine learning model based on XGBoost and an embedding-based neural net for the popularity prediction of videos on online streaming services. The results confirm that hybrid and ensemble models work better than the standalone models.

4.2.8. Topic 8 - AI for Decision-Making and Risk Management

Topic 8 (AI for Decision-Making and Risk Management) concerns the critical business processes related to data-driven decision-making using the combination of AI, machine learning, data mining, and predictive analytics techniques (Yalcin et al., 2022). The data-driven decision-making requires the processing of large volumes of complex data, and AI and machine learning-based methods may provide the business with significant insights in an efficient and agile way (Wang et al., 2020). Research has confirmed that AI-based algorithmic decision-making is more efficient than human decision-makers and delivers superior performance in a variety of contexts and areas requiring both objective and subjective evaluation (Mahmud et al., 2022). The recent developments in multi-criteria decision-making approaches propose hybrid approaches based on soft computing and natural language processing (Carayannis et al., 2018; Heidary Dahooie et al., 2021). These approaches can deliver potentially better decisions in complex business situations that may require managing various types of risks, such as credit risk (Tang et al., 2019). It is well documented in the literature that AI algorithms can provide agile analytical capabilities that can enable firms to understand the potential impact of risks using predictive analytics and recommend risk mitigation procedures using prescriptive analytics (Rodríguez-Espíndola et al., 2022; Yalcin et al., 2022). Hence, AI-based decision-making has progressed from merely supporting human decision-makers via rule-based expert systems to contemporary, sophisticated autonomous systems having cognitive capabilities to transform business models and strategies (Keding and Meissner, 2021).

4.3. Disciplinary influence and impact of AI research

The disciplinary influence on a domain is assessed by identifying the significant knowledge contributors that form the core of the knowledge. A careful examination of all the references and citations of AI articles published in *TF&SC* reveals some interesting patterns of knowledge inflows and knowledge outflows. The 618 articles reviewed in this study have borrowed most of the knowledge from 40,338 articles published in 13,159 unique sources. This study has removed sources with a threshold frequency of less than 25 following a data reduction plan proposed in previous works (Sharma et al., 2022; Sharma et al., 2021a). The data reduction plan resulted in 259 unique sources that have contributed 16,045 references. All these sources are classified into their respective disciplines as per Scopus, and their proportion is visualized in Fig. 7. It is evident that most of the knowledge flows from 'Business, Management, and Accounting' (47 %), 'Computer Science' (12 %), and 'Social Sciences' (12 %) disciplines.

On a different note, this study also tries to assess the disciplinary impact of AI research on other disciplines. All the citations of the 618 articles were analyzed, and their sources were classified as per the predefined discipline categories by Scopus. A total of 14,980 citations of the 618 articles are generated that belong to 3970 unique sources. The data reduction plan resulted in 250 unique sources that generated 8743 citations. All the sources are classified into their respective Scopus disciplines, and the proportion of citations is visualized. As illustrated in Fig. 8, about 44 % of citations are from the 'Business, Management, and Accounting' discipline, while 'Social Sciences' (13 %) and 'Engineering' (12 %) are the next citation generators for AI research published in TF&SC. The assessment of knowledge inflows and outflows discovers that AI research is substantially influenced by the 'Business, Management, and Accounting' and 'Computer Science' domain. However, the influence and impact of AI research on other fields like 'Social Sciences' and 'Engineering' is remarkable and worth reporting.

5. Discussion and future research agenda

5.1. Topical trends and disciplinary impact assessment

STM discovers a total of eight key latent topics from the corpus representing AI research published in *TF&SC*. Fig. 9 displays the relative proportions of all the latent topics. The use of data and text mining techniques for technology roadmapping has been an important theme and focus area of *TF&SC* contributors. Mining the patent text information using AI-driven automatic approaches has given promising results for technology opportunity discovery and predicting the future pathways of technology convergence (Lee et al., 2022; Zhu and Motohashi, 2022). Hence, this study discovers that about 21 % of research on AI is dedicated to technology roadmapping, patent mining, identifying technological breakthroughs, and technology opportunity discovery. The next important theme constitutes about 15.5 % proportion of the entire corpus, and it is related to the use of AI-enabled big data analytics for circular economy and sustainable supply chain. The third significant latent theme represents about 13 % of the corpus, and it is formed by research exploiting AI for developing general-purpose classification and prediction models. As RQ1 of the current study focuses on reporting the most dominant topics of scholarly interest on AI in *TF&SC*, STM efficiently extracts and represents the conceptual evolution of these topics.

