Journal of Open Innovation: Technology, Market,and Complexity 12 (2026) 100907

Contents lists available at ScienceDirect

Journal of Open Innovation: Technology, Market, and Complexity

journal homepage: www.sciencedirect.com/journal/joitmc

Decoding the factors shaping the transformation from industry 4.0 technologies to industry 5.0 banking supply chains and mapping their logistics and supply chain 5.0 innovativeness strategy

Heba Mohamed Adel*[,1,2,3], Eman Hassan Rajab, Muhammad Salah Nafea

Faculty of Management Sciences, October University for Modern Sciences and Arts (MSA), Cairo, Egypt

ARTICLE INFO

Keywords:
Industry 4.0 technologies
Industry 5.0 supply chains
Supply chain innovativeness
Sustainable Society 5.0
Logistics 5.0
Supply chain 5.0 strategy map
Banking 5.0

ABSTRACT

This article aims to decode the factors that affect the intention to transform from industry 4.0 technologies to industry 5.0 supply chains. It investigates the direct and mediating relationships between logistics and supply chain innovativeness (LSCI), perceived ease of operational use of industry 5.0 technologies (PEOU), perceived usefulness of industry 5.0 technologies (PU), and intention to transform to industry 5.0 supply chains (supply chains 5.0) (TII5SC). Conceptually, this interdisciplinary research integrates the fragmented literature themes on industry 4.0 and 5.0 technologies, logistics 4.0 and 5.0, supply chain management 4.0 and 5.0, supply chain innovativeness and the application of TAM through using a bibliometric thematic analysis. Empirically, a research model was proposed and examined quantitatively in the under-researched yet evolving context of banking 5.0 supply chains via using data gathered from 125 questionnaires, which were filled by banking supply chain professionals working in 30 public and international banks in Egypt. Quantitative findings revealed that LSCI, PEOU and PU of industry 5.0 technologies affected positively TII5SC with R^2 value of 36.8% and statistically significant p-values. From a mixed-methods research perspective, qualitative interviews were held to help in analysing the benefits and challenges of the Egyptian banking supply chains' transformation to banking 5.0, and then proposing a sustainable banking logistics and supply chain 5.0 strategy map. Consequently, Egyptian banks are recommended to use industry 5.0 technologies and enhance logistics and supply chain innovativeness to facilitate their transformation to banking supply chains 5.0 and the attainment of society 5.0 sustainable development goals.

1. Introduction

The current digital transformation literature, accompanied by the industrial revolution in the field of production, operations and supply chain management, encompasses interdisciplinary research in which each study focuses on one or more of the following interdependent themes:

(1) industry 4.0 and 5.0 technologies (Agrawal et al., 2024; Martell-Chávez et al., 2026; Zizic et al., 2022), (2) supply chain management 4.0 and 5.0 (Alamsjah and Yunus, 2022; Frederico, 2021; Yuan and Xue, 2023), (3) logistics 4.0 and 5.0 (Fox et al., 2025), and (4) society 4.0 and 5.0 linked to the 17 sustainable development goals (SDGs) of the United Nations (Mourtzis et al., 2022). The industry 5.0 phase of this vivid technological evolution builds upon the pillars of industry 4.0, adding three crucial building blocks: resilience, human-technology collaboration, and sustainability (Andres et al., 2024; Mourtzis et al., 2022). This industrial evolutionary leap has been reflected in the development of the logistics and supply chain management field too, which caused its transition from logistics and supply chain 4.0 to logistics and supply chain 5.0 (Andres et al., 2024; Frederico, 2021; Jefroy et al., 2022; Minculete et al., 2021; Mourtzis et al., 2022). Researchers and practitioners in this field are now called upon to harmonise between the human and technological factors within their research, industries, and across their supply chains. Doing so will boost

* Corresponding author.
E-mail addresses: hadel@msa.edu.eg (H.M. Adel), ehmohamed@msa.edu.eg (E.H. Rajab), mnafea@msa.edu.eg (M.S. Nafea).
[1] Web of Science ResearcherID: E-1129-2019
[2] Scopus Author ID: 36098956100
[3] https://scholar.google.com/citations?hl=en&user=zvs8T1YAAAAJ

https://doi.org/10.1016/j.joitmc.2026.100907
Received 10 March 2026; Received in revised form 3 November 2026; Accepted 4 November 2026
Available online 10 November 2026
2199-8531/© 2026 The Author(s). Published by Elsevier Ltd on behalf of Prof JinHyo Joseph Yun. This is an open access article under the CC BY-NC-ND license (http://creativecommons.org/licenses/by-nc-nd/4.0/).

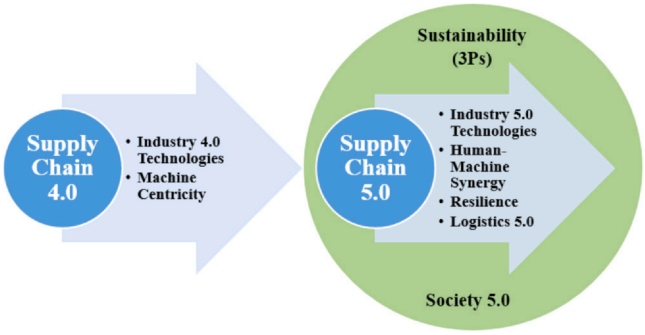


Fig. 1. The Transformation from Supply Chain 4.0 toward Supply Chain 5.0 (Industry 5.0 Supply Chains).
Source: Authors' own work

human-machine synergy and support socially-responsible, environmentally-friendly sustainable development (Jefroy et al., 2022). This harmony can be established through the transformation to industry 5.0 supply chains (Abdallah et al., 2023; Jefroy et al., 2022). Fig. 1 describes the characteristics of industry 5.0-oriented supply chains, which are driven by human-technological collaboration and characterised by a bio-technological, sustainable evolution within organisations and across their supply chain stakeholders (Boudouaia et al., 2024; Frederico, 2021; Mourtzis et al., 2022; Zizic et al., 2022). Furthermore, the implementation of manufacturing 5.0 across digitally transformed supply chains 5.0 within different industries will lead to a sustainable smart society 5.0 (Mourtzis et al., 2022).

The benefits of the transition to supply chains 5.0 involve various improvements across intra-organisational functions and inter-supply chain nodes and stakeholders, including the environment and society at large. For example, transforming to industry 5.0 supply chain management (I5SCM) involves waste management 5.0 (Nayeri et al., 2025) and human-centric innovation powered by industry 4.0/5.0 technologies such as artificial intelligence, blockchain, and the internet of things (Boudouaia et al., 2024; Yuan et al., 2022). Additionally, it leads to a leagile supply chain performance that balances efficiency with speed, flexibility and responsiveness (Adel, 2020; Adel and Allam, 2014; Nazarian and Khan, 2024). Moreover, it embraces logistics 5.0 operations with clean transportation and smart warehouse management (Hsu et al., 2024; Ismail et al., 2024; Szeredi et al., 2024), supply chain collaborative e-forecasting (Abushaikha et al., 2026), mass-customisation using mixed reality (Adel and Younis, 2019), and better visibility and real-time information sharing among supply chain stakeholders (Ghag et al., 2025). Ultimately, these benefits contribute to the transition to society 5.0 through sustainable social, biological, and technological development (Frederico, 2021; Mourtzis et al., 2022). However, this industrial evolutionary leap emerged with a number of limitations and challenges (Emon and Khan, 2025). The challenges of the transition to supply chains 5.0 were highlighted in the literature of developed countries, as well as that of the Egyptian emerging market (Adel et al., 2024; Adel and Younis, 2023; Younis and Adel, 2020; Zekhnini et al., 2024). For example, these obstacles involve the implementation costs of advanced supply chain management systems, cultural resistance to change across supply chain stakeholders, and operational, technical and staffing problems. To overcome these challenges, global and Egyptian organisations need innovation-oriented strategies and innovative logistics and supply chain management practices. Formulating these at both the supply chain and functional levels will effectively and efficiently support their digital transformation initiatives (Emon and Khan, 2025). Therefore, this research investigates the innovation-driven transition to industry 5.0 supply chains within the under-investigated yet growing Egyptian market.

This transition to industry 5.0 supply chains, along with its benefits and challenges, is currently being discussed in the literature (Agrawal et al., 2024; Frederico, 2021), with researchers calling for *empirical studies* to bridge this prominent research gap. Despite existing fragmented studies pointing out the importance of the transformation to supply chain management 5.0 within different industries, the literature to date (Castillo et al., 2025) still calls for empirical rather than conceptual research to investigate *from a supply chain perspective* this dynamic research area and address this manifest gap. Additionally, another research gap identified in the literature (Chen et al., 2026) is that the technology adoption and technology acceptance model (TAM) studies *focus solely on individual perceptions rather than the supply chain innovation capabilities*, which enable organisations to adopt novel technologies. *Hence, this interdisciplinary study integrates the TAM with supply chain innovation capabilities to investigate their effect on the intention to transform to industry 5.0 supply chains*. This means that innovativeness is studied in this research as a supply chain strategic capability that enables the transformation intention toward industry 5.0 supply chains. To bridge this literature gap, this empirical paper addresses the following research question: Do logistics and supply chain innovativeness (LSCI), perceived ease of operational use (PEOU), and perceived usefulness of industry 5.0 technologies (PU) affect the transformation intention toward industry 5.0 supply chains (TII5SC) positively and significantly in the under-researched context of banking 5.0?

In the context of banking 5.0 supply chains, Nicoletti (2021) and Mehdiabadi et al. (2022) pointed out that industry 5.0 pillars – including human-technology collaboration and innovative SCM practices – must be applied to the banking sector; otherwise it risks vanishing without the continuous support of cutting-edge technologies and innovation. Accordingly, this vital yet under-researched context of banking 5.0 is in need of empirical investigation concerning the beneficial transformation to industry 5.0 supply chains. Hence, the historically significant and growing Egyptian banking industry was chosen for this research. This sector actively contributes to building a sustainable digital economy in Egypt through investments in industry 4.0 financial technologies (FinTech) alongside the continuous development of its banking supply chain innovation strategy (Adel and Younis, 2023; Central Bank of Egypt, 2023; Rajab et al., 2025).