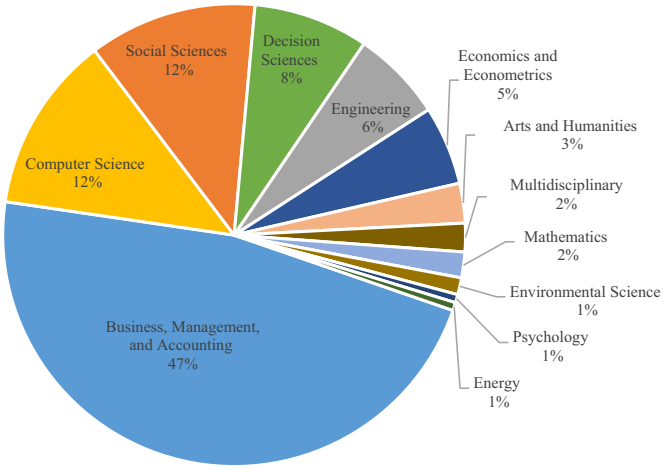

Fig. 7. Knowledge inflow to TF&SC AI Research.

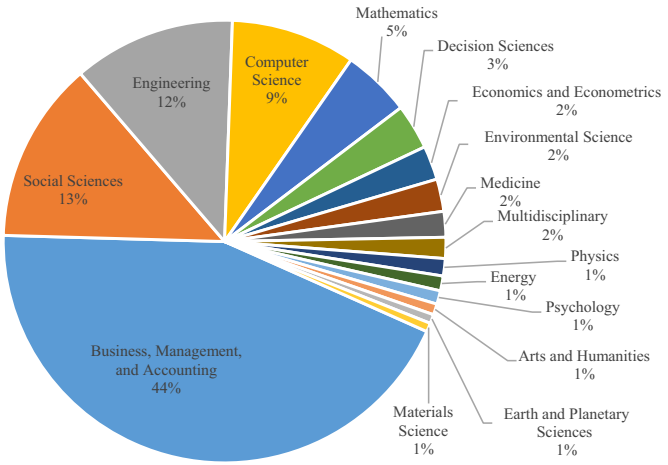

Fig. 8. Knowledge outflows from TF&SC AI Research.

Assessing the quality of the results of any machine learning algorithm is very important, as almost all algorithms suffer from explainability issues (Roberts et al., 2016). This study uses semantic coherence and topic exclusivity scores to ensure that topics are meaningful and the terms that form each topic are mutually exclusive (Sharma et al., 2021b). Fig. 10 plots the semantic coherence and topic exclusivity scores for each topic, and it is evident that all the topics are distantly placed on the plot, which confirms that topics are distinct and the terms which are frequent in a topic are not co-occurring in other topics.

STM also features estimating correlation among the topics where a positive correlation with a value of more than 0.5 shows that the topics are not exclusive, and many documents equally represent two topics. The correlation values less than 0.3 represent no matching of concepts among the topics and the corresponding documents (Sharma et al., 2021b). It is evident from Fig. 11 that all topics are distinct and do not correlate with each other, which indicates good topic modeling results.

RQ2 of the current study maps the avenues for future research and identifies the hot and cold topics. The topics with a rising trend of scholarly interest in the recent past have the potential to become a hotspot soon, and a topic with a gradual declining trend is unlikely to generate much scholarly focus soon (Nunkoo et al., 2021).

The topic prevalence trends with respect to the publication year of articles are shown in Fig. 12. Although the first issue of *TF&SC* was published in 1969 as *Technological Forecasting,* the major focus on AI started developing in the early and mid-1980s when the proliferation of robotics in manufacturing started attracting scholars to explore the technological and societal aspects of AI (Bretschneider and Bozeman, 1986; Howell, 1985). As highlighted, the trend related to Topic 1-AI and Robotics in Manufacturing has been declining over the years. A similar trend is visible for Topic 7-Forecasting and Classification using AI, where we see that it was a core focus area during 2000–2010, but it has reported a declining scholarly interest in the last ten years.