2. Literature review and hypotheses development

2.1. The research gap and bibliometric thematic analysis

The authors followed established literature (e.g., Fares et al., 2026; Mouazen et al., 2025) regarding the methodological steps to conduct the bibliometric thematic analysis. The authors began the comprehensive literature review by searching the Web of Science (WoS) Core Collection website for articles and reviews that are published in English language during the past 10 years up to 2025. It was searched specifically on January 2026 for English-language articles and reviews published up to December 2025. The authors considered the principal indexes relevant to the interdisciplinary scope of this study, particularly the Science Citation Index Expanded (SCIE), Social Sciences Citation Index (SSCI), and Emerging Sources Citation Index (ESCI). The SCIE captured the technological dimensions of Industry 4.0/5.0, including innovativeness, digitalisation, and automation, while the SSCI captured the behavioral and organisational dimensions of the TAM. Moreover, ESCI was included for the sake of providing broader coverage of the emerging Industry 5.0 literature. The search was conducted using the Boolean query ("Industry 4.0 technologies" OR "Supply chain 5.0" OR "Logistics 5.0") AND ("Society 5.0" OR "Banking 5.0") AND ("Supply chain innovation" OR "innovativeness" OR "Technology adoption"), which generated and yielded 2303 records. Then, records were screened for relevance, and duplicates were checked and removed based on DOI and bibliographic matching. The resulting dataset was analysed using the bibliometric visualisation software VOSviewer version 1.6.20. The previously mentioned keywords were standardised by consolidating synonymous terms, spelling variations, and abbreviations. Keyword co-occurrence was examined using full counting, with a

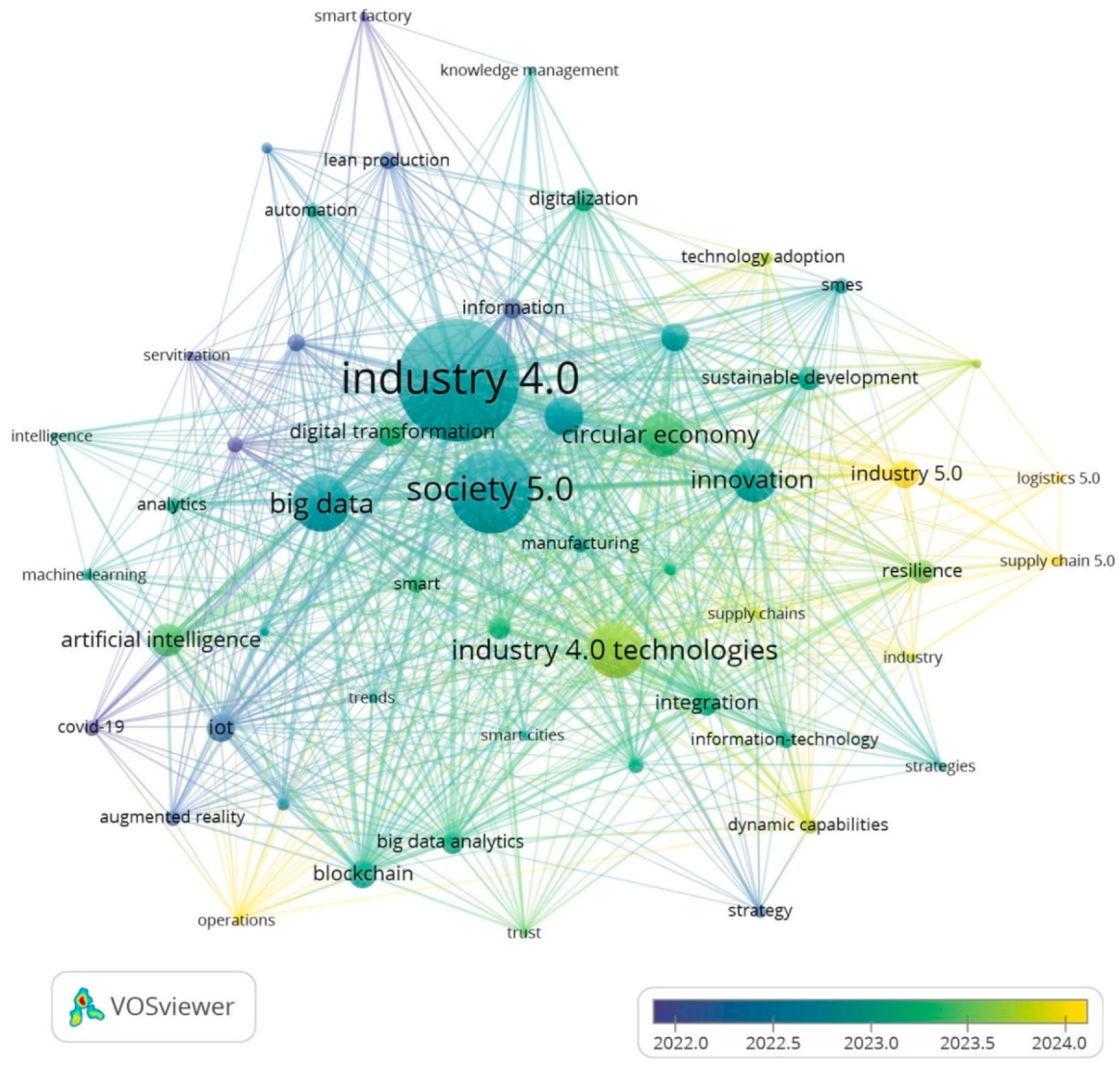


Fig. 2. VOSviewer literature review co-occurrence network map, developed by the VOSviewer version 1.6.20.
Source: Authors' own work

minimum occurrence threshold of five occurrences, for the sake of identifying the dominant thematic relationships and their evolution within the dynamic research area of logistics and supply chain management. Hence, based on the co-appearance of keywords within the retrieved articles from the WoS platform, a network map was created for the sake of revealing the proximity and interrelatedness of key concepts among relevant studies. As illustrated in Fig. 2, the evolution of this dynamic industry 5.0 research area has initially emerged in 2020 but began to gain momentum after the year 2023. This generated map consolidates fragmented research topics into interconnected research patterns and trends. As shown in Fig. 2, there are thematic clusters centered on industry 4.0 revolution and the digital transformation technologies (e.g., artificial intelligence, the internet of things (IoT), blockchain, and big data analytics). Thereafter, emerging research clusters are currently directing toward industry 5.0 phase including sustainability, resilience, supply chain innovation, and human-machine collaboration to describe the emerging research area of sustainable logistics and supply chain 5.0. Accordingly, this visualisation highlights these manifest thematic clusters, building insights into the transition of industry 4.0 to industry 5.0 research trends. It also underscores the central role of supply chain technologies and innovation in shifting toward supply chain 5.0, logistics 5.0, and society 5.0.

Building on the outcomes of Fig. 2, and to provide a closer analysis of the evolution of this dynamic industry 5.0 research area — which



Fig. 3. This word cloud illustrates the keywords frequency of the current literature and was created using WordArt.com (2026).
Source: Authors' own work

gained momentum from 2023 to 2026 – the authors developed a word cloud (as shown in Fig. 3). Using the WordArt tool (WordArt.com, 2026) the authors illustrated the keywords frequency along with their comparative weight in the industry 4.0 and 5.0 relevant literature. As depicted in Fig. 3, the largest research constructs (e.g., industry 4.0, logistics 4.0, and supply chain 4.0) indicates the most main published

research themes in the relevant literature. Yet, at the same time, it points out their apparent evolution, transition, and transformation toward industry 5.0, logistics 5.0 and supply chain 5.0 research areas. Additionally, these emergent research themes started in the recent studies to be linked to the sustainability concepts of SDGs, society 5.0, supply chain resilience, supply chain innovation, and human-machine collaboration together with the TAM factors.

As clearly evident from these VOSviewer co-occurrence network and the Word cloud diagram, in addition to the following relevant literature review section, despite having this well-structured knowledge base on industry 4.0 revolution, the publication work on industry 5.0-oriented supply chain transformation remains limited and conceptual. Accordingly, the authors' analysis of this dynamic body of knowledge calls for further empirical research on the industry 5.0 transformation particularly from a supply chain and logistics perspective.

2.2. Logistics and supply chain innovativeness and transformation intention toward industry 5.0 supply chains (supply chains 5.0)

Innovativeness was conceptualised and studied in the literature from different perspectives and levels in terms of an individual, organisation or at a supply chain level. Innovativeness is defined as an individual or organisation's overall openness, capacity and capability to introduce, promote and embrace new ideas, technologies and processes (Calantone et al., 2002; Hult et al., 2004). Supply chain innovativeness as a construct is rooted in the innovation concept from a supply chain perspective. A number of studies, which are of similar research direction to the current article yet of different context and model, demonstrated that an innovative individual, organisation or a supply chain is more likely to proactively pursue such digital transformation initiatives and adopt emerging technologies (Li et al., 2024). For example, Shahadat et al. (2024) studied the innovativeness as a dynamic capability from a supply chain stance and revealed that it is the supply chain capability that fosters the acceptance of new ideas, supports the upgrading of technologies, and embodies the transformation towards creative processes. In relation to the TAM but from a consumer perspective in the context of sports apps, Kim and Kang (2023) examined the incorporation of innovativeness factor into the technology acceptance model and they reported the positive impact of innovativeness on the acceptance and usage of new technologies. From a supply chain perspective, Shahzad et al. (2023) concluded that the higher the level of innovativeness, the more the willingness of the supply chain professionals to accept new technologies (e.g., blockchain technology) and the higher their continued intention to adopt/use it within their supply chain operations in China. In the context of industry 4.0 technologies, Emon and Khan (2025) studied the relationship between industry 4.0 transformation/adoption and supply chain innovative practices and reported that innovativeness fosters a culture of continuous improvement across the whole supply chain, which may involve the adoption of cutting-edge technologies, development of novel logistics strategies, and designing new supply chain management processes. Zhen and Yao (2025) and Rame et al. (2024) discussed that industry 5.0 technologies together with a well-established innovation culture can stimulate the formulation of contemporary supply chain management strategies, which are characterised by being resilient and sustainable and are shaped by the concerted collaboration of humans and machines. *This deepened focus on innovation is seen as a crucial stimulator for those supply chains that are aiming to adopt new paradigms of the latest industrial revolution, which was coined as Industry 5.0* (Martins et al., 2025; Rame et al., 2024). Drawing on the philosophy of industry 5.0, the concept of banking 5.0 supply chain was inspired by the principles of industry 5.0 revolution from logistics and supply chain management perspective (Nicoletti, 2021; Mehdiabadi et al., 2022), which makes it an attractive context that still lacks empirical research in the digitally transformed logistics literature.

In summary, innovativeness as a supply chain strategic capability can be directly influencing and enabling the transformation toward emerging technologies. *However, there is an obvious lack of conceptual and empirical research investigating the relationship between innovativeness from a logistics and supply chain perspective and the transformation intention toward industry 5.0 supply chains (supply chains 5.0)*. Therefore, to bridge this manifest knowledge gap — particularly in the context of banking 5.0 – and to respond to literature calls for empirical research on this evolving research area, the authors hypothesised that the higher a supply chain's level of innovativeness, the greater its intention to transform to industry 5.0 supply chains.

H1. LSCI impacts TII5SC positively and significantly

2.3. Perceived ease of operational use of industry 5.0 technologies, perceived usefulness, and intention to transform to industry 5.0 supply chains (supply chains 5.0)

Using industry 5.0 technologies is currently revolutionising the logistics and supply chain management field, which incentivise researchers to conduct their future empirical studies on testing various relationships related to the in-depth investigation of this evolving research area (Zhen and Yao, 2025). *Drawing on a well-established technology acceptance model (TAM) and from a logistics and supply chain management perspective*, this research paper studies the direct and mediating relationships between the perceived ease of operational use of industry 5.0 technologies (PEOU), perceived usefulness of industry 5.0 technologies (PU), and the intention to transform to industry 5.0 supply chains (TII5SC). These proposed hypotheses along with their related constructs were developed building on a number of prior studies that conceptualised and operationalised these variables and tested the relationships among them but from different perspectives and within other research contexts. In regard to the perceived ease of use (PEU), it is a core variable in the TAM that was coined by Davis (1989) as the extent to which utilising a particular technology is perceived to be requiring a very limited exerted effort. Building on this model, the recent organisational and operations management studies conceptualised the PEU in operational terms as the perceived ease of operational use of a particular new system or technology. For example, Al-Rahmi et al. (2019) articulated the meaning of PEOU as the extent to which a new technology or system is flexible, less difficult to learn and simple to use while performing its intended operations. Afterwards, Al-Rahmi et al. (2019) reported that the perceived ease of operational implementation of a contemporary technology is a crucial factor that estimates the intention towards adopting that new technology/system within an organisation. From a supply chain perspective, Lin and Lin (2014) examined the TAM within the logistics industry driven by the importance of analysing the factors affecting the acceptance of cutting-edge technologies in the logistics and supply chain management field for the purpose of streamlining the supply chain operations and achieving sustainable competitive advantage across the whole supply chain network. Consequently, Lin and Lin (2014) concluded that if a new supply chain technology or system is perceived to be encompassing a simplicity in its operations that makes it easier and more convenient to be used within organisations, this increases the probability of this new supply chain technology acceptance within the Taiwanese logistics industry. By introducing the acceptance of industry 4 technologies to the TAM within agricultural supply chains, Jain et al. (2023) discussed that the transformation of the agricultural supply chains depends on the incorporation of industry 4.0 technologies within their supply chain operations; thus, making them more productive, resilient, and sustainable. Furthermore, Jain et al. (2023) explained that supply chain stakeholders are more encouraged to accept and adopt a novel supply chain technology when they perceive it to be simple to operate with minimised effort and without supply chain disruptions.

Despite having a well-established literature that examines the impact of TAM factors on the acceptance of different types of information technology, till now there is a clear lack of empirical research investigating the relationship between the perceived ease of operational use of industry 5.0

technologies from a logistics and supply chain perspective and the transformation intention toward banking 5.0 supply chains. As a result, in the context of logistics and supply chain management, the PEOU-TII5SC relationship in this article assumes that the easier industry 5.0 technologies are perceived to be used in banking logistics and supply chain management practices, the more likely banks are to accept digital transformation initiatives toward supply chains 5.0. Accordingly, to fill in this gap in the body of literature, the following hypothesis was proposed:

H2. PEOU impacts TII5SC positively and significantly

As for the PEOU-PU-TII5SC relationships, the authors investigated them from a logistics and supply chain perspective following a limited number of management studies in the literature, which embedded the TAM in their research models but within different research contexts apart from the banking 5.0 sector and they examined the acceptance of different types of technology other the industry 5.0 supply chains. Al-Rahmi et al. (2019) viewed the perceived usefulness of using a new technology as the extent to which an organisation believes that using this new technology in performing particular operations will generate valuable outcomes in terms of maximising the operational effectiveness and efficiency, individual/organisational productivity, and the business performance. After testing the relationships between PEOU, PU, and the intention to transform to a new technology, Al-Rahmi et al. (2019) concluded that the higher the extent to which a new technology is perceived to be flexible, less difficult to learn and simple to use in performing particular operations within an organisation, the higher the valuable outcomes that are perceived to be generated in association with using this new technology in performing these operations, and in turn the greater the intention towards adopting this new technology within the organisation. From a logistics and supply chain perspective, Lin and Lin (2014) and Jain et al. (2023) reported that organisations and their supply chain stakeholders are more motivated to accept and adopt a novel supply chain technology when they perceive it to be simple to operate with minimised effort, and when they believe that learning and using easily that new supply chain technology in performing smart logistics operations and supply chain management practices will be reflected on enhancing the overall supply chain performance in terms of leanness and agility.

Despite the limited number of studies investigating TAM from a logistics and supply chain perspective, a manifest gap remains in the empirical literature. Specifically, current research fails to test the relationships between the perceived ease of operational use, perceived usefulness of industry 5.0 technologies, and the transformation intention toward banking 5.0 supply chains. Accordingly, in the context of logistics and supply chain management, this empirical study assumes that the greater the extent to which industry 5.0 technologies are perceived to be easy to use and highly beneficial to banking logistics and supply chain performance, the more likely they are to positively and significantly affect banks' inclination to accept digital transformation initiatives toward supply chains 5.0. Accordingly, to bridge this empirical research gap in the logistics and supply chain 5.0 literature, the following hypotheses were developed:

H3. PEOU impacts PU positively and significantly

H4. PU impacts TII5SC positively and significantly

H5. PU mediates significantly the PEOU-TII5SC relationship

3. Research methodology

This interdisciplinary research investigated the factors influencing the intention to shift from industry 4.0 technologies to industry 5.0 supply chains. For this purpose, this study began by reviewing and synthesising the fragmented literature across several core themes and clusters — including technology adoption, industry 4.0/5.0 technologies, logistics 4.0/5.0, supply chain 4.0/5.0, and supply chain innovativeness — within the under-researched context of banking 5.0 supply chains. Afterwards, the current article undertook a bibliometric thematic approach to contribute to addressing this research gap. It then conceptually and empirically studies the direct and mediating relationships between logistics and supply chain innovativeness (LSCI), perceived ease of operational use (PEOU), perceived usefulness of industry 5.0 technologies (PU), and the intention to transform to industry 5.0 supply chains (supply chain 5.0) (TII5SC). To achieve this, a graphical research model was constructed (as depicted in Fig. 5) along with the illustrated hypotheses, which were examined quantitatively using data gathered from 125 questionnaires completed by banking supply chain experts working in 30 public and international banks in Egypt. Inspired by the literature (e.g., Sahab and Oulfarsi, 2026), Fig. 4 depicts the methodological steps followed by the authors to clarify how the mixed methods approach was adopted in this research.



Fig. 4. The methodological steps adopted in this research.
Source: Authors' own work

For the purpose of the operationalisation of the research constructs, the measurement scales were extracted from established literature and afterwards were adapted based on qualitative interviews, which were

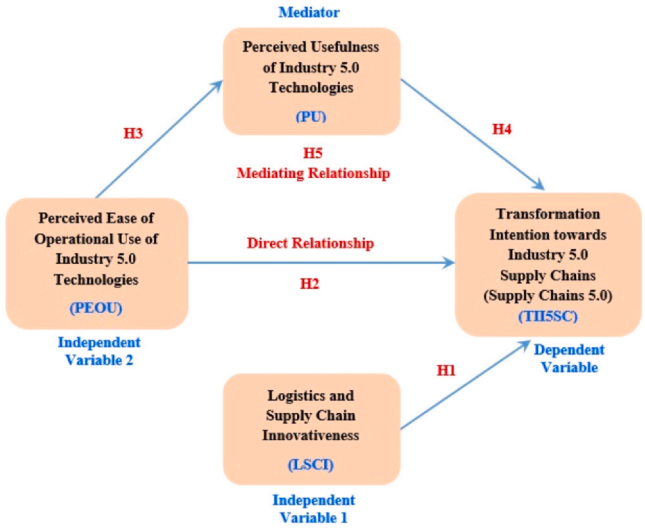


Fig. 5. Graphical Research Model.
Source: Authors' own work

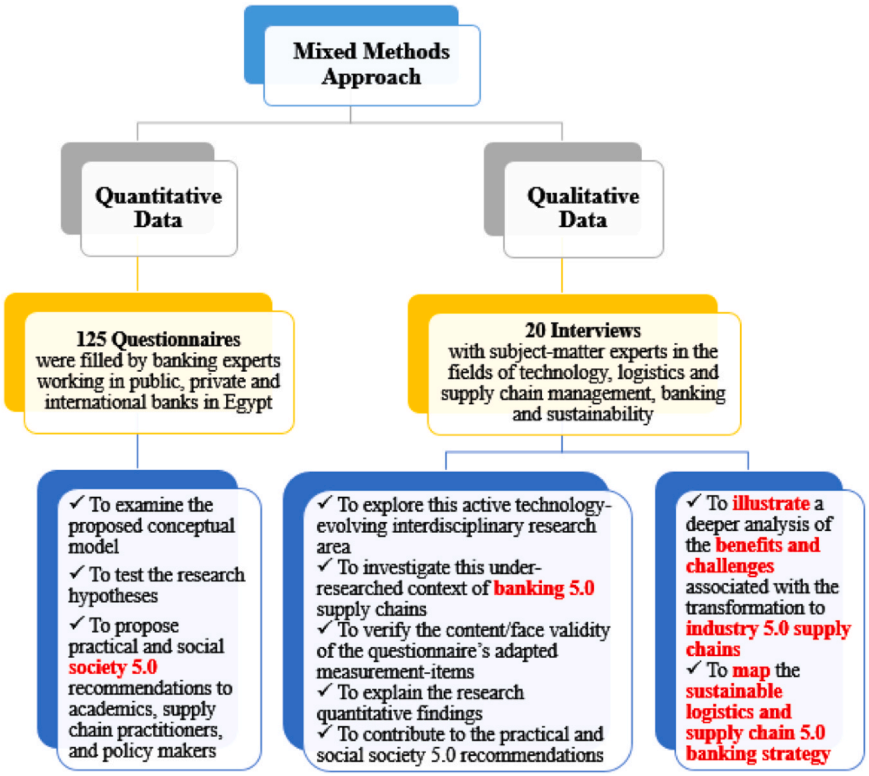


Fig. 6. The mixed-methods approach (techniques and outcomes) adopted in this research.
Source: Authors' own work

carried out by the authors with the relevant subject-matter experts in order to establish and verify the content and face validity (as advocated by Hair et al., 2019a; Nagy and Adel, 2026) of the adapted scale for each factor in the developed questionnaire (as listed in Appendix – Table AI). The two independent variables, logistics and supply chain innovativeness (LSCI) and perceived ease of operational use of industry 5.0 technologies (PEOU), were evaluated through using the adapted measurement items from Agarwal and Prasad (1998) and Kucukusta et al. (2015). In addition, both the mediating (perceived usefulness of industry 5.0 technologies (PU)) and dependent (intention to transform to industry 5.0 supply chains (TII5SC)) variables were operationalised in terms of the adapted survey of Kucukusta et al. (2015).

Subsequently, snowball sampling was implemented to select respondents, as recommended by Giagnocavo et al. (2025) and Schindler (2022), due to the hidden nature of the population, as there is no formal published list of banks in Egypt using industry 4.0 technologies. Initial respondents/banks were selected according to their published materials on their websites revealing the types of technologies that they are currently using across their supply chains. Consequently, these initially selected respondents were asked to recommend other potential banks to participate in the current research according to clear criteria clarified by the authors to the initial respondents. The authors reached a sample of 125 respondents from the banking and supply chain experts, who are working in 30 public and international banks in Egypt. The number of participants obtained (i.e., 125 respondents) exceeds the minimum sample size suggested in the literature. Following the 10-times rule of Hair et al. (2019a), the current sample size of 125 exceed the 40 respondents (i.e., as recommended by the 10-times rule $10 \times 4 = 40$, where 4 is the largest number of measurement-items of a construct in this research model). Additionally, following a number of management studies in the literature (e.g., El-Sharkawy et al., 2023), the G*Power software version 3.1.9.4 was used to calculate the minimum sample size for this research and the software advocated a minimum sample of 74. Similarly, according to Green (1991), the minimum sample size should be $\geq 50 + 8\,m$, where m is the number of independent variables (i.e., the minimum sample size recommended for this research is $50 + 8 \times 3 = 74$).