However, the topics which are showing a sharply rising trend are Topic 3-Machine Learning for Healthcare, Topic 4-Big Data Analytics for Circular Economy and Sustainable Supply Chain, Topic 5-Adoption of AI

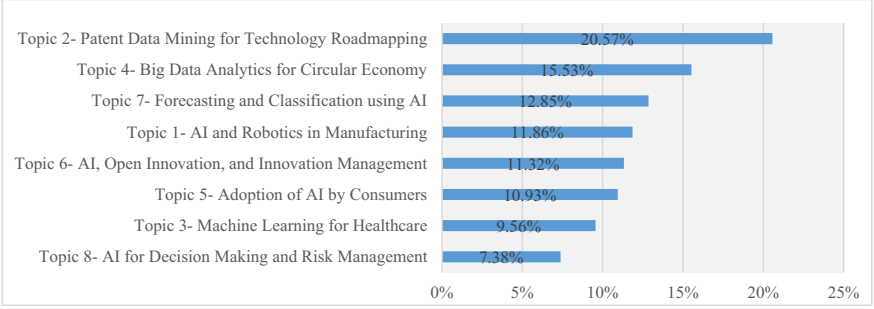

Fig. 9. Topics and their proportions.

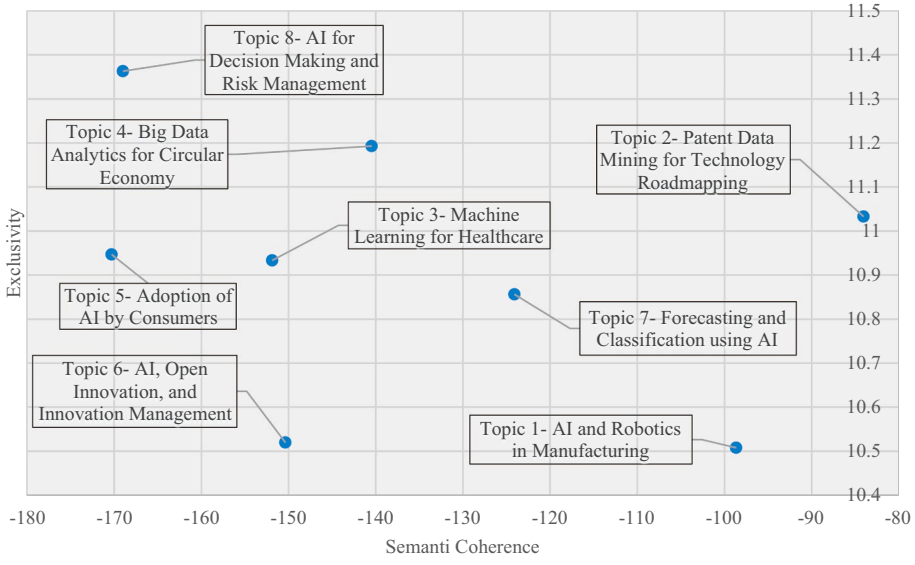

Fig. 10. Assessing topics' quality from semantic coherence and topic exclusivity plot.