Aligned with a mixed-methods approach and its reported importance in the supply chain management literature (e.g., Bag et al., 2025; Creswell and Creswell, 2023; Schindler, 2022), *qualitative interviews* were also carried out for this study with subject-matter experts in the fields of technology and logistics and supply chain management in order to benefit from the following profound research outcomes (as shown in Fig. 6). *First*, through the exploratory lens of qualitative interviews, the current study: (a) explored this active technology-evolving interdisciplinary research area of industry 5.0 logistics and supply chains, (b) investigated this under-researched context of transforming banking 5.0 supply chains in a historically significant and growing Egyptian banking industry, and then (c) verified the content and face validity of the questionnaire's adapted measurement-items. *Second*, through the explanatory lens of qualitative interviews, this article explained the research statistical findings and then proposed practical recommendations to academics, supply chain practitioners, and policy makers. *Third*, as a graphical contribution of this research, the authors built on the qualitative interviews to analyse the benefits and challenges of the transformation to industry 5.0 supply chains and then suggested a sustainable logistics and supply chain 5.0 banking strategy framework. Following the saturation principle in qualitative data collection that was discussed in the literature (Creswell and Creswell, 2023), the authors stopped after conducting 20 interviews as no new insights were found to be deduced from additional interviews. Regarding the thematic analysis approach adopted in this research, the authors followed the steps of the thematic analysis advocated by Braun and Clarke (2006) while conducting the qualitative data collection process as follows. All the responses extracted from the in depth qualitative interviews were transcribed both in English and Arabic languages and the authors ensured that the Arabic transcripts were carefully translated into English language. Subsequently, they were

Table 1
Summary of the sample characteristics.

		Frequency	Percentage
Gender	Male	70	56%
	Female	55	44%
Years of Experience	< 1 year	3	2.4%
	1 – less than 3 years	16	12.8%
	3 – less than 5 years	30	24%
	5 – less than 7 years	22	17.6%
	7 – less than 10 years	18	14.4%
	> 10 years	36	28.8%
Educational Level	Bachelor's Degree	71	56.8%
	Master's Degree	28	22.4%
	Doctoral Degree	8	6.4%
	Professional Diploma	18	14.4%
Age	< 30 years	43	34.4%
	30 – less than 40 years	52	41.6%
	40 – less than 50 years	23	18.4%
	> 50 years	7	5.6%
Type of the Bank	Public	40	32%
	International	85	68%
Total		125	100%

reviewed in order to achieve data familiarisation and generate data coding. Afterwards, the formulated codes were transformed into a number of relevant interdependent themes (i.e., TAM, industry 4.0 and 5.0 technologies, logistics 4.0 and 5.0, supply chain 4.0 and 5.0, supply chain innovativeness, sustainable society 4.0 and 5.0, and banking 5.0 supply chains), which are aligned with the investigated research purpose and model.

4. Data analysis and results

The current research has employed for data analysis the partial least squares (PLS) structural equation modelling (SEM), which is a commonly chosen statistical technique in the literature especially in similar supply chain management studies (Abushaikha et al., 2026; Adel, 2015; Hair et al., 2019a, 2019b; Osman et al., 2025; Sarstedt et al., 2023), as it produces reliable results when examining direct and mediating relationships even with relatively small-sized samples. In general, and specifically for this research, the PLS-SEM is a suitable method for studies that investigate emerging technologies especially when being conducted in developing markets, which are characterised by a population size that is not large enough to obtain a larger sample. For this study, the authors reached a sample of 125 respondents from the banking supply chain professionals, who are working in 30 public and international banks in Egypt. Table 1 shows the summary of the sample demographics.

The two-phases PLS-SEM method was executed via the SmartPLS-v4, following Hair et al. (2019a, 2019b) and Sarstedt et al. (2024), for the purpose of: (1) assessing the measurement model through using the confirmatory composite analysis (CCA), and (2) evaluating the structural model through investigating the direct/mediating relationships between LSCI, PEOU, PU and TII5SC. As disclosed in Table 2, the variance inflation factors (VIFs) were calculated and generated values that are: (1) less than the cut-off value of 3.3, which indicate the absence of common method bias (CMB) (Kock, 2015; Le et al., 2025), and (2) less than the cut-off value of 3, which ensure the absence of multicollinearity issue as well (Hair et al., 2019a, 2019b; Le et al., 2025).

Table 2
The results of variance inflation factor (VIF).

Independent variable	Dependent variable			
	TII5SC	LSCI	PEOU	PU
TII5SC	-	1.194	1.437	1.565
LSCI	1.194	-	1.241	1.145
PEOU	1.437	1.125	-	1.236
PU	1.565	1.256	1.451	-

Table 3
Validity and reliability of the research constructs and their measurement items.

Measurement Items' Reliability				
Measurement Item	TII5SC	LSCI	PEOU	PU
$TII5SC_1$	0.897			
$TII5SC_2$	0.920			
$TII5SC_3$	0.935			
$LSCI_1$		0.949		
$LSCI_2$		0.769		
$LSCI_3$		0.753		
$PEOU_1$			0.878	
$PEOU_2$			0.899	
$PEOU_3$			0.945	
$PEOU_4$			0.933	
PU_1				0.866
PU_2				0.937
PU_3				0.909
PU_4				0.876
Constructs' Validity and Reliability				
	TII5SC	LSCI	PEOU	PU
Construct Reliability				
Cronbach's Alpha	0.906	0.812	0.934	0.919
Composite Reliability (CR)	0.941	0.866	0.953	0.943
Construct Validity				
Convergent Validity (AVE)	0.842	0.686	0.836	0.806
Discriminant Validity				
HTMT Ratio of Correlations	TII5SC	LSCI	PEOU	PU
TII5SC				
LSCI	0.203			
PEOU	0.571	0.326		
PU	0.582	0.434	0.587	
Fornell-Larcker Criterion	TI5SC	LSC5I	PEOU	PU
TII5SC	0.917			
LSCI	0.184	0.828		
PEOU	0.527	0.284	0.914	
PU	0.536	0.394	0.546	0.898

Regarding the descriptive statistics for each variable, the mean values of the measurement items for: (a) LSCI ranged from 3.94 to 4.31, (b) PEOU ranged from 3.83 to 4.09, (c) PU ranged from 4.09 to 4.26, and (d) TII5SC ranged from 3.97 to 4.10. As demonstrated in Table AI, a 5-point Likert scale was used to assess each variable in the distributed questionnaire (where 1 = strongly disagree and 5 = strongly agree).

Moving to the CCA, as exhibited in Table 3, both the reliability and validity of each variable/factor and its corresponding measurement items were checked and confirmed following the criteria advocated by Hair et al. (2019a, 2019b). The reliability checks were conducted at both the item and variable levels. At the measurement item's level, the reliability was verified as evident in Table 3 that the minimum value for each item, which is 0.753, exceeds the 0.708 (Hair et al., 2019a, 2019b). Similarly, the reliability of each proposed variable was proven as the minimum value of both the Cronbach's Alpha in addition to the Composite Reliability (CR) are 0.812 and 0.866, which are higher than 0.7 (Hair et al., 2019a, 2019b). *Four types of validity were evaluated and confirmed. First*, the content/face validity of the questionnaire's adapted measurement-items was supported via the qualitative interviews, which

Table 4
The path coefficients of the research hypotheses.

Hypothesis	Path	Beta	t-value	95% CI	P-Values	Decision
H1	LSCI → TII5SC	0.060	2.159	(0.010, 0.118)	0.031	Supported**
H2	PEOU → TII5SC	0.341	11.245	(0.281, 0.398)	0.000	Supported ***
H3	PEOU → PU	0.546	25.034	(0.501, 0.587)	0.000	Supported ***
H4	PU → TII5SC	0.373	11.458	(0.308, 0.436)	0.000	Supported ***
H5	PEOU → PU → TII5SC	0.204	9.774	(0.165, 0.246)	0.000	Supported *** Partial Mediation

Confidence Level 95 %, P-Value < 0.05 and * Confidence Level 99.9%, P-Value < 0.001, 95% Bias-Corrected Bootstrap Confidence Intervals.

were carried out by the authors with the relevant subject-matter experts as advocated by Hair et al. (2019a). *Second*, as for establishing the convergent validity, the average variance extracted (AVE) was measured for every variable yielding a minimum value of 0.686, which exceeds the threshold value of 0.5 as recommended by (Hair et al., 2019a). *Third*, concerning the assessment and verification of the discriminant validity, the values of Heterotrait-Monotrait ratio (HTMT), which are reported in Table 3, are significantly less than the predetermined threshold value of 0.85 by Henseler et al. (2015) and Sarstedt et al. (2023). Besides, after applying the Fornell-Larcker Criterion for further confirmation of the discriminant validity as supported by Henseler et al. (2015) and shown in Table 3, the authors found that every factor's √AVE generated a value that exceeds its correlation with other variables. *Fourth*, the nomological validity was proven after the empirical findings of this study were found to be supporting the theoretical relationships between the research constructs that were proposed by the authors based on the prior literature as advised by Hair et al. (2019a) and Lim (2024).

Thereafter, SmartPLS-v4 was used to assess the structural model (Hair et al., 2019b) through examining the direct/mediating relationships between LSCI, PEOU, PU and TII5SC. Bootstrapping with 10,000 subsamples was performed. The resulting t-values, p-values (as shown in Table 4), and 95% confidence intervals (2.5% – 97.5%) were used to assess the significance of the five hypothesised relationships based on a two-tailed test at $\alpha = 0.05$. Thus, the results reported in Table 4 point out that logistics and supply chain innovativeness (LSCI) has a significant positive effect on the intention to transform to industry 5.0 supply chains (supply chains 5.0) (TII5SC) by 6.0% (i.e., H1 is supported). In addition, the perceived ease of operational use of industry 5.0 technologies (PEOU) has a significant positive impact on both the intention to transform to industry 5.0 supply chains (TII5SC) by 34.1% and the perceived usefulness of industry 5.0 technologies (PU) by 54.6% (i.e., H2 and H3 are also supported). Moreover, the perceived usefulness of industry 5.0 technologies (PU) was found to have a significant positive influence on the intention to transform to industry 5.0 supply chains (TII5SC) by 37.3% (i.e., H4 is additionally supported). Finally, the indirect mediated effect of PEOU on the intention to TII5SC through the PU of industry 5.0 technologies was proven to be significant by 20.4%, which asserts the case of partial mediation and further supports H5. In addition, as reported in Table 4 based on a two-tailed test at the 5% significance level, all the t-values were found to be more than 1.96 in absolute value, which confirm a statistical significance (Hair et al., 2022). Overall, these results verify the pivotal roles of logistics and supply chain innovativeness along with the PEOU and PU of industry 5.0 technologies in shaping the intention towards the transformation from industry 4.0 technologies to industry 5.0 banking supply chains both directly and indirectly.

The results of robustness checks indicate that the structural model is statistically sound and practically relevant. The Standardized Root Mean Square Residual (SRMR) value is 0.056, which falls below the 0.08 threshold, thus suggesting an acceptable overall model fit. Moreover, the model explains 36.8% of the variance in the transformation intention towards industry 5.0 supply chains (TII5SC) because $R^2 = 0.368$, which is considered as a moderate effect and an acceptable finding in the social sciences and management field. Furthermore, PEOU has a large effect on PU as $f^2 = 0.426$, PU has a small effect on the transformation intention towards industry 5.0 supply chains as $f^2 = 0.141$, and PEOU has a small effect on TII5SC as $f^2 = 0.128$, which indicate that these variables are meaningful predictors (Cohen, 1988). Additionally, a Q^2 value of 0.21 indicates a medium predictive relevance, meaning that the model has an adequate out-of-sample predictive power for the key endogenous construct. Taken together, these metrics support the model's explanatory and predictive adequacy of this study.

5. Findings, discussion, and conclusions

This article decoded the factors that affect the intention to transform from industry 4.0 technologies to industry 5.0 supply chains. The aforementioned results, which were obtained from implementing the structural equation modeling technique via SmartPLS-v4, revealed the following findings and conclusions.

First, H_1 was statistically confirmed. This indicates that the innovativeness as a supply chain strategic capability is positively influencing and enabling the transformation towards emerging technologies. Hence, the authors concluded that the higher the level of innovativeness that a banking supply chain has, the greater the intention to transform to industry 5.0 banking supply chain. This finding is consistent with the results of a few studies with a similar research direction yet different context, methodology and model. For example, Chigbu and Makapela (2025) focused on the core pillars of human-machine collaboration and innovation to drive industry 5.0 transformation through their comprehensive review article, in which they called for empirical studies that link innovation to industry 5.0 transformation model. Shahadat et al. (2024) studied the innovativeness as a dynamic capability from a supply chain perspective, and they revealed that it is the supply chain capability that fosters the acceptance of new ideas, supports the upgrading of technologies, and embodies the transformation towards creative processes. In relation to the TAM, but from a consumer perspective and in the context of sports apps, Kim and Kang (2023) examined the incorporation of personal innovativeness factor into the technology acceptance model and they reported the positive impact of personal innovativeness on the acceptance and usage of new technologies. In contrary, Lowe and Alpert (2015) adopted the perspective of perceived product innovation rather than user or supply chain innovativeness, and they concluded that the consumer's perception of technology innovativeness alone may not significantly affect their willingness and intention to adopt this new technology. From a supply chain perspective, the findings of the current research builds on the work of Shahzad et al. (2023), who concluded that the higher the level of organisational innovativeness, the greater the willingness of the supply chain professionals to accept new technologies (e.g., blockchain technology), and the higher their continued intention to adopt and use them within their supply chain operations in China. This quantitative finding of H_1 was also supported by, and interpreted through, the qualitative interviews in this study. For example, an interviewed Supply Chain Managers in one of the banks in Egypt explained this finding by pinpointing that:

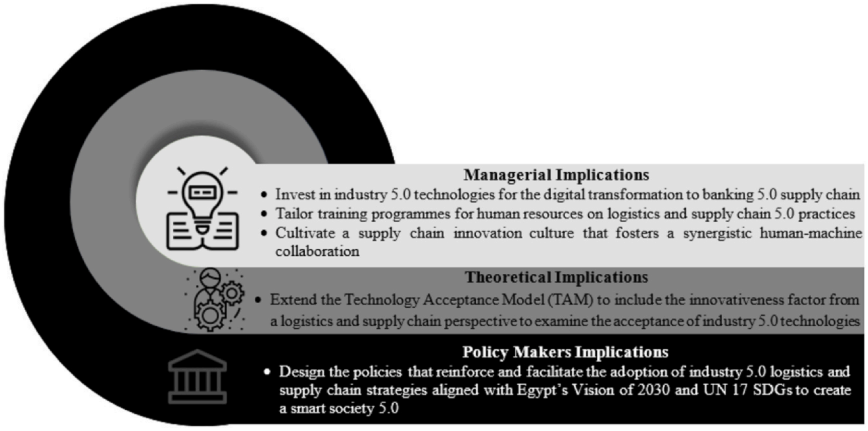


Fig. 7. The current research three-fold implications.
Source: Authors' own work

> "*At our bank, innovativeness is considered as a dynamic supply chain capability. It acts as a catalyst and motivator for our bank and our supply chain stakeholders to accept and try new technologies, supply chain processes and logistics strategies such as supply chain 5.0, which stems from the latest industrial 5.0 technological revolution*".

Second, H_2 was supported. From an operational, logistics and supply chain perspective, the perceived ease of operational use of industry 5.0 technologies was found to be influencing positively and significantly the intention to transform to industry 5.0 banking supply chains. This finding is aligned with, contributes to, and builds on the work of Lin and Lin (2014) and Jain et al. (2023), who proved that organisations and their supply chain stakeholders are more likely to accept and adopt a novel supply chain technology when they perceive it as simple to operate, requiring minimal effort, and free from supply chain disruptions. On the other hand, few articles in the literature (e.g., Aji et al., 2021; Esen and Erdoğmuş, 2014; Kumar et al., 2020) reported an insignificant relationship between the perceived ease of use and the intention to use technologies other than industry 5.0. The quantitative finding of H_2 was also supported and explained by the qualitative interviews that were conducted for explanatory purposes in this research. For instance, an interviewed Supply Chain Managers in one of the Egyptian banks revealed that:

> "*If our bank perceives a new technology or advanced supply chain management system as simple and easy to use, learn and adopt for the purpose of carrying out logistics operations and supply chain management tasks, it is more likely to be accepted by our bank's internal and external stakeholders*".

Third, H_3 and H_4 were established. This confirms that the perceived ease of operational use of industry 5.0 technologies significantly and positively impacted their perceived usefulness, which in turn significantly and positively influenced the transformation intention toward industry 5.0 banking supply chains. Furthermore, the perceived usefulness of industry 5.0 technologies significantly mediated the relationship between the perceived ease of operational use of industry 5.0 technologies and the transformation intention toward industry 5.0 banking supply chains, supporting H5 (case of partial mediation). These findings align with a number of management studies that embedded the TAM into their research models yet across different research contexts to examine the acceptance of other technologies (e.g., Al-Rahmi et al., 2019; Jain et al., 2023; Lin and Lin, 2014; Nafea, 2021). For example, the current findings agree with Chen et al. (2026) and Tannady et al. (2026), who concluded that if organisations and their employees believe that new technologies (e.g., electronic SCM platforms and blockchain technology) can help perform tasks more efficiently and effectively, they are encouraged to adopt these technologies across the manufacturing and agri-food supply chains.

In conclusion, these findings verify that logistics and supply chain innovativeness, perceived ease of operational use, and perceived usefulness of industry 5.0 technologies pivotally shape the intention to transform to industry 5.0 banking supply chains in Egypt.

6. Implications, recommendations, limitations and future research

Based on the research findings, the following fruitful outcomes were derived — including theoretical, graphical, and managerial contributions and implications — offering practical recommendations to academics, practitioners, and policy makers (as summarised in Fig. 7) on leveraging industry 5.0 technologies and enhancing logistics and supply chain innovativeness to transform to industry 5.0 banking supply chains aligned with society 5.0 principles and United Nations' 17 SDGs.

1. ***Theoretical implications***: This interdisciplinary study integrated the TAM with *supply chain innovation capabilities* to investigate their effect on the intention to transform to industry 5.0 supply chains. This means that this research studied innovativeness as a strategic capability *from a supply chain perspective*, enabling the transformation toward banking 5.0 supply chains.
2. ***Managerial implications and practical recommendations***: This paper proposes sustainability-aligned practical recommendations to policy makers and practitioners in the field of logistics and supply chain management as follows:

2.1. Logistics and supply chain managers are advised to employ industry 5.0 technologies and enhance their innovation capabilities to transform to banking 5.0 supply chains.
2.2. Operations, logistics and supply chain professionals are advised to adopt industry 5.0 supply chain practices and align these activities with the United Nations' sustainable development goals. This transition — which includes practices like waste management 5.0, resilient logistics and supply chain management, collaborative AI-enhanced forecasting and capacity planning, smart banking operations, responsible banking, leagile supply chain management, and green logistics with clean transportation and smart warehouse management — is essential to achieving a sustainable banking supply chain 5.0.
2.3. Human resources managers should equip their human assets across banking supply chain nodes with the required knowledge, skills and attitudes to work collaboratively and synergistically with

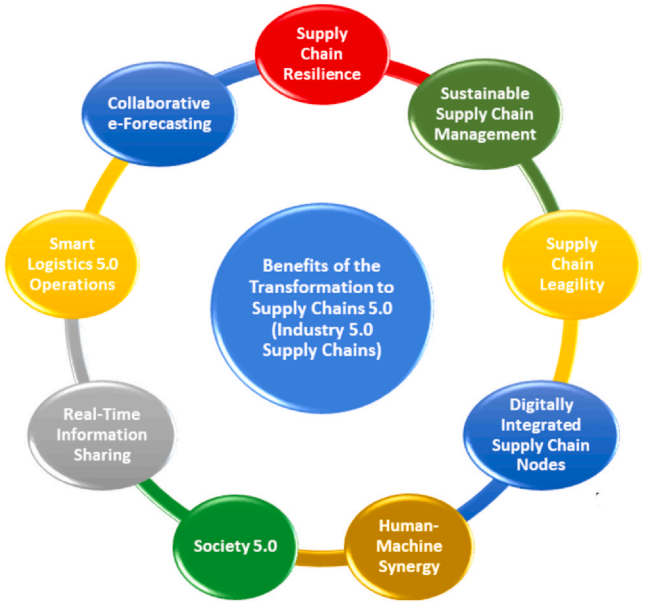


Fig. 8. Benefits of the Transformation to Supply Chains 5.0 (Industry 5.0 Supply Chains).
Source: Authors' own work



Fig. 9. Challenges of the Egyptian Banking Transformation to Supply Chains 5.0.
Source: Authors' own work

machines, robots and industry 5.0 technologies — such as artificial intelligence, blockchain, and digitally-transformed logistics and supply chain management systems.

2.4. Supply chain and human resources managers should collaborate to raise awareness among their banks' employees and external stakeholders on the ease of use and usefulness of industry 5.0 technologies as well as the importance of sustaining these supply chain 5.0 systems to drive the banking 5.0 transformation.

2.5. Banking leaders, along with logistics and supply chain managers, should develop an innovation-oriented culture. This culture must foster a banking 5.0 strategy that aligns with logistics and SCM 5.0 practices both within the bank and across its supply chain stakeholders.

2.6. Policy makers in Egypt are recommended to design policies that reinforce and facilitate the adoption of industry 5.0 logistics and supply chain strategies, aligning them with Egypt's Vision 2030 and the United Nations' 17 SDGs to achieve smart society 5.0.

3. ***Graphical contributions***: Building on the qualitative interviews, the authors analysed and illustrated the benefits and challenges of the Egyptian banking transformation to industry 5.0 supply chains (as depicted in Figs. 8 and 9). Fig. 8 encapsulates the benefits of the transformation to banking 5.0 supply chains and Fig. 9 synthesises the challenges of Egyptian banking's transformation toward supply chains 5.0. *To overcome these challenges*, and following established literature of strategy mapping (e.g., Adel, 2010; Adel, 2021; Adel et al., 2024; Adel and Mahrous, 2018; Andres et al., 2024; Lázaro et al., 2018; Mahrous and Adel, 2017; Mourtzis et al., 2022; Nayeri et al., 2025; Nicoletti, 2021; Valackiene and Andrijauskaite, 2021; Wu, 2012; Yitmen et al., 2023), the authors developed a sustainable logistics and supply chain 5.0 strategy map for the Egyptian Banks (as proposed in Fig. 10), whose four main perspectives link directly to the achievement of the United Nations' 17 SDGs.