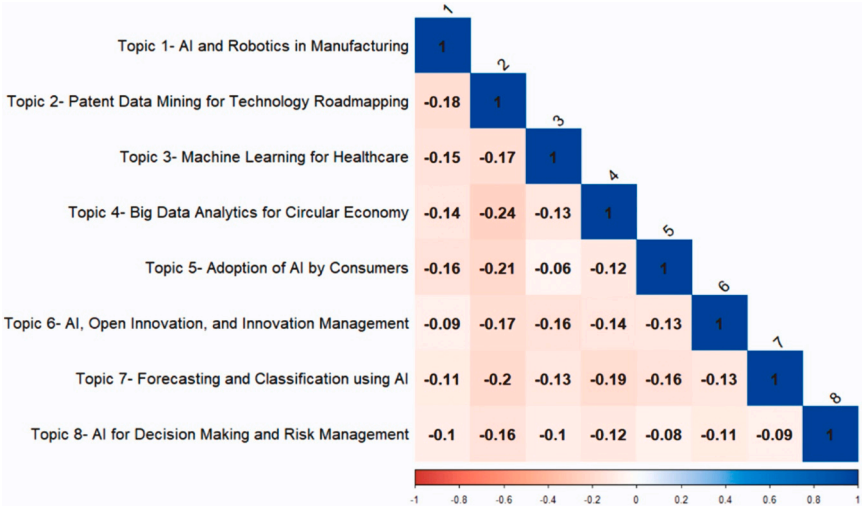

Fig. 11. Correlation among the latent topics.

by Consumers, and Topic 8-AI for Decision Making and Risk Management. An important trend worth reporting is related to Topic 2-Patent Data Mining for Technology Roadmapping, as this topic constitutes about 21 % of overall AI research. Topic 2 observes a rising trend from the year 2000 to 2007. However, being a key focus area of *TF&SC*, the topic prevalence trend stabilizes after 2012. Topic 6-AI, Open Innovation, and Innovation Management, moreover, displays an erratic trend where the overall trend seems to be rising, but there are seasonal, temporal variations in the scholarly interest, which affects its annual prevalence.

The topic with emerging, rising trends, such as Topic 4-Big Data Analytics for Circular Economy, Topic 5-Adoption of AI by Consumers, and Topic 8-AI for Decision Making and Risk Management, have the potential to become academic hotspots in the future. On the contrary, Topic 1-AI and Robotics in Manufacturing and Topic 7-Forecasting and Classification using AI are showing a declining trend or have, alternatively, become stagnant.

RQ3 concerns about the interdisciplinary patterns in the intellectual structure of the overall AI research published in *TF&SC*. The discipline 'Business, Management, and Accounting' constitutes a major section of the intellectual structure of AI research, as about 47 % of references in the AI articles are from this domain. However, this study also discovers that there is a significant knowledge contribution from other disciplines, such as 'Social Sciences' (12 %), 'Decision Sciences' (8 %), 'Engineering' (6 %), and 'Economics' (5 %), that form the foundation of the intellectual structure of AI research published in *TF&SC*. As interdisciplinary research is becoming more significant in advancing technologies for solving societal problems and challenges, the interdisciplinarity assessment of this study is crucial to identify the "intellectual balance of trade" between AI and other disciplines (Appio et al., 2019; Sarin et al., 2020).

On the contrary, RQ4 is related to the disciplinary impact of the published research on AI in *TF&SC*. The analysis confirms that AI research has a significant impact on disciplines such as 'Social Sciences' (13 %), 'Engineering' (12 %), 'Computer Science' (9 %), and 'Mathematics' (5 %). Such disciplinary knowledge exchange is an indicator of a discipline being a "*storer*" or "*feeder*" of knowledge where the "*storers*" collect more knowledge from others and "*feeders*" contribute more knowledge to other domains (Sharma et al., 2022). This study confirms that AI research is an overall *feeder* for 'Social Sciences', 'Engineering', 'Computer Science', and 'Mathematics'. However, the AI research published in *TF&SC* is an overall *storer* for the domain 'Business, Management, and Accounting' because it takes more knowledge (47 % references) than it contributes (44 % citations).

5.2. Implications for future research

The aim of this study is to report the key research topics in AI and trace their evolution in the *TF&SC* journal. The results show that *TF&SC* has received wide attention from AI scholars, and it is expected to grow further in some emerging areas, such as healthcare, circular economy, sustainable supply chains, and decision-making in business organizations.