In summary, this paper integrates the fragmented literature themes of this interdisciplinary research area, focusing on the evolution of digitally-transformed logistics and supply chain management (as portrayed in Fig. 11). Fig. 11 describes the core contribution of this research. *Conceptually and empirically, it integrates the fragmented literature of several interdependent clusters*. These include technology adoption, industry 4.0/5.0 technologies, logistics 4.0/5.0, supply chain 4.0/5.0, supply chain innovativeness, and sustainable society 4.0/5.0 within the under-researched context of banking 5.0 supply chains.

With respect to the limitations of this research, data were gathered from an Egyptian emerging banking market, which is characterised by a population size that is not large enough to obtain a larger sample, and thus affects the generalisability of the research findings. However, the questionnaires were filled by banking supply chain experts who represent their digitally-transforming public and international banks in Egypt, and who currently utilise advanced technologies. Also, only one sector — the banking 5.0 industry — was investigated in this empirical research. This is because the banking industry is a vital and promising sector. In particular, the Egyptian banking industry is a historical and fast-growing market, yet it remains an under-researched context for transforming supply chains 5.0. This promising Egyptian banking industry represents an attractive context for this dynamic research area, as its supply chains possess remarkable innovativeness and are actively driving the sustainable digital economy in Egypt. Previous studies were conducted on other vital industry 5.0 sectors, such as agriculture 5.0 (Brodny and Tutak, 2026), education 5.0 (Chigbu and Makapela, 2025), and tourism 5.0 (Martins et al., 2025). To enhance the contribution to this dynamic research area, further comparative empirical studies are recommended. Future research should utilise larger samples and investigate additional factors or moderators, such as implementation cost, data security and privacy, supply chain stakeholders' resistance, supply chain infrastructure readiness, and regulatory environment. Conducting these studies across different industries (e.g., manufacturing, healthcare, and retail) and multiple developed and emerging markets and countries will provide a more comprehensive understanding of the transformation toward logistics and supply chains 5.0 while enhancing the robustness and generalisability of the findings.

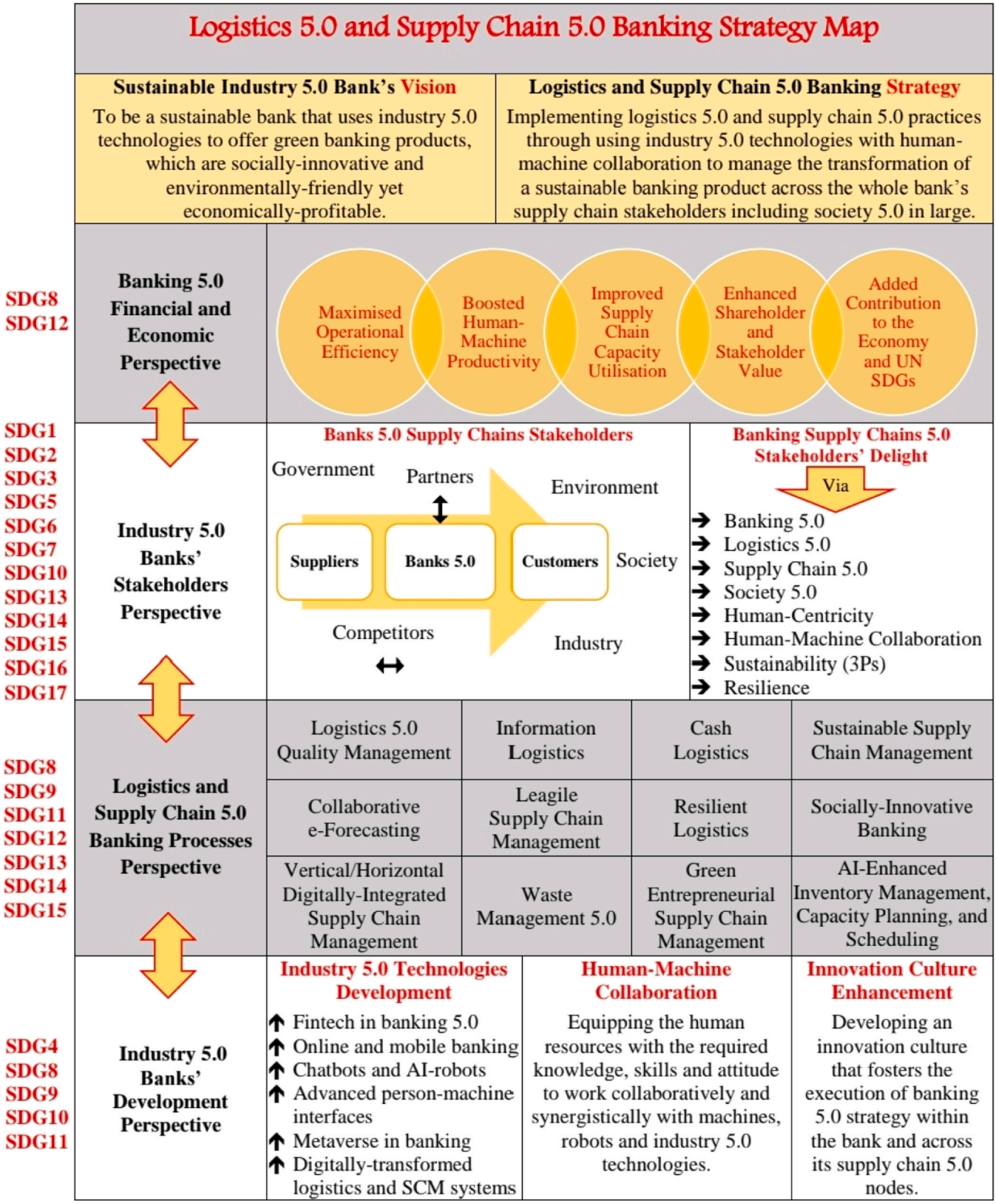


Fig. 10. A Proposed Logistics and Supply Chain 5.0 Strategy Map for the Egyptian Banks.
Source: Authors' own work

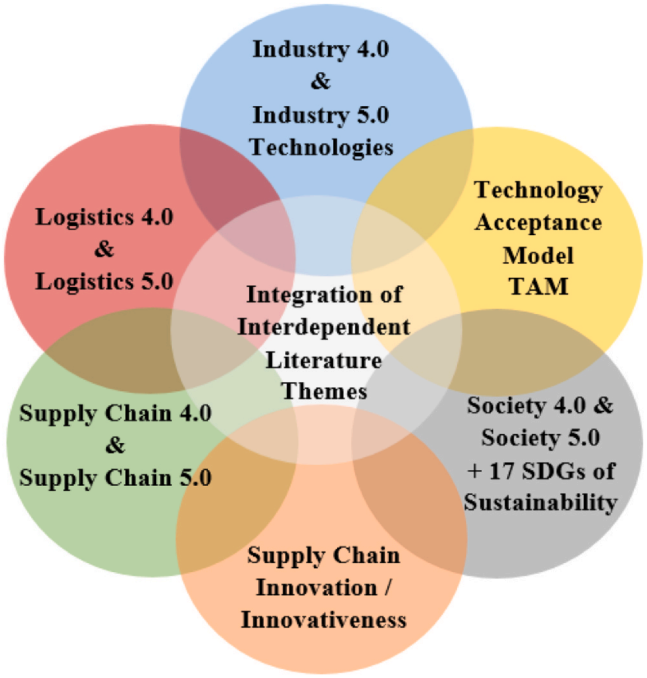


Fig. 11. The integration of the interdependent literature themes represents this interdisciplinary research contribution.
Source: Authors' own work

CRediT authorship contribution statement

Heba Mohamed Adel: Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Software, Resources, Project administration, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Eman Hassan Rajab:** Writing – original draft, Validation, Software, Resources, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Muhammad Salah Nafea:** Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Software, Resources, Methodology, Investigation, Formal analysis, Data curation, Conceptualization.

Appendix

Table AI
Questionnaire's Measurement Items

Factor	Description
Logistics and Supply Chain Innovativeness (LSCI) (Adapted from Agarwal and Prasad, 1998)	
$LSCI_1$	If my bank knew about a new supply chain technology, process or strategy, it would look for ways to experiment with it.
$LSCI_2$	Among our competitors, my bank's supply chain is usually the first to try out new technologies, processes or supply chain management approaches.
$LSCI_3$	My bank's supply chain likes to experiment with new technologies, processes or supply chain management approaches.
Perceived Ease of Operational Use of Industry 5.0 Technologies (PEOU) (Adapted from Kucukusta et al., 2015)	
$PEOU_1$	Using industry 5.0 technologies across my bank's supply chain would be easy to learn.
$PEOU_2$	Using industry 5.0 technologies within my bank would not require much mental effort.
$PEOU_3$	Using industry 5.0 technologies within my bank would be simple to do.
$PEOU_4$	Using industry 5.0 technologies for my bank's logistics operations and supply chain management practices would be easy to use.
Perceived Usefulness of Industry 5.0 Technologies (PU) (Adapted from Kucukusta et al., 2015)	
PU_1	Using industry 5.0 technologies would make my bank's logistics and supply chain management easier.
PU_2	Using industry 5.0 technologies would be useful for my bank's logistics and supply chain management processes.
PU_3	Using industry 5.0 technologies across my bank's supply chain would help me to accomplish the logistics and supply chain management tasks more efficiently and quickly.
PU_4	Using industry 5.0 technologies across my bank's supply chain would help me to conduct the logistics and supply chain management practices more effectively.
Transformation Intention towards Industry 5.0 Supply Chains (SC 5.0) (TII5SC) (Adapted from Kucukusta et al., 2015)	
$TII5SC_1$	My bank will transform to industry 5.0 technologies to perform logistics and supply chain 5.0 management practices in the future.
$TII5SC_2$	My bank will frequently use industry 5.0 technologies in performing logistics and supply chain 5.0 management practices in the future.
$TII5SC_3$	My bank will strongly recommend its supply chain stakeholders to use industry 5.0 technologies in conducting the logistics and supply chain 5.0 management practices.

Informed consent and confidentiality

The authors declare that they obtained a written informed consent from the patients and/or volunteers included in the article and that this report does not contain any personal information that could lead to their identification.

Ethical statement and informed consent

This research has been approved to be conducted on human subjects using anonymous surveys and interviews by the Research Ethics Reviewing Committee of the Faculty of Management Sciences, October University for Modern Sciences and Arts (MSA) on the 18th of October 2025 with approval code MSAMNG-IRB-2025–010. Informed consent for participation was obtained from all subjects involved in the study. The corresponding author of this research is Associate Professor Heba Mohamed Adel. If you have any questions related to the ethical compliance of the study, you may contact her at (hadel@msa.edu.eg).

Funding Information

This work did not receive any grant from funding agencies in the public, commercial, or not-for-profit sectors.

Data availability

Data will be made available on request.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Declaration of Generative AI and AI-assisted technologies in the writing process

This study did not use AI tools during manuscript preparation.

References

Abdallah, R.B., Amara, E.B., Ayed, N.B., Fattouch, S., 2023. ML, AI, and IoT as driving forces from Industry 5.0 concepts for better global food security. Integrating Intelligence and Sustainability in Supply Chains. IGI Global Scientific Publishing, pp. 126–147.

Abushaikha, I., Alqahtani, M.S., Bwaliez, O.M., Bwaliez, O.M., 2026. Cognitive supply chain management and risk management in pharmaceuticals: the mediating roles of forecasting, synchronization, and transparency. Logistics 10 (1), 11.

Adel, H.M., 2010. The relationship between strategy mapping and the strategy formulation, communication and implementation. Master's Thesis. Business Administration Department, Faculty of Commerce, Cairo University., Egypt.

Adel, H.M., 2015. The impact of information and communications technology (ICT) and technology intelligence (TI) on the performance of the lean, agile and leagile supply chains: A comparative study. Ph.D. Thesis. Business Administration Department, Faculty of Commerce, Cairo University, Egypt.

Adel, H.M., 2020. ICT, information sharing and a new hybrid lean-agile performance: Empirical evidence from automotive hierarchical supply chains. Int. J. Technol. Manag. Sustain. Dev. 19 (2), 221–245.

Adel, H.M., 2021. Mapping and assessing green entrepreneurial performance: Evidence from a vertically integrated organic beverages supply chain. J. Entrep. Innov. Emerg. Econ. 7 (1), 78–98.

Adel, H.M., Allam, S., 2014. The direct and indirect effect of ICT on hybrid lean-agile supply-chain performance: An empirical study of automotive industry in an emerging market. Proceedings of the 4th Conference of the International Network of Business & Management Journals (INBAM). Universitat Autònoma de Barcelona, Barcelona, Spain 25-27 June. (ISBN 978-84-697-0478-3).

Adel, H.M., Khaled, M., Yehya, M.A., Elsayed, R., Ali, R.S., Ahmed, F.E., 2024. Nexus among artificial intelligence implementation, healthcare social innovation, and green image of hospitals' operations management in Egypt. Clean. Logist. Supply Chain 11, 100156.

Adel, H.M., Mahrous, A.A., 2018. Sustainability communication and evaluation: A practice-based case study on British-Egyptian universities value-chain. Proceedings of the 32nd Annual International Conference of The British Academy of Management (BAM) 2018: Driving Productivity in Uncertain and Challenging Times. Bristol Business School, University of the West of England, United Kingdom. https://doi.org/10.2139/ssrn.4186830

Adel, H.M., Younis, R.A.A., 2019. Using co-creating mass-customisation and innovation climate for enhanced value: Empirical investigation in international modular jewellery market. J. Humanit. Appl. Social. Sci. 1 (1), 25–42.

Adel, H.M., Younis, R.A.A., 2023. Interplay among blockchain technology adoption strategy, e-supply chain management diffusion, entrepreneurial orientation and human resources information system in banking. Int. J. Emerg. Mark. 18 (10), 3588–3615.

Agarwal, R., Prasad, J., 1998. A conceptual and operational definition of personal innovativeness in the domain of information technology. Inf. Syst. Res. 9 (2), 204–215.

Agrawal, S., Agrawal, R., Kumar, A., Luthra, S., Garza-Reyes, J.A., 2024. Can industry 5.0 technologies overcome supply chain disruptions? — A perspective study on pandemics, war, and climate change issues. Oper. Manage. Res. 17 (2), 453–468.

Aji, H.M., Berakon, I., Riza, A.F., 2021. The effects of subjective norm and knowledge about riba on intention to use e-money in Indonesia. J. Islam. Mark. 12 (6), 1180–1196.

Al-Rahmi, A.M., Ramin, A.K., Alamri, M.M., Al-Rahmi, W.M., Yahaya, N., Abualrejal, H., Al-Maatouk, Q., 2019. Evaluating the intended use of decision support system (DSS) via academic staff: an applying technology acceptance model (TAM). Int. J. Eng. Adv. Technol. 8 (6s3), 565–571.

Alamsjah, F., Yunus, E.N., 2022. Achieving supply chain 4.0 and the importance of agility, ambidexterity, and organizational culture: a case of Indonesia. J. Open. Innov. Technol. Mark. Complex. 8 (2), 83.

Andres, B., Diaz-Madroñero, M., Soares, A.L., Poler, R., 2024. Enabling technologies to support supply chain logistics 5.0. IEEE Access. 12, 43889–43906.

Bag, S., Rahman, M.S., Chiarini, A., 2025. Building sustainable supply chain resilience: insights from a mixed-method study. Bus. Strategy Environ. 34 (2), 2103–2127.

Boudouaia, M.A., Ouchani, S., Qaisar, S.M., Almaktoom, A.T., 2024. Supply chain 5.0: Vision, challenges, and perspectives. 2024 21st Learning and Technology Conference (L&T). IEEE, pp. 203–208.

Braun, V., Clarke, V., 2006. Using thematic analysis in psychology. Qual. Res. Psychol. 3 (2), 77–101.

Brodny, J., Tutak, M., 2026. A human-adaptive, resilient, value-embedded socio-technical framework for agriculture 5.0: the HARVEST-5 model. J. Open Innov. Technol. Mark. Complex. 12 (2), 100756.

Calantone, R.J., Cavusgil, S.T., Zhao, Y., 2002. Learning orientation, firm innovation capability, and firm performance. Ind. Mark. Manag. 31 (6), 515–524.

Castillo, C., Otero-Romero, T., Alvarez-Palau, E.J., 2025. Navigating the transition to industry 5.0: advancing sustainability, resilience, and human-centricity in Spanish supply chain management. Discov. Sustain. 6 (1), 331.

Central Bank of Egypt, 2023. The Central Bank of Egypt's FinTech and Innovation Strategy. https://www.cbe.org.eg/en/financial-technology.

Chen, J., Feng, X., Abdul-Hamid, A.-Q., Zailani, S., 2026. From capability to intention: a DCV-TAM hybrid model for blockchain adoption in circular agri-food supply chains. Agric. Food Econ. 14 (1), 34.

Chigbu, B.I., Makapela, S.L., 2025. AI in education, sustainability, and the future of work: an integrative review of industry 5.0, education 5.0, and work 5.0. J. Open Innov.: Technol. Mark. Complex. 11 (4), 100645.

Cohen, J., 1988. Statistical Power Analysis for the Behavioral Sciences, 2nd ed. Lawrence Erlbaum Associates.

Creswell, J.W., Creswell, J.D., 2023. Research Design: Qualitative, Quantitative, and Mixed Methods Approaches. Sage Publications, United States of America.

Davis, F.D., 1989. Perceived usefulness, perceived ease of use, and user acceptance of information technology. MIS Q. 13 (3), 319–340.

El-Sharkawy, S.A., Nafea, M.S., Hassan, E.E.-D., 2023. HRM and organizational learning in knowledge economy: Investigating the impact of happiness at work (HAW) on organizational learning capability (OLC). Future Bus. J. 9 (1), 10.

Emon, M.M.H., Khan, T., 2025. The transformative role of Industry 4.0 in supply chains: Exploring digital integration and innovation in the manufacturing enterprises. J. Open Innov. Technol. Mark. Complex. 11 (2), 100516.

Esen, M., Erdoğmuş, N., 2014. Effects of technology readiness on technology acceptance in e-HRM: Mediating role of perceived usefulness. Bilgi Ekonomisi ve Yönetimi Dergisi 9 (1), 7–21.

Fares, N., Anass, C., Shardeo, V., Garza-Reyes, J.A., 2026. Supply chain management in the Industry 5.0 era: strategic implications. Benchmark. Int. J. 33 (10), 2949–2977.

Fox, S., Edzard, C., Omar, K., Huelsmann, T., 2025. Logistics 5.0: Biosocial–technical interactions in logistics. Int. J. Logist. Manag. 36 (7), 308–329.

Frederico, G.F., 2021. From supply chain 4.0 to supply chain 5.0: Findings from a systematic literature review and research directions. Logistics 5 (3), 49.

Ghag, N., Sonar, H., Sawant, R., Bankapalli, K., 2025. Examining industry 5.0 and supply chain performance: an empirical study for managing supply chain complexity. Prod. Manuf. Res. 13 (1), 2501181.

Giagnocavo, C., Duque-Acevedo, M., Terán-Yépez, E., Herforth-Rahmé, J., Defossez, E., Carlesi, S., Volpi, I., 2025. A multi-stakeholder perspective on the use of digital technologies in European organic and agroecological farming systems. Technol. Soc. 81, 102763.

Green, S.B., 1991. How many subjects does it take to do a regression analysis. Multivar. Behav. Res. 26 (3), 499–510.

Hair Jr, J.F., Black, W.C., Babin, B.J., Anderson, R.E., 2019a. Multivariate Data Analysis. Cengage, United Kingdom.

Hair Jr, J.F., Hult, G.T.M., Ringle, C.M., Sarstedt, M., 2022. A Primer on Partial Least Squares Structural Equation Modeling (PLS-SEM), 3rd ed. Sage, London.

Hair, J.F., Risher, J.J., Sarstedt, M., Ringle, C.M., 2019b. When to use and how to report the results of PLS-SEM. Eur. Bus. Rev. 31 (1), 2–24.

Henseler, J., Ringle, C.M., Sarstedt, M., 2015. A new criterion for assessing discriminant validity in variance-based structural equation modeling. J. Acad. Mark. Sci. 43, 115–135.

Hsu, C.-H., Wu, J.-Z., Zhang, T.-Y., Chen, J.-Y., 2024. Deploying Industry 5.0 drivers to enhance sustainable supply chain risk resilience. Int. J. Sustain. Eng. 17 (1), 211–238.

Hult, G.T.M., Hurley, R.F., Knight, G.A., 2004. Innovativeness: its antecedents and impact on business performance. Ind. Mark. Manag. 33 (5), 429–438.

Ismail, M.M., Ahmed, Z., Abdel-Gawad, A.F., Mohamed, M., 2024. Toward supply chain 5.0: an integrated multi-criteria decision-making models for sustainable and resilience enterprise. Decis. Mak. Appl. Manag. Eng. 7 (1), 160–186.

Jain, M., Soni, G., Verma, D., Baraiya, R., Ramtiyal, B., 2023. Selection of technology acceptance model for adoption of industry 4.0 technologies in Agri-fresh supply chain. Sustainability 15 (6), 4821.

Jefroy, N., Azarian, M., Yu, H., 2022. Moving from industry 4.0 to industry 5.0: What are the implications for smart logistics? Logistics 6 (2), 26.

Kim, J.-H., Kang, E., 2023. An empirical research: Incorporation of user innovativeness into TAM and UTAUT in adopting a golf app. Sustainability 15 (10), 8309.

Kock, N., 2015. Common method bias in PLS-SEM: a full collinearity assessment approach. Int. J. e-Collab. 11 (4), 1–10.

Kucukusta, D., Law, R., Besbes, A., Legohérel, P., 2015. Re-examining perceived usefulness and ease of use in online booking: the case of Hong Kong online users. Int. J. Contemp. Hosp. Manag. 27 (2), 185–198.