5.2.1. Theoretical contributions and implications

This study reviews the conceptual evolution of AI research and provides empirical insights related to diverse disciplines and research themes. This study argues that text analytics-based methodological advancements such as STM allow the discovery of meaningful epistemological patterns from the voluminous literature using an automated data-driven way. STM uncovers key focus areas and academic hotspots in AI. From a theoretical perspective, the trending topics discovered using STM may become the frontier of future research, guiding theoretically grounded research in the coming years. Hence, the conceptual research landscape presented in the current study may become a roadmap for higher-level theoretical reasoning in AI. For example, Topic 5 (Adoption of AI by Consumers) shows a rising trend that confirms more academic exploration on the adoption of AI technologies using theoretical reasoning, including affect-as-information theory in the context of service robots (Chiang et al., 2022), flow theory to gauge user experience with AI-powered chatbots (Baabdullah et al., 2022), and delegation theory to assess AI product demand (Frank et al., 2021) and many more. Given the rising scholarly attention, there is still scope for drawing deep intellectual insights using a wide range of theories and frameworks that integrate several theories. Hence, the intellectual significance of an academic hotspot encourages more forward-looking theoretical assessments by potential scholars with a significant scholarly impact.

5.2.2. Practical implications for expanding AI scholarship

From a practical perspective, this study provides a roadmap to practitioners, managers, and policy-makers regarding significant focus areas in AI. For example, this study reports that big-data analytics has become a key enabler for sustainable supply chains and circular economy. However, this study predicts that we may still observe a consistent rise in practical applications of AI-driven big-data analytics technologies in the future. Hence, we might reasonably anticipate practitioners and managers making data-driven decisions impacting the entire organization and other stakeholders. Considering the fact that AI has become a key driving force for the circular economy, practitioners and managers