Kumar, J.A., Bervell, B., Annamalai, N., Osman, S., 2020. Behavioral intention to use mobile learning: evaluating the role of self-efficacy, subjective norm, and WhatsApp use habit. IEEE Access. 8, 208058–208074.

Lázaro, J.L., Jiménez, Á.B., Takeda, A., 2018. Improving cash logistics in bank branches by coupling machine learning and robust optimization. Expert. Syst. Appl. 92, 236–255.

Le, T.T., Nhu, Q.P.V., Behl, A., 2025. Role of digital supply chain in promoting sustainable supply chain performance: the mediating of supply chain integration and information sharing. Int. J. Logist. Manag. 36 (5), 1439–1462.

Li, W., Waris, I., Bhutto, M.Y., 2024. Understanding the nexus among big data analytics capabilities, green dynamic capabilities, supply chain agility and green competitive advantage: the moderating effect of supply chain innovativeness. J. Manuf. Technol. Manag. 35 (1), 119–140.

Lim, W.M., 2024. A typology of validity: content, face, convergent, discriminant, nomological and predictive validity. J. Trade Sci. 12 (3), 155–179.

Lin, T.-H., Lin, I.-C., 2014. Factors for information technology acceptance willingness and adoption in logistics industry from supply chain perspectives. Int. J. Electron. Bus. Manag. 12 (3), 167–177.

Lowe, B., Alpert, F., 2015. Forecasting consumer perception of innovativeness. Technovation 45, 1–14.

Mahrous, A.A., Adel, H.M., 2017. Performance evaluation of sustainability in universities. Proceedings of the Cairo University International Conference on Business Sciences (CUCBS 2017): Roadmaps for Sustainable Businesses. Cairo University, Egypt 22-24 April.

Martell-Chávez, F., López-Téllez, J.M., May-Arrioja, D.A., Valenzuela-González, R., Ortiz-Morales, M., 2026. Innovation and technology management strategies for industry 4.0 adoption in small and medium-sized enterprises in developing countries. J. Open Innov. Technol. Mark. Complex. 12 (2), 100769.

Martins, S., Ramos, A.L., Brito, M., 2025. Empowering sustainable tourism through simulation: evidence and trends in the Tourism 5.0 era. Sustainability 17 (23), 10850.

Mehdiabadi, A., Shahabi, V., Shamsinejad, S., Amiri, M., Spulbar, C., Birau, R., 2022. Investigating industry 5.0 and its impact on the banking industry: requirements, approaches and communications. Appl. Sci. 12 (10), 5126.
Minculete, G., Bârsan, G., Olar, P., 2021. Conceptual approaches of industry 5.0: Correlative elements with supply chain management 5.0. Rev. Manag. Comp. Int. 22 (5), 622–635.
Mouazen, A.M., Hernández-Lara, A.B., Chahine, J., Halawi, A., 2025. Triple bottom line sustainability and Innovation 5.0 management through the lens of Industry 5.0, Society 5.0 and Digitized Value Chain 5.0. Eur. J. Innov. Manag. 28 (5), 1965–2005.
Mourtzis, D., Angelopoulos, J., Panopoulos, N., 2022. A literature review of the challenges and opportunities of the transition from industry 4.0 to society 5.0. Energies 15 (17), 6276.
Nafea, M.S., 2021. The antecedents of the intention to adopt human capital analytics among HR professionals - The mediating role of perceived usefulness: An empirical study using technology acceptance model (TAM). Ph.D. Thesis. Business Administration Department, Faculty of Commerce, Cairo University, Egypt.
Nagy, E.-S.A., Adel, H.M., 2026. Does changing the requirements of measurement types and scales used in survey-based research yield different results? An SDG4-aligned quality management experimental study. Manag. Sustain. Arab. Rev. 5 (3), 549–573.
Nayeri, S., Sazvar, Z., Tirkolaee, E.B., 2025. Towards waste management 5.0: a nexus between circular economy and industry 5.0 dimensions. Waste Manag. 203, 114830.
Nazarian, H., Khan, S.A., 2024. The impact of industry 5.0 on supply chain performance. Int. J. Eng. Bus. Manag. 16, 1–19.
Nicoletti, B., 2021. Industry 5.0 and Banking 5.0. Banking 5.0: How Fintech Will Change Traditional Banks in the 'New Normal' Post Pandemic. Springer International Publishing, Cham, pp. 13–53.
Osman, S.M.H., Yin, T.S., Alnoor, A., Alazzawi, M.S., Foo, N.T., 2025. Uncovering the impact of supply chain management practices on supply chain performance: a hybrid PLS-SEM and ANN approach. J. Open Innov. Technol. Mark. Complex. 11 (4), 100684.
Rajab, E.H., Adel, H.M., Nafea, M.S., 2025. Connecting the dots between subjective norms, perceived ease of operational use, and intention towards shaping AI adoption strategies for talent acquisition across supply chains. MSA-Manag. Sci. J. 4 (4), 176–198.
Rame, R., Purwanto, P., Sudarno, S., 2024. Industry 5.0 and sustainability: an overview of emerging trends and challenges for a green future. Innov. Green Dev. 3 (4), 100173.
Sahab, S., Oulfarsi, S., 2026. The role of supply chain risk management in shaping supply chain resilience and robustness: empirical evidence from Moroccan manufacturing firms. Logistics 10 (2), 39.
Sarstedt, M., Hair Jr, J.F., Ringle, C.M., 2023. "PLS-SEM: Indeed a silver bullet"– retrospective observations and recent advances. J. Mark. Theory Pract. 31 (3), 261–275.
Sarstedt, M., Richter, N.F., Hauff, S., Ringle, C.M., 2024. Combined importance–performance map analysis (cIPMA) in partial least squares structural equation modeling (PLS–SEM): a SmartPLS 4 tutorial. J. Mark. Anal. 12 (4), 746–760.
Schindler, P.S., 2022. Business Research Methods. McGraw-Hill, United States of America.
Shahadat, M.M.H., Chowdhury, A.Y., Jahed, M.A., Nathan, R.J., Fekete-Farkas, M., 2024. Innovativeness, visibility, and collaboration effect on supply chain performance: Moderating role of digital supply chain integration. Cogent Bus. Manag. 11 (1), 2390168.
Shahzad, K., Zhang, Q., Khan, M.K., Ashfaq, M., Hafeez, M., 2023. The acceptance and continued use of blockchain technology in supply chain management: a unified model from supply chain professional's stance. Int. J. Emerg. Mark. 18 (12), 6300–6321.
Szeredi, V.V., Trenka, Z.J., Pogatsnik, M., 2024. Smart logistics and sustainability in logistics 5.0. 2024 IEEE 6th International Symposium on Logistics and Industrial Informatics (LINDI). IEEE, pp. 109–114.
Tannady, H., Wicaksana, H.H., Rustanto, A.E., Utami, E.Y., Suprayitno, D., 2026. Examining blue collar adoption of supply chain platforms using technology acceptance model (TAM). 2026 Sixth International Conference on Advances in Electrical, Computing, Communications and Sustainable Technologies (ICAECT). IEEE, pp. 1–4.
Valackiene, A., Andrijauskaite, R., 2021. Model for assessing information logistics systems in banks: Lithuanian case study. Logistics 5 (3), 42.
WordArt.com, 2026. Word Cloud Art Creator. https://wordart.com/.
Wu, H.-Y., 2012. Constructing a strategy map for banking institutions with key performance indicators of the balanced scorecard. Eval. Program. Plan. 35 (3), 303–320.
Yitmen, I., Almusaed, A., Alizadehsalehi, S., 2023. Investigating the causal relationships among enablers of the construction 5.0 paradigm: integration of operator 5.0 and society 5.0 with human-centricity, sustainability, and resilience. Sustainability 15 (11), 9105.
Younis, R.A.A., Adel, H.M., 2020. Artificial intelligence strategy, creativity-oriented HRM and knowledge-sharing quality: Empirical analysis of individual and organisational performance of AI-powered businesses. Proceedings of the Annual International Conference of The British Academy of Management (BAM) 2020: Innovating for a Sustainable Future, London, United Kingdom, 2-4 September. https://doi.org/10.2139/ssrn.4127128
Yuan, C., Liu, W., Zhou, G., Shi, X., Long, S., Chen, Z., Yan, X., 2022. Supply chain innovation announcements and shareholder value under industries 4.0 and 5.0: evidence from China. Ind. Manag. Data Syst. 122 (8), 1909–1937.
Yuan, X.-M., Xue, A., 2023. Supply chain 4.0: new generation of supply chain management. Logistics 7 (1), 9.
Zekhnini, K., Chaouni Benabdellah, A., Bag, S., Gupta, S., 2024. Supply chain 5.0 digitalization: an integrated approach for risk assessment. Manag. Decis. 1–30.
Zhen, Z., Yao, Y., 2025. The confluence of digital twin and blockchain technologies in industry 5.0: transforming supply chain management for innovation and sustainability. J. Knowl. Econ. 16 (1), 5295–5321.
Zizic, M.C., Mladineo, M., Gjeldum, N., Celent, L., 2022. From industry 4.0 towards industry 5.0: a review and analysis of paradigm shift for the people, organization and technology. Energies 15 (14), 5221.

Associate Professor **Heba Mohamed Adel** is a Senior Fellow (SFHEA) of the Advance Higher Education (HEA), Certified Management and Business Educator (CMBE) from the British Chartered Association of Business Schools, and Member of the Chartered Management Institute (MCMI) and the British Academy of Management. She got a PGCert in Higher Education from the University of Greenwich, UK. She is an Associate Professor of Business Administration and Head of Human Resources Management Department at the Faculty of Management Sciences, October University for Modern Sciences and Arts (MSA) in Egypt (a partner to the British Universities of Greenwich and Bedfordshire). She is the Head of British PGCert and Fellowship in Higher Education Unit in MSA University. She leads and teaches under/post-graduate courses (e.g., Production, Operations and Supply Chain Management, Strategic Management, and Research Methodology) in a number of universities. She got her Master's Degree in Business Administration (Strategic Management) and Ph.D. in Business Administration (Production, Operations and Supply Chain Management) from Faculty of Commerce English Section, Cairo University. She is a Member of the National Committee of Humanities and Social Sciences at The Academy of Scientific Research and Technology (ASRT). She has published in Scopus & Web of Science ranked journals (Cleaner Logistics and Supply Chain, International Journal of Emerging Markets, Journal of Entrepreneurship in Emerging Economies, Management and Sustainability: An Arab Review, International Journal of Technology Management and Sustainable Development, Journal of Entrepreneurship and Innovation in Emerging Economies, and Journal of Humanities and Applied Social Sciences).

Dr. Muhammad Nafea is an Assistant Professor of Management specialising in Strategic Management and Human Resources. He holds a PhD in Business Administration (HR Analytics), a Postgraduate Certificate in Academic Practice, and is a Fellow of the Higher Education Academy (FHEA). He serves as Head of the Quality Assurance Unit at the Faculty of Management Sciences, MSA University, and teaches postgraduate studies. Alongside academia, he works as a strategic management consultant for private and governmental agencies, focusing on organisational development, performance improvement, and governance.