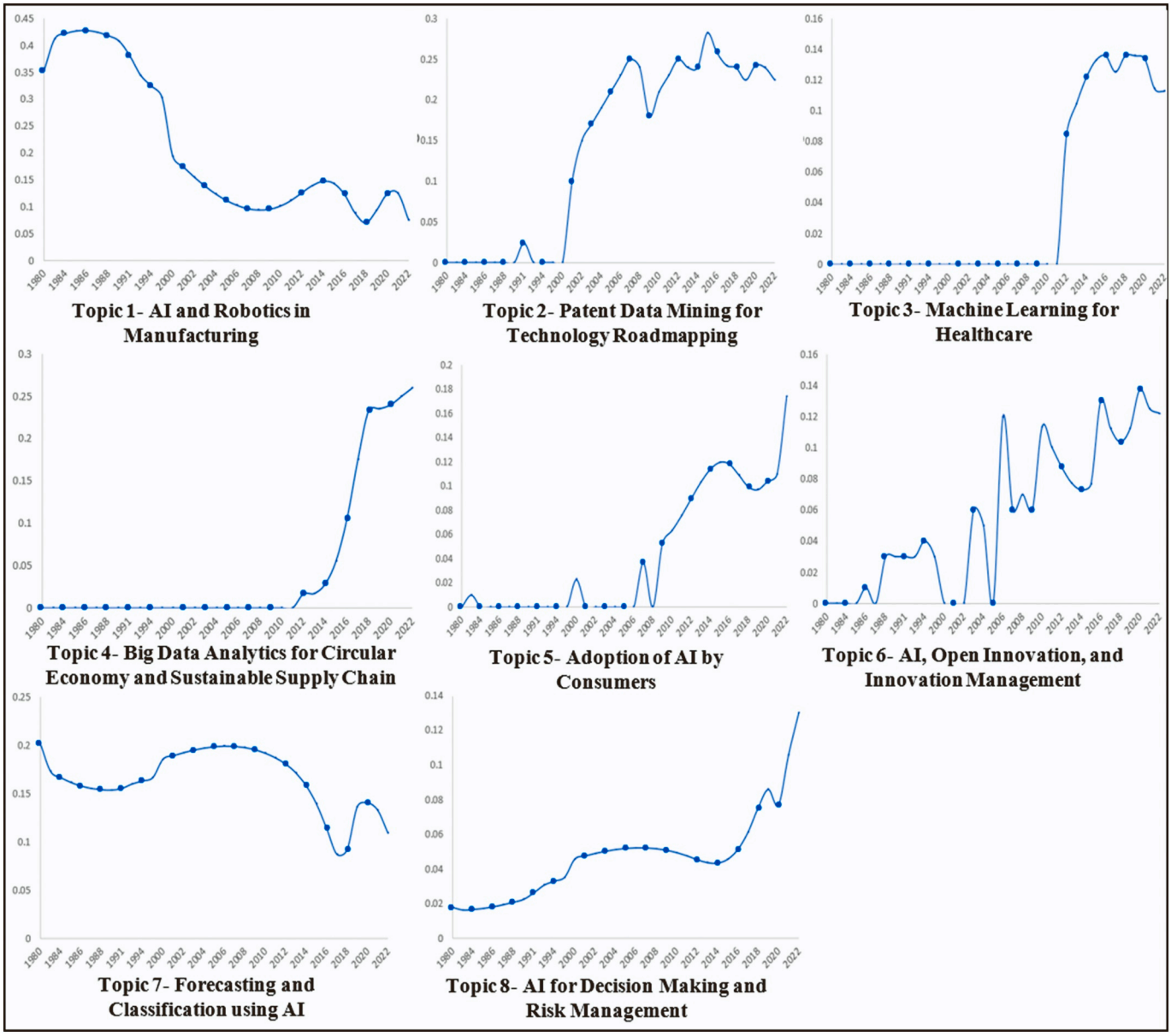

Fig. 12. Topical trends based on expected topic proportions.

must develop an in-depth understanding of contemporary focus areas in AI from this timely research.

5.2.3. *Future research agenda*

To derive an agenda for future research, this study has performed a thorough content analysis of the extracted topics and identified constituting articles published in the last two years. These articles were scrutinized by two co-authors independently, and the sections related to discussion and future research implications were examined. Table 4 summarizes the findings that may guide future AI researchers in expanding AI scholarship by considering more qualitative and empirical research methods for solving complex societal issues.

This study contributes to the research on AI in multiple ways. The use of advanced topic modeling for extracting the key topics as academic hotspots for future research and the topical trends from the literature concerning research on AI can guide future researchers as a roadmap. With a more advanced and comprehensive data analytics approach, this study demonstrates the extraction of latent topics from AI research literature corpus in a data-driven way by automatically digging deeper into the text literature without any subjective bias. The comprehensive review and synthesis of all the critical topics from the AI research published in *TF&SC* will serve as a gateway to the ongoing AI and big data analytics research streams as well as emerging streams of intellectual interest, such as the adoption of AI by consumers and AI-ML for healthcare. In this way, this study makes a significant contribution to the AI research community. Moreover, the editorial team and the policymakers may gain a significant overview of the key themes, which will enable them to design proactive interventions to advance AI knowledge through *TF&SC* special issues in the future.

5.3. *Limitations and future research directions*

This study has certain inevitable limitations. First, this study only considers AI articles published in *TF&SC* that mostly focus on the societal implications of technological advancements. Hence, the findings of the current study may not be generalized in a broader sense. The results confine comprehensiveness as the paper only focuses on the conceptual and intellectual structure. A future study may provide a complete

Table 4
Future research agenda for each topic.

Topic	Future research agenda
Topic 1 - AI and Robotics in Manufacturing	• More research is needed to explore the impact of robotics and automation on productivity and labor participation in service industries (Ballestar et al., 2021) • There is still a necessity for more research on the impact of AI and Robotics on resolving societal challenges related to climate change, environmental sustainability, and energy consumption (Kopka and Grashof, 2022)
Topic 2 - Patent Data Mining for Technology Roadmapping	• More advanced data mining, text mining, natural language processing, and transformation models may be assessed for technology opportunity discovery in the future (Lee et al., 2022) • Technology roadmapping consists of detecting and forecasting emerging technologies. However, benchmark datasets can be developed and made publicly available so that the accuracy of various forecasting approaches can be compared (Xu et al., 2021)
Topic 3 - Machine Learning for Healthcare	• To enhance user acceptance of AI-based healthcare devices, more studies are needed to assess the most significant predictors of the adoption of wearable medical devices with considering the technical differences across devices and cultural differences among users (Huarng et al., 2022) • Future research work may explore further the effectiveness and efficiency of big data analytics in clinical decision-making, hospital data management, medical resource optimization, and precision recommender systems for medicines (Weerasinghe et al., 2022)
Topic 4 - Big Data Analytics for Circular Economy and Sustainable Supply Chain	• The potential applications of advancements in IoT, cloud computing, AI-ML, and blockchain may be explored in implementing digital supply chain twins across sectors (Kamble et al., 2022) • More empirical studies are needed to examine the effect of BDA-AI capabilities on green business practices such as eco-design, sustainable supply chains, clean manufacturing, and eco-friendly goods transportation (Benzidia et al., 2021)
Topic 5 - Adoption of AI by Consumers	• The effect of contextual conditions such as political, social, economic, and cultural dimensions on the adoption of AI products and AI technologies should be explored more in the future (Frank et al., 2021) • A theoretically strong and methodologically comprehensive explanation of the consumer's experience and satisfaction with AI technologies such as digital voice assistants and chatbots is needed (Baabdullah et al., 2022)
Topic 6 - AI, Open Innovation, and Innovation Management	• The managerial challenges related to implementing AI for innovation and R&D processes should be explored and assessed empirically (Johnson et al., 2022) • The potential of new developments in AI technology to resolve the complex challenges in innovation management can be explored more in future studies (Haefner et al., 2021)
Topic 7 - Forecasting and Classification using AI	• The role of big data analytics as a reliable global forecasting method for complex social systems may be explored more in the future (Zhukov et al., 2022)
Topic 8 - AI for Decision-Making and Risk Management	• The applications of AI in many fields have offered extraordinary outcomes, but studies exploring the role of AI in accounting, corporate finance, and investment banking are still very few that open new horizons for future exploration (Gan et al., 2020) • The behavioral effects of AI, such as psychological perspectives, should be explored more in the future when AI-augmented decision-making is adopted at the strategic level in organizations (Keding and Meissner, 2021) • More empirical research is needed to examine the role of big data analytics, AI, cloud computing, and blockchain in managing various risks and building resilience in different sectors other than manufacturing (Rodríguez-Espíndola et al., 2022)

knowledge integration using scientometric analysis methods such as citation and co-citation analysis. Lastly, the study uses only the Scopus database for citation information and disciplinary classification for interdisciplinary assessments. Future researchers may use other disciplinary classification methods, such as Scimago and Web of Science, as suggested by other authors in the past (Sarin et al., 2020).

6. Conclusions

This study offers vital insights into the conceptual foundation and disciplinary impact of AI research published in *TF&SC*. This study found that the extent of research on AI has predominantly focused on eight key topics that have evolved significantly over the years. The content of each latent topic is examined, and future research directions are discovered and reported. The early research on AI focused primarily on industrial process automation and the use of robots in manufacturing. However, contemporary research has focused on diversified themes and topics that hugely impact humans at the personal level, households at the family level, the community at the societal level, industries at the organizational level, and climate and environment (Dwivedi et al., 2022b) at the macro level. The topics such as Topic 3-Machine Learning for Healthcare, Topic 4-Big Data Analytics for Circular Economy and Sustainable Supply Chain, Topic 5-Adoption of AI by Consumers, and Topic 8-AI for Decision Making and Risk Management are showing a rising trend over the years. These scholarly hotspots may be explored more by potential researchers in the future.

Further, this study discovered that AI research contributes knowledge to multiple disciplines, such as Social Sciences, Engineering, Computer Science, and Mathematics, other than the main focus area, Business, Management, and Accounting. Moreover, AI research draws knowledge from various disciplines, enabling interdisciplinary knowledge exchange. The interdisciplinarity in knowledge exchange and key conceptual topics contribute to the profound impact on the theoretical advancement and practical accomplishment of AI-based systems for human amelioration and social betterment.

CRediT authorship contribution statement

Yogesh K Dwivedi: Conceptualization, Methodology, Modeling, Writing- Original Draft Preparation, Reviewing, and Editing. **Anuj Sharma:** Conceptualization, Methodology, Modeling, Writing- Original Draft Preparation, Reviewing, and Editing. **Nripendra P. Rana:** Conceptualization, Methodology, Modeling, Writing- Original Draft Preparation, Reviewing, and Editing. **Abdullah B. Abdullah:** Conceptualization, Methodology, Modeling, Writing- Reviewing and Editing.

Pooja Goel: Conceptualization, Methodology, Writing- Reviewing and Editing. **Mihalis Giannakis:** Conceptualization, Methodology, Writing-Reviewing and Editing, Supervision.

Data availability

No data was used for the research described in the article.

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